ICIMOD

MOUNTAIN INFRASTRUCTURE AND TECHNOLOGY

Discussion Paper Series

DEVELOPMENT OF MICRO-HYDRO SYSTEMS IN NEPAL: PROBLEMS AND PROSPECTS

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MIT Series No. 10

1991

International Centre for Integrated Mountain Development

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June, 1991

International Centre for Integrated Mountain Development (ICIMOD)

Kathmandu, Nepal

PREFACE

This paper was prepared for, and presented at, the Seminar on 'Rural Energy and Related Technologies' held in Kathmandu from 26 to 28 March, 1991, in collaboration with the Agricultural Development Bank of Nepal and the Water and Energy Commission Secretariate of His Majesty's Government of Nepal.

This paper assesses the development of the micro-hydro systems since the last sixteen years, identifies factors that contributed to the success of this technology, and factors that constrained wider dissemination, and also indicates priority areas for future development and promotional efforts.

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Introduction

Experiences suggest that the micro-hydro system[1] has a great deal of promise in Nepal. The dissemination of improved *ghattas*[2], multipurpose power units (MPPU), and cross-flow (Banki-Michel type) as well as Pelton turbines has been encouraging, particularly, over the last fifteen years. Many of these are characterised by a relatively low power output (less than 10kW) in mechanical form that meets the agroprocessing requirements of village residents at an affordable cost. More recently, induction generators have been locally produced. Their availability at relatively low cost and the ease of adding them on to existing installations have been instrumental in facilitating the supply of electricity at night time to nearby households. This has not only helped village enterpreneurs to derive greater benefits by increasing the night time load factor but now also helped remote households who remain outside the reach of the national grid. In this connection, it is worthwhile to analyse the initiatives taken by village entrepreneurs and community groups, by manufacturers in supplying the necessary equipment as per user requirements, and by the Agricultural Development Bank of Nepal (ADB/N) in providing effective incentives towards private ventures. Analysis of these initiatives constituts the primary focus of this paper. Lessons will be drawn from these experiences to examine how the programme might be extended more effectively. In particular emphasis will be placed on how the mountain communities in the more remote and inaccessible regions of the country could be included in the programme in due course.

A related dimension of the micro-hydro system pertains to a possible change in its strategy of dissemination. A recent study has pointed out that at the current rate of dissemination, the saturation point of the turbines' programme under present conditions will be reached in the next 15 to 20 years (Aitken et al. 1991). Given the tremendous potentials provided by the more than 6,000 rivers and streams crisscrossing the mountain terrains of the country, a pertinent question arises: is it desirable to place more emphasis on the installation of larger units, say, 40 to 50kW or higher but staying within the 100kw limit of the micro-hydro system? Technically, local manufacturers are capable of supplying the necessary equipment in that range. The main issue is in relation to organisational and management concerns. The activity will clearly have to extend beyond meeting the milling and lighting requirements to managing multipurpose end uses with respect to fuelwood substitution, rural industrialisation, irrigation management, tourism development, and others. The implications, for village entrepreneurs and community groups as well as for government policies and programmes, are many. Following Meier's (1985) arguments, the preconditions for successful implementation include:

o clear policies pertaining to water rights, licensing procedures, rural electrification, and the use of energy for productive applications,

o practical institutional framework geared to the requirements of small hydropower development in all its aspects,

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1 The accepted convention in hydropower installation is that the micro-hydro system includes units below 100 kW in capacity. Other small-scale systems include the mini-hydro, ranging between 101 to 1,000kW, and the small hydro, ranging between 1,001 to 10,000kW. This paper refers, therefore, to the units below 100kw only.

2 A *ghatta* is a traditional watermill. The improved version consists of a runner, a metal axle, and bearings which increase the efficiency and thereby enable the installation of rice-huller or an oil-expeller, depending up on the water head and flow volume.

o knowledge of the general and specific magnitudes of available resources, on one hand, and energy demand, on the other, and

o trained manpower, budget allocations, and formulation of specific requirements in overall development plans.

Issues pertaining to these concerns will constitute the main focus of this paper. A general background on the development of the micro-hydro systems will, however, be presented, prior to the discussion of specific issues.

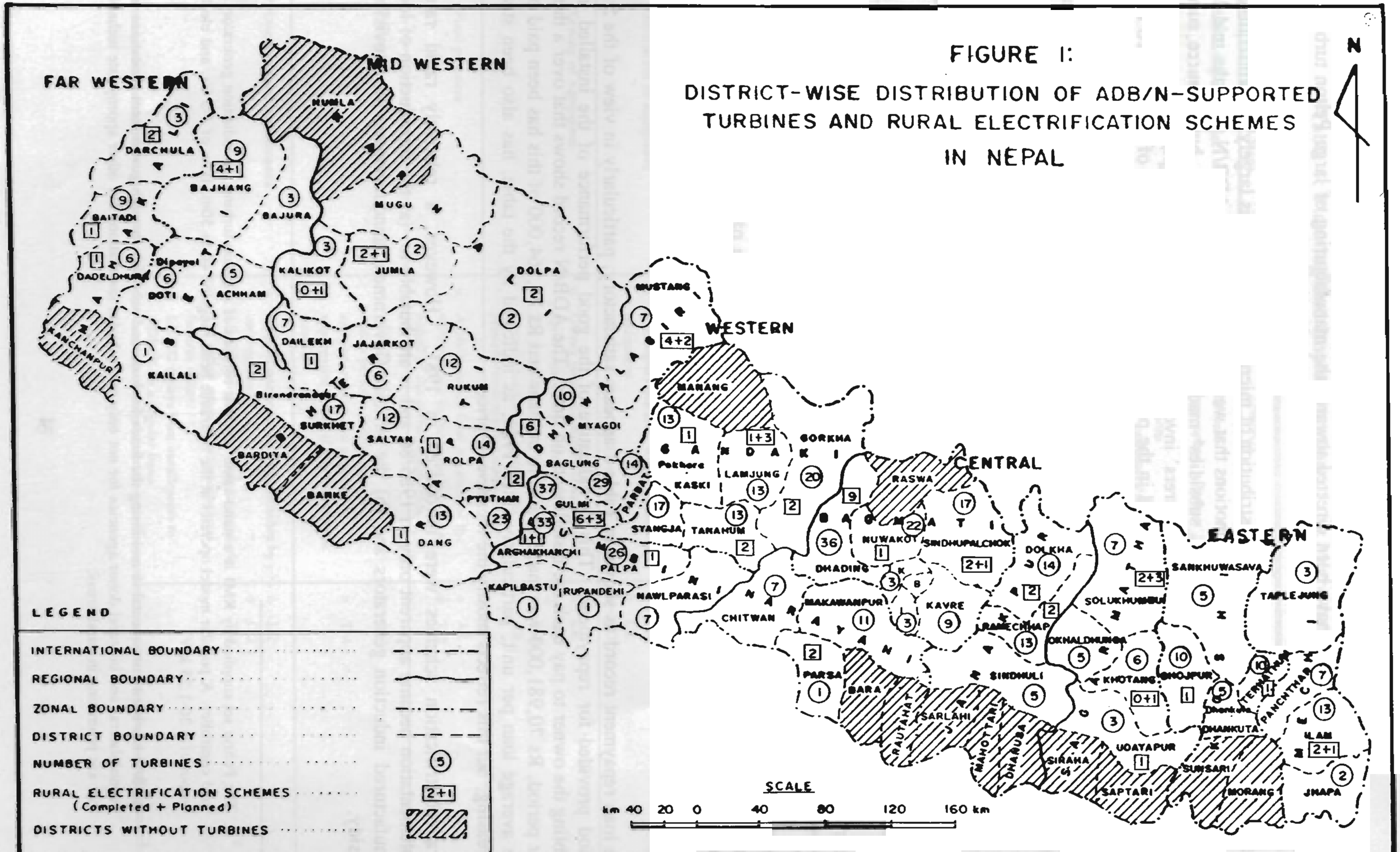
An Account of Micro-hydro Development

As already mentioned, the micro-hydro systems that have performed satisfactorily in Nepal include: (a) the agroprocessing units using turbines, MPPUs, and improved *ghattas* and (b) the electrification schemes using the induction generator. The latest ADB/N records show that there are 574 completed units (and 37 under construction) in the first category and 70 completed schemes (and 18 under construction) in the second. Figure 1 shows that 58 districts have already been covered with the units of one kind or another. The ones left out are either in the *Terai* (12 districts) where the potential is extremely limited by virtue of the terrain, or in the remote mountain regions (4 districts) where access to roads is the main constraint. Bhaktapur District, within Kathmandu Valley, is an anomaly in this respect. The distribution is clearly skewed. Areas in the immediate vicinity of Butwal and Kathmandu, the two supply centres, have apparently benefitted more than others. This indicates, in a cursory way, the potentials of outreach in many districts for some time to come. The four remote districts (Humla, Mugu, Manang, and Rasuwa) might require a different strategy than the one currently pursued if the micro-hydro potentials there are to be put to good use. The figures on the map do not include traditional *ghattas*. Despite its low output, about 25,000 such units are still estimated to be in use in the country (GATE 1988).

The promotion of these micro-hydro systems emerged essentially from the attempts to improve on the functions of the traditional *ghattas*. The first initiative appeared in the early 1960s when eight propeller turbines were installed for agroprocessing in Kathmandu Valley. They had to be abandoned, however, because of problems with the design (Aitken et al. 1991). The more acceptable cross-flow turbines appeared subsequently in 1976. The Balaju Yantra Shala (BYS) in Kathmandu, with Swiss assistance, and the Development and Consulting Services (DCS) and the Butwal Engineering Works (BEW), with the assistance of the United Mission to Nepal (UMN), played pivotal roles in developing and producing the turbines. Today there are at least seven other prominent but smaller manufacturers that distribute cross-flow turbines (Jantzen 1989). Small Pelton and Francis turbines were also initiated in 1978. Almost concurrently, a more powerful form of the traditional *ghatta* that uses metal components and is popularly known as the multipurpose power unit (MPPU) was developed by Akkal Man Nakarmi at the Kathmandu Metal Industries (KMI) and was popularised from 1980 onwards. Although the technical efficiency of the MPPU is lower than that of the cross-flow turbine, its popularity is attributable to its lower cost, i.e., about 60 per cent of the average cost per kW when compared with the turbine. Another important development was the introduction of locally manufactured induction generators in 1984, contributing to the rapid growth of rural electrification. These generators were mostly added on to the pre-existing agroprocessing units. Some stand-alone generators are also now being installed. This need-based development of appropriate technologies and their local manufacturing were all initiated in the private sector by a few ingenious and dedicated entrepreneurs. This has no doubt played a very important role in the popularity and dissemination of micro-hydro systems in Nepal. The latest addition to this healthy trend has been the local manufacturing of electronic load controllers from 1989

FIGURE 1:

DISTRICT-WISE DISTRIBUTION OF ADB/N-SUPPORTED TURBINES AND RURAL ELECTRIFICATION SCHEMES IN NEPAL



onwards. Recently efforts have been directed towards the manufacturing of large Pelton turbines and Peltric[3] units.

The current state of development and distribution of micro-hydro systems is largely the consequence of the active leadership and sustained promotions that were undertaken by the ADB/N from the mid-1970s on wards. Not only were loans and subsidies[4] made available by the bank, but resource surveys, feasibility studies, promotion of manufacturers' involvement, technical backstopping, and training were provided as needed. The process followed in the planning and implementation of micro-hydro units is encapsulated in Table 1.

The ADB/N efforts were also facilitated by two important policy decisions concerning rural electrification by the Government:

- o delicensing of all electricity installations below 100kw (1984), and
- o 50 per cent subsidy (75 per cent in case of remote areas) on electro-mechanical costs, including generators (1985).

The interlinkage between the distribution of micro-hydro systems, the development of local manufacturing capability, and the loans and subsidies made available by the ADB/N is apparent from Table 2. From 1977 to 1981, the distribution of cross-flow turbines could not exceed 18 units per annum. With the introduction of MPPUs and also the increase in the number of manufacturers, it is evident that a sudden jump took place in the number of units distributed (i.e., to 47). The pace of development was quite steady until 1984/85, when it reached a maximum (81). A slow decline is, however, apparent subsequently, indicating some sort of market saturation, at least with respect to the strategy and approach adopted until now. By 1989/90, it had reached a low of 30 units.

The loan repayment record as shown in Table 2 appears satisfactory, particularly in view of the 5 year period provided for repayment. This is indicative of the good performance of the installed units, enabling the owner to pay back the installments on time. The ADB/N record shows that over a thirteen year period, Rs 70,981,000 was made available in loans and Rs 24,764,000 of this has been paid back. The average loan per unit, particularly since 1984, as indicated by the table, has also been steadily increasing, but this reflects mostly the increase in price.

Rural electrification schemes were introduced in 1981. However, a relatively rapid rate of implementation became apparent only in 1985/86 and is attributable to: (a) the introduction of locally manufactured induction generators and (b) the official Government announcement for provision of subsidy.

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3 The Peltric set supplied by KMI is a stand-alone unit that consists of a Pelton turbine, an induction generator, and a load controller. A popular model operates at the hydraulic head range of 40 to 50m, flow of 1-5 l/s, and electricity output of 0.20-1.25 kW.

4 ADB/N has been instrumental in mobilising the funds for loans and subsidies through government allocations as well as multilateral and bilateral donor agencies for not only micro-hydro installations but other appropriate technologies that are promising in rural areas.

Table 1: Planning and Implementation of the Micro-hydro System

Procedural Steps	Activities	Involved Parties
1. Site survey and project identification	o Resource assessment - water volume, speed, effective head - terrain conditions - assessment of customers/services (milling, electricity) o Discussion on water rights o Feasibility/interest ascertained	o Local entrepreneur (LE) o Community group (CG) o Technician/Manufacturer (TM) o ADB/N Staff (AS)
2. Quotation sent to owner	o Owner expresses specific preferences o Manufacturer specifies available equipment	o LE o CG o TM
3. Loan request and assessment	o Owner provides collateral security o ADB/N staff checks financial and technical viability	o LE o CG o AS
4. Loan approval	o ADB/N issues approval notice to owner o ADB/N issues "coupon" for equipment order and provides 50% cash advance to manufacturer on behalf of the owner	o AS o LE o CG o TM
5. Preliminary onsite activities	o Construction of intake and canal o Preparation of turbine site o Collection of construction materials o Transportation of equipment to site	o LE o CG
6. Installation of equipment	o TM supervises civil works and installs equipment o LE/CG does the civil works	o TM o LE o CG
7. Testing of equipment	o Owner issues document of acceptance upon satisfactory operation o TM provides training to owner/operators on operational procedures & regular maintenance	o LE o CG o TM o AS
8. Final payment	o ADB/N makes final payment of the 50% balance to the manufacturer on behalf of the owner maintenance	o AS o TM
9. Follow-up and supervision	o ADB/N and manufacturer makes periodic follow-up and supervision and suggests appropriate action if any corrections needed	o AS o TM
10. Operation and maintenance	o Routine operation and maintenance by own/operators o LE/CG maintains civil works regularly o TM called when electromechanical failures occur o LE/CG repays loan installments to ADB/N on a regular basis	o LE o CG o TM

Table 2: Loan and Repayment Records for Turbines, MPPUs, and Improved *Ghattas*

Fiscal Year	No. of Units	ADB/N Loan	Avg. Loan Unit	Repayment	Cumulative Repayment	Cumulative Outstanding Loan
				Rs '000		
1977/78	4	200	50	-	-	200
1978/79	18	1,431	80	-	-	1,631
1979/80	18	1,357	75	233	233	4,755
1980/81	12	1,672	139	188	421	4,239
1981/82	47	3,013	64	802	1,223	6,450
1982/83	48	3,664	76	1,288	2,511	8,826
1983/84	63	4,976	79	1,043	3,554	12,759
1984/85	81	8,686	107	1,609	5,163	19,836
1985/86	77	8,875	115	2,055	7,218	26,656
1986/87	67	10,252	153	2,963	10,181	33,945
1987/88	67	10,131	151	3,630	13,811	40,446
1988/89	40	8,618	216	6,051	19,862	43,013
1989/90	30	8,106	270	4,902	24,764	46,217

Source: ADB/N records.

As shown in Table 3, about 11 units have been added every year since 1985. The average cost per kw of the added-on units in 1990 was about Rs 36,000 and this is about one-fourth that of the mini - or micro-hydroelectric plants operated by the Nepal Electricity Authority (NEA)[5]. The demand for electricity is mainly for lighting at night. The tariff is normally on the basis of a 40W bulb and ranges between Rs 15 to as high as Rs 60 per month. As noted by Aitken et al. (1991), the willingness to pay such exorbitant prices indicates that *"consumers may take factors other than financial costs and benefits into account in deciding what they are prepared to pay for electricity."*

Another point worthy of note in Table 3 is that as soon as a local entrepreneur demonstrates an interest he is readily assured of the necessary capital for investment through the loans and subsidies' programme of the ADB/N. On the average, he gets 50 to 60 per cent of the total cost in the form of a loan, payable over 5 years, and 35 to 45 per cent of the total cost as subsidy. At this rate, he has to be prepared to pay only 5 to 10 per cent of the total cost out of his own pocket, and that too for civil works where he

[5] According to the estimate made by Aitken et al. 1991, using the exchange rate of US $1 = Rs 23.5 and adjusting to FY 1987/88 values, the cost/kW of NEA-operated hydel plants averages out to about $5,100 or about Rs 120,000.

can invest his own labour or ask for help from friends in the village. The incentive is very attractive and a large queue of applicants for the programme is a good indicator of this.

Table 3: ADB/N Loans and Subsidies for Rural Electrification

Fiscal	No of Units	Total Capacity	Total Cost	Cost Per kW	Total Loan	Loan as % of Cost (Rs '000)	Total Subsidy	Subsidy as % of cost
1981/82	1	3	18	6	18	100	0	0
1982/83	2	13	847	65	624	74	0	0
1983/84	3	14	111	8	88	80	23	20
1984/85	4	21	319	16	172	54	88	28
1985/86	11	72	781	11	400	51	351	45
1986/87	18	171	2,155	13	1,142	53	832	39
1987/88	11	99	1,511	15	800	53	659	44
1988/89	9	79	2,744	35	1,652	60	865	35
1989/90	11	149	4,039	27	973	24	1,355	34
1990/91[a]	11	149	4,039	27	973	24	1,460	34
TOTAL	91	742	16,857	23	8,039	48	5,633	33

Source: ADB/N records

[a] Note: Loans and subsidies approved but not yet implemented. There were actually 18 such cases but complete information is available only on the 11 cases included here.

A large number of the added-on generators fall within the range of 1 to 10 kW. As shown in Table 4, 55 out of a total of 77 units (i.e., about 70 %), including stand-alone generators, are within this category. This is understandable from various perspectives. First of all, a unit in this range is easily manageable by a village entrepreneur. If a large unit is installed, cooperation with other villagers becomes mandatory and the organisational aspects have to be worked out rigorously for successful operation. Secondly, the locally manufactured generators in this range are relatively less expensive and more easily available. The larger units have to be imported and therefore the procedure becomes too complicated. Thirdly, less complicated civil works of the type traditionally used for local irrigation canals, known as *kulo*, are still acceptable for such a unit. For larger units, if the same civil works' technique is used, the cost of maintenance is likely to be too high. Fourthly, given the dispersed population in the middle hill and mountain communities of Nepal, the demand for electricity can be met reasonably by these small units.

Table 4: Distribution of Micro-hydro Units by Capacity (Ongoing and Planned[a], 1981-1991)

Capacity (kW)	No. of Units	Aggregated Power Output (kW)
1 - 2	9	13.1
3 - 4	10	33.5
5 - 6	18	97.2
7 - 8	7	53.5
9 - 10	11	110.1
11 - 12	8	94.0
13 - 14	1	14.0
15 - 16	6	93.0
19 - 20	2	38.6
21 - 22	1	22.0
25 - 26	3	76.0
29 - 30	1	30.0
39 - 40	1	40.0
61 - 62	1	62.5
TOTAL	79	777.5

Source: ADB/N records.

[a] Note: Includes 13 units scheduled for construction in 1991 for which loans have already been approved by the ADB/N.

The potentials of the larger units cannot, however, be ignored. There are already 17 units (22 %) in the 11 to 20kW range and 7 units (9 %) in the range above 20 kW. Important lessons have to be derived from the 'success' as well as from the 'failure' in their operational characteristics. Given the comparative advantage provided by the micro-hydro potentials in mountain communities, they might very well provide the necessary paraphernalia in the transformation of economic conditions there. This requires, however, a more diversified strategy than the one that has been adopted in micro-hydro development until now. This is a critical issue to which we will revert. Before that, we will analyse some of the empirical bases of micro-hydro development by citing selective examples that illustrate various facets of such development.

Elements of "Success" and "Failure": Some Empirical Evidence

Six cases, representing different types of ventures in the development of micro-hydro, are presented in separate boxes on each alternate page below to illustrate the elements of "success" and 'failure'. They include:

- o initiatives taken by village entrepreneurs in installing micro-hydro schemes, first to operate the agroprocessing units and then to gradually add on the electricity generator and diversify further with other income-generating activities (Case Example No. 1: Yagya Rice Mill in Gulmi; and Case Example No. 2: Mohantar Scheme);

- o group attempts by community residents, either as a small farmers' group (Case Example No. 3: Reginas Village Effort) or through cooperation of all the membere entire village (Case Example No. 4: Purang Electrification), to use the hyd effectively for agroprocessing and electrification;

- o successul effort by a small farmers' group (41 members) to operate a turbine pump for lift irrigation and orient it subsequently to other village development activities (Case Example No. 5: Karma Singh *Phant* Lift Irrigation Scheme);

- o difficulties associated with the intervention by a government-sponsored cooperative (Sajha) in the running of a programme that combines milling, electrification, and irrigation (Case Example No. 6: Karaputar Scheme).

Relevant observations that have general validity for most of the micro-hydro systems can be made from the above cases and are described below.

Meeting Locally Felt Needs at Affordable Cost

One overriding reason for the effective spread of the micro-hydro system is that each one of them meets an important requirement of the community. This is evident from the following remark made by Aitken et al. (1991) with respect to the agroprocessing services provided by the Ishaneshwar Mill at Karaputar: "*People come from up to eight hour's walk away to expell oil and up to three hours to grind grain. Rice husking only draws customers from the immediate vicinity since there are diesel mills operating in the locality offering the same service.*" As a general rule, the mill services are clearly perceived to be superior to the manual or other inefficient traditional forms of processing, and the mill owners are sufficiently sensitive to customer preferences concerning pricing so that the charges made on the services are either the same or only slightly higher than those the customers paid previously.

Case Example No. 1

YAGYA RICE MILL, KHAIRENI, GULMI DISTRICT

The mill is situated on the Jumdi Khola in Arunga Village, which is about 3 to 4 hours' walk from Ridi Bazaar. It was established in 1967 by two entrepreneurs from a nearby *Panchayat*, about five hours' walk from the site. The operation was not considered very successful. After five years, it was sold to another entrepreneur, also not from the local *Panchayat*. Because he had to depend on an operator who could not run it profitably, he in turn sold it after five years. The mill was then bought by an entrepreneur who had a house near the mill site and lived there.

In 1980, a flood demolished the mill. It was rebuilt with a loan from the ADB/N (Rs 200,000) only to meet the same fate later that year because of another flood. The mill was relocated and rebuilt with a further loan from the ADB/N. In 1983, electricity was installed, also with an ADB/N loan. All the loans were repaid on schedule, giving an indication of the mill's profitability.

The mill (10kW capacity) operates an oil expeller, grinder, and husker as well as the generator, and an operator and an assistant are employed. The owner makes minor repairs himself and has maintained a stock of bearings which are replaced regularly. The river flow drops during the dry season and can only take one load instead of the usual two. During the peak seasons for each crop, the mill is open from 7 a.m. to 6 p.m.; during the rest of the year it operates for about four hours each day. Electricity is presently supplied to 103 houses in the bazaar. The beneficiaries are, almost exclusively, the more prosperous members of the community. The current annual revenue from the entire venture is estimated to be about Rs 20,000, excluding the annual O&M cost of Rs 3,500.

There are four other turbine mills within an hour's distance of the mill site. The rates have not changed since 1983 and the owner does not intend to do so in the near future. Maintaining the goodwill of the community, he says, is more precious than extra profit. The proximity of competing services could also have influenced his decision.

The community felt that it had benefitted from the mill as it relieves the drudgery for women. The very poor, however, used the mill little except for oil-expelling, therefore traditional modes of processing still persist. One poor farmer observed that the money spent on processing at the mill could be better used in providing a good meal for one of his children. The poor, who cannot afford cash, pay in kind, and this works out to be more expensive.

Source: Aitken et al. 1991.

Regarding electricity supply, there is also a clear cut demand, sometimes for economic reasons (such as longer shopping hours and income-generating activities in the evening) but more often for non-economic reasons (such as prestige and convenience). The interest of the people is evident from the fact that they are willing to contribute towards the capital cost out of their own pocket (as in the case of Purang) and that they pay from Rs 12 to 16 per 40W bulb per month, for a three hour service daily (Reginas and Khaireni), to Rs 25 per month for 24 hour service (Purang). The tariff works out to be about Rs 3 to 4 per kWh which is several times higher than the standard NEA rate (about Rs 0.50 per unit for those consuming up to 25 units).

From the owner's point of view, the micro-hydro unit constitutes a paying proposition. Except in cases of very bad management, the mill and the electric generator (especially with the 50% subsidy) bring sufficient revenue to enable the owner to repay the loan installments in time and make a profit over and above that amount. Aitken et al. (1991) report that, according to ADB/N's estimates, there is a minimum of 15 per cent return on investment in non-electrified private schemes and a 4 per cent return for added - on electrification (after the government subsidy). The Ishaneshwar Mill generates, for example, an annual revenue of Rs 96,000 from electricity distribution and Rs 70,000 from milling services (total cost in 1981 was Rs 2.3 million); in the case of Yagya Rice Mill in Gulmi, the corresponding values are Rs 20,000 and Rs 42,000 respectively compared to the cost of Rs 200,000 incurred in 1979. Given the fact that loans and subsidies are made available easily by the ADB/N, the attractiveness of the venture is understandable.

Reliable and Easily Understood Technology

The shift in technology from a traditional *ghatta* to a MPPU or a cross-flow turbine is not a radical departure and, from the operator's perspective, is relatively comprehensible. In general, the local manufacturers have earned a fairly good reputation from their supply of standard and reliable equipment. With the training on operation and maintenance provided by these manufacturers, and at times by the ADB/N staff, the owners and operators manage to make minor repairs on the machinery as they gain experience over time. When major breakdowns take place, the owners naturally have a vested interest in getting them repaired as soon as possible. They make it a point to pursue the matter vigorously with the manufacturers and, within reason, the latter have been known to be responsive to such requests. At times, the problem arises because these manufacturers are located mostly in Butwal or Kathmandu. Micro-hydro units that are located in relatively more remote areas from the two supply centres do face greater problems in this respect.

Civil works rely heavily on indigenous knowledge that is based on the techniques used in traditional irrigation canals. The owner, together with help from village friends, can easily maintain their upkeep. Although they are not suitable for big schemes, such as the one in Karaputar where the suitability of traditional civil works is questionable because of the huge maintenance costs, they are quite acceptable for up to the 10 to 15 kW range and are crucial because of cost considerations. Occasional problems are encountered because of canal seepage, landslides, and poor siting of the mill house (as in the case of Yagya Rice Mill where the flood destroyed it twice, before it was moved to a new site). A more thorough investigation during the site survey would certainly be helpful. On the whole, however, the smaller popular schemes manage to cope with these problems quite reasonably.

Case Example No 2

A SUCCESSFUL VILLAGE ENTREPRENEUR'S SCHEME IN MOHANTAR

Thir Bikram Basnet runs a mill at Mohantar in Dhading District, about 1km from Gajuri, along the Kathmandu-Pokhara Highway. A MPPU of 13kW capacity, together with a rice huller, a flour mill, a *chiura** (beaten-rice) mill, and an oil-expeller, were installed in 1983 by National Structures and Engineering Works (Kathmandu) at a cost of around Rs 150,000. Another MPPU was later added to utilise the tail-race water. A 3kW generator and another *chiura* mill have been operated at this unit. The electricity is supplied to the military barracks and 20 houses in Gajuri. Recently, Mr. Basnet has added a small unit that produces ice cream and ice blocks that are readily sold in Gajuri Bazaar.

According to the owner, the machine units operate at an average of 15 hours per day. During festivals such as *Dasain* and *Tihar*, he manages to run them around the clock, day and night. During certain periods, when the customers are not around to use the machine, he processes the paddy and mustard seeds that he purchased at a reasonable price during the harvest season. The profit margin on the sale of the rice and oil is indeed high. By his own account, the enterprise generates a daily income of Rs 300 to Rs 400. After meeting the operational cost, the innovative and hard-working Mr. Basnet makes a net income of Rs 8,000 per month. Needless to say, he is very prompt in paying off the loan taken from the ADB/N.

The enterprising character of Mr. Basnet is always looking for some new venture that he cand undertake. His plan now is to install two power looms (1kW capacity each) so that he could optimise his load factor by embarking on another productive activity. Furthermore, he points to the large heap of paddy husk lying outside the mill and thinks out loud, "*I have got tons of paddy husk accumulated daily as a byproduct of agroprocessing. Only a small portion is currently used as fuel for chiura making. I need a technology for making rice husk briquettes that can be sold in Narayanghat or Kathmandu.*"

Source: Shrestha and Bajracharya 1990.

* *Note*: *Chiura* is made by soaking the paddy in water, roasting it, and then pounding on it until it is flat. After removing the husk, it can be readily eaten and is popular in the country as a snack.

The handling of the electricity system is comparatively more difficult. Although the process of generation is made more simple through such innovations as the electronic load controller and the induction generator, concepts related to the distribution of electricity, or its use beyond lighting, for more productive activities require a lot more refinement. In Karaputar, for example, when the system was overloaded, the operator started load shedding by disconnecting one phase of the supply,which is not good for the machinery. He could have beneficially used instead the PTC (positive thermal cutout) switches which were made available but never installed. Also, the innovative use of electricity, as in Mohantar by Thir Bikram Basnet, for making ice cream or operating power looms, is indeed very rare. The diversification of electricity use is an area that needs a great deal of attention in the future if the potentials of micro-hydro are to be realised to a fuller extent.

Gradual Build-up of Entrepreneurship

In three out of the six cases (Yagya Rice Mill, Mohantar, and Reginas), all the owners started out on their venture with the installation of the agroprocessing units and the generators were added on after several years only when the mills were already realising a getting satisfactory return on the investment. This was partly fortuitous because the local manufacturers popularised the relatively inexpensive induction generators only after 1985, and concurrently, the ADB/N became the main vehicle for implementation of the government policy on subsidy to electro-mechanical equipment. In retrospect, this turned out to be an appropriate strategy. The owners were able to gain the necessary confidence through their experience with the mill. Adding on the generators and dealing with the complications and risks were thereafter a logical progression. In the case of Yagya Rice Mill, the motivation also came because of the competition from new turbines in the vicinity, which were instrumental in reducing the milling hours in the evening. More importantly, it was the build-up of the entrepreneurship which led owners to take advantage of the new opportunities and at the same time distribute the load factor more favourably. In Mohantar, the owner was clearly more enterprising than others as, by virtue of his location along the main highway and also at the proximity of an important market centre, he was able to take advantage of the marketing opportunities.

In the case of Ishaneshwar, the mill and the irrigation scheme were visualised as an integrated package from the very beginning; in Karma Singh *Phant*, lift irrigation was the principal motivating factor when the project was started; and, in Purang, the stand-alone generator was the original plan from its inception. Here also, the step-wise progression of entrepreneurship is very encouraging. Karma Singh *Phant* is visibly undergoing transformation as the community residents are planting up to three crops a year and are experimenting with fruits, vegetables, and fodder trees. Livestock holding and the corresponding produces have been increased. A communal fish pond has been operational. These are all very encouraging signs and are worthy of emulation elsewhere. Another interesting development is the thinking in Purang that the community might be able to install hot showers and cater, as an income-generating activity, to tourists and pilgrims who trek through the village. By virtue of its location at high altitude, and the fact that the water is very cold, the hot water will no doubt be much valued.

Athough the primary initiative towards entrepreneurship lies with the owners and village residents, the part played by local manufacturers, in providing reliable and appropriate technologies and training, and by the the ADB/N staff, in providing other support services, are no doubt equally important. Another noteworthy role played by the ADB/N was to organise training and study tours to not only its staff but also to manufacturers. This helped keep them up to date on the appropriate techniques and their applications under varying conditions. At the same time they are encouraged to explore the possibilities of enhanced applications within Nepal.

Case Example No. 3

MILLING AND ELECTRICITY IN REGINAS VILLAGE: A GROUP EFFORT

In 1978, Hom Bahadur Gurung had installed, under ADB/N financing, a 10.2kW turbine with the help of Balaju Yantra Shala at Reginas, Taklung Village *Panchayat*. Technically, the turbine and the agroprocessing units were running satisfactorily. However, because of poor management, it was running at a loss. The owner was unable to pay back the loan installments on time and the delinquent amount had reached Rs 113,000 by December 1984.

At this stage, 5 members of a Small Farmers' Development Programme (SFDP) group proposed to run the problematic mill on a group basis and approached the SFDP Group Organiser for advice and help. After a meeting among the original owner, the SFDP group members, the Group Organiser, and the ADB/N Branch Manager, the ownership was transferred to the SFDP group. The understanding was that the group would pay back the delinquent loan. The SFDP group took over the mill operation in mid-January 1985.

One member of the group was sent for training on the operational and maintenance aspects and, upon return, was given the responsibility of running the mill and acting as the treasurer. The group hired in addition an experienced operator and a helper at the salary of Rs 600 and Rs 400 respectively. The milling service was maintained for 9 to 10 hours per day. Once a month, the group members gathered together and distributed among themselves the commodities received as payment in kind. The cash income was used towards repayment of the ADB/N loan. Gradually, the mill started operating profitably, with an annual revenue of Rs 44,750.

As their confidence in mill operation grew, the group initiated the idea of generating electricity during the evening when the mill was not operating. Twenty-five households and several shopkeepers expressed interest in buying the electricity. A technical survey was done by a private manufacturer and a 3kW asynchronous generator was installed, within a month, at an estimated cost of Rs 30,000. UNICEF agreed to provide a grant of Rs 18,000. The tariff was charged at a monthly rate of Rs 12 for each 40W bulb or 20W fluorescent tube. With 44 bulbs illuminated every evening, the small farmers' group received an additional annual revenue of Rs 44,750.

Many villagers consider electricity a valuable asset. Direct benefits were derived, for instance, by three women from a SFDP group who now operate knitting machines in the evening. The shopkeepers are pleased that they can now keep longer hours.

Source: Gorkhali 1988.

It is these potentials of mutual support that need to be encouraged further and rigid unproductive operations have to be curtailed. In this context, the kind of inflexible auditing rules of the Sajha Committee, that inhibit community initiatives in canal repairs or machinery maintenance, is far from satisfactory. Such cases require careful scrutiny.

Appropriate Organisation and Management

One important contributing factor that led to the success in micro-hydro development is the delicensing of installations below 100kW capacity. Individual entrepreneurs or groups of enterprising farmers were, therefore, able to take advantage of the necessary initiative in making the venture a profitable one. This alone would have been insufficient, if, as mentioned above, it had not been for the ADB/N, which participated actively in the disbursement of loans and subsidies, and the manufacturers, who as indirect beneficiaries were instrumental in technical innovations, supply of reliable equipment, and provision of technical support services. This partnership, and the smooth functioning of the organisational elements within each, was therefore the key.

At the local level, there are a number of factors that have to be properly balanced. Short of that, individual entrepreneurs such as the ones in Khaireni and Reginas are likely to fail. In Khaireni, the first two owners failed, because they were not living in the area where the mill was located and had to depend on unreliable paid operators whose performances were not satisfactory. The success of the current owner is largely accountable to his nearby residence nearby which enabled him to be involved with the management and maintenance of the mill. In Reginas, the first owner was a failure because of his incompetence in managing the mill and for no other technical reasons.

Proper assessment of water resources and delineation of water rights are two aspects that require special attention in micro-hydro development. Usually, the technical assessment is done jointly by the owner (or the local community group) and the technicians sent by the manufacturer, and, sometimes, by the ADB/N staff from its Appropriate Technology Unit (ATU). As Bikas Pandey (1989) noted, "*The most feasible site is located by local groups themselves. The site survey technicians aided by local people generally locate sites with good potentials within a day.*" What is more important is the question concerning water rights. This and how people are organised takes on a more crucial dimension with respect to projects that involve the entire community such as in Purang or Karaputar. With respect to Purang, the following observations by Aitken et al. (1991) are very pertinent:

"*By using the traditional irrigation system, conflicts with agriculture are reduced, as are construction costs, and no new decision-making structure is imposed in the community. One of the main reasons for the success ... is the way that their management is so well integrated into the existing social, political, and economic structures. This ensures that all participants in the scheme understand its management and have access to the decision making process. Strong and supportive representation at the District level has facilitated the villagers' access to manufacturers and subsidies, and enabled coordination between sites.*"

Such harmony was missing in Karaputar. Because of the government's policy, during the early stages of ADB/N's expansion, it had to involve *Sajha* in the management of the project there. Furthermore, the SFDP office was under such pressure to form a group that it was not well-regulated internally. As a result, it became dominated by one or two influential farmers who were not particularly sympathetic to the landless residents of the community. The poor, who contributed to the investment through labour contributions, were deprived of the benefit of having electricity in their homes. The necessary time and support to ensure an organically functional group was missing and consequently inequities and frustrations were rampant.

Case Example No 4

PURANG MICRO-HYDRO INSTALLATION, MUSTANG DISTRICT

Purang is 5 to 6 days' walk from the Pokhara Road. The water source is a perpetual spring and the intake is below the Muktinath temple grounds. The discharge from the turbine flows into the traditional irrigation system. No conflicts about water rights are apparent since the management is nicely integrated into the existing social, political, and economic structures. Ethnic homogeneity is also a contributory factor. The 12kW installation consists of the DCS-made cross-flow turbine and electronic load controller (ELC) and the Indian-made generator.

Demand for the electricity installation (not agroprocessing) originated with the local people and was coordinated by the District *Panchayat* Chairman. There was no initial external assistance or bank loan, although some funds were later made available. The total cost, including transport and local labour, amounted to Rs 470,000 of which ITDG contributed about Rs 100,000 towards the ELC and DCS costs. Local people contributed money in proportion to the amount of power they subscribed to. Communal labour was contributed in accordance with the traditional system.

The consumers are charged Rs 25 per bulb. Detailed accounts are not kept as the capital cost was paid at the outset and there is no bank loan to repay, but the operation and maintenance costs are adequately managed. The plant has already achieved capacity, supplying about 100 houses with an average of 120W each. There is demand from the village to increase the supply. This could be done by increasing the head and substituting the present cross-flow turbine with a Pelton.

The plant operates 24 hours a day, and village women take their washing down to where the discharge comes out of the ELC,taking advantage of the heated water from the ballast load which is available for free to the community. Plans are under way for income-generation by selling hot showers to the tourists and pilgrims who trek through the village, using off-peak electricity to heat the water. The hot water is highly valued as the site is at high altitude and the water very cold.

There is a strongly perceived need for electricity in these communities where the winters are dark and cold and fuelwood is very scarce. Lighting permits indoor income-generating activities, such as carpet-making, during the winter months when the villagers are housebound by the weather.

Source: Aitken et al. 1991.

In contrast, the farmers in Karma Singh took upon themselves to evolve an organisational mechanism that worked. This helped them to strive for new ventures from which everybody benefitted. An important element in the smooth functioning of the local orgnisation is the question of accountability. This was apparent in Purang and Reginas as well. These lessons in local organisation are particularly relevant in the context of the development of micro-hydropower on a scale larger than single individuals are willing to undertake. We will return to this issue again in the following section.

Lessons for Future Development: Issues for Discussion

There are two fundamental options for consideration in the development of micro-hydro in Nepal:

- o continuation of the present strategy in dissemination, but with greater concentration in more remote areas that lie outside the immediate influence of Kathmandu and Butwal, and
- o emphasis on diversification of end uses beyond milling and lighting, by looking into possibilities of extending the larger units and integrating power production with village development.

The attractiveness of the first option is clearly apparent, given the modest success already achieved over the last 14 years. The main concern here is, however, the rate of growth which is not adequate when considering the country's potentials. As already mentioned, there are approximately 25,000 traditional *ghattas* in Nepal, which is a proxy indicator of the need and the potential in the country as a whole. The current figure of some 600 turbines and MPPUs that exist in the more accessible areas are far from having met the requirement. A substantial increase is needed. The fact remains, however, that at the current rate even the target of the Seventh Plan (1985-1990) has not been fulfilled. Against the target of 640 MPPUs and 320 turbines, during the period, the actual accomplishment is only about 100 MPPUs and 181 turbines (i.e., about 29 %). The disparity raises many important issues, ranging from the Government's commitment to the manufacturers' capability to respond to the demand. Some relevant questions for disscussion in this respect are raised below subsequently.

The second option is an even more desirable option. There are some experiments that have been carried out, as exemplified by the Karma Singh *Phant* and Karaputar schemes described in the above section, in which lift irrigation is the primary thrust. Other programmes based on site- specific advantages, vis-a-vis prevailing resources and opportunities, have a great deal of potential. This approach has been carried out with great success in China. As described by Aitken et al. (1991):

"*The Chinese have taken a coordinated approach to small hydropower and rural electrification. Their guiding principle is 'self-construction, 'self-management and self-consumption'. While the central government has set and enforced technical standards, funded research into new technologies and provided some funds to target backward areas, most of the capital for small hydropower development has come from the regions themselves. A multi-purpose approach has been emphasised, in which the water resources of a province or district are seen and developed as a whole; irrigation and flood control works being integrated into SHP projects. This helps to avoid the situation where a hydropower project is in conflict with irrigation needs.*"

Clearly, the approach points out the need for much coordination between the Government, research and development institutes, manufacturers, and local community groups. The organisational aspects here are understandably a lot more complex than in the first option. Against the background of the above two options, the discussion below is on the role of different parties involved in micro-hydro development and also on the interlinkages and interrelationships among them.

Case Example No. 5

LIFT IRRIGATION IN KARMA SINGH PHANT: TOWARDS VILLAGE DEVELOPMENT

Karma Singh *Phant* is a cropping area in Gorkha District, located along the Abu Khaireni-Gorkha Highway, where people could cultivate only one crop, and that too depended upon the Monsoon. The perrenial Daraundi River, flowing at less than 20m below, remained unused for irrigation until 1985. That year, the ADB/N proposed a Lift Irrigation Project to the 41 small farm families who owned land in the Phant. They were asked to organise among themselves to determine a practical approach to water use and think of local resource mobilisation.

When firm commitments were forthcoming, a 16 kW turbine pump was imported from China on the basis of Technical Cooperation among Developing Countries. Community members cooperated among themselves actively, with the assistance of engineers from the ADB/N and a local manufacturer, in constructing the 600m diversion canal and pumphouse and finally in installing the turbine pump. The project was completed in eight months (end of 1986) at a total cost of Rs 1.2 million. About 45 l/s of water are now raised to 25m and 15ha of land are irrigated. Milling units, including an oil expeller, are also attached to the turbine pump.

The irrigation system and agroprocessing activities are being managed by a committee. Instead of the usual one crop, farmers are now cultivating up to three crops per year. Areas under vegetables are expanding, fruit trees have been planted along the canal and bunds, and farm produce has been marketed locally and in Abu Khaireni, Gorkha, and Mugling. Encouraged by the benefits from the project, the community has recently established a fish pond and planted fruit and fodder trees around it. By-products from the agroprocessing units are fed to the fish.

The village has undergone visible change in a few years. Where nobody lived before, farmers have constructed 25 new houses and have started to live in the project area. A new primary school has been constructed through contributions from the villagers themselves. Fodder trees have been planted systematically in areas not suitable for crop production. The farmers now plan to increase the livestock number so that more milk and meat can be produced for the market. In addition, the farmers' committee is now thinking of investing a part of their income in the installation of an electricity generator. Confidence in their own ability to plan and implement has increased greatly. According to Ram Prasad Kaini, an active participant in the project,

"*The hard days have passed and a better future is ensured.*"

Source: Shrestha and Bajracharya 1990

Role of the Government and the Bank

So far, the Government has taken a positive attitude towards hydropower development but the emphasis has been more on the larger scale power plants. The ADB/N has been the only agency which, through its loan and subsidy programme, has taken a direct interest in the implementation of the small units. The Water and Energy Commission has also played an important role in assessing micro-hydro resources in different parts of the country. The neglect of the Government is, however, apparent from the miniscule budget outlay (10 % of Rs 50 million allocated to alternative energy) and the absence of a coordinating agency. Since 1984, when the Government decided on the policy to delicense micro-hydro units below 100kW, even the Small Hydroelectric Development Department of the Nepal Electricity Authority has adopted a hands-off policy. Experiences from China and Norway, for example, indicate the necessity for an active role on the part of the Government. According to Vinjar (1980), *"The experience which can be drawn from the history of electrification of Norway ... demonstrates the efficiency of placing responsibility for the electricity supply on local undertakings. However, experience also shows that a strong national coordination body is required, especially at a later stage."* The role played by the Chinese Government has been already stated above.

The Government's policy of subsidy to electrification schemes, combined with the loans provided by the ADB/N, have led to encouraging the proliferation of several micro-hydro units in the country. This policy requires more careful analysis, with a particular focus on consistency and sustainability over a long time frame. If the current practice of loans and subsidies is continued and the rate of proliferation is to be increased, the budget outlay for micro-hydro has to be increased substantially. Whether the Government can live up to this commitment by mobilising funds from donors is something that will have to be pursued with great seriousness. In this context, it is important to note that a radical shift in the current practice could very well disrupt the progress that has been achieved so far. A realistic plan has to be formulated, based on an all-round assessment of people's priorities, manufacturers' capabilities, and research and development requirements. Hence the attention of the Government has to be directed to the following issues:

- the preparation of nationwide plans for the system, ensuring that each component (power production plants, transmission systems, civil works, etc) is suitably sized and perated with maximum benefit, irrespective of who owns the system;

- the provision of necessary incentives to manufacturers, by providing import facilities to develop and produce more efficient units; to research and development institutes to facilitate investigation into new technologies and more effective ways of implementation and provision of training; and to local community groups to ensure maximisation and diversification of their efforts towards local resources' utilisation;

- the devolution of control for decentralised power production, ensuring equitable distribution, and the monitoring of the effectiveness of operations, especially in the more remote and backward regions of the country; and

- the mobilization of necessary funds and resources and the orientation of donors towards a broader outlook in micro-hydro development.

Case Example No. 6

ISHANESHWAR *SAJHA SANSTHAN* MILL, KARAPUTAR, LAMJUNG DISTRICT

The mill is situated on the confluence of Midim and Madi *Kholas* and has two sponsors: *Sajha* (Cooperative) Organisation and the the ADB/N. A Small Farmers' Development Programme (SFDP) group was formed in 1980 to initiate the mill and the irrigation system. The ADB/N loan of Rs 2.3 million was channelled through the *Sajha* Office which took 4% as a service charge and provided auditing services. This proved to be a handicap because *Sajha's* rules are inflexible and did not meet the operational requirements of the Ishaneshwar Mill. For example, expenditure by operators for the emergency repair of canals or the purchase of bearings, as well as the salaries given to employees, is classified as irregular and left pending. *Sajha* has not allowed any community initiative in reorganising the functions of mill operation or its expansion.

The Karaputar mill is a multipurpose scheme with many competing users for the water and its power. The total area irrigated by the canal system is about 100ha and the irrigation facility is supposed to benefit 218 families. *Sajha* collects water charges for this amounting to about Rs 30,000 per annum. Leakage and landslides have, however, caused problems. The increased canal size, larger volume, and higher water velocity mean less organic silt and more sand and pebbles, thus reducing fertility.

The mill of 38kW capacity operates an oil-expeller, grinder, and huller. All the services are popular. Electrification was added-on five years after the mill was built and has proved to be an important earner, with gross earnings from its sale being almost equal to the combined earnings from irrigation fees and agroprocessing. Electricity supply, while generally good, has problems of quality control. There is also some unauthorised consumption which frequently causes the load to rise above capacity. The operator handled this by disconnecting one phase. This could have been controlled instead with the use of available PTCs.

In Ishaneshwar, payment of irrigation fees was mandatory before an electricity connection was given. Landless families who had contributed labour were originally assured that this would be converted into shares. This has not occurred, however, and the people have not received electricity either.

The Ishaneshwar Mill exemplifies many of the problems found in other 'forced' community installations where the initiative has come from outside the community, rather than from the farmers themselves.

Source: Aitken et al. 1991

Role of the Manufacturer

The manufacturers have until now played an important and innovative role in micro-hydro development. The contributions of BYS, DCS, BEW, KMI, and others are truly noteworthy. They are currently involved at every stage from the identification of potential customers and site surveys to the installation of units and operation and maintenance. However, the examples from Table 5 show that in the dissemination of MPPUs and turbines, the level of their expansion has not been in keeping with the growth that has to take place. Also the number of suppliers does not seem to have multiplied in any significant way. This is indicative of either the saturation of demand or the lack of incentives given to manufacturers to expand their production capabilities. This is a matter of serious concern.

If the strategy of expansion is to be pursued, it is obvious that both the number of firms as well as their production capacity have to increase. For this, the Government has to play a crucial role in promoting such a venture by providing the necessary incentives for capital investment including import facilities. Secondly, the manufacturers also need to specialise in specific activities. Either they have to expand their manpower to engage in such activities as research and development, site survey and feasibility studies, manufacturing, installation, and training or leave the responsibility to some other agencies. This again emphasises the need for promotion of such activities and also for coordination in an effective manner.

A related requirement is the spread of manufacturers and and workshops that supply regular after-sales' servicing to areas other than Butwal and Kathmandu. The provision of production facilities will have to be promoted to that extent. The capability of existing manufacturers to open branch offices could be explored, and at the same time new entrepreneurs could be provided with the necessary facilities and incentives to open new firms. This is an area where Nepal has the necessary expertise even for exporting equipment to other developing countries. There are already some orders placed to such firms as BYS, BEW, and KMI, and this is a good indication of the potential.

Table 5: Production of MPPUs and Turbines: Kathmandu Metal Industries (KMI) and National Structure and Engineering (NSE)

Fiscal Year	KML		NSE
	MPPU	Turbine	
1981/82	2	0	0
1982/83	4	1	22
1983/84	5	3	36
1984/85	4	4	30
1985/86	2	3	35
1986/87	0	5	19
1987/88	1	4	22
1988/89	2	12	11
1989/90	0	6	8
1990/91	0	5	5

Source: Personal Communications, 1991.

Based on experiences to date, the following points deserve specific attention:

- o Encouragement is needed to establish a steel foundry with casting facilities for manufacturing turbines. This is essential, particularly for turbines of higher capacity (above 50 kW) within the micro-hydro range (i.e, less than 100 kW).

- o In order to render technology dissemination more effective, manufacturers need to be availed of additional subsidies to cover the cost of transportation.

- o Site survey is currently undertaken with minimal support from the ADB/N. Manufacturers need to be encouraged to establish a team with specific responsibilities to conduct the survey systematically and recommend workable designs for implementation.

- o Organisation of training and study tours for manufacturers, initiated by ADB/N occasionally, needs to be regularised in order to keep them up to date on techni concerning micro-hydro development in other countries.

- o Import facilities are needed, especially for bearings, lectronic load controllers (ELC), and generators above 20kW.

- o Greater emphasis is needed on the manufacturing and distribution of end use appliances.

Role of Research and Development

Development and Consulting Services (DCS), Balaju Yantra Shala (BYS), and Kathmandu Metal Industry (KMI) have distinguished themselves by their innovative research and development activities on different aspects of micro-hydro technology. The contributions of the formal R&D institutes such as the Research Centre for Science and Technology (RECAST) and the Royal Nepal Academy of Science and Technology (RONAST) have been rather disappointing in this respect. This state of affairs needs careful scrutiny. As already stated above, manufacturers can involve themselves in such activities only in a limited way and even then it interferes with the scope of expansion of production facilities. R&D institutes have to be provided with the encouragement to do relevant research. Simultaneously, there has to be an arrangement for the smooth transfer of information from these institutes to the manufacturers. This is an area which needs substantial strengthening in the country. Areas of research that deserve attention are listed as below.

- o Assessment of potentials for micro-hydro development on a district by district basis, and the design of a systematic plan to develop appropriate schemes through location-specific feasibility studies;

- o Technological research to develop cost-effective equipment designs and civil construction by fine-tuning available techniques in accordance with site-specific characteristics that prevail in the country,specific attention on governor technology and application of end use appliances is of particular relevance;

- o Systematic collection and dissemination of hydraulic, geological, and socioeconomic information (including water rights, indigenous technical knowledge, and irrigation requirements);

- pilot projects to investigate in an action research style the various potentials of comprehensive end use of electrical and mechanical power findustrialisation andother development schemes and the possible organisational and management aspects of implementing such schemes;

- establishment of a quality control centre with particular focus on performance testing of turbines and generators and standardisation of equipment design;and

- training programmes on the operation and maintenance of micro-hydro plants and also on raising awareness about various alternatives in the use of electric energy for productive activities in the village environment.

Organising People for the Use of Power

Hydropower has no doubt the potential of transforming village economies. So far it has been used by people to perform tasks that they know best, i.e., milling and lighting. The challenge ahead is to organise rural communities ,as in Karma Singh Phant, to engage in using power for enhancing agricultural production and building the base of rural industrialization. As pointed out in a study: "Bringing an electricity supply to an area, is in itself not sufficient to cause development to occur. Rather than electrification causing development, it may be the other way around with development creating the conditions under which successful rural programmes can be implemented"[ITALICS] (Foley 1989). This indicates the imperative for creating an environment that lends itself to development of the people and communities living in the mountains. From this perspective, electrification has to be expanded within the context of the limited purchasing power of the people and of developing the land use and marketing opportunities. The Government has no doubt an important role to play in creating a favourable policy environment and providing the complementary infrastructure. Concurrently, at the community level, local cultural and political factors will have to be considered in building up the organisational strength of local people that would pave the way for establishing rural enterprises on an individual as well as on a community basis. The supportive activities of manufacturers, research and development institutes, and credit organisations can be oriented to this purpose. The Government has done the right thing in privatising the installation of micro-hydro units. The lack of a supportive role has, however, led to *ad hoc* development. Consequently, the poor and those living in the remote regions have been left out. To this effect, the Government has to develop a comprehensive and integrated policy to promote micro-hydro development. This has to be complemented by realistic plans of action in which people can participate with effectiveness and derive tangible benefits. A diverse strategy has to be adopted, given the physical, cultural, and economic conditions in the country. The range of activities can be expanded from the provision of inexpensive construction kits for improving the traditional *ghatta* to the installation of agroprocessing facilities to larger schemes that integrate electrification with various rural industrialisation activities. In the final analysis, it is the political commitment to work towards the benefit of the poverty-ridden mountain people and allocate the necessary economic investment that will count. The physical resources, technological options, and organisational strengths of the people are already in existence.

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