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SUSTAINABLE DEVELOPMENT OF SMALL HYDROPOWER IN NEPAL

Edited by :
HARI BANSH JHA

CENTRE FOR ECONOMIC AND TECHNICAL STUDIES

in cooperation with

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Hari Bansh Jha

(M.A., Ph.D. Economics)

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PREFACE

In Nepal, there are numerous rivers and streams with perennial supply of water from the glaciers of the Himalayas. With such huge resources of water resource, hydro-power generation has been accorded high priority in the country's plans. The estimated exploitable hydropower potential in the country is 25,000 MW. Harnessing water for power is important not only for household consumption but also for the commercial and industrial growth of the country.

According to the World Development Report 1995, the per capita consumption of energy in Nepal was merely 22 kg. (oil equivalent) whereas the corresponding figures in other South Asian countries were 242 kg. in India, 59 kg. in Bangladesh, 209 kg. in Pakistan, and 110 kg. in Sri-Lanka. In fact, Nepal's per capita consumption of energy is almost the lowest not only in South Asia but even in the world.

Over the past years, Nepal has been experiencing huge shortage of power. Load shedding is a common phenomenon. Each year, the demand for power is increasing at the rate of 35 MW. But in near future there is no way to meet the power shortage in the urban or remote areas of the country because no plant of medium or mega size could be built in the country until the end of the current century. The few power plants that exist in the country today are not in a position to increase their production capacity. The need for increasing power through the Small Hydropower Projects (SHPs) is therefore not only desirable but most essential.

Although the per unit cost of small hydro-power plants is comparatively high and their supply area is limited, establishment of such plants in the rural hilly areas is to be encouraged in view of the benefit that accrues from them towards community development. The increase in the use of electricity will also replace other fuels, like firewood, which are essential for environmental conservation. Apart from this, it will also help develop rural areas by making industrial development feasible.

However, there are many constraints in developing SHPs. In this context, it is noteworthy that the Centre for Economic and Technical Studies (CETS) organised the two-day national seminar on "Sustainable Development of Small Hydropower in Nepal" in cooperation with Friedrich Ebert Stiftung (FES) on June 2-3, 1995 in Kathmandu. FES is a non-profit, private research and educational institution committed to the concepts and basic values of social democracy. Its wide-ranging activities in the field of political education and assistance to partners in developing countries incorporate -among others - comprehensive projects in the areas of societal development, labour relations, business, science, and culture.

This book has been prepared on the basis of the papers submitted in the seminar by the distinguished scholars having expertise in small hydropower development. There are six chapters in the book. Chapter One begins with my work in which I have tried to analyze the government policy towards the development of small hydropower in Nepal and also the cost effectiveness of this sector. In Chapter Two, Mr. Mohan Dhoj Karki throws light on how small hydropower could increase irrigation potentiality and thereby contribute to the growth of agricultural sector of the country. Mr. Indu Shumsher Thapa, in Chapter Three, presents retrospective and prospective views about the impact of small hydropower on the development of cottage and rural industries. In Chapter Four, Dr. Binayak Bhadra dwells upon how small hydropower could promote the development of various sectors of the national economy without adversely affecting the environment both in the hill and mountain regions of the country. An analytical study has been made in Chapter Five by Mr. Ramesh C. Arya about the prospects of the development of the tourism sector by promoting small hydropower. And finally in Chapter Six, Prof. S.P. Sinha presents a detailed analysis of sustainable development of small hydropower in Indian perspective.

I would like to express my deep sense of gratitude to the authors who have made valuable contributions on various dimensions of small hydropower development. In particular, I am obliged to Mr. Mohan Dhoj Karki, Mr. Indu Shumsher Thapa, Dr. Binayak Bhadra and Mr. Ramesh C. Arya for their monumental contributions. My Guru Prof. S.P. Sinha deserves special admiration for his work and I express my profound gratitude to him.

My thanks are also due to Mr. Venkata Ramana, Prof. S.N. Jha, Prof. Madan K. Dahal, Mr. Kirti C. Thakur, Mr. Ram Chandra Chaudhary, Mr. Tirth Nath Thakur, Mr. Banbarilal Mittal, Mr. Jagdish Pokhrel, Mr. Gopal Sharma and Prof. P.P. Timilsina who helped the authors to improve and enrich their papers by making various good comments on them. My thanks are also due to Mr. P.P. Shah, Mr. P.N. Sharma, Mr. Surya Bahadur Shrestha, Mr. Pradip Duwadi, Mr. Ram Chandra Malhotra and Mr. Sachidanand Mishra for their valuable comments on the work of the authors.

I am obliged to FES for the financial support made to CETS not only in organising the seminar but also in bringing out the present publication. For this, I would like to express my profound gratitude to Dr. Heinz Bongartz, Resident Representative, FES. My gratitude is also due to Mr. Dev Raj Dahal who made all possible efforts to see that the seminar and the publication of its report make valuable contribution in the sustainable development of small hydropower in Nepal.

Last but not the least I will fail in my duty if I do not thank my daughter, Divya Jha, who extended all possible help to me in coordinating the entire seminar activities and also in the publication of this book.

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ABBREVIATIONS

ACAP	Annapurna Conservation Area Project
ADB/N	Agricultural Development Bank of Nepal
AEPC	Alternative Energy Promotion Centre
AEW	Agro Engineering Works
AMHM	Association of Micro Hydro Manufacturers
BEW	Butwal Engineering Works
BYS	Balaju Yantra Shala
CDR	Central Development Region
CRI	Centre for Rural Technology
DOI	Department of Irrigation
EDR	Eastern Development Region
FAKT	Association for Context Appropriate Technology
FAO	Food and Agriculture Organisation
FMIS	Farmer's Managed Irrigation System
FWDR	Far Western Development Region
GDP	Gross Domestic Product
GNP	Gross National Product
GTZ	German Technical Cooperation
ha	Hectare
HMG/N	His Majesty's Government of Nepal
ICS	Improved Cooking Stoves
ILO	International Labour Organisation
ITDG	Intermediate Technology Development Group
Km	Kilometre
KMI	Kathmandu Metal Industries
KV	Kilovolt
KOE	Kilograms of Oil Equivalent
KW	Kilowatt
LF	Load Factor
LRMP	Land Resources Mapping Project
MHP	Micro Hydroproject
MOA	Ministry of Agriculture

MW	Megawatt
MWDR	Mid-Western Development Region
NEA	Nepal Electricity Authority
NGOs	Non-Governmental Organisations
NHE	Nepal Hydro and Electric Pvt. Ltd.
NMSS	Nepal Machine and Steel Structure
NSE	National Structure and Engineering Company
NYS	Nepal Yantra Shala
NPC	National Planning Commission
NPP	National Power producer
O&M	Operation and Maintenance
PLF	Plant Load Factor
PREP	Private Rural Electrification Project
R&D	Research and Development
RECAST	Research Centre for Applied Science and Technology
SATA	Swiss Association for Technical Assistance
SCECO	Salleri Chialsa Electric Co.
SHDP	Small Hydropower Development Project
SHPDF	Small Hydropower Development Fund
SHPs	Small Hydropower Projects
SKAT	Swiss Federal Institute of Technology
TEI	Thapa Engineering Works
UMN	United Mission to Nepal
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
VDC	Village Development Committee
WDR	Western Development Region

1

SMALL HYDROPOWER DEVELOPMENT: COST EFFECTIVENESS AND PRIVATE SECTOR PARTICIPATION

Hari Bansh Jha

Background

DURING the Eighth Five Year Plan, the government of Nepal accorded high priority to the energy sector. Apart from the medium/mega hydropower projects, emphasis has also been laid on the development of small hydropower projects. Development of small hydropower is essential not only for reducing regional imbalances in development but also for arresting the migration of population from the hills to the Terai.

Among the different natural resources available in Nepal, water resource is the most important. Having nearly 2.27 per cent of the world's water resources, Nepal is the second richest country in this aspect in the world.[1] However, among all these different sources of water, river water is the most important. It is estimated that there are nearly 6,000 rivers in the country with an approximate total length of 45,000 km. The Koshi, Gandaki and Karnali form the three main river systems receiving substantial portions of their water supply from the snow melt, glaciers and

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1. HMG/N, National Planning Commission Secretariat, Central Bureau of Statistics, Statistical Year Book of Nepal 1993, Kathmandu, 1993, p. iii.

small tributaries. Apart from the large rivers, the small rivulets and streams have immense potentiality to generate hydropower at small or micro level.

The theoretical hydropower potential of Nepal is 83,000 MW; of which an estimated 25,000 is exploitable. Although the production of hydropower quadrupled to 253 MW[2] from what it was in 1981, the country produces less than 0.3 per cent of its total hydro-power potential of 83 thousand MW. As a result, only some 13 per cent of the total population of the country have access to electricity. Only 2 per cent of the rural population (90 per cent) have access to electricity. Each year the demand for electrical energy is increasing at an average rate of 15 per cent. It is estimated that the supply of power falls short of its additional demand to the extent to even 50 MW each year.[3] Power shedding has become a common phenomenon since 1992-93.[4] The annual per capita energy consumption of Nepal is estimated at merely 20 kilograms of oil equivalent (KOE), which is almost the lowest in Asia.[5] Nepal's poverty is also due to the extremely poor base of energy per capita.

Nepal is starved of power and is poor despite the fact that the potentiality to exploit water resources for economic development of the country is phenomenal.[6] According to the World Development Report 1995, Nepal with its GNP per capita of US $ 190 (1993) occupies the eighth position from the bottom and is one of the least developed countries of the world.[7] The National Planning Commission (NPC) estimates that the people below the poverty line in the country constitute 40 per cent.

One of the major reasons for poverty and backwardness of the Nepalese economy is power deficit. Shortage of power creates a problem in the development of agricultural, industrial, trade and other sectors of the economy. With a view to meeting the power shortage, it is needed to generate power not only at the medium or mega level but also at the small

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2. The World Bank, Nepal Fiscal Restructuring and Public Resource Management in the Nineties, 1994, p. 112.
3. HMG/N, National Planning Commission, The Eighth Plan (1992-1997), Kathmandu, 1992, p. 284.
4. HMG/N, Ministry of Finance, Economic Survey FY 1993-94, Kathmandu: 1994, p. 65.
5. HMG/N, no. 3, p. 282.
6. Shrestha, Hari Man, "Water Resources Development in Nepal" paper presented at Symposium on Water and Energy Resources Development jointly sponsored by NWREC, UNDP, CEDA, November 23-25, 1976.
7. The World Bank, World Development Report 1995, New York: Oxford University Press, 1995, p. 162.

level so that each can prove to be complementary rather than competitive to one another.

The small hydropower may play a crucial role in increasing production and productivity of the agricultural sector, including the processing of agricultural produce. Lift irrigation in the hills may also be promoted in a meaningful way through the development of small hydropower. Additionally, the food processing and cottage industry might benefit a lot from the development of small hydropower.

Furthermore, considering the fact that merely 2 per cent of the total rural population have access to electricity, the small hydropower might contribute significantly in providing electricity to the rural areas and even to the isolated pockets. Since electrification is related to productivity,[8] the small hydropower might help increase the working efficiency of the rural poor.

Like the small hydropower projects, the micro hydropower is also important from the consideration of national welfare in diverse fields, such as conservation of forest, creation of self-employment opportunities and also promotion of the tourist industry.[9] Work on micro hydropower projects can be started by mobilising local talent, labour and materials, which per se is very important.

Policy

As per the hydropower policy of the government, licensing is not required for the hydroelectric projects up to 100 KW capacity; while information with necessary details needs to be given to the concerned agency prior to the initiation of the hydroelectric project between 100 KW to 1,000 KW capacity. For the hydro-electric projects with more than 1,000 KW capacity, it is required to seek permission from the Ministry of Water Resources.[10]

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8. Bohm, Robert A. and el et (Ed.), **World Energy Production and Productivity**, Massachusetts: 1981, p. 75.
9. Bastola, Surya Nath, **Water Resources Development of the Mighty Himalayan Rivers**, Kathmandu: Sunil Bastola, 1994, p. 96.
10. HMG/N, no. 3, pp. 296-97.

According to the energy policy of the government, there is a provision for external, internal and joint collaboration with the private sector in the development and financing of small scale hydropower projects. In addition, there is also a provision for legal and institutional arrangements for support to exchange and pricing of such power. Investment varying upto one hundred per cent is allowed. There is also a policy under which the national private sector desirous of generating and distributing electricity up to 1,000 KW in any rural area will get loans from the financial institutions of the country. Besides, the hydro-electric projects established by the private sector are not liable to nationalisation during the validity of the license. Income tax as well as royalty will not be levied on the projects of the private sector generating and distributing electricity up to 1,000 KW capacity.

Small Hydropower Plants

The number of existing small hydropower plants in Nepal is 39. By definition, the small hydropower constitutes plants generating power up to 5 MW. The small hydropower plants have been established in the country basically in the public sector whose installed capacity varies from 25 KW to 5,100 KW (table 1.1). However, none of these plants could be run profitably. As such, they proved to be burdensome to the national exchequer. Considering this reality, five of the thirty-nine small hydropower projects, including Jomsom (240 KW), Darchula (300 KW), Bhojpur (250 KW), Khandbari (250 KW) and Bajhang (200 KW), were given to the private sector on lease.

Cost Effectiveness of Small Vs. Big Projects

Table no. 1.2 shows that the small hydropower projects are not as cost effective as the medium/mega type projects. The per KW cost of the small hydropower on average is US $ 8,140; while the same of the medium/mega projects is US $ 3,243. It indicates that the per KW cost of medium/large projects is merely 40 per cent of that of small hydropower. In other words, the per KW cost of small hydropower is nearly two and

Table No. 1.1: **Existing Small Hydropower Plants**

S.No.	Name of Plants	District	Installed-Capacity (KW)	Year in Operation	Remarks
1.	Pharping	Kathmandu	500	1911	Not in service
2.	Sundarijal	Kathmandu	640	1935	Grid Connected
3.	Panauti	Kabhreplanchok	2400	1965	Grid Connected
4.	Phewa	Kaski	1088	1967	Grid Connected
5.	Dhankuta	Dhankuta	240	1971	Grid Connected
6.	Surkhet	Surkhet	345	1977	Grid Connected
7.	Gajuri	Dhading	25	1978	Village
8.	Tinao	Rupandehi	1000	1978	Grid Connected
9.	Thansing	Nuwakot	20	1979	Village
10.	Baglung	Baglung	200	1981	DHQ
11.	Doti	Doti	200	1981	DHQ
12.	Phidim	Panchthar	240	1981	DHQ
13.	Dhading	Dhading	32	1982	DHQ
14.	Gorkha	Ilam	64	1982	Village
15.	Jumla	Jumla	200	1982	DHQ
16.	Jomsom(L)	Mustang	240	1982	DHQ
17.	Syangja	Syangja	80	1984	DHQ
18.	Seti	Kaski	1500	1985	Grid Connected
19.	Helambhu	Sindhupalchok	50	1985	Village
20.	Salleri-Chialsa	Solukumbu	400	1986	DHQ
21.	Darchula (L)	Darchula	300	1992	DHQ
22.	Manang	Manang	80	1988	Village
23.	Chame	Manang	45	1987	DHQ
24.	Taplejung	Taplejung	125	1988	DHQ
25.	Ramechhap	Ramechhap	75	1989	DHQ
26.	Okhaldhunga	Okhaldhunga	125	1990	DHQ
27.	Bhojpur (L)	Bhojpur	250	1989	DHQ
28.	Khandbari (L)	Sakhuwasabha	250	1989	DHQ
29.	Bajhang (L)	Bajhang	200	1989	DHQ
30.	Bajura	Bajura	200	1990	DHQ
31.	Chaurjhari	Rukum	150	1989	DHQ
32.	Serpodaha	Rukum	200	1989	DHQ
33.	Tehrathum	Tehrathum	100	1988	DHQ
34.	Surnaya Gad	Baitadi	200	1991	Village
35.	Rupal Gad	Dadeldhura	100	1991	Village
36.	Arughat	Gorkha	150	1991	Village
37.	Tatopani-I&II	Myagdi	2000	1991	2000 kw,DHQ
38.	Andhi Khola	Syangja	5100	1991	Grid Connected
39.	Namche	Solukhumbu	600	1993	Village
		TOTAL:	19714	-	

Source: Nepal Electricity Authority

half times more than the medium/mega projects.[11] Studies suggest that the per unit cost of generation of the micro hydropower plants is higher by three to four times the unit cost of generation in medium/large projects.

As the per KW cost of the small hydropower is high so is the tariff rate. Studies show that the tariff rate of private micro hydropower plants is normally Rs. 30 for a 40 W/lamp, which is about 5 times higher than the baseline tariff levied to NEA customers.[12] The tariff rates levied by the micro hydropower plants are so high that the common mass of the population cannot afford to pay. It is mainly the high income earning group people, like the shopkeepers, tea shops and groceries that can afford to pay for the light supplied by the micro hydropower. It is also due to the fact that such commercial units have no access to any other suitable energy.

Private Sector Participation

For a long time in the past there was a controversy as to whether the private or the public sector should be given priority while launching development programmes. In Nepal too, certain demarcation has been made between these sectors in the industrial policy. But the fall of the Soviet empire, the leading advocate of the public sector, and the denouncing of the socialist system by the Eastern socialist block countries themselves have removed much of the controversy. Most of the former socialist block countries have now been moving towards market-friendly economies away from centrally planned economies. The success of the Western block countries in the field of development has clearly established the superiority of the private sector over the role of the public sector.

People's attitude towards privatization has also undergone a change all over the world. In South Asia, India, the biggest partner among the SAARC countries, has been replacing the policy of control by de-control in its economic system. The Narsimha Rao government in India has been gradually promoting the cause of privatization and for this liberalization is

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11. Samiksha, March 8, 1985.

12. Thapa, Bhekh B. and Pradhan, Bharat B., **Water Resources Development: Nepalese Perspectives**, Delhi: Konark Publishers Pvt. Ltd., 1995, p.113.

Table No. 1.2 **Cost of Small vs. Medium/Large Projects**

Name of the Hydropower Plants	Installed Capacity (MW)	Cost per KW US $
Small		
Terhathum	0.100	10404
Okhaldhunga	0.125	5907
Bhojpur	0.250	4915
Taplejung	0.125	12032
Khandbari	0.250	6389
Ramechhap	0.075	9691
Syarpodaha	0.200	11088
Bajhang	0.200	6899
Manang	0.080	6933
Chame	0.045	7231
Bajura	0.200	8710
Chaurjhari	0.150	10546
Rupalgad	0.100	7382
Tatopani	1.000	5834
Average	0.207	8140
Medium/Large Projects		
West Seti	360	3095
Upper Karnali	240	2794
Budhi Gandaki	600	2526
Kali Gandaki - 2	660	2575
Kali Gandaki "A"	140	1875
Sapta Gandaki	225	4418
Bagmati	140	4596
Kulekhani - 3	37	3064
Kankai	60	5266
Arun-3 (Full Phase) Upper Arun + Lower Arun combined)	1045	2221
Average	350	3243

being introduced in the different sectors of the Indian economy. Countries like Pakistan and Bangladesh in this sub-continent have also been marching ahead towards liberalization of their economies. In Nepal, too, a greater role is attributed to the private sector in the various development activities, including the small hydropower sector.

With a view to providing a greater role to the private sector, altogether five small hydropower plants established under the public sector have been handed over to the private sector on lease for a period of 20 years as per the decision made by the government in December 1993. There is a plan to transfer more and more of the small hydropower plants to the private sector in future. Considering the fact that the hydropower plants in general are running in loss, it is expected that the leasing of the plants would reduce part of the financial burden on the national exchequer. One of the reasons why the government could not run small hydropower plants profitably was mismanagement on the one hand and higher operation and maintenance cost involved in them on the other. Moreover, some of the hydropower plants have been established at the district headquarters merely on the political ground.

It is to be noted that four of the five small hydropower plants given in lease to the private sector are running in profit. Only one lease plant of Baghang of 200 KW is in loss.

By having leased a few small hydropower plants to the private sector, the government is feeling a sigh of relief. What the government is receiving against the leasing of the plants is the royalty which ranges between Rs. 67,000 and 200,000 per annum. The cost on O & M is also the responsibility of the private sector. For the consumers, leasing the plants makes no difference. As per the NEA rule, the private sector is not allowed to charge a tariff rate on the customer which is higher than that levied by the NEA.

The private sector is also benefited by taking the small hydropower plants on lease. On the one hand it has helped grow entrepreneurship in the private sector and on the other hand new management skill is developing. It is mainly due to these factors that the condition of the small hydropower given on lease is, by and large, satisfactory.

Additionally, with the objective of reducing the pressure on the forest resources for domestic fuels and also of developing village industries, the government has laid stress on the need for setting up mini hydro-electric plants (100 KW or less) in the private sector.[13] Such plants are used mainly in agro-processing activities, like grain milling, rice husking and oil expelling.[14] The Agricultural Development Bank of Nepal (ADB/N) with participation of the local people has been carrying out the rural electrification programme in various parts of the hills. Subsidy is also provided through the bank to ensure speedy development of this sector. In 1984-85, the government decided to subsidize the electrical costs by 50 per cent for stimulating the growth of such plants.[15] In the remote parts, the amount of subsidy is given to the extent of 75 per cent of the total costs of private installation.[16] As a result of the policy of the government to promote private sector investment in micro hydropower, there has been some tangible progress in this sector. The total generation capacity of the micro hydropower stations operated in the private sector was estimated at 0.92 MW during the beginning of the Eighth Plan in 1992. By mid-April 1994, altogether 104 of such plants were installed whose total capacity accounted for nearly 1 MW.[17] Studies carried out in the past shows that the micro-hydro electricity plants run by the electricity users' committees, as in the case of Purang, Sikles and Seema, were making profits.[18]

There is also a large potential for small scale electrification at the existing sites. Nearly 25,000 traditional water wheels throughout the country are in an inefficient stage in terms of design and operation. With the addition of a domestically produced cross flow turbines they might be made to provide power not only for the traditional functions of grinding

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13. HMG/N, no. 4, p.64.
14. Acharya, Mahesh P. and Shreshta, Ram M., **Rural Electrification in Nepal**, (Unpublished Report), Kathmandu: 1991, p. 4.
15. Thapa, no. 12.
16. Acharya, no. 14, p. 4.
17. HMG/N, no. 4, p. 64.
18. Ranjitkar, Siddhi B. and el at, Final Evaluation of Private Rural Electrification Project, USAID/Nepal, August 4-September 30, 1994.

and hulling but also for generating up to 10 KW at each site, making the total potential to be as much as 250 MW.[19]

The private sector participation, particularly in the micro hydropower plants is important for manufacturers as well. Nearly 8 private manufacturers fabricate and install turbines, governors, load controlling devices, etc.[20] Additionally, some industries have emerged as manufacturers of transformers up to 100 KW. Apart from that, consumer electrical items, such as bulbs, switch gear, cables solar panels for water heating systems, improved cooking stoves (ICS) used for domestic purpose and commercial establishments are also produced by the private sector.

Conclusion

The small hydropower plants including the micro ones generate nearly 22 MW of power, which is about 9 per cent of the total hydropower produced in Nepal. Thus, the contribution of small hydropower plants cannot altogether be overlooked.

The role and importance of small hydropower in the economic development of Nepal is substantial despite the fact that the per unit cost of production is huge as compared to the medium/large projects. However, there should be no confusion as to the fact that the small hydropower is the second alternative for medium/large projects. However, besides other things, the importance of medium/large projects cannot be under-estimated for the country's economy of scale on the one hand and its multiplier effect on the different sectors of the economy on the other. Therefore, the small hydropower cannot be the substitute for the medium/large hydropower even as the medium/large hydropower cannot be the substitute for small hydropower. Both these two types of hydropower projects are needed in our country depending on the geographical location, cost and marketability. Therefore, small hydropower and the medium/large hydropower projects can only be complementary rather than competitive to each other.

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19. HMG/N, Ministry of Water Resources: Water and Energy Commission, **Energy Sector Synopsis Report**, Kathmandu: 1983, p.97.

20. Thapa, no. 12, pp. 112-13.

One of the major objections to the small hydropower, however, appears to be the relative cost of electricity generation. Though small is beautiful, the economic viability of small hydropower projects is questionable. Cost is a major factor in determining the sources of power generation. However, small projects have also some distinct advantage over the medium/large projects. While the cost involved in the small hydropower is affordable and so it is within the reach of all, the enormous cost involved in the medium/large projects in most of the cases become out of the reach of the poor countries. Quick completion of individual projects and early commencement of the flow of benefits (contrary to the position in large power projects) is also another advantage in favour of small hydropower. Also, requisite technology is available both in the public and private sector to develop small hydropower; which is not so feasible in the case of medium/large projects. Since no dam or storage is needed, small hydropower appears to be more eco-friendly than medium/large unit.

Small hydropower should be established considering the factor like marketability rather than the water availability and other technical factors. In future, this will help small hydropower to become much more competitive.

2

SMALL HYDROPOWER AND THE DEVELOPMENT OF AGRICULTURAL SECTOR

Mohan Dhoj Karki

Introduction

The statement "Power means progress and prosperity" is quite valid throughout the world and more so in the case of Nepal because of the enormous water resources as well as favourable topographic and climatic condition it has. The average annual run-off of $200,000*10^6m^3$ of water from the country and the underground reservoir created by monsoon rainfall has got tremendous potential both for year-round irrigation and the development of micro to mega hydropower projects. After meeting its own need, the country can substantially meet the irrigation and hydropower needs of downstream riparian countries besides the prevention of large-scale flood damages during the monsoon season.

The coverage of 73 per cent of the total area of the country by hill, mountain and the Himalayan ranges provides an ideal condition for multifarious water resources-related development. In the absence of all-round development of these regions, a state of scarcity amidst plenty makes the living of the 56 per cent of the total population quite difficult. The well distributed river system and the changing rainfall pattern is causing more damages at its present un-harnessed stage. This has led to seasonal and permanent migration of the population in the Terai plain which covers only 23 per cent of the total area of the country.

The Terai plain, before the eradication of malaria, was sparsely populated. But the population increased tremendously in this region after the eradication of malaria due to the migration of people from the hills and mountains and also from across the border with India. The density of population at present is 408 persons per km^2 in the Terai which is quite high as compared to the national average of 136 persons per km^2. The cultivated area in the hills is around 11 per cent whereas in the Terai it is around 40 per cent.

It is not only the human population but also the large livestock population (in the absence of well-planned fodder production) that have been creating environmental degradation in more than one way. The scattered cultivated area with varying soil texture and uneven and sloping land is not suitable for similar type of agricultural development as that in the Terai plain. The delivery and application of water for irrigation in the hills should be different from the environmental protection point of view also. To maintain ecological balance and to prevent degradation of environment in the Terai plain, to support the conservation of land, forest and water, the traditional type of farming and irrigation have to be changed in the hills and mountains through implementation of development programmes in packages such as hydropower, irrigation, agriculture and small scale agro-based industries. Such a policy only can raise the standard of living of the people living in this area and check the seasonal and permanent migration from this part to urban areas which recently has increased at an alarming rate of 71/2 per cent per annum.

The small hydropower development can play a pivotal role in introducing the "Development packages". The construction of mega hydropower projects take a long time for project preparation and mobilization of external financial resources and it also involves a lot of uncertainties as exemplified by Pancheswar, the Karnali high dam project and recently Arun III project. Moreover, without meaningful cooperation from India, it is practically impossible to move ahead for the mega power projects. Even though India is having power shortage by 7.1 per cent at the national level and 33 per cent in Bihar, no serious effort has been made for bilateral development of Nepal's hydropower potential for mutual benefit. Hence HMG/N should not pin too much hope on and waste valuable time on its development in the near future but should proceed with the development of medium, small and micro hydel projects.

Not only the hill agriculture but all round development of the hill and mountain can be achieved through the development of small and micro hydropower projects together with the development of agro-based industries and cottage industries which will make these projects economically viable also. The design and approach of such development will have to be changed from the present one to meet the broad-based objective. In the Terai, the conjunctive use of surface and ground water will foster rapid development of medium and large irrigation projects as these power-driven tubewells will supplement surface irrigation system during low flow in the rivers. The large-scale development of hydropower projects with other development packages mentioned above will help to preserve the environment by meeting the energy requirement.

The total hydropower generated in the country right now is only 253 MW in NEA and in the private sector (Table 2.1). The contribution of small hydropower projects numbering 35 in the total generation is 12.0 MW which is quite negligible. This is mainly because of the poor performance of the small hydropower plants due to inadequate maintenance and poor utilization of the generated power. So the poor performance of the small hydropower projects till now should not be generalized for its viability. It is also quite difficult to synchronize the different small hydropower projects developed so far and in the absence of promotional activities the load factor is quite low which should be increased.

Small Hydropower Development

The topography of the country with significant elevation difference in combination with the monsoon rainfall, snowfall and glaciers etc. has generated thousands of rivers and streams throughout the length and breadth of the country creating a favourable condition for the development of micro to mega hydropower projects. The generation of hydropower in Nepal dates back to 1911 with the construction of Pharping hydropower project having 500 KW capacity. After that 253 MW hydropower and 42.42 MW diesel power have been generated till now. This is far below the need to meet the increasing demand both for domestic and industrial purposes which is increasing at an average annual rate of 11.4 per cent. The shortage of power has direct impact on the industrialization programme on the one hand and the consequential import of commercial

Table No. 2.1 **Hydropower Project**

MAJOR HYDRO PROJECT (Existing)

S.No	Categories	Capacity (KW)	S.No	Categories	Capacity (KW)
1.	Panauti	2,400	6.	Devighat	14,100
2.	Trisuli	21,000	7.	Kulekhani No. 2	32,000
3.	Sunkosi	10,050	8.	Marsyangdi	69,000
4.	Gandak	15,000	9.	Andhi Khola (BPC)	5,100
5.	Kulekhani No. 1	60,000	10.	Jhimruk (HMG)	12,300
		TOTAL		**240,950**	

SMALL HYDRO PROJECT (Existing)

S.No	Categories	Capacity (KW)	S.No	Categories	Capacity (KW)
1.	Sundarijal	640	18.	Taplejung	125
2.	Pokhara	1,088	19.	Manang	80
3.	Seti (Pokhara)	1,500	20.	Chaurjhari (Rukum)	150
4.	Dhankuta	240	21.	Syarpudaha (Rukum)	200
5.	Tinau (Butwal)	1,024	22.	Terha Thum	100
6.	Surkhet (Jhupra)	345	23.	Ramechhap	75
7.	Surnaya (Baitadi)	200	24.	Bajura	200
8.	Baglung	200	25.	Arughat Gorkha	150
9.	Doti	200	26.	Tatopani/Myagdi (I+II)	2,000
10.	Phidim	240	27.	Okhaldhunga	125
11.	Gorkhe	64	28.	Rupalgad Dadeldhura	100
12.	Jumla	240	29.	Namche	600
13.	Dhading	32	30.	Achham	400
14.	Syangha	80	31.	Jomsom**	200
15.	Helambu	50	32.	Darchula (I+II)**	300
16.	Salleri (SCECO)*	400	33.	Khandbari**	250
17.	Chame	45	34.	Bajhang**	200
			35.	Bhojpur**	250
		TOTAL		**12,093**	

Source: Nepal Electricity Authority
* Private & Others ** Leased to the Private Sector

fuel to meet the energy demand is draining foreign exchange on the other hand. Only about 3 per cent of the rural population have access to electric supply whereas the national average is 11 per cent. Electricity contributes to 0.8 per cent of the total energy consumption whereas around 94 per cent of the energy need is fulfilled by fuelwood, cowdung, agriculture residue, etc. The use of the fuelwood to meet the energy need is accelerating the deforestation process which has a chain reaction affecting ecological balance, environment, rainfall pattern, flood frequency, etc. To overcome these problems, HMG/N decided to develop small hydropower projects upto 5,000 KW to meet the energy demand in the hilly region and to establish Small Hydropower Development Board in the year 1975.

Due to the low level of operational efficiency and poor generation of revenue, the government has to incur direct loss of around Rs. 600,000 per plant. The load factor of these plants varies from 5 to 34 per cent from plant to plant. Poor management and lack of promotional activities are the main reasons for the poor performance. The load curve of Darchula Small Hydropower Plant which is typical of a small hydropower project operation shows the peak load during the evening and small peak during the morning hours.

Keeping in mind some of the above shortcomings in load distribution, the government permitted the private sector for the installation of small hydropower project upto 1000 KW without taking licence from the government. No royalty and no corporate income tax have to be paid for this. On the purchase of equipment, machinery, tools and spare parts, only 1 per cent custom duty is charged. Import licence fee and sales tax are exempted in those items which are not manufactured in Nepal. The government is providing subsidy upto 75 per cent of the total cost of generator and electro mechanical part in the remote areas and 50 per cent in the rest of the country for the development of micro hydel projects. In capacity beyond 1,000 KW mentioned above, royalties and corporate income tax are charged. There are around 92 micro hydel plants established in the private sector. In most of the small hydropower projects, there is no provision for synchronization. All the plants have to be operated individually. Tatopani is connected with Pokhara and this is going to be extended to Jomsom which will increase its load factor. The revenue generated by small hydropower plants cannot meet the expenses required for maintenance and operation of the system as is shown in the table. 2.2.

Table No. 2.2 **Revenue Collection and O & M Expenses of Selected Plants (1990-91) `000' Rs.**

Plant Name	O & M Expenses	Revenue	Net Benefit
Taplegung	690	259	- 431
Ramechhap	607	121	- 486
Khandbari	775	591	- 184
Bajhang	778	311	- 467
Chaurijhari	740	302	- 438
Bhojpur	819	480	- 339
Bajura	745	234	- 511
Arughat	470	122	- 348
Okhaldhunga	799	335	- 464
Serpodaha	571	332	- 239
Terathum	936	372	- 564
Sub Total	7930	3459	- 4471
Gumgadi[1]	370	263	- 107
Simikot[1]	412	91	- 321
Kodari Tatopani	325	93	- 232
Sub Total	1107	447	- 660

Source: Small Hydropower Department, NEA

HMG/N has decided to lease the small hydropower projects to the private sector and five plants have already been leased. The leasing of small hydropower projects should not however create an impression that it is due to government's failure to run these system effectively.

Micro hydel projects developed under the private sector have also not been running successfully. Water and Energy Commission has recently carried out a study in the hill districts for identifying the probable sites for the development of micro hydel projects under the technical assistance of UNDP. About 12 districts are already covered under this programme - each district recommending ten promising sites for development.

Most of the small hydropower projects' failure seems to be due to poor planning and design, absence of promotional activities, lack of maintenance and operational facility and reliability of supply. So the future development of small hydropower projects should address these shortcomings to become effective. Its use should not be limited to domestic requirement only, it should help to promote small scale industries and modernization of agriculture. Till now half-hearted action has been taken for its development as can be assessed from the projects under construction and from the projects that are as shown in the table, planned and proposed.

Irrigation Development

The economy of the country is based on agriculture which contributes about 51.38[1] per cent in the national GDP. The contribution of the manufacturing, services and other sectors is only 49.62 per cent in the GDP. About 80 per cent of the total population have been employed in agriculture, though not on full time in the absence of irrigation facility. Irrigation is the main input for agricultural development without which the contribution of other inputs are quite ineffective. The agriculture sector could not move beyond subsistence level because of its dependence on the monsoon rainfall heavily due to low return compared to the ever-increasing investment cost.

Since time immemorial the farmers used to organize themselves irrespective of their caste and creed, both in the hills and the Terai plain, to bring water from the rivers and streams and arrange its distribution, maintenance and operation through voluntary contribution in cash or kind as agreed upon by the community as a whole. There were different types of such a system operated by the farmers depending upon the requirement to be met such as for round-the-year irrigation, for monsoon crop only and for meeting seasonal requirement in the event of drought and long spell of monsoon breakdown. The irrigation system developed by the beneficiary used to be governed by the customary law for its functioning. Even now the area covered under such a farmer managed system is quite substantial as shown in table 2.3.

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1. HMG/N, Ministry of Finance, **Economic Survey FY 1994**, Kathmandu, 1994.

Table No. 2.3 **Area Covered under Farmer Managed System**

Region	DOI*Managed Projects	FMIS^	Sub-Total	Other FMIS	Total Irrigated Area
Tarai Districts	250,000	161,000	411,000	314,000	725,000
Hill Districts	15,000	20,000	35,000	144,000	179,000
Mountain Districts	-	5,000	5,000	24,000	29,000
Total	265,000	186,000	451,000	482,000	933,000

Source: Irrigation Master Plan

* DOI = Department of Irrigation
^ FMIS = Farmer's Managed Irrigation System

Due to the creation of ecological imbalance, pressure of increased population in forest and marginal land and change in the river environment, these FMIS failed to be effectively functional so that started causing more damages to the cultivated land due to flash flood with high intensity entering the cultivated area through open inlets. Lack of sustained use of forest, soil and water resources, flash flood, landslides etc. have also become a regular feature destroying more life and property. So the traditional farmer system has become more vulnerable to frequent flooding during the monsoon due to the rise in the river bed also which is considerably destroying the cultivated area besides the standing crop. Increase in agricultural production is greatly affected by these flooding, erosion of the agricultural land and gradual desertification due to the deposition of river bed material. Hence HMG/N has decided to intervene in such FMIS with twin objectives of improving performance by rehabilitating and modernizing the system and of conserving the limited cultivated area of the country. Rehabilitation and modernization of the FMIS will also save labour on the part of the farmers; they usually have to contribute to keep the system in the running condition and reliable supply of water will provide them with the opportunity for the cultivation of more than one crop. Large FMIS mostly exist in the Terai and valleys and medium and small ones are in the hills. The total number of intervened system till the year 1995 in the Western, Mid-western and Far-western region is 241 covering an area of 42,496 ha under the irrigation line of the credit programme financed by the World Bank/DOI. Similarly, the intervention in 346 no of FMIS covers an area of 46,495 ha in the Eastern and Central region under the irrigation sector development programme financed by ADB/HMG.

The Chandra Canal system was the first public sector irrigation Project developed in the year 1922 to irrigate 10,000 ha in the Saptari district which is even now in operation after its rehabilitation and modernization. The systematic development of irrigation was taken up from 1956-57 when the DOI for its development was separately established from the Public Works Department. During the early stage after the establishment of DOI, medium and small projects were taken up with the assistance of the donors and international agencies. The availability of data was the main constraint for the design and development of such projects. An investigation and design team, which was established by FAO, was working in the irrigation sector development and it prepared the first broad-based Master Plan for its development. Later on, the design team was converted into Investigation and Design Division in the DOI. All the projects developed till then were identified in the Master Plan prepared by the FAO team for the rivers and streams originating in the Siwalik range and in the vicinity of the Siwalik range which used to have large fluctuation of discharge totally dependent on monsoon rainfall.

The Kosi river agreement of the year 1954 and the Gandaki agreement of the year 1959 generated a lot of controversies due to the large difference found in the sharing of benefits between the two countries, because of the location of the barrage close to the border and also in terms of the operation of certain clauses in the agreement which restrict its use in the upper catchment area of these rivers freely as per requirement which have to be modified in the Kosi agreement but not fully in the Gandaki agreement. These two agreements are mainly responsible for the bilateral development of Nepal's potential water resources as it has set a bad trend in sharing of costs and benefits. The total capital cost of the development of these projects was borne by India for the facilities developed in Nepal and India. Nepal has provided land for the location of the barrage site and other facilities of materials like boulder, timber, sand, etc. required for the construction. During construction and afterwards in the management, maintenance and operation of the systems, Nepal did not have any say. As a result, Nepal is also suffering due to frequent closure of the canals. Now, in the changed context Nepal wants to develop the potential of its water resources bilaterally or multilaterally with the assistance of some international donors as its own project. In the mega multi-purpose projects, the involvement of India will be limited to finalizing the design and scope of the project as well as the modality of the cost and benefit sharing. The construction, maintenance and operation responsibility will rest with Nepal. The sharing of the benefit and cost specifically will be in the consumptive use of water and flood benefit whereas Nepal will like to enhance its generation of revenue through the sale of power to India.

In the early stages of development, the irrigation projects were mostly of an extensive type with the main and branch canals and in some cases distributaries without field channels and participation of the beneficiary farmer. The minor irrigation programme that was launched in the year 1966 was the first programme which initiated the people's participation. Under this programme, FMIS mostly in the Terai and some in the hills which covered an area of 3700 ha. were rehabilitated. In the year eighties under the ILO special Public Works Programme, Bhorletar and Arutar gravity irrigation schemes in Lamjung and Gorkha districts respectively were implemented by organizing the water user's group and involving them in the decision-making process right from the design stage under the DOI. These were the pioneer projects for the user's group involvement in the decision-making process right from the planning stage with their contribution to meet part of the capital cost of the project. Regular training programme also used to be organized to develop the capability of the farmer. This helped the evolution of irrigation sector development programme through beneficiary participatory approach. To streamline irrigation development with uniform approach and to accelerate its development with a uniform policy, irrigation development programmes were brought under one umbrella in the DOI from other agencies in the year 1988. However, ADB/N continued with its programme of shallow tubewell development as usual within the policy framework of DOI.

The performance of the irrigation projects without effective participation of the beneficiary during construction, maintenance and operation was quite poor. Heavy resource mobilization was concentrated in the development of few command areas and large projects under the World Bank, ADB, etc. finance for the intensive use of water without effective participation of the beneficiary on account of which the result has been far from anticipated. The physical annual target to bring additional area under irrigation could not be met as shown by the development in successive plan periods in table 2.4 due to large allocation of fund in few big Command Area Development Projects only.

Table No. 2.4: **Achievements in Irrigation during Plan Period**

PLAN	PERIOD	TARGET (Ha)	ACHIEVEMENT	
			Plan Period	Average Per Year
First Plan	1957-62	20,785	85,000	-
Second Plan	1962-65	32,544	1,035	345
Third Plan	1965-70	50,654	52,860	10,572
Fourth Plan	1970-75	253,711	37,733	7,547
Fifth Plan	1975-80	230,220	95,425	19,085
Sixth Plan	1980-85	233,482	172,928	34,582
Seventh Plan	1985-90	235,000	176,419	35,284

Source: Irrigation Master Plan

In the early stage of the development, the irrigation projects were mostly of an extensive type and they supplemented the monsoon rainfall. Later on due to the research establishment of soil, water, plant relationship and the expansion of the extension services, use of improved seed and chemical fertilizer, intensive type of irrigation became necessary and the development of command area was taken up in most of the completed medium and large projects instead of field to field irrigation. Small field channel networks were constructed to deliver the required quantity of water at the required time. The designed capacity of the projects for extensive irrigation could not meet the demand for intensive one. There was no other alternative left except the rotation type of irrigation which is adopted. In the hilly region command area development is required in different perspective because of the small size of the project. In the present changed scenario, new dimension is added to any type of development and we have to take into consideration the environmental part of the project and maintenance of ecological balance. This will put restriction in the choice of crop that can be cultivated in the hilly region.

The total area covered under agriculture is 3,217,977 ha. Out of this, 2,612,714 comes under cultivation comprising 1,354,805 ha of field farm and 1,282,206 ha in the upland (Task force report for preparation of the 8th Plan end of 1994-95). The area covered by irrigation projects till now comes to 576,534 ha which is shown in table 2.5.

Table No. 2.5 **Area Covered under Public Irrigation System up to 1994-95**

Geographical Area	EDR	CDR	WDR	MID WDR	FAR SDR	TOTAL
Mountain	3731	999	1466	560	4040	10796
Hill	6252	22448	18457	13570	3358	64085
Terai	162776	116968	60231	5630	32140	377745
Unspecified Region	-	-	-	-	-	123908
Total	172759	140415	80154	19760	39538	576534

Source: Department of Irrigation

After the introduction of the Irrigation Sector Development programme in the year 1988, the area covered by irrigation has tremendously increased to boost up the production so as to meet the immediate need of food for the increased population. Under these programmes, medium and small new irrigation projects are constructed and the rehabilitation and modernisation of the existing farmer managed irrigation system are carried out on the demand of the beneficiary farmer who has to contribute to meet the small part of the cost and also should take over the responsibility of maintenance and operation of the system after completion.

The beneficiary farmers are involved throughout the development period of the project. Besides the surface water, exploration of groundwater is also carried out and development of shallow, medium and deep tubewells is done on the demand of the beneficiary farmer. The development of the shallow tubewell programme on the basis of demand is carried out by ADB/N also. This programme approach has been effective for rapid expansion of irrigation area by mobilizing the beneficiary farmer who till now used to be dependent totally on the government. There is no provision for the development of lift irrigation under the Sector Irrigation Development Programme. Tubewell development in clusters instead of as isolated ones here and there was taken up after identifying and selection on the basis of demand from the farmer under Irrigation Line of Credit Programme. The target fixed for development under this programme was 9,102 ha.

Till now three medium lift irrigation projects are developed in the Terai and one in the hills namely Chitwan Lift Irrigation Project, Kosi Pump Canal, Marchawar Lift Irrigation Project and Battar Lift Irrigation Project respectively. Performance-wise Marchawar Lift Irrigation Project is the best followed by Koshi Pump Canal and Chitwan Lift Irrigation Project. Battar Lift irrigation Project is the worst, Chitwan and Battar Lift irrigation Project has technical snags in the design for which remedial measures will have to be carried out to improve its performance. All the four lift irrigation projects do not have sound maintenance and operation support with adequate budget. As a result, frequent interruption in irrigation is a regular feature. As lift irrigation is expensive in maintenance and operation, the cropping pattern will have to be changed to make economic use of water together with the improvement of irrigation area.

Deep tubewells are extensively developed in the western Terai followed by central and far western Terai region. The World Bank-financed project alone in the western Terai irrigates an area of 25,840 ha from deep tubewells which are electrically operated. The consumption of power is about 34 kw per tubewell and each tubewell which has to pay around Rs. 24,000 per annum to meet the power consumed irrigates about 100 to 130 ha of land. It is practically impossible to recover the operation and maintenance cost from the farmer. Under the Irrigation Line of Credit programme, large, medium and shallow wells are developed which irrigate around 2,075 ha of land till now. ADB/N has drilled shallow tubewells throughout the country which are diesel-operated but they are not functioning satisfactorily. In a recently concluded study, the potential for development of deep tubewells is around 160,000 ha and that of shallow well is 200,000 ha. Out of the total potential of 360,000 ha around 110,000 ha is already exploited. Due to the small size of the irrigation area, 100 to 130 ha for deep tubewell and 5 to 10 ha for shallow tubewell, the cost of construction is cheaper than that of the surface irrigation. The cost of construction of surface irrigation in the Terai per ha comes to around Rs. 80,000 whereas it is around Rs. 54,000 for each deep tubewell and Rs. 46,000 for a shallow tubewell as shown in table 2.6.

Table No. 2.6: **Cost of Construction of Tubewell**

S. No.	Description of Work	Cost	
		Shallow	Deep
1	Tubewell Construction & Pump Test	100,000	490,000
2.	Purchase and Installation of Pump and Accessories	20,000	450,000
3.	Construction of Pump House & Battle Tank	90,000	120,000
4.	Construction of Deep (1 km.) Shallow tubewell's (0.3 km.) Distribution system	245,000	800,000
5.	Electrification (L.S.)	-	300,000
	Total	460,000	2,160,000
Command Area (ha)		10	40
Cost per ha.		46,000	54,000

The shallow tubewells mentioned above are well developed scientifically but they are not the wells where local technology is used. As the life of these wells is quite short ranging from 5 to 10 years for shallow and 15 to 20 years for deep tubewells, compared to the surface irrigation having a life of 50 years and above and as the cost of operation and maintenance of these tubewells is quite high, the farmers cannot sustain this type of irrigation without the intensive support from the concerned agriculture sectors for introducing the right type of cropping pattern. However, the economical use of water minimising the losses and with full support of maintenance and agriculture extension services, it can generate better returns for the farmers than the surface irrigation as water is delivered immediately in the field. The shallow and deep tubewell areas are located mostly in the Terai plain where the recharging condition exists in the Bhabar Zone immediately after the Siwalik range.

The development pattern of irrigation till now is only to meet the immediate need of increased production. It has not yet switched over to market-oriented cash crops. The present planning and design of projects takes into consideration merely the subsistence level development. It is high time now to switch over to long-term planning to increase the generation of benefit through cultivation of cash crops. The parameters that require preservation of ecological balance and prevention of deterioration of environment will require change in the planning and design and type of irrigation system along with the cropping pattern. Livestock fodder requirement for 17.1483[2] million domestic animals and production of organic manure make a strong case for developing agro forestry. The long term objective should be to provide modern irrigation technology to the total area of 3.22 million ha which is covered under agriculture to meet the requirement of food, fodder and better return from the farm.

Contribution of Hydropower for Agriculture Development

As per Land Resources Mapping Project (LRMP) study, the country is divided into five physiographic regions namely - the Terai, Siwalik, Middle Mountain, High Mountain and the Himalayas which are better suited for agriculture development as it is more precise than the three ecological belts namely Terai, hills and mountains due to the soil formation and the different landscape. Accordingly, the cultivated area is defined into two broad divisions namely valley and slope. As per the finding of the LRMP study, the average size of farm in the hills and mountain is in the range of 0.6 ha to 1.6 ha which differs from the sample study of Ministry of

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2. National Planning Commission, Central Bureau of Statistics, Statistical Pocket Book 1994, Kathmandu, 1994.

Agriculture (MOA) which is on the lower side. As per the same report, 3.9 million ha of gross area used for under agriculture and 0.7 million ha is used for grazing. The cultivated land per person comes to only 0.16 ha which will gradually decrease over the years with the increase in population unless encroachment takes place on a large scale in the marginal land. As per the ceiling of income fixed by National Planning Commission (NPC) for the poverty line of Rs. 3,850 per capita per annum for the hills and Rs. 3,680 for the Terai, about 29 per cent of the rural population in the Terai and 55 per cent of the rural population in the hills are below the absolute poverty line. This is because of the high population growth and subsistence level of agriculture development resulting in low productivity in the absence of high quality irrigation and other agriculture support services. Due to several constraints for increasing the income from farming and the absence of off-farm employment opportunity, there is seasonal migration in search of work to make some cash income to supplement their means for meeting the minimum requirement for livelihood, especially from the hill and mountain. Besides increasing the return from the farm, opportunities should be created for the generation of the off-farm income to raise them above the poverty line. The intensive development of the land beyond the subsistence level and creation of off-farm income opportunity can only be achieved through the development and optimal utilization of small hydropower projects. The World Bank poverty alleviation study estimates that about a third of the poor in the agriculture in the hills have enough land for improvements but only if their land is irrigable otherwise they may be able to produce about half of the poverty-level income on their own land. For the balance who make up about half of the population of the rural hills, their holdings are too small to ever produce more than a third to a half of the poverty level income from field crops even under the best circumstances.

Though the location of the country comes under sub-tropical monsoon climatic zone, it is not so due to the topography of the country. The climatic condition is governed by the topography and the elevation which can be broadly divided into five types namely (a) Sub-tropical monsoon climate (b) Warm temperate climate (c) Cool temperate climate (d) Alpine climate and (e) Tundra climate. Even the rainfall pattern is governed by the topographic elevation having higher rainfall on the southern side of the Mahabharat range and less on the northern side from the south-east monsoon which contributes about 80 per cent of the total annual rainfall. As the monsoon proceeds from east to west, it is getting dry as the result of which the western part of the country does not have much rainfall as that in the eastern part which receives monsoon rainfall one month later than in the eastern part of the country.

Highest rainfall takes place in Pokhara and Lumle area. The average rainfall is around 2,000 mm per annum. Moreover the rainfall during the monsoon period from June to September is not uniformly distributed and there are frequent breakdowns for long periods which in most of the cases is not useful to meet the plant requirement.

Without irrigation under the existing condition the farmers are reluctant to change their agriculture practices. One of the most important resources of the country is arable land which is limited by hill and mountainous topography having different type of soil. The soil in the Terai is alluvial with medium to heavy texture. The soil in the dun valley is of recent alluvial origin which is lighter in texture and is more porous than that in the Terai which is easily eroded. Mostly rainfall farming is practised in this system as it lies in the valleys and the lower slopes of the Siwaliks, and maize, mustard, millet etc. are cultivated. The middle mountain covers most of the arable mountainous area and consists of valley floors, tars and hill slopes. The soil type of valley floors is derived from the depositional alluvial with sandy and bouldery loamy texture. The tars are formed from the soil derived from old alluvial and the mountain slope consists of shallow depth of soil with variable texture. The principal crops grown are maize, millet, barley, potato, etc. Soil in the high mountain is of a coarse textured, loose type mixed with stones and gravels. Above 3,000 meter elevation only one crop can be grown because of low temperature requiring a higher maturity period. Mainly the winter barley, wheat, potatoes, buck wheat and finger millet are cultivated. Recently, Lumle Agriculture Farm has developed a paddy variety which can be cultivated even in an altitude above 3,000 meter. In the hill and mountain a mostly traditional type of farming is practised with little impact of modern agriculture practices. The soil mentioned above is mostly acidic with value ranging from 4.5 to 5.5. The organic matter present is in the range of 0.2 per cent to 5 per cent which also applies to nitrogen.

The topography, varying soil texture and different climatic condition require the development of agriculture in each physiographic region differently to optimize the generation of benefit at a minimum cost. In the Terai belt, flood irrigation through gravity flow is quite feasible and it is the cheapest way of providing irrigation whereas in the other region it is not the same. In the physiographic region of *Siwalik*, hill, mountain, *dun* valley and the high Himalayan higher gradient and uneven nature of agriculture land, hill slope, low level of clay content and high porosity of soil make the development of gravity irrigation system and flood irrigation expensive as well as detrimental to the agricultural land in the long run; it is expensive in the sense that it has to make higher provision for seepage losses and it is detrimental in the sense that due to steeper gradient and uneven nature of the field, the thin layer of top soil is eroded and carried away into the river system. Generally, the water requirement for a crop is 3 to 4 times higher in the hills, mountains, *dun* valley etc. than that in the Terai where the clay content of soil is quite high. So we will have to think in the new line for the development of irrigation in different physiographic region differently to make it cost effective and to optimize the benefit per unit cost.

The strategy should be to optimise the production per unit of land in the Terai plain and per unit of water in the other physiographic region as the diversion cost of water is quite high in the hills and its economic use is required. Besides the texture of soil, the long length of an idle canal brought by cutting the hill slopes is detrimental to the environment as well as it increases the cost of the project. To overcome these shortcomings we will have to switch over from gravity to lift irrigation system and from flood to sprinkle and other mode of irrigation. All the irrigation development activities should provide environment conservation part within the development plan itself. The extensive use of hydropower for directly lifting water will minimise or eliminate the idle canal length, reduce cost of construction and prevent environmental deterioration. The application of water through sprinkle and trickle irrigation will make efficient use of water minimising the losses and erosion of limited top soil in the hills and mountain. As mentioned in the Irrigation Master Plan, EIRR reduces below 10 per cent if the height of lift is more than 40 meter. This will limit the use of lift irrigation only to lower terraces of land located on the river bank only. However, a combination of partly gravity flow canal and partly lift canal will reduce the height of lift and the long length of idle canal which should be considered as per the site condition.

Small hydropower development in the hills and mountain, where the condition exists for such development, can boost agriculture production and prevent the adverse effect in the environment by conserving and optimizing the use of land water and forest. It is estimated that about 24 million m^3 of sediment materials are produced annually in Nepal. This huge sediment carried by the rivers flowing through Nepal is not only due to slippage of hill slopes, land slides, earth and rock movement but also due to soil erosion on a large scale. The continuous process of erosion in the hill and mountain region is mainly due to the large scale deforestation, disturbance created in the stability of the hill slope as a result of large scale construction, cultivation without making terraces, choosing a cropping pattern which requires more water throughout the irrigation period and which carries away with it the top layer of soil of the cultivated area. To overcome this problem a traditional type of subsistence agriculture practices adopted by the farmers should be changed to high value horticultural crops and vegetables, spices, herbs, tea, pasture, etc. which can yield better return as well as have minimum adverse effect on the environment. The 0.7 million ha of land used for grazing and marginal land should be used for the cultivation of fodder for cattle and for producing organic manure. Sprinkle irrigation has got high efficiency and can be used in all types of soils, topography, etc. There is no chance of soil erosion and the most economical use of water can be made. There is no loss of land for the construction of distribution system as it is not required. So the diversification of crop should not be promoted on an adhoc basis but only in a planned way by carrying out adaptive research to develop suitable technology and preparation of guideline taking into consideration the present changed scenario with the development of transport and communication and high mobility within the country which helps movement of one part of the produce to another part comfortably.

Hydropower development can not only lead to the diversification of crop and boost up the production but also be of help in the processing of such products through establishment of small industries which can be marketed easily and which can fetch better returns to farmers. For this, comprehensive institutional base will have to be established to provide support services such as extension, input supply, marketing services, credit facility, etc. and development of the capability of the farmer.

Instead of generalizing on the poor performance of projects, like the Chitwan and Batter Lift Irrigation Project, a lesson should be learnt from such projects. There are more than one way of lifting water with or without the use of power or any type of fuel such as:

a) Hydraulic Lift - does not require power for its operation.

b) Water Turbine Pump - does not require power for its operation.

c) Hydraulic Ram - does not require power for its operation.

d) Positive Displacement Pump - requires power for its operation.

e) Rotodynamic Pump - requires power for its operation.

The first three types of pumps are suitable for small cultivated areas at higher elevation which requires only a small quantity of water. The latter two types of pump are suitable for lifting large quantities of water to smaller height.

The performance of the other two lift irrigation projects namely Koshi pump canal and the Marchawar lift irrigation project is better than that of these two projects because of the improvement in the design of the project. Even now there is enough scope in these projects for improvement in the design and creation of cheap and effective maintenance and operational facility for the development of lift irrigation project for improving its performance and making it cost-effective.

The conjunctive use of tubewells with surface irrigation has got tremendous scope in the Terai plain where the productive aquifer with recharge condition are available for such development. All the rivers - large, medium and small - cannot provide reliable irrigation as the quantum of flow depends upon the monsoon rainfall which is not uniformly distributed throughout the cropping period coupled with frequent dry spell. Tubewells can supplement during the low flow in the river, the dry spell and the critical period of the crop when there is heavy demand of water. Tubewell irrigation becomes expensive when it is used independently for the cultivation of crops such as paddy, sugarcane which requires more water because the operation cost of the tubewell is directly proportional to the height and duration of pumping. An analysis of energy costs versus the initial investment cost indicates that the yearly cost of power for pumping may be two to three times higher than the initial investment amortized cost. It will be more economical to use it for irrigation of cash crop such as vegetables, wheat, fruits, etc. The power required for operation of the tubewell can be made available from the national grid system as the power distribution is well covered in this region. Micro hydropower projects can be installed in the drop structure of the ridge canal of surface irrigation projects in the Terai also which can be utilized for the operation of these tubewells. This stage of development is not mature at the present state of irrigation development.

Conclusion and Recommendation

The construction of big dams causes bigger displacement of people, displacement and extinction of wildlife and submergence of historical monuments. This displacement is permanent whereas the displacement due to flood and political riot is only temporary. So the development of large, medium and small run-off river hydropower schemes should be preferred at the early stage of the development which will provide job opportunities to the people who are living in the remote area of the country and also who are likely to be displaced by the proposed storage reservoir. The promotional activities such as the establishment of small agro-based industries, cottage industries, etc. which can be promoted with the availability of firm power will also prevent voluntary migration to other places like in big cities and town area which is happening at present. As Nepal is in the early stage of its development but is blessed with tremendous hydropower potential, its planned development strategy will provide clean and efficient energy sources without much disturbance. So planned development of small hydropower projects should be carried out to meet its multifarious use and make it economically viable.

Agriculture continues to retain its strategic significance and is the largest source of employment. It is the main source of the supply of raw material and a base of effective demand for most of the industries. A given amount of resources has the multiplier effect if it is invested in the agriculture sector. The change in the cropping pattern in the hilly region from cereal to horticulture, etc. can double the employment opportunity besides increasing the return from the farm. The agro-based industries and cottage industries can be developed to add additional value to the agriculture products to generate additional income to the farmer. The income of the farmer can also be increased due to the full time employment opportunity which is associated with these developments. This can be only possible through adequacy and continuity of power supply at a reasonable rate, greater attention to human resources development in the rural area besides tackling the problems rooted in the social structure. Promotion of horticulture development will require creation of a market which can be available only through the processing of raw product because of the high cost incurred as a result of the duration required for haulage of raw products up to the market place.

Irrigation projects always consume not only large quantities of water but also require huge capital and recurring finance and skilled manpower. For example, 10,000 m^3 of water will be sufficient to:

1) Irrigate 0.5 ha of rice, 0.8 ha of cotton and 1.2 ha of wheat.
2) Supply 100 consumers in a modern industrial city for two years.
3) Supply 100 luxury hotel guests for 55 days.

Therefore, the concepts and methods of alternative forms of irrigation development followed by suitable design, location, and operating procedures are required to make for its viability. The capital cost of water diversion by gravity @ 1 lit/sec costs about Rs. 60,000 besides the recurring cost of maintenance and operation and occasional rehabilitation. So far the reduction of capital cost, the economical use to minimise the losses and selection of the right type of a cropping pattern which can provide increased return per litre of water are required.

So, the long-term comprehensive planning for the development of hydropower in association with irrigation, agriculture and small scale industrial development can only increase the living standard of the people. This will result in the protection of environment, maintaining ecological balance, preventing seasonal and permanent migration, etc. As we did not have mineral resources to produce commercial fuel instead of wasting too much time on the investigation of these minerals, we should devote all our energy and resources to developing this alternative source of energy which is nothing but hydropower available in plenty.

The development of irrigation in the present form, especially in the hills and mountains, may prove counter-productive in the long run. Drastic change is required which can be provided only through the hydropower development.

Implementation of small and micro hydel projects by adopting the programme approach instead of a specific project and by involving the beneficiary customer instead of providing subsidy for each individual should be the motto for implementation. The programme approach has been quite effective in the development of the irrigation sector. This model of development can gather support for the establishment of small agro-based industries. Heavy subsidy and concession in royalty and tax should be provided for the establishment of such industries with adequate provision of market protection. We should always bear in mind that the development of any project is not so important as its optimal utilization.

Lastly, we should not forget the vast talent inherited by our farmers from generation to generation which is quite different than the farmers in the European countries who mostly inherit the farming knowledge from their educational background. The only thing we have to do is to upgrade their talent and modernize it to suit the changed context of agriculture development.

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3

DEVELOPMENT OF SMALL HYDRO ELECTRIC POWER AND ITS IMPACT ON THE SMALL AND RURAL INDUSTRIES

Indu Shumsher Thapa

Introduction

In Nepal, before the introduction of electrification i.e. prior to the development of hydropower project, the industrial sector was dominated mostly by cottage and rural industries including traditional handicraft. The agro-processing rural industries were largely employing water wheels whereas traditional handicraft and other kinds of cottage industry were dependent on manual labour and skills. Water wheels are still dominant especially in the agro-processing industries in the hilly regions where electrification is yet to be introduced.

There is a lack of historical record when electrification was introduced in the industrial sector in Nepal with the development of hydropower. With the beginning of World War II, there was a spur on the promotion and development of modern industries in Nepal. Many rice and oil mills were set up using steam engines in the Terai regions and other agro-based industries such as cotton mills, jute mills and sugar mills, etc. were also established.

With the advent of democracy in 1951, the industrial sector was planned and developed and electric power was used in the productive sector for manufacturing purpose. As per the hydropower policy in Nepal, emphasis is being given to rural electrification programme in order to support the development of cottage and small industries and agricultural production in the hill and Terai regions.

Energy consumption in Nepal was 6.36 million tonnes of oil equivalent in F.Y. 1992-93 and the share of electricity was 0.9 per cent only as shown below in table 3.1.

Table No. 3.1: **Situation of Energy Consumption, 1993-94**
(Preliminary Estimate)

(Thousand Tons of Oil Equivalent)

Traditional	**5910**
Fuel Wood	4403
Agri Waste	984
Animal Dung	523
Commercial	**644**
Petroleum	513
Coal	67
Electricity	64
TOTAL	**6554**

Source: Economic Survey FY 1993-94, HMG, Ministry of Finance

Hydropower Development in Nepal

Hydropower in Nepal has been used in two forms - mechanical and electrical. The practice of use of hydropower in the form of mechanical energy in traditional water-propelled mills, called Ghatta, goes back to time immemorial. However, the first hydropower plant to generate electricity was established in 1911 with a capacity of 500 KW. At present, the largest existing hydroelectric plant has an installed capacity of 69,000 KW. The total number of hydroelectric plants of all sizes (public and private) is reported to be about 356 and their cumulative capacity is around 254 MW. Out of this total, only about 8.2 MW or 3.2 per cent of total developed capacity belongs to mini/micro category. About 12.4 per cent of the population have access to electricity. The peak load of Nepal Electricity Authority (NEA) in FY 1993-94 was 222 MW.

The hydropower plants have been classified into four categories - micro, mini, small and medium/large as shown in the following table.

Table No. 3.2: **Installed Capacity, KW**

Categories	**Capacity**
Micro	< 100
Mini	101 - 1000
Small	1001 - 5000
Medium & Large	> 5001

Small Hydropower Projects in Nepal

There are about 39 small hydropower projects in Nepal with a total installed capacity of 18,689 KW under NEA and four with total installed capacity of 2,060 KW under construction (Appendix I). Similarly, about 104 micro hydro electric plants with total installed capacity of 1,062 KW have been installed with financial assistance of the Agricultural Development Bank of Nepal (ADB/N) with local people's participation and subsidy from HMG/N under the Rural Electrification Programme. This programme has been carried out in 54 districts adjacent to the Central Grid and sub-grid (33 KV) and where mini hydropower plants are located.

Over 900 micro hydro units with a total capacity of about 10 MW are estimated to be installed providing services to people in rural areas. Micro hydro plants have been primarily used in agro-processing activities, mainly in grain milling, rice husking and oil extracting.

The small hydro plants are connected to the National Grid whereas mini and micro hydro plants are isolated ones.

Institutional Arrangement

With a view to developing hydropower of the various categories, the following institutions have been established at the government level in Nepal:

(1) Water and Energy Commission
(2) Ministry of Water Resources
(3) Department of Electricity
(4) Small Hydropower Department
(5) Nepal Electricity Authority
(6) Electricity Development Centre

At the non-governmental level, the agencies, private companies and institutions established for the promotion of small hydropower are as follows (Appendix II):

(1) Annapurna Conservation Area Project (ACAP)
(2) Association of Micro Hydro Manufacturers (AMHM)
(3) United Mission to Nepal
(4) German Technical Cooperation (GTZ)
(5) Swiss Association for Technical Assistance (SATA)
(6) Swiss Federal Institute of Technology (SKAT)
(7) United States Agency for International Development (USAID)
(8) Intermediate Technology Development Group (ITDG)
(9) Association for Context Appropriate Technology (FAKT)

The names of the companies capable of building and installing micro-hydro schemes in the country upto 100 KW are given below:

(1) Balaju Yantra Shala (BYS)
(2) Nepal Yantra Shala (NYS)
(3) Kathmandu Metal Industries (KMI)
(4) National Structure and Engineering Company (NSE)
(5) Butwal Engineering Works (BEW)

(6) National Power Producer (NPP)
(7) Thapa Engineering Works (TEI)
(8) Agro Engineering Works (AEW)
(9) Nepal Machine and Steel Structure (NMSS)
(10) Nepal Hydro and Electric Pvt. Ltd. (NHE)

The following institutions have been providing consultancy services to micro/mini hydro units:

(1) Research Centre for Applied Science and Technology (RECAST)
(2) Centre for Rural Technology (CRI)
(3) United Nations Development Programme (UNDP)

Industrial Development in Nepal

The share of industry in GDP is less than 10 per cent and modern manufacturing establishments engaged 364,247 persons in 1991-92. The overall Index of Industrial Production is on an increase since FY 1990-91 and its growth rate was estimated at 11.1 per cent in FY 1993-94 (table 3.3).

Classification of Industries

The industries in Nepal have been classified into four parts:

1) **Cottage Industries**: The traditional industries utilizing specific skill or local raw materials and resources and labour intensive and related with national traditional art and culture.

2) **Small Industries**: Industries with a fixed asset of upto an amount of Rs. 10 million.

3) **Medium Industries**: Industries with a fixed asset between Rs. 10 million and Rs. 50 million.

4) **Large Industries**: Industries with a fixed asset of more than Rs. 50 million.

Table No. 3.3: **Production Index of Manufacturing Industries**
(Base: 1986-87 = 100)

Particulars	1987-88	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94
Food Manufacturing	112	96	134	190	210	219	282
Beverage	148	142	159	180	207	234	201
Tobacco	107	100	109	114	118	133	154
Textile	97	86	77	95	86	93	148
Leather & Procucts	51	57	97	114	55	64	141
Footwear	177	274	614	834	1264	680	379
Wood & Products	63	54	9	18	30	26	17
Paper & Products	177	274	195	233	236	249	470
Other Chemical Products	99	110	102	120	118	132	55
Rubber Products	131	165	175	221	212	142	76
Plastics	119	156	214	423	369	215	283
Non-metallic Miner	122	121	57	93	129	121	55
Iron & Steel Based	74	101	105	132	173	175	253
Cutlery, hand tool	92	57	47	61	49	86	131
Electrical, Indus. machinery, apparatus, appliances	122	99	94	92	154	90	111
Overall Index	107	102	101	130	142	144	160
Growth rate %	-	-4.7	-1.0	28.7	9.2	1.4	11.1

Facilities

Industries are given facilities considering their needs. For example, no cottage industry is levied sales tax, excise duty and income tax. Manufacturing industries (except cigarettes, bidi, alcohol, beer, vegetable ghee, plastic and electronic assembly), energy-based, agro and forest-based (except saw-mill and catechu) and mining industries are entitled to income tax exemption for a period of five years from the date of commercial production by the industry.

Industries classified under national priority are entitled to income tax exemption for an additional period of two years provided that the agro and forest-based industries are entitled to a five-year income tax exemption. The hydropower generation and distribution is included in the National Priority Industries list.

Manufacturing, energy-based, agro and forest-based industries (other than those of cigarette, bidi, alcohol, saw-mill and catechu) that utilize 90 per cent or more of the local raw materials in their production (which are not listed in the noted category), upon the expiry of their five-year income tax exemption period are entitled to income tax exemption for an additional period of two years.

Industries, other than those of cigarette, bidi, alcohol and beer, established in the remote, undeveloped, underdeveloped and relatively developed areas (Appendix III) are granted a rebate of 60, 50, 20 and 10 per cent of the income tax and 35, 25, 15 and 10 per cent of excise duty respectively.

Fruit-based fruit processing and cider and wine industries with a fixed asset up to Rs. 2.5 million established in Mugu, Humla, Jumla, Dolpa, Kalipot, Bajura, Darchula, Bajhang, Achham, Mustang, Manang, Solukhumbu, Sankhuwasabha and Taplejung districts are entitled to excise duty and sales tax exemption for a period of ten years and fruit-based alcohol industries are entitled to excise duty and sales tax exemption for a period of five years. On completion of this exemption period, HMG/N might grant excise duty and sales tax exemption to the fruit-based alcohol industries up to an additional period of three years.

Eighth Plan

Emphasis is being given to the development and expansion of cottage and small scale and agro-based industries in order to generate income so as to improve the purchasing capacity of the people by increasing opportunities for productive employment.

Institutional Policy

HMG/N introduced New Industrial Policy 1992 and enacted Industrial Enterprises Act 1992 and Company Act 1989 to enhance the private sector participation. It also enacted Foreign Investment and Technology Transfer Act 1992 with a view to attracting foreign investment and technology and also to promoting industrial projects through privatization and market oriented approach.

Institutional Arrangement

In order to develop industries, the following institutions have been rendering their services:

1) Industrial Council
2) Industrial Promotion Board
3) Ministry of Industry
4) Department of Industry
5) Department of Cottage and Small Industries
6) Department of Mines and Geology
7) Bureau of Nepal Standards and Metrology
8) Cottage and Small Industries Board
9) Cottage Industries Handicraft Emporium
10) Nepal Industrial Development Corporation
11) National Productivity and Economic Development Centre
12) Cottage Industries leather Cell
13) Hand Made paper and Ready-made Garments Project and other related projects.

Electricity Consumption in Manufacturing Industries

There were 4,271 modern manufacturing industries engaging 10 or more persons and 46,418 small industries engaging less than 10 persons in the country in 1991-92 of which 14,121 (27.9 per cent) were in the municipalities and 36,568 (72.1 per cent) in the VDCs. The consumption of electricity by modern and small manufacturing establishments were 199.4 Gwhr (80.4 per cent) and 48.7 Gwhr (19.6 per cent) respectively in 1991-92 as shown in table 3.4.

Table No. 3.4: **Quantity and Value of Electricity Consumed by Manufacturing Industries (1991-92)**

Categories	No of Establishments	%	ELECTRICITY Quantity, KWH	%	Value'000	%
Modern	4,271	8.4	199,429,865	80.4	402,102	78.3
Small	46,418	91.6	48,703,845	19.6	111,576	28.7
TOTAL:	50,689	100.0	248,133,710	100.0	513,678	100.0
All Municipalities	14,121	27.9	-	-	-	-
All VDCs	36,568	72.1	-	-	-	-

Furthermore, Table 3.5 indicates that 75.2 per cent of the total small manufacturing establishments are in the VDCs; whereas the share of these units in municipalities is 24.8 per cent. The Central Development Region (CDR) has the largest number of small manufacturing establishments (46.1 per cent) followed by the Eastern Development Region (EDR) (25.1 per cent), Western Development Region (WDR) (13 per cent), Mid Western Development Region (MWDR) (10.9 per cent) and Far Western Development Region (FWDR) (4.9 per cent). Interestingly, the small manufacturing establishments of the CDR consume nearly two-thirds (64.5 per cent of the electricity) followed by the EDR (13.2 per cent), WDR (11.1 per cent), Mid-WDR (7.6 per cent) and Far-WDR (3.5 percent). All this shows a major discrepancy in the consumption of electricity by the small manufacturing establishments.

Table No. 3.5 **Quantity and Value of Electricity Purchased by Small Manufacturing Establishments - 1991-92**

(engaging less than 10 persons)

Categories	No of Establishments	%	ELECTRICITY			%
			Quantity, KWH	%	Value'000	
Modern	4,271	8.4	199,429,865	80.4	402,102	78.3
Eastern	11,635	25.1	6,445,642	13.2	14,452	13.0
Central	21,414	46.1	31,408,565	64.5	68,578	61.5
Western	6,047	13.0	5,415,734	11.1	13,772	12.3
Mid-Western	5,057	10.9	3,718,544	7.6	10,866	9.7
Far-Western	2,265	4.9	1,715,360	3.5	3,908	3.5
Nepal	46,418	100.0	48,703,845	100.0	111,576	100.0
All Municipalities	11,488	24.8	-	-	-	-
All VDCs	34,930	75.2	-	-	-	-

Source: Survey of Small Manufacturing Establishments, Nepal, 1992.

Industrial Consumers

The electricity consumption by industrial consumers of NEA was 246.374 Gwhr in F.Y. 1991-92 which accounted for 32.8 per cent of the total consumption excluding power loss (table 3.6).

Out of Small Manufacturing Establishments (SME), 34,930 (75.2 per cent) were in the VDCs. CDR accommodated 21.414 (46.1 per cent) of SME whereas FWDR accommodated 2,265 nos (4.9 per cent) only. Similarly, grain mills accounted for 30.8 per cent of SME in 1991-92 followed by carpets and rugs (12.8 per cent). Grain mills accounted for 55 per cent of total electricity units consumption of SME followed by oil mills.

Table No. 3.6 **Use of Electricity 1993-94** (Thousand of KW)

Categories	1991-92	%	1993-94 (Estimated)	%
Household	275,248	-	300,312	-
Industrial	246,374	32.8	270,584	35.4
Commercial	45,200	-	46,105	-
Export	85,411	-	45,000	-
Others	98,739	-	101,544	-
Sub-Total	**750,972**	**100.0**	**763,545**	**100.0**
Power Loss	230,133	-	228,965	-
Total	**981,105**	-	**992,510**	-
Peak Load	**222 MW**			

Source: Economic Survey 1993-94

The industries registered in Cottage and Small Industry Department as of mid-July, 1994 vary from 13 nos in Manang to 846 nos in Sindhupalchowk in High Hill districts and from 63 nos in Achham to 20,550 nos in Kathmandu in Hill districts.

The number of industries established in different VDCs and consuming electricity from the SHDPs are shown in the following table.

The time series data regarding the number of SMEs in operation are not available. The 101 industrial consumers in 20 SHDPs appear to be insignificant as compared to 34,930 SMEs in all VDCs. However, the SHDPs have helped establish industries in remote hills and mountain districts, including Jumla, Doti, Terhathum, Phidim, Ramechhap, Okhaldhunga and Myagdi.

Table No. 3.7 **Industrial Consumers in Different SHDPs in May 1995**

S. No.	Name of SHDP	Capacity (KW)	Industrial Consumers	
			Nos.	Type
1.	Taplejung	125	3	
2.	Phidim	200	9	
3.	Gorkhe, Ilam	64	-	
4.	Terhathum	100	5	Textile, paper
5.	Ramechhap	75	2	Cheese
6.	Okhaldhunga	125	4	Radi pakhi
7.	Dhading	32	4	Soap, candle, agr. lime
8.	Helambu	60	-	
9.	Arughat, Gorkha	150	3	Textile, furniture, Ayurveda
10.	Baglung	200	28	
11.	Tatopani, Myagdi	2000	13	
12.	Chame, Manang	45	-	
13.	Manang	80	-	
14.	Jumla	200	13	
15.	Serpodaha, Rukum	200	1	
16.	Chaurjhari, Rukum	150	-	
17.	Rupal Gad, Dadeldhura	100	1	
18.	Surnaya Gad, Baitadi	200	2	
19.	Bajura	200	-	
20.	Doti	200	13	
	Total:	**101**		

Source: Small Hydropower Department, 1995

The average growth rate of industrial customers in Chitwan district between 1981-1988 was about 33 per cent per annum. Similarly, the annual growth in consumption of electricity for industrial purposes in the district was reported to be over 32 per cent during 1981-1986. The average daily working hours of the industries in Chitwan district was reported to be 8.4, which was at a level of 2.5 hours before the area was electrified.

Similarly, there has been a tendency of general substitution of diesel by electricity. The slackened growth of rural industries in Nepal is due to the inadequate and unstable supply of electricity among others. This may be more true in the hills and mountains where the number of industrial customers are fairly limited. The average growth rate of electricity consumption per industrial customer was estimated at 36 kwh per year.

Potential Industries in Rural Areas

The cottage industries that can be established in rural areas with the availability of electricity have been identified in different studies with consideration of raw materials, market, level of technology, manpower, credit and finance, physical infrastructure and business complexity . The identified potential industries are as follows:

1. Animal husbandry
2. Bakery
3. Battery charger for lighting
4. Bee-keeping
5. Chalk
6. Carpentry
7. Carpets
8. Chiuri ghee processing
9. Cold storage
10. Dairy
11. Dalmot
12. Dhaka caps
13. Educational materials including stationery
14. Fruit processing
15. Furniture
16. Herbs processing
17. Horticulture
18. Hosiery
19. Hotel/Tourist lodges
20. Iron related works
21. Khadi weaving
22. Semi-automatic looms
23. Metal utensils
24. Mini-colour lab

25. Noodles
26. Photocopy
27. Modern poultry farming
28. Nepali paper making
29. Rice, oil and flour mills
30. Sewing and knitting training
31. Soap
32. Typing Industries
33. Water turbines
34. Small woollen quilts, etc.

The small rural industries are established in villages after electrification with the availability of other factors like having good transportation system for materials to be transported or having access to adult education, loans and skills. In the more remote areas, electricity is used mainly for lighting.

Role of Private Sector for the Development of SHP

The private sector is playing an important role in the development of micro/mini hydro projects in various capacities. Private Rural Electrification Project (PREP), a pilot project launched in conjunction with ADB/N and ACAP, has been launched to develop a model of financing and management of micro hydro electricity projects (MHPs) in remote and isolated pockets in the private sector. Under this project, three MHPs - Purang (25 KW), Sikles (100 KW) and Seema (16 KW) have been completed.

Salleri Chialsa Electric Co. (SCECO) has been formed with local people's participation. Andhi Khola Hydro Plant in Syangja (5100 KW) is being run by Butwal Power Co. and it is connected with Grid. On the other hand, Namche Hydro Project in Solukhumbu (600 KW) is being run by OKO Himal, a private company.

Government Policy on Rural Electrification through SHP

HMG/N is providing subsidy to rural electrification schemes of upto 100 KW through ADB/N under Bank's rules and regulations. Work done by recognized companies for electricity generation from water turbines are eligible for the subsidy. Subsidy is only available for the electric portion of the micro-hydro plant. Penstock pipes, civil works and transport costs are not eligible for subsidy. For electrification projects using peltric sets, the subsidy is available for 100 m of polythene penstock pipe in lieu of generator controller. The subsidy is 75 per cent for remote areas like Humla, Jumla, Solukhumbu, etc. and 50 per cent for other districts.

Benefits from SHDP

The main benefits from SHDP are given below:

1) Better communication and interaction among the villagers and development of new relationship among ethnic groups because of common ownership and management of the MHPs.
2) Increase in production and productivity of agricultural as well as industrial products.
3) Diversification of industrial products.
4) Awareness of industrial culture and promotion of small industrial area.
5) Enhancement of skill through upgradation or substitution of traditional technology.
6) Improvement in quality of life (soot-free environment, livelier and cleaner environment, health improvement, education including working conditions).
7) Development of indigenous capability to design, build and operate SHDP projects.
8) Integration of rural and urban market.
9) Replacement of kerosene and reduction of firewood used for lighting.
10) Environment conservation i.e. less cutting of firewood.
11) Increase in literacy rate.
(12) Enhancement of employment

Constraints of SHDP

1) Requirement of high capital investment for small hydropower projects.

2) Insufficient demand of electricity in the productive sectors of the economy in the rural area.

3) Low capacity utilization of micro-hydro plants, higher tariff, and thus insufficient income to the plant for its viability.

4) Repair and maintenance problem.

Recommendations

Socio-economic study be undertaken for all hydro projects in order to coordinate with other sectors responsible for the use of electricity. Monitoring and impact study of SHDPs be undertaken regularly so as to assess the social and economic benefits from electrification such as productivity improvement, employment generation and diversification of products, etc.

Growth of connective load of industrial sector be monitored annually so as to assess the power demand in the industrial sector. Priority should be given to construction of SHDP/MHPs in remote and undeveloped areas for industrial development and for the development of the area. Regular and stable supply of electricity be maintained for the growth of industries in the rural areas. Entrepreneurship Development Programme be launched in order to create business opportunities in the project areas so that there will be sufficient demand for electricity in the industrial sector. HMG/N should develop relevant institution for Prototype Development and Design Training Centre in order to enhance indigenous capability of engineering firms engaged in design manufacturing, installation and commissioning of such hydropower plants. Nepal can benefit by participating at UNIDO sponsored "Asian and Pacific Regional Network for Small Hydropower", which promotes regional and interregional cooperation in R & D, training, information and consultancy services.

APPENDIX I

Existing Small Hydropower Plants

S. No.	Name of the plants	District	Installed Capacity (kw)	Year in Operation	Remarks
1.	Pharping	Kathmandu	500	1911	Not in service
2.	Sundarijal	Kathmandu	640	1935	Grid Connected
3.	Panauti	Kabhreplanchok	2400	1965	Grid Connected
4.	Phewa	Kaski	1088	1967	Grid Connected
5.	Dhankuta	Dhankuta	240	1971	Grid Connected
6.	Surkhet	Surkhet	345	1977	Grid Connected
7.	Gajuri	Dhading	25	1978	Village
8.	Tinao	Rupandehi	1000	1978	Grid Connected
9.	Thansing	Nuwakot	20	1979	Village
10.	Baglung	Baglung	175	1981	DHQ
11.	Doti	Doti	200	1981	DHQ
12.	Phidim	Panchthar	240	1981	DHQ
13.	Dhading	Dhading	32	1982	DHQ
14.	Gorkha	Ilam	64	1982	Village
15.	Jumla	Jumla	200	1982	DHQ
16.	Jomsom(L)	Mustang	240	1982	DHQ
17.	Syangja	Syangja	80	1984	DHQ
18.	Seti	Kaski	1500	1985	Grid Connected
19.	Helambhu	Sindhupalchok	50	1985	Village
20.	Salleri-Chialsa	Solukumbu	400	1986	DHQ
21.	Darchula (L)	Darchula	300	1992	DHQ
22.	Manang	Manang	80	1988	Village
23.	Chame	Manang	45	1987	DHQ
24.	Taplejung	Taplejung	125	1988	DHQ
25.	Ramechhap	Ramechhap	75	1989	DHQ
26.	Okhaldhunga	Okhaldhunga	125	1990	DHQ
27.	Bhojpur (L)	Bhojpur	250	1989	DHQ
28.	Khandbari (L)	Sakhuwasabha	250	1989	DHQ
29.	Bajhang (L)	Bajhang	200	1989	DHQ
30.	Bajura	Bajura	200	1990	DHQ
31.	Chaurjhari	Rukum	150	1989	DHQ
32.	Serpodaha	Rukum	200	1989	DHQ
33.	Tehrathum	Tehrathum	100	1988	DHQ
34.	Surnaya Gad	Baitadi	200	1991	Village
35.	Rupal Gad	Dadeldhura	100	1991	Village
36.	Arughat	Gorkha	150	1991	Village
37.	Tatopani-1	Myagdi	1000	1991	2000 kw,DHQ
38.	Andhi Khola	Syangja	5100	1991	Grid Connected
39.	Namche	Solukhumbu	600	1993	Village
	TOTAL:		18689		

Source: Nepal Electricity Authority

APPENDIX II

NGOs, Private Companies and Others Associated with Small Hydropower Development in Nepal

1. Annapurna Conservation Area Project (ACAP)

The ACAP which operates under the guidance of the King Mahendra Trust for Nature Conservation (KMTNC) is established in Ghandruk village.

2. Association of Micro Hydro Manufacturers (AMHM)

The AMHM was set up during 1991 to share experience and information amongst the manufacturing companies. All the turbine manufacturing companies of Nepal are associated with this organization. the association has set common standards for the industry in agreeing to follow the mechanical and electrical guidelines developed jointly by ADB/N and Intermediate Technology Group (ITDG).

3. United Mission to Nepal (UMN)

The UMN has been actively involved in Nepal since March 1954. It has established a number of projects to support and implement the mini and micro-hydro programme in Nepal through the establishment of Butwal Training Institute (BTI) in 1963, Development and Consulting Services (DCS) in 1972, Butwal Engineering Works (BEW) in 1977 and Nepal Hydro Electric Company (NHE) in 1986. It has also established Butwal Power Company (BPC) in 1966 for the construction of Tinau Hydro-electric Plants in the private sector, Himal Hydro General Construction Company in 1978.

4. German Technical Cooperation (GTZ)

The GTZ has collaborated with different local agencies in the field of improved ghatta project. It has collaborated with NEA in preparation of Small Hydro Master Plan Project (SHMPP) recently.

5. **Swiss Association for Technical Assistance (SATA)**

Since 1960, SATA (presently named as Swiss Development Corporation) has supported the development of micro-hydro programme in collaboration with Balaju Yantra Shala (BYS) in Nepal. It has provided technical expertise to improve the different models of cross-flow turbines in Nepal. It has also given support to the field of small hydropower development through the technical and financial assistance programme.

6. **Swiss Federal Institute of Technology (SKAT)**

The SKAT, jointly owned by the Swiss government and Helvetas, is an agency for the promotion of appropriate technology. It has provided technical and financial assistance to different institutions working in the field of mini and micro-hydropower.

7. **United States Agency for International Development (USAID)**

The USAID signed an agreement with ADB/N in 1990 to support the Private Rural Electrification. It is a pilot project to develop different modalities of the micro-hydro project. It provides the grant and training support in the field of micro-hydro installations.

8. **Intermediate Technology Development Group (ITDG)**

The ITDG established in the UK in 1960 has been working to strengthen the micro-hydropower sector in Nepal. It has financially and technically supported the Development Consulting Services (DCS) and rural electrification projects since its inception in 1979.

9. **Association for Context Appropriate Technology (FAKI)**

The FAKI is a German church-based consulting company concentrating in the field of appropriate technology. It has supported through UMN the development of the micro-hydro end-use technology in Nepal.

10. **Balaju Yantra Shala (BYS)**

The BYS was started in 1961 in a small mechanical workshop as a joint venture project of Nepal Industrial Development Corporation

(NIDC) and SATA. It introduced propeller turbine and later specialized in manufacturing cross-flow turbines.

11. **Nepal Yantra Shala (NYS)**

The NYS was founded in 1975 by a Swiss trained technician in Lalitpur. Its products range from improved grinding wheels to the cross-flow turbines.

12. **Kathmandu Metal Industries (KMI)**

KMI is the oldest turbine manufacturing workshop owned by a self-trained technician, who first designed the first MPPU, a turbine that closely resembles the turbo design. It also specializes in the field of manufacturing cross-flow and pelton turbines. It has also developed Peltric set, Pelton wheel coupled with induction generator for rural electrification.

13. **National Structure and Engineering Company (NSE)**

Established in 1966 as a mechanical workshop, the NSE adopted the design of the MPPU developed by KMI and popularised it in the rural areas. It also manufactures the cross-flow and turbo water turbines.

14. **Butwal Engineering Works (BEW)**

It is one of the leading manufacturers of water turbines for the DCS micro-hydro installations. BEW, JOINTLY WITH DCS, has developed an improved cross-flow model, v-belt transmission system, load controller and governor and end use equipment like heat generator and low wattage cooker.

15. **National Power Produced (NPP)**

The NPP specializes in the generation and transmission sector of power.

16. **Thapa Engineering Industries (TEI)**

The company specializes in the field of cross-low turbines.

17. **Agro Engineering Works (AEW)**

It manufactures irrigation canal water wheels (Poncelete type) and cross-flow turbines.

18. **Nepal Machine and Steel Structure (NMSS)**

It manufactures water turbines and related equipment.

19. **Nepal Hydro and Electric Pvt. Ltd. (NHE)**

The NHE, set up jointly by BEW, UMN/DCS and Kvaerner Eureka in 1985, repairs, installs and commissions medium sized hydro power equipment.

20. **Development Consulting Services (DCS)**

It is a non-profitable development institution to carry out the survey, design and installation of the micro-hydro for agro-processing and rural electrification.

21. **Centre for Rural Technology (CRI)**

It promotes and disseminates rural technologies.

22. **United Nations Development Programme (UNDP)**

The UNDP founded WECS to make studies on micro/mini hydro aiming at compilation of an inventory of the prospective MHP sites and scheme preparation works of most attractive sites in six districts and training programmes for prospective MHP entrepreneurs.

Source: Institutional Development Hydropower Sector with particular reference to Mini/Micro Hydro

APPENDIX III

Classification of Areas

Remote Areas

1. Darchula
2. Bajhang
3. Bajura
4. Humla
5. Jumla
6. Mugu
7. Kalikot
8. Dolpa
9. Mustang
10. Manang
11. Solukhumbu
12. Sankhuwasabha
13. Khotang
14. Bhojpur
15. Achham
16. Dailekh
17. Jajarkot
18. Rukum
19. Okhaldhunga
20. Myagdi
21. Terathum
22. Ramechhap

Undeveloped Areas

1. Taplejung
2. Rolpa
3. Baitadi
4. Rasuwa
5. Gulmi
6. Parbat
7. Dadeldhura
8. Pyuthan
9. Doti
10. Salyan
11. Panchthar
12. Baglung
13. Sindhupalchowk

Underdeveloped Areas

1. Kailali
2. Surkhet
3. Arghakhanchi
4. Palpa
5. Syangja
6. Dhading
7. Lamjung
8. Tanahu
9. Gorkha
10. Sindhuli
11. Udayapur
12. Dhankuta
13. Ilam
14. Kanchanpur
15. Bardia
16. Dang
17. Nuwakot
18. Kavrepalanchowk
19. Dolakha

Generally Developed Areas

1. Jhapa
2. Siraha
3. Sarlahi
4. Mahottari
5. Rautahat
6. Saptari
7. Nawalparasi
8. Kapilbastu
9. Kaski

4

SMALL HYDRO POWER DEVELOPMENT AND ENVIRONMENTAL PRESERVATION IN HILLS AND MOUNTAINS IN NEPAL

Introduction

Modernization of agriculture and promotion of cottage and small-scale industry form the essential elements of a strategy for the transformation of the hill and mountain economy of Nepal towards a more sustainable state. The generation of off-farm employment and off-farm income is seen to be more desirable than expanding subsistence farming activities. It is often observed in hills in Nepal, that, many off-farm activities reduce dependence on the forests and diminish the dangers of ecological imbalance resulting from over-exploitation of forests.

The rural energy development in general, and small hydro-power development in particular, therefore should be viewed from the perspective of energy constraints in agriculture, cottage industry, tourism, transportation, and communication. The provision of rural energy in general, and electricity in particular, does provide a new impetus for sustainable rural development through infusion of modern technology, new skills and higher labour productivity.

Environmental preservation can be well served through the development of rural electricity, through small hydro, particularly when alternative forms of gainful employment are made possible through off-farm employment. It is in this sense that rural electricity, from small hydro-power, has an important role to play in the preservation of the environment. It may be noted that, the main contribution of small hydro-power may be through indirect effects.

The preservation of the environment may be helped through the reduction of pressure on agricultural land and on fast dwindling forests, which small hydro-power makes possible through the enhancement of rural transportation, cottage industries, and agricultural diversification. Although, frequently, small hydro-power development has indirect impacts, it does make its impact directly also. For instance, it can certainly help the rural communities to climb out of the subsistence trap, by providing them with alternative sources of income and employment within the immediate future.

The decentralized nature of small hydro-power sources, and the electricity demands emanating from scattered and diffused settlements in the hills and mountains, indicates that both generation and distribution of small hydro electricity be localized in small clusters of households, pointing towards the evolution of a number of decentralized and small-scale utilities in both the private sector and community forms.

These electrified villages/clusters are most likely to be nucleus or growth center for marketing, small-scale industries, tourism, communication, health, education, legal and administrative services. In short, urbanization in the hills and the mountains will be promoted through rural electrification and small hydro-power development. There are further possibilities in this direction of urbanization, with the development of small towns and urban centres in the hills, which will make it possible to provide various services to larger population at lower delivery costs.

The transformation of the subsistence agricultural communities into townships specializing in agro industries based on horticultural/livestock activities and /or tourism and other off-farm activities, seems to be likely, with rural industrialization through rural electrification, provided other infrastructures such as roads/bridges, ropeways and telecommunications are provided. It may be re-emphasized that, such a transformation would entail a more sustainable type of development, in terms of optimal utilization of forest, land and water resources. Small hydro-power development therefore can contribute positively towards the preservation of the environment in the hills.

The major hurdles are however likely to crop up from the institutional side. The promotion of private sector participation in the development of small hydro-power requires the provision of a "safety net" for the private and community investors, primarily because of the long term nature of the project. For example, lack of an effective and operational, legal and legislative framework for the generation, transmission and distribution of hydro-power and establishment of water rights, can drastically reduce the rate of private sector investments in small hydro projects.

The existing Electricity Act allows for the development of up to 1000 KW of small hydro power project without license, although there may be a need to get a license anyway on account of ensuring the use right of the water. It is clear that, in many areas, the water use conflicts are already manifest or are likely to manifest in the near future. Similarly, the existence of the so called "third party access to the grid" , will go a long way towards promotion of hydro-power investment in Nepal, by facilitating access to markets for the many independent power producers envisaged to emerge due to the Electricity Act.

Development Strategy for Hill and Mountain Regions of Nepal

The development strategy for hill and the mountain regions of Nepal is dependent on their natural characteristics. The Nepalese hills and mountains are characterized as inaccessible and ecologically fragile and are known for very harsh living conditions. These characteristics have been elaborated below:

Inaccessibility

The most important physical characteristics of the hill and the mountain regions is inaccessibility, as it results from the rugged terrain and the complex river system. These, in turn, have resulted from the most energetic interactions between the two most powerful forces of nature, tectonics and the monsoon. Inaccessibility, therefore, cannot be given less importance by the policy makers and planners in Nepal.

The priorities given to the development of hill and mountain roads is obvious. The infrastructural development imperatives for attainment of sustainable mountain agriculture has already been indicated elsewhere (B. Bajracharya,1992). The transport infrastructure opens up the area for transfer of modern technology (HYVs), new market openings, new opportunities for capital formations and human resource development. Thus inaccessibility results in lower productivity in agriculture, because of inputs constraints, which when coupled with population pressures leads to unsustainability.

Ecological Fragility and Multiple End Use of Resources

The heavy dependence of subsistence farming on biomass resources has been well documented in Nepal and other hill regions (Sharma and Bhadra, 1986; P.S. Ramakrishnan, 1986; K.K.Pandey, 1986). The food-fodder-manure linkages are indeed very strong in many parts of the hills. The forests, the major source of fuelwood and fodder, are being destroyed for additional land for cultivation and increasing fuelwood needs.

The analysis of biomass-balance in the Arun Basin, has clearly indicated that, depletion of forest resources, through multiple end usages(fuelwood and fodder), is the general rule rather than an exception in the populated middle and lower part of the basin. It has been concluded, that without further interventions, this biomass imbalance can lead to a failure of the hill eco-system, after a long period of unsustainable subsistence farming (Bhadra et al, 1991). As fuelwood collection times are increased due to receding forests, it is very likely that more dung and crop residue is burned as a fuelwood substitute, with drastic effects on soil fertility of the sloped terraces or *bari* land.

For example, when the fodder supply falls due to forest depletion, fewer livestock are sustained, although they are essential for providing draught power and manure for crop production. So less fodder means that the quantity of crops produced is low. This in turn reduces crucial supply of human food and animal fodder. The carrying capacity of the hill farming system therefore appears to fall drastically with decline in the fuel/fodder supply, due to this "feedback effect". By the same token, if fodder supply can be enhanced due to, say, irrigation, then the carrying capacity will also rise dramatically.

There are other "feedback" mechanisms that may be noted. The labour intensity of subsistence economy has been well recognized, in terms of water, fuelwood, and fodder collection, and depletion of resource base or increase in collection times result in severe hardships in conditions of scarcity, especially for the disadvantaged groups, such as women and children (Pachauri, 1986). The deforestation results in drying out of the water sources near the villages, making it difficult to sustain livestock. Out-migratory tendencies have been thus observed within Nepalese hills where forests have dwindled.

Strategy of Sustainable Development in Rural Hills

The conclusion is that, the present hill farming systems are subsistence systems, a majority of which appear not to be on a sustainable path. The prospects for sustainable development in the Nepalese hills therefore appear grim, although, it has been argued that a workable strategy of agricultural diversification and rural industrialization may be evolved, specially in conjunction with transport infrastructure (KMTNC, 1991).

Such a strategy has been advocated based on the experience of spontaneous diversification of agriculture that took place in Ilam area in Tamur basin in eastern Nepal. It has been argued that provision of a link road to the Terai (Charali-Ilam road), allowed the importation of cheap paddy from Terai (Jhapa) area, and permitted the farmers in Ilam to escape from the "subsistence trap", and concentrate on cash crops, such as ginger, seed-potato, cardamon, and tea (grown under an outreach programme initially, but supplying large tea factories in the adjacent Darjeeling district at present). Similarly, dairy and livestock development has been very rapid (due to production exceeding the processing capacity of the Dairy Development Corporation, now there are two or three "milk holidays" every week).

A strategy of agricultural diversification, based on the provision of north-south road, has been advocated as "the growth-axis theory", often attributed to Harka Gurung. The growth axis concept, among many other things, attempts to exploit the regional complementarities that exist between hills and the Terai, due to their agro-climatic and agro-ecological differences. The latter manifests itself in the form of comparative advantages, to the Terai in cereals (irrigated), and to hills in horticulture, spices, dairy and livestock, tourism, etc.

It is clear that tourism development and cottage industry can actually succeed, in the hills, provided, among a host of other "necessary things", the road and energy infrastructures are provided. The strategy, thus consists of an intervention, consisting of "a package of complementary things", rather than a single factor, such as, small hydro-power development.

Prospects for Sustainable Development in Hills and Mountains through Rural Electrification Initiatives

There has been generally, a lack of industrialization associated with the rural electrification in Nepal (Aitken et al., 1990). The same conclusions are also available through the experience in hills of India (Joshi, 1986). The disappointment with the performance of rural electrification in this regard may be well understood, however, there are numerous sets of factors which are noted to be responsible for lack of rural industrialization despite the presence of rural electricity. It is now clear that electricity is a necessary but not a sufficient condition for rural industrialisation.

End-Use Diversification

There are limited end-use opportunities for utilizing the hydro-electricity, apart from its use in lighting. In a recent case study carried out for ICIMOD, in the far-western district of Baitadi, the load factor of Surnaiya Gad small hydro project was only 10% after two years of commissioning (RECOS,1993). There are also other problems associated with the inception, formulation and management of small hydel and turbine mills, which makes these projects fail. Many of these problems, such as lack of proper maintenance of equipment and water canals, can be expected to be resolved gradually with more experienced and technically competent entrepreneurs coming to work in small hydro arena.

The main constraint seems to be the limited purchasing power of the potential consumers, who have yet to take advantage of electricity to enhance their income and employment. The chicken-and-egg stasis is real and the provision of technical information and credit facilities is often quite effective in enhancing diversification of end-use. Interventions are needed to break the chicken-and-egg stasis, as indicated below with a properly designed integration of small hydro with the rural production and distribution system and a complimentary set of investments in rural infrastructure.

Rural Industries and Off-farm Employment Generation

The agricultural diversification and specialization, can lead to demand for irrigation and transportation services. The opportunities for agriculture-based rural industries also expand with agricultural diversification. The provision of motive powers in these services and industries creates demand for hydro power.

However, as has already been pointed out, the expansion of transport, communication and marketing infrastructures (warehouses storage facilities) is a highly complementary intervention on the part of the government.

The viabilities of rural industries and employment generation are not always guaranteed if local consumption and demand alone are considered. It has been pointed out already that the existence of transport and marketing facilities often times plays a critical role in making a success of these enterprises. The case studies of turbine mills and micro hydro installations indicate that, often times, hard nosed economic analysis has been replaced by excessive enthusiasm on the part of both entrepreneurs and credit institutions (RECOS, 1993).

Such unchecked enthusiasm, of course, ultimately leads to unnecessary pessimism about the finance/economics of small hydro technology, and probably does more harm in the longer term. It may be noted that sound project formulation demands creativity on the part of the entrepreneurs and financiers alike in identifying the initiatives needed on both supply and the demand side.

A diverse set of end-uses needs to be designed in such a way that the small hydro scheme becomes viable in economic and financial terms. It should be noted that for a given level of initial outlay/investment in small hydro scheme, the cost-price of a unit of energy, (i.e. Rs./KWH) is inversely proportional to the load-factor or capacity utilization. In the short run with excess capacity therefore, the more energy is used, the cheaper its sales-price is likely to be (primarily because the unutilized capacity has already been paid for). Thus in managing the supply and demand for electricity, a good degree of flexibility remains in promoting the use of electricity in non-lighting applications.

Cottage Industries

The role of rural electrification in enhancing cottage industries can not be over-emphasized. For example, it is clear that hand-looms are no longer competitive with respect to machine-made imported textiles, although mechanized looms probably are still competitive. So in envisaging a textile industry in rural areas, it would be important to take this into consideration, and see if small hydro/ rural electrification can contribute to the rural industrialization process. Similarly, food processing, metal working, dyeing, paper-making, saw milling and wood furniture making, electrical, electronic and a host of other industrial processes are possible candidates to be integrated with small hydro development.

Transportation and Communication

The small hydel development can very well complement the development of electric road transportation, such as trolley buses, or electric rope-way transportation. The later is more attractive for areas where roads are either uneconomical or undesirable (as in trekking and recreational areas). The load factor improvements can reduce the selling price of small hydro electricity. Communication sector also benefits from small hydro.

Irrigation

Use of electrically pumped irrigation during the day, during the night and during the off-peak times are beneficial, especially in the context of cash crop development through provision of irrigation water (e.g. sprinkler for cardamon growing in Ilam). The cost advantages are high, for already electrified areas, specially if one compares an electric pump with the diesel/ kerosene type of installation. In remote areas, in the hills with large porter transportation, small hydros are quite cost-effective compared to diesel/kerosene pump sets in terms of operation and maintenance costs and also in terms of the initial outlays.

Lighting/Space Heating

The lighting demand, in the absence of other industrial and agricultural loads, results in very low load-factor. This means that lighting electricity is rather expensive on its own. The end-use diversification can reduce this imputed cost of lighting electricity. It should be noted that, compact florescent light bulbs are more cost-effective in the longer run, although their initial outlays are comparatively high. In remote and inaccessible areas, the cost of fossil fuels is quite high, due to porterage, and under those circumstances small hydros and even photo voltaic are comparatively cheaper. Space heating may also be feasible if the load-factor is low.

Cooking

The use of electricity for cooking, although very attractive from the fuelwood saving and environmental perspective, becomes a problem if the cooking time coincides with the peak demand during the evening hours. A recent seminar held on rural electric cooking highlighted the technical viabilities of using thermal storage to reduce the wattage requirements per household for cooking (ITDG, 1994). Similar storage technology using hydrogen, based on electrolysis of water, although proposed, has not yet been tried in Nepal (Bockris and Veziroglu, 1991).

The technology consists of the use of aluminium containers, cast iron or stone pebbles in insulated containers, to store and extract heat energy. Electricity at low wattage is used to heat vessels, cast iron or stone pebbles, and is stored as heat. This heat can be used for slow cooking, as in the case of **Bijuli Dekchi**, which operating at about 80 per cent efficiency, has been demonstrated to be feasible in Ghandrung, Salleri and Andhi

Khola areas (ITDG, 1994). This type of slow cookers does not permit the frying of foods, the traditional cooking style, and thus may have limited popularity.

The heat stored in the **Pebble Bed Storage Cooker** is used for cooking with the help of a fan blower, which takes the high temperature heat through the media of air to the cooking vessel for normal or fast cooking, and permits frying of foods. Although more expensive initially, this type of pebble bed cooker may become more popular, due to high cooking temperature and speed.

The social acceptance has been proven for these electric cooking technologies under a subsidy, although, it is clear that if the subsidized cost is higher than that of fuelwood then users will most likely revert back to using traditional fuelwood chulo. However, when the opportunity cost of labour is high, say due to agricultural diversification, electric cooking may be acceptable without subsidy.

Assessment of Direct Environmental Benefits and Costs from Small Hydro-Power Development(SHPD)

The assessment of direct environmental benefit from SHPD, is necessary, because there is a number of "clean energy benefits", that tends to be ignored when normal analysis of benefits are carried out. The major one is the benefits derived from reduction of green house gases and "carbon sequestration", in replacing the fossil fuels with hydro-power. Similar benefits are obtained in reducing the NOX and other pollutants. These clean energy benefits are real at global and local levels, and must enter into the policy analysis exercise. Such assessments will favour SHPD in contrast to fossil fuel-derived electricity.

Divergence in socio-economic and financial costs are also seen in the analysis of costs of hydro electricity. For example, it has been indicated that, although the financial costs of electricity are real, when capacity utilizations are less than 100 per cent, the socio-economic cost of electricity is nearly zero (with the exception of increased operation and maintenance cost). Thus there is a scope for subsidized electricity distribution, when under-utilization of installed capacity occurs.

Legal, Financial and Institutional Framework needed for Private Sector Participation in SHPD

The major hurdles to private sector participation are however likely to crop up from the institutional side. The need for capacity building in the water sector institutions has emerged quite strongly now (Alaerts et al, 1991). The promotion of private sector participation in the development of small hydro-power requires the provision of a "safety net" to take care of the risks and to share them in an equitable manner between the private and the public sector institutions.

The risks emanate from the vagaries of nature, such as floods and landslides, for the private and community investors. The risks are also enhanced primarily because of the long-term nature of the project. For example, lack of an effective and operational, legal and legislative framework for the generation, transmission and distribution of hydro-power and establishment of water rights, can drastically reduce the rate of private sector investments in small hydro projects.

Setting up of funding mechanisms and organizations is also vital for the development of small hydro-power development. Therefore, Small Hydro-Power Development Fund (SHPDF) is necessary and so its establishment has been proposed. The technical and policy back-stopping is also vital, for instance in promoting the end-use diversification, in guiding and facilitating research and development activities, and, in creating the standards and norms for the small hydro equipment manufacturing sector. Therefore a separate promotion center for small hydro development is deemed necessary. This may be an autonomous part of the proposed "Alternative Energy Promotion Center (AEPC)" or an independent institution on its own right (NPC, 1993).

The existing Electricity Act allows for the development of up to 1000 KW of small hydro power project without license, although there may be a need to get a license anyway on account of the need to ensure the use right of the water. It is clear that, in many areas, the water use conflicts are already manifest or are likely to manifest in the near future. It is clear that, within the government, no mechanism or administrative capacity exists, which is capable of dealing with these inter-sectoral water use conflicts.

Creation and Maintenance of Local Electricity Grids/ Third Party Access

The decentralized nature of small hydro-power sources and the electricity demands emanating from scattered and diffused settlements in the hills and mountains have been well recognized. This implies or indicates that both generation and distribution of small hydro electricity be localized in small clusters of households and communities. This, in turn, points towards the evolution of a number of decentralized and small-scale utilities operating in both the private sector and at community levels. The evolution is ultimately expected to result in a set of larger regional network of interconnected local grids. The creation of mechanisms and institutions to manage and operate such regional grids will be the challenge for the future.

Similarly, there will emerge a need for the so-called "third party access to the local and regional grids" which will open up the possibilities of "captive generation" at large. The provision of a third party access to the local and regional grids will go a long way towards promotion of hydro-power investment in Nepal, by facilitating access to "wider local and regional markets" for the many independent power producers envisaged to emerge due to the Electricity Act. There are as yet no regulations pertaining to the purchase or "wheeling" of power from independent small hydro power producers (for example see a regulation from Thailand, EGAT-MEA-PEA, 1992), which are almost the "prerequisites" for private sector participation in local or regional electricity "markets" and grids.

Conclusion

The rural energy development in general, and small hydro-power development in particular, should be viewed as an opportunity to overcome energy constraints in agriculture, cottage industry, tourism, transportation, and communication. The provision of electricity provides a new impetus for sustainable rural development through the infusion of modern technology and new skills. This results in higher labour productivity.

Modernization of agriculture and promotion of cottage and small-scale industry are essential to bring about the transformation of the hill economy of Nepal towards a more sustainable form. The generation of off-farm employment and off-farm income is more desirable than extending subsistence farming activities, which have led to deforestation, soil erosion, and land slides.

Given the intrinsically environment friendly nature of small hydro, the goal of environmental preservation can be readily enhanced through the strengthening of local and central level regulatory institutions, fine tuning of regulatory framework, and setting up of funding mechanisms and organizations. Therefore setting up of a "Small Hydro-Power Development Fund (SHPDF)" has been proposed.

At the present, the focus should be put on the regulatory and institutional dimensions of small hydro-power development. This may provide more benefits and help towards environment preservation in the long run, provided the rural electrification is able to provide the "comparative advantage" to rural hills in Nepal.

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5

SMALL HYDRO-POWER AND TOURISM PROMOTION

Ramesh C. Arya

Introduction

Tourism, the second largest and the only smokeless industry of the modern world, depends entirely on the natural ingredients (aesthetic beauty, mountain terrain, sylvan canopy, bracing climate, varied flora and fauna) as its raw material. The entire mountain chain provides unending tourist resources to the visitors.[1]

Nepal is promoted amidst international tourists mainly for the beauty of the Himalayas. The Himalayas stand for the greenery, the snows, challenging mountain peaks and above all, for the unpolluted environment. Any attempt to spoil them, knowingly or unknowingly, will be suicidal for the promotion of tourism and will result in a big set-back to its national economy.

The mountainous regions have certain common characteristics. They are not easily accessible and are isolated. They are sparsely populated and have very limited economic activities. Promotion of hydropower projects in the Himalayas may be one of the important steps for sustainable

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1. Chakravarti, P.K., "Environmental Degradation and Development Strategies in India" in Tourism in the Himalayan Mountains: Blessing or Blight: Ed. Dr. M.M. Jana, Ashish Publishing House, New Delhi, 1991, p. 182.

development of tourism in the country. It will add quality to the present state of tourism as well as promote economic activities in the backward regions. Sustainable development of hydropower in the regions not only demands dependable source of water resources but also a reliable rate of return on investment. The blending of natural potential for tourism, modern technology promoting environment conservation and financial viability of such an endeavour could bring out the best result.

The Clientele

Tourist arrivals crossed 200,000 figure in 1986 and reached a peak of 334,000 in 1992. It came down to 293,000 in 1993 and slightly improved to 321,000 in 1994. This is far below the 450,000 figure targetted in the Eighth Five-year Plan. The concerned circles are expressing concern at the degrading environment and the resentment at the lack of service quality that is affecting international tourism in the country.

In Nepal, an average tourist stays for 11.94 days (1993). The pleasure tourists stay for 5.9 days, whereas the trekkers and mountaineers stay for 25.8 days.[2] In 1993, out of a total of 193,567 tourists, 58 percent came for pleasure, 23.7 percent for trekking and mountaineering, 6.6 percent for business and the others for pilgrimage, meetings and seminars, etc.[3]

Contribution from Tourism

In 1993, the tourism sector earned about US $ 63 million. It is 2.1 percent in the national GDP. Tourism is the third major source of earning foreign exchange, after the garment and carpet industries.[4] The sector has earned as high as up to 36.8 percent of the total foreign exchange (1982-83). But in terms of net contribution, it is far below other countries in the region. According to Nepal Rastra Bank study, the `leakage' rate is as high as 70

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2. Nepal Rastra Bank : Income and Employment Generation from Tourism in Nepal (1988), p.105.

3 Department of Tourism

4. The Gorkhapatra, May 13, 1995.

percent. The average per capita/day expenditure of the pleasure group varies from Rs.1,034 to Rs. 1,148 whereas the trekkers spend only Rs.536.[5]

As obvious from the earlier paragraph, trekkers are the least spenders. Except for employment as porters and guides, mountain tourism has hardly promoted other business and industrial ventures in the region. Most of the margin of profit is taken away by the business activities in the capital and nearby towns in arranging for tours, travels, supporting services and various amenities. There has not been a detailed study on the margin of profit in the business enterprises in the hilly areas.

Electricity in the hills will not only support small business activities in the region, but will enhance service quality. Only by promoting quality can the margin of profit be enhanced, business activities in the region promoted and leakage in foreign exchange earning reduced.

Consumptive Needs

Sightseeing is the most essential element of tourism. So long as the tourists pay for `seeing', it is the most desirable output from tourism. But if the facilities for providing the `seeing' have some consumptive portions, one should be cautious about it, especially if the consumption includes the ingredients that are essential for preserving the potentials which the tourists love to `see'. The consumptive facilities include items such as food and fossils for energy. The quantity of consumptive materials is directly proportional to the period of their stay. It is therefore better to estimate the tourists in terms of tourist-days (sum of the product of the number of tourists and their duration of stay). Out of the total tourists, 23.7 per cent consisting of trekkers and mountaineers stayed for 58 per cent of the total tourist days. On the other hand, the pleasure tourists, amounting to 58 per cent of total arrivals stayed for only 33 per cent of the total stay.

The road transport system in the country is stretched over 8,909 km while the tracks (*gorayto, ghorayto, chakrayto*, etc.) cover 20,000 km. Still now, 22 district headquarters of the remote areas, including Solukhumbu, Manang, Mustang, Myagdi, Dolpa, Jumla, Humla, Mugu, etc. which attract

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5 Nepal Rastra Bank: Tourist Expenditure Survey, 1988. p115.

mountain tourists, are cut off from road links.[6] Out of 69,699 trekkers (1993), 57 per cent have visited Annapurna, Manang and Jomsom area, 17.9 per cent were in the Khumbu area and 13.2 per cent in Langtang. These areas are not linked with the national power network. Access to electricity could significantly improve their life style as well as the contribution from tourism in the areas.

It is also interesting to study the environmental impact of consumption. Pleasure and business tourists normally stay in towns and other places where infrastructural facilities are better developed. Their number constitutes a very small fragment in the over-all population of the locality. A significant portion of their total spending goes for lodging which includes energy facility for heating/cooling. This is very insignificant for the trekkers at a site. The boarding and lodging facilities utilized by the former is better than that by the latter. They use standard facilities such as hotels for their stay and disposal of garbage. They have access to commercial fuels such as kerosene, Liquified Petroleum Gas (LPG) and electricity for their energy needs.

Tourism is the last nail that has been put into the coffin of the mountain eco-system. This important and growing industry has made deep inroads into the hitherto inaccessible tracks, thus exposing the unpolluted environment and extracting and robbing off the surrounding to the fullest extent possible for meeting their recreational needs.[7]

The mountainous regions have very little options for such fuels. There, about 80 per cent of energy is consumed in boiling water. Here the energy needs are met through the consumptive use of fuel-woods. The local inhabitants and the tourists are the highest `users' of national resources. This is aggravated by the fact that these tourists may tent up at any site and use the local plants for fuel for warming up and for cooking the food. Besides the `lone' trekkers and the locals who are permanent consumers, a number of trekkers are accompanied by carriers and also liaison officers for those visiting restricted areas. The consumption should also take into account this additional number. A survey (1978-1993) on the number of mountaineers and the employment created thereby reveals

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6. Kantipur, Kathmandu, April 22, 1995.

7. Op cit 2, p. 184.

that in mountaineering expeditions, for example, more than ten `additional number' of locals are employed for each mountaineer.

Energy Needs

In course of 10 years (1984-85 to 1993-94), the share of fuel-wood has changed from 73 per cent to 67 per cent and that of electricity in the national energy consumption has only improved from 0.47 per cent to 0.86 per cent and petroleum products from 3.11 per cent to 7.8 per cent. In absolute terms, petroleum consumption has increased from 158,000 to 513,000 TOE (3.25 times) while that LPG from 1107 to 7703 (7 times) between 1984-85 and 1992-93. Obviously, the use of LPG is catching up faster, but its distribution network hardly covers the hilly areas.

In the absence of proper road links, friendly fuels such as kerosene and LPG will be too costly to be adopted by the mountain people. It may therefore be concluded that the fuelwood consumption behaviour in the hills has not changed. It has greatly affected the productivity of the local people. According to a sample survey carried out in 1988, almost 2/3rd of the sample house-hold reported that they spend 6 hours per day on fuel-wood collection and the collection time has increased over the previous five years.[8] The trans-Himalayan region of Mustang is a classic case of acute fuel-supply. Here, six-month young plants that grow during the summer are uprooted and `preserved' for use during the winter days while the region has a number of potential sites for hydro-electricity.

The situation is gradually changing though. The government is prohibiting the use of green trees for fuel and directing the mountaineering expedition teams and trekking organizers to use kerosene and LPG. The guide-line has not yet been very effective though. Due to the complimentary role of a number of NGOs, the local villagers are being more and more conscious about environment preservation and the ill effects of felling trees. And above all, the tourists themselves are promoting eco-tourism. In fact, as one of the trekking guides has mentioned, some of them have protested the use of trees for heating and cooking. They would rather go on fast and shiver than make use of the `local energy'. Better be

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8. S.P. Sharma (Ed.), Energy Pricing Policy in Nepal, Bangkok: UN ESCAP/ILO ARTEP, 1988.

idle than be ill doing. Practitioners of eco-tourism have gone beyond this Scottish prescription of remaining `idle'. They are willing to pay higher price for alternative fuels.

Annapurna Conservation Area Project (ACAP) has promoted environment-friendly life style and energy-efficient heating systems among the residents. It has introduced a `levy' from the visiting tourists. This income is spent for environment development among the locals. But the awakening and the efforts, on the whole may be too slow and too late to really preserve the charms of the Himalayas for long! If only they could have access to alternative sources of energy, which is also sustainable, the calamity could be waived. It is therefore desirable to establish hydro-power plants to fulfill the local energy needs, wherever there is a potential. For this forest-users' community must be properly educated and promoted for self-sustenance.

Energy Supply

God gives the nuts, but he does not crack them. Nepal is one of the richest countries in the world in hydro-power resources. But its exploitation has been very poor. In the field of hydro-power development, Sundarijal with an installed capacity of 640 KW was commissioned in 1935. By 1983, there were 22 hydro-power stations and only five of them had installed capacity exceeding 5 MW. By 1991, 25 such stations were added with only 2 stations with more than 5 MW capacity.[9] Though energy sale in Nepal has increased from 288 GWh in 1984-85 to 588.6 GWh in 1990-91, (1 GWh = 1,000 MWh), yet the people of the mountains have hardly been given access to these facilities in the same proportion. And, due to their poor economic activities, scattered population and distance from the East-West national power grid, they would still remain an outcast, unless the government/ people are serious to develop something of their own for their own subsistence and survival.

Being away from the national grid, the power stations in the region have to be isolated. The state-run enterprise, the NEA, is not keen on developing such isolated pockets. It is presently taking up medium scale

9 Central Bureau of Statistics : Statistical Pocket Book, 1994.

projects and taking over the smaller ones already existing in the project site. The government has promoted the private sector into establishing small hydro-power projects (SHP) with installed capacity of upto 5 MW. A few private sector entrepreneurs have come up even for larger projects. But a good number of them have come forward in the development of `micro hydro-power ' projects. They have endeavoured to set up hydro-power stations of different capacities, mostly of 1 KW, in various parts of the region.

Between the year 1981-82 and 1993-94, the ADB/N has granted loan for 188 projects with a total output of 1,606 KW. In 1993-94 alone, 75 projects were sanctioned for an output of 342 KW. These include 12 in Paanch-thar district, 18 in Baglung, 3 in Solukhumbu and 6 in Dailekh. Based on the latest report, the project cost works out in the range of Rs. 60622/KW, i.e., $ 1212/KW.[10]

Besides generating electricity, hydro-power is extensively used in the hill in driving turbines and using the mechanical energy for various milling operations. More than ten enterprises are capable of manufacturing turbines of upto 100 KW capacity and more than 800 turbines in use are produced in the country. Such installations have definitely changed their life style. Salleri Electricity Utilization Project (SELUP), set up in 1991 at Solukhumbu , with an installed capacity of 2x180 KW is one such case. Its supply area is spread over 60 Kilometer square, around 20 settlements of 6,000 -7,000 inhabitants living at an altitude of 2,000-2,8000 meters. According to a recent study, 60 per cent of the families utilize the energy for cooking stoves only, a partial substitution by using the `bijuli-dekchi'(electric kettle), rice cookers or even heating plates. But there is a trend towards replacing the traditional energy.[11] Significant changes in the economic life-style have been noted in similar tourist destinations such as Ghandruk and Mustang where hydro-electricity has been generated at private initiatives.

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10 Agricultural Development Bank : Field Report as on Aug.9, 1994.

11. Susanne Wymana and Cordula Ott : Impact Monitoring of a Small Hydel Project in the Solu Khumbu District, Nepal in European Bulletin of Himalayan Research, No.7, 1994, Sudasien Institut, Heidelberg. P37-41.

Threats to Nature Tourism

Eco-tourism has now been a by-word among the educated and well-to-do tourists. The eco-tourists are serious on nature preservation. Fortunately, under-development of some of the remote hilly areas has helped keep nature in its natural form in Nepal and has in fact been one of the positive factors in carrying out economic activities through tourism - better known as adventure tourism. Nepal was the first to promote trekking tourism, whereby tourists could pass by the most natural setting on Earth. Eco-tourism is the metamorphosis for the trekking-tourism. The country is now facing competition from other new entrants which were better known in the past for other attractions, but are now promoting their resources under nature tours. Thailand, for one, has changed its slogan.

Continuous invasion by outnumbering population has hit the fragile nature and disturbed its balance. Nepal cannot remain blind to the environmental degradations caused by its image as the `cheapest destination' for nature tourists. Sustaining its image as cheap destination will be self-defeating. At the same time, without improving the product quality, it cannot make a steep upward revision in its tariff within a short time. The State has to invest for preservation and conservation of nature to survive in the world of international competition. Greenery of its hills could only be promoted by providing an alternative source of energy for the trekkers and mountaineers. The local community could also discourage the outpour of cheap tourists. They could, for example, decide the number of lodges (and thereby the beds) that would be developed for a specific period. A committee initiated by ACAP has been successfully setting this issue of facilities extension in the locality.

Energy Economics

Utilization of water resources for hydropower activities has not been awarded top priority. The priority is for irrigation, followed by drinking and hydropower generation. Due to this order, some hydropower projects run `dry' during the monsoon when farmers use water as their first right. Also, due to lack of industrial activities at the day time, there is a wide fluctuation in peak hour demand and little or virtually zero demand during the slack period. This affects the capacity utilization and hence the average unit cost of energy. The 20 KW establishment at Jiri, for example, is simply incapable of meeting the peak hour demand of the locality. According to a recent study of 18 micro and small hydropower establishments (32-1000 KW), they are running at a plant load factor (PLF) of just 18 per cent. The one at Ramechhap (75 KW) has a PLF of just 5 per cent and it has to undergo load shedding even during the monsoon.

A project is launched after deciding its economic/financial viability. The criteria for viability may be different for the state and its individuals. The former looks into long term benefits while the latter primarily for its financial prospect. For sustainable development, it is always desirable to have a holistic approach to development projects. Generation of electricity vis-a-vis a number of activities supporting the utilization of energy for other economic activities could be the most ideal proposition, but not easy to integrate and implement. At the enterprise level, taking up micro and small hydropower projects in hilly areas with sufficient tourist concentration could still be a favourable proposition.

The projects need low investment for run-of-the-river type of generation. Most of the equipment needed for such projects are readily available in the country. They have insignificant environmental impacts. But much of the generation and distribution cost of small hydropower could be recovered through service agencies catering to tourists. The latter would prefer being the clients to the enterprises providing `modern' facilities in place of the traditional fuelwood. The eco-tourists may readily pay a dollar a day more for electricity than `starve' in protest against the felling of trees for fuel needs. This will also help make electricity available at `subsidized' rate for the local inhabitants for lighting and cottage industries.

The state has to look after the welfare of all its people. The economic life of the people, south of the Mahabharat range, is comparatively better. But there is no short term scheme to generate economic activities for its people in the hilly region which seriously lacks basic infrastructure such as road, energy and skilled/educated hands. Due to its limited resources, the state cannot afford massive investment in developing infrastructure and diversifying economic activities in the region.

Investment for Energy

Larger hydel projects take a long time to materialize, mainly due to lack of domestic financial resources, long time required for finalizing loans and grants and the last but not the least, the detailed environment impact study.

Unlike the popular belief, micro/small hydro-power projects are cheaper than larger ones. According to a study, a micro/mini hydro-power project cost US$ 1600/KW, including its installation, generation, transmission and distribution. Even for the most cost- effective larger hydro projects, this amount may be just enough to meet their generation cost.

Electricity is an essential component of a luxury life style which needs sophisticated electric/electronic gadgets requiring `quality' electric supply. But in the present context it is a better substitute for their basic needs: heating and lighting. They can meet the increased cost for quality when they are economically better off to afford the luxury.

The per KW composite figure for generation, transmission, and distribution of electric power in the neighbouring regions is as follows : China $1502, Papua New Guines $1925, India $2016 and Nepal $4346. The only country that matches Nepal in the $4,000 range is Sri Lanka where the disastrous foreign aid-funded Mahaweli Scheme seems to have done its bit.[12]

Micro and small hydro projects do not have so much of implications. If the State cannot go whole-heartedly for diversifying economic activities, it may support activities that promote the existing ones and share the cost of development projects launched by certain entrepreneurs by providing grants, subsidy or soft loans etc.

The growth in the number of micro-projects is partly due to the subsidy policy adopted by the government. Other agencies such as the USAID/Nepal and the SNV/Nepal are the international actors in the programme. Entrepreneurs setting up projects in remote districts such as

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12 Deepak Gyawali commenting on Foreign Aid and Technological Development', a paper presented by Ramesh C. Arya at the National Seminar on Foreign Aid and the Role of NGOs in the Development Process of Nepal,' later published by Nepal Foundation for Advanced Studies(NEFAS), 1992. p. 43.

Humla, Jumla, Solukhumbu, Mugu, Manang, Mustang and Kalikot/Dolpa get a subsidy of as much as 75 per cent, while for the others, it is 50 per cent. The subsidy is available for electrical parts i.e., generator and related accessories and conductors, simulators, transformers and load controllers. It does not cover expenses incurred in the construction of dams, power-house/sheds, poles, transportation and installation and turbines. Under the subsidy programme, a sum of Rs.20 million has been disbursed through the ADB/N by July 1994. Those set up under the ADB/N assistance are initiated by individuals. Some others such as those at Muglin, Kuringhat, Ishaneswar, etc. have been cooperative ventures. Not all the projects have been equally successful and the pay-back scenario is not encouraging.

The Power and the People

Though hydropower will be a welcome development in the hilly areas, nature conservation would be effectively carried out if the population pressure is manageable. This population includes the number of porters as supporting local hands for trekking/mountaineering entourage and the influx activated by new economic activities and ease of life in locality brought about by electricity. The SELUP Experience reveals the same. If substitutiton takes place at the expected rate in future, the process of forest depletion could be slowed down even more but with the limited capacity of the small hydel, it will never be possible for it to fully substitute fire-wood. And it is even quite impossible if balance of deforestation and revegetation can be reached. There is also a danger that the saving made in firewood (*daura*) is being consumed by new houses built in the area. In the last 8 years, the number of new houses increased by 26 per cent using timber for construction and increasing the demand for firewood.[13]

As far as set back in tourism-related employment is concerned, it may be off-set by employment created through other service activities such as operating permanent tent facilities at selected sites and cottage industries to cater to the needs of the tourists. Tent service may stop haphazard exploitation of beautiful sites and the adjoining vegetation. But in so doing, due consideration should be made regarding the essentials that such nature tourists cherish. Relaxing by the camp fire could be one such. Hence

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13 op cit 9.

special attention to supply fuelwood should be made in developing commercial forestry in such sites.

The value of any goods and services depends upon its demand for economic gains. Saving of six hours per day from the daily routine of collecting firewood is useful if the time can be utilized for gainful activities. Similarly, a project for availing electricity at the cheapest rate may be viable if the consumers have the capacity to pay. Electricity could enhance the capability latent in the people and would support local industries. Local level enterprise availing `boiled and filtered bottled-water' under a reliable trade name, for example, may be a wonderful substitute for the `aqua-minerale' carried all the way from Kathmandu. The cottage industries could provide fresh and nutritious food products. And these industries are `energy intensive' industries. The national value addition from such improved services would be much higher than that from the services of porters accompanying the tourists. And all these through exploitation of hydropower potentials of the locality!

The present size of micro hydel projects under the ADB/N is really insignificant. The projects greatly underscores the hydel potentials of the respective sites. It may be mainly due to the financial limitations of the individual entrepreneurs. A collective approach such as an `electricity co-operative' may be more desirable. The `cooperative' practice has however been more successful in a homogeneous society. Recently, the government has launched a massive programme of providing annual grants to every village under `Rural Self Reliance Programme. The capital can be utilized in hydropower development projects for selected villages and contribute to economic development through developing sustainable quality tourism. Depending upon the social/economic composition of such settlements, the modality of organizations may defer.

Sustainable Development

In course of the mountain tourism, the people of the hills are gradually losing their greenery. The mountains generate income but its benefits are reaped off by people somewhere else. In certain cases, exploitation might have been carried out to such an extent (such as degradation of forests) that local efforts may not be enough for self-sustenance. The damage may not only affect the region but also the country or a much wider region and hence might deserve a national or even international will. At some places efforts have been made to redirect a part of the earning for preservation and conservation of the region. But in most of the cases it has begun too late and the effort is too insignificant to really fulfill the desired goal. Local level effort for development and its sustainability may simply be impossible. Environment, after all, has been accepted as a global issue now.

Hydropower development may be a positive step towards revival or conservation, but judging its viability on the basis of the financial rate of return may not be the right approach. State should be considerate enough to provide subsidy and incentives to hydropower development activities in the touristic areas. After all, the subsidy is an act of siphoning back a little of the total earned from the same touristic sites. Subsidy sounds outdated, but not always and not in all cases. It must go to the place which would help it self-sustain in the long run and earn lasting and higher divideds.

6

SUSTAINABILITY OF SMALL HYDEL PROJECTS

S.P. Sinha

Energy from flowing water is perhaps the oldest renewable energy technique in the world dating from the 12th century. However, the transition to electrical energy could take place only in the 19th century. The first ever small hydro-electric power station was installed in 1882 in the USA. In India, it was first set up in Darjeeling (130 KW) in 1897, followed by two 100 KW units in Shimla in 1908. Around the turn of the 20th century, more efficient hydro-power plants in the mini and micro hydropower range developed in the Western countries, including South countries.

As oil and its products became cheaper and more reliable, the trend received a setback. But after the oil crisis of 1973, interest in the mini and micro hydropower (MMHHP) was revived again. China started its installation programme in early 50s and has continued to improve upon it, with the result that it has now about 65,645 MMHP plants, under 500 KW capacity, with a cumulative installed capacity of about 6000 MW and an estimated potential of 70,000 MW. In Bhutan, there are 19 MMHP plants having a total capacity of 340 MW. In India, there are 145 existing MMHP/SHP plants (up to 3 MW capacity), with a total capacity of 106 MW installed by various government agencies; while 159 additional plants, with a cumulative capacity of 198 MW are under construction. Most of these plants are located in the North Eastern States, U.P., ;Bihar, J.K., and are managed by the State Electricity Boards. More recently, some

NGOs have also started installation of these plants in Ladakh and U.P. After the installation, the plants are handed over to the communities for operation and use of electricity. (Table - 1).

Rationale for Mini-Micro Hydel Projects

MMHP Projects are extremely important and useful as they can invariably be located in rural and hilly areas of the country. With standardized adoption of canal or cluster approach to achieve larger volume and turnover and careful planning to achieve short gestation periods, small hydel installations can prove to be competitive with thermal, diesel, gas-based or large hydel projects. Besides, being highly reliable, small projects have the advantages of being environmentally superior, requiring no resettlement or leading to deforestation or submergence and have reduced transmission and distribution losses. Such installations also do not contribute to the infamous greenhouse gases nor do they cause damage to the stratospheric Ozone layer. They are best suited for construction on canal falls, irrigation dams and natural falls in the hilly regions with reduced capital and recurring costs and commissioning en-schedule. Large benefits are claimed for such projects as they promote decentralised utilisation of hydel power, energy production close to consumers, insignificant environmental changes, high operation costs, high durability, high reliability, saving of irrecoverable fossil energy resources, limited initial investments, short gestation period and reduced transmission losses.

The hydro-electric potential in India has been assessed at 84,044 MW at 60 per cent load factor (L.F.). Out of this potential, 11,383 MW (at 60 per cent L.F.) i.e. 14 per cent was developed by June 1991 and further 5,941 MW (60 per cent L.F.) i.e., 7.1 per cent was under various stages of development. The utilization percentage of the hydel power was 27.8 per cent on 31st March, 1992. As such, great potential exists for the development of small hydel power in India, in future.

Constraints

A number of constraints have been identified for the slow progress of small hydel projects. Firstly, the technologies involved in the development of small projects are largely miniaturised versions of large stations. As such, they are more expensive than high hydro on per KW basis. Secondly, the per KW administrative and managerial costs are higher than big hydro-projects; as a minimum component of staff has to be deployed regardless of size. Thirdly, power generation and distribution, though on the concurrent list, is basically a state subject specially for schemes with a capital outlay not exceeding Rs. 25.00 crores, which can be taken up without clearance from the central government. The State Electricity Boards are hesitant to undertake the projects due to their financial constraints. Moreover, hydel does not, as yet, enjoy either 100 per cent depreciation under the Income tax or any exemptions or concessions under the Excise, customs or Sales Tax as compared to Wind Power projects. Fourthly, "Smaller the size, higher the cost" is the real constraint with hydel power projects. Planning of small hydro is one of the most complex activities due to the fact that their financial benefits are reduced by high operation and maintenance cost. Fifthly, the plant load factors of isolated small hydel power stations, particularly in remote locations are extremely low due to the absence of off peak hour loads. They have little or no peaking capacity. These are the constraints on account of which, the ratio of hydro-energy as a ratio of the total energy has declined from a high percentage of around 50 in 1962-63 to about 30 percent at the end of the seventh plan. The desired hydro-thermal mix is presently considered as 40:60. About 78 per cent of the total estimated hydro-power potential of 4044 MW at 60 per cent load factor remains undeveloped.

Sustainability of MMHP

Sustainable development means meeting the basic needs of the present generation without interfering with the legitimate rights and without impairing the abilities of the future generation to meet their own needs which we are morally obliged to maintain. MMHP projects are capable of achieving these objectives as they are renewable sources of energy, pollution free and capable of developing grassroots management strategies. Energy supply of MMHP projects are to be made qualitatively better. Use of electricity for more productive and traditionally important applications, such as, irrigation needs to be promoted. Rural industries, agro-processing units and cottage industries could be developed. Further demand for domestic and commercial cooking needs to be developed. The most important basis of sustainability would be to adopt the Chinese model for India. Most of these projects in China are initiated, constructed and managed in a decentralised manner, based on the policy of `Self-Construction, Self-Management and Self-Consumption'. The plants are managed and operated by local governments, including village, township or country. Funding for the plants is obtained from Central Government, Provincial Governments and many other administrative systems. About 35 per cent of the funds are arranged through bank loans on interest. The owners (individuals as well as communities) also contribute 14 per cent of the costs. In India too, with the emergence of the Panchayats, Nagar Palikas and District Boards, the decentralised model of the development of MMHP could be attempted.

The Ministry of Non-Conventional Energy Source (MNES) has evolved the following subsidy schemes to encourage development of Small hydropower projects up to 3.0 MW station capacity during the 8th Plan period.

1) Survey and Investigation: Up to 100 per cent subsidy limited to Rs. 0.40 lacks for canal drop schemes below 500 KW to Rs. 1.50 lacks for projects in hilly areas.

2) Detailed Project Reports: Up to 50 per cent subsidy ranging between Rs. 0.40 lacks for canal drop schemes to Rs. 1.0 lack for projects in hilly areas.

3) Subsidies on Capital Cost: Subsidy on the cost of E & M equipment and civil works up to 25 per cent for grid connected projects and 50 per cent for non-grid connected projects and those located in the North East and other specified regions. The acceptable per KW installed cost is limited to between Rs. 27,000 for canal drop scheme, above 500 KW to Rs. 50,000 for remote locations.

The government has also offered attractive norms to motivate the private sector in this field. The success, however depends upon the participants and the involvement of beneficiaries of the project.

Table 6.1: **State-wise List of Installed/On-going Small Hydel Projects Upto 3 MW Capacity**

(As on February 1994)

Sl. No.	State	Projects Installed		Project Under Construction	
		No.	Capacity (MW)	No.	Capacity (MW)
1.	Andhra Pradesh	5	5.01	20	29.35
2.	Arunachal Pradesh	34	21.52	2	21.60
3.	Assam	2	2.20	-	-
4.	Bihar	-	-	1	1
5.	Goa	-	-	2	2.90
6.	Gujrat	-	-	1	2.00
7.	Haryana	-	0.20	1	0.10
8.	Himanchal Pradesh	13	9.33	4	8.30
9.	Jammu & Kashmir	8	2.96	13	13.34
10.	Karnatak	5	6.35	24	30.30
11.	Kerala	3	0.52	7	14.50
12.	Madhya Pradesh	2	1.20	7	9.05
13.	Maharastra	3	3.58	4	6.20
14.	Manipur	6	3.90	5	4.70
15.	Meghalaya	2	2.63	-	-
16.	Mizoram	8	3.666	6	10.00
17.	Nagaland	4	2.82	5	5.60
18.	Orissa	3	0.65	8	10.58
19.	Punjab	4	3.90	4	4.20
20.	Rajasthan	3	2.02	4	3.71
21.	Sikkim	11	7.50	2	2.40
22.	Tamil Nadu	3	4.75	10	10.40
23.	Tripura	2	1.01	-	-
24.	Uttar Pradesh	41	23.98	31	25.50
25.	West Bengal	12	8.46	1	1.20
	Total:	175	117.85	172	216.98

Courtesy: Alternate Hydro Centre, Roorkee

Source: Er. Bhagwan Prasad, F.I.E., Small Hydel Electric Development: Indian Scenario and Strategy: Public Energy Requirement for Tomorrow: 10th National Convention of Electrical Engineers held at Patna on September 16-18, 1994.

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APPENDIX I

RAPPORTEUR'S REPORT[1]

Honourable Minister
Mr. Chairman
Distinguished Participants
Ladies and Gentlemen

The Centre for Economic and Technical Studies in co-operation with Friedrich Ebert Stiftung, organised an extensive two-day national seminar on Sustainable Development of Small Hydropower in Nepal.

The objectives set for the seminar were to:

1) Discuss the potentiality and constraints of the commercial use of SHPs in agricultural, cottage industries, tourism and environmental fields;

2) Review the role of the private sector for the development of SHPs;

3) Evaluate the government policy on rural electrification through SHPs; and

4) Suggest measures for sustainable development of SHPs.

The seminar deliberation, with a note of caution, made it very clear that with the ever-increasing demand for power, there is no way to meet the power shortage, either in the urban or remote areas of the country

1. The rapporteur's report was prepared by the noted journalist, Ram Babu Shah.

because no medium or mega size power plant will be commissioned until the end of the current century. Besides, there doesn't seem to be any way the existing power plants can be made to increase their production capacity.

Mr. Chairman, highly qualified experts in the field of power energy, in their meticulously prepared papers based on rich studies noted that the small and micro hydropower plants constitute about 9 per cent of the total hydropower produced in Nepal and therefore its contribution is substantial. However, there was a great deal of debate on the question of whether the per unit cost of production of SHPs is higher or lower as compared to that of the medium and large projects. Whatever the case may be, it was argued that the per unit cost could be brought down through an integrated development package scheme that incorporates industrial and irrigational aspects. Support of local people, private investors and the government would help make SHPs sustainable.

Mr. Chairman, it was also declared that high investment cost and poor performance of the existing small hydropower projects should not be generalised to undermine their utility. The potential of small hydropower, specially in the hill and mountain region is great. There was a repeated stress that the SHPs should not be seen as an alternative to mega hydropower. Rather, it should be seen as complementary to the larger ones. Participants were of the opinion that private investors are ideal for carrying out SHP ventures. But so far successive governments have failed to provide subsidies or incentives to interested private investors. Therefore, their reluctance to undertake SHP projects is evident.

Mr. Chairman, the seminar agreed on the question to promote sustainable development of small hydropower in Nepal. In this regard, some remarks were forwarded by the learned participants in the form of comments, recommendations, preconditions, benefits and challenges.

The noteworthy comments, beside others, were as follows:

- A sound and uninterrupted supply is a vital precondition to invite foreign and local investment in Nepal. Without this, it is futile to expect meaningful investment in the country. Hence, the need to promote hydropower.

Decentralisation is the essence of hydropower development, but there is no sign of decentralisation move from the government on the electrification issue.

It is high time to conduct a micro level evaluation of the present hydropower policy of the country.

Care should be taken keeping in mind that today's technology can become obsolete tomorrow.

Any hydropower projects must be managed by technocrats.

Investment environment is more important than the investment amount.

Enough confidence must be created in the mind of private investors to provide them a feeling of investment security.

Small hydropower should not be seen as an alternative to mega hydropower. They should rather be seen as complementary to mega hydropower.

Small hydropower should not be aimed at only rural electrification but also at the overall development of the area.

Training and operational components must be adequately addressed before undertaking small hydropower projects.

Coordinating body for meaningful dialogue in the sector is necessary.

Many of the existing small hydropower projects are running below capacity or are under-utilised.

It was questioned whether subsidy or incentive would be more effective to promote this sector.

It was reminded that the largest segment of the people are still inclined towards wood cutting which cost them nothing but their leisure time. Therefore, unless they are further educated about the horrendous cost to the society and the environment as a consequence of wood-cutting, they would be reluctant to pay for the energy.

- The generating aspect, the transmission aspect and the consumption aspects of small hydropower should be adequately addressed.

- Sustainability and cost-effectiveness of small hydropower would be meaningless as long as leakages are not controlled.

- A dual tariff system on the basis of relative peak load hours could be evolved.

- Small hydropower projects have their own distinct edges over the mega hydropower projects namely with respect to the environment, the social aspect, cost-effectiveness, imposition from donors, etc.

- The seminar also noted with concern that the existing small hydropower plants are constructed primarily on political considerations rather than the cost-effectiveness factor.

- The private sector must be more encouraged in small hydropower.

- A return of 25 per cent to 30 per cent is needed in the case of private investment for sustainable development of small hydropower.

- Small hydropower projects can be undertaken in some feasible areas. Feedback could also be obtained from the VDCs for potential areas where such ventures could be launched.

- Different banks operating in the country can play a vital role in lending assistance to the private sector for launching SHPs.

- Suggestions also came that the local chamber of commerce should be mobilised to transfer know-how to the common people and identify local raw materials.

- Special exemptions or concessions should be provided in the purchase of machinery needed to set up SHPs.

However, Mr. Chairman, inspite of a consensus on the need of sustainable development of small hydropower in the country, there was an expression of pessimism and frustration from the floor which consisted among others NEA officials and engineers specialized in the hydropower sector.

Some of the strong allegations were:

- Regional planning was and is not sincerely implemented.

- The Energy Commission is busy in undertaking study alone with little achievement in giving any input to the public.

- The Ministry of Industry, the Ministry of Water Resources and the Ministry of Local Development are overlapping their operations so as to become a big hindrance to the development of small hydropower.

- There is no clear-cut provision in the country for the promotion of SHPs. Even the concerned authorities of the government are in confusion as to whether the Industrial Act or the Electricity Act governs the Small Hydropower sector.

- The government has failed to attract the private sector.

- The nation is undergoing a political confusion. In such a situation, the issue of coordination has become secondary.

Mr. Chairman, the seminar made due notice of the fact that about 88 per cent of the population in the country are without power and also of the fact that private investors are reluctant in the present given situation to go for small hydro power venture despite their interest and the enormous potential to generate electricity in the mountain and the hilly region.

Mr. Chairman, since power is the only way to development, there is no time to debate whether to promote mega or small hydropower. The need of the hour is to go for the optimum generation of energy keeping in mind factors like cost benefit, sustainability and the environmental impact of projects. There has been enough politicking in the name of hydropower in the country. It is indeed an irony that despite our being the second richest nation in terms of hydropower, our per capita energy consumption is the lowest in South Asia. With the fast growing demand for energy, there is no other option but to make a great leap forward in the energy sector because after all power is the vehicle of development.

Finally, Mr.Chairman, I would like to wind up my appraisal by saying that time has come to seek the answer to the vital question as to what comes first - whether we are poor because our per capita energy is low or our per capita energy is low because we are poor?

APPENDIX II

COMMENTS ON THE PAPER DEVELOPMENT OF SMALL HYDROPOWER AND ITS IMPACT ON SMALL AND RURAL INDUSTRIES

T.N. Thakur

The papers and the comments presented in this seminar by different learned scholars and the floor discussions were very interesting and informative. In this background, I would like to put forward some of my observations and suggestions.

The Small Hydropower Projects (SHPs) in Nepal may not be sustainable and economical in itself. But it can be easily sustainable or economical if an integrated approach is taken up in which mainly the possible industries, the tourism and the social benefits are considered.

As it came out in this seminar, the cost of SHPs varies from US$ 1,250/KW to US $ 5,000/KW but it is not correct to evaluate the SHPs on the kilowatt basis alone, rather it should be evaluated on the basis of the electrical energy i.e. Kilowatt-Hour which will give an actual picture as rightly pointed by Binayak Bhadra.

We know that for any development work infrastructure plays a vital role. So in the case of the development of SHPs, the approach road plays a vital role. This not only makes the approach to the project easier but also reduces the overall cost of the project along with the maintenance cost during gestation.

After the project is completed, repair and maintenance aspect shall become a very important factor for smooth generation of the project. For this a well planned and optimum inventory level should be designed based on the fast wearing parts, long lasting parts, etc.

The manpower engaged in the operation of the small hydel plants plays the most important role. At present most of the SHPs are run by supervisors, foremen and helpers and they are untrained. This brings a lot of problems. So for this a trained team of staff should be posted for which a training programme for these staff should be conducted by the concerned authorities.

Lastly, a clear and attractive policy should be made by the Government so as to encourage and attract the different possible industries dependent on SHPs. Similar policy along with the strong awareness programme shall have a positive effect on the people around the SHPs. The awareness programme should be organised before the SHP and also after the completion of the project. It must be made a continuous activity of the SHP.

It has been seen that the payback of SHP is around 4 to 6 per cent but if the above suggestions are followed it is sure that the payback of SHP shall shoot up and more and more people will be benefited. For this a case pointed out by Managing Director of NEA clarifies that the few small hydel plants were running at loss when run by NEA but when they are leased the SHPs started running in profit. This clearly specifies that there is some drawback in handling the SHP when run by NEA, which was overcome by the private parties when the SHPs are leased to them. This does not substantiate the views of many of the seminar participants who hold the view that the SHPs are uneconomical.

Let me take this opportunity to comment on the paper presented by Indu Shumsher Thapa on "Development of Small Hydro Electric Power and its impact on Small and Rural Industries". The paper is partially objectively analyzed and many useful suggestions have been put forward. The author has taken a lot of pain in collecting valuable data.

However, there are some flaws in the paper. While dealing with institutional arrangement, the author has wrongly given the name Department of Electricity which does not exist. Similarly, the Small

Hydropower Department is not a separate organisation rather it is a wing of NEA. Also the classification of different sizes of power house made by the author with respect to the installed capacity cannot be taken as a standard classification. It varies from country to country and time to time.

The author has presented may useful data related to the number of industrial units, hydropower stations, generating capacity, etc. The date are informative but the impact of the units on rural development has not been analyzed. Had this analysis been incorporated, the paper might have proved to be a guideline for the planning of SHP. A correlation analysis between SHPs and the cottage and small scale industrial development could have been incorporated and the result would have helped in strategic planning of the same. Secondly, SWOT analysis in relation to the productivity cost and socio-economic benefit would have been more beneficial and objective too.

In the conclusion and recommendation section, the author has highlighted the benefits categorically into social, cultural, economic and ecological aspects of the rural area. In short, the author has projected the socio-economic upliftment aspect. But in my opinion the benefits are even more. If SHP is carried out on the basis of technological, managerial and marketing feasibility, the revenue aspect shall enable the public and the private sector to expand their area of operation thus a contribution towards the overall economic development of the country can be visualized.

Constraints that are highlighted by the author need certain analysis. Insufficient demand of electricity in the productive sector of the economy in the rural areas cannot be justified in the present context as awareness about the utility, benefit of electricity and the cost benefit analysis related with cost of production has been widely observed among the entrepreneurs and the rural business community. Secondly, the constraint cannot be accepted in the line and spirit. A project developed without proper feasibility study may face the said constraint, but it cannot be a limitation for a well feasibility tested project.

In the recommendation part, the author has forwarded very useful suggestions. The author has rightly emphasised on monitoring and impact study of SHPs but he did not become specific about the agency who should be made responsible for it. In my opinion, this study can be classified into technical and economic study. The technical study can be carried out by a technical committee related with the concerned agencies whereas the economic empirical study can be carried out by economist and management expert from HMG/N and the banking sector. Had these details been included, the recommendations would have been more objective and specific to implement.

In this context, I would also like to submit that the hilly areas of Nepal occupying more than 65 per cent of the total land has enormous hydro potentiality as lots of high speed springs and small rivers are abundantly present. Presently, there are 39 small hydro plants under operation and 4 under construction. As such with a strong awareness campaign and with strong coordination linkage, the high potentiality of hilly areas could be utilised and construction of SHP be carried out on the basis of objective feasibility study, thereby the development of small and cottage industries shall be enhanced. As a result, the socio-economic upliftment of the people of the area shall not be a slogan only, but a reality. A significant increase in the contribution of the industrial sector to GDP can be realised. Furthermore, the dream of self-reliance can be achieved in due time. Lastly, the slogan that we have "what petroleum has done to the Arabs, water can do to us" shall become a reality instead of a mere slogan.

APPENDIX III

COMMENTS ON THE PAPER DEVELOPMENT OF SMALL HYDROPOWER AND ITS IMPACT ON SMALL AND RURAL INDUSTRIES

Ram Chandra Chaudhary

The topic is very important in the context of Small Hydel Development in Nepal. The paper starts with energy and electricity consumption in Nepal and the share of electricity is found to be only 0.9 per cent of the total energy consumption. The paper proceeds to describe the hydropower development and the present power installation in Nepal. Hydropower plants are categorised as micro, mini, small, medium and large. Though this classification in size is not valid for making general rules, however it may have limited use for the purpose of this paper. Lists of governmental and non-governmental institutions are provided which are involved in planning, design and construction of hydropower plants and manufacturing of small turbine units. The paper is silent about the activities of these institutions. What impact these institutions have on development of small hydel plants?

The paper further describes industrial development in Nepal and provides production index of manufacturing industries from 1987 to 1994. And electricity consumption by these industries in the same period is also tabulated. Looking at these tables in the year 1993-94 the growth rate of production index is given as 11.1 per cent and in the same period the growth rate of electricity consumption is 1.1 per cent. These figures need explanations to clear up relation between industrial production index and electricity consumption.

Classification of industries like cottage, small, medium and large industries is described and facilities provided by HMG/N to these types of industries are also mentioned. It will be useful if comments on these facilities and concessions are made regarding cottage industries in remote regions.

Names of institutions for industrial development are enlisted. There are many organisations involved in industrial development. The paper does not mention the role of some of these organisations for cottage and small industry development in hills and mountains. Lists of the consumption of electricity made by different types of industries are provided but impact of these consumption are not explained.

Twenty districts where electricity is supplied by small hydel plants have only 101 industrial consumers in comparison to about 35,000 small industrial establishments enlisted in VDCs all over the country. Out of these 20 districts five districts do not have even a single industrial consumer. These data need analysis and the impact of electricity on development of small and cottage industries could be assessed.

The example of Chitwan district is not suitable in this context because this district is supplied electricity from national grid and has better infrastructure than remote regions where small hydel plants are implemented. Hence example from a remote district could be presented.

Towards the end of the paper benefits from small hydel plants are mentioned and recommendations are enlisted. These recommendations need explanation and justification to understand the situation. The paper is supplemented by several annexes and tables. The author has taken a lot of trouble in collecting data regarding industries as well as electricity. The topic of the seminar emphasises on the subject "Impact of Small Hydel Plant on Small and Cottage Industries". Analysis of this subject matter seems lacking in the paper. For example, twenty districts having small hydel plants have a total of only 101 industrial consumers. Out of this twenty plants one has 28 such consumers whereas five plants have not a single industrial consumer. There are other more than 20 small hydel plants elsewhere. There is the recent history of 25 years of small hydel development in the remote region of the country. This needs further study to have an indepth assessment of the impact of small hydel plants on small and rural industries.

Like other forms of energy, electricity also has two sides e.g. demand and supply. In the Nepalese context, problems are being faced on both sides. The lower level of infrastructure development has further aggravated the situation. Electrical energy is costly therefore demand is lower or because the demand is lower electricity is costly? This is really a chicken and egg situation. Therefore it needs very careful and well coordinated efforts involving the supply-demand problem for the future development of the country. Nepal does not have any other source of commercial energy except water power. Agricultural waste is not sufficient for rural needs and the dwindling forest resource is creating environmental problems. Therefore, water power plant remains the only hope for the future energy supply.

The recent phase of development of small hydel plant started with the completion of a small hydel plant in Dhankuta (240 KW) in 1971. This plant was entirely planned, designed and built by Nepalese technicians. Dhankuta did not have any road link at that time and it was later designated as the development centre for Eastern Development Region. Surkhet was the next town in the remote region to get electricity from small hydel plants. Later on a policy to supply electricity to all district headquarters was adopted. Accordingly, the national power grid was extended to the Terai and some hilly districts and small hydel plants were planned for the remaining districts in remote regions. Thus the planning of small hydel plant was based on supply criteria only. Financing came from the government and foreign agencies (through government), therefore less efforts were made to lower the unit cost of electricity production. Though the first few projects were planned and built by national manpower, extensive use of foreign consultants at the later stage, reduced the local participation and pushed the unit cost of power generation much higher. The result is the limited use of electricity for lighting only. This means very low plant factor at power plants increases the supply cost further. Nearly 25 years have passed since the implementation of the first small hydel plant in the remote region, very little is achieved in the field of industrial development in these areas. Hence the impact of small hydel plant on cottage and rural industry development is found to be not very encouraging up till now. One reason for this situation is said to be the higher cost of electricity. Maybe this is true to some extent but there are many other aspects which are to be considered for the development of cottage/rural industry in the hill region.

There are three small hydel plants under construction at present. They are to be completed within two years. With the completion of these projects, all the district headquarters will have electricity supply. This phase of small hydel development will be completed. Valuable experiences to planners, engineers, managers and small contractors and manufacturers are attributed to these developments. It is right time for the representatives of government, communities and private entrepreneurs to discuss together and share the experiences of the past to establish strategies for future development of small hydel plants. The first phase could be to use existing power plants most effectively by proper operation and maintenance and increasing the load factor by various use of electricity including cottage/rural industries. And the second phase could be the development of small hydel plants on a demand basis in contrary to the supply basis in the past. The existing demand may not justify small hydel plants in many places but planned demand can always make such plants feasible. This is possible only when planners, professionals and consumers take a coordinated approach for such development. Thus there is the need for extensive studies to lend on concrete recommendation for sustainable development of small hydel project in Nepal. It is certain that if sustainable development is the target, small hydel development could be the engine for such development.

APPENDIX IV

SMALL HYDROPOWER DEVELOPMENT: COST EFFECTIVENESS AND PRIVATE SECTOR PARTICIPATION

S.N. Jha

At a glance the paper authored by Hari Bansh Jha seems to be quite informative. The paper is divided into six parts - (1) Background (2) Policy (3) State of Hydropower Plants (4) Cost Effectiveness of Small vs Mega projects (5) Private Sector Participation, and (6) Conclusion.

So far as the background of the paper is concerned, it suffers from some statistical error. For instance, Nepal's hydropower potential is estimated at 83,000 MW and the basinwise distribution is as follows:

Saptakoshi Basin	25.5%
Gandaki Basin	44.5%
Karnali Basin	24.5%
Mahakali Basin & Others	5.5%
Total:	100.0

However, the statistical estimate of the exploitable potential, according to the author is 25,000 MW. This seems to be the official estimate and if we take the total potential figures, the existing utilisation figure comes to 0.3 per cent. But according to independent estimates about 27,000 MW has been investigated for development potential. Now the question arises which of the potential development figures should we take to make the installed capacity figure more accurate i.e. 83,000 MW total figure or potentially exploitable figure (25,000 MW or 27,000 MW) which is estimated by UNDP/World Bank? The author is advised to provide different exploitable and utilisation figures in order to avoid further confusion about hydrological data.

Secondly, the author has attempted to establish positive correlation between poverty and per capita energy consumption which of course is the lowest by SAARC standard. It may, therefore, be very conveniently asked whether the observation of Jha i.e. Nepal's poverty is also due to the extremely poor base of energy per capita and whether it is based on any empirical research or not. If not, this observation gives rise to Hen-Egg problem i.e. cause and effect problem.

Apart from the public sector's insufficiency, there may be more reasons like locational, operational, technical, etc. The author is completely silent on this issue.

But more surprisingly, the paper reveals that the government's policy in terms of economic incentives and facilities is restricted to our such small plants having generating and distributing capacity of up to 1000 KW, that too in the rural case. How can we justify the government policy which defies the very definition of small hydropower plant. Private sector's participation, among others, depends on investment climate and sustainability in the government policy. In Nepal, unfortunately we find none of them.

It is well known that the terms mini, medium and mega are relative concepts. However, in Nepal according to the author, a small hydropower plants are those whose generating capacity is up to 5 MW and numbering 39 (though the country has about 6,000 rivers and tributaries) whose installed capacity varies from 25 KW to 75 or 100 KW and all are running in loss. However, he does not give reasons that why they are not running in profit.

According to the author, the small plants are not cost-effective as compared to medium and mega projects. In terms of unit cost, it is 3 or 4 times higher than medium and mega projects and the tariff rate is, therefore, high in the case of small hydropower plants. But the question again arises as to which cost it is - fixed or variable cost - real or opportunity cost. The author has failed to elaborate on the various components of costs like fixed and variable cost, real or opportunity cost.

Besides, we do not find functional harmony and consistency in the different types of hydropower projects and lack of institutional mechanism.

APPENDIX V

COMMENTS ON THE PAPER SMALL HYDROPOWER DEVELOPMENT AND ENVIRONMENTAL PRESERVATION IN THE HILLS AND MOUNTAINS IN NEPAL

Jagdish C. Pokharel

The paper begins with the problem introduction and discusses (a) the strategy for hill and mountain development, (b) prospects for sustainable development in the hills and mountains, and (c) the environmental benefits/costs of providing electricity to the rural areas of Nepal.

It suggests a certain necessary policy frame work - legal, financial and institutional and creation of a system for electricity generation and distribution.

The basic argument is based on the following assumption regarding hill economy:

- subsistence based
- overly dependent on biomass energy
- puts too much pressure on forests for fodder and fuel

It, therefore, assumes that off-farm income and employment only can save the environmental balance. The paper argues that:

- energy can provide necessary impetus for such off farm employment;
- small hydro is feasible and is a desirable source of electricity

As there are no real environmental costs in such projects, it is environmental friendly and desirable.

The paper argues that if there are problems, they are mostly related to the institutional aspect of the things which can be resolved with appropriate regulatory arrangements.

These policies once put together can reduce environmental (forest mainly) pressure and the environment will be preserved and people will also have better living conditions.

The paper strikes a very optimistic chord in that it tries to drive home the fact that if the suggested model is adequately operated, the mountain/hill villages would look like a serene, clean and happy place to live in because:

- cluster of villages will emerge as a center of marketing and social activities;
- horticulture growth will take place;
- small scale industries will crop up;
- tourists will be coming in;
- villagers will have cash in hand;
- administrative centres will be established in these village clusters; and
- the environment will be well protected as pressure on natural forest will decrease.

The path (stratagem) for reaching this almost poetic stage of development is supposed to happen through private sector initiative and in close cooperation with the community.

Gaps and Limitations

Conceptually, this is a rich paper. It introduces certain dynamic and fresh concepts to make things happen such as:

- Spontaneous diversification of agriculture,

- Using comparative advantage of geographic region,
- "Package of complimentary things" as intervention strategy.

These concepts make this paper academically satisfying and policy-wise attractive.

However, the paper could have been further enriched had there been some analysis of the past efforts for lessons and insights. The paper is "historical" and "static" in the sense that it does not draw or discuss any past experiences to answer the basic question - "what made those project initiatives end up as they did" and "what would it take to do it differently" and "what does it take to replicate its satisfactory result, if any".

It is static in that the paper does not give any sense of "state" beyond the model. That is, it ignores the fact that any intervention is likely to change the very "stable state" that we assure in planning and therefore, thinking beyond the stable state is necessary. How is the introduction of hydropower likely to affect the life and nature in the hills?

To some of the hopelessly unsuccessful efforts for such development, probably, the "end-use multiplication" concept is a good answer. Also, the recognition that transportation is the key to complete the picture for development is important. This answers the phenomenon of returning NEA meter back by many villagers, today as they could not pay Rs. 50/m., the new monthly cost for electricity.

Environment

As far as environmental preservation is concerned, the paper's assumption that once income is generated, purchasing power of the villagers goes up through diversification in agriculture and pressure on the natural resources will decline, although correct, it does not consider factors that come into play before we reach that point. For example, it does not consider:

- The commutative effect of SHD development on ecology at the local level what if series of small hydro are constructed in a region or river?

- Implications of increased intensity of non-biomass based production and a shift in agriculture mostly towards monoculture and heavy introduction chemical fertilizer, for natural system.

- Population concentration and increased demand for space.

And all this, obviously, is leading to greater demand for electricity. The S.H. local grids might meet the demand for some time but what other options can we think of without destroying the model? Some discussion beyond the model is needed.

Benefits of following the path suggested in the paper include:

- Clean energy
- Carbon sequestration
- NOX and other pollutants-free air

However, the following should help explore the issues further:

- Water is not available everywhere;
- Water is a scarce commodity and users, quite often, fight for it.

From biodiversity and ecological standpoint impact assessment at the local level must be supplemented with expert opinion. Even small disturbance such as cutting an old tree, breaking a rock, will have serious negative effect on wildlife birds and mammals, albeit in a small scale in the beginning. This fact should be understood at a broader level.

Therefore, some discussion of impact on diversity could be made in the paper. On the whole, the paper, I think, has fulfilled its promise to discuss the issue of "Small Hydropower Development and Environmental preservation in the Hills and Mountains in Nepal" if one subscribes to the proposition that the real threat to environment is "poverty" related to subsistence living and resultant pressure on natural resources.

CETS PUBLICATIONS

- The Terai Community and National Integration in Nepal (1993)
- Nepal Me Terai Samudaya Abam Rastriya Aekta (Hindi: 1994)
- Duty-Free Border Trade and Special Economic Zone between Nepal and India (1995)
- Neal - India Border Relations (1995)
- Sustainable Development of Small Hydropower in Nepal (1995)

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