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DEMOCRATISING MICRO-HYDEL:

Structures, systems and agents in adaptive technology in the hills of Nepal.

Amreeta Regmi

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To my father

Chiranjibi Nath Regmi (1937-1982)

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Abbreviations

AC	area centre
ACAP	Annapurna Conservation Area Project
AD	Anno Domini
ADBN	Agriculture Development Bank of Nepal
ADB	Asian Development Bank
AEPC	Alternative Energy Promotion Centre
AMHP	Association of Micro Hydropower Manufactures
Amp	ampere
ANWA-R	All Nepal Women's Association Revolutionary
ATU	appropriate technology unit
APP	Agriculture Perspective Plan
BC	before Christ
BEW	Butwol Engineering Works
BTI	Butwol Training Institute
BYS	Balaju Yantra Shala
C-2C	capacitor
CBO	community-based organisation
CDO	chief district officer
CDR	Central Development Region
CECI	Canadian Centre for International Studies and Cooperation
CEF	community energy fund
CFL	compact fluorescent lamp
cm	centimetres
CO	community organisation
CPE	Carlsen Power Electronics
CPN	Communist Party of Nepal

CPN-UML	Communist Party of Nepal–United Marxist Leninist
CREDA	Central Region Energy Development Advisor
CRT	Centre for Rural Technology
DANIDA	Danish International Development Agency
DC	District Council
DCS	Development and Consulting Services
DDC	district development committee
DEA	district energy advisor
DEC	district energy committee
DEF	district energy fund
DENET	district energy network
DFID	Department for International Development of the British Government
DKK	Danish Kronner
DOI	Department of Irrigation
DREMC	District Rural Energy Management Committee
DRMHCS	Daunne River Micro Hydropower Cooperative Society Ltd
DRMHEC	Daunne River Micro Hydro Power Executive Committee
DRMHMC	Daunne River Micro Hydropower Management Committee
EC	executive committee
ELCB	earth leakage circuit breaker
ES	Energy Systems
ESAP	Energy Sector Assistance Programme
EUC	energy users committee
FG	functional group
FG	first generation
FMIS	farmer-managed irrigation system
FNCCI	Federation of Nepalese Chamber of Commerce and Industries
FUG	functional users group
GTZ	German Technical Cooperation
ha	hectare
H	head
HDPE	high density polyethylene pipe
HMG-N	His Majesty's Government of Nepal
HP	horsepower
ICIMOD	International Centre for Integrated Mountain

	Development
IGC	induction generator controller
IPP	independent power produces
IREF	interim rural energy fund
ITDG	Intermediate Technology Development Group
ITDG-N	Intermediate Technology Development Group-Nepal
km	kilometre
km^2	square kilometre
KMI	Kathmandu Metal Industries Pvt Ltd
kV	kilovolt
kVa	kilovolt adaptor
kW	Kilowatt
kWh	kilowatt-hour
LEDCO	Lamjung Electricity Development Company
LDO	local development officer
L/sec	litres per second
m	metre
m^3	cubic metres
m^3/sec	cubic metre per second
masl	metres above sea level
MC	management committee
MCCB	moulded case circuit breaker
MGSP	mini-grid support programme
MHES	micro hydro energy system
MHFG	micro hydro functional group
MHPG	micro hydro promotion group
MHSC	micro hydro service centre
MLD	Ministry of Local Development
mm	millimetres
MoFSC	Ministry of Forestry and Soil Conservation
MoST	Ministry of Science and Technology
MoWR	Ministry of Water Resources
MP	member of parliament
MPPU	multi-purpose power unit
MVA	multi volt adaptor
MW	megawatt
MWH	megawatt hour
NC	Nepali Congress
NEA	Nepal Electricity Authority
NGO	non-governmental organisation

NIDC	Nepal Industrial Development Corporation
NMHF	National Micro-Hydro Forum
NMHPDA	Nepal Micro Hydropower Development Association
NPC	Ninth Plan Period
NTU	Nottingham Trent University
NYSE	Nepal Yantra Shala Energy
O&M	operation and maintenance
PDDP	Participatory District Development Programme
PDF	Power Development Fund
PPD	Periodic Plan Document
PPP	pico power pack
PRA	participatory rural appraisal
PTA	participatory technology assessment
PTC	positive temperature coefficient thermistor
PVC	polyvinyl chloride
Q	flow (volume per unit), discharge
RADC	Remote Area Development Committee
RCC	reinforced cement concrete
R&D	research and development
REA	regional energy advisor
RECF	Rural Energy Consultation Forum
REDS	Rural Energy Development Section
REDP	Rural Energy Development Programme
REMREC	Resource Management and Rural Empowerment Centre
RET	renewable energy technology
rpm	revolutions per minute
RECAST	Research Centre for Applied Science and Technology
RKMHC	Roshi Khola Micro Hydro Cooperative
RONAST	Royal Nepal Academy of Science and Technolgy
RRA	Rural Rapid Appraisal
RRMHMC	Roshi River Micro Hydropower Management Committee
RRMHP	Roshi River Micro Hydropower Project
SC	steering committee
SG	second generation
SATA	Swiss Technical Assistance
SKAT	Swiss Federal Institute of Technology
SSA	structures, systems and agents

TEI	Thapa Engineering Industries
UC	Unity Centre
UK	The United Kingdom
UML	United Marxist Leninist
UMN	United Mission to Nepal
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
UPF-N	United People's Front-Nepal
USSR	Union of Soviet Socialist Republic
VDC	village development committee
VEC	village electrification committee
W	watt
WECS	Water & Energy Commission Secretariat
WRA	Water Resource Act

Glossary of Local Terms

Aagri	An artisan or a community that works on stone
Angan	Courtyard usually located in front of a village home
Ama	Mother
Andhyaro	Darkness
Baari	Un-irrigated upland
Bahun	Also Brahmin, the highest caste, of priests, within the Hindu caste hierarchy
Basti	A small cluster of houses or a hamlet
Besi	Foot or base of a hill or lowland
Bijulee	Electricity
Bikas	A Nepali term for development that is used both as a noun and as an adjective
Bivah	Wedding
Bhagbati	Goddess Kali
Bratabandha	A ritual undergone by Hindu boys to mark their coming of age
Chakrabyuha	An array of soldiers or a circular arrangment of army
Chautara	A resting-place in villages usually built around a tree, along a trail
Chaytti	A local term for bamboo like trees, also *shita*
Chowkidar	Guards or watchmen
Crore	The figure ten million particularly used to refer to equivalent amount of money The figure ten million, used especially in reference to money
Danda	Ridge of a hill or a mountain
Danda Pari	The other side of the ridge or hill
Dasain	Also Vijaya Dashami. The biggest festival of

	Nepalese Hindus, and the national festival of Nepal, dedicated to Goddess Durga, the Goddess of Power.
Dekchi	A cooking pot usually made out of aluminium (also *see* karai *below*)
Dhal Paale	A traditional concept of a canal guard usually hired to check stealing of water
Dharni	A measurement of weight equivalent to 2.4 kilograms
Dhiki	A traditional wooden device manually operated with the leg to husk grain, still in use in rural areas in the hills of Nepal
Dhindoe	Popular cornmeal dish in hills and mountains, which is also identified as a poor man's meal
Dipawali	A Hindu festival of lights when gambling is culturally practised
Doko	A locally made basket of cane or bamboo to carry goods on one's back
Durga	A female deity in Hindu mythology, symbolic of power, goddess
Dwaper Era	An epoch in mythology around 6th century BC and the times of the Mahabharat period
Elaka	Area or territory under jurisdiction or control
Gagri	A traditional clay or metal vessel for carrying water
Gaon	A village
Ghatta	A traditional water mill usually located on the banks of rivers and streams
Ghattera	A traditional term used to describe a mill owner
Gorkha	A district in Western Development Region of Nepal
Gorkhali	A resident of Gorkha
Gosti	A small assembly, discourse or symposium
Goth	A shed for keeping cattle
Gurkha	A Nepalese soldier (or of Nepalese origin), Anglicised version for a person from Gorkha
Hariyali	Evergreen, green grass surrounding everywhere
Jaat	Caste; Hinduism has four principal castes, viz Brahmin, Chhetri, Vaishya and Shudra, respectively the priest, the warrior, the agriculturist, trader or cattle farmer, and the so-

	called untouchable caste, into which one is born
Jaisi Brahmins	The offspring of Brahmin men and women who have eloped or of a widowed Brahmin man and a Brahmin woman and, therefore, have lost their original caste position and relegated to a position socially lower than that of Brahmins in the Hindu caste hierarchy
Jal	A Sanskrit and reverential term for water
Jambiya	A dagger of symbolic value carried by men in Yemen
Janajati	Ethnic/indigenous people/nationality; Nepal has more than sixty-five *janajati* or subgroups of people within a certain caste group (see *jaat* above)
Jnato	A traditional term for a grinder for cereal and grains, which is operated manually
Jyapu	A sub-caste of peasants within the Newar ethnic group
Kaaj Kriya	Ceremonies related to death, (see *sraadha* below)
Kami	The caste of blacksmiths, considered untouchable, within the caste hierarchy
Karai	A cast iron cooking pot
Katush	A tree that belongs to the family of chestnut trees
Kaudi	Also *kauda;* a small notch in a *khukuri* (see below)
Kham Magar	Classification of a sub-ethnic group within the caste group of *Matwalis* (see below)
Khar	local weeds used for roofing (see also *shaulo* and *paral*).
Kharif	First season of the agricultural year; starts in July/August when the monsoon rains begin
Khet	Levelled lowland or terraces for cultivation
Khola	Stream
Khukuri	A sharp knife of Nepalese origin carried by Gurkha soldiers and also used by households for myriad purposes
Kiratis	A Mongoloid group of people believed to have arrived in Nepal around 7th century BC. Rai and Limbu belong to the category of *Kiratis*.
Kopis	Greek Sword
Kosa	A measurement of distance where 1 *kosa* is approximately equal to 2 miles
Kosi Pari	The other side of the river Kosi

Kacchi	Temporary construction of mud mortar or earthen lining
Kulo	An irrigation canal or a drain which is dug across fields
Kuru Dynasty	An expansion of the Kingdom of Kuru, which began in the Gangetic plains and spread across Asia
Kuruwa	A measure of weight equivalent to 2 *mana* (see below) or 20 *muthi*; also, a metal vessel that contains up to that measure
Kuruwasi	An inhabitant of the Kuru dynasty
Laal mohar	The royal seal
Lakh	The figure 100,000, used especially in reference to money
Lalpurja	Land title certificate that testifies the legal ownership
Lalteen	A portable transparent case to hold or protect usually a kerosene lamp. Also known as *lalten*.
Lampat	Wood carving
Lekh	The highest slope of a mountain or an area identified with high hills
Lord Shiva	Powerful male deity in Hindu religious texts, male god
Machira	Macedonian sword
Muluki Ain	Civil code
Mana	A measure of volume; eight *mana* makes one *pathi*
Mandal	An association or an assembly of people, derived from the word *mandala,* which signifies a circular object.
Mantra	prescribed mystic or esoteric word, words or pharases
Masu ra bhat	Meat and rice, considered a luxury in poor Nepalese homes
Mathillo kulo	The upper canal
Matwali	A caste group traditionally identified as a liquor-consuming group
Muri	A measure of volume where one *muri* of grain is equivalent to approximately 50 kilogram
Nagar Palika	Municipality
Nepali	Locally, the term refers to both the people of Nepal and the national language of the country

Nigyalo	Miniature bamboo (see *chaytti* above)
Paani	Water
Paani ghatta	Traditional mills, usually located on the banks of a river or stream, that run on water
Paani Kumari	Water Goddess
Paathi	A measure of volume; one *paathi* of grain is equivalent to 2.3 kg
Paisa	A unit of Nepalese currency
Pajero	A make of a Japanese four-wheel drive vehicle, which has come to symbolize the wealthy and elite of Kathmandu in a contemptible way
Pakho/pakha	Slant area of a hill or a mountain where water cannot be retained for agricultural purposes
Paral	Dried paddy straws commonly used as a roofing material
Pari	The other side of the shore or boundary
Phant	Flat land with moderate slope and terraces
Pingi	A Tamang (an ethnic group of Nepal) term for ridge
Pode	A division within the caste hierarchy of the Newar ethnic group that traditionally took on the profession of garbage cleaning and were considered untouchable
Pradhan Pancha	Elected head of a village during the Panchayat political system
Pueblo joven	A term referred to as 'young and growing village' for slum areas in Peru
Pukki	Strong and durable construction using modern construction materials such as brick and cement
Raj Kulo	Royal canal
Rabi	Second season of the agricultural year; starts in October/November, towards the end of the monsoon
Ropani	A measure of land used in the hills of Nepal. One *ropani* is equal to 0.05 ha.
Rupainya	Unit of the Nepalese currency, 100 *paise* makes one *rupainya*
Sahu	Merchant or moneylender
Samiti	A small group of people constituted for any special task. (*see also* gosti *above*)
Samsad	An assembly, council or parliament

Samuha	An informal gathering of people which may not necessarily be constituted, *(see* mandal *above*), which has the same meaning.
Sarsaun	Oil seed similar to mustard
Shakti	One of the manifold words for power
Shangri-La	An imaginary land
Shaulo	Leaves of a particular tree used for roofing, also known as *shaula.*
Sraadha	Annual ritual of paying obeisance to one's dead ancestors (*see* kaaj kriya *above*)
Tallo kulo	The lower canal
Tantric	One who can exercise mystical powers
Tarai	Flat land and plains of southern Nepal
Thanka	An old art of painting that was practised as early as 3rd century BC in Tibet and Nepal Also *Pauba;* a traditional form of colourful painting done on paper or cloth, associated with Buddhist religion
Thar	A sub-caste or title of a clan and or a tribe, usually identified by a surname
Tika	A sacred substance, usually made of vermilion powder and rice, worn by Hindus on the forehead after a religious ceremony
Tihar	Also Dipawali or Deepawali; the festival of light
Tole	A locality or part of a town
Tuki	A small kerosene lamp made of earth, tin, etc that is usually attached with a wick
Ujjwyalo	Clean, bright, clear, well lighted and without darkness
Urja	Energy and power
Vaishya	The caste of agriculturists, traders and merchants and cattle farmers in the Hindu caste hierarchy *(see* jaat *above)*
Vidyut	Electricity
Wari	This side of the shore or boundary

Preface

Unfolding the teleology of the triad of structures, systems and agents in adaptive technology of hydel power in the hills of Nepal has been both an enriching and a humbling experience to me. The triad is not really as grand as I thought it was. The interfaces, however, seem to operate in various parallel minuscule worlds and at various levels, all being interrelated within the larger triangle. During this journey, I have been reminded, on many instances, of paradoxes and dichotomies of parallel models. Indeed, this has been the sum of my experience in the quest for this knowledge while moving between theory and practice, between the computer and the field, between the city and the rural hills of Central Nepal. While, on the one hand, I have been a prisoner of my own accord, enclosed within the four walls of thesis writing – a long, lonesome and painful experience, on the other hand, this has been an enriching journey. I have particularly felt satisfied for having undertaken this research during times of immense political significance in Nepal's history. Knowledge is so vast and, after all, one gets the feeling of having scraped only the surface of what it has to offer.

This book is an attempt at demystifying the concurrent philosophy of 'waterpower', which dominates and prevails the technical and political circles of water resource management in Nepal. In many ways, this is also an attempt at reconciling the ambiguities between policy and practices and at demonstrating how designs of technology impact the lives of rural citizens. My interest in this attempt at bridging these gaps of understanding through practical knowledge largely emerged out of my involvement in the Vision and the Framework for Action for Water, Life and the Environment for the twenty-first century. I wished to return to the reality of field research and find out what was really happening with those we supposedly stand and lobby for. This book attempts to present some ground realities of how 'power' and 'waterpower' are conceived and perceived at the sociotechnical level, and how such designs of power unfold to adapt, transform and evolve at the local level. I do so by examining three micro and one small hydel power sites in Kabhre Palanchowk district through an interdisciplinary viewpoint. I do this by first etching a technography by looking at participatory approaches to system design and implementation. Then I document internal communicative and adaptive dynamics and sharing of knowledge. With this, I conclude by embedding these systems in the various interfaces of structures, systems and agents. My intention behind this thesis is to liberate technology by advocating for a conceptually independent and democratic hydel power in Nepal.

Analogous to the triad described in the conceptual framework, this book is also an outcome of these interfaces. This study became a reality because of the contributions of three primary agents: Margreet Zwarteveen, who led me towards the right structures, Ujjwal Pradhan, who opened up the systems for me, and Linden Vincent, who graciously accompanied me, along this long, intriguing and profound pathways of systems and structures. I am simply indebted to Linden Vincent for her critical supervision of this research. I thank Wageningen University; in particular the Irrigation and Water Engineering Group and the Matching Technology and Institution (MTI) Group, for providing me with the intellectual and administration support and the Ford Foundation for providing me with the financial support required in making this endeavour possible. I am grateful to Peter Mollinga for his continuous support and I would like to formally thank him for warmly welcoming me within the MTI Group.

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Also to be thanked are Mukti Nath Taujale and Dilip Sharma from REMREC and Paras Mahat from Kabhre Palanchowk District Development Committee. Many individuals from Kabhre Palanchowk provided their support during the research period. I am particularly grateful to Posa Prasad Humagain, Gopal Shrestha and Neema Raj Lama for their help in water measurements. I have also enjoyed the helpful companionship of Devi Shrestha and Gyan Bahadur Lama in Kabhre Palanchowk district.

I also take this opportunity to formally acknowledge the stimulating exchanges of ideas with Kavita Rai from University of Bonn. Also to be mentioned is the support of Mahendra Lawoti from University of Pittsburg, whose perspectives, openness and references on the notion of 'democracy' I have found to be

thought provoking. I thank Jeroen Warner from Wageningen for his support and encouragement and the many exchanges of ideas on the concepts of democracy, advocacy, activism, legitimisation, conflict and identity. I also thank Jeroen for translating the English summary into Dutch. I am grateful to Dik Roth for the brief exchanges on the concepts of community and national identity, and I thank him for providing relevant literature. I have also been touched by the interest shown by Bert Bruins, Gerben Gerbrandy and Flip Wester on issues of Nepal, in particular pertaining to my research. I also take this opportunity to formally thank Gerrit van Vuren for his support in facilitating my trips to Wageningen. Likewise, I am grateful to Gerda de Fauw and Maria Pierce for their continued administrative assistance.

Finally, this book would not have been complete but for the support of the extended and dispersed Regmi clan of 21/471, Kalikasthan. Throughout this process and in a significant manner; I have been fortunate to have received the support and encouragement of Tom Alcedo, Jason Rahul and Joel Sagar. I thank these three important men in my life for having held this enterprise together and for accompanying me during my tenuous moments in this quest for knowledge.

Jakarta, December 2003

FIGURE 1.1: Map of Nepal showing research district

1

Introduction

Chadhne ghoda bhanda man-ko ghoda dhulo hunu parcha: the horse of our imagination should be bigger than the horse we ride.

Singha B Lama, Pinthali Village, February 2001

Over the past few decades, Nepal's existing water wealth has been recognized as a powerful resource. With a theoretical hydropower potential estimated at 83,000 MW (Malla 1995; Verghese and Ramaswamy 1994; Verghese et al. 1994) and an established inventory of approximately 30,000 feasible sites (WECS 1994a; WECS 1994b). Nepal's rivers hold promise for energy generation not only for the country but also for the entire South Asia region. However, only 20,750 MW is potentially available for development (Rijal 1999; WECS 1994a). Hydroelectric power, and the hydel[1] technology that can generate it, has emerged as a powerful potential tool visualised in transforming the development process of the nation (Verghese 1999), especially at the macro level. The discourses surrounding hydropower technology choices and water resource management in Nepal are contested (Gyawali 2001; Dixit 2000; Pandey 1996), as they have not really coherently addressed the 'community[2] needs'. The focus rather has remained on 'power from water' rather than 'power for the people'.

Since time immemorial, indigenous practices and local knowledge have been embedded in the rural hills of Nepal, with traditional technology for water control and energy generation, notably as *paani ghatta* (water wheels) and water mills. Now with an experience of over four decades of micro-hydel power development, Nepal has become prominent and well known in this field. It is estimated that there are 56 small hydel plants in Nepal with a total installed capacity of 592 MW (about 482 MW is hooked to the national gridline) and 2046 micro-hydel schemes including peltric and mechanical sets with a total installed power capacity of 13.6 MW (AEPC/ESAP 2002). This technology has, to some extent, replaced traditional methods of agro-processing in many parts of rural Nepal as well as providing domestic energy sources. The promotion of hydel technology is expected to increase in future particularly with the role of the private sector. Yet over 76.9 per cent of micro-hydel in Nepal is categorized as not functioning optimally due to technical, economic, political and social shortcomings (Nepal 1998). Critical problems have been stressed as not entirely technical in nature but rather within institutional shortcomings linked to poor understanding of community contexts (Ghale, Shrestha and de Lucia 1999). This shows the need for better understanding of the implications of this technology for local livelihoods, institutions and the environment, of processes of development around it, and innovations by micro-hydel entrepreneurs. Very little research still exists on the evolution of the micro-hydel sector or impact of this technology in rural areas. As a result the micro-hydel development debate is easily co-opted and controlled by macro power options and interests. Decentralised systems such as micro-hydel even represent a symbol of freedom in rural politics. Conversely, the Maoists have also attacked the bigger and centralised grid electricity systems as a symbol to demonstrate a social and political agenda.

This study sets out to document and critique micro-hydel technology and the hydropower policy in Nepal through the study of the field reality of four hydel systems in Kabhre Palanchowk district, the majority implemented under one programme, the Rural Energy Development Programme (REDP). Three of these systems are in the micro-hydel category for supplying local communities and one is in the medium category that also supplies electricity into the national grid. All of these four studies look at how technology can be designed and evolve to provide wanted outputs and accepted governance. These case study choices also reflect how and why different levels of technological adaptation have come into being beyond a 'hydraulic ensemble', and whether technological democracy is achieved through these adaptations. In generic terms, the focus of the study is on 'community-oriented micro-hydel systems', to study systems generating electricity for a community but also shaped by them. In technical terms, the community model is used to denote rural interventions through non-grid electrification. This adaptability occurs with the democratisation of technology.

The reason for the opening quote is to celebrate the openness of local people in actively seeking technology and agents that help new creation of systems. However, these interventions are often State-directed and are expected to function through a regularised framework mediated by external agents. In fact, both local people and state agents may be struggling to implement policies and materialise visions, but the dynamics of interaction - the adaptation process, local action, and the community's struggle for understanding of technical performance - are very seldom understood. Therefore, the fundamental question I ask in this book is how micro-hydel technology can be designed and democratised to provide services and operating systems wanted by the rural community. Beck (1994; 1999) questions the terms used by neo-institutional proponents such as 'common-property' and 'common-pool' resources (Bromley 1992; Ostrom 1992), in the management of natural resources. He suggests that undertaking a theoretical and practical analysis of user groups ought to encompass a wider understanding of social struggles. Advocating this approach, Beck asks 'to what extent can we expect community management of water (cf. micro-hydro) to flourish in a society where individual property ownership, within a liberal democratic framework common to South Asian countries is the norm?' He suggests that approaches in community management of natural resources ought to look at contestation between the excluded and their excluders, and the potential for conflict resolution through various social relations and with a moral economy mediating confrontations over access and entitlements to basic necessities. This investigation approaches the study of groups using micro-hydel systems with recognition of these contestations. This analysis encompasses the various struggles of class, ethnicity, state agents and user groups around artefact and habitat in the pursuit of micro-hydel development. Similarly, a policy analysis within a sociotechnical frame is anticipated to inform, guide and shape hydro sector development in Nepal. This study contributes to the body of literature on the hydel sector of Nepal and also more generally is of interest to water, technology and irrigation professionals. The primary target audience of this thesis includes policy makers, engineers, external agencies and researchers.

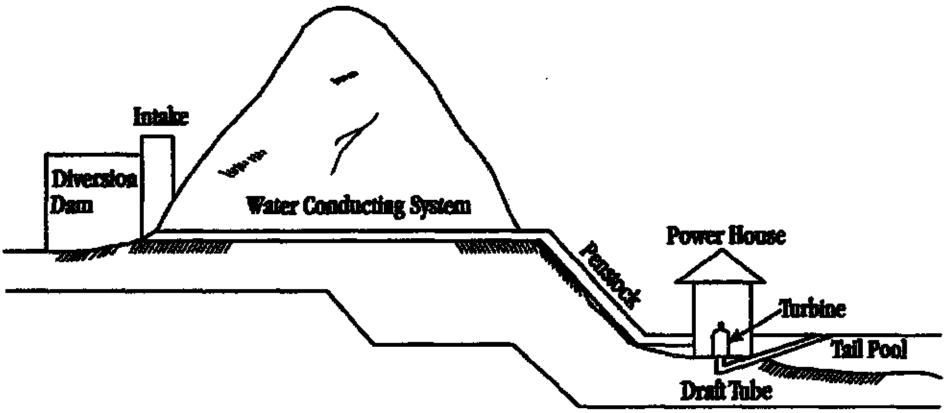
Micro-Hydel Energy Systems (MHESs)

The classification and definition of micro-hydel power energy systems (MHESs) are overlapping and, to some extent, vary among planners, manufacturers and implementers in Nepal. There is no practical definition of sizes and capacities of hydel systems. However, the standardization of categories that are widely referred to in literature from Nepal, comes from the United Nations Industrial Development Organisation (UNIDO) Kathmandu Convention of 1996 classification. This classification defines the systems as effective devices for converting the motion of flowing water into steady mechanical power for generation of electricity. An MHES produces up to 100 kW of energy. Plants generating power from 100 kW to 1000 kW are considered 'mini' systems, while 'small' plants range from 1-5 MW (Pandey 1998).[3] Micro systems can be further classified as 'pico' or 'nano'. Picos are turbines that generate from 3 to 5kW and nanos produce less than 0.5 to 3kW. The nano systems include the improved traditional wheels and Multi-Purpose Power Units (MPPU). The wooden runner in a traditional wheel is replaced by a metallic runner and thus improved to increase its operational efficiency and capacity. MPPUs are mostly used for milling purposes such as hulling, grinding and oil expelling, and electrical lighting for the miller.

Only about 3 per cent of the micro-hydel plants have sizes higher than 20 kW (Rijal 2000). This is because both the policy structure and the manufacturing sector had been promoting smaller peltric sets in the past. Systems below 50 kW are classified into four basic types of unit, which are considered for rural application (Rijal 1998). These are: *(i)* traditional water wheel, *(ii)* multipurpose power units (MPPU), *(iii)* cross-flow turbines and *(iv)* peltric sets, which are also known as `pico systems'. Design of micro-hydel in Nepal is seen for five main purposes: lighting; agro-processing; lighting and agro-processing; lighting and irrigation; and lighting, agro-processing and irrigation. Other combination of purposes includes the promotion of small-scale industrial activities and for tourism purposes. Private ownership of such plants is also on the rise. Individuals as well as groups of households are increasingly using such sets for electrification. Cross-flow turbine units of lower capacity (5-15 kW) are particularly suitable for electrical 'add-on' systems for agro-processing and are also the focus of this study. The medium capacity (25-50 kW) units are suitable for electrical power production. The inherent elements of a hydel system are evaluated in this research to study their design, function and use within the local environment.

A hydel system, in principle has eight inherent elements, which enables to examine the various components that complete this ensemble of hydro system. Figure 1.2 shows a typical hydel system design ensemble, henceforth a 'hydraulic ensemble'.

FIGURE 1.2 Elements of a hydel system



These elements are first connected with the water source with a supply structure such as a dam or a weir, which is designed to store water for creating head and for controlled utilisation of water supply. Other features then include an intake structure, which contains a trash rack and gate to control and regulate the flow to the water conductor system. The water conducting system contains an open channel and/or a tunnel with a forebay tank or a surge shaft and penstock. A turbine, which is a prime mover of hydropower may be either of impulse or reaction type. An impulse type converts energy of water supplied in the form of kinetic energy, such as the Pelton wheel. The reaction type converts energy of water supplied mostly in the form of pressure energy, such as the Francis Wheel turbine. A generator is then utilised to transform mechanical energy of the turbines to electricity energy. A hydel system usually includes a powerhouse where electro-mechanical machines are installed. With reaction-type turbines, a draft tube conveys water from the turbine to the tailrace and recovers a large portion of the kinetic energy of the flowing water. The last component of a hydel system is a tail pool and/or a tailrace tunnel or channel for releasing the water back into a flowing water body.

Other physical components of a hydro system can include a feeder canal, forebay, penstock, desilting and desanding chambers, reserve pond, powerhouse, tail race canal, intake controller, inductor and generator.

At the onset of this research, there was no consolidated and comprehensive inventory on the micro-hydel systems in Nepal. Some studies have shown inventories of sub-categories of MHESs. The number of traditional water wheels (less than 1 kW capacity) throughout rural Nepal is estimated to be over 25,000 (GATE 1988; GTZ and CRT 2000). Such traditional water wheels are used to meet the agro-processing energy needs of the scattered rural communities. About 350 such units have been improved to a power output in the range of 1 to 3 kW. There are 947 units of MHESs (3-30 kW), with an installed capacity of 8.6 MW, out of which 311 units (2.65 MW) are for electricity generation (Rijal 1998). There is estimated to be around 400 units of peltric sets or `pico-systems' (1-5 kW) in the hills of Nepal (Kapali 1997). Since 2001, the Alternative Energy Promotion Centre (AEPC) has compiled and maintained published databases for a micro-hydel inventory in Nepal.

On power

The amount of electricity that can be generated at a hydroelectric plant depends upon two factors: *(1)* the vertical distance through which the water falls, called the 'head', and *(2)* the flow rate measured as volume per unit time. The electricity produced is proportional to the product of the head and the rate of flow. The following is a hydraulic equation that can be used to roughly determine the amount of electricity that can be generated by a potential hydroelectric power site.

$$\text{POWER (kW)} = \text{FLOW (Q)} \times \text{HEAD (H)} \times 10 \text{ (Factor)}$$

The total power absorbed by a hydel scheme is the gross power (P_{gross}), however the power delivered is the net power (P_{net}). The efficiency (E_o) of the plant, therefore is the loss between power absorption and power delivery (Harvey et al. 1993).

$$\text{Power}_{net} \text{ (kW)} = H_{gross} \times Q \times 10 \times E_o$$

H = head (m) Q = discharge (m^3/s) E_o = plant efficiency

Hydroelectric power plants are generally divided into three technical design categories. *(1)* Plants with high head, which generally utilise a dam to store water at an increased elevation. *(2)* A medium head plant *(3)* Low head plants, which may utilise a low dam or weir to channel water or no dam at all with the 'run of the river' type.

Ontologically and epistemologically, the word s*hakti* (power in Nepali), carries a syncretic significance. While shakti in a literal sense translates into physical strength, mental power, calibre, vigour, this word also signifies energy as 'power' from natural resources. Shakti, is also synonymous with *Durga* (goddess), who is symbolized as a fearless and powerful female deity, at times possessing destructive *tantric* (mystic) powers. Power in Nepali, is also commonly used for authority, right, agency, capability, command, domination, pressure, regime and hierarchy. There is also a close association made between power and wealth, *paisa bhaye pacchhi power aaihalchaa* (power comes along with money) where the common understanding that money can buy 'power' strongly prevails. The common phrase *myero power chyaina* (I don't have the power) is also used to denote lack of one's freedom and political power. Power also signifies synergy, momentum, *vidyut* (hydroelectricity) and *urja* (energy). When power is combined with *jal* or *paani* (water) as hydro liquid, energy is generated. Socially, hydropower has a manifold of meanings. Micro-hydel as *bijulee* (electricity) or urja is also perceived as a symbolic metaphor that characterises the progress of a community, as will be seen in the case studies. In contrast, this technology also castigates those who live in *andhyaro* (obscurity) the symbolic darkness representing lack of progress, without access to the resource energy or knowledge. The 'design' of a hydro system is thus also linked to different definitions and senses of power.

Kabhre Palanchowk District and Research Sites

Kabhre Palanchowk district is situated in the Bagmati zone in the Central Development Region (CDR) of Nepal in the Middle Mountain Region of the physiographic division. The maximum rainfall occurs in August, which accounts for 80 per cent of the total annual rainfall. Heavy rainfall takes place in Bagmati and Roshi watershed areas, which form the major catchment within the district. There are a total of 61,556 hectares (ha) of land available for cultivation, of which 13 per cent are irrigable. Agriculture covers 43 per cent of total land area of the district. So far, 62 per cent of irrigable land has irrigation facilities through 353 irrigation systems. Figure 1.3 shows the map of Kabhre Palanchowk district and Research Sites.

FIGURE 1.3 Map of Kabhre Palanchowk district and research sites

There are about 492 small and big rivers and streams in the district. These water sources are used not only for energy generation but also supply drinking water and irrigation schemes. The Sun Kosi, Bagmati, Kokhajor, Roshi and Indrawati rivers are the major water sources. There are 178 traditional water wheels, 246 diesel-operated mills and 279 electric mills in the district. There are 21 micro-hydel plants in the district, of which 12 plants are used for rural electrification (Kabhre DDC/REDS 2000), and the others are used for milling purposes. Kabhre Palanchowk district has one small hydel plant at Panauti. There are no large hydropower plants in the district; however, ten different potential sites have been identified along the Sun Kosi, Roshi and Indrawati rivers (WECS 1988). This district is divided into 87 Village Development Committees (VDCs) with 3 municipalities of Banepa, Dhulikhel and Panauti. Out of 87 VDCs, 35 VDCs and 3 municipalities are connected to the national grid for electricity supply.

This district has been acclaimed also as a progressive one in the last few years in the development of its educational institutions centred primarily within the town areas. However, development has focused around the major urban hubs and small towns of the district and this district still largely consists of zones that remain isolated from the district's development interventions. Thus, the Maoist movement (See Chapter 3) gained success in setting up guerrilla cadres in areas where the community was deprived of development support.

Roshi river regime

The Roshi River is one of the major tributaries of the Sun Kosi River and originates from Phulchoki *danda* (hill) at an altitude of 2286 masl (meters above sea level) in Lalitpur district. Crossing the northern face of the Mahabharat range, the Roshi drains into the Sun Kosi near Nepalthok at an altitude of 609- masl in Sindhuli district, meandering through Kabhre Palanchowk district. The Roshi River drains from west to east with an average gradient of 1:35. The catchment area of 8527 (ha) hectares includes sloping terraces of 3432 ha, level terraces of 168 ha, and valley floor land of about 2035 ha (DOI 1998).

Most of the watershed of the Roshi River lies in Kabhre Palanchowk district, and all four research sites are supplied by this river system. The watershed area of this sub-basin includes 3 municipalities (Dhulikhel, Panauti and Banepa) and about 32 Village Development Committees (VDC). The length of this river is estimated to be about 67 kms. This river relies primarily on the monsoon rainfall and is spring fed during low flow. With its numerous tributaries, this system experiences a large discharge during the monsoon with a large sediment load, but is almost dry in the remainder of the year.

Site selection

Based on a rapid appraisal undertaken in November 2000, Kabhre Palanchowk district was found to provide a range of micro-hydel and hydel systems with different installation dates and development approaches, within diverse hydrological, topographical, institutional and agro-ecological settings. The variations in the turbines also provide an opportunity to examine some of the design features of the technology. With these conditions in mind four specific sites were chosen for investigation: these are *(1)* cross-flow turbine of 12 kW in Pinthali, Mangaltar *(2)* propeller turbine of 8 kW at Katunje Besi *(3)* Pico Power Pack (PPP) of 4.2 kW in Nayagaon, Kusha Devi and *(4)* Panuati Small Hydro Plant of 2.4 MW at Khopasi. Diesel-powered mills and electric-mills as MPPU were also included in this initial appraisal. See Table 1.1 for the summary on each site.

These sites under investigation range from State-run to community-run systems involving a number of institutions and a variety of institutional approaches. The sites have intakes that provide from low head systems to medium head supply conditions in the Roshi River system. These sites furthermore provide an interesting interface with irrigation and energy water uses given the agro-ecological setting of some of these systems. The Panauti Plant is a state-run centralised system. The electricity is generated from three different Francis Wheel turbines and the power feeds into the national grid service. Pinthali, Kusha Devi and Katunje Besi plants are categorised as community run or 'decentralised' systems.

The Roshi River is the source of water for the Panauti system. Water from the Daunne River is diverted to generate electricity for the Pinthali Plant where the design of the system is categorized as having a medium head. The Kusha Devi plant is also another medium head system and uses water from the Gudgude Khola. The Katunje Besi Plant is a low head system, which uses water from the Roshi River. While the planning of the three decentralised systems was carried out by REDP, the implementation of Pinthali and Katunje Besi was overseen under the supervision of REDP. The Intermediate Technology Development Group (ITDG) and Nottingham Trent University (NTU) supported the Kusha Devi plant.

TABLE 1.1 Summary of case study sites

Name	Pinthali Mangaltar	Katunje Besi VDC-1	Kusha Devi Nayagaon	Panauti Khopasi
Planning Platform	REDP	REDP	REDP	Russian
Date	1997	1998	1999	1965
Approach	Holistic	Not first choice	Not first choice	Centralised
Other Agent	REDP (UNDP) KMI	REDP (UNDP) KMI	ITDG/NTU REDP/PDDP	NEA
Design Capacity	12 kW	8 kW	4.2 kW	2.4 MW (3 Units of 850 kW)
Source	Daunne	Roshi	Gudgude	Roshi
Turbine Type	Cross-flow	Propeller	Pico Power Pack	Francis Wheels
Households	118	66 (48 receiving Electricity)	88 (not all receiving Electricity)	Grid Services
Other Interventions	SINKALAMA Forestry	SINKALAMA Drinking Water Forestry	PDDP Drinking Water	NA
Irrigation	Increased Flow	Strong	Weak/No Other Framework	Strong, affected
Additional	Agro-Processing	Ghatta	NA	NA
Electricity Operation	Micro-grid Management Committee Cooperative Manager Operator Chairman	Micro-grid Management Committee Manager Operator Guard Chairman	Micro-grid Management Committee Cooperative Manager Operator Chairman	Centralised NEA
Household Allocation	Max 100-Watts	40-Watts	80-Watts	NA

Theoretical Approach: An Introduction

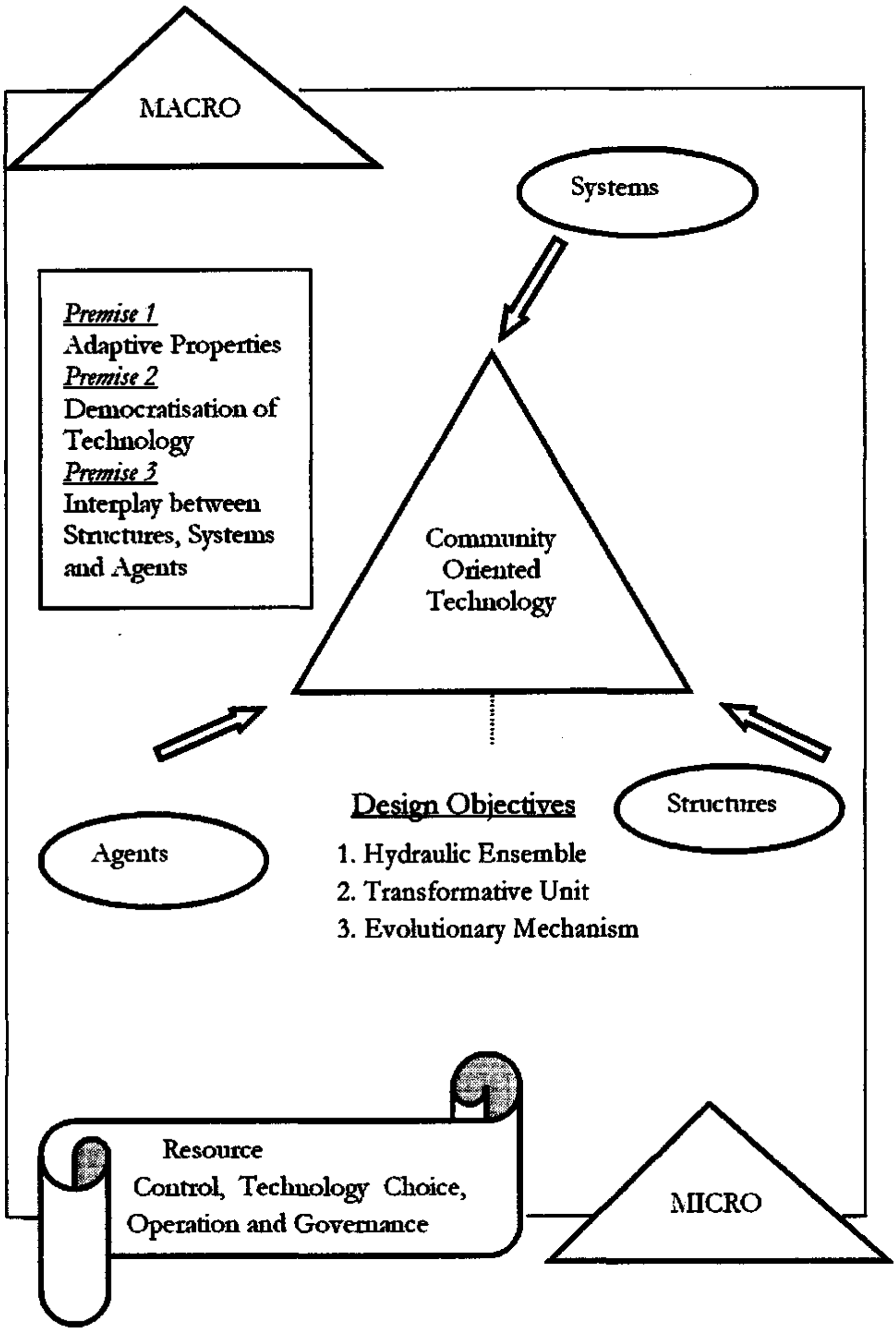
The stark statistics that only 23.1 percent of MHES in Nepal were running well, that the rest do not function optimally and 73.4 per cent are categorised functionally as failures (Nepal 1998), contradict the support in this sector by various institutions.[4] This initial reality was the primary motivation that led to my investigation and in the formulation of my initial inquiry: 'How does a micro-hydel technology become adaptive?' Micro-hydel has been emphatically linked and romanticised as being the panacea for rural electrification, the case-study sites indicate that these small capacity turbines rarely meet the community's energy needs.

After subsequent visits to Katunje Besi, Pinthali and Panauti plants, it also became apparent that where the technology was being applied effectively to meet the needs of both energy and irrigation uses, technology was more 'adaptive' to local sociotechnical conditions. In contrast, the Kusha Devi plant indicated that where technology is not applied to support rural agrarian conditions, politicisation of technology became prominent. This led to the second question as to 'what then is an adaptive system?' With an adaptive system, design, innovation and transformation became core processes for investigation. Subsequently, the intellectual inquiry as to how the system interfaced with existing structures and what really is the role of humans, as agents, became the issue for engagement.

To summarise my conceptual and theoretical framework, I perceive 'community-oriented' technology to be cast inside a triad of three dominant forces, which represents respectively Structures (policy, institutions and governance), Systems (designed physical system in its environment), and Agents (people and knowledge). Figure 1.4 shows the conceptual and theoretical framework of this study.

This research studies community micro-hydel technology as an adaptive sociotechnical system of water control for energy generation. There are threefold dimensions studied to this characteristic of adaptability. First it can be seen as a *hydraulic ensemble* in its early design and choices integrating technology, agro-ecology and society. Second it can adapt as a *transformative unit*, where the technology design enables users to meet and transform both productive and consumptive uses of water (for power and irrigation). Finally it can emerge as an *evolutionary system*, yielding tangible and intangible benefits, with local institutions that can control and manage their own resources, and reflexive coping with change.

FIGURE 1.4: Conceptual framework: reflective design



The basic premises for the development of the conceptual framework for this study are the following:

1) The conceptualisation of technology as possessing adaptive properties i.e. can transform from hydraulic ensemble into evolutionary unit, with capacities to serve agricultural and well as power supply.

2) The democratisation of technology as the focus of interaction within the processes of governance, implementation, performance and resource control.

3) The understanding of domains of actions - structures, systems and agents (SSA) - as distinct yet interactive cognitive forces with reciprocal interfaces influencing each domain.

Implementing evolutionary system

This study takes implementation as an entry point to study public action around MHES. In their timing, all the MHES were all developed in the era of 'participatory approaches', but also when Nepal already had a structure of local agents in place to drive rural transformations. In order to understand the implementation for a planned change, it is better to study how these various agents interact with each other and across communities. This approach also better demonstrates the process and execution of designs as a pilot or recursive approach.

In the broadest sense, to implement is to put into practical effect and complete a given task. It is a means of achieving an end. Implementation is connected to a specific policy or a particular response to a specific problem in a society. Weaver (1996) defines policy as an 'implicit or explicit representation in the form of an act, statement, attitude, regulation, law or rule of an ideology, belief, doctrine, conviction, or philosophy' that serves as an instrument in guiding public agency or private corporation's action. Understanding how a policy gets formulated, the issues that control the process and what it means for the changing nature of governance is important. Then implementation becomes a matter of concern in particular in an era where 'government' gets transformed into 'local governance' pre-empting a wider range of actors to participate in the process of implementation (Hill and Hupe 2002). I take a similar stance in this thesis that the linking of implementation with the governance structure is central to the emergence of democratic technology.

This focus on implementation makes it simpler to review different styles of implementation, between the more formalised requests for MHES steered by agencies now (see Chapter 2) and the differences in supposedly participatory approaches followed by groups supporting REDP in specific villages. It also facilitates study of the strategies followed by villagers to get power supplies for their villages. As Vincent and Khanal (2003) point out, approaches can range from practical requirements for financial and labour input, with no design consultation, to real consultation and involvement in participatory technology design in participation. The gap between rhetoric and practice in participation has been critiqued (Gow and Vasant 1983), but others have more concern that participatory approaches have become a new orthodoxy (Biggs 1995) or even a tyranny (Cooke and Kothari 2001). To move beyond this current impasse of critique, Visser (2003) has proposed that attention to building accepted governance become a new focus beyond planning and intervention techniques. I argue that 'democracy' might be a better objective to pursue in technology development than participation as it is currently practiced in MHES. This speaks out more clearly for people to voice their needs and preferences, and structures enabling them to negotiate within wider societal dynamics.

Premise 1: On Technology and its Adaptive Properties

I study technology as defined by Feibleman (1982) as 'the invention and employment of artefacts', where artefacts are the materials altered through human agency for human use. This definition of technology is synonymous with skill and production of artefacts. However, it is constraining as it fails to capture wider technological and social knowledge forms. Then, MacKenzie and Wajcman's (1985) distinction of three levels of technology, as artefacts, activities and knowledge systems, becomes useful in studying technology. In the hydel context these can be seen first as physical artefacts such as turbine, generators, light bulbs, transmission poles, etc. The second level refers to activities or processes that consolidate the artefacts together. Third, technology refers to knowledge systems in terms of designing the entire power plant, supply system and supporting governance. These concepts also enable the study of who is included and excluded through these levels and through what wider social mechanisms (Beck 1994). The adaptiveness of technology is a reflection of whose choices shape its levels, whether they are imposed and whose interests and cultural norms shape options (Feenberg 1982). Furthermore, it shows whether these choices are decided by performance concerns of technique and efficiency (Ellul cf. Hood, 1982: 191)[5], or the knowledge and coping requirement of the farmer (Richards 1993). The differences in technical and Nepali cultural meanings given to 'power' have already been alluded to.

Appropriate, alternative or adaptive?

Since the 1970s, Nepal has been a conducive playground for the 'Small is Beautiful' paradigm which has predominantly given rise to what is now seen by the State as an utopian solution to fulfil the rural energy needs through 'alternative' micro-hydel systems. This movement also has links to beliefs in renewable energy approaches. Hence micro-hydel technology has fitted with the romanticisation of small, eco-friendly and renewable energy systems to fulfil the energy needs of the rural community. With the emphasis being put on 'pilot, participatory and proactive' ideology, 'appropriate technology' was perceived as being seen as 'what is fit' for the community, rather than 'how it fits' within the community. While these movements have assisted in developing the hydel industry in the country and have been important in the development of micro-hydel, they have also demonstrated some insensitivity to rural energy needs and rural society with inappropriate experimentation and service levels. Within a debate on 'intermediate technology', has also come a struggle of orientation between design and service provision, in whether the focus is on components of design rather than how micro-hydel might work with other energy supply sources in a location. These dominant ideologies took very little notice of the local social and political relations in reciprocally understanding how the 'appropriate' technology has been conceived, and perceived within the local context, and how indeed the rural society has coped with these technological interventions.

I prefer to study micro-hydel as 'adaptive technology' rather than 'appropriate technology' because 'appropriate'[6] is rather a subjective term where we as development experts assume that the technology is the right fit given a certain under-developed or ecological context. Adaptive, on the contrary, illustrates the evolutionary ingredients of technology where the 'power' of technology can be measured by its adaptiveness within social and agrarian systems and also links with creativity of local people. The standard definition of 'appropriate technology' fails to capture the shaping of technology where benefits gained are measured through unit dissemination, rather than through local interaction. Further, the term 'appropriate' questions the legitimisation of 'appropriate': designated by whom, for what purpose and for whom?

In its basic sense 'adaptation' signifies making a technology fit for a specific or new use or situation, often by modifications in response to a changing environment.[7] Adaptability of technology is therefore the process of adapting or the state of adjustment to environmental conditions where a composition is re-written in a new form where its parts make it more suitable for existence. This concept of technology implies a broader meaning of not merely involving methods of tools and machines but also raises the significance of intuition and imagination to fit both technical and social needs. The introduction of a new technology into a given social environment also becomes a powerful culture-transforming process with political, social and economic consequences. Neither the artefact nor the technology is said to be politically neutral (Feenberg 1991), therefore the technique also becomes laden with political intentions. Feenberg highlights the interplay of technology and politics in design systems that "inscribe" decisions that remain biased, where:

> Undemocratic design procedures have substantive consequences through the attempts by powerful players to preserve their technical initiative and control in the systems they create. (Feenberg 1995:6)

Winner (1985) argues that in order to regain democratic control we must look for less oppressive techniques of design.

These definitions and processes of such a technology are therefore closely linked with the concept of design system adopted in this research, where compositions get transformed into creative ensembles that push forward towards evolutionary systems.

On design

Ferguson (1993) illustrates that ignoring intuition and non-verbal thinking in design systems, produces engineers who are dangerously ignorant of the many ways in which the real world differs from the mathematical models represented in computers or conceptualised through theodolite surveys. His conceptualisation of design beckons the notion of 'creativity and imagination' as an integral component of the design process. But design in a development context is much more than just an 'idea' and the 'representation of this creativity', as it also involves planning with an objective for a specific purpose and use. Design then becomes a concept, a process and an activity, generating outcomes whose functions can be assessed. Van Halsema (2002) has argued for irrigation, that a 'design concept' must include realistic management, to operate and maintain technology that local operators and users understand and support.

In the context of irrigation studies, design processes are differentiated in relation to changing objectives and ideologies of rural development (Vincent 1994). Different development ideologies are said to influence the objective of transformation, the type of agency involved in design and the design processes they choose to use. This is not entirely different from the development of micro-hydel technology in Nepal. The design has taken place in a wide range of circumstances and historical epochs. These designs have emerged under influences of donors, macro policies, private sector and manufacturer involvement and their Research and Development (R&D) initiatives, economic analysis, micro-economic factors, and public debates on technology. Certain manufacturers seem to lead on certain models. Manufacturers are also installers in a given project. Then design is also linked with the behaviour of organisations involved with producing, disseminating and adapting technology, and not just those using technology. Therefore, in Nepal the idea of design and the process of designing involve complex social systems with intended consequences and concealed and unobserved outcomes.

Papanek (1997) presents the concept of the 'function complex' of a design to allow reflection on both the design processes and its performance in relation to users and society. This concept conveys practical, imaginative and directive features of designing. These include methods, use, need, telesis, association and aesthetics. The act of designing includes method, which involve tools, processes, working elements, materials, which need to be relevant, optimal and honest and open to local creativity. This also depends on how things are built in consultation with the local community, which have a big effect on demands on local people and skills. The precepts by which the designers decide on the problem - for example the use, efficiency and security of water - and how comprehensively management of systems and artefacts fit with use, then become important.

The design system symbolises needs and desires including identity, spirituality and survival and not just productive technology use. Telesis is the purposeful goal in the use of nature and society, the values being placed behind the pursuit and promotion of a particular design model. The association to design is strongly linked with reactions and even resistance to products and designs and even through its adaptiveness and fit in a community. The aesthetic value is also represented by how the design is harmonious and fits to the users' satisfaction, pleasure and meaningfulness the design symbolises.

Design produces technology with the intention for it to be used, and by its consequence the design can be judged. In this respect the phenomenon of design also becomes important in the way in which design is conceptualised. Design dynamics can be differentiated between prototype and evaluative design (Vincent, 1994). While prototype design is restricted to the technical procedures and routines through construction and manufacturing, subsequent redesign of the prototype is a separate process that leads to an evaluative design, which requires an amendment in execution and production. In this process, as Vincent notes, 'it is difficult but important to rectify design errors after the evaluative design process takes place'. However, evaluative design allows us to judge the design intentions, choices, decisions, use and consequences, subsequently to a higher level of solution.

To design, then, is to formulate a creative entity, which reflects both the conceptual and pragmatic expressions of intended consequences and unobserved outcomes.

Premise 2: Technological Democracy Can Be a Unifying Focus

One orthodox view on technology and democracy holds that authoritarianism in the bureaucracy (cf. work place, Gendron 1982:25) is the price we must pay for technological progress. This undemocratic view is closely associated with another view, of technological determinism where technology does not embody power relations nor do they express political values. Yet others suggest that technology is devoid of any social control. Countering these views, others recognise that technological components have political characteristics, where political values and political power relations are part of technology rather than just an effect. This response opens up choices among technologies, where those technologies either seen as 'democratic' or 'authoritarian' can be selected, and their political components reinforced in a given political structure. The argument of this book is not a demand for 'alternative technology', but a demand to liberate technology from these assumptions of neutrality and autonomy. In the same light, the concerns for Nepal, within the discourse of technological democracy, is how democracy can influence policy and how this influence can then be exerted on technology and its operation. This analysis attempts to explore the linkages between technological democracy, participation, governance and implementation.

Many modern theorists of democracy make a distinction between formal or electoral and substantive democracy. The formal is a precondition for the latter, but formal democracy (representative government) by itself, is inadequate. This statement brings us to the issue on the relationship between bureaucracy and democracy where the nature of representative government is also crucial for setting the modern implementation agenda. Within this strand, three ways of democratising bureaucracy are identified (cf. Hill and Hupe 2002, 28-29).

First, a system is perceived more democratic when the 'representative bureaucracy' resembles those of the nation as a whole in terms of socio-economic and ethnic background. Second, when the public decision-making system and governance[8] become pluralized instead of operating through a centralized political authority. Third, when 'democratic control' links up the representative institutions with a wider administration in accountable ways to participate in policy-making and implementation.

As democracy is linked to the formal government structure and the bureaucracy - in the case of micro-hydel through the State 'institutions' created in the policy process - the implementation process becomes the missing link in the conceptualisation of democracy and the governance structure. In order to be cognisant about the background inequalities and to guarantee individual and collective rights in the process of democratisation of technology, this study focuses on implementation in relation to the governance structure, participation, community, performance knowledge and the wider realm of policy making. It is also worth noting here that at times, an overcomplicated and ambiguous implementation structure deter technological democracy. It is such structures, as well as the choices of technology that Maoists have tried to paralyse in their attack on hydel administration and sites, in their desire to confront the government (see Chapters 2 and 3). This research presents 'writings from below' by looking up from system to understand both what systems seem democratic and which structures and agents are really shaping options and shaping technological democracy, as opposed to just the rhetoric found in the policy circles and coalitions found at different levels. Technological democracy shapes both the domains at the societal and system level.

Summing up this premise, technological democracy is about allowing representative and inclusive debate, decision-making and implementation where the user society can shape the world and things significant to them. It is then, about how members of society shape the world and things significant to them. It is also where the workers and users shape the product through their knowledge, experience and performance, but through selected representatives, and not the sellers or managers. Democracy is thus different from pluralism, which is more typical of the world of MHES implemented in Nepal; and different from the authoritarianism existing in reality in Nepali energy policy exerted by State and funding agencies.

In this thesis 'technological democracy' as a concept is defined to express an opposite to the authoritarianism that is so pervasive in technological systems and their respective institutions. Hence, democratic technology is desirable because it shapes how work, social life and technology are bound with our human nature. Democratic technology is related to human and society as it conjures the image of agents and institutions that run the systems, define access and local services. Democracy is including the recognition of collective action that emerges through groups and their communicative forces within a polity.

Habermas (1990) maintains that it is only through communication under conditions of rational argumentation that societal actors can co-ordinate their actions in terms of mutual understanding. He asserts that modern society replaces the traditional by democratic forms of communicative social interaction (Habermas 1987). Modernity is also linked with the economic and political system. However, this new modernity is founded on the principle of plurality, diversity and tolerance. In Nepal this freedom to express right, choice and to include under modern technology is not being destroyed per se, but still requires an ambience for creation in particular to access and benefits.

Premise 3: The Interplay of Structures, Systems and Agents

Policy as structure and resultant agency

Technology like hydropower is explicitly linked to its ability to extract a natural resource under a certain given set of laws, rules, institutions, social and cultural norms and functionality in design. Waller (1994) argues that both the technical nature of intervention and the heavy reliance on expertise can make for elitist and conservative water management institutions rather than fostering a democratic and progressive enterprise.[9] This implies that policies often elevate expert systems and management regimes on a platform, thus limiting reform in accordance with the changing needs and choices of the wider citizenry. Waller suggests that an alliance of experts and elite within resource management regimes may even hinder achieving needed policy reforms. He perceives every reform and every series of negotiations as a mechanism for gaining more authority in framing policies by the experts. The vested interest of experts makes core issues such as water and hydropower less inconspicuous and divisive. Therefore structure is founded on the idea that rules and practices, which structure social actions can, be both enabling and constraining (Giddens 1984). Human agency itself is reciprocally dependent of rules, which reflect practices.

This study suggests that while elite domination in hydropower intervention is visible and can be a hindering factor in stimulating policy reform, lay-persons are capable of acting for themselves in making water resource management and technology choices more conspicuous and contested. Widening participation in water and power debates and policy issues can lead the public to assert a reform process in setting new policy debates and outcomes. Technology configuration can be designed to reduce these existing biases.

The intent of viewing policy as structure is not to segregate between the macro and micro spheres of the policymaking process. Rather it is to emphasise the inter-related administrative 'recursiveness' that occurs simultaneously in formulation and implementation of the policy process and in shaping policy outcomes. This recursiveness is made possible through the interface of 'human agency'. This aspect is contextualised here as an open exchange of ideas and arguments, alliances, coalitions, public hearings, forums, participatory processes and policy dialogues not only in the policymaking community but also encompassing a larger citizenry, inclusive of technology users. This endeavour directs the democratisation of technology. The emphasis here is to improve the connection between macro and micro networks by strengthening links and focusing on interaction. These links underline the strengthening of institutions, as laws, directives and organizations break through expert systems to include lay-persons through decentralisation processes, forums, alliances and coalitions.

Micro-hydel as a system

A micro-hydel system is actually a complex technology despite its rhetorical linkages to simplicity and renewable energy. First, micro-hydel is an 'adjunct system' frequently superimposed on an existing irrigation technology. It is very rare, in this Nepal context, to find a stand-alone system of micro-hydel operating independently. Second, the production of energy is firmly embedded in the sharing of water resources along with the production of agriculture. Thus the focus on technology and its duality of interaction as an irrigation system and an electrical system bring a stronger focus on the nature of linkages within the technology itself, where the existing technology becomes an important precondition for transformation and adaptation. Thirdly, power may not be provided under similar rules of access, and inclusive and exclusive mechanisms to provide services and these issues become critical to success. In this study local people in the design system take on prominent role in later outcomes.

Sociotechnical systems have a designed physical system at its core. Van Halsema (2002) drawing on the work of Checkland (1981; 1989) has emphasized that the design concept used is central to how well these systems work. Critical to this theory is the design of the management aspects of technology, where technology must be manageable in relation to resources and preferences of local users and operators; rules, roles, resources and rights associated with artefact need to fit socially and incrementally. Vincent (1997a) has pointed out how 'engineering systems' fail and can often be just an assemblage of artefacts, as a hydraulic ensemble in this case. She suggests that by looking at: dimensions of control (hydraulic, organisational, political), design dimensions (concept, process, function) and (hydraulic) property rights, such misfits can be revealed. Therefore in this thesis, the sociotechnical approach studies the following linkages.

This sociotechnical system perspective of micro-hydel highlights the linkages between technology, people and the environment from a perspective of resource utilisation, conservation and production. In micro-hydel systems and irrigation, the design and assembly of technology are not only concerns in conveying, controlling and channeling water but also in sharing of resources. Therefore not only water control but technology structures become major elements of control or points of negotiation and struggle about rural transformation (Vincent 1997b). Technology is also the mediation between social relations and natural mechanisms (Benton 1992; Mollinga 1998; Knegt and Vincent 2001). With this understanding, this research focuses on practices of water provision, availability, design, management, and operations in relation to electricity generation and irrigation uses of water.

The concept of hydraulic property not only describes functioning principles of systems and construction of objects (Coward 1986; Pradhan 1987; and Abeyratne 1990) but is also used to describe relations among people with these objects (Gerbrandy and Hoogendam 1996). This understanding of both the functions and construction also provide an understanding of the wider claims to access and use of water and electricity. This investigation examines the social relations and change in resource access and use, including reciprocity relative to ethnicity and gender. When a hydel system is put into place not only does it alter traditional production practice and agrarian conditions but also the rules and practices for water distribution. These alterations get created due to agreements, contracts and service mechanisms. A planned institutional structure is put in place; management and operational conditions change; these also change the hydro-ecological and agro-ecological dynamics.

Local level institutions such as community organizations, and managerial and technical leadership are created to support the function and use of the system. Thus the modalities of management and key actors also change with the creation of new institutions such as an 'energy users group', and through skills development.

Actors and actants

In understanding technology from a wider sociology of development and social processes of transformation, I have found Long's (Long 1989; Long and Long 1992) interlocking of actor strategies in generating social forms relevant to the observation of interventions at the local level. These observations also become revealing to see how the formulation of actor strategies and social practices actually influence a wider macro level. Vincent (2001) notes, however, that Long's interpretation on agency in development policies and programmes provide limited reflection on public action, and on social relations acting within technology and not just across it. To overcome this, I study a range of actors and actants[10] to understand how actor networks build agency to introduce and adapt MHES.

Micro-hydel technology is a planned implementation as well as intervention and by the very definition of the term 'planned', social encounters alone are insufficient to adequately comprehend transformational processes. Thus I draw also on 'Actor-Network Theory' as developed by Callon and Latour (Callon 1980; 1992; Law and Callon 1992; Latour 1987; 1992). The perspective I adopt in applying the Actor-Network Theory is that social relations are mediated relationships between humans as actors, which are also made possible and shaped by technologies. Artefacts and technologies such as canal, weirs, turbines, generator, energy and agriculture are needed to make larger more complex societies possible. Micro-hydel technology is a network that is built up within space and time and with a set of resources in which innovation may take place. This actor network involves, donors, designers, manufacturers, implementers, policy makers, the community, operators, managers and users in micro-hydel.

To show the Nepal hydropower perspective, this network is visualised as two processes at the macro and micro level: one prior to implementation and the other after implementation. The macro network is active until the stage of implementation and from this perspective, once the technology is installed, it is presumed to be stabilised and this phase is also the phase for the macro network's withdrawal. However, technology at the micro level is stabilised only after the network of relations by the users reaches some sort of accommodation (Hughes 1983; 1987). The focus of this study is on 'relevant agents' or social agents at the micro level, which in this thesis are contextualisd as the relevant community or the actual users of technology.

Technology has served as a political symbol of control, and also progress. On the one hand micro-hydel technology has been encouraged with the decentralisation movement, and both state and societal actors have used the technology as communicative tools for their representation. On the other hand, micro-hydel technology has not only given an opportunity to the rural community to engage in collective action but has also provided the Maoists movement local representation and bargaining power.

In this context, a critical question therefore is to whether MHES technology would have survived without external intervention, and if brokering power by itself is sufficient to ensure local representation. In examining these processes, the study looks at various actors and agencies and the politics and platforms they represent in bringing technology within local governance structure in an attempt to make systems more adaptive. In this respect, it also examines the policy and policy-making process in the hydel sector, the national and local-level institutions, and the institution building process in local governance and rural technology development. The dynamics of social and political networks at the village level are also part of such a study, and leadership and representation are also concerns in this context.

Central Research Question

How and why have the interplay of structures, systems and agents shaped the design functions and adaptive properties of micro-hydel technology, and the possibilities for technological democracy in MHES and hydropower policies in Nepal?

Sub-questions

1) What are the different design choices of MHES in use and available at the local level and how have the system functions been shaped by external agencies, habitat and the community?

2) How and why have various actors and agencies intervened in implementing, managing, controlling and interfacing power supply and water sources?

3) How have hydel technology support and energy policy evolved at the national, district and local level?

4) To what extent has technological democracy emerged, within system technology in its adaptive design, and in accountable system governance?

Research methodology

To test these premises I draw on the typology of approaches to study technology listed by TAO (2002), including *(i)* a technography of the MHES, through studying the actor-networks introducing and reshaping systems of micro-hydel *(ii)* information on past local and in-system technology experimentation, through diagnostic studies and *(iii)* the study of current governance, and how institutions and performance are shaped by actual changes and learning from past experiences.

The research methodology applied in this thesis is based on multiple case studies. Both Yin (1984) and Sayer (1984) highlight the effectiveness and practicality of the case study method in analogous processes. In this respect, the case study method has proven appropriate in answering both 'why', 'how' and 'what' types of questions. To validate and minimize this situational character of 'findings', discourses by the actors were also recorded to account for oral history and ethnography.

This investigation involved physical yet scattered technology. A long-term field research applying a research methodology involving many case studies and scheduled hydrological measurements would not be easy to conduct simultaneously in various districts.

Given the harsh topography of Nepal and the dispersed locations of power systems, it was essential to maintain focus on one district. Thus I first conducted a rapid appraisal of sites (see Appendix 1.1). Case studies undertaken were not entirely pursued on the basis of comparisons, rather they were observed as separate studies. The nature of interventions at the four sites differed quite substantially between State run systems, donor-assisted and interventions under R and D initiatives. As highlighted by de Vries (1992), comparisons were rather seen as a way of clarifying the specific contextual features between interventions, and processes within a specific contextual arena. These interventions and implementation processes were then juxtaposed into a comprehensive sociotechnical reality determining the development of both electricity and agriculture.

A variety of techniques for information collection were applied. The qualitative techniques included structured and semi-structured formats, key informant interviews, observations, surveys and measurements, also following and interacting with relevant actors. Quantitative data included the primary information gathered on socio-economic conditions of the users and non-users, hydraulic features of the design system and water availability. Scheduled hydrological measurements were conducted during the research period (See Box 1.1).

In the three community-system sites, using a structured format, a total of 325 households were studied out of which 25 percent were non- electricity users. This figure includes 116 households in Pinthali as energy users and 29 households of non-electricity users within the peripheral area. The Katunje Besi study included 45 households as users and 11 as non-users. Similarly the Kusha Devi study included 59 households as users and 15 households as non-users. As Panauti plant was different, with all households served by the national electricity grid, 50 households were studied. Given the nature of the centralised grid intervention, the format was modified to structure questions relevant to small hydro systems rather than micro units as in other sites. Two community mobilisers from the local area assisted with data collection.

BOX 1.1 Hydrological measurements at the case-study sites

From June 2001-August 2002, discharge measurements, were undertaken at the four case-study sites, encompassing two dry seasons and one wet season. These measurements included bi-monthly volumetric calculations of discharge at selected points in the intake and canal system. The various measurement techniques applied at the site have primarily been conducted by training the local operator of the power plant. In the case of the Panauti plant, NEA had initially provided assistance in conducting the measurement. The measurements were carried to address the following questions:

- What is the volume of water that is taken from the river at the source?
- What is the average flow/volume in the canal?
- How much water is used for energy use by measuring the discharge at the intake and the canal system?
- How much water is used for irrigation through the canal discharge?
- Calculation of leakage/seepage, where 20 per cent losses is estimated (average based on the Irrigation Department's Manual for water balance calculations).
- How much water (approximate volume) is returned back to the source (or different source).

Depending on canal dimensions and technical design, the measurement techniques of current meters, float methods or bucket measurements were used.

Research concerns

During the span of this research between January 2001 and August 2002, significant challenges presented themselves through dynamic social and political changes. Due to the ongoing conflict between the Maoist movement and the State, field visits and research in research sites were at times undertaken during tense circumstances.[11] As a consequence, Chapter 3 is included to explore the dichotomies of conflict and power struggle with personal insights and encounters during my research journey in the field.

Kabhre Palanchowk district is a minefield for researchers. There seem to be two major reasons for this. First, some of UNDP/REDP's successful programmes are located in this district and as a major player in the rural electrification sector, researchers are invariably directed to this district. Second, with the ongoing conflict between the State and the Maoist insurgency, Kabhre Palanchowk's proximity to Kathmandu provides much easier access to conduct research where the location allows researchers to make day trips during times of tension. Although this district is inundated with researchers and I have been disturbed on few occasions, this is not so much over territorial competition of sites but rather with issues of research integrity and validity.

The proximity of the sites ranging from 30 kilometres to 80 kilometres from Kathmandu has created dynamic change. At the start of the research, the sites seemed like representative samples of a rural environment, but Kabhre Palanchowk district has witnessed tremendous changes within the past three years. Where sites such as Kusha Devi, Pinthali and Katunje Besi were once isolated, the road construction from Dhulikhel to Sindhuli has not only provided access to the rural community but also present the paradoxes of changing urban/rural linkages. This access has further proved quite convenient for men to travel around in search of supplementary income or new politicking, while this phenomena has put the responsibility on women to ensure the running of the farms. Increasingly bazaar areas have sprung up with more shops and people from the *gaon* (settlement on top of the hill) have installed temporary housing in the *besi* (low land) area. This has not only allowed the community to organise themselves through collective dairy initiatives but also augmented their income

Structure of the Book

This book is divided into 9 chapters. These chapters are arranged and organised in a tripartite layout.

In Chapters 1 to 3, I debate the conceptual and theoretical framework and give broader historical and political policy perspectives on hydropower, water and micro-hydel development, for the structures/systems/agents interface. The empirical Chapters (4-7) all show and enable, study of different sequences of action around and within the technology, to transform the original devices and establish working practices. They provide technographies, by looking into the materialisation of the design and its functionality, and the interplay of structure, system and agents shaping outcomes. Following a timeline in intervention that range from 1997 to 1965, the micro-hydel studies are presented in turn beginning with Pinthali, then Katunje Besi and Kusha Devi. Then one small hydel system at Panauti is studied to show how socio-political dynamics may also have shaped the technology in a historical sense, and provide a comparative study from a grid-source.

Chapter 8 explores the extent to which transformative units and evolutionary systems have come into being, to make MHES work for their users. It first examines evolution in power generation and water use. Then, the chapter shows how different dimensions of accountability have been pursued by users and related agencies to build more democratic MHES. Chapter 9 concludes with a discussion of the contribution of this research to policy, practice and theory.

Notes

[1] The term Hydel (abbreviated from HYDroELectric) is used particularly in the context of the equipment and plant generating hydropower or power from moving water (as in a micro-hydel system) and is in widespread use in South Asia and the USA. Elsewhere, the term hydro equipment is still in use, as in micro-hydro systems. The term hydel is used in this study.

[2] The concept of community adopted in this thesis is of spatially associated group of people within a boundary politically defined by a legislative code. Within this group I look at sub-groups, as associated by various internally recognised properties. I recognise a moral economy that may exist that shape how communities move beyond the basic definition of a 'mythical community' (Agrawal and Gibson 1999).

[3] Even within the mini and small category, turbines are classified as large (above 5,000kW), small (1,000kW-5, 000kW), mini (100kW-1, 000kW) and micro (up to 100kW). The micro systems are further categorised as very small (up to 8kW), small (8-20kW), medium (20-50kW) and large (50-100kW).

[4] A study sponsored by ITDG and International Centre for Integrated Mountain Development (ICIMOD) and conducted by Dr.Govinda Nepal indicated that out of 91 micro-hydel sites under investigation 31.9 per cent were running with problems, 8.8 per cent were running partially, 7.7 per

cent were closed temporarily and 15.4 per cent were closed permanently. In addition, 3.3 per cent had been destroyed completely for various reasons, 2.2 per cent had been sold and shifted away, 3.3 per cent could not be located, 2.2 per cent were never installed and 2.2 per cent were under construction. The study further indicated that 75 percent of the micro-hydro plant owners were farmers by occupation.

[5] Jacques Elhul expresses technique as 'the totality of methods rationally arrived at and having absolute efficiency (for a given stage of development) in every field of human activity (cf. Hood, 1982: 191).

[6] Oblepias-Ramos (1991: 165 cf. Warner and Henderson, 1995) emphasize that technologies become appropriate 'when they carry a deliberate bias for a specific under-privileged sector of a community, as well as an appreciation of that sector's overall physical and cultural environment', and the farming systems.

[7] As late as the 1950s, that Kusha Devi village elders recount searching through the forests in search of *nigalo or chyati* (miniature bamboo) for their nightlight, this practice still persists in certain areas of Nepal because of lack of alternatives. Miniature bamboo groves were valuable natural resources then. Around the 1960s, when kerosene first started making an appearance in village households, small glass bottles became a prized commodity to adapt with a wick to create a simple *tuki* (oil lamp). Now with electric lighting, light bulbs have replaced glass bottles as valued item.

[8] Following on the formulation used by Hill and Hupe (2002:14), I use the term governance to express the conditions created for collective action and rules to include multiple of actors from the private, non-governmental, the civil society arena and the users of technology. The governance of MHES puts a particular emphasis on the governing mechanism such as grants, contracts and agreements, which not necessarily rest on the authority and sanctions of government.

[9] In discussing the dilemmas facing resource use and policy reform, Waller characterizes two key concepts as 'resource management regimes' and 'expert systems' asserting that the nature of the force exercised by the experts, elites and technical gentry characterize the water management institutions. In this respect, expert systems are elite systems. Giddens (1990) however does not see expert systems as being elitist. Rather, the lay-person's conditioning of social life leads to their disinterest to understand technical knowledge.

[10] The central argument of actor-network theory, in relation to technology, is that all technological innovation involves the construction of durable links that connect together with human and nonhuman entities. However, MacKenzie (1996), argues that Callon and Latour should not privilege human beings by making them the only active agents. Unlike in conventional sociology, where the term 'actor' usually refers solely to human beings, 'actant' at times refers to both human and nonhuman entities.

[11] The only time I felt threatened at the personal level was in November 2000, as I was descending down from Pinthali hill to Shyauuli Bazaar with a young research assistant. My companion and I were suddenly surrounded by young police officers pointing their AK47s at us. After discussions, we were let go but the interrogation and handling by the police in particular of the research assistant was not pleasant. Some of these young police officers that interrogated us were later posted in Katunje Besi police post where we managed to resolve our misgivings. As the Maoist increased their stronghold in the area, this police post merged with the one in Bhakunde Besi and some of them were killed in the January 2002 Maoist attack. Subsequent visits to the sites, during the Emergency period, necessitated securing an official 'travel permit' to certain research sites from the Chief District Officer (CDO) and numerous interviews by the district police officer. The Japanese supported road construction from Dhulikhel to Sindhuli, yet delayed travel permits, followed discussion in Kathmandu with the Nepali project leader. However, these restrictions were gradually lifted as the road construction progressed and after the Emergency was annulled, travel became easier.

2

The Dynamics of Hydropower, Water and Electricity Supply in Nepal

NEA is not concerned with the social dimensions of hydropower development but with the internal rate of return. Social water activists in Kathmandu can worry about the "social rate of return" of hydropower projects.

Anonymous, NEA office, Chilime, Rasuwa, November 2000

Introduction

This chapter examines the historical development of hydropower, and the agents, policy structure, models and institutions that have shaped the water and power sector of Nepal. At the macro level, I show the State's water and energy policy path and trace the recursive shaping of the hydel sector. At the micro level, I show how various agents, design networks and prototypes have historically shaped the micro-hydel sector, and the implication of these in the process of adaptation at the local level. I emphasise the significance of the linkages between the macro and micro level. By macro and micro, I also refer to: the grid versus non-grid development of electricity as well as these parallel policy structures of hydropower development at the central and local level. This chapter also emphasises the dilemmas of hydropower policy in Nepal (Regmi 2001), looking at policy issues, policymaking[1] approaches, and different technology options and institutions involved. These dilemmas lie in choosing adaptive technology options (see Chapter 1) for the wider citizenry, and determining who will make these choices.

Government Policies and Policy Actors at Macro Level

Historically the State's control of water resources has been a dominant practice in Nepal. The first codified law of Nepal known as the *Muluki Ain* or the civil code of 1854 included some legislation for the control of water resources. This legal system promoted the ties between the lawmakers, elite landowners and citizens within the purview of tenant and landlord rent-seeking relationships (Regmi 1976). Prior to the formulation of modern legislation, the State as a lawmaker yet controlled much of the water resources through the control of agricultural economy, labour and production. The evolution of electricity supply began with the bilateral assistance to Nepal with the Pharping plant in 1911.[2]

In 1912, the first users of electricity began paying for the services provided from the Pharping plant. However, the electricity from this service was not for the general public and services were given to ruling the Rana family, their extended families and the elite courtiers, for domestic consumption.[3] Depending on the political hierarchy, exemption on payment for electricity consumption was also taken for granted.

In 1940 the industrial town of Biratnagar was the first to be given access to electricity outside of Kathmandu. Coinciding with the construction of the case study site of Panauti, legislation was also initiated to deal with issues around the interaction of electricity generation with water resource control and agricultural water use. Both the Pharping[4] and the Panauti plant had witnessed resistance from the farmers when water was diverted for electricity production. Thus, in 1961 the first Canal and Electricity Act came into effect to manage the development of electricity and irrigation canals. Subsequently, this act was followed by the establishment of the Nepal Electricity Corporation in August 1962 to manage electricity distribution and generation, as bigger projects such as the Panauti plant made it possible to expand access to the general public. In 1964 the first Electricity Act was introduced in Nepal. When promulgated by 1965, the first amendment to this act kept an emphasis on 'electricity'. However, the State's control over both the irrigation and the electricity sector gradually converged and in 1967 the Canal, Electricity and Related Water Resources Act was introduced. This Act not only emphasised the 'national wealth' through the control and regulation of water resources. It also provided the provision for issuing licenses for generating hydro electricity for the first time in Nepal, although not for domestic, irrigation and ghatta uses.

In 1984, the Nepal Electricity Authority (NEA) Act was introduced which realigned the entire power production structure in Nepal by creating a central direction of hydropower generation. Along with the State's reaffirmation of the claim to ownership of water resources in Nepal with the Water Resources Act (WRA) of 1992, amendments to the Electricity Act were also made in 1992 (WECS 1992; 1993).[5] This Act is a comprehensive legislative structure that reaffirms the HMG-N's power over the water and hydropower sector not only in terms of the aspiration of revenue generation, but also with Clause number 40. This clause confers the state's over-riding power to 'frame necessary rules in order to carry out the objectives of the Act'. This Act has opened up the private sector in the development of hydropower in Nepal, but not without various State restrictions and control.

After 1992, hydropower has prominently re-emerged in various documents, reports and policy papers. Some of these include the 1995 Agriculture Perspective Plan (APP), which emphasises the electricity demand from groundwater irrigation using shallow and deep tube-wells. The World Bank supported Water Resources Strategy Formulation Phase –1 of 1996 emphasises that successful hydropower generation in Nepal is contingent on demand and the country's policy environment. However, the 1996 Medium Hydropower Study Project (MHSP) financed by the World Bank has been deemed perfunctory and not reflective of the entire picture of medium hydropower projects of Nepal (Pandey 1998).

In 1998 the Tariff Reduction and the Buy-Back Rate Announcement provided support to Independent Power Producers (IPP). Now IPP is a contemporary dominant paradigm in hydel discourses. The Water Resources Strategy Formulation Phase - II Study of 2001 has put a broad range focus on power export, exchange and private sector involvement. In a similar manner the production of electricity, by involving the national level power producers and joint ventures was encouraged by the Power Purchase Agreement of 2001, which provided provisions for the power companies to sell electricity to NEA. Finally, these various acts have culminated with the Hydro Power Policy of 2002, which places considerable weight on bilateral alliances between Nepal and India (WECS 2000) for power sector development. While substantial weight has been given to the macro policy formulation level, the micro-level has been given contradictory attention, often left to a mix of external donors and local entrepreneurs and innovators.

Major players in the micro-hydel

In a nutshell, four major government institutions are currently involved in the rural electrification sector in Nepal. Although NEA as a central-level electricity institution carries a mandate for rural electrification, the agency has not been proactive in this sector. In 1977, the Remote Area Development Committee (RADC) was established under a directive of the Home Ministry to oversee social and economic development of remote areas. Thus, RADC under the aegis of Ministry of Local Development (MLD) began its work in about 22 remote districts in collaboration with the local governance structure. The RADC is still actively involved in rural electrification schemes in remote areas and working in close collaboration with international NGOs. Other critical institutions are the Rural Energy Development Programme (REDP), Alternative Energy Promotion Centre (AEPC) and King Mahendra Trust for Nature Conservation, and others in addition to donors, manufacturers and private companies that are involved in the sector.

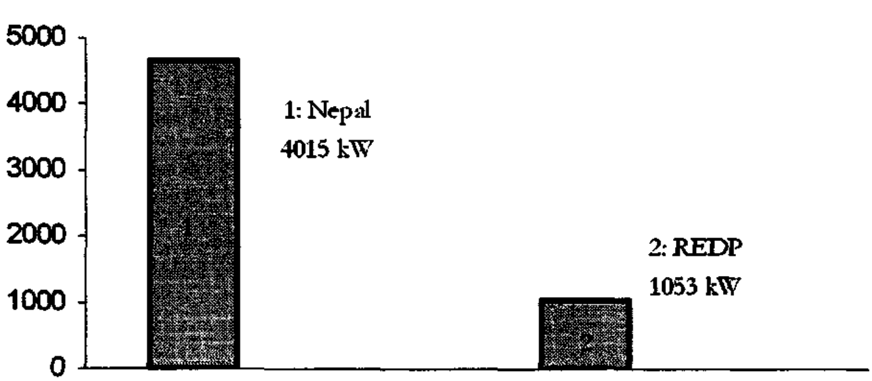
Since the advent of electricity in Nepal, a single-structure policy model paved the path to the urban and elite households. In spite of the fact that modern hydropower was introduced in Nepal more than ninety years ago, the country's energy sector development reflects a slow, costly, inefficient and urban biased process (Pandey 1998). Rural electrification started in early 1960s based on the use of fossil-fuel generators, improved traditional wheels (water mills) and micro-hydel. Geopolitics made Nepal a focus of attention for hydel technology; the Panauti plant from this period was built with Russian Technical Assistance. Hydro policy was also an outcome of Nepal's petroleum crisis experienced during that time period, a geopolitical consequence of the 'management of powerlessness'. This epoch became important in setting up a parallel electrification structure: rural versus urban, grid versus non-grid with different possibilities for macro, small and micro-hydel technology and accepting multiple influences in technology.

This period also saw the emergence of growing private companies involved in the micro-hydel sector. Synchronising with the country's prospective national plans, rural electrification was pursued, beginning in the Seventh Plan period (1985-90). The initial thrust was placed on conservation of forest resources, followed by basic needs, to the present focus on decentralisation in the ongoing plan period.

The Swiss also influenced some prototype designs, as did the NGO Intermediate Technology Development Group (ITDG). ITDG has been actively involved in the power development sector in Nepal from 1979 until 1999. The first peltric set was brought over from the UK and was introduced in Nepal by ITDG. ITDG's assistance has been primarily in four sectors: capacity building, policy level, subsidy policy and research. ITDG played a crucial role in the formation of the Alternative Policy Development Centre, an energy formulating body at the Water Energy Commission Secretariat (WECS). ITDG was also actively involved during the Ninth Plan Period (1997-2000) developing the energy policy. Now ITDG has changed its strategic focus in the country moving away from micro-hydel towards alternative energy sources such as solar, wind, biogas and waste. This change has occurred primarily because energy through micro-hydel is not automatically perceived as an optimal solution in meeting the electricity needs of rural Nepal. The Ninth Plan Period (NPC 1998) has set the objective of developing a total of 5.3 MW of electricity with the installation of micro and mini-hydel schemes during the plan period.

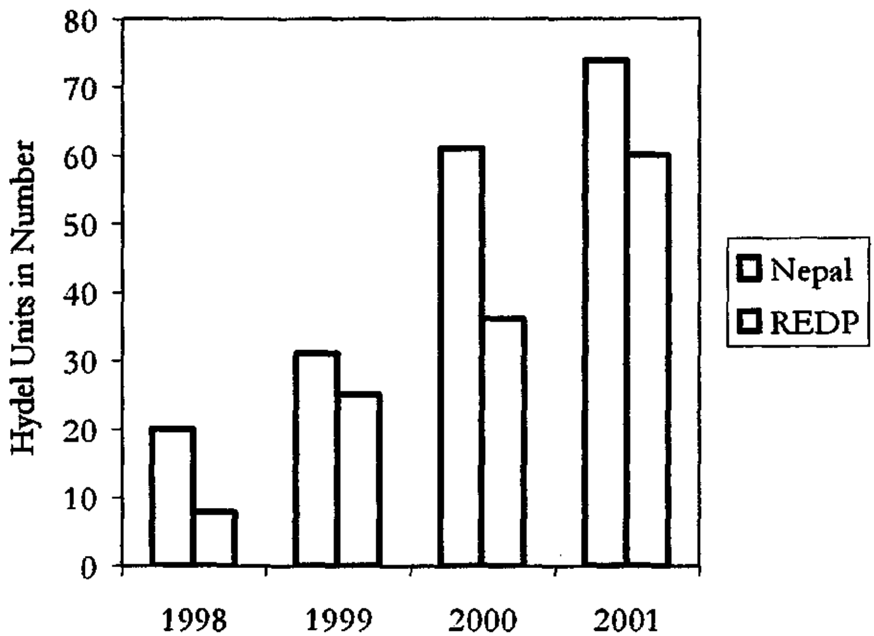
FIGURE 2.1: Micro-hydel production

Nepal (1962-Mid July 2002) and REDP (1998-2002)



In 1996 the REDP was created, within which generation of some 1.1 MW (AEPC/ESAP 2002) has been achieved, or one-fifth of all micro-hydel generation (see Figure 2.1). Three of the case studies have links with this programme. Figure 2.2 shows the total units installed during 1998-2001 within the REDP programme and Nepal by the assistance from other institutions, mainly NGOs and other projects.

FIGURE 2.2: Total Micro-hydel units installed (1998-2001)



The 1980s witnessed a period when diesel-operated mills diffused rapidly in the rural areas for milling purposes. In 1984 the micro-hydel sector was de-licensed and restrictions were detached for systems of less than 100 kW capacity. However the peak in the revival of micro-hydel in the country took place after democracy was resumed in 1990. This revival followed the introduction of liberalisation, privatisation and decentralisation, consequent to new external support programmes, new Nepali planning initiatives, and subsidy arrangements. However it now had to do this in a space where local entrepreneurship had already brought small diesel units into power generation and local agro-processing, as the case studies will show.

In particular, this period from the 1990s brought in new donor assistance for MHES from DANIDA, the UNDP and the government's REDP structure, the government's AEPC, and the NGO sector. A total number of 119 schemes were installed. REDP carried out 74 schemes, RADC 27 sets, and Annapurna Conservation Area Programme (ACAP) under The King Mahendra Trust for Nature Conservation Project installed 9 projects. The Canadian Centre for International Studies and Cooperation (CECI) implemented 6 projects. The United States Agency for International Development (USAID) and German Technical Cooperation (GTZ) are also players in the micro-hydel and improved ghatta field. As the new millennium moves forward, the search will continue for a coherent 'energy strategy' in which policies respond to changing public needs and values. Prominent donor players within the energy arena who have large resources both in the macro and micro-hydel sector, such as the ADB/Manila, World Bank, USAID and DANIDA have moved forward to promote energy development for the country. UNDP is also supporting WECS and DANIDA in defining certain policy guidelines and issues related with micro-hydel in Nepal.

With UNDP's assistance in the rural energy sector, REDP was created to oversee the UNDP funded rural electrification programme at the national level, maintaining its focus on micro-hydel technology. Subsequently within a year HMG-N, with the financial assistance from DANIDA's Energy Sector Assistance programme (ESAP) established the AEPC as a central level-coordinating agency for all Renewal Energy Technology (RET) under the Ministry of Science and Technology (MoST). Micro-hydel was included within this portfolio along with biogas, solar home systems, solar cooker, solar dryer, solar water pumps, improved cook stoves and wind energy. Danish bilateral aid through DANIDA has significantly increased the assistance in the micro-hydel sector providing central level support and policy reform assistance through ESAP. As a direct consequence of this programme, the subsidy policy (AEPC/ESAP 2000a) and the mechanisms for delivery (AEPC/ESAP 2000b) were reformulated. REDP's installation experience also promoted to the formulation of the new subsidy structure. Under the REDP initiative, subsidy was provided by the government and by the project, i.e. from two channels. A closer look at the structures, systems and agents involved in the policy process for rural electrification reveals that rural electrification paradigms are closely linked with external assistance during each planned period.

The mini-grid concept

The Energy Sector Assistance Programme (ESAP) at AEPC assisted by DANIDA, supports all RET activities, and within this category micro-hydel is also included. The concept of the mini-grid has emerged since the year 2000. This concept encompasses a typology of conditions. The mini grid can be and often is used as a generic term to refer to isolated units that interconnect 5 to 200 households, where the entire power generation is by 'micro-hydel'. However, the term 'mini-grid' is also used in place of 'micro-hydel' to convey the possibility of connecting the micro-hydel with the national grid line or larger regional grid systems.

This mini-grid concept is promoted under the management unit known as the Mini-Grid Support Programme (MGSP). The MGSP was created to support DANIDA funded projects, and is thus closely linked with donor support. The primary difference between the REDP and MGSP models fundamentally concerns the control over finances. Subsidies are provided to projects under the 'MGSP' where proposals are expected to adhere to certain prescribed forms, undertaking of studies and is expected to follow detailed procedural guidelines. A clause in the subsidy delivery mechanism grants the Interim Rural Energy Fund (IREF) as a subsidy bank to authorize a direct release of 50 percent of the subsidy to the manufacturer. In this respect, the MGSP model does differ to a certain extent from the REDP model (see page 57 for REDP process). With the REDP model a subsidy is released first at the central level and transferred at the district level. While the stated focus of the approach of REDP is on the 'community' through rural electrification, the subsidy was not really under the control of the community. DANIDA's course is distinctly a 'market' approach towards rural electrification.

The REDP programme maintains a strong 'district' and village level presence. However, the MGSP has central-level representation where the district effort is coordinated by the concept of Area Centres (AC). Again this AC concept is not much different from the REDP approach where the programme has focused on a local NGO to interface with the programme and the community. In a similar manner, the AC is expected to also play the role of interfacing between the programme and the local institution. The AC is operated by NGOs and provides assistance with studies, selection of contractors, choice of technology, supervision and funding arrangements. Under the MGSP programme, ACs are established in various districts in the development regions, but not necessarily at each district headquarters. However, the AC emphasises the developer, manufacturer and the consultant, which envisages direct technical and institutional support to the programme. The principal strategy of this support at the central level is to develop institutional, organisational and regulatory framework for isolated grids (AEPC/ESAP 2001).

New Coalitions

Until the beginning of the 1990s the influence in policy formulation can be largely seen as an exogenous process, as the hydro sector, both macro and micro, was an outcome largely influenced by donor and external assistance. Sharma (2001), in *Procuring Water: Foreign Aid and Rural Water Supply in Nepal,* notes that hydropower made its way from the mid-1970s when energy was largely perceived as a means of earning foreign currency within the mainstream discourse of water development. This view dominates the macro policy structure. He further states that 'exporting hydropower to earn money has officially been projected as the only solution for the country's ever-downward spiralling trade deficit'.

Policy models and platform

Only 1 per cent of electricity in the country is produced by local investment (NEA) and the micro sector is entirely funded by external agencies and is closely linked with the soft loan and grant support of larger projects.

It was during the period when the popular national view of a 'hydropower bonanza' emerged, that the WECS was established in 1979 with Canadian financial assistance. However, the macro hydro sector in the 1990s has seen the epitome of public action within the history of Nepal, the crux of which was the coalition movement, initiated by public debates on Tanakpur Barrage on the Mahakali River. Contestation on macro policy issues became increasingly common, in the form of coalitions, alliances and public hearings.

The movement culminated with the cancellation of the proposed Arun III high dam, signifying the emerging role of public action in Nepal. This symbolises a historic keystone in policy evolution for technology development in Nepal. The development of rural-electrification could have an important impact, bringing about democratisation in technology, changes in institutional interventions and transformation for rural energy users.

Gyawali (2001) elaborates extensively on the pre- and post-cancellation of Arun III providing details of the political, technical, social and economic tussles and ramifications of the project. He exposes various institutional and structural distortions within the hydropower sector made apparent by Arun III. Coalition movements through the 'Arun Concern Group' and the 'Alliance for Energy' led to the cancellation of Arun III, by arguing that the project would have strong negative social, environmental, technical and economic impacts. The estimated cost for Arun III was over a billion dollars, pledged by the World Bank, the ADB-Manila and the governments of Germany, Japan, Sweden, France and Finland including NEA's own investments. Arun III, envisaged to be a 402 MW hydropower scheme, instead came as a combination of mini projects, signalling an opening for smaller-scale projects through the private sector.

The Alliance for Energy-Nepal and Arun Concern Group, protagonists during the anti-Arun III campaigns, are examples of stakeholder coalitions affecting macro policy. Since the nature of policy changes cuts across various sectors and interest groups, changes must be implemented in highly open systems (Crosby 1996; Mazmanian and Sabatier 1989) - but the decision makers in Nepal are still a small confined group of actors. However diverse the stakeholder coalition, it can largely be seen as a closed system when the technology is confined to a narrow set of decision-makers. Coalitions can coalesce around broad or narrow themes (cf. Hajer 1998), including a particular aspect of technological change and diffusion. In this respect users become an important stakeholder of coalition groups and movement, particularly when designing the technology for their use. Examples of coalitions in technology development indicate that sometimes groups are formed to cope with complexity, conflict and change (Biggs and Smith 1998). Coalition movements can indeed influence policy and this is increasingly visible in the sector of rural electrification.

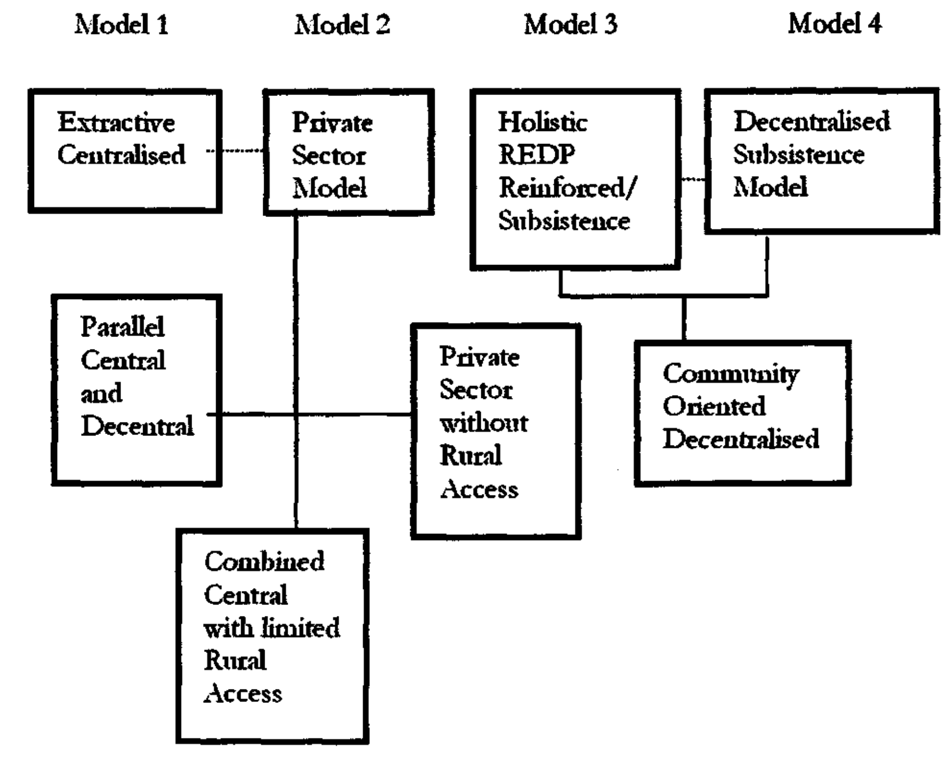
Another platform between implementation and policymaking can also be seen from the constituency of the National Micro-Hydro Forum (NMHF) in Nepal. This stakeholder policy forum was established in 1996 with the assistance of ITDG and represents donors, manufacturers, policy makers and NGOs. The Nepal Micro Hydro Power Development Association (NMHPDA), a forum of micro-hydel developers and manufacturers established around the early 1990s, is an example of a promotional platform. In a similar manner, the concept of Micro-Hydro User's Groups has also been recently developing with the support of NGOs such as WINROCK. These various changes will influence the outcome of development processes. However, so far the coalitions in the public sphere has remained incomplete and without the inclusion of the users of the technology in policy discourses.

The Subsidy Policy of 2000 for Renewable Energy can perhaps be termed the hallmark of Nepal's rural electrification programme and the rural electrification policy for the country. Rijal (2000) highlights the inconsistencies in the subsidy policy and states that some donors in Nepal have provided a larger subsidy than that given by the government. As will be illustrated by the case studies, this was also true for REDP supported projects. Micro-hydel is clumped together within the RET category along with solar and other biomass, including wind energy forms. Another emblem of this confusion in the macro versus micro portfolios is seen between the MoST and the MoWR and the relevant line of agencies that fall under these respective ministries. While the NEA and WECS, under MoWR, are responsible for the crafting of strategic directions for hydropower policies at the macro level, the AEPC, established in 1996 is put under MoST. AEPC is responsible for assessing and promoting rural electrification through alternative technologies, even though the agency is not directly involved in operational activities at the field level.

Rural electrification models

There seem to be four imminent design models in promoting hydel technology in Nepal at the moment. *(1)* The centralised and controlled Nepal Electricity Authority (NEA) model of power generation that feeds into the national grid (Extractive Model). This model I refer to in this section as model number one. *(2)* The private sector model. An example is the Lamjung Electricity Development Company LEDCO[6] model, with its geographical focus in the Western Development Region. In the two-track LEDCO model a larger unit is designed to feed into the central grid line whereas an adjunct micro system provides electricity to the local community. Another variant of the private model is what I refer to as the Andhi Khola model[7] commissioned in 1991 as a combined intervention. This system functions with two independent structures, albeit within one system. Figure 2.3 provides the complete picture of hydel models of Nepal.

FIGURE 2.3: Hydel models



In the private sector model, the power is generated by a private company and is sold to NEA for the central grid; a segment of the profit was previously used to extend the rural electrification network in the district. At present, the company fully supplies electricity to the local community. Other common private sector models primarily focuses on grid-fed systems while the community around the plant remains alienated without access to grid services. *(3)* A community-oriented holistic model that uses systems as entry points for other development objectives promoted by REDP and funded through bilateral and multilateral aid (Reinforced Decentralised/Subsistence Model). *(4)* A fourth community-focused model, which is a combination of community or private ownership that focuses on end-use promotion along the tourist trail (Decentralised/Subsistence Model), such as of the Annapurna Conservation Area Programme (ACAP) region.

The two community-oriented models fit within two service perspectives (Figure 2.3 shows where these model fit in). First is the subsistence consumptive perspective where technology is designed to cater to minimal need (40-200 watt per household). Second is the productive/consumptive model, where technology promotes both productive and consumptive demands - these include supporting the tourist industry irrigation, and/or agro-processing needs within the community. These various approaches are also concerns of this study. The third and fourth models are the main focus of this study: however Panauti is an example of model 1 studied for comparative understanding.

Prototypes and design networks

Donor assistance in the micro-hydel sector has developed a pool of local-level technology, and also a pool of design professionals, engineers, manufacturers and supporters of this sector. With co-operation and support of SATA/HELVETAS and less formally the United Mission to Nepal (UMN) and other non-governmental organisations, two parallel efforts were being supported in the design and dissemination of micro-hydel prototypes in Nepal. While SATA emphasised support in building up the Kathmandu manufacturing sector, UMN focused on establishing the manufacturing base in Butwol, in the Central-Western region of Nepal. The Butwol Training Institute (BTI) was established in 1963, Development and Consulting Services (DCS) in 1972 and Butwol Engineering Works (BEW) in 1977. The manufacturing innovations were a foreign intervention. A quasi-government institution known as Nepal Industrial Development Corporation (NIDC) supported the manufacturing sector. The NIDC, which is closely associated with the Ministry of Finance and the Ministry of Industries, Commerce and Supplies, cooperated with SKAT (Swiss Federal Institute of Technology), SATA/HELVETAS and ADBN.

The early 1960s were important for the development of both grid and non-grid electricity networks which for the first time provided electrical services to people outside of Kathmandu. In 1962, the Francis Wheel turbine imported from Russia (see Panauti case study) was introduced to Nepal. At the same time in early 1960s, the MPPUs were transferred from abroad and Kathmandu Metal Industries (KMI) developed an improved version of MPPU. KMI then began working on a variety of other design prototypes such as Pelton, cross-flow and propeller turbines. In addition, this technology was also developed to produce more efficient and powerful cross-flow and Pelton turbines. In 1962, a locally manufactured 5 kW propeller turbine was also installed and later there were seven more installations of this turbine. However, due to design problems, the investigation of alternative turbine designs began to increase in Nepal (Aitken et al. 1991). By the late seventies, the manufacturing sector in Kathmandu and Butwol had gradually accepted the cross-flow turbine as the most suitable technology for the rural hills, in particular the mid-hill region of Nepal. Two private companies, the Balaju Yantra Shala (BYS) in Kathmandu and DCS in Butwol, played an important role in development of cross-flow turbine. During the fiscal year 1987/88, there were 423 installations of cross-flow turbine plants (Jantzen and Koirala 1989). In addition in 1988 over 600 Pelton turbines were installed. The Thapa Engineering Industries (TEI) has also been conducting manufacturing research in particular with cross-flow and Pelton turbines and specialises in cross-flow turbines. Nepal's private sector experience began to expand (Inversin 1994) as various designs were experimented with. Today most of the manufacturing companies in Nepal can locally design and fabricate these popular prototypes. However, as the case studies will show, there remain problems due to lack of standardisation of fabrication and spare parts, and support services sometimes cannot even repair breakdowns during guarantee periods.

The various actors involved in this sector have also shaped the private-sector development of manufacturers and installers in Nepal. In this respect, the use of the word 'cartel' would perhaps not wholly capture some of the pioneering work carried by various individuals in the development of this sector: it is rather an 'old boys' network. I use this terminology with a positive conjecture and for two reasons: first, the originally established agencies and actors are still active in the arena of micro-hydel. Second, there has been a total diffusion of the popular prototypes and newer variety of design systems and approaches continue to be experimented with. This technical network of agents is distinguished here as two separate generations of pioneers. The First Generation (FG) of these pioneers included men who were involved in the promotion of this technology during the era when ADBN was actively promoting this technology at the local level. Some of these FG actors were involved in the operationalisation of the technology at the rural level and were involved with the Alternative Technology Unit (ATU) of ADBN. These actors are still involved as important leaders and innovators of this sector. Some of the leading FG promoters and innovators are Sri Krishna Upadhaya, Ganesh Ram Shrestha, Akkal Man Nakarmi, Surendra Mathema, Govinda Nepal, Sri Dhar Devkota, Dewan Thapa and Kiran Man Singh. However, a Second Generation (SG) of promoters has emerged in this sector. Some of these actors among others are Bikash Pandey, Mahendra Neupane, Devendra Adhikari and Subarna Kapali. While other prominent actors that have also shaped this field such as Kamal Rijal, Girish Kharel, Kavita Rai and Kamal Banskota have also changed their strategic focus from micro to small systems. These actors represent diverse platforms that range across NGOs, manufacturing companies, government agencies, donor companies, implementing agencies, research institutions, activist groups and private companies.

The technology prototypes in diffusion can be basically delineated as peltric and non-peltric. The peltric turbine is one of the simplest forms of design, which is combined with a generator. The turbine is the impulse type, whereas the generator is induction type. Normally, peltric sets can be manufactured and installed for more than 5 kW, even for 20-30 kW, but in practice in Nepal are used for generating electricity below 5 kW capacity. While the design of this technology requires a high head, typically above 40 to 50 meters, this system can be operated with a small quantity of water. Non-peltric sets are used for plants requiring more than 5 kW of electricity. This turbine is used for systems with medium and high head. For low head system usually a cross-flow turbine is used, as has been done in the case study of Pinthali. While there is not much variation in turbine design, R and D initiatives in the past few years have encouraged other design types to be experimented with at the field level. For example, under the REDP programme, turbine models other than the cross-flow have been installed. The

Kusha Devi plant under the initiative of Nottingham Trent University (NTU), and the Katunje Besi plant with a local manufacturer, are examples of such experiments. The propeller turbine in Katunje Besi VDC-1 (low-head), and a Turgo turbine[8] (high-head) in another location in Katunje Besi using the source from Pota Khola, were installed by KMI.[9] Recently, a peltric set, for low-head design systems (where propeller turbines are coupled with a generator) are also being developed and field-tested in Nepal at two different sites by DCS.

Nepal has installed a total number of 1990 micro units in the country through national private manufacturing and installation companies. The majority of these have been peltric sets. In the new policy subsidy structure, the subsidy for plants below 3 kW (peltric sets) is lower than for projects above 3 kW capacity, which indicate that turbines other than peltric are being encouraged. In this respect NMHPDA has played a critical role in moving the design processes ahead. Most of the key actors and key agencies belong to this group. In addition to this stakeholder platform, there is the Association of Micro-Hydro Manufacturers (AMHM), established during 1991 for the manufacturing sector, which includes members of all turbine manufacturers. This is a forum where issues of market, design and implementation are discussed as well as standardization of mechanical electrical guidelines. Peltric sets are said to be the most suitable design system for Nepal's topography and hydrology. Thus the design and development of this turbine has been historically encouraged in Nepal. Perhaps, Mr. Akkal Man Nakarmi of KMI can be named as the father of the 'peltric' set from the perspective of design, diffusion and manufacturing sector in Nepal. Between 1962-2001, KMI has installed a total of 508 plants out of which 421 schemes have been peltric sets (multi-jet systems) and 42 have been mono-peltric (single-jet) units.[10] Furthermore, about 45 mechanical schemes have also been installed by KMI (AEPC/ESAP 2002). KMI's continuation as a pioneer in the hydro sector is seen by its representing about 52.6 percent of the total peltric set installation in Nepal - and about 26 percent of the entire market share for turbines in Nepal between 1962 to mid July 2001.

In the fiscal year of 2000, 36 micro-hydel plants were installed. About 22 of these plants were cross-flow turbines and the remaining design systems used a Pelton turbine. About 53 per cent of these schemes were undertaken by REDP, about 9 of these plants using cross-flow turbines. In addition, improved ghattas were installed; these are modernised traditional water wheels, with steel wheels with round buckets replacing a wooden shaft. These are primarily used as a mechanical installation for agro-processing and milling needs. Technology categorisation can be delineated with the functional connection to design. For example an 'add-on' design is capable of generating both mechanical power and electricity. The Pinthali case study can be categorised as an add-on scheme, as electricity is used during the nighttime and mechanical power for milling purpose is used during the day. The site in Katunje Besi is a 'stand-alone' system as it is solely used for the generation of electricity. However, the Katunje Besi site is an adjunct system as it also provides water supply for irrigation. Most of the case study sites indicate that hydel systems are linked with agriculture, and the categorisation of an 'adjunct' system reflects the functional needs of irrigation and power.

Since 1962 the private manufacturing companies have been promoted by donor agencies to develop local capacity in manufacturing, fabrication and installation of this technology. Today, except for components such as generators, local manufacturers undertake various different mechanical designs of turbines and other parts. These include conductors, wire, cable, switchboards, insulators, arrestors, poles, transformers, governors, pulleys, ballast heaters and Moulded Case Circuit Breaker (MCCBs). Various other private suppliers and manufacturing companies have also emerged. The AEPC/ESAP-Mini Grid Support Programme (MGSP) has registered a total of 36 pre-qualified companies between mid July 2000 and mid July 2001 alone and lists them as companies qualified to undertake manufacturing, supply, installation and undertaking feasibility studies in Nepal. Out of these, 20 companies have been listed only to undertake feasibility studies.

Some of the leading companies based on past installation history are KMI, Krishna Grill and Engineering Works, DCS, National Structure and Engineering (NSE), TEI, Balaju Yantra Shala (BYS), NYSE, Nepal Machines and Steel Structure, Gautam Engineering, Agro Engineering, Housing Services Company and Universal Consultancy Services. These agencies have installed more than five plants in Nepal between 1962-2001 (ibid 2002). Now with the annual implementation of an average of about 60-70 schemes including various add-on plants, market competition between these companies has become strong. Some manufacturing agencies are also linked with certain prototypes of foreign design initiatives such as KMI and BYS with SATA, the Energy Systems with NTU, DCS with UMN, and KMI with UNDP.

In summary, tremendous effort by various actors and institutions has gone into developing the rural electrification sector in Nepal. However, whether focusing on a private village entrepreneur, a R&D model or a community operated system, all these have served, nonetheless, as learning models for the challenges and possibilities of community models. Design prototypes prior to the year 2000 maintained a focus on the production of small capacity turbines; therefore, the rise in peltric sets reached the peak. Recent design models are aiming for a higher capacity with the use of non-peltric turbines. Similarly the recent subsidy policy also emphasises the criterion to set aside a 10 per cent of the total load production for productive activities.

The Local Planning Interface: REDP/DANIDA/DDC-VDC

REDP

In the process of pursuing a 'decentralised' community-oriented model, REDP commenced its initiative with the creation of various structures at the central level to provide support to the micro-hydel programme (Bhadra 1998). At the primary level a Rural Energy Development Board (REDB) was established under the chairmanship of the Minister of Local Development. Other members of the board represented various ministries and line agencies such as Ministry of Forestry and Soil Conservation (MOFSC), WECS, ADBN and Federation of Nepalese Chamber of Commerce and Industries (FNCCI). While the objective of the board was to strengthen the linkages between various institutions, coordinate activities and provide policy inputs on issues related to rural energy development, it is unclear as to how their effort was involved in the process of decentralisation. In addition to this Board, a Management Committee (MC) was created to ensure that the implementation of REDP was managed in an appropriate manner. The MC consists of the representatives of the MLD, WECS, NPC and REDP. The AEPC is a special invitee to the MC.

Noteworthy of the process was the creation of two coalition network groups such as the Micro-Hydel Promoter's Group (MHPG) and the Rural Energy Consultative Forum (RECF). Both MHPG and RECF were created to share collaborate, coordinate, information and promote various linkages within the rural electrification sector in Nepal. MHPG included members from ICIMOD, ITDG, UMN, RADC, DANIDA and REDP. The RECF was created more as a consultative group that involved broader memberships of NGOs, manufacturers, producers and technical support institutions such as Royal Nepal Academy of Science and Technology (RONAST) and Research Centre for Applied Science and Technology (RECAST).

Clearly the REDP installations during the period 1998-2001 indicate a rapid diffusion of their 'community' model, which became the dominant 'decentralised' policy model for community-oriented systems at the district level. However, the 'decentralised' path commenced with the establishment of numerous agencies within the village, district and national level structures. For example in Kabhre Palanchowk district, at the district level and the VDC level a total of eight institutions have been set up through the REDP programme. These have included the Rural Energy Development Section (REDS) under the DDC. Other institutions at the district level, are the District Energy Committee (DEC), District Rural Energy Management Committee (DREMC), central level institution as District Energy Network (DENET), Support Organisation (SO) and Micro-Hydro Service Centre (MHSC). The Community Organisations (COs) and Functional Groups (FGs) were created at the VDC level. In some interventions the institutional set up of a 'cooperative' has also been introduced. For example the case study sites in Pinthali and Katunje Besi were registered as co-operatives towards the latter phase of the project intervention. The case study sites indicate that as these institutions were created simultaneously during the implementation period, their involvement was minimal in the decision making process of site selection and during the implementation phase. At a latter stage, institutions such as REDS coordinated with REDP and the VDC management team in the process of registration of the schemes as cooperatives. At the field level, ideally when a particular ward in a particular VDC puts in a formal request for rural electrification (that is for isolated micro-hydel systems), the request from the Ward chairman is put forward to the VDC office.

VDC local planning

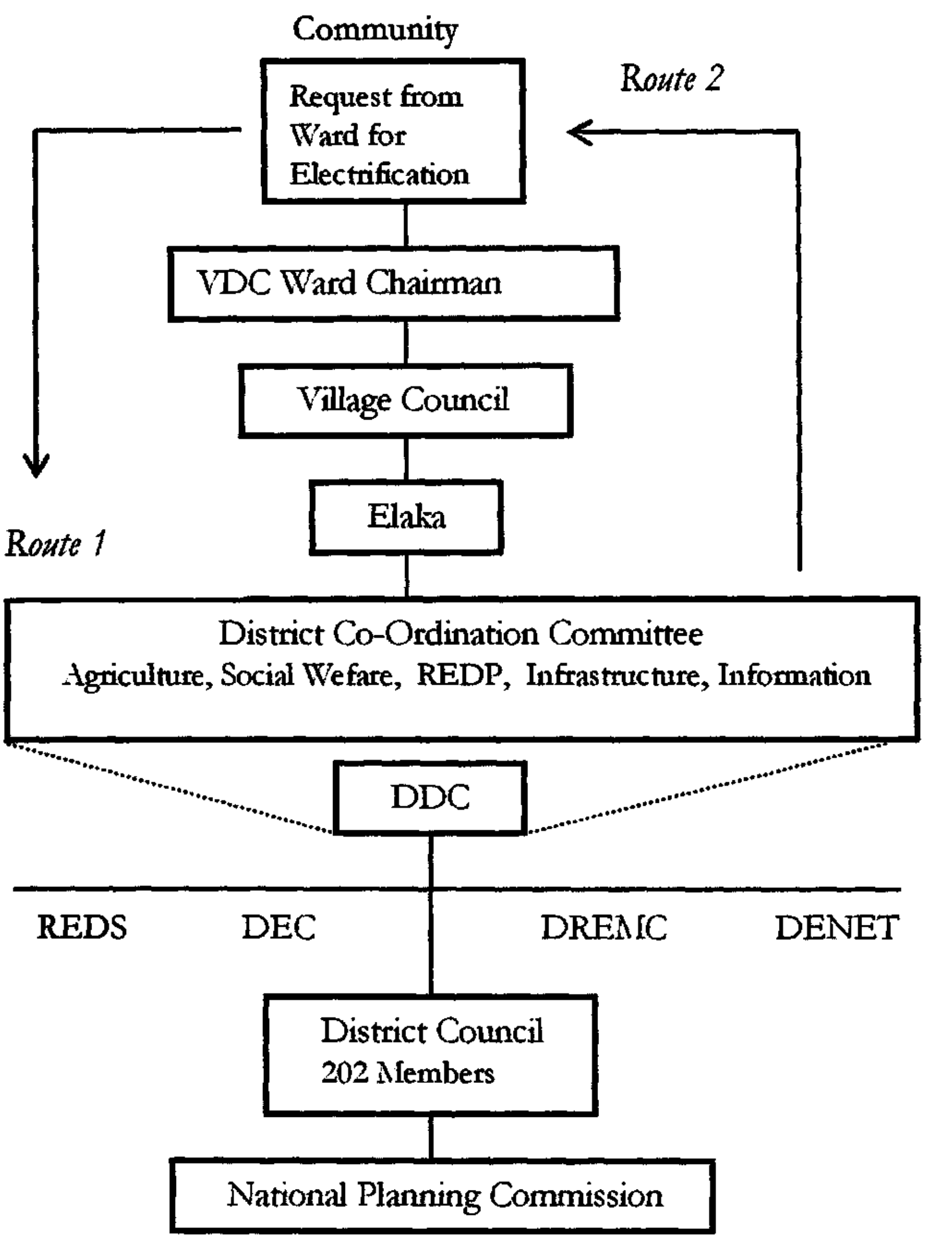
The above mentioned request is then presented to the Village Council. However, as the case studies will show, sometimes initial selection was made by the REDP, with retrospective completion of formalities. In certain areas, the Maoist groups also influenced and intervened in the decision-making process during site selection, implementation and also management stages. Under the standard procedure, after the approval of the VDC, the request moves on to a second level at the respective *elaka* (area), which includes the said VDC within its administrative geographical boundary.[11]

When a formal request by a ward to electrify the village gets submitted at the district level, this process begins when the internal District Energy Committee (DEC) and REDS conducts an initial feasibility study. The DEC was established by REDP at the district level to coordinate energy related activities within the district. The DEC includes the department heads from Forestry, Cottage and Small-Scale Industries, UNDP/REDP, ADBN and Participatory District Development Programme (PDDP) representatives as advisors as well as the DDC chairperson. This committee is perceived as a district-level co-ordinating committee for energy related development issues and in keeping the rest of district level departments within the loop of energy development. Various sectoral activities are also governed and coordinated with the formation of respective sectoral committees.

This preliminary feasibility study for the request of a micro-hydel intervention from a village is undertaken by DEC and REDS and upon completion is then forwarded to DDC. The DDC in turn advances the request for endorsement of DDC's decision to the District Council (DC). The DC includes the highest level of members and political representatives from a district. The DC meets once a year; its primary role is to endorse DDC's annual board meeting. In Kabhre Palanchowk district, the DC includes all of 87 VDC chairpersons and 87 vice-chairpersons, 3 mayors of Nagar Palika, 3 vice-mayors, the DDC chairperson and the VDC chairperson, 15 elected DDC members and 2 nominated representatives. The *samsad* (parliament) members from 3 zones are also included in Kabhre Palanchowk district. The council further includes all district level department heads such as agriculture, social welfare, information and infrastructure development sectors - and also the LDO, CDO, and the REDP energy advisor, who serve as observers in the process.

Figure 2.4 shows the summary of the village electrification planning/decision process.

FIGURE 2.4: Village electrification planning/decision process



When the DC approves the request from the ward, then further action takes place. The potential intervention then lies within the REDP district office for further studies and investigation of the proposal and the sites. The REDP office then assigns for the technical investigation. The district technical staff from REDP conducts a detailed survey and the feasibility study of power plants that have the capacity of 20 kW and below. If the system under investigation is above 20 kW, an external consultant is hired to conduct the survey. REDP attempts to adhere to their basic principles in making a decision for intervention.[12] After REDP has finally decided to intervene in a given area, the ball again moves back to the DDC for the management of the financial resources of the project.

In addition to this DEC, three members at the district level constitute another committee, known as DREMC, and presided over by the DC chairperson, Local Development Officer (LDO) and the District Energy Advisor (DEA). This member committee manages the District Energy Fund (DEF) and forms the district level signatories in releasing the funds for a micro-hydel intervention. Once the project is finalised, the contribution from various sources such as the VDCs, DDCs and REDP is put into the DEF. The DREMC deals with all management issues, also decisions on day-to-day management issues, consultations and referrals and undertakes minutes of the meetings.

At the village level, once DREMC releases the budget, a Community Energy Fund (CEF) is created for the finance. The signatories for the release of these funds at village level include the Functional Group Chairman, Functional Group manager and the DEA. Purchases involving a smaller amount get cleared within the village-level community organisations but larger amounts require the approval of the members of CEF. During the implementation phase, an annual audit is undertaken and the accounts are disclosed in an open community monthly meeting. Pinthali, Kusha Devi and Katunje Besi sites indicate that these meetings do not always occur at regular time intervals but only when called upon with certain pressing issues. These meetings rarely take place once the implementation phase is over and when social mobilisers withdraw from the sites.

Changes in the REDP model with World Bank funding

The commitment of the World Bank in the micro-hydel sector along with its macro-level soft loan package to HMG-N brought about distinctive changes at the district level. Along with the combined World Bank and UNDP support for operations and management, the REDP programme is currently envisaged to expand from 15 districts to 25 districts.[13] The project model basically adheres to the existing REDP structure except for certain funding mechanisms and hierarchical changes. As the World Bank money for rural electrification is tied up with the central government, this funding comes along with the creation of a new position at the regional level: that of a Regional Energy Advisor (REA) and a new fund, the Power Development Fund (PDF). Now, this role of REA operating from the regional level is envisaged to link up within the process of district level decentralisation. It appears more as a lever of budget control. However, it can be assumed that some justification also has to be made on the donor's part in terms of channelling the overhead cost of the funds, which will be an attempt to write off a portion of the soft loan within the macro level energy sector assistance to Nepal. For Kabhre Palanchowk district, the Central Region Energy Development Advisor (CREDA) would be ultimately responsible for the energy-related undertakings for all CDR activities. As with the previous UNDP funding, an UNDP/REDP staff member on secondment was assigned as a DEA at the district level to manage and oversee the programme. This regional level new control puts an additional layer in the institutions in district level rural electrification.

Currently, REDP is perceived at the district level as a rural electrification entity that functions in close collaboration with the DDC and VDCs. REDP has the autonomous authority to support or reject projects based on the various criteria laid out. In the previous arrangement, REDP along with the DDC and VDC also had the authority to release funds directly to the community. Now, with the World Bank funding, the process seems to have moved a step backward and a level upwards, with the creation of an extra tier. While REDP-created REDS will remain at the district level, the CREDA created by World Bank funding will monitor and supervise the energy programme in the district. With the new funding scheme, the DDC is made responsible to appoint the DEA from the government side, so that the signatories for finances come directly from central level of HMG-N. In this respect, the financial responsibility is given totally to the centralised DDC rather than involving a third party or, as in the previous case, to the community CO. The previous arrangement under the REDP programme gave it the authority to assume financial transactions with other government officials such as the LDO and the DDC chairman. The budget was then moved directly to the village level. This process is expected to continue after the funding moves to the district from the regional level.

Further changes with new DANIDA funding

The Phase I programme period of the DANIDA's involvement in the rural energy sector of Nepal ends in the year 2004. This period has seen considerable changes in the energy sector. DANIDA has assisted HMG-N to redefine the subsidy policy for Nepal in the micro-hydel sector and simultaneously opened up the space for further discussion in the rural electrification sector. In a longer time span, DANIDA's involvement in the energy sector envisages to remain active for the next 10-15 years (DMFA/ESAP 2000). Working in close coordination with the AEPC apparatus, DANIDA's strategy emphasises the promotion of the private sector and entrepreneurs in micro-hydel while simultaneously strengthening the bureaucratic apparatus. Through AEPC, it has generated documents and guidelines on the standardisation of micro-hydel technology components, information on manufacturers and installers and a database of micro-hydel intervention in Nepal. At times it does become difficult to disassociate AEPC from ESAP/DANIDA because in reality DANIDA's financial resources sustain AEPC. Therefore one can question how sustainable the institution is. For example, the total budget allocation for the first phase is 11.7 million DKK (USD 1.7 million)[14], of which about 2 million (USD 293, 565) is used to support the subsidy programme while the remainder is being utilised for institutional support (ibid 2000). Under the ESAP programme, the AEPC was established by HMGN in 1997 as a focal agency to oversee the promotion of RETs, which also includes micro-hydel.

The subsidy policy

In the year 2000 the existing subsidy was reformulated and two new policy documents were released. The first document of the subsidy policy proposed various subsidy schemes for RET (see Box 2.1 for micro-hydel). The second document illustrated the mechanism for channelling the subsidy funds. Subsequently new committees and management units were also created to align these changes.

The policy subsidy proposes different schemes for micro-hydel power, biogas, solar home systems, solar cooker, solar dryer and solar water pump. Under the new scheme, there is no subsidy provision made for improved cooking stoves and wind energy. Objective number two of the policy document states that the subsidy provision is made in order 'to support rural electrification as well as gradually reduce the growing gap of electricity supply and consumption between rural and urban areas.' In this respect, the subsidy policy provides a substantial support for the micro-hydel sector including additional provision for transportation and rehabilitation.

Box 2.1: The subsidy policy

- A subsidy amount of Rs.55,000 per kW is provided for new projects upto 3 kW capacity.
- A subsidy of Rs.70,000 per kW is provided for power plants that range between 3-100 kW.
- A subsidy of Rs.27,000 per kW is provided on add-on systems such as the Improved Ghattas, if the electricity is for village use.
- An additional transportation subsidy is provided for equipment and material handling where projects located at the distance of more than 5 days walking distance from the road head is given Rs.21,000 per kW installed capacity.
- Projects located at a distance between 2 to 5 days walking from the nearest road head is entitled to Rs.8,750 amount..
- Aside from the technical and transportation subsidy, a rehabilitation subsidy of 50 per cent and not exceeding Rs.35,000 per kW is provided for rehabilitation projects.

As the case study sites such as Kusha Devi, Pinthali and Katunje Besi were donor-assisted, these projects received a subsidy of over 70 percent. When the new policy structure came into effect, a rehabilitation subsidy was also approved for Katunje Besi site, which was encountering technical and institutional problems. Most of the REDP projects, as mentioned earlier had been receiving subsidy through two sources, the government and project funds. With the World Bank's involvement; the subsidy is channelled through AEPC.[15]

At the initial stage of the introduction of the subsidy policy, an interim fund at the central level was created to channel the funds. Subsequently, ESAP established this institutional apparatus as IREF at AEPC to support and administer subsidy for all RET. A separate board was also created to include representatives from MoST and the Royal Danish Embassy to govern the IREF. This board functions in close coordination with DANIDA's ESAP Steering Committee (SC). The AEPC and ESAP manage the SC through a secondary committee, which is known as the Executive Committee (EC). While the objective of IREF is to provide cash subsidies to micro-hydel plants, a separate delivery arrangement is established through a Mini Grid Coordination Committee (MGCC). In addition to the management unit MGSP, the IREF has the ultimate decision-making power to decide on the eligibility for subsidy. The IREF also has the authority to appraise the project by using the assistance of MGSP. The MGCC is chaired by AEPC Executive Director and includes members from the National Planning Commission, MGSP, leading NGOs such as ITDG, WINROCK, the private sector and financial intermediaries. This committee is responsible for the formulation of policies.

If we examine the number of private companies, manufacturers and installers that have emerged in the rural electrification sector, it can be surmised that the subsidy policy has been quite successful in creating and developing this market base. In addition the recent efforts has also created an abundance of committees and units to monitor and regulate installation with the expansion of institutions. However the installation of the plants has not quite followed the pace of the emergence of the manufacturers and installers nor the newly formed institutions. The case studies will also highlight that the quality of various electro-mechanical components has also been the culprit for numerous breakdowns. Despite subsidies provided, the success rate of micro-hydel plants is limited (Banskota 2000), therefore a specific anomaly arises for reflection on the subsidy structure. The subsidy thrust created a temporary surge in installation on the one hand and on the other also created competition that has led to 'low bidding' that often compromises quality control. If the idea behind a subsidy policy is to target the 'community' to benefit from a given technology, this has not quite been the outcome. The subsidy structure illustrates a centralised mechanism where 'control' is reflected merely at the Kathmandu and expert level.

District planning

There are two major development-plan documents for the Kabhre Palanchowk district: a Periodic Plan Document (PPD), normally undertaken on a Five-Year Plan basis and an annual plan. In addition, at district level periodic planning is undertaken from time to time and documented as minutes or notes of the planning process. There is no integrated energy planning mechanism or policy instrument for district energy planning. For the national transmission controlled by NEA, decisions are undertaken at the NEA central level for the rural expansion of their services.[16] However, a NEA district representative is also present in the PPD meetings. In this district level planning, energy needs are primarily pursued through micro-hydel systems - but documented less in terms of planning and more as implemented projects or a dominant donor's commitment. The only direct policy reference at DDC level for rural electrification is the mention of micro-hydel intervention in a document in the minutes of the DEC meeting. The newly created function of CREDA and the potential role that this position may play at the district planning level is perhaps quite crucial. The DDC is required to provide a mandatory 5 percent of the non-local cost as its share to the project for undertaking a micro-hydel intervention in the district. REDP has emphasised the financial contribution of DDC and VDC as an important contribution for the implementation of the micro-hydel schemes (Maharjan and Pradhan 1998). Likewise, by registering as a cooperative, the VDC is obliged to return a share of the profits back to the DDC. For example, Pinthali is the first case study site to have returned a 5 per cent profit back to the DDC.

In reality, as already shown from the VDC planning process, the energy planning gets documented after implementation is undertaken at the VDC levels. At the district-level, the energy planning process consists of four phases, which includes assessment, planning, implementation and monitoring. The first two phases are conducted externally by project experts through the collection and assessment of data of existing plants. These data then get converted into an Energy Situation Report. The energy report is basically an outline of the energy plan of a particular VDC or an elaka, which represents a number of VDCs that have implemented hydel projects. These data get cumulatively compiled at the district level, which on an annual or a five-year basis gets included within an overall district development plan and programme (Kabhre DDC/REDP 2002). It is also noteworthy to mention here that only those areas that have been selected for implementation of energy programmes - whether it is micro-hydel or solar technology - gets mentioned within the district report. Therefore documentation basically reflects a progress 'assessment' of selective sites and not an 'overall district plan'.

This fact is also illustrated by the contents of the Tenth District Council report of Kabhre Palanchowk district (Kabhre DDC 2001). This document also forms the basis for the Five-Year Plan of the district. Electricity is mentioned only on one occasion on page 12 where the creation of REDS at district level is highlighted. This report again describes the progress in terms of the number of micro-hydel plants and the committees that were formed during the process of REDP intervention. Nowhere in the district-planning document is rural electrification or the energy development of the district through other sources such as the national grid line mentioned. Likewise, the annual document has highlighted what has been achieved rather than what the district envisions to achieve. The PPD (Kabhre DDC 2000) for the current development period encompasses a time frame of seven years. In the PPD of the district, the rural electrification target is set under the planning process of environmental conservation and development, where the target for Kabhre Palanchowk district is expansion in 20 VDCs of REDP initiatives by the fiscal year 2006-2007 with coverage of an additional 4000 households. While NEA has set aside a budget allocation of Rs.117, 163 thousand (ibid: 98), the target set against the REDP allocation is not defined in the district document. The role of DENET (see Figure 2.4) as a district energy network institution that was created to co-ordinate the efforts of energy planning at the district level is unclear.

The District Energy Plan does not reflect the needs or the aspiration of the district nor its people, in striving towards a comprehensive energy development programme for the district.[17]

The number of interventions in a particular district depends on the budget already predetermined and defined by a certain aid package. In summary, the district policy planning of rural electrification scheme basically adheres to the regular endorsement process of HMG/N, which is a typical process for externally funded projects. This report eventually gets integrated within the national planning commission's report. For example, the VDCs together with NGOs collate and collect requests from various wards. These projects are then passed on to the central district level, which then pushes the request for special review to a specialised committee, the DEC. After the pre-feasibility study is conducted, projects are put forward for either approval or rejection based again on a second feasibility report by REDP. DDC provides the approval and the project is then submitted to the DC for final approval. This final step ensures that the project gets included in the annual plan and the budget allocation is processed accordingly. During the period of 2000-2001, out of 27 sites that had been approved by the DDC, only two were selected by REDP. While there are many positive instances where 'REDP' has functioned as a technical, political and social watchdog, ADBN has been unsuccessful in spending 50 per cent of the subsidy allocation.

Conclusion

In this chapter I have examined various policies and models in the electrification sector. The macro-level focus has remained on strengthening bilateral collaborations that can provide huge investments to synchronize the Indo-Nepal transmission lines, with the intention of selling power to India. The micro policy often reflects a 'tinkering' process for rural electrification through non-grid systems, which often times legitimise the macro level policy option. The micro-hydel sector is deeply dependent on and greatly shaped by donors. These have multiplied technology options but have also increased institutional brokerage between village and State often to highly confusing levels. These external brokers have also affected mediation between macro and micro policies, and subsidy policies, which have recently acted against micro-hydel.

Forums such as coalition groups that include technology users can cut across various sectors and diverse interest groups, and can help reform and change policy, as well as play a role in developing 'process' models of policymaking by fostering the participation of diverse local stakeholders. With the re-installation of a multiparty political system in 1990, public discourses and various schools of thought have increasingly questioned the current hydropower development paradigm of the state. Given the State's perspective on power and politics, I advocate that by understanding power, and the potential power of new coalitions in water management and technology issues, new ways can be generated to study policies and promote the democratisation of technology.

It is quite evident that on the ground, the rural electrification design, primarily through the implementation of micro-hydel, has largely remained as deficient systems despite continued liberalisation in the policymaking process. Mediocrity in technology design has been attributed to donor-pushed projects (Rai 1999), which has led to a lack of understanding of socio-technical issues and poor quality service. This mediocrity is also reflected in an overload of institutional interfaces where personal projects gets pushed through even if inappropriate. Micro-hydel technology within the RET category has marginalized the transformation of this technology. It has not only failed to deliver 'electricity' but also been unable to utilise all the allocated funds. However, it has been successful in creating manifold agencies.

To a village-level rural energy supplier or water user, the processes of democratisation, in terms of technological democracy and choice, are a long way from open debate and choice. There are successful examples from the field, primarily under the UNDP/REDP programme, where micro-hydel projects have operated as autonomous community cooperatives. However, there are also failures, as this study will show. These illustrate the complexities that need to be confronted and negotiated if energy policy and implementation of MHES is to be recognised as a process, and action developed accordingly.

Notes

[1] Weaver (1996) views policy formation from a perspective that considers power interrelations among policies and policy makers by emphasising the relevance of the history of past policies and the social relations among relevant institutions as a stage setter for ongoing policymaking. Thus, his view holds that the articulation process 'is a product of historical and

current policymaking and of negotiations among elites over self-serving policies', where a given policy ideology sets the policy agenda for a society. Policy diffusion is the transmission of the 'idea' to different levels of society and its acceptance in the different branches of bureaucracy. The policy making process is also said to work on the principle of 'survival of the fittest, where fitness is assessed in largely political terms (Hemple 1996).

[2] It was during this time when Nepal and British India's relationship was evolving in a dominant path, and out of this evolution electricity was first introduced to Nepal. In order to gain the support of the Nepalese polity, it was a strategic move for the British to provide the incentive to the ruling elite by 'lighting the palaces' with electricity. Other strategic political interests would then be negotiated, such as, the border patrol by the Gurkha soldiers and the recruitment of Nepalese men in the British India army.

[3] In order to coordinate and manage this effort, Chandra Shamsher Rana, who was then the Prime Minister, established an office known as 'Sri Chandra Jyoti Prakas' office. In 1934 the succeeding Rana Prime Minister Judha Sumshere Rana changed the name of the office to reflect his regime and the electricity office of the Ranas became known as Sri Tri Judha Chandra Prakash Jyoti'. By this time smaller projects such as the Letang Project were also in the pipeline.

[4] The Pharping plant of 500 kW is currently non-operational due to a dispute between energy and irrigation users. Another installation of 640 kW followed at Sundarijal in 1934. British engineers under the support of British-India bilateral assistance designed both these installations. There were no new installations until the 1960s. By 1988, twenty-one new small installations took place in the various parts of the country. Simultaneously, as early as 1962, small-scale interest in privately owned hydropower began growing with the introduction of a propeller turbine (Aitken et al. 1991). Problems with the design systems further prompted the investigation of alternative turbine types, which led to the development of the cross-flow design. Other design types such as Pelton and Turgo have also been introduced. Through R and D, more and more design experiments have been introduced in various parts of the hills of Nepal.

[5] This act removed the requisite for acquiring license for plants up to 1000 kW. However, this act introduced a new 'royalty' and taxing structure. A licensee is obliged to pay a rate of Rs.100 for each installed kilowatt of electricity to HMG-N per annum excluding a 2 per cent tariff per unit (per kW hour (kWh) production for a term of 15 years from the date of electricity generation. This applies only for commercial production of electricity. This royalty structure after 15 years of generation is further increased to a rate of Rs.1000 for each installed kW of electricity generated per annum in addition to a 10 percent of the average tariff per unit per kWh.

[6] The LEDCO model addresses energy development interventions with a two-track approach. Track 1 increases the capacity of the central grid under the control of NEA. In this track, small hydropower projects are implemented through commercial development by involving national and international private investors. With the enactment of the Power Purchase Agreement (PPA) of 1999, NEA has facilitated the production of energy through commercial development by independent power producers. Track 2 aims toward the development of decentralised and integrated renewable energy technologies through micro-hydels and other schemes.

[7] The Andhi Khola model of 5.1 MW capacity, uses three Pelton turbines of 1.7 MW each. Under the PPA, over 90 per cent of the energy produced are sold to NEA, which feeds into the 33 kV grid connection. Under the rural electrification centre programme, a 1 kV rural distribution system offers electricity to the rural consumers. A rural energy Users' Organisation must be formed in order to subscribe to electricity. An average allocation of 100 watts per household is granted.

[8] A Turgo turbine is an impulse type of machine and is very similar in design to that of a Pelton turbine. However, as this design is suitable for high head systems, the blade shape of this turbine is more complex as the jet is usually designed at an angle to control the water flow. Because of the design complexity, a Turgo design requires precision in fabrication.

[9] While the propeller turbine is not a new innovation in Nepal, the high head Turgo turbine installed in Pota Khola in Katunje Besi has encountered design difficulties - primarily because of the extensive and sinuous temporary canal system which includes very basic civil works and temporary structures. Pota Khola is a wild river and the dam and canal structure encounter problems annually.

[10] The traditional simpler designs of single jet micro hydel systems are gradually being replaced by multi jet machines because multi-jet turbine has advantages for water control, has high rotational speed, reduces surge pressure and decrease in blockages. A turbine is categorized as multi-jet or mono-jet depending on the number of nozzles in the system that discharge jets of water that strike to produce electricity.

[11] The Kabhre Palanchowk district has 15 designated elakas. Each elaka has a *gosti* (committee) that meets every six months. After the elaka approves this process, the request finally moves to the district level with the DDC.

[12] The criteria for feasibility and selection of sites have included various factors. The selection process is based on a set of 12 criteria, which lists the theoretical output in kW as the first criteria (Q = H x F). Various other factors have been mentioned such as canal length, canal cost, use of water, distance from the road and availability of materials. One stated criterion is also 'where the possibility of connection through the grid line or national transmission line does not exist within the projected five years of completion of the project'. A VDC's willingness to provide financial

matching, voluntary labour and local material, the proximity of the village to a water source, and the potential water discharge in terms of height and flow and the leadership skills available within the local level institutions are also included in the selection criteria.

[13] UNDP is supporting the operations and management cost totaling up to US $ 800,000 and the World Bank has committed US $ 5.5 million for this effort as a grant package.

[14] 1 United States Dollar (USD) = 6.81 Denmark Kroner (DKK) as per the exchange rate for August 29,2003.

[15] A recent monitoring and evaluation of subsidy releases for RET programme, indicated that some manufacturers in particular with biogas schemes were found to have taken subsidy from AEPC for non-existent schemes. When the monitors visited the village and site of the implemented scheme, they discovered that in some cases the technology had never been installed and at times the villagers were unaware of any previous discussion of schemes. *Personal Communication* with Saroj Lal Shrestha, East Consults, April 2003.

[16] Informal discussion with NEA officials at the Central Office also indicated that the path of 'privatization' currently pursued by the department and 'rural electrification' through the national grid are mismatched development concepts. Therefore, rural electrification has been neglected as a sector and perceived as not fulfilling the long-term goals of NEA's privatization objectives. Thus it has been easy for NEA to sideline this sector. It is therefore not surprising that the rural electrification sector has been taken over by the donors and the NGOs.

[17] The national plans, have as a general rule of thumb planned for a target to achieve a generation of about 5 MW of electricity with the installation of micro-hydel systems, however this has not always been achieved.

3

Rural Politics and Social Transformation

From Shangri-La to Friends from the Jungle

> *Sanjha pare pachhi-ta aba bijulee balna chodeyon; sabai daraunchhan; eka teera bata army aunchan, arko teera bata jungle-ka sathi-haru aunchhan.* We have stopped switching on the electricity in the village in the evening because we are afraid; the army comes from one direction and the friends from the jungle from the other.
>
> Anonymous, Pinthali, December 2001

Introduction

This chapter examines some wider societal forces, which are shaping and responding to social change in Nepal. It presents some key structuring ideas and associated agents in this wider change, as seen in rural transformation, politics and governance but also in the symbolism of violence, conflict and identity, which are touchstones of communication and self-realisation. Changes in ideas can be pursued intellectually but are also driven by social movements of various kinds. The approach in this chapter in understanding these changes is threefold. Firstly, the identity of Nepal and a Nepali is examined within the context of ongoing conflict and violence by briefly examining the historical processes, culture and society. This book attempts to reconstruct the Nepali identity. Secondly, the eras of village development and national planning is alluded to, in particular from the perspective of the external agencies and technological change by looking at the industrial and manufacturing relations that external relations have brought into Nepal and the imagery they have created.

This thesis prefers to avoid the detailed review of approaches to rural development and reform of government more commonly cited in literature but rather maintains the focus on technological structuration. In discussing technological change a brief overview of the conflicting discourses on development on Nepal is provided by juxtaposing with an overview of key political changes in rural governance and politics. Thirdly, the Maoist movement is examined, as it has interacted with these politics of identity and the wider development apparatus and water resource management structures in particular.

Building social movements from conditions of social disorganisation and isolated and alienated segment of society is not unusual. The Weberian view highlights that the success of social movements rests on resource mobilisation either through charismatic leadership or the resources available to them. The success of social movements also depends on coalitions, campaigns and political pressures. Hydropower has been an important agenda point and practical focus of the Maoist movement. It has also been a means to highlight understanding necessary of local politics and cultural and political expressions of power.

Destruction of new technology and violence against key actors is not uncommon in water in various cultural and political contexts. Technology symbolises the creation of actors that also represents their actions. Technology in a moral economy also suggests how these actions can be constraining or liberating because norms that govern the economic activity of technology get overridden and compromised by moral considerations. Then technology, from a moral economic standpoint, raises the subject of equality and social justice and the norms that influence such economic activity. Hence, technology is also attacked for its symbolic manifestations to violence towards technology as a manifesto that citizens be free to make their own choices under the established rules of certain accepted sets of actors as it also affects their economic activity. Technology further assists the attackers to evaluate the economic activity generated by the technological arrangement and how the actors have shaped the actions. Unlike an attack on 'people', attacks on technology can represent opposition to a particular form of technological regime and a quest for reform.

This chapter examines the Maoist movement in Nepal, and its activities in Kabhre Palanchowk district, as they exploded into local action during the period of the fieldwork. It then looks at the genesis of the movement briefly at the national level, then the district level of Kabhre Palanchowk and finally at the field level. By providing examples from the field, the book then describes the effects of the struggle on the community and the dichotomy of conflict on social relations in the strife for a 'People's War'. The last section of this chapter links with the hydropower and water management review of the previous chapter.

Culture, Society and Individuality

Conflict and violence often indicate the manner in which collective action takes place, unfolding the hierarchical social and political power relations that generate social identities with meanings. They can explode as these are relating and identities change and get influenced over time. Therefore, the cultural and political aspect of violence can also become euphemised as 'shields' that link with communicative tools such as symbolic language, actions, metaphors and visual effects. Such shields may even mask, represent and conceal the nature of violence and new technologies often allow such masks to slip. Violence also shapes group boundaries and can become important in negotiating collective and personal identities. Violence also helps define the context in which the conflict takes place (Gilsenan 2002: 101), promoting a sense of belonging and a temporal sense of history. Conflict and violence are about identities either in individual or collective form. They also represent quests for recognition and justice for groups previously oppressed and exploited by earlier social relations.

The creation of such boundaries is reflected in the opening quote of this chapter, which not only conceals the social relations but also accepts the fact that conflict and violence are omnipresent. The term '*jungle ka sathi haru*' (friends from the jungle) used to describe Maoists represents both an open and a cautious way to refer to the movement, than can encompass attitudes and sympathies for and against them, keeping each other in thrall. The expression also symbolises an orientation to a given social environment of conflict. The shape of identification relates to the social foundations that direct the historical and social construction of collective identity and how this relates to kinship, a spatial and temporal unit of community, a socio-economic network and to a nation-state. In this respect, identification is about exclusion and inclusion. Identity illustrates 'who we resemble and who we differ from' (Jenkins 2002: 117), where similarities and differences become important elements of social identity.

This thesis asserts that a Nepali and Nepal is a socially constructed product of a *khukuri*[1] (knife) and a *Gorkhali* culture. This khukuri culture has constructed a product as 'identity', a resultant of a process of identification (Regmi 2003a). Therefore, there is a streak of violence ingrained in this characteristic either in a dominant or recessive form. The general perception that the Nepalese are inherently peaceful people is really a misconception that has resulted with an intermingling of a historical process, modernisation and the politics of development. There is a direct relationship between the social process of identification and its product as identity (Jenkins 2002: 118). These social processes have contributed in this identity formation of Nepal[2] and a Nepali. This chapter attempts to unfold this construction of identity, by providing three specific processes that have contributed in this identity formation. First, the discovery of Nepal by the British India Raj fostered a myth of isolation that promoted the romanticisation of a khukuri culture. Second, the new beginnings of a nation-state introduced the politics of modernisation and development, by creating the identity and character of unexploited and orderly Shangri-La amenable to planned development which image international development also promoted and worked with. Third, historical cultural subjugation, globalisation and lack of democracy revealed the struggles of being a citizen of Nepal. This book argues that these three processes of identification have contributed in the germination and promulgation of the Maoist movement in Nepal and contemporary impasse for development work in general and micro-hydel in particular.

However, the image of the '*Gurkha*', and with the khukuri is not just of violence per se. The image is also of a person and society that have developed skills and tools to survive and even thrive in a difficult environment, and that these older traditional artefacts still have utility and meaning in contemporary society. They are also about people who follow orders and are capable to work across new coalitions of states and agencies. These meanings signify that people are resilient and resourceful as well as perhaps ruthless in defending and pursuing their society and interests. There exists not only a èsprit de corps in this image, but also links with the moral responsibilities and restructuring of the moral economy which is reflected under the various regimes including the caste system that is being mentioned in the forthcoming chapters. Different aspects of this identity and individualisation are not only declared by Maoist actions but also find a place in the army, the state and the community. This chapter attempts to unfold this interplay of culture, society and the individuality of a Nepali.

Khukuri culture

There is no precise time in history that traces the existence of khukuri in Nepal, but evidence suggests that it has been in existence since at least the 7th century BC during the period of *Kiratis*. Further, evidence suggests that there is a close resemblance in the physical features of this knife with that of a classic 2,500 years old Greek *kopis* (sword). Another theory proposes that when the troops of Alexander the Great invaded north-west India in the 4th century BC, the local *kamis* (black smiths) crafted the cavalry *Machira* (sword), which is an ancient Macedonian sword that was carried by Alexander's troops.[3] Every shape and component of this knife has some religious and cultural significance. The curve of the blade is said to represent the symbol of Nepal with its crescent moon. The *kaudi* (notch in the blade) near the hilt represents the trident of the Hindu God, Shiva, the reincarnation of destruction and re-creation, who slays foes obnoxious to his followers. The handle is usually made out of wood or animal horn.

Oral history and local tradition provide ample examples of the significance of this knife in day-to-day life. A khukuri is used to butcher buffaloes with one stroke during the annual ritual of the important festival of *Dasain*. We even worship the knife with a holy *tika* (vermillion). We keep the knives fully sharpened at all times and even sleep with the knife under our pillows. Similarly our quotidian vocabulary abounds with idioms and riddles that signify the importance of khukuri in a Nepali life. Some of these sayings convey a powerful message of identity. For example, while phrases such as these, illustrate the remnants of violence within our inner personalities: '*khukuri ma dhaar lagayeko jasto*' the analogy of the sharpness of the blade, '*khukuri jhikyera chyatta pardin chu*' the act of taking a khukuri out and hurting someone. Other phrases such as '*achanu ko pir khukuri le jandyaina*', (a khukuri cannot understand the pain of a log that is used for cutting),' *ayi lagne lai jai lagno parcha*' (have no mercy on those that pounce on you), also illustrate forms and modes of resistance to violence.

History has now shown that the general perception of a mythical Gurkha with a mythical knife and from a mythical land, Shangri-La could always do as commanded, obviously has been proven wrong. The highest example, the Royal Massacre of June 2001 perhaps indicates that the politics of identity and repression, when combined together can be a lethal force. The young generation of today is a creation of this cultural dichotomy of a Nepali: a new sociological 'cult' that can no longer be commanded by mainstream controllers. Therefore, a khukuri has had a significant role in creation of the nation-state and of an individual.

The outside world, for the first time, noticed Nepal and a Nepali only around 1800s when in 1850 Jang Bahadur Rana became the first envoy from Nepal to visit England and France. This was a defining moment for the development of political history between Nepal and British India when Nepal offered assistance to the British in 1857 to quell the Indian Mutiny. It was in 1950 when Nepal was finally exposed to the outside world when the Shah dynasty restored its sovereignty from the clutches of the Rana regime with the collaboration of anti-Rana forces based in India.

Gorkha, Gurkha and the foundations of a nation-state

The creation of a nation-state all began with the Gorkhali King in 1768 from a small town of Gorkha. Today this act personifies a Nepali as a soldier with the Anglicisation of *Gorkha* as a place, to *Gurkha* as a person. In Nepali, a person from Gorkha is known as *Gorkhali*. Gorkha, currently a district of Nepal and it is from this area that the first King of Nepal, Prithivi Narayan Shah united all small kingdoms to form one nation-state of Nepal. Therefore, the idealisation of a Nepali began with this historical event. A few years later, after the Anglo-Nepal war of 1816, the colonial powers converted Nepal into a quasi-British protectorate. By 1923, the British Raj had formally recognised Nepal as an independent state while the foreign relations of Nepal had remained under the total control of British India.

As an individual, a Gurkha had already been noticed in 1814 during the Anglo-Nepal War that lasted for two years. After the war, under the peace agreement, provision was made for the

Gurkha to volunteer for service in the East India Company. In 1815, these first volunteers were recruited to form the first regiment of the British-Indian army. The Treaty of Segowlee of 1815 established an agreement between Nepal and British India. However, it was only in the mid 20th century that the Gurkhas came into the international limelight along with their abode of the imaginary land, the Shangri-La.

Shangri-La was first termed by the English novelist James Hilton in 1933 to describe his 'imaginary' land in his novel Lost Horizon. The politics behind the conquest of the Himalayas and the Everest was at its peak during this period. The English had been involved since the 1900s in conducting the survey of the Himalayas both from the Tibetan and Nepalese sides (Hagen 1994:76). Various attempts were made to scale the Everest and coinciding with the publication of 'The Lost Horizon', the British Alpine Club and the Royal Geographic Society made attempts to climb the peak in 1933, 1934 and 1936 from the Nepal side. It was perhaps the film 'Shangri-La' which made the wider impression. Some of the critical aspects of the book and the film can be compared with that of Nepal. The book is set in a mountain area and is inaccessible and is remote and even makes reference to a valley containing a lake, presumably the Valley of Kathmandu (Hilton 1998:129). The population is largely staged as a passive and 'content one', who is willing to trade security for gain and excitement. The ruling power is benign and quasi-religious where the head Lama is neither Chinese nor Tibetan. The book celebrates external intervention. The book further celebrates tutoring change in technology and knowledge. The book carries a rather conservatism and political message like other Hilton books 'our future lies in our past, conscious commitment through a political public service' within a local governance structure surrounded with mediocrity.

Shangri-La

The Encarta English World Dictionary defines Shangri-La as 'an imaginary and remote paradise on earth'. It was a sheer coincidence that this figment of imagination was borrowed to describe Nepal, which went way beyond to provide a tangible nation territory as an imaginary one.[4] Examples of studies undertaken in Indonesia and the Philippines also indicate how communicative tools in the form of census, map and museum were constructed as institutions during the Dutch rule to 'profoundly shape the way in which the colonial state imagined its dominion' (Anderson 1991:164). This imagination shaped the human beings that were ruled, the physical boundaries of nation states and as well as the legitimacy of the ancestry. However, a well-known Nepali historical novel 'Wake of the White Tiger' (Rana 1984) casts Nepal entirely in a different arena. Here, the Nepalese dissociation with the Tibetan and the high Himal culture is quite evident. The novel primarily revolves around plots, intrigues, conspiracies and counter-plots at palaces and parliamentary level and is about violence and power. Women are put in starkly different roles and are as consciously portrayed as Bollywood film stars, although in reality women don't win much.

World War II and the 1950s coincided with the globalisation of a Gorkhali's participation in world wars in France, Malaysia, Borneo, Cyprus and the Middle East. The Gorkhali behaviour was also in sharp contrast to the British experience of guerilla warfare and some Indian soldiers in India and Burma during World War II. The various reflections and perceptions, created an image of a Gorkhali as 'plucky', ruthless, brave and resilient in difficult terrain. The image externally does not always include the knife but is promoted by the military. Therefore, it is symbolic that a Gorkhali soldier is allowed to keep this knife as part of identity within wider army apparel and armament. The politics of construction, therefore, can also be attributed to the politics of globalisation and modernisation in the wars where Nepalese have fought as neo-colonial mercenaries including the Falklands and Iraq at the time of this thesis writing and has been strengthened with external development intervention in Nepal. Yet, with all the changes, a Gorkhali is still tied to the Treaty of 1947 and loss of their legal battle for the equal treatment of a Gurkha soldier in the British army indicate the gaps between what Habermas (1998) has termed as the tension between 'facticity and validity'.

Beginnings of Rural Transformation

Nepal under the Rana regime became involved in trans-border negotiation of trade and water share. In addition with geopolitics during and after World War II came Indian and other independence from colonial rule, and tourism began to develop.

The 1950s and the 1960s became important in the history of Nepal due to dramatic changes in the political structure, which not only laid the foundation for modern day development of the political economy of Nepal but also defined the shapes for bilateral and multilateral development intervention in Nepal. The first rural development and planning was initiated in Nepal in 1952. The first Five-Year Plan was launched in 1956 under the guidance of the USA and India as donors. A planned development approach was adopted based on Lewisian economic development model[5] of industrialisation-led-growth. The Panchayat System was introduced in Nepal in 1960 where the programmes and interventions were under the control of the directives of the King (Paudyal 1994). During this regime, seven various plans were undertaken and the last two, the Eighth Plan and the Ninth Plan were undertaken in the post-1990 democratic period. A multi-party system was introduced in 1990. Most of the development plans maintained the primary focus on 'rural development'. Those that were implemented during the Panchayat era were perceived not to act as catalysts for change but rather to assist the decentralisation scheme of a new era in order to collaborate with the Shah regime. The Decentralisation Act was promulgated in 1982, where under central technical guidance development planning was encouraged at the district and village level. However, various contradictions were manifested during the implementation, as such initiatives became just a reflection of the old structure. The period beginning 1991 has been an era of reflection where Nepal's rural development and development policies are seen as a state mechanism that has alienated the process of governance. In 1999, the Local Self-Governance Bill granted more autonomy to local government institutions.

At the outset, technology development was also pursued following a Lewisian model where policies included the expansion of power facilities and established industrial parks in Kathmandu and West-Central Region of Nepal. For example, the foundation of BYSE and some other hydel manufacturing companies can be traced back to the history of the development of industrial parks. The NIDC was established in 1959, which provided financial assistance for the development of medium and small-scale hydel technology development. Thus, technology development was also pursued in a similar manner where international agents and agencies thus collaborated with the bureaucracy and became brokers in the creation of a new political economy of Nepal. The technology development in rural and remote area concentrated primarily on the construction of suspension bridges, micro-hydel systems and technical assistance in agricultural transformation. These were mainly supported and supplied by workshops from Kathmandu and Butwol under the supervision and guidance of foreign technical experts.

In the history of technology development in Nepal, it is the spatial and temporal analogy of Shangri-La and more recently the 'empowerment' paradigm that has dominantly shaped and influenced various 'foreign' institutions involved in development intervention. Such an image is also visible in the writings of Tony Hagen, perhaps the foremost 'development guru' of Nepal. Surreal, yet tangible images are vividly portrayed in his books '*Nepal*' (1980) and '*Building Bridges to the Third World*' (1994) and these images have contributed in the politics of rural development (Regmi 2003b). Hagen provides various allusions to technology development assistance in Nepal, primarily with the Swiss government funding. The contribution of SATA/HELVETAS and SKAT's (Swiss Federal Institutute of Technology) in technology design and diffusion primarily in suspension bridges and micro-hydel sector is acknowledged as a positive step in design and diffusion and providing rural access to technology development. There appears to have been planning of technology development in terms of defined spatial territories where for example SATA decided to keep the focus in developing technology in certain geographical locations, however the planning in developing the local bureaucratic structure did not accompany the process. In a similar manner bilateral agencies, such as DFID and USAID also maintained this focus at specific locations for example while USAID concentrated in the Western zones of Nepal, DFID's implementation of programmes were centred around the Eastern zones.

Today, Nepal has been made synonymous with Shangri-La, obviously the roots of a heritage inherited from the British-India colonial era but exploited for economic gain and geopolitics. This strengthening of identification was further cemented with Nepal as the country increasingly became exposed to development aid, which catalysed in spreading a false assumption of an 'imaginary land'. Despite all the interventions the UN Human Development Report (UNDP 2001) indicates that Nepal is home to 10 million people living in absolute poverty where Human Poverty Index (HPI) ranks Nepal 77th out of 90 developing countries.

Various modes of intervention and poverty review by 'foreigners' has hardly ever linked with a review of local politics except more on how 'they should be'. While, indeed the overall failure of rural development in Nepal is linked to its dependency on foreign aid and foreign institutions, it is the construction of the politics of rural development that is significant. However, there have been individual success stories as well as a lot of genuine commitment. In *Nepal in Crisis* Blaikie, Cameron and Seddon (2001) use the theory of 'centre-periphery' relations to describe under-development between Kathmandu and the rest of Nepal. This analysis is also useful in understanding the relationship between India and Nepal and between bilateral/multilateral agencies and Nepal as a State. While their book does not provide much analysis in governance and poverty issues with regard to village voices and democratic options, it perceives the Maoists movement as a response to Nepal's underdevelopment.

The current conflict between the State and the Maoist movement is provided in a compilation of ethnographic studies (ed Gellner 2002), however the narration fails to capture the local rural politics vis-à-vis rural development and resistance. Some Nepalese authors have analysed the failure of Nepal's development process with a socio-cultural insight. For Bista (1991) the culture of 'fatalism', a cultural system of 'various forms of dependency', has not only retarded Nepal's productivity but also undermined the roles of caste and ethnicity by camouflaging the strengths of indigenous qualities of various groups. Fatalism in Nepal is accepted as an overriding justifiable clause that legitimises class and caste segregation within a given structure and cuts across all social relations. However, the pervasiveness of fatalism is not totally the only element that has undermined the productive sector. Corruption and nepotism has also played a prominent role in weakening the development structure (Thapa 2002a), undermining the democratic process for change. The prevailing conditions furthermore legitimised donor approaches and the accompanying texts to create a dominant development culture of Nepal. Therefore phrases and words such as 'community mobilisation', 'empowerment', 'participation', 'gender mainstreaming', 'ethnic inclusion', 'decentralisation' and 'local governance' become political constructs woven together in the name of development, while a very different set of dynamics and conditions existed in practice.

The changes in Nepal since 1990 have been overwhelming, even for the political astute to digest holistically. While democracy has set the stage for these rapid changes to occur, the break between the 'centre and the periphery' has also occurred with the freedom of press in Nepal. The newspaper '*Janadesh*' that represented Maoist views was widely circulated all over the country, including the remote hills of Nepal. While State politicians on one hand were busy settling their political squabbles, their underestimation of the wave of democracy that was sweeping over the rural area led to the misjudgement in responses. An analysis of the Maoist movement, within the role of polity, has linked the centralised political structure and political culture of Nepal as contributing to the impact of the movement (Lawoti 2003), alienating the community further in the process. However, the movement had its own structure and its own culture, and technology could be used as an effective tool in integrating the community. A controversial development intervention that was also a powerful symbol such as the hydropower sector in Nepal, became a tool in the quest for control over resources and for the accumulation of collective action.

The Genesis of the Maoist Movement in Nepal

The roots of the Maoist movement in Nepal are traced back to the communist party of Calcutta in 1949. The political process has been a sorting and reforming of groups in the formation of a cohesive ideology. The evolution has meant various splinters, unification and re-unification during different historical junctures in the expansion of the movement. With the institution of democracy in Nepal in 1990, various communist political wings that represented ultra-left, left, centre and right ideology asserted their political 'identity' formation as a single communist party of Nepal. Thus the many factions and splinters came to a common platform in 1991 when the existing parties joined hands together to form the Ekata Kendra or the Communist Party of Nepal-Unity Centre (UC). Out of UC emerged a political wing, which then became known as the United People's Front (UPF) under the chairmanship of Dr. Baburam Bhattarai (Thapa 2002b). This was also the period when fully-fledged planning for the movement began. The primary distinction made between groups came along two separate paths: proponents for an intellectual movement versus proponents for a militaristic ideological movement.

The planning for the 'People's War' with a military platform is traced back to the Nepal Communist Party of Nepal (CPN) in 1974. During that time, CPN under the leadership of the founding member, Pushpa Lal Shrestha, held the Fourth Convention of the party. This convention became the defining platform for the formation of today's movement. There were two specific groups that emerged out of this congress: one that supported a 'People's War' and the other 'a mass uprising', the former led by Pushpa Kamal Dahal pseudonym Prachanda, and the other led by Nirmal Lama. Based on the ideological difference, the ultra left became known as the CPN-Fourth Congress and the CPN further split in 1983 as CPN-Masal and CPN-Mashal. Going back again into the ideological differences of People's War versus the proponents for mass uprising: Prachanda remained with the ultra left (Mashal) whereas the movement for mass uprising came under the leadership of Dr. Baburam Bhattarai (Masal). From 1991, UC adopting an ideological path of Marxism-Leninism-Maoism has embraced the People's War. In February 13, 1996 the Maoists began an armed rebellion in the name of 'People's War'.

Even though the first offensive started in 1985 with organised attacks in the Kathmandu Valley[6], planned attacks took place again almost after a decade. It can be surmised that the period between 1985-1990, the Communist Party itself was evolving in the search for its collective identity. The movement was carried forward in three different strategic stages such as strategic defence (which is ongoing), strategic stalemate and strategic offence. Strategic defence phase further included two separate plans for initiation: development of guerrilla zones and development of base areas. With this official declaration, the training of guerrilla activities in two-hill districts of Mid-West, namely Sisne in Rolpa and Jaljala in Rukum began. This programme was known as the 'Siege Campaign' and was undertaken largely by mobilising the ethnic backward community of Magars. Parallel to this training, the State initiated a counter programme, which was known as the 'Operation Romeo' to quell the rebellion of the 'People's War'.

The initial years followed with a nation-wide accelerated dissemination of various publications through media: newspapers, articles, the Internet, posters and pamphlets under the publicity campaign. The official Maoist slogan therefore, mobilised the rural community with the propaganda of 'March ahead on the path of Peoples' War by overthrowing the reactionary government to establish a new pro-people government'. In the following years, after the revolution had built up momentum, political slogans such as 'Strengthen and extend the base area and local pro-people government' and 'March forward for the formation of national peoples government' sent powerful messages across the country. By 1998, the armed rebellion of underground Maoists movement had significantly gained momentum. This phase also saw the use of more coercive war like tactics including obliteration of people, extortion in cash and kind (food) and destruction of property became the focus, often time combined with sensational violence. Maoist activities then, had accelerated in hill districts, in particular in the central hills. To quell this movement, the government started the '*chakrabyuha* operation' around November of 1997. This campaign particularly focused the districts of Kabhre Palanchowk, Dolakha, Ramechap, Sindhupalchowk and Sindhuli districts of Bagmati and Janakpur zones. This counter attack was then followed with another rebuttal by the State with operations such as Kilo Sierra Two (1998), which inflicted considerable damage on the movement and confiscated arms and ammunition from the movement. Subsequent State intervention also led to conducting campaigns, such as 'Silent Kilo Sierra Three and 'Jungle Search' operations. In these campaigns many non-politically affiliated community members and innocent victims were also affected, detained and killed.

Between 1996 and 2002 various actions were undertaken on the ground either in the form of 'fight for freedom' or retribution against State operations, in the name of 'People's War'. In a similar manner State campaigns to quell the movement provided ample actions of communicative forms for observation. The Maoist movement perceived the 'law and order' problem of the country as a 'socio-economic problem of extreme poverty and exploitation in the rural areas' (The Independent 1995). Hence, violence is also justified with the difference made by eliminating 'the class position' and not necessarily eliminating the 'class enemy' in the physical sense. However, this ideological viewpoint has not necessarily reflected at the community level. This is where a struggle between lifeworlds and systems is visible. This tension has affected some of the case study sites, where for example requests for donations in form or kind has led to the control of techno-political institutions making managers and operators abandon the job.

If we examine some of the actions propelled by the Maoist movement at the community level, the culture of khukuri as expressions of the inner and outer identity is prominently conspicuous. Violence has been utilised in the elimination of the class enemy in the physical sense. In a similar manner, women and ethnic groups have also been constructed to herald political platforms and adopt militaristic ideology by the state and the movement. It has been largely acknowledged that the backlash of various police atrocities on women rebel captives has created the emergence and strengthening of a female cadre and female guerrilla squads within the Maoist movement. In a similar manner, the stereotyping of a 'Tamang' youth or a *Kham Magar* of Rolpa, as a suspicious rebel has also led to the strengthening of the *janjadi* (ethnic)[7] platform within the movement.

The Maoist movement in Nepal and the State campaigns to quell the movement have both manifested territorial strategies in different forms. In this process, the community has been caught in between the power struggles. The platforms of gender and ethnicity have operated as strategies of 'add more fuel to the fire'. Whether State instigated, or a fight in the 'People's War' violent acts are perceived as 'honourable shields' and have been deployed to legitimise claims. In the next section, I argue that violence is not a rational character of a democratic process but rather a deviant that conceals greater social inequalities. Social movements build around charismatic leadership also causes social changes. Legitimate claim in a democracy becomes an institutional procedure that has the capacity of transforming the citizens to assert their rights through communication and participation. Violence creates the tension between 'validity' as an ideological claim and 'facticity' as an empirical claim.

The Interplay between the Maoists and the Government

The social and political turbulence the country encountered in this single year of 2001, in aggregate terms, perhaps, surpass the social, political and economic upheavals Nepal has faced during the last twelve years of democracy. The massacre of Nepal's Royal Family of King Birendra Bir Bikram Shah and of the immediate heirs to the throne took place in the Naranhiti Royal Palace on the evening of June 1st 2001. The curse of the Royal ghosts cast a spell on Girija Prasad Koirala's floundering regime, which was then replaced by that of Sher Bahadur Deuba. The NC administration was then challenged to negotiate with the Maoists movement. The Deuba administration initiated a dialogue between the government and the Maoists on July of 2001. The Maoists, who had been in opposition to the NC administration of Koirala, welcomed the process for dialogue. However, three rounds of dialogue proved futile and without conclusion, and the ceasefire was called off when the movement launched massive attacks in November of 2001 in the district headquarters of Dang, Syangja and Solukhumbu. The Royal Nepal Army barracks were also attacked and heavy damage caused, with a corresponding seizure of sophisticated weapons from the army. Following this incident, the government imposed emergency rule for three months throughout the country and initiated three policies. This was the first time when the army was mobilised in Nepal against the Maoists with the imposition of emergency rule. Then the Maoists were labelled as 'terrorists' and the Terrorist and Destructive Activities (prevention and control) Act to control and persecute the Maoists was implemented.

In January 2002, following US Secretary of State Colin Powell's visit to Nepal, the Nepal Rastriya Bank, announced the freezing of all the accounts of Maoists. In March, the government again succeeded in getting an 'emergency' imposition endorsed from the parliament for an additional three months. During the period, the press releases from the Defence Ministry stated that on average around 10 Maoists were being killed everyday. The validity of such statements, the political affiliation of those being captured and even the press releases have been questioned by many. The estimated number of dead seems to vary but has increased substantially to over 4050 Maoists and over 1000 police officers being killed. However, there has been insufficient evidence to support these figures.

In July 2002, the Maoist rebels made an offer for peace talks to initiate the dialogue process once again, however the government rejected this offer. Finally in August of 2002, the government lifted the state of emergency. In September 2002, another major offensive by the Maoists left 40 police officers dead and over 100 security personnel and 250 rebels dead. Deuba's government delivered very little to the general public and his regime was beset by rumours of his working style based on corruption, sycophancy, nepotism, favouritism and discrimination (Thapa 2002a). His partiality of granting positions and appointing officials based on their caste and class also fuelled the general public's feeling. Finally, in October 4 2002, King Gyanendra Bir Bikram Shah, in an unprecedented act, superseded the constitution to make the announcement of Deuba's dismissal as the Prime Minister, by announcing him 'incompetent' and accusing him of not being able to hold elections.

The Maoist movement in Kabhre Palanchowk district

The Maoists succeeded in exploiting the hilly and harsh topography of the rural area and the high level of youth unemployment. On many occasions, the raising of the ethnic agenda, corruption within the State institutions and the rampant politicisation of police administration and political parties were also adopted strategies, that made these issues of interest to both the government and the Maoist movement. Consequently, the various strategies adopted by the State to curb the movement and by the movement to expand the mass mobilisation effort, eliminated the neutral role of civil servants and the community, that were caught in-between the power struggle. Mid-level government officials at the district level were also incapacitated. While strict orders from the centre to report to duty had to be maintained, they represented their superiors, therefore the absentees were monitored and/or the non-reported days were counted as allocated sick days. Simultaneously, the threat from the Maoists to abandon their respective jobs was also increasing. The district of Kabhre Palanchowk provides a good example of how the movement gradually built its stronghold in this area and in the same manner how the State reacted to quell the movement. The strategies deployed by the state in fact assisted the Maoists in strengthening their popular community support. These have been visible at both the managerial and administrative role of civil servants and community leaders at the case study area. The external agencies had a powerful balancing role to play, as development agents within the struggle between the State and the movement for successful intervention of projects. It was not just a struggle of balancing between various political groups at the local level but also between the community and the movement.

The strategic location of Kabhre Palanchowk shows, how key events in other neighbouring districts have shaped ideas within the district, as well as the dynamics of the district itself. This point can be seen historically for all eras and not just the Maoist movement. The Panauti small hydel plant is an illustration of this kind where the control for water resources after the installation of the power plant involved a struggle between the local community and the state.

From a historical perspective, the armed struggle of Jhapa of 1972-73 had some impact in the central hills of Nepal where during that time; the bordering district of Sindhuli adjacent to Kabhre Palanchowk was directly participating in the peasant struggle. Sindhuli, which included some landmass of Tarai, witnessed the peasant's struggle against the feudal landlords who owned and controlled the agricultural land and production. While the effect of this incident had an impact in Kabhre Palanchowk, the peasant's struggle did not become prominent at that particular era primarily given the nature of land holdings and land tenure by the people of the district. However, the peasant's struggle did have an impact on the intellectual and petty bourgeoisie in Kabhre Palanchowk, in the form of conversion of the 'educators'. Thus intellectually it had quite an impact as also represented by the State's political constituency of the local governance structure, which largely constitutes members of various communist factions. Sites such as Pinthali and Katunje Besi were spearheaded at the initial stage by local reformists representing communist factions. Furthermore, the proximity of this district to the centre, and in particular to Bhaktapur has always had a benign impact on the changes of this movement in this district in a historical sense. In a similar manner, the Jhapa peasant movement of 1973 was an illumination to many of the *jyapu* (farmers) community of Bhaktapur who were involved in production that benefited the *sahu* (land owners) and the rulers from the city. All these transformations that Bhaktapur was undergoing, had a direct influence on Kabhre Palanchowk. The big sahus and elite from the cities were also controlling the large fertile lands of Panuati, Panchkhaal and around the Roshi watershed. Agricultural land was also being purchased by rich families from Kathmandu and was left barren to evade obligations from the existing tenancy laws. The large farming communities around Panauti were heavily influenced by the transformation of Bhaktapur.

Therefore, surrounded with progressive districts such as Sindhuli, Ramechaap, Dolakha, Makawanpur, Sindhupalchowk and Bhakatpur, it is not surprising that Kabhre Palanchowk was included in the agenda of the Maoist movement from the beginning. At the time of writing this, over 95 percent of the district was said to be under the control of the movement (See Appendix 3.1).

In 2001, this district was one of the few to have all the upper level local and district representatives be elected from the communist United Marxist Leninist group (UML) with the exception of one MP from a NC ticket. UML is active in this district and considers the Maoists as an ultra-leftist party representing fundamentalism within the communist movement, therefore rejecting violent activities both ideologically and institutionally. While the various factions of the communist party were involved in the political development of this area, it was only around the early nineties when the movement explicitly accelerated its plans in the district. For example, Nanda Raj Lama who was a former VDC chairperson of Katunje Besi VDC-1 was elected on the ticket of UPF-N. Even after Dr. Baburam Bhattari's faction went underground, he continued his work in the community, by affiliating himself to the Niranjan Govinda Vaidya faction, being actively involved in development projects. He was very popular and liked by the community. Many of the movement leaders continued active politics in the villages. Nanda Raj Lama was one of the early victims of the police operation of Kilo Sierra Two.

After the police operation, which was code-named 'Romeo' was carried out in 1995; the Maoist movement took a strategic focus in Kabhre Palanchowk district. The state had ostracised the rural ethnic Magar community and this example sparked the development of collective identities of ethnic groups in other districts. For example, the Tamang group of Kabhre Palanchowk was also then given attention (See Katunje Besi, Kusha Devi and Pinthali case studies). The various countervailing State interventions provided an appropriate setting to move and legitimise the movement forward within the community's eyes. Hence, with the declaration of the People's War in 1996, Kabhre Palanchowk was included as one of the Strategic Defense operations in the First Plan of the movement. This historic initiation began with a symbolic action when the house of Daulat Singh Dong in Machhe VDC located on the border of Sindhuli, Ramechap and Kabhre Palanchowk was attacked making it the first attack in the district.[8] Unable to bear the torture, and after having failed to receive any assistance from silent neighbours, the victims requested the attackers to kill them, but were spared.

This incident was also carried out simultaneously with the attacks of police posts, including the one in the bordering town of Sindhuli. Claiming that about 150 people were involved in the incident of Machhe VDC, police prosecuted the top ranking activists of the UPF-N. In this incident about 66 persons were charged with looting while four women activists under state custody were raped and tortured. It is widely considered that the development and leadership of the female cadre in Kabhre Palanchowk district began with this incident.[9] For about a year this district remained calm. However with the police counter rebel operation of 'Kilo Sierra Two' the Maoist movement again began to gain popularity as the police continued its random interrogation, torture, custody and imprisonment of many community members. This operation was carried out all over this district, which included VDCs of Katunje Besi, Saldhara, Bhimkhori, Bhumlusalle, Anaikot, Shisaakhani, Majhipeda, Pokharichauri, Chyasingkharka and Ambote. In this operation the disclosed and reported number of killings amounted to 49 young men and women. However, the community relates that many more were unaccounted for. These killings were conducted between November 1996 and September 2000. In addition, numerous other people from the community were detained and various methods of torture tactics were applied, in an attempt to extract information from the detainees. Several others were also arrested on this basis and the ex-president of UPF Govinda Prasad Mainali is one such example. With the increase in the chain of police tortures, Maoist activities also increased in Kabhre Palanchowk district and became widespread by the end of 2000.

At the community level, the political messages mobilised hundreds of rural communities through dissemination of pamphlets. Some of the community members expressed that the Maoist movement represented the community interest and development, as interlocutors between the rural society and the urban political leaders and structures in place. The local political leaders had become powerless and their empathy remained with the state as in the case of Katunje Besi, until the local elected leader was rumoured to have supported the capture of Nanda Raj. When

Nanda Raj was taken by the police at mid-night, his wife went to seek assistance from the local elected leader who refused to intervene for fear that he would also be taken by the State. It did not take the armed struggle much time to establish its stronghold in this area. This district was included in the Second Plan of action, which began in October 1996 and focused on guerrilla warfare, by building up the military capacity of the movement in the strategic locations. In terms of local government, Kosi *paari*, the area colloquially known for the west-bank of Sun Kosi River, and *danda paari* (the other side of the Mahabharat mountain range) were already under the control of the movement prior to 1997. However, the efforts on the rest of the district were hampered by the police operation of 'Kilo Sierra Two', which did come as a surprise to the movement. The obliteration by the police campaigns faced and resulted in the Maoist retribution for the next few years to follow.

The Panauti small hydel station has been a frequent target for the Maoists activities. The plant was attacked for the first time on July 13, 2001 causing minor damages and a warning note for further attacks was left behind. Immediately, after the failure of government-Maoist dialogue in November 2001, the station was again attacked causing minor damages. Then followed a major attack in January 2002. The administrative building was partially destroyed by a petrol bomb, all the documentation including the water measurements was lost and the NEA vehicle was destroyed. The final attack occurred in September 2002 causing yet further damage where the explosion of petrol bombs damaged two generators inside the powerhouse. This rendered the Panauti plant dysfunctional and the station came to a standstill. The irrigation system remained unaffected by the series of attacks and the farmers had more water than they could use.

At the micro-hydel sites, the impact of the conflict took various forms. After the killing of the community leader Nanda Raj Lama from Katunje Besi, the state pressure on the community in the surrounding VDCs also increased. The community elected manager of Pinthali, an active community leader with communist party affiliation went underground during this period because of the rumour that he was also in the police hit list. The succeeding manager also abandoned his job allegedly because of the increased pressure from the Maoists groups for cash contribution. The elimination of Nanda Raj Lama from Katunje Besi had a profound impact on the community. After the implementation of the programme, which was undertaken in a rushed manner given the volatile situation, the management committee was selected in a haphazard manner and it received very little support from the community.

By October of 1997, the movement began its retaliation against the police aggression and started attacking state institutions. This district played a strategic role during the time of the highly publicised Bethan raid, where police posts all over the western, eastern and central hills were attacked and raided. The ADBN office in Kabhre Palanchowk was sabotaged. It was on 2nd of October of 1997, that the first killing by the Maoists took place in the Kabhre Palanchowk district, when the ward chairman of Dhuseni Shivalaya VDC was killed on charges of informing police of hidden arms. With this incident, then followed a series of killings by the Maoists. In 1998, a 65- year old man was shot in Anaikot VDC and a 35 year old in Saldhara VDC-9. There were about 59 reported killings conducted by the Maoist movement from 1997 until 2002 in various VDCs including Katunje Besi. The motive for killing have ranged from being police informants, harbouring police officers, following a different political ideology, not supporting the Maoist movement or criticising Maoist violence at the community level. For example the brutal murder of Krishna Prasad Sapkota, ex-chairman of Rayale VDC on 15 September 2002 was executed on the charge that he was not supportive of their aggression against another Maoist captive from Rayale. Sapkota's death was carried out in a gruesome manner by chopping off his head with a khukuri.

The increasing presence of the military concentration in Dhulikhel, after the declaration of Emergency, isolated the rest of the district. The military was making random searches at night around any accessible area. By this time there was police presence only in Dhulikhel both during daytime and nighttime. In Banepa and Paanchkhal there was police vigil only during the day. The Maoists were very much left by the State to govern themselves and expand their platform. By July 2002, the movement had managed to make many symbolic attacks, destroying 37 VDC offices and burning documents, police posts, banks and post offices in various VDCs. The VDC offices in the three research sites were also destroyed. A telephone tower was bombed in Devithan on July 1997. By September of 2002, even REDP projects had decided to stop their intervention and field visits, because they were asked to temporarily halt their programme in the district. The project staff curtailed activities in the field. The district level officials and bureaucrats were literally occupying their desks with their hands upon their heads. The army had advised them to vacate their residences that were located within the bazaar area; therefore the officers were spending the nights in the periphery of the district headquarters or in Kathmandu. The Maoists activities increased during the imposition of emergency rule. While the army, in Dhulikhel, imposed curfew in the evenings, the Maoists had their own system of curfew instituted in various locations and VDCs. The Maoists had also organized the issuance of identification cards, which were used by the community during travel within the district. The military cadre of the movement spread quickly during this period from remote villages to Kosi *wari*, the eastern side of the Sun Kosi River, including Panauti, Kusha Devi and Banepa moving closer to the district headquarters.

Maoist movement and the female proletariat

If we look at the role of women in conflict situations in Nepal, the historical mobilisation of women in social and political movements had taken place to counter attack the regimes during the Rana and Panchayat periods. However, such movements were limited within the feudal bourgeoisie state and were patriarchal in nature. Therefore the arena, for political interventions were limited to the involvement of members from the political elite. The 1990 democracy period provided an opportunity for women from all strata of the society to be involved in various organisations and represent various platforms. The All Nepal Women Association-Revolutionary (ANWA-R) emerged in 1996 together, when the Maoist movement took shape. It was formed as the Women's Wing to fight alongside the Maoists in their campaign. The female mobilisation, at the political level, began with regrouping of splinter members of the UPF party who initially began work from the hills of Rolpa and the surrounding areas. It quickly established itself in Kabhre Palanchowk district, as representation of the political male leadership from this area was strong. The ANWA-R began its work in this district a year after they began their campaign from Rolpa, and the family members of some political leaders became involved in the gender platform. In this respect, the emergence of the female leadership can also be closely linked with the politics of male leadership within a given family structure[10], perhaps more so as the male leaders had been victims of the conflict.

Therefore, the mass grassroots mobilisation of women only began after the declaration of the People's War and in particular in Kabhre Palanchowk in 1997. Aside from the historical economic, social and political repression of women in Nepal, there was another strong factor that directly contributed to this collective identity. The counter insurgency operations led by the police had a negative impact, where every human right abuse acted as a means of accelerating further politicisation of the movement's propaganda. Specific cases of torture and violence committed by the police, then, encouraged the women victims to lead the crusade forward. Such incidences were also highly publicised through the media. In a similar manner the stereotyping of an ethnic group, in particular arrests of young Tamang men by 'profiling' either for sporting a beard or looking suspicious also increased the enrolment of Tamang youth within the movement.

At the political policy front, the Maoist proletariat had opened up the space for women mobilising them both at the village and the district level. While initially each guerrilla squad had two to three female representatives in a 9-10 person squad, the increase of female cadres in the movement began with the establishment of women's wing of the movement. The movement spread like brush fire after the emergency was declared in Nepal. Women from the community were disappearing gradually from schools and homes. A forty-two year old lady recounted the reason of her son and daughter-in-law joining the movement. Rumours circulated that the Maoists had promised the daughter-in-law a full provision for medical care, as she was sickly. On one occasion, a group of young girls were accosted to join the movement. These girls were again returned back for two days to fulfil a commitment they had undertaken in a school cultural programme. They were also told, 'if you don't come back, we will come and get you'. In another case, the enchantment of training in arms and possessing a personal rifle convinced a young girl to join the movement. This factor, as related by some youths, gave the women unprecedented power to control and simultaneously protect themselves, which they had previously never experienced. In another case, a married woman was told to leave her controlling in-laws. In this manner, the gradual mobilisation occurred at the micro-level where women were trained for multiple of chores. Women also seemed to have played multiple roles, being engaged in normal routine duties during the day and at night involved in combat missions. It is rumoured that, it was not uncommon for an all-or majority-female led squad to undertake an attack. The Bhakunde Besi attack of the police officers on January 2002 was recognised by the community as a mission undertaken by the sister of 'Lekali' who was killed by the police. However, it is not clear as to who the squad leader was, other than the fact that the attack was led by a female and identified with the codename 'Arpan'. To avenge her brother's death, she was alleged single-handedly to have brutally killed few police officers using a khukuri with the assailants shouting the name of 'Lekali'. For few days prior to the attack, the police post had allegedly been under the surveillance of a female observer who was disguised as a 'peanut hawker'. The district chairperson of ANWA-R is also said to have participated in this assault. The community around the Bhakunde bazaar area was aware of the various movements going on within the premises, however, the silent majority seemed also to have been tolerating the violent minority, signalling again an omnipresence of violence.

At the macro political level, the main agenda of the ANWA-R as presented in the written document of Maoist demands, included one requisition that specifically related to women's rights. This demand called on the State to revise the inheritance laws and grant 'women equal property rights on a par with the brothers'.[11] These gained rights were never pursued so specifically under the 'participatory approaches' of donors. The ANWA-R has raised and propagated various issues that have indirectly touched upon the 40-point agenda presented by Dr. Baburam Bhattarai to Deuba's administration in 1996 (See Appendix 3.2 for details). Some of these request for changes have addressed issues such as the current banning of recruitment of women into the Royal Nepal Army, discarding of current traditional cultural and religious practices, secularism and women's freedom from sexual repression (equality in male polygamy versus female monogamy) and unequal economic opportunities (Parvati # 5 1997). Perhaps the most successful of their efforts has been in the mobilisation of this organisation in anti-alcohol and anti-gambling movements. The ANWA-R has banned alcohol from the villages they control in Kabhre Palanchowk. They have also taken action against people who discriminate on the basis of religion and those who practice untouchability. The latest campaign is targeted at punishing men who are involved in polygamy.

Struggles for Secularism: Ethnicity and Cultural Norms

Now, moving back to the community, the movement has imposed restrictions on traditional and cultural activities and everyday life including *bratabandha* (thread initiation ceremony), *sraadha* and *kaaj kriya* (death ceremonies), *bivah* (wedding rituals) and the only available entertainment options such as playing cards or drinking alcohol. These restrictions also contradict with the notion of secularism. Likewise, the popular political platforms of gender and ethnic minorities have also been propagated to secure social foundations for social and cultural justice in the name of emancipation.

The open sale of alcohol was prohibited in parts of Kabhre Palanchowk. The village shops stopped selling liquor even though alcoholism was not a problem within certain community. Furthermore, alcohol in some of the ethnic communities, where it was prohibited, was a part of life from birth to death and was required for ethnic and cultural ceremonies. In these communities, it is not just men who consume alcohol on a social/cultural basis, but also women. Some of the villagers defied the Maoists prohibition and were brewing in their *goth* (cow-shed). In some area, it was also found that some shopkeepers were selling under the table and the consumers were mostly police officers posted in the neighbourhood. Yet, they were other households who admitted that 'we have been ridiculed and branded with the tag of *matwali* (a liquor drinking caste group), maybe it is time to stop drinking'. Some responded, 'we don't beat our wives like other mixed communities do, but we drink together with family and friends like civilised people, even our old parents drink together with us unlike in other communities'. However, in the process of searching for a meaning and lobbying of 'secularism', the rights of the community to practice their cultural beliefs and values and the collective identity of ethnic groups is socio-culturally being redefined.

An anti-gambling campaign was also on the Maoist agenda and led by the local women's movement. In the villages, gambling is a favourite past time, a means of unwinding after a day's hard work.

In one particular incident, a group of community members were caught gambling and they were warned not to do this. Following the warning, the cards were stuffed into the mouths of the players. The movement cortiased gambling as being an idle practice using the issue of women's rights because again men get stereotyped as being gamblers and therefore, not contributing as much as women do in productive activities. However, during the *Dipawali* (festival of lights) of 2001, the village elders including women members, gathered at the *chautara* (resting place) with a deck of cards ready to gamble in provocation and defiance. As anticipated, the Maoists came in fully armed to fulfil their mission of disbanding the game; this time, however, the community elders managed to chase them away with tightened fists and a barrage of verbal abuses.

Correspondingly, a similar kind of control was imposed on production and cultural practices. In one community, Maoist imposed control on the local market. For example, corn was sold for Rs.50 per *dharni* (about 2.4 kilograms) in the local market in 2000 until the Maoists established a new selling rate of Rs.18 in 2001. The petty bourgeoisie from the village opted not to take the produce at all. Opinions of the community on this imposition vary. A village shopkeeper noted that it was better to sell the produce at a loss than put his life at risk by not following the orders. A second opinion on this sanction by a community member was, 'if going at a loss this year signifies that the next year will be better for all of us, I'd rather eat *dhindoe* (corn meal) this entire year and wait to buy rice the next year'. Rice, in areas of close proximity to Kathmandu, is still a rich man's meal and corn from the villages is usually sold and/or exchanged for the purchase of rice.

In a mixed community, a Brahmin man had shifted the wedding ceremony of his son from the village to Kathmandu for the fear that the Maoists would disrupt and prohibit the rituals from being performed. In another case, the Maoists chastised an elementary school teacher, because of his second marriage and his life was threatened when he justified his case and questioned the 'friends from the jungle' on their liberal values of sexuality. The school teacher, justified his action with the words, 'I was abiding by the law, I went for a second marriage without divorcing my first wife because my first wife could not conceive.'[12] This particular case reflects law as again illustrating the tension between beliefs, values and practice, which exists within the normative and empirical frame of reasoning.

Struggles over Water Resource and Hydropower Management

In comparison to the class struggle that occurred in Europe in the early 1700s, 1800s, 1900s, the Maoist movement for social and political changes in Nepal is cast under a different skyline. The fundamental difference between then and now is that unlike other communist movement's that took place in countries such as China, Russia, Cuba and even the peasant's struggle in Europe, the Maoist movement faces various challenges from globalisation. The struggle is not just about differences between the State and the movement, but is also a struggle to control resources among a wider circle of interest groups that encompass the water and energy landscape. In particular when discussion involves trans-border or trans-national negotiation and global partners', contestation also becomes highly argumentative.

Nepal as a State has historically viewed water resources as a political tool and being situated as an upper riparian in relation to India has also strengthened this political stand. Thus the premise around this political image has also built the chimera that water resources will bring a 'quick return' to relieve the country of its poverty. A second view emergent from a majority of the public sphere, and concurrent to Maoist views, is that most of the bilateral agreements between Nepal and India, have in fact, disenfranchised Nepal's integrity, rights and reserves of water resources.

The politicisation of water in Nepal began with a global entry. In 1977 the late King Birendra Bir Bikram Shah's defining speech at the Colombo Plan Consultative Meeting configured the political image of water at the South Asia level.[13] Water was perceived to possess the capacity for producing food through irrigation, harnessing for electricity and in addition conserving the forests with alternative energy sources. However, it was only in 1992 with the Dublin Statement in Ireland, water became recognised as a limited resource. As such, the chagrin expressed by the public sphere against the clauses and conditions of the various treaties, between India and Nepal, and in particular the Mahakali Treaty indicates that struggle over resources, first does begin at the national front.

Perhaps the climax of the 'politicisation' of water resources in Nepal is reflected by the Article 126 of the Nepal's constitution, which has made it mandatory to seek for parliamentary ratification of water treaties and agreements, which have a long term and serious implications. The signing of the Mahakali Treaty in 1996 also coincided with the declaration of the People's War. The Mahakali River, which covers an extensive boundary line between major stretches of India and Nepal, envisages the construction of a 315-meter high dam called the Pancheshwar on the river, which divides India and Nepal. The project is expected to generate 6,480 MW of electricity for supply to India's northern power grid and also to provide the Gangetic plains with large volumes of regulated water for irrigation. Almost in correspondence with the State politicisation process, the Maoist movement has also made strong 'political' statements, with regard to the management of water resources in Nepal; therefore, people's movements have also politicised water. However, the 'politicisation' has also occurred as more explicit expressions were manifested with destruction of water and energy infrastructure. While at the state level, the political symbol of water has managed to alienate the public; the Maoist's resistance to the 'politicising water' has caused material damages. The past three years, in opposition to State control, the Maoist movement has undertaken incessant bombing and attacks on NEA-controlled electricity infrastructure such as power plants, sub-stations and transmission lines. In the fiscal year 2001/2002 alone 9 small hydroelectric plants were attacked and damaged by the Maoists (NEA 2002a:16). Subsequent damages were incurred on the transmission tower that affected Khimti, Bhote Kosi and Sun Kosi plants in December 2002. These damages coincided with the government's initiation of negotiations to sell excess electricity to India. The damage to date is estimated to be worth Rs. 40 million with an estimated loss of 100 MW of electricity from the central grid (The Himalayan Times 2002). At a normative level, the opposition of State control and the demand for the dispersal of power in a more democratic manner are reflected in some of the points that the Maoists have raised in their agenda.

A few major demands of the Maoists directly relate to water resources, control and management at both the State and local level. There are four statements that the Maoist movement makes by these actions. First, there is an emphatic opposition to the State's disposition of water resources, where Nepal is merely seen as a puppet of India. India's hegemony over Nepal's water resources is heavily emphasised. Second, the trans-boundary rights and allocation of water resources is put under the microscope by using terms such as 'nullify', 'repeal' and 'revise' the existing treaties and agreements. Third, the globalisation and privatisation policy path of Nepal is not particularly challenged per se. However, the movement highlights the inconsistency in civil society actions which also get influenced by technological and economic considerations; the action that succeeded in cancelling Arun III on one hand while on the other hand maintaining a blind eye to mega-projects such as the Mahakali project (Worker # 3 1997). Fourth, the focus of electricity and water resource use emphasise the need for a democratic governance process, which is also being reflected from the case study sites.

Insufficiencies despite current advocacy, activism and militant action

While partly a progeny of the global water policy discourse, the legislative development of water resource management in Nepal is also a reflection of this historical political process involving the industrial/manufacturing relations of the external agents. As highlighted in Chapter 2, there is a distinct linkage between hydropower policy development, the political shaping and control of water resources by the State. Therefore, the impasse over water policy in Nepal is not surprising because, water policy in reality has seen very little change. It is yet under the control of the first generation policy-makers that continue to conform with the global imagery and are the political construct of the political economy of power. Similarly technology designs reflect the elite networks of manufacturers so far not admitting many problems in the functioning of MHES.

The action from various coalition groups and the Maoist movements indicate that there is a difference between advocacy and activism but still leave a gap where local aspirations for technology and technological democracy and the associated benefits. The concept of 'power' is closely interrelated to show these differences. While the elite activists became active to challenge a middle class dream with the cancellation of Arun III, substantial noise by the Maoists opposing other larger multi-purpose water projects indicates that the consensus of the elite activists has not quite been disturbed. This is because activism in the water sector in Nepal in a civil society context has been generated not from rural social movements but from a formal academic and science perspective including amber of logic of stakeholders, cost-benefit analysis, privatisation and Indian hegemony. While activism augurs well with dark forces of irrationality, it also egresses as means to get things done. Activism generates questions thrown by the society themselves. Activism then, can be seen as both a formal and informal process where the formal activism then becomes associated with advocacy. The formal activism through 'coalition' movements has rather functioned as advocacy platforms unlike the Maoist articulations regarding hydropower development in Nepal. This is because advocacy is closely linked with established power, rules and regulations as it legitimises the direction for the causes for activism. The Maoist movement in Nepal has not only emerged from a political movement but also egresses through a social movement, however, their hydropower agenda and the resource mobilisation movement has not touched the democratic imagination of the policy makers nor elite activists. Activism in this regard then has also not moved beyond visual effects as it does not quite suggest a plan of action in terms of access to electricity and rights to power use for the rural community. However, it has generated a lot of new questions.

Therefore, in concurrence to the intellectual mainstream debate that has emerged from Nepal, the Maoist movement has opposed the State's control of water resources at two symbolic levels. At the macro level, the specific demands as cited in the 40-point agenda reveal a pursuit for a more democratic system. At the field level, various government institutions in particular hydropower projects have been attacked and destroyed. The actions from the field and the case study sites indicate a quest to decentralise 'hydropower' development rather than water resources per se in terms of other water uses. Therefore, the movement has also acknowledged the value of water in the context for a struggle for more public control of the resources. The various attacks on the hydropower sector have been a popular strategy for manifestation of discontent against exploitative resource control, globalisation and empty development ideology.

The social movement surrounding hydropower and water resource management in Nepal through these new coalitions has either been hegemony or tinkering processes (Thompson and Warburton 1985), a real sustained public activism for conscious changes in hydropower policy are missing. The real activism visible from the case studies is when village leaders make genuine effort in bringing about changes and these efforts are not necessarily linked with wider influences.

Conclusion

Neither the rational communicative realities of modernity of Habermas through advocacy, new coalitions and development neither dialogue nor militant ideology is bringing changes in Nepal. This book shows that advocacy, activism and militant activism are still failing to lead to democratic technology, since none are so far leading to relevant technology choices and policies despite all the new coalitions of these social movements.

This chapter has summarised some of the key political events and influences that have shaped rural politics and programme of water resource management and hydropower development. As clearly shown by the social action generated by the Maoist movement, while the attacks on *bikas* (development) and *urja* (hydropower) offices and agencies on one hand symbolises a modus operandi that represent the social struggle against the forces that operate in a moral economy. Alongside this, the violence and khukuri is also used to reinforce a counter-identity around the struggles for equity and different interests, almost histrionically symbolic of another Nepali society, culture and identity.

Given the historical political context of rural intervention and development in Nepal and the failure of development as practised so far, it is not surprising that there is a significant degree of resistance emerging. Such resistance is also manifested with the use of violence. However, actions from the field provide reflections for identifying the linkages between development needs and a wider social change in terms of technology design, governance, control and benefits. The communicative modes that have been used in technology development and their participatory development tools have maintained a normative focus on social modernisation, often de-linked from the cultural modernisation of Nepalese identity. As evidence from the research district suggests, the culture of violence and the ability to be violent cuts across class, caste, gender and collective boundaries. However, such methods of communication have also not served to connect technology with the reality of the polity and local governance systems.

Development aid in general, and the village and local development has signified the perception of Nepal and Nepali as passive collectors and receivers of donor aid and apolitical administrators for local government. Such projects in the form of texts or symbols have been moulded to work according to the external agent's and State government's perception of how development should be undertaken and these have also shaped industrial and manufacturing relations. I hope that this chapter and the case studies that follow break this image. The myth of the Shangri-La is an imagination of the imagined where the image of the passive village and the helpless state that comes through various texts will not assist in democratising technology. This recognition will also bring about technological development in providing the rural sector with power. The Panauti, Katunje Besi, Kusha Devi and Pinthali sites indicate that resource control is a dominant theme in rural politics and technology operations that can be effectively utilised as a binding element in communicating this message to the polity. I return to this point in chapters 8 and 9.

To sum up, the following highlights are significant. Agents need to recognise the political world in which they act, and understand that struggle and identity impacts into technology. At times of political struggles and regime change projects affecting rights and access will also attract struggle, and their personnel may become targets. The images of positive and peaceful change and involvement cast by supposedly extensively practised participatory approaches are belied by the field realities of State and revolutionary violence actually present in the 1990s. Many of the issues and discussions in the forthcoming chapters link to these issues in village dynamics and hydropower.

Notes

[1] A khukuri is a knife that as a 'cultural artefact' is closely linked with the identity of Nepal and a Nepali. A khukuri plays an important role in both our inner and outer lives.

[2] The existence of Nepal as an independent country is mentioned in the ancient text '*Athrab Parisist*' which was written around 600-800 BC.

[3] The knives carried in the Middle East, for example the Yemeni '*jambiya*' (dagger) is more like a broad curved dagger, which is usually worn on a belt. These knives are attachments of deep symbolism and identity. A khukuri is shaped like a curved dagger, however one side of the blade is

blunted.

[4] See Anderson (1991) for a fascinating insight on how identity is understood within large cultural systems. He states that 'cultural artefact' is not only closely linked to identity but in order to understand this link, requires understanding of the sum total of how 'artefacts' (cf. *khukuris*) have come into historical shapes and in what ways has the meanings changed or have changed. At a normative level the term '*Shangri-La*' can be conceptualised as this 'artefact' in interpreting in what way it has assisted in the process of identification. He provides various paradoxes of the politics of identity within an imagined community. I quote (1991:11) 'If nation-states are widely conceded to be 'new' and 'historical,' the nations to which they give political expression always loom out of an immemorial past, and, still more important, glide into a limitless future. It is the magic of nationalism to turn chance into destiny.'

[5] The economic development model during the early 1950s maintained the focus on the model of Aurther Lewis, hence the Lewisian model. This model visualised the rural/urban linkages where the rural sector was seen as a source of supply of labour, which could be tapped for the development of the industrial sector. Public investments in infrastructure and basic industries were considered necessary to facilitate development. This model also assumed that the level of technology would increase over time and that there would be capital for investment into the formal sector. In Nepal this model was also pursued where alternative technology development in the urban area was promoted to support the rural industrial growth.

[6] Kabhre Palanchowk district can be considered to have been included as part of the encircling strategy. Encircling the pie is not really any new political strategy. It was practised by the Gorkhali invaders in 1768, it was also used by the *Sendero Luminoso* (The Shining Path) in 1990 to control the *pueblo jovens* surrounding Lima. The Maoists in Nepal were using a similar strategy to take control over Kathmandu. The strategy was also to establish an undercover presence. In 1991 while visiting Kathmandu from Peru, I was taken aback to see the name of Abimael Guzman written in red and bold letters outside the rear boundary wall of Bir Hospital. It was a reaffirmation of the link between *Sendero* and the movement in Nepal and also the presence of the Maoist in Kathmandu then. In discussing the link between the rural and the urban strategies of *Sendero*, McCormick (1992) highlights the two mutually reinforcing strategies. The first one focused in surrounding the city from outside and the second one from inside via actions that undermine within the city.

[7] Both the Sendero Luminoso and the Maoist movement in Nepal have taken up their support for ethnic platforms. My perceptions are that, this support, however is not so much an illustration of tolerance for secularism or respect for ethnic values. Rather, the actions illustrate that the ethnic platforms has been utilised as a political strategy for collective

action through indoctrination of a given political ideology in a quest for an egalitarian 'collective identity'. The empirical examples from the field suggest that the manifesto rather demonstrate apathy towards such cultures and traditional rituals. The movement has abhorred Brahminic practices as its ideology clashes with the anti-bourgeoisie practices, as such practices are perceived as an import of Indo-Aryan origins. The similarity between Nepal and Peru within the movements indicates that by drawing apathy towards history and class struggles, international aspects of staging a revolution have been focused. This characteristic by itself is a new feature in the political history of Nepal as a consequence of the 1990-multi party system.

[8] This attack manifested itself beyond the symbolic assertion of an ideological movement but rather adopted intimidation tactics through violence, exposure of vulnerability and actual lack of power. Not only was the house looted in cash and property but also according to the neighbours, the female members of the house were tortured by having chilly powder sprinkled in their eyes, private parts and in fresh wounds. Thus, the oral prophecy of '*ghaau ma nun chook halne*' where a fresh wound is made to aggravate more by the use of salt and ascorbic concentration came true. Chili peppers became just one more ingredient in the manifestation of violence.

[9] The court later cleared these women of the looting charges. It has been talked about among the community that to revenge the torture imposed by the police; Ruku Chaulagain entered into politics and is now known to be the Maoist Commander of Kabhre-Ramechhap area under the pseudonym of Rachana RC. The community members also recognise her as a powerful female guerrilla of Kabhre Palanchowk.

[10] Since Maoists leaders like Yan Prasad Gautam, Krishna Prasad Bista and Navin Gautam who were residents of this district were killed by the State; their female relatives became involved in the campaign.

[11] On March 14, 2002 Nepalese parliament passed a bill that guaranteed a Nepali woman equal rights to parental property and conditional abortions. Finally on September 2002, King Gyanendra Bir Bikram Shah gave the royal assent to this bill. Thus, the Country Code on the 11th Amendment Bill on property rights and abortion rights became listed in the legal gazette for implementation. For the first time in history, a daughter from Nepal was declared an heir to her parental property and married women were given rights as owner of one share of the husband's property. The same rule applied to divorced women. Widows were granted full ownership of their husband's property. The legalisation of the abortion bill grants the right to an abortion up to 12 weeks of pregnancy and up to 18 weeks in cases of rape and incest. Interviews with women vendors, hawkers and rural women with regard to women's equal rights to paternal property indicated that it is only the daughters of the urban elite and the rich who would benefit with such changes in the legislation. These

women placed higher value on education than on land ownership.

[12] The legal system as a 'law' can sanction a Nepali man to a second marriage if the union through the first wife does not produce a child. In this case, if the couple remains childless for ten years after marriage, the man is entitled to select a second bride.

[13] In his address, King Birendra not only emphasised Nepal's position as an upper riparian sitting on a large volume of water resource wealth but also projected an image that this water could potentially transform the nation. Part of his speech said: "one of our chief resources in Nepal is water, which if harnessed and managed properly holds a magic key to all-round development of our country. Used properly, not only can rivers generate electricity but also provide water for irrigation abundantly. More than that, it can also act as a catalyst for multiple forms of development including energy as an alternative to our forest wealth". (cf. Pradhan 2000:40, Pandey 1998:165-66).

4

Creative Technology and Proactive Processes

The Cross-Flow MHES at Pinthali

Bijulee-le ta hamro gaon-ma chamatkar laayo; mare-pachi gaonle-haru bata ayeuta chhitthi liyera janchhu; ani bau baraju-le pattaulan. Electricity has transformed our village; and after I die, I will take a letter from the community to inform our ancestors so that they believe me.

Kainla Lama, Pinthali Village, June 2001

Introduction

The Pinthali plant, located in Pinthali village in Managaltar VDC, utilises a 12 kW cross-flow turbine and a design developed by UNDP/REDP. This is a site that shows how communities have innovated and struggled to maintain and attain their desired design goals. From the outset, lighting and agro-processing was introduced in the design. An oil mill for grinding seeds and a rice huller for husking grains, have been installed in the powerhouse. All three electro-mechanical components were designed, manufactured and installed by Mr. Akkal Man Nakarmi of KMI. The design and fabrication of the turbine took place in his workshop in Kathmandu. It was later brought to Pinthali. The turbine is of an impulse type, which supplies the kinetic form of energy.

The struggle of the community for a creative technology represents their pursuit of productive uses of water and mirrors the historical shaping of the community and their values. However, this progress has also meant responsibility for the designed system. The adaptation of this system has meant increased income through the sale of cash crops. In addition to having electricity, the community of Pinthali is content with the increase in agricultural production. The transformation induced by this adaptive system is well conveyed by the incredulous opening quote, which expresses the desire to convince the ancestors of the fact that the village now has electricity.

This chapter examines the agents, structures and system interfaces that shaped the local process of MHES transformation. Against a backdrop of technological development, the tales about this strangely creative and moral community unfold their various attempts and struggles in going out to get technology of different kinds as well as improving other systems in the process. This chapter also describes the intervention process and the methods utilised in constructing the hydel system. The last section shows the various technical elements of the Pinthali hydel system and how they fit in the local environment. The chapter shows that design adaptability is not only a creation of technical engineering of systems but also a collective dynamic process that is shaped by socio-cultural forces.

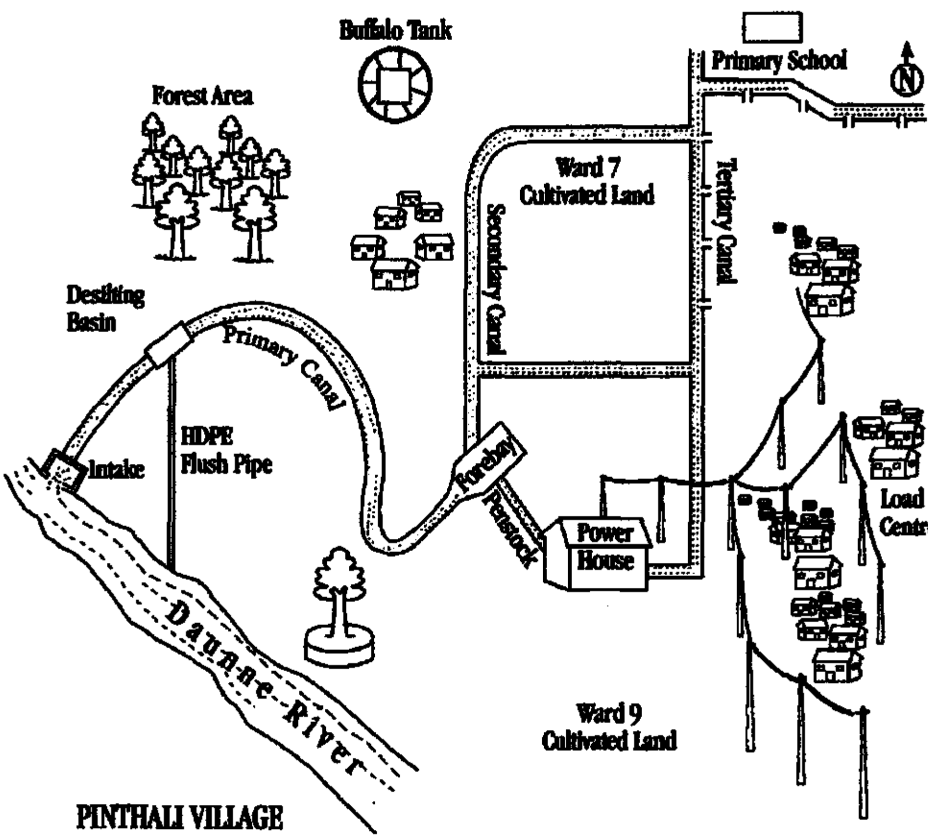
Social Action and Change in Pinthali Village

Situated in the Southeast part of the Kabhre Palanchowk district, Pinthali Village is about 40 minutes walk up a steep hill from the recently constructed Banepa-Sindhuli motorable Road. The village is about 28 km away from the district headquarters of Dhuilkhel. This picturesque village is nestled in the Himalayan plateau, 1190 meters above sea level (masl), and is surrounded on three sides by the Mahabharat Range. In 1997, a micro-hydel intervention began on a local irrigation system. The project was completed in 1998, with an improved and widened canal system, using the water source of the Daunne River. This intervention increased the volume of water in the canal system from 30 litres per second (l/sec) to 60 l/sec. The increased volume of water not only enhanced the possibility of generating electricity for the village community, but also increased its irrigated command area, addressing both consumptive and productive aspects of water use

(Regmi 2003c).

The smallholder farmer households, of Tamang ethnicity, started harvesting four crops a year after the installation of Pinthali micro hydel. However, the progress for this community has not occurred overnight. Development of this community has meant a slow struggle for many years and an attempt to re-identify themselves socially and technically, from an ethnically backward group to a hardworking innovative community.[1] The recently constructed buffalo tank nearby the community *chautara* (resting-place built around a tree) located in the heart of the village symbolises development of water resources, from drought to self-sufficiency. Figure 4.1 shows the layout of the plant, the village and water supply.

FIGURE 4.1 Pinthali village: plant and water supply



Map: Not to scale

Pinthali village today has 118 households, with a total population of 709 people. The males and females are evenly divided and the ratio is equal. The literacy rate of the population is about 43 per cent, with education to the third level of the elementary education being the average level achieved. Agriculture, in particular cash crop production, is the main occupation of all the households. Wheat, soybean, garlic, potato, maize, paddy, mustard and oil seeds are the major crops grown in this area. About 54 percent of the households have more than 0.25 ha (hectare) of land and the rest own holdings that can be as small as 0.05 ha.

Due to relatively easy access to the market the community is increasingly practising livestock rearing. Buffalo raising, herding cows, goats and chickens are popular livestock activities among the farmers. Other off-farm income generating activities are daily wage labour, contracting jobs in road construction and the sale of milk. About 20 households have organised themselves into a village milk co-operative and deliver the milk for sale to the nearest diary. Besides these livelihood occupations, the community of Pinthali also includes many members who are skilled wood carvers and practice *lampat* (woodcarving) and *thanka* painting. However, most of the skilled artists have moved to Kathmandu to practice their trade. Even though the community is ethnically homogenous, there exists an axis of differentiation, perceived spatially according to their genealogy, as well through the size of land holdings, food production and annual income.

Local Forces of Association

The historical account of Pinthali elders indicates that the current Tamang community of Pinthali are the families of two brothers whose ancestry dates back to the early settlers from Tibet around 7th century AD. The families of the first son and his children have followed the political path being involved in local governance issues, while the descendants of the second son focused on production, as hardworking agricultural workers and tillers. Both families are argumentative and not inhibited in voicing their differences and yet have managed to live in harmony for decades, bounded together by mutual dependency. Pinthali village was named after the *pingi* (ridge) that now overlooks the village on the Eastern side. The ridge symbolises the wealth of one particular family liaison that connected the families through matrimony. This gift was brought in the form of a dowry to this homogeneous unit, which basically established the community of Pinthali.[2] With the gift of the ridge of Pinthali, the human settlement of Pinthali began expanding with the clearing of forestland and enlargement of the surrounding area for agriculture. In this process, terrace fields were constructed, linking the foothills of Pinthali, which now connect with the flat land of the Roshi river watershed. The hardwork of the residents of the Pinthali village then provided much reward through the harvest collected from this area. This area indicated promise of agricultural production and became the envy of the surrounding villages, which was predominantly settled by the upper caste community of Brahmins. In 1975, an incident occurred in the village whereby the Tamang community reinstated their identity and moved forward as a single 'moral community' where the members were bound together with shared interest and norms.

The legend of the black sheep and the Brahmin

According to the narration of the local elders, in 1976 a discontented young man turned out to be a black sheep of the Tamang community. This young man sold his land to a neighbouring Brahmin without consultation with the elders or prior knowledge of the community. The village elders convened a meeting and came to a decision that the Pinthali village was not in a position to harbour a Brahmin;[3] he had to leave the community. Hence, the elders gathered together and a collective contribution was made to refund the buyer and the Brahmin's investment in the purchase of the property was duly returned.

Other than in the sector of formal education, the community acknowledges that significant progress has taken place in the community as a consequence of having closed the doors to a heterogeneous caste structure. The Brahmin elite symbolised the cultural capital of being the educated class. Some of the community members felt that the village would have advanced in education had it been more heterogeneous in terms of caste. However, various other tales and evidence from this area suggests that shared values and interests have assisted the community in moving forward, and with this in developing various other co-operative solutions that have minimised hierarchical interests. For example, the history of the pine trees in Pinthali village indicates that communities are capable of coalescing for their own development, utilising their natural resources, setting up rules for resource management without any external intervention.

The Legacy of Beli Lama

As the settlement of Pinthali gradually increased in size, expansion of the cultivated area took place by reclaiming the surrounding forest area. Some community members still recall foraging through the forest area in search of edible herbs and plants. Making arrangements for drinking water needs and irrigation have been a gradual process of development for various generations. At various times, this area faced severe water scarcity including drought. At such times villagers hired water carriers to transport drinking water from a distance, by paying them 4 *manas* (measurement in volume) of corn as compensation for carrying one *gagri* (water pot) of water. Some of the village elders recall having established a rule of exchanging a pitcher of water with their neighbours for a *kuruwa* (measurement in volume) of maize or wheat to quench their thirst. Villagers also remember the female icon Beli Lama with pride and associate her as the *paani kumari* (water goddess), who used water to rejuvenate the community. Beli Lama's technical contribution is deeply engrained in Pinthali's transformation.

Beli Lama was a lady with an urban upbringing and was married to a member of the Pinthali community. She was an active woman for her time (1950s) and has been attributed a major role in transforming her village. She took on a personal mission to resolve the water scarcity problems of Pinthali and convened a meeting of 60 households. She initially proposed to the villagers the idea of bringing in water from the Daunne River by constructing a long canal to channel the water above the flat land to irrigate the cultivated area. She believed that irrigation would transform the lives of the drought-stricken Pinthali community and is quoted as having said 'a person without education is like land without irrigation'. The landscape was wild with no organized cultivation and farming. Water was scarce, both for rearing livestock and for drinking purposes. Given the distance of the source and the rugged topography, the majority of the community felt that Beli Lama's proposal was not technically feasible and did not merit much consideration.

However, Beli Lama's proposal did touch the imagination of two other active community members. These men were Chhedup Namgel and Palden Wango, who decided to support her and pursue her proposal. Despite the support guaranteed by these two men, this vision was not able to convince the community to contribute financial and labour resources for the construction of this canal. In 1959, these three members, with a joint investment of approximately US $ 33 were determined to proceed forward with a plan to irrigate Pinthali. They decided to hire a canal contractor '*aagri*' (a local term) for the construction. The construction, through the jungle and rugged slopes of the hills, took 11 months. Thus Beli Lama's *mathillo kulo* (upper canal) became a reality. The canal was narrow and was built using local material with stone and mud. The volume of water conveyed through this canal was sufficient for drinking purposes and was adequate for irrigation during certain seasons. However, as the community expanded, the demand for water proportionately increased. With the annual repair and maintenance work, the canal was widened, thus increasing the volume of water in the canal. Yet water scarcity persisted with the expansion of cultivation and with an increasing population.

Renegotiating irrigation access and water rights

After having seen Beli Lama's innovation, the adjacent Brahmin community of Mangaltar VDC 5 and 6 decided to follow suit. This step became important in the formalisation of water rights[4], and contention and conflict between the Tamang and the Brahmin community in the sharing of water from Daunne Khola. However, rights to water for the Tamang community were well established, as ownership was based on first come, first serve basis. Technology had also provided legalisation of ownership, represented and manifested with a document in the form of a voucher issued by the *aagri*, at the end. As customary rule prevailed then, the *aagri* after having completed the construction of the canal, issued a receipt voucher in favour of the person who had assigned the construction contract. The *aagri*'s voucher was as good as *laal mohar* (the royal seal). In 1960, the *aagri* who constructed the canal had issued a receipt voucher for this canal in favour of Beli Lama, Chhedup Namgyal and Palden Wango. Thus, these three pioneers became the sole owners of the canal. These three owners performed the task of water distribution in rotation. Irrigation use was secondary, after drinking water use. When sufficient water was available, irrigation use was therefore granted by these three owners of the canal. Although the painstaking effort of yearly expansion of the canal continued, the scarcity of water for irrigation use persisted. Drinking water was acquired free of cost. However, for irrigation purposes permission and payment in kind (usually maize or other agriculture produce) had to be made to the three owners by the villagers for use of the water. Since the right to distribute water in the village was limited to three persons, this created a considerable rift within the community and divided the group into two segments. Those that supported the existing allocation of rights to distribute water and those that resisted it. The segment of the community that was in opposition decided to construct a secondary canal diverting the water from the lower section of the existing conveyance system, i.e. the *mathillo kulo*. After discussing the matter with the owners of the first canal, this group of people had the approval to use the same weir to divert the water through a secondary canal.

The *tallo* (lower) *kulo* (canal), received only excess water from the *mathillo kulo*, thus anticipated improvement in irrigation efficiency did not take place. In fact, the additional diversion canal created more confusion, as water resources had to be shared and distributed in two different canals. This increased conflict over water use rights and the conflict climaxed when a third kulo was constructed by the *pradhan pancha* (elected representative) who took advantage of his position when he was in power, bringing in direct canal access to irrigate his land. Disputes over water became frequent and in 1986, the village convened a mass meeting and decided to merge the three kulos into one integrated system. A decision was made to expand and use only the upper canal. In 1988, with the HMG/N's SINKALAMA intervention[5], the project agreed to provide support for the irrigation canal in Pinthali village. A permanent semi-lined canal was constructed in the village and the *baari* (irrigated upland) was gradually converted into an extended field. Paddy had been introduced in this area together with garlic, potato and cumin with the assistance of ADBN in the late 1970s. Water was abundant for irrigation purposes and Pinthali flourished with cash crop production. However, there was no formal water distribution mechanism. With the integration of the three canals, the distribution of water was based on demand and cropping pattern requirements.

With the provision of better water supply and an increased agricultural production, the community of Pinthali became more aware of other village needs. Demands from the farmers for livestock rearing, vegetable gardening and other small-scale entrepreneurial activities began to increase. Local knowledge and experience had shaped much of their progress and this aspect also became important in the shaping of their local management structures. Innovation again facilitated the needs of the farmers to support the activities they desired.

Institutional innovation: The endowment of the twin pine trees

As the story goes, in 1985, rain and fierce winds of a monsoon storm toppled two large pine trees that were situated within the community periphery. The two fallen trees induced the Tamang community to reorganise a much larger pool of shared resources. The community decided to unite together one more time with the idea of initiating a small community fund. They got together and cleanly prepared and sawed the timber into marketable sizes as rafters, beams and frames ready for construction use. The community then decided to take the timber to the nearest market and sell the wood. The proceeds were deposited into a community seed fund. The timber sale generated about US $ 180 and the money was made available for loans to the community. The concept behind the fund was to revive and expand the loan reserve to initiate community development work. This was made possible by instituting stringent rules and regulations. For example, a person from the community could get a short-term loan for a period of about one-month at an interest rate of 4 per cent per month. Similarly, a long-term loan extended to more than six-month period with a higher interest rate. This interest rate was quite high; the reason stated was that in this manner all the members of the community had an equal opportunity to borrow money for diverse activities. In addition it meant that a large sum of money was being generated and pooled into the community fund. Since the borrowers could not always repay the loan within a month the loan period was extended up to six months and sometimes even to a year. The annual interest rate was effectively about 48 percent.

There were other rules that ensured that the recovery process was a success. The loan was disbursed and recovered on the 18th day of each month. If a community member required to borrow an amount any other day, he or she just had to wait for the 18th day of the month. Recovery of the loan was made before noon. The reason that the date and timing was instituted, was to ensure that the process was transparent, well-understood in terms of scheduling and that all the members abided by the rules. The rule was created because the community members were busy with farming and other activities and business could be conducted and taken care of efficiently by using a minimum amount of time, without disrupting the regular community routine. Furthermore, if a borrower failed to return the loan of his/her term by noon, an additional 2 per cent fine was included as part of the punishment. In certain cases, when a community member was not able to repay the loan, livestock was confiscated from the member and/or banning him from any future borrowings. Within a period of five years this community initiative had become so successful that the village was able to contribute significantly to building of a local school and other development interventions. The fund is still operational and the community has Rs. 40,000 capital available for investment. Having organised themselves financially, lighting by electricity became a development allure pursued by some leaders of the village. The community made various attempts to bring electricity to their village. The village leaders went out different ways to bring this technology in their community.

Applying for Electricity

In 1980, the community of Pinthali first put in a formal request to ADBN. Subsequently, the community submitted two other applications in 1985 and 1988 to the Ministry of Local Development. Finally, after a long wait, in 1992 the community put in an application for electricity to the Economic Development Council and made a deposit of a collective sum of money. A feasibility study was then undertaken. In the meantime, a community entrepreneur, Bajra Dhoj Lama, installed a *paani ghatta* (water mill) to facilitate the agro-processing needs of the community. In addition to providing milling services, he was also able to generate sufficient electricity to light some houses in Pinthali. The entrepreneur further installed a diesel generator and by 1997 was able to provide electricity to about 35 households of Pinthali and was charging Re1 for every 25-W bulb. Since this local initiative was not able to supply sufficient electricity to all households, the community approached the REDP office for the electrification of Pinthali village. A feasibility survey indicated that Daunne khola could generate 12 kW of electricity. The designer, KMI, visited the site once to determine the selection of the turbine, based on head and flow and other site-specific characteristics such as the distance of the source. The normal design practice in Nepal involves the selection of a prototype for electrical generation to be determined by visiting the source. The head is the determining factor that allows the appropriate turbine model to be specified. The turbine selected then is modified to suit the site-specific requirements depending on the overall efficiency estimation.

UNDP/REDP Pinthali micro-hydel

In January of 1997 REDP, applying its holistic approach to achieve 'the rural livelihood enhancement through sustainable development' began its first intervention in Pinthali village. The holistic REDP model included various other goals along with rural energy development (REDP/UNDP 2000a; 2000b). These were natural environment preservation, local economy improvement, capacity building and institutionalisation of rural energy development, as the components required for the ultimate goal of the social mobilisation process.[6] This community mobilisation package consisted of six basic principles, which were: organisation development; skill enhancement; capital formation; technology promotion; environmental management; and women's empowerment (Kabhre DDC/REDP 2002).

Intervention method and process

With the assistance of the local partner organisation Resource Management and Rural Empowerment Centre (REMREC), a mass meeting was conducted in which all the community members were informed about the upcoming project. In August 1997, REDP initiated its community mobilisation programme and formed five female and six male community organisations (CO).[7] The female CO included 107 female members from 108 households and in a similar manner, the male CO was constituted with 115 members from 108 households (REDP 2000). The social mobiliser lived in the village for about six months assisting the COs to mature and transform themselves into Functional Groups (FGs). After the initial six-month period was over, various field visits were undertaken intermittently, to ensure that the groups that were organised were functioning according to REDP's expectations. Various FGs were formed to undertake sector activities such as the micro-hydel, forestry, health and sanitation, adult literacy, improved stove and small business enterprises. In the course of the mobilisation process, the final committee was organised by selecting a member from each FG, thus forming the highest tier of the new local institution, which became known as the Micro Hydro Functional Group (MHFG).

The MHFG became responsible for resource mobilisation and implementation of the project. The MHFG, constituted an 11-member team including six males and five females. The community selected a chairperson and a manager. The implementation process then secured contributions and commitments from the community and various stakeholders for the proposed programme. Using a bid process to identify the installer and the designer, the lowest bidder, KMI, was selected to install the cross-flow turbine to generate electricity.[8] As mentioned earlier on, cross-flow turbines have low efficiency, are suitable for low to medium head systems and are less expensive than Peltons. The bid process is also influenced by these determinants, as certain designers are associated with certain design types. Once the bid process was finalised, REDP transferred a cheque for Rs.1,257,336 to Daunne River Micro Hydro-Power Executive Committee (DRMHEC) for the initiation of the project. In addition, about 20 community members guaranteed their land as collateral to ADBN, for the additional loan of Rs. 189,686 that was required to be pledged from the community. Other contributions included Rs.100,000 from the DDC, Rs. 200,000 from the VDC, an HMG grant in subsidy of Rs. 199,150 and Rs.79,500 from the village community funds, in addition to in-kind labour and local materials. The cost per kilowatt production of electricity amounted to about Rs.123,459. About 70 percent of the total budget was spent on the purchase of the turbine. Extensive canal work and other civil structures were carried out at a low cost utilising the contribution of labour in kind from the project participants in the village.

The project implementation phase was hampered for some time by disputes over the issue of erecting poles on certain land holdings. The villagers were able to resolve the issue by negotiating and discussing the issue in a mass meeting. The MHFG was converted to an executive committee known as the DRMHEC after the implementation phase was over. On June 14, 1998 electricity was generated for the first time through the DRMHEC effort. The DRMHEC, after completion of the project, did not function as smoothly as anticipated. This was partly because the police operation of Kilo Sierra Two that was created to eliminate traces of the Maoist movement, created tension in and around the community, as discussed in Chapter 3. As a consequence, two consecutive managers abandoned their positions. Following this institutional set up, two youths from the village were trained as technical operators. Mass meetings have been taking place regularly as and when required for consultative purposes. Notes and records were also taken during each meeting.[9]

In January 2000 the DRMHEC was again converted into a management committee and was named the Daunne River Micro Hydropower Management Committee (DRMHMC) with a change in chairperson. The primary objective of this refocus was to steer the committee into registering as a cooperative. As functional tasks evolved, along with technological development, institutions were also redesigned to adapt the management function. As day-to-day management and operations were running smoothly, the move for decentralisation was also directed at making the committees autonomous in all respects, including resource generation. The management of repairs, maintenance and operation of the plant had been running smoothly. The tariff collection was also conducted smoothly. There were a few incidents of misappropriation and use of excess beyond what was allocated, however, the operator was generally able to appropriately deal with such situations. Now in 2003, the community maintains a micro hydel fund known as the Community Energy Fund (CEF). On July 2001, DRMHMC was registered as the Daunne River Micro Hydropower Cooperative Society Ltd (DRMHCS)(REDP 2001). This registered cooperative has 25-charter members, out of which 18 are male and 7 female. The 25-charter members are the executive members, who are the founding signatory members of the cooperative and are involved in the decision-making process. In addition, the total general membership of shareholders includes 228 persons as community members, including the representatives from the DDC and the VDC. The total outstanding shares at 16,000 were valued at Rs.2500 per share. In September 2002, the cooperative handed over a cheque for Rs.1371 as part of the obligatory 5 percent of the total profit to the DDC.

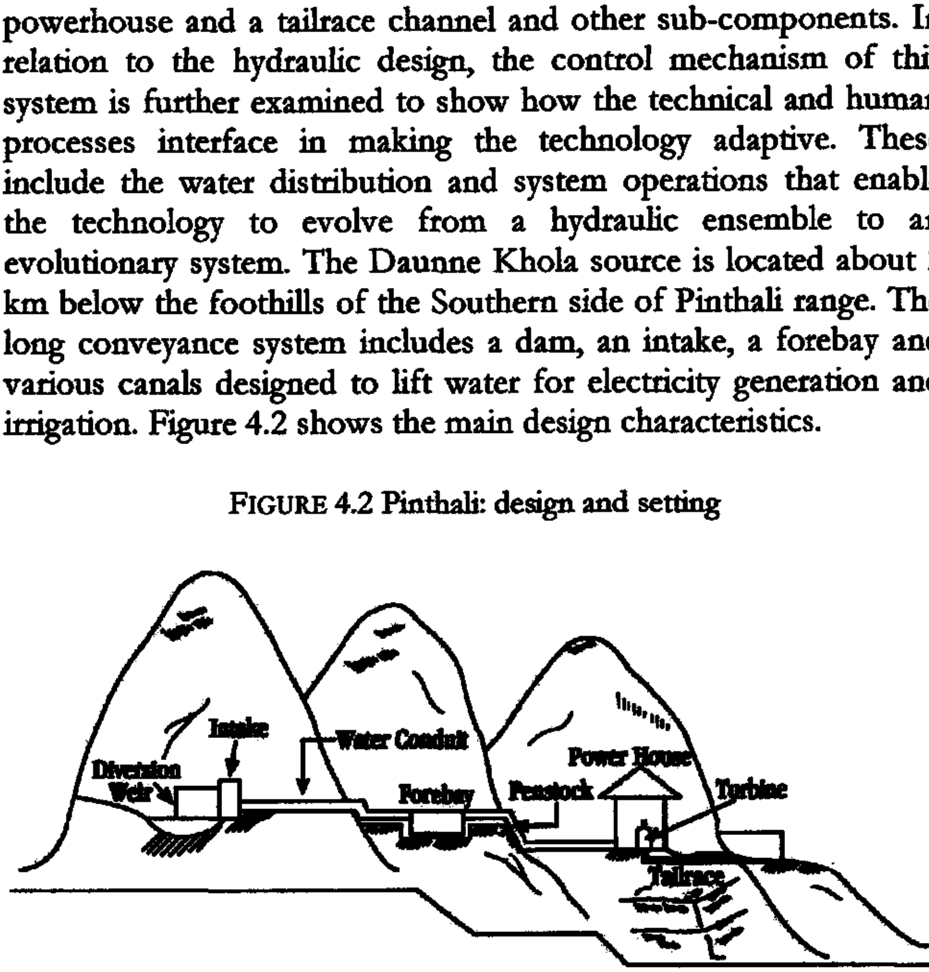
The community's initial vision of improved agricultural practices, institutional adaptation and technology development were critical factors for the success of the Pinthali plant. Resource generation from cash crops had been introduced prior to the micro-hydel intervention. Furthermore, the highlight of success also points to the agility and adaptability of the community to evolve various management functions in the process of decentralisation based on need, association, telesis and function. In addition to a transparent management team, sound leadership and reliable technical performance of this plant, a success factor for the DRMHCS has been the installation of agro-processing machines. The introduction of the agro-processing machines made a substantial and positive difference in the lives of the community in terms of reduction of drudgery and technology development. The rice huller and oil expeller, installed inside the powerhouse, are contracted out to the operator for a period of one year on an annual basis of Rs.9000 and Rs.20,000 respectively for rice and oil processing, to be paid to the DRMHCS.[10]

The committee, during a mass meeting, decided to hand over the contracting responsibility to the operator as it was felt that with his formal technical training, he would be the best person to run the plant successfully. The operator who was the leaseholder for the fiscal period of 2001, remitted the funds on a monthly basis to the committee and charged his customers about Rs.8 per *pathi* (measurement in volume) for grinding oil and one pathi of grain for husking one *muri* (measurement in volume) of grain. The community has decided to grant the lease to another community member for the second financial period.

System: Technology Design and Ensemble

An interesting feature of Pinthali MHES is the forebay design, which integrates the provision of water supply for irrigation and power use. This section first provides a critique of the design function by examining the various elements of the technical system, how they are designed and how they interact within the local ecology. In this regard, the hydrological characteristics are examined to describe the source of water supply, which will then show characteristics of the water flow relevant to the design. Subsequently, various physical components of the hydel system are described. These include the eight primary elements, which are, a dam or a weir, an intake, a water conduit, a turbine, a generator, a powerhouse and a tailrace channel and other sub-components. In relation to the hydraulic design, the control mechanism of this system is further examined to show how the technical and human processes interface in making the technology adaptive. These include the water distribution and system operations that enable the technology to evolve from a hydraulic ensemble to an evolutionary system. The Daunne Khola source is located about 2 km below the foothills of the Southern side of Pinthali range. The long conveyance system includes a dam, an intake, a forebay and various canals designed to lift water for electricity generation and irrigation. Figure 4.2 shows the main design characteristics.

FIGURE 4.2 Pinthali: design and setting



The design of the hydro power plant comprises a powerhouse with a cross-flow turbine connected with a rice huller for husking grain and an oil expeller for extracting oil from seeds. One hundred watts of power is assigned to each household. A meandering headrace canal, 1,890 meters long, which bifurcates at the forebay into two separate canal systems, constitutes the main design characteristic of the canal. A secondary canal diverts water to the powerhouse to turn the turbine. A tertiary canal from the powerhouse draws water for irrigation at the point of transfer through the turbine. A combination of human and hydraulic factors 'controls' the system. Allocation and distribution of water is dependent on seasonal variability, rainfall patterns and local practices. Water is used to irrigate fields and run agro-processing machines during the day and during low flows. At night the water is diverted to generate power. The *tariff* collected from the users of electricity and the mills is maintained in a collective cooperative bank account and is used for the operation and maintenance of the system. The profit generated from the plant is shared as a dividend with the owners of the shares, the DDC and the VDC.

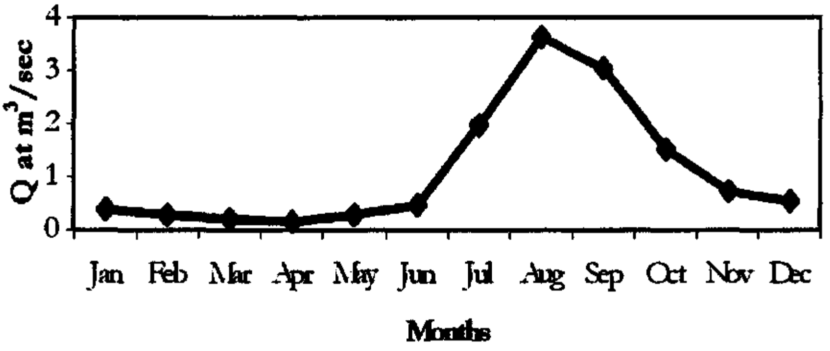
Water supply and technological elements

The MHES is a relatively new design system, both in terms of technological innovation and in terms of time. As previously mentioned, unlike other MHES systems that integrate with irrigation water use, this design provides separate channels to divert water at the forebay. The common design practice of MHES in Nepal usually makes provision for irrigation outlets in the headrace canal and very often the tailrace water is utilised to support agricultural needs of the area. This tailrace feature is also incorporated in the Pinthali system. This section discusses the key components that make up the Pinthali MHES and discusses some of the implications of design on functions and use of the system.

Daunne khola: system design and water releases

The source of water supply for both irrigation and power use for Pinthali village is the Daunne khola. As mentioned earlier the Daunne stream source is also utilised by neighbouring settlements for irrigation purposes. The difference in elevation between Daunne intake and the Pinthali village is about 480 m. Daunne is situated at an altitude of 703 masl. As mentioned earlier the Daunne khola, is a tributary of the Roshi River and it drains within the Roshi watershed. The catchment of Daunne Khola encompasses an area of 11.90 km^2. The catchment area covers about 75 per cent of cultivated area with the remaining made up of forestland. This area consists of steep slopes, rocks and depressions. This khola, which is a stream source, primarily depends on the monsoon rain for an adequate volume of water. The hydrograph indicates a close relationship between the stream flow and the monsoon rains. The discharge in the stream fluctuates following the rainfall pattern and peaks during the months of July, August, September and October, with the volume averaging a maximum peak of 2.53 m^3/sec. The dry season is during the months of February, March, April and May, when the volume decreases to an average of 0.22 m^3/sec. Given the source's dependency on monsoon rains, the canal volume is not only affected by this flow increase, but also along with it there are various challenges in controlling the system in terms of maintenance and operation issues. Figure 4.3 illustrates the first estimates of mean predicted flows of Daunne Khola based on dry season flow measurements.

FIGURE 4.3 Releases and flows in Daunne Khola: 2001



The source is located at a considerable distance from the powerhouse. During times of monitoring and cleaning a substantial amount of work time of the operator is spent in regulating the supply of water.

The diversion weir

The water from this stream is diverted to flow immediately through a semi permanent weir that is constructed with stone, mud and cement facing. The water releases during the monsoon period often obstruct and divert the flow in unintended directions, which require the operator's maintenance attention. Due to the nature of the dam construction the operator is again in charge of dealing with emergency maintenance. Every monsoon season, the weir breaches on average about three times. The operator mobilises resources and the farmers assist him during events when maintenance work may require more hands to repair. As the dam is located far away from the village, attending to this takes a substantial amount of time. The height of the headwork structure is 1.95 m. The flow is released through an open channel that is included as part of the headwork design. The channel has an opening of 0.8 cm and a length of 240 m. The water is directed towards the intake of the system. Other than the seasonal washing away of the weir, the farmers have been adeptly handling the system.

The intake

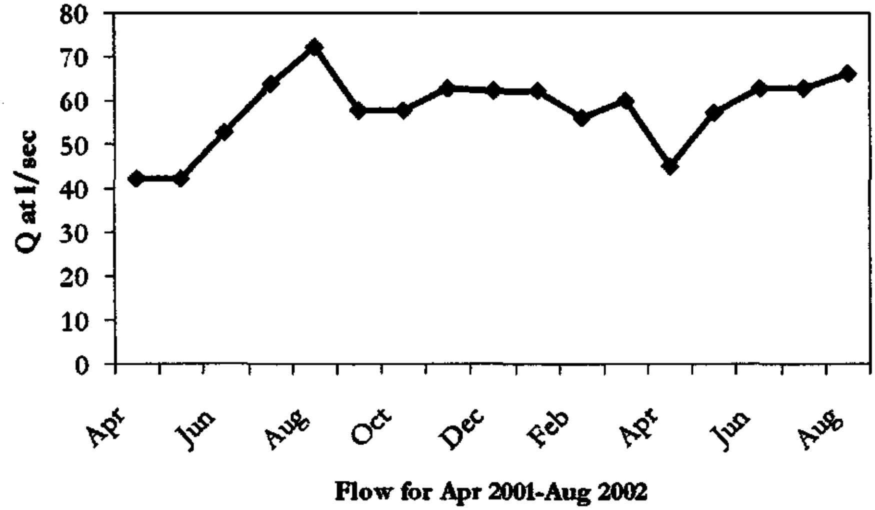
The water is diverted towards an open intake system, which consists of a trash rack and a sedimentation tank. The intake is a permanent open construction of cement mortar and stone mixture with a height of 135 cms. The sedimentation tank is a permanent structure of stone and cement construction and controls much of the obstructing particles such as sand and boulders before the water is discharged into the canal. The length of the intake is 270 cm with a width of 120 cm and the tank extends to a height of 150 cm. Towards the lower section of the tank, the structure has a spillway that checks the overflow. The spillway is fitted with a trash rack for desanding purposes. Depending on the season, these systems require cleaning and monitoring by the operator who flushes out and removes the obstructing particles such as stones, sand, leaves and even sometimes earthworms. As these components are located in an area where there are no settlements within close proximity, regular maintenance is the operator's responsibility. Whenever the operator senses a decrease in the flow of water in the canal, this provides him with an indication that routine maintenance may be required. Inspection of the headworks also includes observation of the overall canal system and the intake. Other than the regular maintenance, the intake has been suitable to support the overall system.

The water conduit

The entire conveyance system is a remarkably long and steep gravity flow construction, which consists of a headrace and a tailrace canal with provision of water supply for both electricity and irrigation uses. This system further includes an open forebay tank, penstock and irrigation outlets that lead into various field channels. The headrace canal is about 2 *kosa* (a distance of about 2 miles) long from the dam to the powerhouse. The starting point of the canal is located about 400 m away from the dam, which is located on the eastern face of the stream. The canal is erected on a 20 cm stone soling and is combined with a 5 cm lining of plain cement concrete. The canal structure is a semi permanent construction of stone and cement mortar and the width and the height of the canal vary in different locations. A partially lined canal has replaced the previously designed unlined canal system and in areas where landslides are common high-density polyethylene pipes (HDPE) have been used. The width of the canal varies from 59 to 63 cm. The canal is long and windy and in sections with rocky facing, the rocky face is utilised as the canal wall. Given the land formation and steep slopes, certain sections of the canal system use HDPE (high-density polyethylene pipe) pipe, whereas in other areas both sides of the canal facing are lined with cement. The canal then flows to the primary control structure, the forebay tank, where cast iron gates with notches are adjusted to control and distribute the water for irrigation and electricity purposes. The design discharge of the canal is calculated at 60 l/sec with a turbine discharge of 30 l/sec. The actual total canal capacity is 200 l/sec. The Figure 4.4 shows the water availability in the canal during April 2001 through August 2002.

The graph indicates that an average of 72 l/sec is available during the wet season of August and about 41 l/sec during the dry season in April. While there have been major changes in the water control after the provision to run the turbine to generate electricity, the design itself has taken the volume of water and outlets for consideration in allocation and distribution of water supply. Figure 4.4 gives an average discharge per month. This water supply in the canal is sufficient for irrigation and electricity needs even during the dry season.

FIGURE 4.4: Water availability in the canal



Integrative design of the forebay

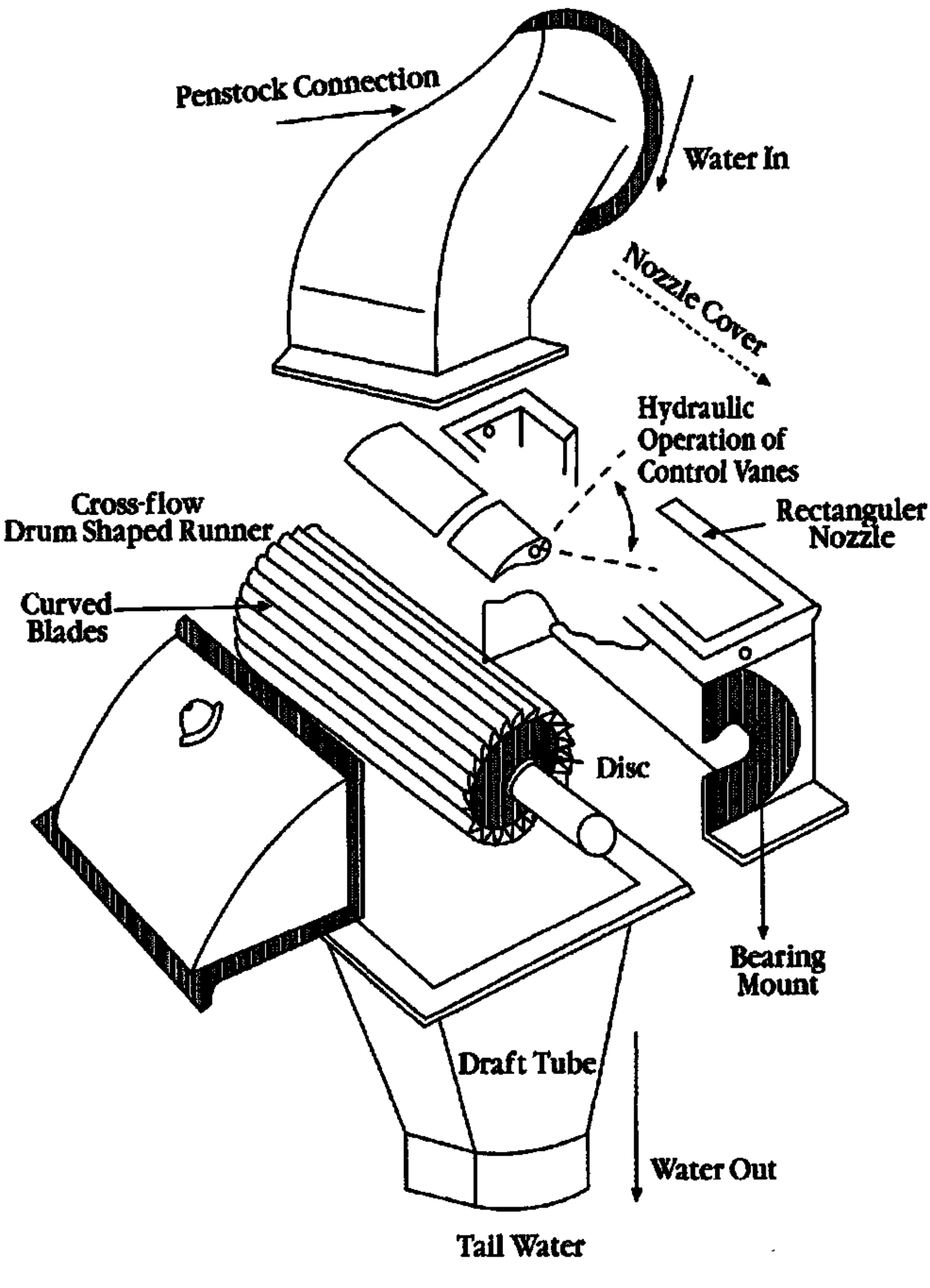
The forebay tank is a permanent structure that is designed to distribute water over two separate channels. The size of the forebay tank is about a meter in length with 185 cm internal width and depth of 110 cm. Sluice gates installed inside the forebay enable the distribution of water supply into two different directions, for power and water supply. The forebay structure has a trash rack to control obstructing objects from entering further along the distribution process. A pipe plug is used to sluice the forebay silt tank. At the rear end of this structure, one outlet connects the flow to the irrigation canal that is designed to run through the cultivated land for irrigation purposes. A second canal diverts the water towards the penstock for the purpose of running the turbine inside the powerhouse to generate electricity. Water at this point is controlled for two different uses. For the purpose of irrigating the fields the forebay directs the water towards the primary canal, which is a temporary canal of earth lining. This canal further diverts the water and distributes it to various outlets that lead into the field channels of the cultivated command area. The outlets are open and run through individual landholdings. Stones, rubble and mud are used to block the outlets when water is not required for irrigation purposes. The forebay design has minimised conflict between irrigation water supply and power use by facilitating the distribution of water at the major control point. In this respect, there is a strong conception of hydraulic control integrated in the physical system of this MHES, which supports the control of water through human processes. The farmers are generally responsible for the outlets provided in the headrace canal and the operator of MHES is responsible for the control at the forebay. Adjusting the sluice gates regulates the water flow at the forebay.

Given the steep topography, the canal is long and a prolonged time is required for the conveyance system to bring water to the forebay structure. Water losses due to leakage and seepage is observed to be much higher than the standard 20 per cent (MOWR/DOI/HMG-N 1990) that is usually considered acceptable in irrigation calculations for Nepal. There were at least 4 seepage sites that were observed within 100 m of canal length. These were mostly leakages through semi-lined canal structures, not including other water flow through the irrigation outlets that had been left open by the farmers. The installation of trash rack at the intake and at the last point at the forebay has assisted in reducing foreign objects. It has also minimised obstructions and losses. The water supply then moves through the penstock pipe, which releases water for use inside the powerhouse, through the iron-gate, fitted at the entrance of the outlet, that leads onto the penstock. The penstock pipe is made out of HDPE and has a length of 65 m and an internal diameter of 25-mm (KMI 1997a). The penstock has a head of 38 meters. The Pinthali MHES is considered a medium head system.[11] The HDPE penstock is suitable for this topography as it is cheaper and is placed above the ground instead of being buried underground for easy repair. The location of the penstock allows the operator to check the flow regulation as this unit is situated next to the powerhouse.

The cross-flow turbine and the agro-processing machines

Because of the medium head available at the source, a cross-flow turbine was chosen for Pinthali site. Cross-flow turbines are also cheaper than other turbines and have an efficiency of between 60-80 per cent. However, the efficiency of the cross-flow turbine is said to depend on the sophistication of the overall design (Harvey et al. 1993) because the design can be adapted to suit a wide range of heads, power ratings and a simple fabrication technique. This prototype is an impulse type and is suitable for medium-head systems. Figure 4.5 shows a schematic model of a cross-flow turbine.

FIGURE 4.5 Sketch of a cross-flow turbine



Source: Sketch adapted from Harvey et al. (1993)

The cross-flow turbine that is used in Pinthali's design system has a drum-shaped runner, which consists of two parallel discs. These discs are connected together near their rims by a series of curved blades. The runner shaft of the cross-flow turbine is horizontal to the ground, unlike a regular Pelton turbine.[12] When the turbine is in operation, a rectangular nozzle directs the jet spanning the full length of the runner. When the water comes into contact in the jet, the flow strikes the blades and releases kinetic energy.

Given Nepal's heavy reliance on the monsoon for water supply, there is a tendency of streams in hill regions to carry a lot of sediment. Cross-flow turbines are suitable as this turbine is more tolerant to sand and other particles in the water. Unlike, in the model shown in Figure 4.5, the system in Pinthali is not installed with a draft tube, which is a generally recommended component for this type of turbine. The cross-flow machines are easy to fabricate locally and Nepalese manufacturers have built a name for themselves in adapting to various location specific design modifications. Thus, the design of these systems has not quite reached the level of sophistication required for their operation. As seen at this site, the design configuration to increase the efficiency with the use of a draft tube is not practised. A disadvantage of this type of turbine is that it is unsuitable for low head-power ratios.

The expeller to grind seeds in order to produce oil and the huller for husking rice are of 8 and 10 HP (horsepower) respectively. Both these machines, as mentioned previously, were locally manufactured in Kathmandu. The expeller has a design capacity of expelling 240 kg grain per day, estimated at about 30 kg per hour. The huller has about 120 kg capacity per day, or 15 kg per hour considering 8 working hours in a day. Both machines consume 4 kW power for operation. However, extra electricity is being released and utilised while starting the machines. The electricity consumption by the agro-processing machines therefore is quite substantial and amounts to about 33 per cent of the total installed capacity. These two machines have to be operated alternatively, as the design does not allow the machines to run simultaneously. The villagers are now looking into ways where both can operate together, as the clients who come for milling service tend to wait long hours, because this service is also used by members from the surrounding settlements. The installation and incorporation of a pulley to regularise the system to function as one unit could fulfil this adjustment.

The oil expeller and the rice huller have not only given Pinthali its claim to fame but also the operator has been cast under a different 'economic' slot. He is the leaseholder of the mill. For example, on average, about 8 pathi of mustard and *sarsaun* (oil seed) is processed every day at the mill during off-season. This volume increases to about 15-20 pathi per day during peak and festival seasons such as *Dasain* and *Tihar* (festivals). Even with a rough calculation, the villagers estimate that the profit margin from the mill itself is a substantial commensuration for the operator to 'do his job' and keep the community satisfied. The agro-processing services have been welcomed by the community members as it has not only reduced drudgery in terms of travel and time, but also has replaced manual husking of rice, which is still practised in areas by using the *dhiki* (traditional technology for husking grain)

The generator

The energy that is released is then transmitted to an induction generator of 20 kVa (kilo volt adaptor) for converting the mechanical energy of the turbines to electric energy for a rated power capacity of 18 kW (KMI 1997a). As with normal REDP practice, this Chinese generator has been locally modified to make it suitable to the site. This generator uses a three-phase 220-volt induction motor. Regulating power control through sophisticated generators may require advanced technical expertise as well as prove costly for small-scale intervention.

In most of the rural areas in Nepal, single-phase induction generators are used to minimise the cost, in particular in systems that have an installed capacity of 10 kW or less. An ELC (electric load controller) governor controller of 13 kW consists of an electronic circuit and is connected to a ballast tank to regularise the flow and power output. During breakdowns, the community mobilises resources for repair and spare-parts. The operator can usually replace when coils burns out. Spare parts and servicing is usually available in towns such as Kathmandu or Butwol. The warranty period of manufacturers such as KMI is for the duration of one year. The community can approach the manufacturer for problems related to malfunctioning or spare-parts during this time frame.

The powerhouse and powerlines

The powerhouse is a permanent brick structure of about 6 x 8 m in dimension that houses all the electro-mechanical machines and transmission connections. The powerhouse is centrally located to provide milling services to the community as well as for the operator to attend to his regular duties.

In most micro-hydel systems in Nepal, individual metering is not encouraged as this also indicates open access to electricity for the users of the system. This implies that households can consume an unlimited and desired supply of power. For example, with limited power being produced, individual metering indicates high risk. If communities were to use gadgets such as an electric iron, which consumes high power and where 4 or 5 households were to use electric irons, the overall system would be put at risk since micro-hydel are small capacity systems. Therefore chances of using other electrical devices are limited. Furthermore, individual household meters have high capital and operational costs. Therefore a meter is placed inside the powerhouse, which indicates the amount of electricity being generated and the amount that is being collectively utilised.

The switchboard on one side of the powerhouse contains various switches, fuses and electrical connections. A transmission line of 1020 m distributes the electricity to 112 households. Wooden poles have been used as transmission posts to run the wires. As trees were felled during the project implementation period and were installed without proper curing, some of these now have been replaced with metal ones. Fuse boxes and MCCB (moulded case circuit breaker) have been installed in individual homes to give control over use of power. However, these sometimes get by-passed and are not effective in regulating control and access

The normal practice in Nepal is to install a 5 amp lightening arrestor every 1-km. However, as other MHES have also proved, this norm is not sufficient. This is because certain geographical locations in Kabhre Palanchowk are situated in high lightening zones, where the frequency of lightening often exceeds the capacity of the arrestors. The Pinthali MHES has faced occasional problems caused by lightening.

Water supply that is released from the turbine after the generation of electricity is directly connected to the tailrace.

The tailrace canal

For high to medium head impulse turbines, such as cross-flow, draft tubes are not generally utilised in Nepal. However, for the effective driving of the turbine, a draft tube fitted below the runner would prevent water from backing up and submerging the runner. The runner in a cross-flow turbine remains full of tail water at all times.

The split tailrace of 1,000 m channels water towards the terraced agricultural fields through a primary canal, which has been designed with a provision of various open distribution structures. Moving through various field channels the tailrace provides irrigation water through open outlets as it flows along the slope and ultimately converges with the Roshi River.

Water distribution and system operations

Both the water distribution and system operation depend on the hydraulic layout and human and technological control systems, and how these fit within the local needs. The Pinthali site shows that with every technological development, change and adaptation is also occurring at the institutional interface.

Before the micro-hydel intervention there were three community-constructed irrigation canals in the Daunne catchment. The first was built in 1959 to irrigate fields in sloping unbunded terraces. In 1979 a secondary canal was constructed to irrigate lower-level bunded terraces for growing paddy, buckwheat and maize. Pinthali continued to face water scarcity due to high conveyance losses, difficulty in maintaining the canal alignment, and the narrow width of the canal. A third canal was later constructed to irrigate cash crops such as cumin, garlic and grams in the plateau of the village. This canal became a bone of contention over water rights, as there were no formal mechanisms for water allocation and distribution among different claimants. The water division structure was based on a temporary adjustment, where the flow was either adjusted or changed by opening an orifice or changing the operating head, which affected the upstream and downstream flows. The human intervention increased disputes, and in 1981 the community decided to resolve the issue by merging the three canal structures at the source. This was done by expanding the width of the canal to augment the volume of water and also by extending its length to irrigate the fertile terraces of Pinthali. However, the efficiency of water distribution remained contingent on the ability of the farmers to divert adequate water when required, as well as on the establishment of parity in distribution between the head-enders and the tail-enders.

The micro-hydel intervention began with an intensive community consultation process. This technology has introduced a new kind of hydraulic design and social legislation, reshaped the social and agrarian organisations and minimised conflicts. As previously discussed, a micro-hydel users group was established with a manager and an operator to oversee the system. The primary responsibility of the group was to ensure that the financial revenue of the plant was properly maintained by collecting monthly tariffs, keeping account books and approving purchases of major spare parts. The operator of the system functions as a technical watchdog and oversees that the allocation and distribution of electricity is being maintained according to the wattage allocation plan and that there is no stealing of water. He is also responsible for minor cleaning of the canal, minor repair of the plant, and regulation of flow for distribution between electricity generation and irrigation. The construction of the power plant, therefore, introduced not only a formal local irrigation institution but with specific roles and tasks to which people were employed. In the case of Pinthali, these new tasks also regulated water distribution for irrigation on a time-share rotational basis.

The 127 ha of cultivated land in the command area of the canal lie under Ward-Numbers 7 and 9. The area under Ward-Number 7 is one-third of the area under Ward-Number 9, and water allocation is made for three and four days per week respectively. With this rule in place, ward number 7 uses water on Mondays, Wednesdays and Fridays whereas Ward-Number 9 uses water on Tuesdays, Thursdays, Saturdays and Sundays. However, water distribution was not rigidly practised according to this rule. The community maintained flexibility for negotiation in times of high demand, according to the cropping pattern and season when times and days for allocation are transferable. In normal circumstances and practice, water distribution starts either from the tail-end or from the head-end, alternating the sequence on a daily basis. The water distribution among the farmers starts with paddy seedbed preparation in mid May to early June.

TABLE 4.1

Cropping pattern and water requirement, Pinthali, Mangaltar VDCCommand area = 127.25 ha

Soil type = Sandy Loam

Kind of crop	*Season*	*Days*	*Base Period*	*Assumed Area for Harvesting (ha)*	*Duty (thousand ha/ m^3)*	*Water Requirement (l/sec.ha)*	*Water Requirement (m3/sec.ha)*
Paddy	Mid May to June	30	130	127	750	169.33	
Maize	March/April	45		76.35	2650	28.81	
Soya Bean	April to May	45	110	38.175	2650	14.41	
Garlic	September/October/ November	60	90	45	780	57.69	
Wheat	November/December	60	120	127.2511	2000	63.63	
Oil Seed	October to February	150	120	50.9	1750	29.09	
Potato	Mid January/February to April	90	110	63.625	700	90.89	
Vegetables	October/November	45	110	63.625	700	90.89	
	Water required in l/sec.ha					544.74	
	Total water requirement for 127 ha.					69,181.98	69.180

During this period water distribution is exclusively provided to the farmers whereas at night the flow is distributed for power use. In Pinthali maize is grown from March to April combined with soya beans. Table 4.1 shows the cropping pattern and water requirement of Pinthali village. The paddy cultivation period is the most water intensive time. The paddy area requires about 169 l/sec of water per ha. The paddy cultivation is combined with other seasonal crops. During other seasons, the cropping pattern typically follows with garlic cultivation and wheat, oil seeds, potato and other vegetables are also grown. Given this cropping pattern, about 69.180 m^3 of water is required to irrigate 127 ha of the command area. The farmers have well adapted to the hydraulic regime with the new design choice that now includes distribution of water for irrigation and electricity use.

Conclusion

At Pinthali, structure and agents have interfaced effectively within themselves and together to steer the evolution of the MHES. Despite social differentiation in the community, leaders have acted on behalf of others to access new systems, and ensure village wide, equitable access to electricity at prices people can afford. VDC, DDC, REDP and donors have followed agreed procedures, and joined in participatory actions that have given the community a technology they wanted and can manage: funds have flowed on time and even allowed creation of funds for maintenance, while villagers also honoured requirements for labour contributions. An operating system is in place that gives the operator incentives to work and he is involved with technology within his control. There were effective feasibility studies, and site visits by the manufacturers. Disputes over compensation were resolved. Thus democracy, through consultative and representative processes, has supported creation of an evolutionary system and democratic technology.

The Pinthali MHES is a system that has combined lighting, agro-processing and irrigation functions. It has thus offered the village a range of changes in their domestic lives beyond just light: lighting and agro-processing are offered at prices considered acceptable new options. The powerhouse is even a meeting place of sorts for the community. The entire village receives basic electricity supply:

the system also operates with safety features, and has a monitoring system of electricity use that is more or less effective and acceptable to the villagers. More on this follows in Chapter 8.

KMI's innovative progress in the micro-hydel sector has contributed in the development and design of various turbine prototypes in the country including the cross-flow turbine used here. However in order to achieve the level of sophistication that this turbine provides, cross-flow adaptation in the hills requires investigation of how to increase efficiency of the plant, while simultaneously strengthening the local O&M support systems in place.

The turbine selected is appropriate to the agro-ecology and is accepted by the villagers. There has been no experimentation involved. While the ensemble involves some foreign devices (like a Chinese generator), most parts and expertise to service them appear easily available in Kathmandu. The artefacts and processes for electricity generation do not interfere with irrigation supply, and the system design has even helped to increase irrigation water supply. Thus the design function of the system meets many social criteria. However, the level of electricity generated is still relatively low. Thus villagers have lighting but cannot use equipment with higher energy demands and there is no spare capacity for individual entrepreneurs to access this electricity supply for other processing or industrial uses. In this respect, the Pinthali MHES has met basic needs through a technology based on renewable energy. However, it is 'intermediate technology' from the perspective of longer-term electricity use. This is a dilemma for Pinthali, and Nepal, which is taken up in Chapters 8 and 9.

The Maoist insurgency impinged only indirectly on Pinthali, through tension and insecurity generated for certain individuals in the village. Two managers resigned (see Chapter 8), leaving the community to identify operators that now effectively run the system in a very 'horizontal' management structure. However, Pinthali was spared any direct ingress of army and police for interrogation. The Maoists did not target the infrastructure (other than the blowing up VDC building which was part of a district-wide led aggression), as happened also in the case studies that follow. This is perhaps because no key agency or service official was present there as a target and the system has been initiated and largely managed as a village affair.

The Pinthali micro-hydel case study has shown that various knowledge systems can be embedded in adaptive technology and historical and cultural processes shape these possibilities. These processes become forms of a communicative medium that can act as coalescing factors to bind community and identity together. Within the conditions of such socio-cultural binding, technology gets adapted and transformed to support the various local efforts and interfaces that take place between the agents, structure and system. The Pinthali community was able to negotiate effective interaction with other coalitions and service providers, which became important in the use and functionality of technology adaptation.

The Pinthali MHES indicates that the design process has recognised demands of local society, and was not just directed and imposed by certain network sectors. The design has enabled fulfilment of basic needs, and capacity to manage well in this agro-ecological setting and has fostered social interaction and space for people to build knowledge and accountable governance. It can be argued that this system is suitable on most design considerations of the design function and the design process seemed quite consultative not only because of certain agents involved in the designing process, but by the processes followed.

Notes

[1] There seem to be two processes that bring ethnic identification into transformation with wider social action around them. On one hand, the social-cultural domination by upper caste groups is used as a motive for ethnic upliftment, while on the other hand; the marginalisation of the ethnic group is projected to attract development aid even at the cost of distortion of facts. One of the community members expressed that the higher caste groups have always made fun of the Tamang community with derogatory statements such as "*Tamang ko dimag pucchar ma buncha*". A literal translation reads as "Tamang's head is in his tail". The upper caste groups often ridicule the Tamang community, for their lack of intelligence. The leaders of the community felt that they had to disprove such traditional discriminatory beliefs as being mis-perceptions, by demonstrating to the upper caste groups that they can work productively. During the semi-structured survey and focus group discussions, community members specifically requested not to mention their actual property value or sizes of landholdings for fear that they would be considered self-sufficient and would not be able to attract development

aid. While under-representation of property values and landholdings is a common practice that prevails even among urban property holders for the purpose of decreasing tax charges, its association with the politics of poverty and development aid is clearly understood by the rural community.

[2] Renje Dorje Lama who moved from Tibet to settle in Kabhre Palanchowk district had four sons, of whom the second son married a wealthy local girl. Her wealthy parents gave the groom's family the Pinthali Ridge as a dowry and the name over the years has evolved from *pingi* to Pinthali. This second son in turn had two sons who now constitute the extended family of Pinthali.

[3] The present community of Pinthali feels that their forefathers took a right decision. They expressed that the current group would not have progressed if this Brahmin would have been allowed to enter the community, as he would have gradually usurped power and control over their community. On the other hand, some members also expressed that perhaps the entry of this person would have allowed the community to develop effective strategies in dealing with people other than their own ethnic community. For example, interaction with other upper caste members at the VDC, DDC and Kathmandu were mentioned.

[4] See WECS (1992) and NLP (1996), for the State's formalised water rights provision in Nepal and the prioritisation of use. The Water Resources Act, 1992 characterises the priority of order on the utilisation of water resources into 8 different uses. In this manner, irrigation water use is listed as second after drinking water/domestic use. Hydroelectricity use of water comes fourth, after the third category of use for agricultural purposes such as animal husbandry and fisheries. The fifth use is associated with cottage industry, industrial enterprises and mining purposes. The sixth use is listed as for navigation, the seventh is for recreation. The eighth priority is for 'other purposes'.

[5] The SINKALAMA intervention of HMG/N was an integrated project that included all components of rural development including road, irrigation, water supply and livestock. This project was implemented in Sindhupalchowk, Kabhre Palanchowk, Lalitpur and Makawanpur districts and carried out technical improvements in numerous small-scale irrigation schemes in these districts. The name SINKALAMA is derived from the names of the first districts where the project was implemented.

[6] Latrine construction has been a successful initiative, which has had a positive impact on the health of the community and the environment. However, some community members expressed that the Rs.10, 000 allocated for individual households for latrine construction have been received only by a selective few and mostly by the active political and community leaders of Pinthali.

[7] See Chapter 5 for details on the REDP social and community mobilisation process and creation of local institutions such as the COs

and FGs.

[8] The quotation for the bid usually involves the cost (installation and supply) of the turbine and does not always include civil work expenses. The community usually covers these costs. The quotation from KMI was substantially lower than those of the other bidders. For example, Balaju Engineering Works had quoted an amount of Rs.1,561,900 and Nepal Engineering Energy had estimated an amount of Rs.1,262,900. KMI, the bid winner, had quoted an amount of Rs 826,010.

[9] The accounting books, financial ledgers and project documents were destroyed when the Maoists attacked the VDC office and set fire to the building in June 2002.

[10] Sanga Bahadur Lama owns a 10 HP diesel mill in the village, which is of Indian make. This machine has been in operation since January 2001. He states that the villagers and the surrounding community prefer to use the agro-processing machines located in the powerhouse because of the fee structure, which is cheaper than that of the diesel-mill. However, the diesel mill has a grinder, which does not exist in the powerhouse, and people use this mill for grinding corn, paddy and wheat. The powerhouse mill can only husk and not grind flour. The grinding charges are 12 *manas* per *muri*. He would prefer to connect his mill and run it with electricity from the powerhouse. The electricity generated from the powerhouse is insufficient to operate his mill.

[11] A defined classification of the 'head' of the plant depends on the height of the situated penstock. In this respect above 100m head is considered a high head, 20-100m is considered a medium head and 5-20m is considered a low head. Below 5m is ultra low head. There are variations on this interpretation depending on the calculation of gross head. For example the Kusha Devi site has a gross head of about 80m and uses a single nozzle Pelton turbine. The designers (NTU and ES) have referred to this site as having a high head, but according to the defined classification, this site can be categorised as a 'medium head'.

[12] Pelton turbines are used at sources with high head. Pelton turbines are more expensive and have an efficiency of about 80 per cent.

5

Technology Trials and Prototype Testing

The Propeller MHES at Katunje Besi

Yo urja ta hamro ghaanti-ma yetro thulo haad adhkeko jasto bhayo; na nilnu na ukalnu: This project has become like a big bone that is stuck in our throat, we can neither spit it out nor swallow it.

Devi Shrestha, Katunje Besi, May 2001

Introduction

The 8 kW propeller turbine installed and implemented under an R and D (research and development)[1] initiative between a national designer and manufacturer, Kathmandu Metal Industries (KMI) and REDP in Katunje Besi village, has witnessed various local actions. The design option chosen to supply electricity was not the community's first choice. The struggles of adaptation, around this design, have links with the technical, managerial and socio-political dynamics of the area, which as is clearly shown by the opening quote, have not been easy.

This chapter describes the interface between systems, structures and agents, amidst water availability, a changing society and a community caught within various power struggles, where technology has served as an interlocutor for change. Historical changes have occurred through geographical movements and also socially, politically and technically, by challenging development approaches. Changes have also been brought forth through local innovation by reformists from this area.

The Changing Society of Katunje Besi VDC-1

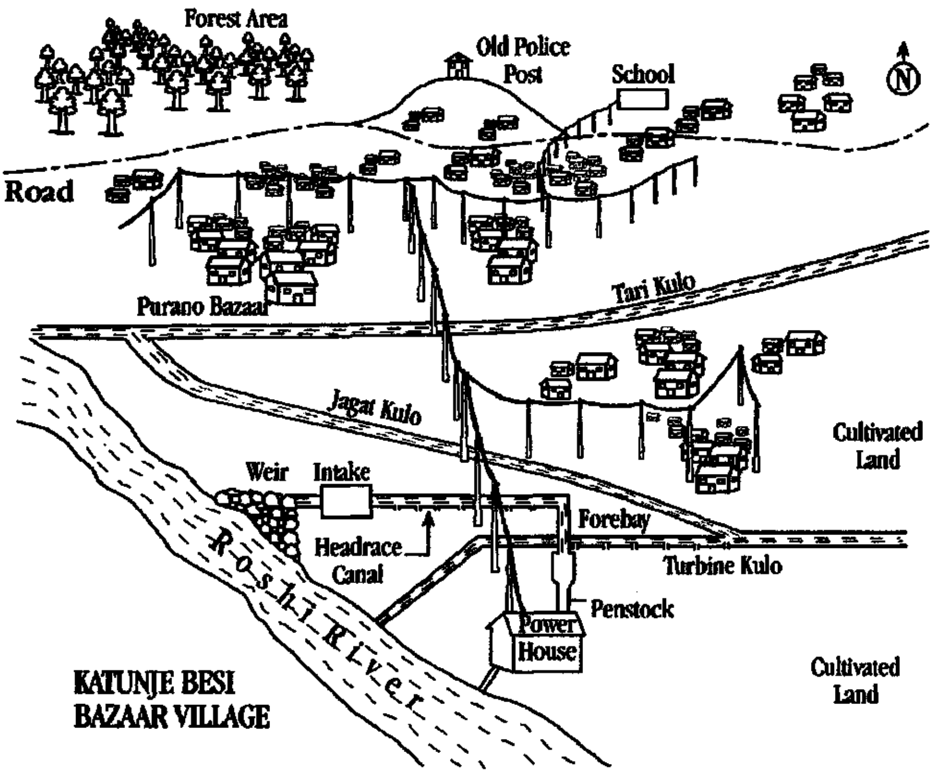
From gaon to besi to bazaar

The concept of community requires a rethink (Agrawal and Gibson 1999), and as the development environment changes, the definitions also change. This community is not 'mythical' at all, but is one that is upward and mobile, and *bikas*[2] (development) in many ways signifies this mobility, which is precisely measured from relocation from *gaon* (village on top of a hill) to *besi* (base of a hill). Indeed, the besi has been an attractive option for rural development intervention. Development initiatives also become more accessible to communities who maintain two homesteads: the gaon and besi homes, where the farmers come down to besi to work during the day and attend to the farm, and return at night to their gaon homes. Katunje Besi fits a perfect profile of a community striving for change in the midst of this bikas while sandwiched between various power struggles. This bikas has involved the move from the hillside to the bazaar, as well as from the hills to the plains and even from Nepal to India and where opportunities for a better life exist. The migration has not come easy to the community of Katunje Besi bazaar. Bikas also signifies understanding of the technological wealth of the community that exists in the form of local innovation and entrepreneurship. For them, bikas in technological development also means having connection to electricity and using the power of their choice to improve their lives.

The basti (community) of Katunje Besi is located about 105 km East of Kathmandu. The river Roshi has created a narrow valley along this area, where the major span of cultivated land is situated in the besi. At the start of this study there was a police post situated on the hillside overlooking the bazaar. Climbing from the bazaar up to the gaon, one felt under the minute gaze of the police station, as well as the wary eyes of the community. The historical evidence from Katunje Besi bazaar, located in Katunje Besi VDC in Ward-Number 1 suggests that the concept of community is not at all monolithic.

In 1979, this area had only one house that belonged to Moti Lal Shrestha. Because of the proximity of this area to Sindhuli and Kathmandu, this area became a trade thoroughfare. As men started becoming more active in the political arena, this area gradually expanded with the lower section designated as the *bahun* (Brahmin) locality of the GAM *Tole* (locality of Gautam, Adhikari and Mainali). The *Purano Bazaar* (old market area) developed as the Newar community and became involved in the opening of the small teahouses and convenience stores. Figure 5.1 shows the village, the plant and water supply of this area.

FIGURE 5.1 Map of Katunje Besi village bazaar, water supply and plant



Map: Not to scale

Other ethnic groups such as Tamang groups also settled in this area. For some, the movement meant opportunities for cash income through labour and for others, to get involved in trade of consumer products. The ethnic groups of Brahmins, Shresthas and Tamangs each have a stronghold and niche within the community. While the Brahmins seem to be active in politics and farming, the Newars combine farming with trade and the Tamangs seem to be busy with road construction as labourers, contractors and also in politics. Opportunities for local labour and trade links that existed through infrastructure development seem to have been the primary impetus in developing this community. By 1985, the settlement started picking up with the road construction that ran through the main bazaar area; there were about five households at that time. In 1988 two more families settled in this area and by 1994, this community grew to 11 households. By the end of 2002 Katunje Besi had a community of over 66 households that included seven landless households and new shops, diesel mills, saw mills and other small business enterprises that have all sprung up in the vicinity.

With the construction of a motorable road, built with Japanese development aid, the Japanese construction-company known as Hazama Corp's presence in the area, communication and trade with Kathmandu has also been facilitated. The bazaar area has also now moved nearer to the intersection of the motorable road. A closer look around the area reveals a thriving and hardworking community, regardless of the difficulties the community has undergone since 1997. This struggle has not been easy, as conflict, dichotomies of development, divisive politics and social unrest have co-existed side by side within the community life.

Around 60 to 70 per cent of the communities in this area depend on agriculture and the fertile plains of Roshi watershed to provide two crops per year. In this rich watershed, comprised of sandy loamy soil, two staple crops are sown and harvested annually. Agriculture is the main occupation and the major source of earning of the people in this area. The dominant cropping pattern for the irrigated condition is maize, paddy, mustard and wheat. Wheat is grown on about 30 per cent of the area. Potatoes and vegetables are also grown in a smaller area. Normally, paddy is grown from mid-May to mid-June and is harvested around November/ December. The cropping intensity in this area is estimated about 180 per cent, depending on the size of the farm holding (DOI 1998). In the rain-fed area, mostly maize, millet and some pulses are grown. Formation of local collectives of milk for dairy purposes has also provided this community with additional income. Access, facilitated by the construction of the road, has enabled the community to supplement their income by selling milk. These livelihood practices are prevalent within the low-lying Roshi watershed. The rest of the community depends on daily wage labour and migrant work. Most of the youth from this village have moved elsewhere due to the Maoist insurgency that has affected this area. Many households have one or more family member who has migrated to India for better economic opportunities.

Design needs, innovation and local reformists

Innovations were brought about in this village by some of the community leaders and entrepreneurs. Their vision foresaw that convergence of the economic and domestic sectors was required for enhancing their livelihoods and this was part of the bikas that the community longed for. During the period when migration to the plains started, the *dhiki* (traditional technology for husking grain) was used for threshing, while a ghatta was used for grinding. The rate for grinding one *muri* (about 50 kg in volume) of grain was one *pathi* (about 2.3 kg in volume) of the grain. This practice of payment still persists in the surrounding mills in this area. Around 1981-83, a gentleman by the name of Subarna Shrestha of Sisne in Khanalthok VDC established a diesel mill for processing mustard and rice. The establishment of this mill was the first technological intervention in this area that had a profound impact in the burgeoning of this community. People from all over the surrounding villages began to throng the mill for pressing oil and threshing rice. The rate for threshing one pathi of rice was two *mana* (about 0.35 kg in volume).

A tribute to Nanda Raj Lama

During the 1980s there were only two houses in the bazaar area. As the number of households started increasing, in 1990 Nanda Raj Lama established a mill with a loan of Rs. 140,000 from the Agriculture Development Bank (ADBN). The diesel-operated mill provided the facility for a seed grinder, huller, sheller and rice beater. This was just the start, as new mills sprung up in the area. In 1996, a mill was established for beating rice. In 1998, a diesel-operated saw mill was established in the area.

Having succeeded with the diesel-operated mill; entrepreneurs from the village started focusing their attention towards electricity. In 1989, the community decided to put in a formal request at the district for a grid connection to access electricity. Transmission of electricity through the grid connection was about 2 *kosa* (about 4 miles in distance) away in Khanalchowk VDC. Subsequently, after the application was filed, the electricity department surveyed the area. The community then started sharing ideas of a bakery, ice cream parlour, mills, and other facilities. Between 1991 and 1992, the community organised themselves and distributed electricity to 30 homes from a diesel run generator. This effort ceased midway, as the community was scattered and the capacity of cables and voltage was not regularised for the load transmission. In that effort, however, the mill owner Nanda Raj Lama had successfully distributed 5 kW of electricity, at the rate of 75-W per household charging Rs.95 per 75-W. This practice ceased ultimately after the untimely demise of this entrepreneur.[3]

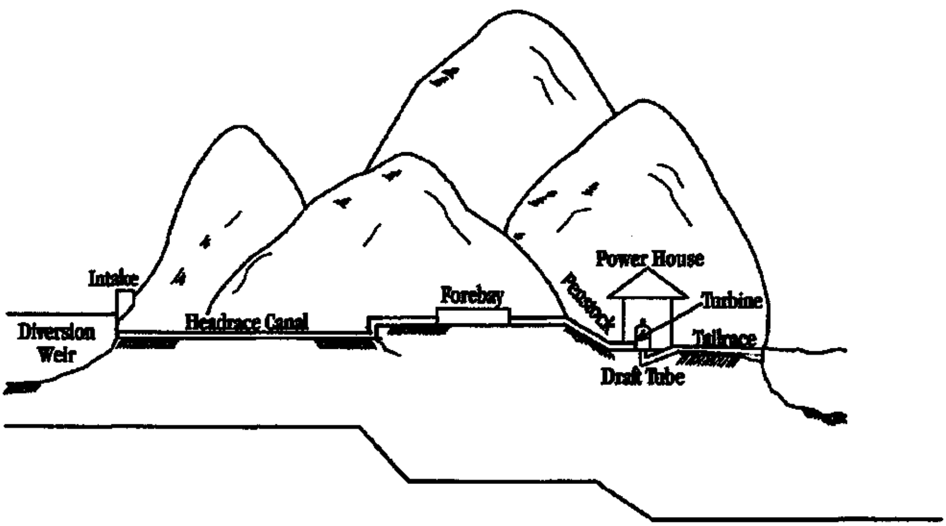
Now this area boasts 4 mills, one sawmill, 3 ghattas, over 7 television sets, various radios and one refrigerator, all operated through diesel. Four television sets are run from car batteries. Most of the radios and transistors are also run in this manner. The car batteries are usually chargeable and last as long as 15 days. Three households are also using solar power to light their households. Now, they have aspirations to get a local telephone to communicate with the urbanised world, and a regular supply of electricity that meets all the requirements of a growing community. An REDP MHES programme became located here, after social mobilisers for the Pinthali MHES project came to know the village as they regularly drove through the bazaar.

Caught in-between the power struggles, Katunje Besi bazaar today stands in the shadow as a withered plant in need of water despite the fact that the giant Roshi River flows next to it. The '*Hariyali Lodge and Restaurant*' the tallest building standing in the bazaar area, that still has its bullet holes, perhaps best symbolises the once existing vibrancy of this community, its technological interventions and the struggle for development. The police post that was once located atop the hill is no longer there. There have been significant changes in the community between 2000 and 2002, during the process of this research. Like the falling of domino blocks, the state institutions around the Katunje area collapsed one by one. With the aftermath of the state intervention of the infamous Kilo Sierra Two operation, Maoist resistance began gaining a momentum of its own.[4] The disappearance of state institutions in the village first began with the burning of the Forestry Department building, then the health post, followed by the drinking water office, then the bombing of the VDC office and finally the post office on March 2002. However, even after the police post had long disappeared, the community vibrancy remained intact and the community was looking for ways to rebuild the dysfunctional turbine and the plant once again. A lot of history, sweat, effort, money and time had been put into this MHES, and the community has demonstrated that guinea pigs of development do not give up easily.

River Regime and System Setting

Lying at an altitude of 800 meters in this cleavage in the mountains, Katunje Besi is situated within the sub-basin of the Roshi watershed and encompasses a command area of about 11 ha (hectares) of land (ibid 1998). The catchment characteristics in this area include forestland, grazing land and cultivated land. The entire catchment in this area falls below 1400 m. At this juncture, the Roshi River flows eastward with a variable gradient. Figure 5.2 provides the design of the plant in its setting.

FIGURE 5.2 Design and setting



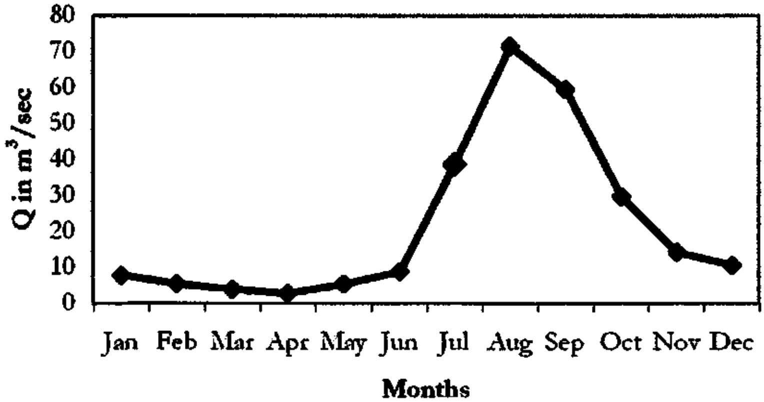
One can view the gurgling Roshi clearly from the bazaar. A network of irrigation *kulo* (canal) provides adequate water for agriculture. The powerhouse is located about 10 m (meters) away from this river, which is the source for the generation of electricity. Along the southeast side runs the Mahabharat range where two spring sources of the Pota Khola and Gopeshore Khola feed into the Roshi River. The community has indicated that the Pota Khola and Gopeshore transform themselves in the monsoon period and become the main culprits in creating hydro-havoc each year into the Roshi. The rainy season brings much flooding, and landslides gathering material like soil, stones and boulders and spill onto agricultural fields. Those living in the villages used the besi along the banks of the Roshi River to practice farming in their own traditional ways, and bore the brunt of natural calamities affecting their location. In 1972 a massive flood from the Roshi River hit this area: it inundated the entire plain, leaving no trace of agricultural fields and irrigation structures. After the flood, the locals reclaimed their land by collecting stones and soil, making the land arable for farming again. This flood was so severe that the community of Mainalis, Adhikaris, Gautams, Tamangs and Shresthas living in the gaon had difficulty sustaining their livelihood. The extent of famine abated when land was fully reclaimed, and it was only around 1981 that farmers managed to get a full harvest from the besi area. In 1992, this area again witnessed an unprecedented flood when the water level rose above the field level. Boulders and rocks were brought down from the Pota Khola catchment area. The villagers now fear that this area may be prone to natural calamity every twenty years. With a road construction in progress, the continuous retrieval of boulders, gravel, sand and rocks from the riverbed is straining the agro-ecological dynamics of the watershed. Not only do the dam and the water supply system get affected, but this area also suffers annually from small-scale flooding from the Roshi River.

Water supply, design flows and releases

The River Roshi has created a narrow valley along this area where the major span of cultivated land is situated in this besi. During the monsoon, tracts of land above the river get inundated, at times destroying the harvest. The volume of water in this area increases substantially and peaks in the months of August and September. Figure 5.3 shows the monthly water availability in Roshi Khola at Katunje Besi, based on dry season field measurements from 2002.

The first estimate indicates a maximum flow of 71 $m^3/$ sec in the wet month of August and the minimum flow in the month of April ranges is 2.86 $m^3/$ sec. The fluctuation in discharge at Roshi River in Katunje Besi is also heavily influenced by upstream releases, in particular by water control at the Panauti Hydro Power plant, which utilises a much larger volume of water. Therefore, the Katunje MHES does not entirely depend on the monsoon flow: the volume available for use is influenced by other upstream uses.

FIGURE 5.3 Water releases and flows in Roshi Khola at Katunje Besi

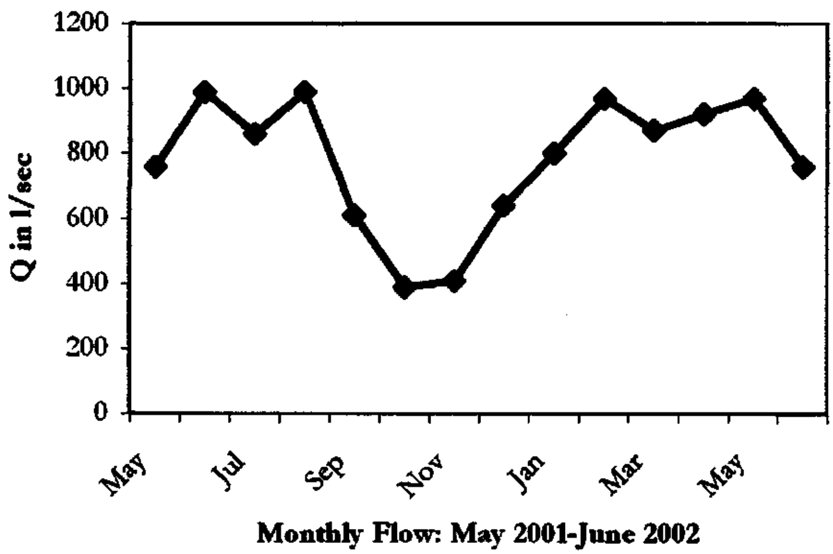


The discharge measurements at the source in Katunje Besi, indicates that there is adequate water available for generating electricity and other uses during the dry season. Taking advantage of these natural resources available, various irrigation systems in the past have provided irrigation facilities in this area. Since the volume of water flow is substantial, due to the confluence of other Roshi tributaries in this area, there exists a long history of irrigation intervention in the community. During 1961, on the initiative of the local people who resided in the gaon, but owned land in the besi, construction of a canal to irrigate around 500 *ropani* (measure of land, 0.05 ha) of land took place. However, in 1968, the canal was severely damaged due to a heavy landslide and the steep topography. The community's engagement in repair and reconstruction of this canal led to the accidental death of three community members in December 1968. After few years, the community came together and initiated the irrigation system, which became known as the Tari Kulo. In 1988, through the HMG/N intervention, the SINKALAMA project was implemented, in which the Jagat Kulo was constructed, with financial support from the community. Thus, prior to the REDP intervention, there were two existing irrigation canals in this area, the Tari Kulo and Jagat Kulo. The third canal, a segment of which was also built in 1988 was improved and expanded, to form the Turbine Kulo for power generation through REDP intervention. All three irrigation systems are farmer managed.

The farmers are quite satisfied with the irrigation system, as water is abundant. Therefore, conflict over water use is minimal. Most of the farmers living around this area are small landholders and own in average about 10 ropani of land. There are about 7 households that do not own land and some of these households belong to ethnic minority groups. Water is adequate all year round.

The field measurements of canal discharge undertaken in May 2001-June 2002 indicate that water availability and occurrence of peak flows basically follows the annual river hydrograph, however other influences can also be observed. Figure 5.4 shows the monthly average flow measured at the site.

FIGURE 5.4 Turbine Kulo monthly supply and releases



In 2001, the maximum supply of water occurred during August when discharge was higher than 990 l/sec in the canal. In the hot month of May, there was 25 per cent less volume of water supply in the canal. During the same month in 2002, there was no significant decrease in the volume of water. The community has attributed this fact to an increase in rainfall in 2002, and also to the power plant at Panuati being in-operational for a period of time. In February 2002, the discharge indicates a high volume of water of 970 l/sec. Only one measurement was undertaken for this month.

Intervention Method and the REDP Prototype

The Lalitpur and the Kabhre Palanchowk district were the two districts that implemented R and D initiatives under the REDP programme. A total of four R and D initiatives were carried out in Kabhre district between 1997-2000 and the propeller turbine was one of those that was introduced in Katunje Besi. The testing of the propeller turbine was included as one of REDPs technology development package.[5] As REDP had other ongoing activities in Kabhre Palanchowk district and also because of the close location of the district with Kathmandu, this area was chosen, the decision of which again was partially influenced because of the ongoing Maoist conflict. The REDP technical staff and KMI had initially selected a site in Falametar for this prototype testing. This site was later abandoned because of ongoing community conflict. Then, REDP decided to move this project in Katunje Besi. Initially the REDP Kabhre Palanchowk office had expressed its inability to work in Katunje Besi VDC since this VDC was not a programmed area. The community was diverse, fragmented, dynamic and undergoing severe social and political changes. The community had not put in a request at the district for this project and they were not aware that the turbine was part of an R and D intervention. The prototype intervention was initiated in an interesting way,[6] where the experiment sought to ascertain the suitability and adaptability of a low head propeller within a turbulent river regime.

At the beginning, there was opposition to this project, ostensibly because the suggestions of the community for site selection were not considered. The implementing agency seemed reluctant to intervene. Given the nature of the experimentation, where a low head site with an abundant flow of water was required, this site was ultimately selected. During the design and implementation phase of this project and continuing afterwards, particularly between 1997 and 1999, this area was one of those under investigation by the police operation of 'Kilo Sierra Two'. The strong presence of the police force in the area, together with their accompanying interrogation activities disrupted and created uncertainties among all stakeholders, in particular the community. In the process, the lives of some of the community members were lost. The project went ahead during these difficult times and after the killing of Nanda Raj Lama, the project was completed overnight. Elders recount that at night they were ordered by the police force to patrol the village to ward off the Maoists and protect their neighbourhood while during the day the community made contributions in cash for the cause of the movement.

Under these circumstances and under diverse socio-political contradictions, this project was implemented.

Hydraulic ensemble

The Katunje Besi VDC-1 plant is an integrative agro-energy[7] system where the water conduit is designed to supply water for local irrigation requirements as well as for electricity generation. Unlike the design system in Pinthali where the forebay is designed to supply water for power and irrigation use, this plant has made a provision for irrigation supply through the main water conducting system. The main features of the hydel system include: a temporary weir; an intake; and a water-channelling system with a forebay as described below. Unlike other micro-hydel systems, this plant uses a draft tube because of the nature of the reaction turbine that has been used at this location.

The diversion weir and the intake

The water from the Roshi River is diverted through the construction of a temporary weir made out of stone and rubble to direct the water, which flows through a constructed open channel, then accumulates at the open dam. The size of the pond at the diversion point changes every monsoon given the nature of the diversion system, which is located next to the Roshi River. Measurements taken during the research period at the head of the dam, where semi-permanent construction begins to supply water, the external dimension of the weir measured at the site is 1.475 m in width. The internal depth of the canal measures about 1 m.

The intake is an open structure of permanent construction and is fitted with a trash rack. Given the abrasive nature of the source that often carries heavy bed loads and has characteristics of unpredictable flood frequencies and erosion prone environment, the trash rack requires regular maintenance. Due to the temporary construction of the diversion dam, the design of the open intake has been useful; as it allows easy maintenance to regulate the flow and the obstructing particles are visible for cleaning. A metal sluice gate, immediately after the intake, regulates and controls the water flow in the canal.

For regulating the water supply for the powerhouse, the technical operator (responsible for turning the machines, to release electricity) ensures that there is sufficient water available to run the turbine. Therefore, he visits the conveyance system up to the weir, checks the outlets and makes sure that there is a regular supply available. As the farmers in this area depend on this system to irrigate the fields, they are actively involved in the maintenance and cleaning of the system. They also jointly undertake the seasonal repair and re-construction of the weir. Women members equally participate in these activities.

Water conveyance system

The water conveyance structure consists of three separate canal systems in this area. The canal that supplies water to the powerhouse is known as the Turbine Kulo and supplies water to the agricultural fields. While the main canal channels water towards the powerhouse for generating electricity, the provision for irrigation is made at the lower section of the command area, where 2 inches diameter HDPE pipes are installed. In addition, open outlets in the canal at intervals about every 3 m provide water towards the south-eastern zone of fields. The water flow in these open outlets is further directed to run through various field channels, which then run through individual land holdings. The length of the headrace canal is 650 m and is designed with a canal capacity to carry 1200 l/sec of water. About 400 l/sec is diverted and regulated by the sluice gate, which is placed before the forebay to channel water into the forebay. The remaining flow in the canal is designed to provide for irrigation. The open canal system is a semi-lined permanent construction, which is 90 cms wide. The width and depth of the canal seems to vary in different location, ranging from 90 cm to above one m. The lower end of the Tari Kulo and Jagat Kulo also connect with the Turbine Kulo and water supply is used for irrigation.

There is no particular person assigned to check and supervise this inter-connected network of irrigation canals. The designing of this system, which is spatially organised, seems also to be shaping the distribution structures. The operation and management of these structures therefore, are influenced by the design of the canal itself. These locally designed and farmer managed systems have been documented for their design capabilities in mediating relationships between water flow, distribution and mode of delivery (Parajuli 1999). The Katunje Besi technological design and networks of canal allow the community to spread a flood easily through these various sub-systems if a surge comes into the canal. As this is a flood-prone area, the local technology design has included the control of this aspect in the design feature. Respective community members and farmers, who own land next to the canal undertake the operations, maintenance and cleaning of the kulo. Both men and women share responsibility in organising water distribution, maintenance and cleaning their respective kulo. Therefore, each sub-system of a kulo seems to function independently, yet is arranged within the design complex of a larger technological system.

Forebay

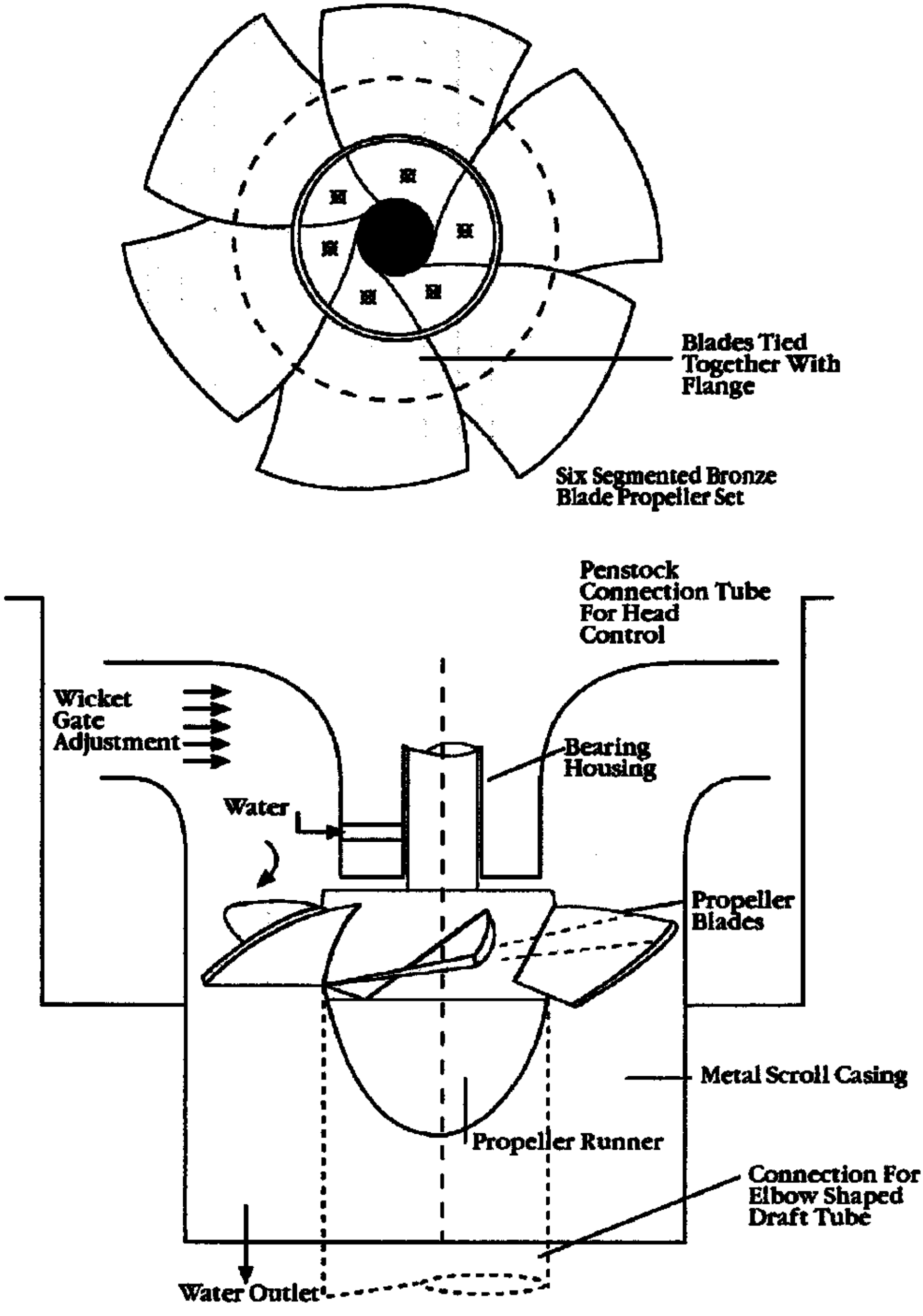
The 400 l/sec water from the headrace is then designed to flow into the forebay and then immediately through the penstock which connects to the turbine in the powerhouse. The forebay and the powerhouse are connected by a steel penstock pipe of 13 m, which is placed at an angle of 45 degrees, to allow for a 5 m head for discharge of water. The forebay structure is a permanent open construction of reinforced cement concrete, with a total length of 21 m, a width of 1.4 m and height of about 1.90 m. This structure consists of a silt basin, a trash rack and a spillway. In addition, at the mouth of the structure, a metal spillway gate of 0.8 m x 1.75 m is placed, which is opened for periodic flushing of silt and sand accumulation. As previously mentioned, provision for another sluice gate of 1.6 m x 1 m, at the head channel of forebay, is made to control the irrigation flow at the Turbine Kulo.

As the forebay is a new design element that was introduced with the MHES and being located very close to the powerhouse, the farmers in this area are not involved in the management of this system. The forebay is disconnected from the local irrigation design, as the main purpose in this system is to regulate the water flow for the turbine in the powerhouse. When the powerhouse is in operation, the technical operator is responsible for both the maintenance and cleaning of the system. For cleaning that may require more help, the manager usually mobilises the local community to volunteer their services. Informal meetings are usually undertaken in teahouses in the bazaar area, where solutions to various technological problems are discussed. For replacement of spare-parts and those problems that require financial assistance, the office of REDP in the district is also approached.

The propeller turbine

The propeller turbine was assembled and installed by Mr. Akkal Man Nakarmi of KMI.[8] This prototype implemented through REDP support was built on March 1998 in KMI Kathmandu workshop and the installation of this turbine took place in Katunje on May 1998 and was finally tested in June 1998. The main objective of the Katunje project was: to evaluate the technology reliability of a locally built propeller set, running under extreme condition of a wild Nepal river; to develop local capability for the repair and renewals; and to harness low head power potentials of 1 to 5 m (KMI 1998). This type of turbine is a high speed and high capacity pump suitable for low head. This turbine is a vertical axis machine and is covered by a metallic scroll case, which is fitted inside a continuation of a penstock tube. Water flow is regulated by the use of swivelling gates often times known as wicket gates. Given the technical mechanism of the design, the turbine requires a high volume of controlled water releases and is generally installed in close proximity to the source. The basic function of this turbine is that the higher the rotator, or rpm speed is made, the less torque is needed to produce a given power (KMI 1997b). The blades of the propeller vary in number according to the design and are either fixed or adjustable. This adjustable type of turbine is also referred to as a Kaplan turbine, in this case the blades are movable and the design is more complex. The prototype used in Katunje Besi has six-segmented bronze blades with fixed guide-vanes and a fixed blade runner. Figure 5.5 shows the six-segmented bronze blade propeller turbine that is being used at this site.

FIGURE 5.5: Sketch of a propeller turbine



Source: Sketch adapted from KMI (1997b)

The total design head of this turbine is 5 m and the water supply required to operate the turbine is 400 l/sec. The propeller turbine requires a controlled and regular water flow. A low-head micro-hydel plant usually requires in-depth civil engineering input and the traditional and local methods of diverting a wild river are not adequate. Virtually, all low head potential sites are utilised for lift irrigation purposes and have been found suitable for irrigating in the *terai* (flat plain) area of Nepal. However, propeller turbines can be designed to make use of more sophisticated versions by swivelling the blades simultaneously with wicket gate adjustment. A wicket gate induces velocity and the wheels to whirl in the water, which subsequently defines the 'variable pitch' and thus defines efficiency. Harvey et al. (1993) notes that propeller turbines are viable for bigger systems but are not considered cost effective for smaller systems due to the precision required in design, regulation and control of water flow. The high operation and maintenance requirement for such systems make design considerations more complicated. In addition the fabrication details and intricate profiling of the blades make this turbine less attractive for use in rural areas.

The components of Katunje plant were specifically designed for this particular site. The operation and maintenance of these systems require regular technical support, knowledge and precision with regard to functions and use of the various components that support the running of the turbine. The technical operator is responsible to operate the machines. However, due to the sophisticated need of these systems, the local expertise by itself is insufficient to deal with major breakdowns, spare-part issues and technical trouble shooting aspects. As a result, the efficiency and safety mechanism of this system becomes highly dependent on the building up of technical skills and knowledge support systems.

Generator

The propeller turbine is coupled to the generator (induction), via V belts and is further coupled to the electronic IGC to keep the speed constant. The generator consists of a single phase 13 kVa, with a 220-voltage induction motor. An IGC developed by KMI was used for this project (KMI 1998). In principle, the water from the guide apparatus enters the space above the propeller with a whirling motion from which the torque in the shaft is developed by water that is being released onto the runner. The water pressure puts the runner into rotary motion and power is generated, which is then transferred to the generator. An induction motor is used as a generator under the C-2C configuration; i.e. normal phase generation is converted to a single phase in order to simplify the transmission distribution network at the village level.

The technical operator is responsible for cleaning and maintenance, of the general surface of the electro-mechanical components only. This upkeep generally entails regular lubrication and cleaning of surface areas. The manufacturers, in most sites do not encourage the operators to open up the mechanical components for repair and maintenance. The Katunje Besi site has encountered break down problems on a few occasions with the bearing in the generator. The first time it failed during the manufacturer's warranty period, KMI replaced the part. Normally, the manufacturer provides a warranty for one year. After the warranty period, the committee has directly sent messages to KMI when breakdowns occur and they also collectively generate financial resources for the purchase of the required spare parts. On other occasions, when the community members happen to be travelling to the city, they also prefer to shop around in Kathmandu for cheaper prices.

The powerhouse and powerlines

The powerhouse has been constructed using local material. Inside the powerhouse, an 8 kW capacity propeller turbine is visible with a 14 kW controller, ballast tank and a switchboard. This electronic load control governor consists of an electronic circuit, connected to the ballast tank. Under routine maintenance check, it is important to inspect the supply to the ballast tank and to regulate the water flow. This inspection was not happening at this site and as a result, overheating, leakage and corrosion of the ballast tank were common problems. The switchboard inside the power plant contains various switches, fuses, electrical connections and meters that show the amount of energy being produced and locally utilised. As in most Nepal micro-hydel sites, constant replacement of the fuses was required at this site. This was caused because regular maintenance has not been practised to check the fuse ratings. Frequent fuse failure also occurred because the ratings of replacement fuses differed from the ones that the designer would recommend installing. For example, when fuses require replacement, the operator uses any locally available fuse without making sure the rating coincides with the design. Such substitution has also been influenced by the lack of spare parts available at the local level. Therefore because of inappropriate ratings in available fuses, the switches burn out quite fast. Towards the end of the second year of installation, the maintenance of this MHES was so behind that neither the meter nor other instruments on the switchboard were working properly. Thus, this indicates that the plant was functioning at risk when in operation, and without appropriate safety trips and protection devices.

In this system, a transmission line of 1410 m in length connects 48 households with electricity. Not all houses in this area have electricity supply. This community has expanded since the introduction of the propeller turbine; therefore there are houses here without connection to power. None of the houses in Roshi *pari* (the other side of the river) are connected to electricity supply. New homes have also emerged in this area; therefore the capacity of the plant does not provide electricity to about 25 per cent of the houses in the vicinity of the Katunje Besi. As in most case study sites, wooden poles are used for transmission. Some of the wooden poles have been destroyed because of insect infestation and also because of the road construction. Recently, the Japanese construction company HAZAMA has replaced the infested poles with a few metal ones, in and around the road construction sites situated closer to the embankment. As shown also from the Pinthali site, the use of uncured wooden poles, invariably require replacement after few years of installation.

The draft tube and tailrace

An elbow shaped draft tube complex designed by KMI connects the turbine with the tailrace canal. The draft tube is made of mild steel and the total length of the tube is 1.8 m. This type of design has two functions. First it enables the turbines to be placed above the tailrace to protect the turbine against flooding. Second, it converts the kinetic energy of water left over by runner circulation into pressure energy. However, the use of mild steel also increases the problems of erosion. The tailrace canal, which is located very close to the source, is designed to flow directly to Roshi River through a temporary outlet structure after the generation of electricity.

Water Distribution and Systems Operations

The intervention of MHES in Katunje Besi introduced changes in the existing local irrigation system. Since an existing irrigation system was combined to supply water to produce power, a new institution was also created to support the power management, operations and system control. A 16-member management team was established that included a chairperson, manager and an operator (a process similar to Pinthali in Chapter 4: see Chapter 8 for more details). The operator was in charge of regulating the water supply to run the turbine. His main responsibility included his morning and evening duties of switching on the power supply and thus releasing electricity in the community. He was also responsible to oversee the general maintenance and operations of the system. As the trained operator had moved from this area, there were many O&M shortfalls in this plant in addition to making the funds available for the purchase of various spare-parts. Under normal functioning of the plant, it is recommended that about 5 per cent of the capital cost (Harvey et al. 1993) be set aside for spare parts. This fund in most MHES in Nepal is usually generated through tariff collection from the electricity users. However, as this collection of fees was not functioning properly in Katunje Besi, spare-parts purchase became affected.

At the local level, the village of Katunje Besi bazaar VDC 1, does not have a formal water users group to manage the water system. The principles of water allocation and distribution have not been drastically affected, as water supply is abundant. There are networks of canals in this area. The main Turbine Kulo is also designed to supply water for irrigation. Determining water distribution, therefore, depends on the sizes of land and households that are adjacent to the respective canals that have more control over the system. The Turbine Kulo irrigates about 11 ha of cultivated land in this area, which is mainly located within the downstream reaches of the system. The open orifices divert flow directly from the canal to the fields. The upper reaches of the canal lie on an elevated bed of terraces with a steep slope. Hence, rain-fed agriculture is practised in these upper slopes. Each orifice then diverts water through an open-close field channel system, which is maintained by individual farmers adjacent to their land. In this respect, the owner of the land is responsible for opening and closing the water conduit. When irrigation is not required, water control is maintained by blocking the outlets with stones and mud. Each household is allocated water based on demand and requirement, which varies during preparation, nursing and transplantation times. A general consensus and mutual understanding among the farmers could be observed in following the simple rules of allocation and distribution. Specific cropping times of the year are important periods for water utilisation. For example, paddy is the most water intensive crop and water demand increases between the months of mid- May to June. Water requirement for paddy cultivation amounts to over 35 per cent of total water requirement per l/sec.ha for a command area of 11 ha. Table 5.1 provides the cropping pattern and water requirement for this area. As water is not required at all times for irrigation, households often help each other out and shut off their flow to benefit the neighbour when requested for water. As with most Farmer Managed Irrigation Systems (FMIS) in Nepal, repair work is undertaken and conflicts are resolved through mutual discussions and informal meetings at teashops, respected elder's homes or in the market area. This practise still prevails in Katunje Besi.

The MHES design at Katunje Besi differs from that of Pinthali in terms of the design provision for water distribution for power and irrigation supply and use. Provision for irrigation is made through the water conveyance system rather than from the forebay. The tailrace water is released at the source and is not used for irrigation due to the low head design of the turbine. The water supply is used for irrigation during the day and for power generation at night. However, as water is abundant for both uses, negotiation between different uses usually does not take place. When the power plant is in operation, the operator diverts the water supply towards electricity generation, and since this takes place mostly at night, water supply for other uses is not affected. Since the role of the technical operator responsible for the powerhouse is not very well defined, the farmers in this area have assumed more responsibility in the canal system. Given the low head design and a relatively short conveyance system as compared to Pinthali and Panauti, monitoring of flows and releases is not difficult.

TABLE 5.1

Cropping pattern and water requirement, Katunje Besi VDC-1

Command area = 11 ha

Soil Type = Sandy Loam

Kind of Crop	*Season*	*Days*	*Base Period*	*Assumed Area for Harvesting (ha)*	*Duty (thousand ha/m^3)*	*Water Requirement (l/sec.ha)*	*Water Requirement (m^3/sec.ha)*
Paddy	Mid May to June	30	130	11	750	14.67	
Maize	March/April	45		6.6	2650	2.49	
Wheat	November/December	60	120	11	2000	5.50	
Oil Seed	October to February	150		4.4	1750	2.51	
Potato	Mid Jan/February to April	90	110	5.5	700	7.86	
Vegetables	October/November	45	110	5.5	700	7.86	
	Water required in l/sec/ha					40.89	
	Total water requirement for 11 ha.					449.74	0.450

Most of the farmers in this area are responsible and make sure the outlets are shut when water is not required. This section shows that water availability and technological design render special organisation unnecessary and local government can cover such issues arising.

REDP's Approach to Governance and Participation

The community mobilisation for Katunje Besi differed from REDP's regular programmes as it was considered as a prototype intervention. The agreement to intervene in this area was signed by the donor, designer and the VDC prior to the community mobilisation process. The creation of membership organisations is basically the fundamental strategy of the process of 'community mobilisation' in the REDP model. Both the notions of participation as practiced and 'governance through institutions of the system' is linked to this social mobilisation process. The process begins first at the district level. In each of the districts where REDP operates, the programme supports the creation of a local NGO to carry out the activities. This NGO plays a key role in carrying out the community mobilisation activities on behalf of REDP. The Resource Management and Rural Empowerment Centre (REMREC) was established and registered in 1997 in Kabhre Palanchowk district as an NGO through the support of REDP.[9] After the establishment of a local NGO, the concept of 'participation' in empirical terms then takes the form of mobilisation at the community level. This mobilisation occurs through the creation of village level institutions. The REDP process visualises the formation of such institutions also for the purpose of attaining the goal of 'mobilisation of community resources' (REDP/UNDP 1997; REDP 1998). Local governance and 'participation' are viewed as two distinct structures and not overlapping. 'Institutions' are established and adapted to suit various intervention needs beginning from resource mobilisation, implementation, management and operations to the final governance of the system after the withdrawal of the external agents. Participation of the community members is seen as a goal to achieve the aims of institutions, i.e. in taking up membership and practices created in institutions. The former (participation) is created for the purpose of the mobilisation of resources and the latter (institutions) for involving representative members through local level committee in various schemes during the different phases of implementation.

In the REDP model, the process at the village or the VDC level creates a larger group organisation known as the Community Organisation (CO). Then, the second step follows with the creation of a selective group, called the Functional Group (FG), during the implementation phase. Finally, the third institution, as the Energy Users Group (EUG) is created after the implementation phase is over. Often times, the same FG operates or evolves as the third institution and other times, some of the members of FG get replaced or rotated depending on the availability of people. Other times, there may be insufficient membership in such group formations, simply because the community members move to other geographical locations or become disinterested to participate after the implementation phase is over.

After the REDP Kabhre Palanchowk office decided to intervene in Katunje Besi, a community mobilisation programme was started in late 1997 using the REMREC mobilisers. The mobilisation process took over six months before the COs were put in place. This process first began with the group formation. A common practice is to spread the word around the village asking all community members to congregate at a common ground, such as the *chautara* (resting place built around a tree) for a mass meeting at a certain given date and time. The visitors from the district (social mobilisers) make their way to the village. Members are then informed about the potential project, the level of commitment offered from the donor and expectations explained as what will be required from the community. The selection process for CO formation begins. The community mobilisers then live in the village with the community for a given period of time to get the group organised, and assist in the collection of the *lalpurja* (land title certificate) for a loan sanction from the bank. Then other processes such as collection of cash, material and labour contributions from the community begins. The COs in Katunje Besi consisted of eight groups of four men and four women (8x4 = 36 men and 8x4 = 36) with each CO representing 46 households of Ward No. 1 of the VDC. These households were the primary targets of the rural electrification scheme and the potential beneficiaries. This step was basically the formation of CO representing separate men and women's groups.

In the second process of community mobilisation, as according to the REDP rural electrification model, various FGs are created in accordance to the planned activities. For example, there may be a micro-hydel FG, solar FG, biogas FG, forest FG and so on and so forth. Hence, in a community that comprises of 40 to 60 households, the tendency of one member to serve in various FGs is not unusual. On occasion one particular FG may be conducting business for all different activities. In the same manner, one chairperson and or manager may be conducting and dispersing fund for all activities.

After this initial step of the CO formation, then 8 male and 8 female members were selected from various COs to form a final FG that included a total membership of 16 people. In this manner, one member from each CO is selected to represent his/her CO in the FG. The selective group then identifies a chairperson and a manager for the FG. Then the rules and the modalities for project implementation are undertaken. Thus, in the beginning of 1998, an agreement was made between this Katunje Besi VDC-1 FG and REDP to formally begin the micro-hydel project. With this agreement, REDP was responsible for providing electrical equipment, including turbine and electro mechanical components. The FG was responsible in mobilising the community in making arrangements for the construction of the canal and powerhouse and in providing poles and cables.

Unmasking the creation and process of RRMHMC

According to the holistic model of REDP (REDP/UNDP 1994), various community development activities were carried out in the village and the villagers selected 2 operators and a manager according to the criteria laid down by REDP.[10] After the formation of the FG, the cash contribution was collected for the construction of the scheme.[11] Katunje Besi area was developed at a crossroads between the rural and the urban centres. Thus, voluntary labour was difficult to come by and some of the community members felt that they were being unduly taken advantage of. However, one household was made responsible for constructing 17 m of canal length, which included masonry work, carrying cement, stone and the preparation of gravel. In transmission alone, the community had spent over US $ 1000. In addition, 7 members of the community representing the Katunje community had deposited their land titles to the ADBN as collateral, for a community loan, to meet the community's share of cash contribution. The construction of canal and the powerhouse affected the agricultural land of 11 members of the community and this was acquired free of cost for the project. The community members said that they were fooled by REDP to committing to financial burden. They were convinced that the supply of electricity would not be a successful project, and mocked by saying that the canal they were digging was meant to bury the REDP staff and the social mobilisation members. Though there remained differences over this project, some active members, in particular those who had deposited the land title, ensured that the project got completed and thus in June 1998, the Roshi River Micro Hydropower Project (RRMHP) was successfully tested.

For about five months, the project seemed to be running fine. At the beginning of the sixth month, diverse problems that were technical and managerial in nature started appearing. After the completion of the project, the FG and RRMHP became transformed into a management committee with the election of a chairperson and a manager and were called the Roshi River Micro Hydropower Management Committee (RRMHMC). Although no written by-laws of the committee existed, the RRMHMC was to conduct monthly meetings, disclose financial statements and note down the minutes of the meetings. However, these procedures did not take place and there was no documentation available for review. Initially, there was a separate member identified to collect the electricity tariff and after he declined to take on the responsibility, REDP intervened. The management committee decided to hand over the project to the previously elected manager of the FG on a contractual basis of Rs.1500 per month. This system was unsuccessful, as the contractual obligation for monthly remittance to the committee was not fulfilled.

After a few months, the community's discontent started gaining momentum. The maintenance of financial records and disclosures were non-existent. With REDP's presence in the district, the district office provided continuous support and supervision even after the completion of the project. However, REDP was also being put under the observing eye of members, who represented both the state police as well as the Maoists. Amidst these developments, discontent was increasing within the community because of the temporary construction of the dam, which created conflict and redistribution of maintenance obligation and uncertainties of supply of water for crops as this same dam also provided water to irrigate the fields of the farmers. As a consequence, REDP issued an additional amount of approximately US $ 1300 to the management committee to support the re-construction of the dam.[12] In addition, REDP had provided about US $ 2060 to RRMHMC for other development activities. The community was not aware of the financial situation at the village level, as meetings disclosing financial statements did not take place. The dam continued to remain temporary. There were several rumours being circulated of financial mismanagement by the manager of RRMHMC. Finally, the community gathered together and decided to confront the manager for his financial accountability at the police post in September 2001. The manager was able to reimburse part of the money that was unaccounted for. As a result, the committee members were reshuffled and the management leadership was replaced. It was during this meeting, the committee was able to collect the long pending dues of electricity charges from the police post.

The formation of the second committee or the replacement of some of its members took place for various reasons. The community in the second committee replaced three members including the manager. First, the management contract given to the manager of the previous committee was unsuccessful (See Chapter 8) as he was unable to collect the established tariff and thereby remit the obligatory dues to the committee. Second the many other unresolved financial issues led to the nomination of a different person to fulfil the role of the manager. Third, in the previous committee, the manager was also actively involved in the technical operation (for releasing electricity) to the village, so the second committee identified a person to function as the operator. Towards early 2002, the trained operator who had initially left the village during the Kilo Sierra Two Operation returned back to the village to assist with the technical operation of the powerhouse.

The project had faced such severe technical and management problems that it remained shut down for three months. In April 2002, with renewed interest of REDP in the project, which coincided with visits by various scholars and potential donors to the site[13], additional development took place. After the management change resulted in no progress, the idea of a 100 percent female represented management committee was proposed to the community by REDP. Subsequently, a mass meeting was held with REDP representatives, community mobilisers and some of the representatives of the community. The community wanted only the daughter-in-laws to get involved in this process, as it was felt that the daughters would get married and leave the community. However, towards the end of the meeting, the female members felt that they were looked upon to resolve the management problems of the committee. This proposal did not materialise. During this phase, REDP decided to spend an additional amount of US $ 400 in repairs to the system. Finally, KMI was brought back to the village in April 2002 and with them additional fund for repairs.[14] This represented their first visit after the installation was complete in 1998.

Gender and participation

The REDP programmes support the female COs by getting them involved in income generating activities and community forestry management. In many of the sites visited in Kabhre Palanchowk district, women who had received training in soap and incense making, and *thanka* (an old art of painting) painting either had moved to the city or were no longer practising the trade.[15] The income generating activities basically came to a stop after the training was over. Poultry farming, particularly among the Tamang community was a preferred practice. Previous studies have shown that lighting and agro-processing facilities by electricity generation has decreased the drudgery for women (Rai 2000), and the views expressed by many female members and users also reinforce this conjecture.

In Katunje Besi command area, there are about 23 female members who are users of micro-hydel power. Therefore they became eligible to participate within the various committees. However, this eligible number became reduced, as females often times require the permission of either the husbands or the father-in-laws to actually participate in the committees. Some women have young children or elderly in-laws to attend to, and thus are unable to attend such COs; others are simply not interested. Therefore, the actual 'available' number of females in committees is not as abundant as the 'gender' quota criteria (be it 30 per cent or

50 per cent representation) specify and the headcount is not as simple as it was made to appear. As a result the tendency of a few active female members to be involved in various existing and parallel committees is not unusual, just because the available number is often just not there.

For example, Tara Kumari from Katunje Besi VDC-1 is a member of the CO, and a member of the FG. She is also a member of RRMHMC. She is also the chairperson for the informal Water Users' Association. She makes at least two trips a month on average to get documents signed at the district headquarters in Dhulikhel, because she is also a member of Women's Savings and Credit Group and, as well as, the Forest User's Group. Very recently, she was asked to form a committee for the Drinking Water Supply Group because the district drinking water fund had a budget allocated of about US $ 150 for gender activities. Her last trip to Dhulikhel was made in an attempt to register this group, so that the concerned agency could disburse the allocated budget to her group. She has completed the required registration of 36 female members at the village level who were required to sign a document confirming their consensus in 'participating.' Now, her task is to register the group at the district level, so that her group can have access to this allocated fund. She is fortunate in that her children are adults and have left home, and her spouse takes care of all farming activities and the tea shop that they own in the village, while she spends most of her time dealing with all the committees she has been involved with.

The role of women through these various groups has segregated the society in terms of their division of labour, identity and occupation. User groups within community organisation are formed, to disburse project funds during a given time frame. Generally, there is no follow-up that this money that has been disbursed for 'gender activities' or that it is being used for the intended purpose. There is also no guarantee of the continuity of the activity after the one time payment or grant has been made. The relevance of women as active members in particular in technology development could be encouraged through committees of mixed groups (both male and female) instead of the current imposed practice of separate male and female groups. In the current REDP model the final FG is a mixed group, however, women have not been successfully integrated into managerial and technical decision-making and operational positions. As evident from the preceding section, the male members made the final decisions, even regarding whether they wanted their daughters or their daughter-in-laws involved in projects. In Katunje Besi site, it was observed that women who were outside the formal constituency of the FGs were actively involved with community issues and were knowledgeable about technological development. Some of these women were daughters and not daughter-in-laws.

Continuing pilot testing

In January 2002, the RRMHMC with the advice from REDP was registered as a co-operative with the objective of ensuring a 'smooth operation and management of the scheme'. Thus RRMHMC evolved into the Roshi Khola Micro Hydro Cooperative (RKMHC). The plant, at the time of registration, was not in operation. On May 17, 2002 another agreement was made by RKMHC, DDC, Carlsen Power Electronics (CPE) of Denmark and REDP, with the intention of upgrading the Katunje Besi plant. The chairperson of RKMHC signed the agreement on behalf of the community. The DDC chairman and REDP Energy Development Advisor represented the State authority. The representative from CPE represented the donor, in this case DANIDA, as the budget allocated for this programme came from DANIDA's financial support to Nepal through the Private Sector Support Programme. CPE's national level local partner, was identified as a Kathmandu based agency called the Hyonjan Electrical Engineering Fabricator (Pvt.) Ltd. Besides upgrading the system, the donor's undertaking to intervene in this area was stated as a repayment of the kindness shown towards the 'foreign representative' by the villagers. The contract agreement specifically stated one of the objectives was "For CPE to reimburse the villagers of Katunje Besi VDC-1 for their help to Mr. Steen Carlsen, the proprietor of CPE, in connection with his accident in Katunje in 2001".

With this potential proposal for renewed intervention, the Katunje Besi VDC-1 site was again becoming an R and D demonstration area. For a second time in 5 years, a cross-flow turbine was being considered for testing under a low head design system, whereas in normal practice this impulse turbine is considered suitable for high to medium head systems (see Chapter 4). Therefore, a 10 kW capacity turbine, a new penstock, generator and load controller was being provided by CPE. The project was being implemented and installed as part of 'building local private sector capacity' by using the services of Hyonjan Electrical Engineering. The community's responsibility was again to provide their share of contribution in cash, kind and labour, which also included the canal, the intake and the dam.

On December 4, 2002 the community and CPE withdrew the agreement, because of discord regarding responsibility of the construction of civil works. CPE was not going to support this particular component and the community felt that that there were not sufficient resources available from their own major savings to undertake this responsibility. Members of the community also felt that the leaders, without the community's consent and knowledge, were representing RKMHC and this agreement was being recommended as a facelift to the original system. Consultation had not taken place within the community prior to the agreement, which explicitly laid out the requirements and expectation of the community's share of contribution. Some members expressed that they were not aware if discussions had taken place prior to the signing of the agreement. One schoolteacher commented, 'they did not listen to us and made us the guinea pigs of electrification; had we known the first time around, we would have suggested a better source.'

Conclusion

This chapter demonstrates that the design was introduced based on technological precepts without full understanding of the social dynamics, or appreciation of site specifics and sufficient consultative process with the residents of Katunje Besi, which resulted in re-occurring dissatisfaction among the villagers. Yet pilot testing has been ongoing and despite all the previous development of institutional building, the internal networks that support technology development continues. Interestingly, the community has previously shown themselves to be entrepreneurial and their early actions have shaped technological development in this area. These foundations of understanding and managing issues of accountability have been important trajectories that reflect a progressive profile for the community of Katunje Besi.

A simpler version of a propeller contraption is clearly unsuitable for community lighting purposes. The case study has shown that design accountability of the designers, lies beyond just an assemblage of a hydraulic system, i.e. the technology trials to prove if a design will operate outside its usual standard location. Lack of aesthetics or designer's appreciation in the overall design of this prototype indicates that contact with the community during the initial stages was minimal, and insufficient consideration of community O&M needs was made. The contracts between the agents and the structures were made amenable to test a turbine without adequate consideration of social dynamics. This clearly indicated that the system was not made open to local creativity. The lack of consultation with the community has led the design to be irrelevant as a power-generating device, the prototype as a viable technical object was also questioned. Consideration to supply the whole community was not made initially, not even for basic needs let along entrepreneurial growth. Although a later plan for upgrading and increasing power supply was made, by this time villagers had no trust either in the technology or the consultation process. Despite the contacts from REDP, and local efforts to develop management structures that could run the turbines, the villagers never stopped feeling like guinea pigs. While the water conveyance system function and intake utilised local materials, the operations needs to manage power supply were more sophisticated and quickly became dysfunctional for the community.

There was a superficial albeit complex effort to mobilise local collective action in various user groups, but this did not result in a fully functional management system despite significant individual effort. In this respect, it can be argued that the concept of participation, as is currently practised, is monolithic and conceptually distinct and separated from membership organisations that are being imposed or artificially created. As projects and programmes expand and problems of failures increase, the community themselves become the evaluators and interlocutors. Social and political unrest can also shape to bring about social transformation and adaptation of technology development where social mobility and technical mobility becomes more closely interlinked and involved directly in the ownership process.

Notes

[1] Research and Development (R&D) has been a recognised process in industrial production since the 1950s. Typically it follows a path from a (laboratory) through pilot or prototype production into manufacture and marketing. The 'development stage' of R&D includes the stages necessary to bring a new or modified product into production. As seen in this study, it denotes an approach where the design processes are differentiated between prototype and evaluative systems.

[2] *Bikas* in the 'colloquial' sense is also associated with material possession, and comfort and luxury in life. If this *bikas* cannot be attained through hard work in a rural setting, then opportunities of acquiring these modem day amenities may only remain in the choice of migrating to the urban areas. The term *bikas* is misused and overused and has become part of the daily vocabulary. See Shah (2002) where he unfolds various interesting meanings of *bikas*, consequently the interpretation on a gamut of terminology has had profound implication on rural development itself.

[3] On 21 of June 1998, riot police stormed "Hariyali Lodge and Restaurant" a lodge cum residence owned by Nanda Raj Lama and dragged him out of his bed at midnight. Some representatives of KMI sleeping in the next room witnessed the incident, were terrified, completed the project the next day, and left for the city. The next morning, the local newspaper carried a photograph of Nanda Raj Lama with a rifle slung over one side of his shoulder, in the act of climbing a hill with police officers apparently chasing from behind. It was quoted in the paper that Lama was found by the police while on the run and the abduction from his "Hariyali Lodge" bedroom just remained as an eyewitness story. The police killed Lama, allegedly, because of his association with the Maoist movement. Ironically *hariyali*, in Nepali translates into evergreen.

[4] By examining political dynamics over different regimes in rural Mexico, Fox (1996) asserts that the building block organisations of an autonomous civil society in repressive regimes depend on 'political construction' of social capital. He presents a political construction approach by using a concept of three building blocks. These are political opportunities, social energy and ideas, and scaling up. He first states that elite political conflicts have a causal effect on collective action depending on how the state reacts whether by supporting or dismantling social capital. Second, political conflicts include actors with ideas and agendas and accordingly the formation of collective action revolves around such political affiliations, which is linked to opportunities and threats. Third, political construction approach highlights the significance of such organisations that generate opportunities for others to engage in autonomous collective action. Fox describes 'scaling up processes' to be closely interlinked with local representation and bargaining power.

[5] An amount of US $ 59,730 was allocated for micro-hydel R and D, which supported 11 different technology-related activities. These activities were testing of pumps, designing of manuals and software, development of IGC, gasifier and diodes. *Personal communication with Mr.Kiran Man Singh, UNDP/REDP headoffice, Kathmandu*

[6] The designer, the donor, nor the implementing agency seemed to have a plausible answer to why this site was selected. From the discussions held, it was also learned that the Maoist conflict with the State influenced the decision-making on site selection, as designers based in Kathmandu would prefer accessible location. The R and D was programmed for the particular given year, hence the project had to be implemented to achieve the targets set in the project documents. According to the community, REDP had an ongoing programme in Pinthali, Managaltar that is located about 17 kms away from the Katunje bazaar. As the social mobilisers drove through the bazaar during field visits to Pinthali, interest in electrification was expressed through informal conversation by some of the community members.

[7] The term agro-energy (Regmi 2003c) refers to a technological system that includes water provision and distribution for power generation and irrigation requirements.

[8] The use of a propeller (low-head) turbine is not a new invention for Nepal. During the early 1980s, in collaboration with SATA, BYSE manufactured a number of propeller turbines. An assessment made during 1985 led to the conclusion that a versatile turbine was required to be developed for the hill mountain context (Meier 1985). The previous experience used a similar mechanism of turbine, a prototype known as 'propelift' which was coupled with a centrifugal pump called a Water Turbine Pump (WTP) and was used by a private farmer for lift irrigation and milling purposes (Hulsher 1987; Jantzen and Koirala 1989) in Gorkha *phant.* Because of continuous flash floods, the use of this low-head turbine had to be abandoned.

[9] At the community level, REDP and REMREC have become synonymous with *urja*. The perception that if one is associated with *urja*, you can bring money for the community prevailed strongly in the research area. The five staff members of REMREC that operated out of REDP office in Dhulikhel were young men and women, energetic, committed and hard working. While some of the founding members of REMREC have moved on either to other jobs and or for further education, the remaining have taken other assignments from UN agencies and other development organisations.

[10] These management decision-making positions seem to overlap with political leadership, where leaders chosen also happen to be either ward chief, or ex-political party members, or from the respected professionals. Demonstration of leadership skills is an important criterion of REDP in the selection of chairman and manager.

[11] At the approximate exchange rate of a dollar, which was equivalent to about Rs.66, a total amount of US $.28,182 was collected for the scheme. This budget included Rupee equivalent of about US $ 830 from DDC funds, US $ 1515 from VDC funds, US $ 378 from the MP's funds, a bank loan to the community of US $ 4924 from ADBN and US $ 2954 from UNDP/REDP in the form of grant assistance.

[12] Once the social mobilisation process takes place and the manager and chairperson are identified, financial disbursement takes place and the official signatories to checks become the manager (from the village level) and the district energy officer at the district level.

[13] These visits included one by a Nepali research scholar investigating gender aspects in micro-hydel projects, a second one by a German citizen and the third by the Danish company CPE who showed interest in increasing the capacity of the existing turbine.

[14] It has been difficult for me to gauge the extent of influence on the various developments of this project by my research and my field visits. However, the community was raising issues that related to technical, management and financial problems during different visits. Despite the fact that this site was not a 'mainstream' project for REDP, the necessary support was being provided to this area unlike the Kusha Devi site.

[15] In Singhe of Nayagaon VDC, which is a homogenous Tamang village, KMI under REDP project has installed a Pelton turbine with a multi-jet deflector of 16 kW. This site has been designated as one of the success stories of REDP. During the time of the RRA, the manager of the plant had offered to slaughter a rooster and invite the community for '*masu ra bhat*' (meat and rice) if the women's group agreed to raise pigs in their farms. A certain amount of money had been made available by REDP for the income generating activities. However, poultry farming became the popular one. After the project was completed, the community complied as desired by the leader, but the leader failed to keep his promise of the feast of 'masu ra bhat.'

6

Experimental Design in a Struggling Community

Pico Power Pack in Nayagaon, Kusha Devi

Hami-lai Congress le pradhikaran ko bijulee dinchhu bhaneko chha; yasto jaabo madhuro turbine ko batti chahindaina; pahile hami lai diyenan: The Congress Party has promised us NEA electricity; we don't want the flickering light of the turbine; they didn't give it to us before.

Mohan Singh Tamang, Nayagaon village, February 2001

Introduction

The Nayagaon Pico Power Pack (PPP) of 4.2 kW[1] capacity located at Kusha Devi VDC provides electricity to only a section of the community. The PPP was developed and designed in England and manufactured in Nepal, for the purpose of experimenting to ascertain if the Nepal hill/river context was conducive for the operation of this turbine. While the goal of the designer's model has been successfully implemented, this invention has been struggled over within the arena of various actors and has represented according to their contentions and desires. The opening quote not only expresses the various design networks embedded within the symbolism of this technology but also is strongly linked with resistance and freedom that a technology choice represents.

This chapter first examines the materialisation of the design of the PPP and the functionality of the design itself, then describes the various networks within which the design is embedded. This chapter looks at the agents and actions that moved this prototype design beyond being just a black-box. The networks, within which the technology is embedded, reveal various techno-political interfaces with complex relationships in the adaptation of this MHES.

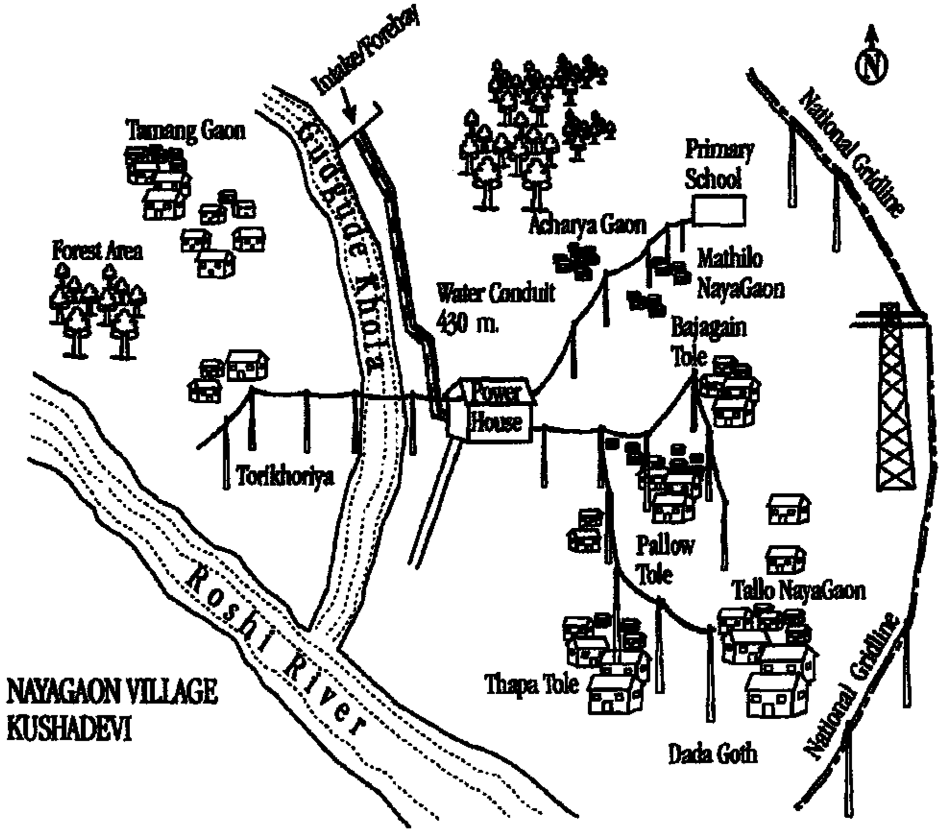
System Design, Interfaces and Method

In 1999, Nayagaon became a science laboratory when the Nottingham Trent University (NTU) from the UK launched its first demonstration project.[2] This project, as a component of the UK Department for International Development (DFID), within the "Pico Hydro for Affordable Village Power Worldwide", Programme, was implemented by the NTU in collaboration with Intermediate Technology Development Group (ITDG) (Kapali and Shakya 2000). For the first time, at the international level, the horizontal Pelton, known as the PPP[3], was tested in Nepal. The research department in the NTU with the help of a German exchange student (Maher and Smith 1999) built the first design of this technology in the UK. The design was then imported to run through a test in Nepal, where it was fabricated and manufactured by Nepal Yantra Shala Energy (NYSE) in Kathmandu. The intent was to replicate this model in other developing countries through DFID and NTU's global package proposal. Thus, the installation of PPP began in November 1999 in the village of Nayagaon, with the turbine's design capacity of 4.2 kW.[4] The objective of the project was to connect 88 households with 40-W electricity each, generated through the PPP using a combination of Compact Florescent Light Bulbs (CFLs) and conventional light bulbs. These CF light bulbs were unknown in the village before this time. The model was again tried in Peru in 2001.

The dynamics of the Nayagaon village in Kusha Devi

Nayagaon village, nestled 2000 meters above sea level, in the *lekh* (the highest slope of a mountain) of Mahabharat range, is situated in the southwest part of Kabhre Palanchowk district. Located in Wards-Number 5 and 6, beneath the foothills of the Phulchowki hills, the traffic of Patan in the Kathmandu Valley from Nayagaon almost seems within the earshot. Yet, it takes over 40 minutes to walk up the steep hill to reach the area, from the road head. Nayagaon is designated as the most backward ward under Kusha Devi VDC, an indicator that education, agriculture, transportation, electricity and water services are well below neighbouring wards. Figure 6.1 shows the village, the plant and the water supply.

FIGURE 6.1 Map of Nayagaon village, water supply and plant



Map: Not to scale

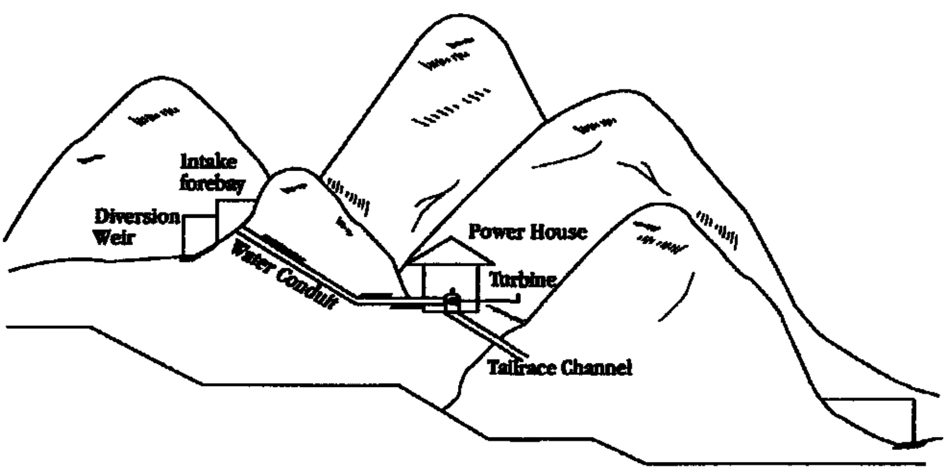
The village has seen many changes, in particular, after the 1990 transition to democracy and after the Local Self-Governance Act of 1997. With these changes, local leaders became more involved in village development efforts, such as widening access roads, implementing water supply schemes and lobbying for other infrastructure development of their respective wards. Likewise, these reforms also provided an opportunity for minority groups, such as the landless, to initiate legal processes to legitimise their rightful claims and entitlements, such as acquiring land titles. These changes also brought about catalysing political affiliations, the disbursement of political power in governance processes and the local level actions surrounding these. Unlike other wards in Kusha Devi, where the Communist Party of Nepal-United Marxist-Leninist (CPN-UML) group dominates, Ward-Number 6, also has Nepali Congress (NC) representation. The majority of political leaders including the local representatives in Ward-No. 5, belong to the CPN-UML party. Along with these changes, and as custom prevails in such rural settings, most adult men are actively involved in politics and congregate around town bazaars, while the women folk tend more to the farms and take care of the children. Given the proximity to urban centres, many youth from the village have migrated to nearby towns including Kathmandu.[5]

The community around Nayagaon micro-hydel catchment consists of 160 households. Farming, is the main occupation of the people. The *Jaisi* Brahmins ethnic group account for about 60 per cent of the village population and live in the settlement of Mathillogaon and Tallogaon. Tamangs account for 35 per cent as an ethnic minority and have been settled in the area for decades, though they do not own legal title to their land.[6] The Tamang community occupies the settlement in Torikhoria. The village settlement also includes some Chettri households. There is not much arable land in the *pakho* (slant slope unsuitable for agriculture) terrain; the remaining land is heavily terraced. In spite of the tremendous labour contributed by the people, the steep slope of the landscape mitigates against intensive production. In recent years, farmers have depended on livestock and buffalo raising. Livestock husbandry is taking over agricultural production and the community is coming together in an effort to build their economic capital. With access to a fair weather road-head a few kms away, which connect the village with Panauti bazaar, urban/rural market linkages are well facilitated. The villagers have organised themselves with milk cooperative and collectively sell milk for cash, which they use to purchase other commodities. While this intervention by the community suggested collective organisation within the community, on the other hand, it has also represented the collapsing of social relations. The monthly proceeds of the dairy venture, a collective fund, were stolen at midnight from the chairman's house at gunpoint by a group of masked youths. Although the theft of this remuneration represented the hard, month-long work of farmers, vanished overnight, the community bounced back to continue supplementing their income with this collective dairy activity.

Gudgude Khola, Water Supply, Design Flows and Releases

Gudgude Khola, a snow-fed rivulet runs through the Southern and Northern ridge of the two steep slopes and dissects Nayagaon village. The total watershed catchment of the river is 1875 km² and has a monsoon wetness index of 1500.[7] The river originates in the Northern face below the foothills of the Phulchowki *danda* (ridge) and flows North to South. The gradient is very high, as it flows through the narrow gorge that is deep and narrow and finally meets Roshi River at the foothills of the river valley. Figure 6.2 provides the agro-ecological setting of the area and the design.

FIGURE 6.2 Design and setting



Given the gradient and topography, the sediment load is quite high and the soil composition consists of hard rock mixed with gravel. The sediment that is brought down, collectively through various adjoining networks of spring sources, along the mountain, carry along boulders and rocks. Particularly, during the monsoon, this phenomenon seems to increase occasional landslides. The river interlinks two sides of the ridges and connects the Brahmin and the Tamang communities together.

Gudgude Khola has served as the main source of water for multiple uses in this community. This water is used for drinking, washing, bathing and even irrigating when required. The Tamang community in particular, uses this water for drinking, bathing and washing needs. In 1995, a drinking water scheme was brought into the community with the help of the village leaders through Participatory District Development Programme (PDDP).[8] Although the Tamang community were made to participate in the implementation of the project by voluntary labour contribution and in collection of materials, the community did not benefit from this initiative as the pipeline was designed to run exclusively through the strongholds of the Brahmin households.[9] This water channelled through Shishakhani is sufficient to meet the drinking water needs of the headenders of one settlement. However, at the tailend, water is scarce even for meeting livestock use. Around 25 houses at the tailend have problems in meeting their drinking water requirement. For the tailenders, at the bottom of the hill, problems exist for both irrigation and drinking needs. Irrigation is a sector that has not received much attention in this area. Maize, wheat, barley and mustard are the main crops grown in this area and are mostly rainfed. Some vegetables are also planted during the month of October onwards. Due to the unavailability of irrigation, the production level is quite low and the farmers produce food to last for about three months of a year. Maize is the principle crop in this place and is grown from April to May with oil seeds from October to February, followed by wheat in November and December. Table 6.1 shows the cropping pattern of this area with the calculation of total water requirement.

Given the harsh terrain, every year, the maize crop gets partially destroyed by wind, rain or hailstorm. The outflow of Gudgude Khola that passes through the powerhouse could be utilised to support some vegetable growing schemes around this area. Likewise, given the altitude and the soil formation, potato and onion do not grow well in this area. Other seasonal vegetables such as garlic, pumpkin, cucumber, beans, tomatoes and greens appear to do well when sufficient water is available.

Hydraulic ensemble

This section describes the characteristics of the technical design elements of PPP and discusses the use and functionality within the

TABLE 6.1

Cropping pattern and water requirement, Nayagaon, Kusha Devi VDC

Command area = 4.3 ha

Soil type = Gravel mixed soil

Kind of Crop	*Season*	*Days*	*Base Period*	*Assumed Area for Harvesting (ha)*	*Duty (thousand ha/ m^3)*	*Water Requirement (l/ sec.ha)*	*Water Requirement (m^3 / sec.ha)*
Maize	April/May	45		3.44	2650	1.30	
Wheat	November/December	60	120	2.15	2000	1.08	
Oil Seed	October to February	150		1.72	1750	0.98	
Vegetables	October/November	45	110	1.29	700	1.84	
	Water required in l/sec.ha					5.20	
	Total water requirement for 127 ha.					22.35	0.022

local environment. The salient features of this system include a weir, the water channelling system and powerhouse installed with electro-mechanical components. This design uses a combination of an intake/forebay structure. A long HDPE (high-density polyethylene pipe) water channelling system and an underground water conveyance system link the source with the turbine. Power is generated to provide primarily services for lighting.

Diversion weir and intake/ forebay combination

The water from Gudgude Khola is diverted through the construction of a simple stone masonry dam, which is supported on two sides with two gabion boxes. Water flow is then channelled to discharge directly into the intake and forebay structure. An interesting feature of this design system is the combined system of intake/forebay structure. From the source of Gudgude Khola, the water is diverted through a short channel from the source immediately to flow into the intake. As this is a small stream source, the discharge of water is quite low and because of the topography, it would be costly and inefficient to design a separate intake and forebay system. This combination structure of an intake, together with a forebay, not only reduces the risk of canal water losses through seepage and leakage, but has also reduced the capital cost, and made the maintenance of the structure easier. The intake/forebay, which is situated alongside one of the banks of the khola, is constructed with concrete and stones and has a size of 1 m x 1 m with 1.4 m depth measured at the site. Such structures are normally permanent constructions, and their lifetime is usually estimated at about 10 years. This structure is installed with a wire mesh trash rack that obstructs foreign objects from passing through. This structure also includes an overflow and a flushing pipe to serve as a desilting mechanism. The overflow is designed to return the excess water back into Gudgude Khola. The outlet of the intake narrows in aperture, to fit with the diameter of the channel that releases water.

The operation and management of this structure is undertaken on a seasonal basis. While the farmers around this structure use the water for washing, bathing and drinking purposes, some of the households also use smaller diameter HDPE pipe to irrigate seasonal crops. For routine maintenance, as the house of the powerhouse guard is located nearby, he makes his normal round around the headwork before switching on the turbine and releasing the electricity to the community. The technical operator of the PPP usually delegates the duties for the powerhouse guard.

Water conveyance system

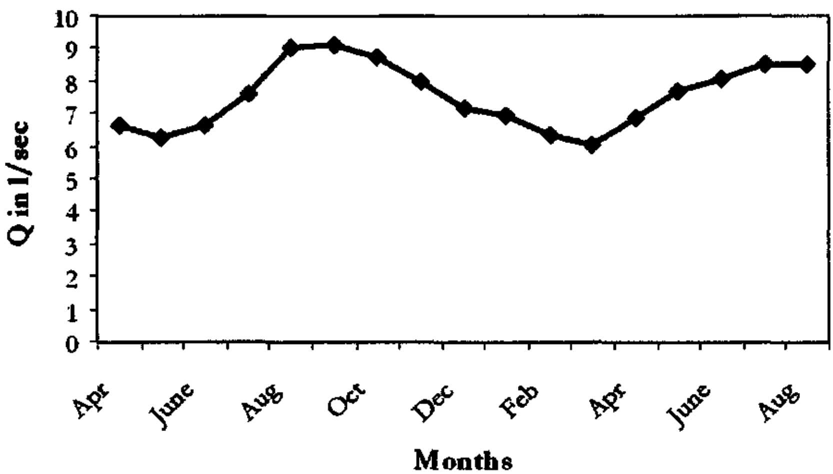
Instead of a canal of mud and stone construction, HDPE pipe has been used to convey water from the intake. The intake is connected with the HDPE pipe by an open canal that measures 3 m in width and has a depth of 0.4 m. From this construction, the conveyance system begins, measuring almost 430 m in length in a closed system. There is no penstock utilised in this design as the source is situated at an elevation where there was no need to drop the head to obtain the design requirement. Also given the topography, this design has reduced civil works cost: constructing earthen or semi-lined canals in the rocky and mountainous elevation would have been expensive. In addition, given the length of the conveyance system, conveyance losses would be high. In this respect the use of HDPE pipe has minimised these disadvantages. The mouth of the pipe, which connects towards the powerhouse, is covered with a wire mesh that prevents stones and gravel from entering with the discharge. The major portion of the conveyance system is not a visible structure as it has been installed in a below-surface trench. The outlet is designed to release water directly inside the powerhouse for the running of the turbine in order to produce electricity.

The conveyance length is made up from 6 separate sections of HDPE pipe that measured 72 m each in length. These were joined and fused together with the use of a hot plate, and under the supervision of the turbine fabricator. However, the use of HDPE pipe has also shown some operational problems. In July 2001 the powerhouse guard turned the water on without releasing the air pressure. The impact of this led to fissures in the HDPE pipe and the plant had to be shut down leading to a black out for two days. The fusing of the sections of HDPE, if not undertaken well also lead to water losses. For example, on one occasion there was leakage of water from the turbine and it was accumulating in a puddle inside the powerhouse. This resulted because of a loose joint in the turbine casing and the HDPE joint. Then technical help from Kathmandu had to be brought over to repair this leakage.

Channel releases and design flows

The Kusha Devi PPP is a very small system that is installed using a source with low water supply and releases. The dry season flow measured for the months of March and April 2002 at the source of Gudgude *Khola* (stream) indicate that the minimum water supply available during this hot period is about 23 l/sec. The field measurements were undertaken both at the source and the inlet channel using a 40 litres capacity bucket. Three separate measurements were taken at various intervals. The discharge pattern of the source tally with the discharges measured for the canal supply and releases for the year 2001 and 2002. Figure 6.3 presents the average water releases measured in the field.

FIGURE 6.3 Water supply releases from Gudgude river (April 2001-August 2002)



These measurements indicate that the March-April discharge in the canal was in the range of 6.255 and 6.67 l/sec for 2001 and 2002 respectively. The discharge increases during the four monsoon seasons of July, August, September and October reaching to a peak of on average 9.06 l/sec during the wet months of August and September. The initial estimate (Smith and Ranjitkar 2000) prior to the PPP intervention, indicate a dry season estimate at approximately 10 l/sec of water. However, the measurements do not indicate where and when the estimate was taken. They also indicate that the available head to generate power exceeded 100 m.

A second measurement during the survey phase of the intervention showed a discharge of 9 l/sec (ibid 2000) during the 'long dry season'. Assuming a worst-case scenario, the design flow for the PPP was kept at 13.5 l/sec (ibid 2000).

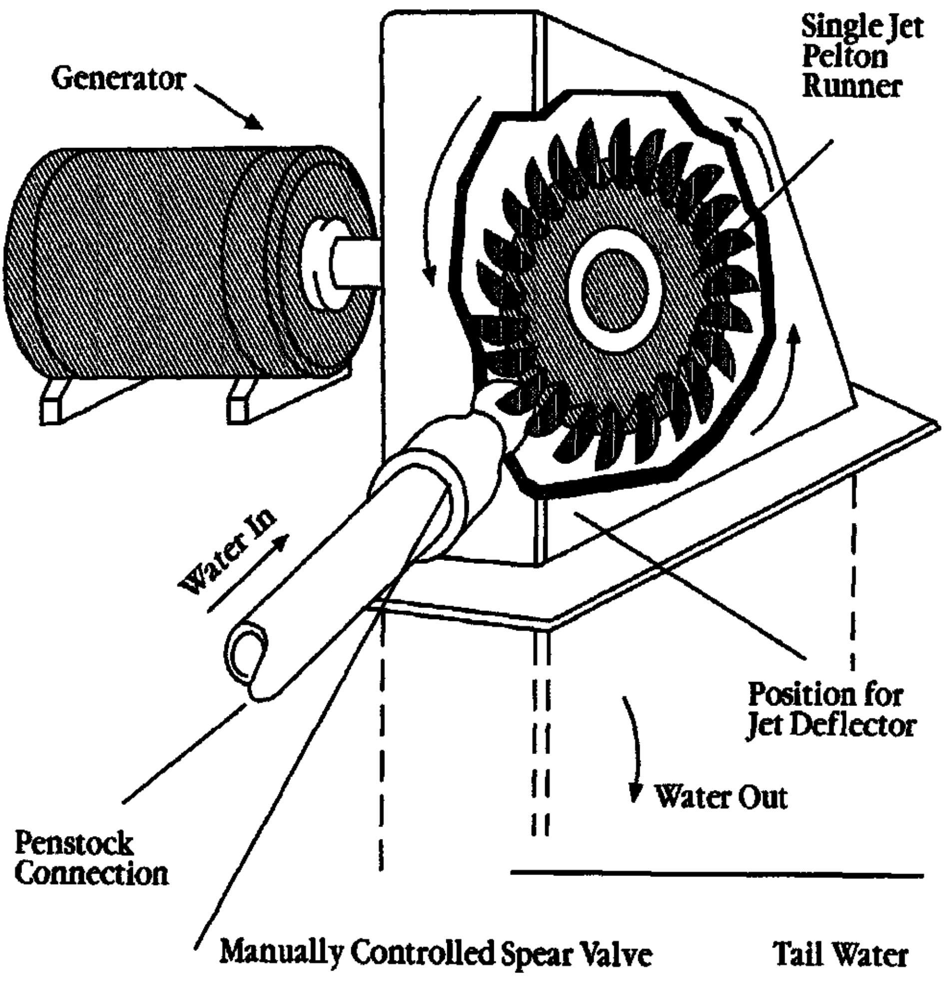
There is a variation in the dry season discharge during the design phase in comparison with the field data available from 2001 and 2002. The field data indicates that the discharge does not exceed 9.52 l/sec at any time. The minimum flow in the hot month of April 2002 was 5.52 l/sec. However, a leakage was observed above the measurement location, which could have influenced the flow measured. In spite of this, assuming a 20 percentage leakage, being accounted for to the dry season flow of 6.67 l/sec, we can still comfortably estimate a discharge of about 8 l/sec, which still differs from the original design estimates of 13.5 l/sec.

Likewise, the minimum dry season discharge calculated by the Dhulikhel Municipality's Drinking Water Scheme and measured in March 2002 indicates a flow of 18 l/sec for the Gudgude Khola. The measurement at the source, during the intervention of the PPP indicated an availability of 23 l/sec of water during the hot months. This indicates that water availability at the source itself ranges from 18-23 l/sec. It can be assumed, therefore, that there are some conveyance losses during the transfer of water from the source to the intake and then further onto the powerhouse. The leakage in the system during the time of the measurement further verifies this point. Water has been adequate to experiment with the turbine.

Prototype of pico power pack

A Pelton turbine, coupled with an induction generator, in a 'peltric set' design arrangement, has been pioneered in Nepal by Akkal Man Nakarmi. This design offers a low cost option in rural areas and is normally not used in low head sites, as the operating head becomes low and the runner becomes unsuitable for the quantity of power generated. The PPP prototype uses a Pelton runner, which is of an impulse category. Through field tests in Nepal, the designers experimented to validate a modification in the turbine design and thereby increase its capacity by operating through a horizontal axis and thus adapt to the head available. Figure 6.4 shows a conventional model of a single jet Pelton turbine that is commonly used in Nepal.

FIGURE 6.4 Pelton turbine

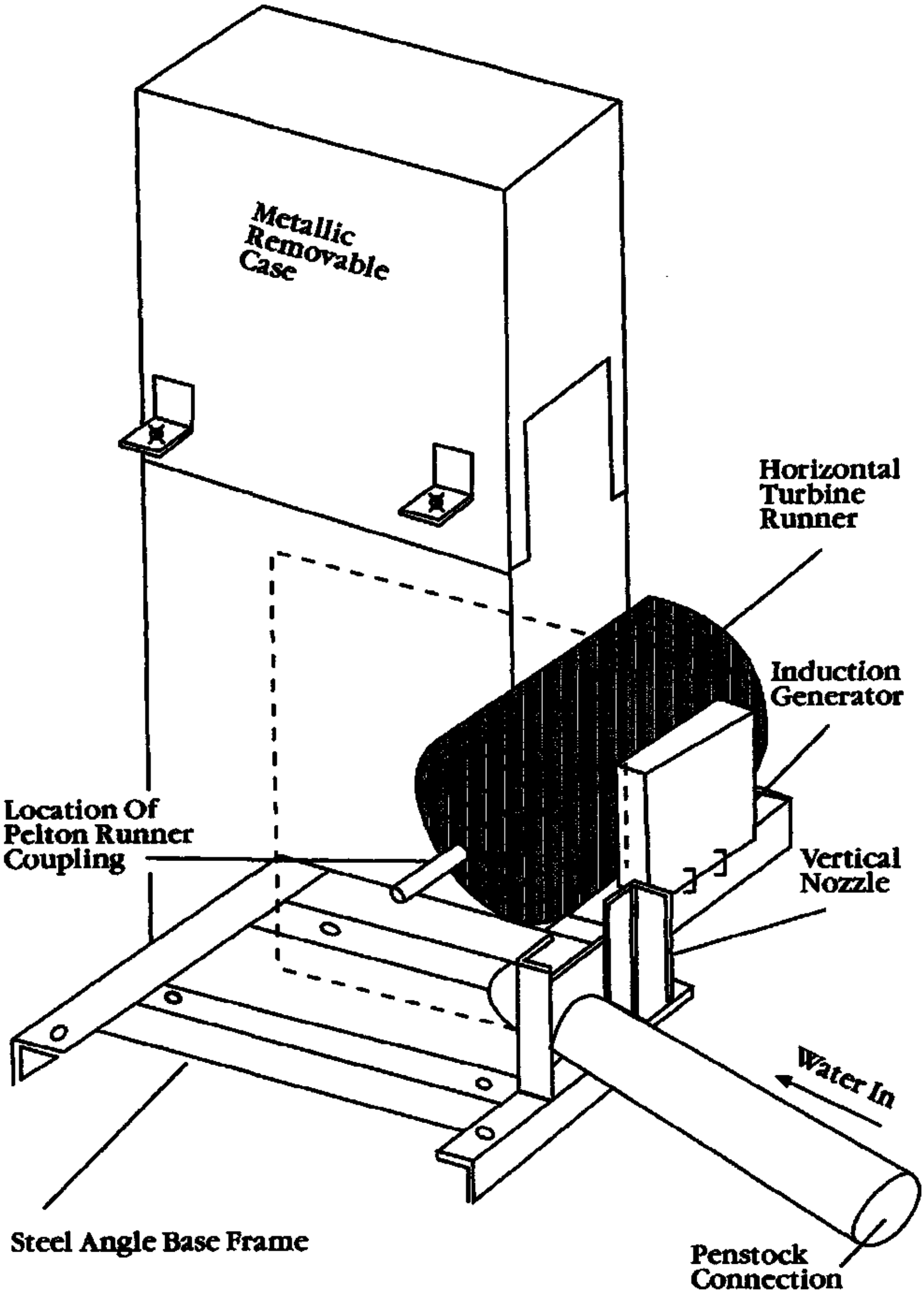


Source: Sketch adapted from Harvey et al. (1993)

The normal practice in a conventional peltric set, is to fix the generator turbine in a vertical position. An additional feature of this project was to experiment and maximise the number of households to be electrified with the use of energy efficient lighting such as the CFLs. One of the advantages of the horizontal design modification aimed to make it suitable for driving mechanical loads.

Consequently, one of the objectives included demonstrating whether the turbine could operate the grinder from an extended motor shaft. Therefore, a 12-inch electric metal grinder was assembled in the powerhouse to assist villagers with the grinding of corn. Figure 6.5 shows the prototype that is used in Kusha Devi.

FIGURE 6.5: Pico Power Pack at Nayagaon in Kusha Devi



Source: Sketch adapted from Maher and Smith (1999)

Other advantages of the turbine included the technology's portability, given its weight and size, easy fabrication and operation norms and requirement of relatively low discharges, ranging from

3-15 l/sec. In this case, the Pelton runner and induction motor is designed to suit the site and the source conditions to adapt to the head and the flow. With the use of capacitors to the induction generator and an electronic load controller, electricity is produced when the water flow is channelled to run through the turbine. A small vertical nozzle is adapted to fit with the turbine, to control a release of 9 litres of water per second. The PPP therefore uses a single jet Pelton turbine, which is arranged and modified to produce electricity of 4.2 kW.

The cost of production of PPP per kilowatt output of the generator was high at US $ 2,300, compared to other micro-hydel systems, primarily because it involved a foreign designer. Locally designed systems range from US $ 1000 to about US $ 2000 depending on the type of turbine, conveyance system and the hydrology and topography of the site. The subsidy granted to the PPP was not equally shared among the community, as not all the community members have access to power. The loan repayment process has been arduous and the community has over Rs. 137,000 pending for repayment, out of which Rs. 77,000 is the accumulated interest against a principle of Rs. 60,000. Currently, there is no balance available in the community coffer.

The generator

The pico turbine is attached to one side of the surface of the generator with the use of a steel angle base frame. A 7.5 kW induction motor is used to perform the function of a generator. The electricity is produced on a 220-volt operation and is then passed onto the generator where the controller diverts excess power to the heater load. Two miniature Induction Generator Controller (IGC) boards, each with a 3 kW capacity are used in a parallel arrangement. The first long breakdown of the Nayagaon project occurred at the end of March 2001 and lasted for about the 3rd week of April 2001 when the turbine became dysfunctional. The IGC had burnt out due to a lightening strike, bringing the turbine to a standstill (See more on lightening storms in Chapter 4 and 8). The IGC for this project was designed by NTU and a representative brought a replacement for the damaged unit from NTU from the UK. In addition, lightening arrestors were also handed over to the community. Whenever the weather conditions present the likelihood of occurrence of lightening, the technical operator runs to the powerhouse, which is about 5 minutes away from his house, turns the electricity off to protect the IGC from damage. A lightening arrestor of 500 volts has been installed and if the lightening surpasses this voltage level, the system will not withhold because of higher energy level surges. The problem of earth leakage was rectified by the NTU in September 2001 with correct connections of the lightening arrestors and distribution network.

One of the pico boards connects with a 3 kW ballast that consists of 3 air heaters and the second one with 2 air heaters. A C-2C capacitor connection is used to stimulate the induction for a single-phase operation; the electricity produced operates in a cycle of 220 volts. A new controller was installed in May 2001 because immediately after installation, the generator wire burnt out, due to a faulty connection of the capacitor. To protect the system from further burning out, a 25 Amp double-pole MCCB was installed and thereby provided protection to the capacitors, generator and wiring from overheating. As with most MHES installed in Nepal, the services for repairs and the provision for spare-parts are available in bigger cities such as Kathmandu. These small communities run systems do not have sufficient funds available for repair and maintenance and therefore the dependency for operations and maintenance on external agents is quite high. This dependency further increases when foreign designed electro-mechanical components are utilised within the design, making spare-parts difficult or expensive to obtain locally.

The powerhouse and powerlines

The powerhouse, situated towards the north of the village was constructed with the help of the citizens using locally available construction material such as mud, wood and stone. The internal dimensions of the house measures 4.8 x 2.7 m and the sloping roof of corrugated galvanised iron sheet blends in along with other locally constructed village homes. Entering the powerhouse, the turbine is visible along with other artefacts located inside such as the grinding mill or the metallic ghatta, two IGC boards and the ballast. Although the powerhouse and the units inside are strategically located to connect various settlements in the village, the installed capacity technically cannot meet the requirements of 108 households.

The main grid line runs from the powerhouse to the Tallo Nayagaon, Mathillo Nayagaon and connects the centre of Pallow Tol, which is a settlement located in between the two. Towards the left bank of the source, the grid line comes to an end towards the lower edges of the Tamang community at the base of Torikhoriya. The electricity in these settlements is distributed by using 12 units of *Katush* (tree belonging to the chestnut family) poles that connect 1100 m of PVC with weasel aluminium wire for transmission. As improperly seasoned wood had been used, some of the poles required repair. During the time of repair, the community felt that the original installation of the poles was placed in a manner where optimal connection to the households could not be achieved. They felt that in hindsight, 8 units of poles if strategically placed, would have sufficed, to provide a wider coverage, than laid out in the initial design. This installation would have reduced some transmission and wiring costs of the community. The villagers undertook the transmission and the individual household wiring with the help of the village operator and some households through a hired technician. The PVC cable that has been used for the main transmission line has peeled off in certain sections, in particular around the pole joints. This condition has led to short circuits on a few occasions.

Loose connection and faulty wiring are also causes of blackouts in some of micro-hydel sites. For example, in this PPP system, about seven houses in Tallogaon did not receive power for two days, due to a bad connection in one of the main cables. The technical operator takes care of such transmission problems encountered by households. The open wire, single phase of electricity has caused a series of problems, as the wires tend to rub together and create a short circuit every time they touch. This problem affected not only individual households, but also at times, entire segments of the settlement.

The ghatta and agro-processing

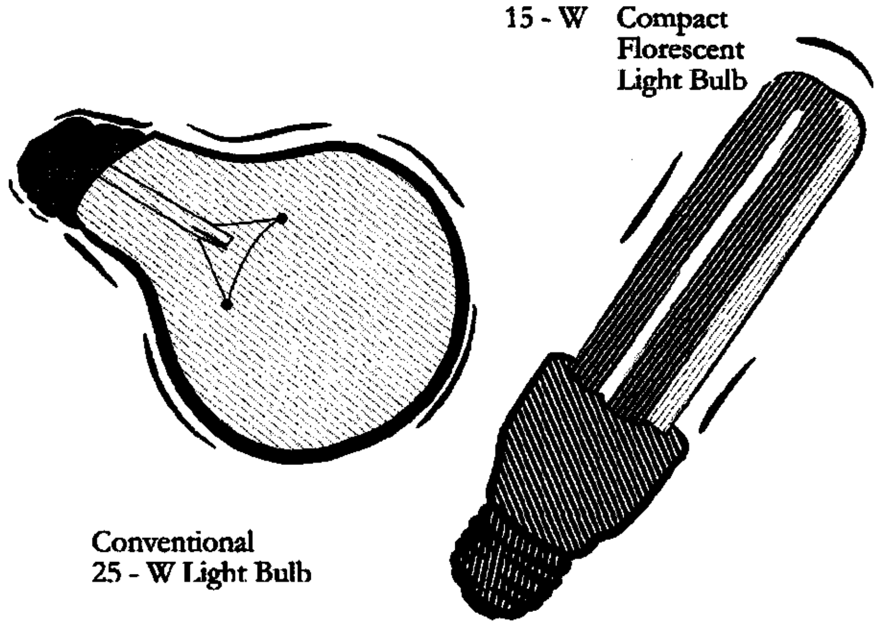
An additional feature of the powerhouse is the arrangement that has been made for the installation of the ghatta, which is located in the opposite face of the turbine. The design of the ghatta in principle follows the traditional form used by the local *ghattera* (a mill owner) of Nepal with two stone wheels placed with a grinder, which is a similar motion to a *jnato* (traditional grinder). The mill is designed to process 150 kg of grain per hour and consists of a 12-inch metallic grinder. The grinder has an operating speed of 400 rpm and interacts with the turbine by two-way belts. The mill, if in operation, utilises a total power of 1.4 kW, which normally would occur for daytime uses. Six weeks after the installation of the grinder, the mill became dysfunctional, as problems were encountered in the metallic grinder leading to a breakdown. It appears that during installation, the gap between the two stones was not estimated correctly therefore the grinder and the shaft were damaged. The mill was repaired in September 2001 by NTU. The ownership and the responsibility of the operation of the mill have not been clearly defined; the technical operator of the turbine as a knowledgeable agent in the village assumes responsibility for operation when required. When the grinder is in operation, corn for animal feed is processed at the mill. There are about five other water mills around the periphery and the community prefers to use these mills to process corn for human consumption. The villagers prefer to use the traditional mill which is an hour's walk downhill on the banks of the river Roshi to grind their corn. The community believes that the metal grinder does not give them the desired consistency when the grain is pulverised and therefore creates bubbles while preparing the traditional *dhindoe* (cornmeal) The tendency for infestation of the grain powered through the metallic grinder is also believed to be higher.

The compact florescent light bulbs

When the objective to provide electricity to 88 households was initially established, the allocation from PPP was estimated at about 45-W (watts) per household (88 households/~4 kW). In order to provide sufficient lighting, electricity was distributed through a combination of two light bulbs. Figure 6.6 shows the two types of light bulbs that were used in Nayagaon, Kusha Devi. This combination included a 25-W conventional light bulb and a 15-W CFL, which had been initially distributed to each connected house. A new runner was also replaced in 2001 that increased capacity of the old runner to produce 4.5 kW of power. However, not all houses have been electrified. In the beginning, the power access was controlled in each household with a positive temperature coefficient thermistor (PTC) instead of load limiters. These current cut-off gadgets are currently non-functional, as the users have learned to bypass PTCs and have perceived these to be obstructing units. Initially, these units were not effective because of a high tripping current and the overheating of the generator.

As many case study sites have demonstrated, pico and micro-hydel plants in Nepal are prone to overloading of power. This is because the load connected by the users, frequently exceed the load produced by the generator. The use of PTCs, at the household level, is a common practice in some micro-hydel plants in Nepal. However, these systems are not effective, as the users quickly learn to bypass these units. Other sophisticated devices, such as load limiters (See Chapter 4 on household metres) that control access and usage automatically are considered costly and inappropriate for low-cost micro-hydel sites.

FIGURE 6.6 Conventional and Compact Florescent Light Bulbs



The CFLs are not in use in Kusha Devi site any more. The CFLs that were initially supplied by NTU burnt out within 6 months of installation and were not replaced by the villagers. The success rate of CFLs adaptation in Nepal has been minimal. There are various reasons for this. First, the users have cited the lack of availability and the high cost associated in the purchase of these lamps as an impediment. The CFL is not easily available in rural areas, except for district level towns and is not locally manufactured. The European, Indian and Chinese brands are available and the price ranges anywhere from Rs.100 to Rs.700 depending on the quality of the lamp. Second, the voltage fluctuation and lack of voltage regulators, in rural power plants, increase the tendency of the lamps to burn out prematurely. The community expresses feeling more comfortable using the conventional light bulb. According to the operator, the NTU was willing to pay for 50 per cent of the costs on CFLs if the community wanted to revert back to CFLs again.

Tailrace releases

The outflow from the powerhouse is released using a HDPE pipe directly onto the sloping terraces without the use of any diversion channel. The released water gradually trickles downhill and connects to a nearby spring source, which ultimately discharges with the Roshi River at the foothills. The tailrace water from the powerhouse could be channelled to support some irrigation activities. However, the resources from Gudgude Khola itself are in jeopardy. Very recently, the DDC has collaborated with the Municipality of Dhulikhel and has made an agreement with Kusha Devi VDC to transfer the water from Gudgude downstream for the municipal drinking water scheme. In this process, an advance of Rs.200, 000 has already been released to the VDC as per the agreement. This agreement has been made without the consent of Ward-Number 6 community members.

Agents, Agencies and Design Networks

The electricity generated from the PPP was designed to produce power mainly for night-time lighting purposes and daytime ghatta use. The installation of the project began in November 1999 and the villagers recall having completed the construction and installation within 26 days. At the onset, a total of 88 households that were situated within close proximity of the source were targeted for electrical connection. However, there was no grid extension planned for in the Tamang community, which is located adjacent to the source. Two Tamang houses situated close to the powerhouse were provided with electricity connections. The farmer from the first house had contributed land for the construction of the powerhouse and the second farmer's house was located adjacent to the powerhouse. The latter had a ghatta located in the place where the current turbine is situated. At the beginning, eligibility for connection to electricity was based on three criteria. First, in order to participate in the project, the households had to put forth their land titles as collateral to secure the bank loan and hence access to electricity was provided on the basis of this deposit. Second, those who did not contribute with voluntary labour were not provided with a connection. This criterion was interlinked with the first initially. Later on, this restriction was removed, as there was surplus electricity as only 68 houses were then connected to electricity supply. The third criterion was associated with property rights and statutory entitlement to land. These three factors were the explicit conditions laid out for the right to access electricity. If the owner was able to produce a legal land title, then the access to electricity was assured. There was also a fourth criterion, political affiliation that became an implicit condition in making claims or in rejecting entitlements.

Notwithstanding, all the participating houses were not required to submit land titles for loan sanction, as there is a rule of discretion. The lending agency such as the ADBN does not have any stated legal policy document, which outlines that household that do not submit land titles cannot have access to electricity. As such, there is no hard and fast rule that binds access to land titles with 'access to electricity', as such, rules and norms remain at the discretion of village political leaders. Prior to the intervention, the community usually approaches the bank collectively to secure a loan in the name of the ward and the VDC. Therefore, not all-participating households are obliged to deposit the land title as security deposit. Rules vary from project to project, however, as a normal practice some members prefer to provide voluntary labour in lieu of depositing their legal land ownership document in the hands of a lending agency. Consequently, the active members come forward as the organisers, who then approach the bank, collectively representing the interests of the community. Given the difficulty in securing land titles and the interest of households in connecting to PPP, the organisers of Nayagaon electricity committee decided to change the rules in order to accommodate more households and thereby generate renewed interest among the non-users. Those who could not provide land titles, either for political reasons or due to not possessing one, could acquire access to power connection with an initial fee of Rs.3500 to the management committee.

There were two groups of households that qualified for this privilege. The first set of actors was from the political group and the second set was composed of landless households. During this initial stage, there was a rift between the two dominant political parties. Members belonging to the Nepal Congress (NC) were unwilling to put forward their legal land documents. They either believed that the project was not capable of materialising or else did not wish to see the project being implemented. At a latter stage, some Brahmins belonging to the UML (United Marxist-Leninist) party and who did not previously submit their land titles, were able to influence the Energy Users Committee (EUC) to connect their homes with electricity. While those belonging to the NC party, were denied access, in spite of their Brahmin ethnic association. Not surprisingly then, political identification and association was a more important determinant to resource access than ethnic identification. The majority of the Tamang group did not possess land titles, therefore, they were unable to benefit from consideration. An Electricity Users Committee (EUC) was established and the EUC collected land ownership papers from the potential beneficiaries of the project. Some Brahmins belonging to the NC were reluctant to provide titles as collateral for political reasons. A technical feasibility study conducted in 1999 indicated that the Tamang households had explicitly expressed their desire to connect their homes to electricity. Similarly, a baseline survey report (Simkhada and Kapali 1999) conducted for ITDG and NTU recommended that the participation of the Tamang community was an important factor that required and a priority to be emphasised during the project period. However, the technology design failed to integrate the communities together.

There were three distinct groups that could potentially have been connected with electricity from the Nayagaon powerhouse. The first group, were the micro-hydel advocates that belonged to the UML party and were led by the chairperson of Ward-Number 6. The second group, were the national grid line advocates belonging to the NC party and were determined to wait for the grid-line connection. The third group, were the Tamangs, who initially were excluded because of the lack of legal title to their land. Thus, they could not participate in the implementation of the project and were subsequently denied access to electricity. At a later stage, around November 2001 and with political pressure from NTU, the Tamang group was invited to connect to the PPP. A decision to increase the initial connection fee to 5000- rupees per household was made in the village, with the rationale that these households had not previously contributed any labour. Thus, the Tamang community could be provided with electricity supply, on condition that they were willing to put this increased amount forward. However, the Tamangs decided to wait for the NEA connection. It was also economically not feasible for the landless Tamangs to advance such hiked-up fees instituted by the EUC.

By February 2002, three houses from Nayagaon had connected to the NEA central grid and these households were the supporters of the NC political group. Around 68 houses are now connected to electricity from the PPP plant. There are 17 households that have television sets installed in their homes, 40 homes have radios and the political leaders are using more wattage than was initially allocated. The groups of people that use micro-hydel power refuse to connect to grid connection, as most of the power consumed is free of cost now. With the refusal of the other groups to connect to the PPP, more power is now available for those who are connected, i.e. above 40-W. Yet, another group in the meantime continue to use *tuki* (kerosene lamp) and await for an egalitarian grid connection that is being promised by the politicians.

Hierarchies in design networks

There were multiple of actors involved in the entire process of Nayagaon village electrification. Therefore, it becomes imperative to understand these major players, the structures they represented and the roles they played, in order to understand the design, planning and implementation process of PPP. There were about 12 different active agencies that were involved during the various stages of this 'pico' intervention. These agencies can be generically described and identified within four various hierarchical structures operating as design networks. First, at the external agency level, DFID, NTU and ITDG, functioned as the pioneering agencies. Second, at the national level, ITDG, NYSE and the Energy

Systems (ES) as local NGO, manufacturer and installer, respectively supported the innovation as partners of the pioneering agencies. Third, at the district level, DDC, PDDP, ADBN, REDP intervened as the authoritative body representing local governance and decentralisation process. Fourth, at the village level, EUC, VDC and the community were also involved as 'participating' groups during different phases of this intervention.

At the primary level, the external agency DFID entered with its horizontal implementing partners NTU and ITDG, with a global agenda.[10] The decision regarding the 'output' of the scheme was made by these three agencies in accordance with the objectives set in the DFID/TDR project on pico hydro (Kapali and Shakya 2000). In essence, the planning, design and the implementation were predetermined outcomes closely linked to the contents of the initial project document. NTU had a task, not only to demonstrate a new model, but also to identify a site that was easily accessible to visitors that were associated with the identification of the technology.[11] Hence, along with the process of ensuring that the turbine was running to produce electricity, also came an essential need to ensure continued donor support, with the objective of minimising donor abandonment and sustaining the system.

The second level of design network represented the designer and the technical support agency at the national level. These were the manufacturer and the installer. At the initial stage, Nepal Yantra Shala Energy (NYSE) became involved in providing the fabrication, installation and technical/mechanical advice as a local manufacturer of the turbine. The pre-installation period was supervised by ITDG-N. Then, a national manufacturer/installer ES[12] became involved during the post installation phase. The ES, towards the latter phase of the intervention, was introduced as a mechanism to facilitate local level technical support. The ES made few visits whenever required during the post installation phase providing technical assistance and follow up during breakdowns.

Third, at the district level, the stakeholders involved at the decision making level in terms of the location, site selection and intervention modalities were DDC, PDDP, ADBN, REDP. The DDC as the ultimate approval granting body deferred the process to PDDP and REDP. The PDDP, then again deferred the process to REDP. ADBN as the financial institution provided the loan but entered in the decision-making process only towards the later stage after the decision had been processed by the DDC.

At the fourth and final level, and as a development receiving agency, the community, the ward, EUC, VDC and the community leaders had an important role to play.

Local development support structures

Two national level development programmes supported by UNDP are being implemented and operational in Kabhre Palanchowk district. These are PDDP and as previously mentioned the REDP. The PDDP focuses on district development in general and works closely with the DDC. The PDDP budget allocation for VDCs is tied and controlled through the DDC financial structure. The initiatives undertaken by this programme have supported infrastructure development in the district, including schools and fair-weather roads, which is primarily visible around bazaar areas. The PDDP was operational in Kusha Devi VDC since September 1997 and was initiated with the objective of organising local people into 'participative self-governing local organisations' within poverty alleviation programmes. In the Nayagaon Ward-Number 6; the PDDP had formed four community groups involving 85 households. These were the self-help groups that were initially designed to collaborate with the set up of a revolving community fund. However, these groups did not function according to the initial objective set out and became dysfunctional after the programme period was over.

All REDP programmes are village based and enjoy more autonomous operational rules and guidelines. Given their institutional structure, even though the programme operates in close coordination with the DDC, REDP is in control of their own resources. The image of REDP, at the district level is of a technical institution that provides rural electricity and works in collaboration with the community. In an REDP supported project, the manager as the elected village committee member is a signatory to the financial resources along with other DDC representatives.

Electrification was identified as one of Kusha Devi VDC's development priorities. Consequently, the Ward-Number 6 had made various attempts in the past to bring in a micro-hydel project to their village. The ward approached PDDP to request for electricity support programmes, primarily because of PDDP's involvement in undertaking other development interventions in their ward. During this stage, REDP had been actively engaged in the promotion of renewable energy in the district and was in the process of site selection for possible projects. Nayagaon was not included as one of REDP's mainstream programmes. The request to install a micro-hydel plant by the district on behalf of Nayagaon was deferred by PDDP to REDP. It was REDP, who in turn, linked up the villagers with ITDG.[13] In the meantime, NTU was looking for a possible site for the demonstration of the horizontal Pelton. Nayagaon, thus became selected for the pico pilot intervention. REDP came in the picture initially, to recommend this site and later to undertake the second level community mobilisation, with the formation of the EUC. Following this recommendation, the EUC was created at the community level. Then, the formal agreement for implementation was made by ITDG along with the DDC and EUC representing the local community. At a later stage, ITDG supported training programme courses and technical training for the manager and the operators.

During the installation phase, ITDG coordinated with NTU, NYSE and other material suppliers and local contractors. The village men and women provided a free labour contribution for the construction of civil structures like the powerhouse, intake, erecting the transmission poles, stretching of the transmission lines and house wiring. The majority of the grant was covered by NTU. The grant was provided as an incentive for the community to use a new turbine that had not been tested in the field before (Kapali and Shakya 2000). PDDP, DDC and VDC provided additional cash contribution to complete the required budget. Inclusive of the government subsidy, the project enjoyed a substantial subsidy of over 86 per cent. The ADBN, as the local level financial institution, provided the community with a bank loan at the interest rate of 16 per cent.

At the local level, the only existing technical and operational support structure is the technical operator. The PPP is today running in Nayagaon solely because of the dedication of the technical operator. He is employed by the EUG on behalf of the community. As a service community employee, the leaders of the committee, i.e. the chairman and the manager make provision to remunerate his monthly salary. However, as much of this will be discussed in Chapter 8, this function of fee collection and payment of salary is not functioning very well.

Governance of PPP: The formation of Energy Users Committee

The phrase, the Village Electrification Committee (VEC) that has been used in the PPP project documents, is not entirely representative of the composition of the electricity users and non-users; it assumes representation of the entire community. Likewise, the REDP's model of Functional Users Group (FUG) is relevant, as long as a committee remains functional. Hence, the term EUC is used here: those who use electricity belong to this committee, and those who are denied remain on the periphery and are not represented in the committee by the users.

The EUC formation at Nayagaon shows how the concept of 'participation and social mobilisation' also differs when programme and projects are not immediately perceived as being under the control of one dominant design network. A village mass meeting was held in Nayagaon, on the afternoon of April 1999 in the presence of the representatives of agencies such as the VDC, DDC, PDDP and REDP. These representatives, together with the active community members selected and formed a 13-member village electrification committee, which is referred in this text as EUC. Unlike other REDP programmes where the process of social mobilisation ranges from three months to two years, depending on the context for intervention, the process of social and community mobilisation in this particular case was completed in less than one day. Thus the EUC for PPP was established in Nayagaon. Unlike other REDP interventions, a PDDP mobiliser was used in the process and not a REDP mobiliser.[14]

This accelerated process included not only the formation of the committee, but also the election of chairperson and manager. This further included the planning and organising of the local labour contribution, loan processing and project implementation and management. A users group, following a similar model of REDP functional committee (Kabhre DDC/REDP 2002) was undertaken. The members of the EUC were selected from the four existing community groups already established by the PDDP in the project area. Under the PDDP programme each settlement had separate male and female community groups. Given the settlement pattern of Nayagaon, the Tamang community had a separate Tamang ethnic community group. In addition, there existed a female community group at Tallo Nayagaon. Hence, homogenous and segregated male and female groups were created in each of the three settlements. Following this step, 13 representatives were selected from various settlements, which included one Tamang from the community group of Torikhoria and one female from the female community group of Tallo Nayagaon. The 13 selected members in turn selected a chairman of EUC who also happened to be the chairman of Ward-Number 6. Subsequently, a manager from the Mathillo Nayagaon was selected for the scheme and later on, two men were selected for the training of the operators. The manager also assumed the role of secretary.

The EUC was a loosely created management apparatus designed in an impromptu manner to serve the purpose of emphasising 'community participation', hence facilitating the process for intervention.[15] The formation of EUC, legitimised 'ownership' of the plant, hence the onus of accountability was bequeathed to the community. The PPP is termed as a 'community owned' project. As such, no formal documentation, written rules and regulation governing it's functioning was undertaken. However, it was stated verbally that the EUC had to maintain the documentation of the proceedings of meetings, income and expense book. The manager was assigned to record the minutes of the meetings. However, responses from the manager indicated that this practice has not been put into effect. The chairman and the manager are the signatory of the bank account of the EUC. The manager has abandoned his job (See Chapter 8). Hitherto, bookkeeping, balancing of accounts and the tariff collection has also been abandoned.[16] Recovery of monthly charges with established formal rules, was never institutionalised, as such, recovery became a difficult task. After the departure of the manager, the chairman of the committee designated himself as the manager of EUC. The committee is now almost non-functional. The committee is supposed to meet once a month but the meetings rarely, if ever, take place.

The chairman of the EUC, in his capacity, also as a political leader, makes most of the decisions for the community. Furthermore, he is the coordinator for the milk cooperative, organized by the village and is in charge of distribution of the daily proceeds from the milk sale. Every morning, the collection of milk, takes place in his house where the villagers congregate and prepare for the days' chore through the collection. A person from the village is assigned to carry the milk canteens for sale to the Panauti bazaar. This congregation of the community functions as an informal forum and provides opportunity for the villagers to discuss many of the community woes. In essence, the milk cooperative has become a coalescing factor that is binding the community together, as the Tamang members also participate in this initiative.

Conclusion

This chapter has described the development process of PPP in Nayagaon village. The Nayagaon case-study site shows that an energy conservation approach in micro-hydel is inappropriate especially with the use of CFLs as this design system has not been sympathetic to the community's aesthetic values or needs. The intervention failed to investigate sufficiently the desire of the community, and this lack of understanding continues to be a problem with these small supply turbine systems. A closer look at the PPP intervention process reveals that various governance and design networks interfaced in the function and use of building up of a technology. There were too many layers and too many agencies interacting with each other who, used the category of a 'backward' ward to bring PPP in this village and yet failed to understand the complex community issues underlying this technological intervention.

This study suggests that decentralisation and autonomy can function as a double-edged sword, pre-empting the need to examine the discourse on governance and representation, where the backward and underdeveloped wards such as Nayagaon can protect their resources from a higher-level 'decentralised' bureaucracy. The multiple layers of agents and agency, actually support in making the community more powerless, therefore a simpler and more straightforward governance structure could potentially assist in the democratisation of technology. Multiple design networks and the diffusion of the powerbase are rendering the technology to function more autocratically, totally missing out the goal and purpose of design. It is also revealing that the current participatory intervention methods and the surrounding rule and norms in technological intervention do not allow equitable access to water resources nor social justice. Consequently, because of unequal access and rights to water resources, the current rules, norms, and modalities supporting entitlement and 'access to electricity' itself is further put into questioning. While evidently the politics behind technology development emerges as a powerful interface between various actors, actants and their design networks, it is also a hard fact to swallow that the political accountability influences intervention processes in such explicit ways. These influences also led to association of the MHES with particular groups (and exclusion of others), whose powerful representatives rarely pays tariff themselves.

The system was designed to include agro-processes, which has been of interest to villagers, however not really in use. The 'method' in design of the water conveyance system is effective, with low costs and relatively easy management. However, the overall alienation that has come from problems with lighting has left this function complex unstable.

Design and designing in a plural networking arena is not an easy task. However, the Kusha Devi site highlights a degree of technical design arrogance that can account for several of the problems. There was minimal consultation with the local community in the process of designing, the uses and functions of the design system was very limiting in community servicing, the methods and tools applied solely focused on prototype experimentation, the evaluation of which clearly shows the incongruity in the application for the local needs. Committees were created in an effort to ensure continuity of the programme. However, the undermining of the political dynamics also rendered the implementation of the committees ineffectual leading on to examine these techno-political relationships as not merely being simplistic. The already diverse community is atomising further with proximity to Panauti Bazaar, Banepa and Kathmandu that also led them to expect grid electricity. It is surprising that the diverse network of agents did not consider these issues in their decision to bring the PPP in Nayagaon. The technology design supported unequal access to both electricity and water resources, thus sustaining patterns of authoritarianism in technological development.

Notes

[1] The installed design capacity of this PPP is not clear. While the designers have assumed that there was sufficient head to generate year round

potential of an excess of 5 kW power at an overall efficiency of 50 per cent (Smith and Ranjitkar 2000), the scheme capacity was also configured on the basis of the light bulb combinations intended for the lighting to be supplied. For example, this scheme used 15-W Compact Fluorescent Light bulbs (CFL) and one 25-W conventional bulb. While the initial design figures suggested 4 kW of power, in the end a 4.4 kW design scheme seems to have been followed. This thesis has used the installed design capacity of 4.2 kW as this figure has been obtained from the field site.

[2] Simkhada and Kapali (1999) note that this project was under the second phase of DFID/TDR project and was carried out by Nottingham Trent University in conjunction with non-governmental organisations (NGOs) and local manufacturing companies in Asia and South America. They state that the objective of the project was to work directly with a community in exploring the benefits of small waterpower installations. In Nepal, Nottingham Trent University, in collaboration with Intermediate Technology Development Group (ITDG-NEPAL), implemented the project.

[3] There are about 700 conventional pico hydropower systems installed in Nepal that range from 0.6 to 5 kW capacity. The majority of them are not operating smoothly and the issue of sustainability of this technology has been questioned at various times. Kapali (2001) highlights that the concerns on performance have centred on technical, financial and institutional shortcomings.

[4] Smith and Ranjitkar (2000) state that the scheme was designed with a worst case power output from the generator of 4 kW, with a voltage drop on the distribution estimated at 12 per cent and 3.5 kW of minimum power available to the consumer. The community was then expected to divide the power 'equally' between the 88 households as against the set target specified in the project documents.

[5] The social and the political movement spearheaded by the Maoists followers have also influenced some youth from this area. While some may have left the village in search for political and social gratification, others have left the village simply to avoid being conscripted by the Maoists followers.

[6] It is controversial as to which community settled first and there seems to be two sides to the story. According to the Brahmins, they were the first settlers and the Tamang community worked as bonded laborers. However, according to the Tamangs, they have been cultivating the land since 2016 BC and are the original inhabitants. The land inhabited by the Brahmins is the property, which was acquired and bought out from the Tamangs. Given the historical domination of marginal ethnic groups, the practice of bonded labor, and their current occupation of the marginal *pakho* land, the latter is perhaps the factual side to the story.

[7] The monsoon index reflects the average precipitation in hydrological

region number 3, which is calculated by examining the mean monsoon rainfall through a regional analysis. This index is used because of the unavailability of sufficient rainfall data for the research sites.

[8] The PDDP programme is implemented in 30 districts in Nepal. The programme was introduced in Kabhre Palanchowk district in 1996 and was initiated in Kusha Devi in 1997, and ended in 2002. Directly working with the DDCs, PDDP focuses on infrastructure development initiatives by involving the community in the implementation. Most of the documents and plans of PDDP that were kept in the VDC office for Kusha Devi have been burnt by the Maoist revolutionaries.

[9] Kapali and Shakya (2000) note that while it was technically feasible to design the pipelines to run through the upper elevation of Torikhoria, the community was excluded from this basic service. Hence, the Tamangs did not get a single tap from this scheme and currently continue using water from Gudgude *Khola* for their drinking needs.

[10] Khennas and Barnett (2000) provide a synthesis report to DFID, ITDG and the World Bank on micro-hydel power for developing countries. They review some experiences from Sri Lanka, Peru, Nepal, Zimbabwe and Mozambique. One of the key findings of their report states that 'in certain circumstances micro hydro can be more appropriate and profitable than other energy supply options, and therefore should be treated as part of the "full menu"of energy options, and therefore should be considered in meeting the needs of rural people.' In the Nepal examples 3 units are privately owned and the fourth one is community owned. Their analysis suggested the concept of 'intermediation', be emphasised with 'project developers' to undertake these various forms of intermediation - social, technical, financial and organisational.

[11] From 2000 to 2002, groups of students from NTU were brought over to Nayagaon to study and learn from the PPP experiment.

[12] While some members of the management committee expressed that the PPP had already been handed over and was owned by the community. ES continued to be involved in major breakdowns and in the provision of spare-parts. The presence of the '*Pajero*' car was associated with the visits of the staff members of the ES and NTU to the village. At the district level, it was voiced that the ES itself was a creation of ITDG-N after a former employee left the organisation and started this entity. At the DDC level it was expressed that while a coordinating body of REDP existed at the district level, the involvement of the ES was seen as interference by a private engineering firm based in Kathmandu. On the other hand, at the community level, some members expressed that the issue of 'technical turfs' demarcated the boundaries for assistance. Those programmes or projects perceived as not belonging to REDP received less attention from REDP coordination. A decision taken at district meeting in October 2001 formally gave the coordinating responsibility of PPP to REDP.

[13] A staff member at ITDG-N was in close contact with the District

Energy Advisor of REDP Kabhre Palanchowk programme. Prior to the project's finalisation, this staff member departed to the UK to pursue further studies. ITDG had requested the Rural Energy Development Section (REDS) at the DDC for a feasible site. The DDC chairperson supported this initiative and deferred the request to REDP. Nayagaon was considered an appropriate site for this project. Therefore, both the PDDP on one side and DDC on the other put the ball in REDP's court. Initially the villagers were not aware of the capacity of the turbine and did not know that only a segment of the community would receive electricity.

[14] As mentioned in previous chapters (4 and 5) social mobilisers that belong to the NGO-REMREC, support the intervention in the village as key partner group. Along with the REDP intervention, an NGO also gets created and registered at the district level in the process of institutional development. REMREC, as a local level institution, focuses in developing a close relationship with the leadership and the elite in the village, which then forms the main linkage in mobilising the community. The parallel processes of UNDP initiatives through PDDP and REDP is not complementary in the social mobilisation effort, rather is overlapping and competitive - contrary to what has been mentioned in the REDP/UNDP Strategic and Operational Framework (REDP 1998).

[15] Some REDP programmes, in spite of being phased-out, enjoy occasional visits by the district level community and/or technical mobilisers. The interaction again at this stage is with the leadership such as the chairman, the manager and the operator and not the entire committee members. Monthly meetings are also held at the district level for REDP operators and this meeting continues even after the project is handed over to the community.

[16] It can be questioned whether the accounts and tariff collection were ever put in place. During various visits, the chairman was unwilling to share the books if any existed. Some of the villagers related that tariff had not been collected for over a year. Some houses were said to have charges out-standing for over two years. In September 2002, the operator also complained that he had not received his salary for several months. When this question was put to the chairman, he retorted that he had a plan and since most of the milk cooperative members were electricity users, he was going to institute a new rule. With this new rule, the proceeds from the milk share would be given to the household only after deducting the electricity fee. However, this system has not been put in place.

7

Technology Transfer and Transformation

Panauti Small Hydel System and Francis Wheel Turbines

Dhindoe mattrai khana parla bhanne dar thiyo, tara, bhat pani khana paiyeko chha: We were afraid that we had to make do with eating just cornmeal, but fortunately we are able to eat rice.

Damodar Guragain, Khopasi, July 2001

Introduction

The 2.4 MW Panauti hydropower plant at Khopasi is one of the first small hydel systems built in Nepal to provide electricity nationally, rather than locally: it was designed and implemented by Russian technical assistance. This power system has impacted on several local irrigation systems, and become a site of contestation for local people, both for water and power. However, there has been some restitution of access through this struggle, which is how, as the opening quote says, people feared they would get corn, but were able to eat rice.

This chapter is provided to assist debate on comparative design choices, both on grid versus non-grid intervention, and on grid system evolution. It also examines the historical shaping and reshaping of one of the early interventions of the State in hydropower grid system development. This case study shows how intervention methods in technology development shape the local structure, which in turn is reshaped by the local dynamics of agencies. It looks first at the historical construction of the project, then describes its agro-ecological setting and then examines the transformation processes in the design of this plant. Thereafter, the chapter shows how structure, system and agents further interface to portray how farmers and the state have intervened in power supply and water use.

The Panauti plant has also witnessed various encounters of symbolic resistance by Maoist groups who have attacked the plant during the course of this research period.

Social Shaping and Technology Intervention

The name 'Khopasi'[1] according to the local community seems to have been derived and socially constructed beginning with the *Kuru* dynasty that ruled over the region during the *Dwaper* Era in Nepalese history. According to the locals, the name changed from *Kuruwasi* to Khopasi with time.[2] Just as there exist plenty of legends in the naming of this place; Khopasi is alive with the history of the past and the present. This area boasts to have situated the palace of King Virata. The location further became well known because of its advanced industry in iron works. Some of these iron kits can still be found in Kitni where iron weapons of cast iron were made and coins were minted.[3] This place also seems to have been the centre of Nepalese civilization during the Licchavi[4] period, which dated from the 7th century AD and hosted the famous alliance between the daughter of Nepal, 'Bhrikuti' to King Tsrong-tsong Gompo of Tibet. Surrounding this area are ancient relics, historical pagodas and holy rivers that have upheld the culture and tradition of the hardworking and laborious farmers, primarily from the Newar community of Khopasi for centuries. Khopasi, in Kabhre Palanchowk district, is not only renowned with a rich historical evidence of a thriving culture. In modern times, this area has been known for what was at one time the largest hydropower plant in the country, as well as for the pristine and extraordinary sprawling agricultural fields of Panauti and Paanch Khaal; and the temple of Panauti *Bhagbati* (goddess Kali). It is also now known for the social and political upheaval caused by the Maoist movement.

The local villages surrounding the Panauti plant landscape has begun to urbanise, yet retains some of its medieval architecture with clusters of households sporadically located within extensive expanses of cultivated agricultural fields. Traditional Newar farmers, who have a historical connection with Bhakatapur's social transformation, predominantly occupy this area. Besides achieving good yields of agricultural produce, the farmers in this area are well versed in the new politics that prevail today. The landscape has gradually changed over the years with new settlers and settlements. Rich farmers have also relocated close to the bazaar area and have also become involved in commercial activity. The Newar group is the ethnic majority in this area with other groups like Brahmins, Chettries and Tamangs also present. Ethnic minorities such as the *podes* (untouchable category) also live in the community and own smaller plot holdings and they also follow the demand-based principles now prevailing in irrigation. Noticeable, given other farmer-managed irrigation systems in this district, is that there is no formal farmers' organisation in this area. The farmers congregate in the evenings in the community elders' home to resolve conflict or dispute if required. However, these disputes are not necessarily limited to dealing with just water control issues.

The Khopasi area was considered remote during 1965. It took over a day's trip by truck to transport the construction material during the project implementation phase. Khopasi is still considered rural even though the Panauti municipal boundary designates the area as urban; it now can be reached in about 45 minutes by bus from Kathmandu. The location of the NEA administrative building separates the municipal and the village administrative boundary.

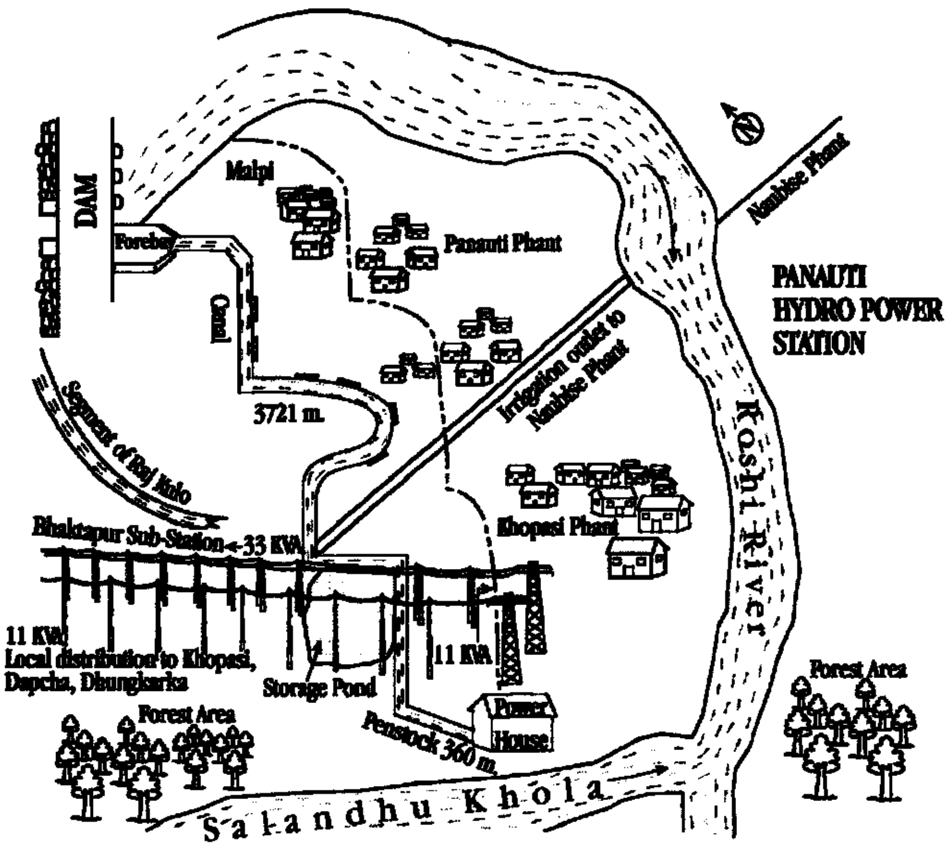
The power generated by the Panauti plant was designed primarily to supply the urban needs of Kathmandu. The power generated from the station was meant to feed into the gridline, through a 33 kVa transmission line via the substation in Bhaktapur. A second transmission line of 11 kVa brought the electricity back to the station in Panauti and distributed power to the town of Bhaktapur. When the project was inaugurated and the gridline connected, the community of Khopasi did not have access to electricity. With due negotiations, the houses around the main area were to be connected to the power line on the basis of *pukki* (permanent construction) versus *kachhi* (temporary construction) houses. Around 10 *pukki* houses in the main bazaar area in Khopasi were lighted. Some village elders also explain that by providing electricity to these houses the project was meant to keep the resistance and noises on compensation low. However this created more conflict in the area. From the dam to the powerhouse, around 150 households were affected during the construction of the power plant. Around 10 to 15 households were relocated to a nearby area. There was very little conflict with regard to the issue of compensation, as the community at that time was more preoccupied with making provision for irrigation. However, those that were affected directly through the construction of the powerhouse, construction of the administration building and the staff quarters were compensated. An initial decree had sanctioned an amount of Rs.1650 per ropani for those that were affected directly. However, Rs.1225 was the actual amount made available to the community. There was no compensation provided for the land that was acquired along the canal route. Similarly, compensation was also not given while installing poles for transmission of electricity. There was no resistance to this issue as the community was not aware that poles would not cause any significant damage. However, the land prices where the poles have been erected witnessed a gradual decline over the years.[5]

The farmers in and around the Khopasi bazaar were wealthy in land and production, and they put forward various petitions for electricity connection. Initially, only a few houses with tiled roofs in the main bazaar area were given electricity from this plant. After a prolonged negotiation, that took the community over ten years, the rest of the farmers of Khopasi succeeded in lighting their village.

Technology design, social and political processes

The Panauti plant laid a historic corner stone in the development of bilateral donor relations in the energy sector in Nepal. The first hydropower plant in the country at Pharping in 1911 (British-India) and the second power plant in Sundarijal in 1936 was built with Indian aid. For the first time, however, a country other than India provided support in the hydro development sector, when Russian bilateral aid gave support to Nepal's energy development sector. The former USSR's bilateral package came to Nepal characterised in the form of Francis Wheel turbines. This gesture was an attempt by Nepal to balance the power structure of the neighbouring giants, with China in the North under a communist regime and India on three sides, with a prevalent strong pro-Russian political stance. Under the programme, material, financial and human resources arrived from Russia for the construction of the canal, dam and staff quarters. Figure 7.1 shows the layout of the plant and its water supply.

FIGURE 7.1 Map of Panauti plant and water supply



Map: Not to scale

The Russian work involved Nepali engineers from the Electricity Department in Kathmandu, in the development of the Panauti plant. While the management of this plant was envisaged for supervision under the Kathmandu office, a separate management structure was also created for the Panauti plant at the intervention site, which ultimately was converted into the operations, management and administrative structure. There was another liaison office established in Banepa. For the first few years, Russian experts assisted then Nepalese counterparts in the management and operations of this system. When this plant provided power to the neighbouring towns such as Sanga and Dhung Kharka, the local NEA office expanded. The tariff collection department was established at the NEA office located in Khopasi, and later moved to the municipality of Panauti, located in Panauti Bazaar. The Bhaktapur office functions as an electrical distribution centre.

The technological artefacts such as the turbines, penstock pipe and other components, and the construction material such as cement and corrugated iron sheets were all imported from Eastern Europe. Three spare penstock pipes and other technical components were also supplied during the initial phase. In addition to the material and technical input, the Russian bilateral aid allocated a total budget of 3 and a half *crore* (one crore is equal to ten million) rupees[6] for the project, out of which a surplus of 50 *lakh* (one lakh is equal to 100,000) was later returned to USSR. The Nepalese government input was 10 lakh rupees.

The Panauti hydel power plant is a run-of-river type hydropower station and came into full operation in 1965. Water from the Roshi River is dammed, and channelled to the Panauti hydel power station via a 3,721-m long canal. The plant produces energy through 3 separate turbine units and feeds into the central gridline. This plant is a state-controlled system, and NEA directs and manages the supply of energy through the national gridline. The Panauti hydel power station is located in Balthali VDC in Ward-Number 9 with the NEA office located in the adjoining Panauti *Nagar Palika* in Ward-Number 12. The entrance to the main bazaar, also the main gate to the town, is adorned with pillars made from the spare penstock pipe donated by Russsia. The presence of steel pipes at the entrance is emblematic of the significance of the technological intervention to this area.

The site investigation began in 1959, which was undertaken by a team of Russian engineers in collaboration with Nepalese technical support. Coincidentally, the first General Election of Nepal was held on 18th February 1959. The construction of Panauti plant began in 1960. The construction work with the powerhouse was temporarily discontinued for a few months after a major landslide submerged the site under water. In early 1961, according to the local community, this landslide was symbolic of the bad times that had befallen the nation. This bad luck coincided with the cessation of work imposed by King Mahendra on the first bout of democratic fervour that was sweeping the country, when he arrested the leaders of Nepali Congress party. Construction work all over the nation was temporarily halted for an entire year because of a national decree that proclaimed the year to be inauspicious for the nation to embark upon new initiatives. This work resumed again in the beginning of 1962. King Mahendra inaugurated the plant, in 1965 after completion of the project.

The intervention site encompassed the command area of Khopasi and Panauti *phant* (flatland with moderate slope) through which ran the main *Raj Kulo* (the Royal Canal). Two other smaller irrigation canals originating from the upstream Salandhu Khola converged with the traditional Raj Kulo. These two canals were integrated with the Raj Kulo to form a larger system to connect with the powerhouse for power generation. Furthermore, because of the road construction at Tal Dhunga, the kulo at Patti Kharka was destroyed and stopped functioning after the civil works of the powerhouse were complete. As such, various small canals were integrated into a larger system, which later became known as Panauti Kulo, also sometimes referred to also as the Power House Kulo, to ensure that sufficient volume was made available to run the turbines.

The integration of these network of irrigation canals created many uncertainties for the farmers living in this area who were beginning to raise some concerns regarding their livelihood. The project was of such a high profile, that during the initiation, the then Prime Minister of Nepal, B.P. Koirala and his minister, Surya Prasad Upadhaya, attended a mass meeting to listen to community concerns. It is also significant from a historical point of view that Nepalese political leaders were then interested in attending to community woes, as such this period was also undergoing the first wave of democracy and pluralism in political constituencies. However, this phase was quite short lived. According to some of the elders in the community, a few months after their visit to meet the farmers of the Khopasi area, King Mahendra arrested many national political leaders including Mr. B.P. Koirala, Surya Prasad Upadhaya and Ganesh Man Singh. This incident took place on 15th of December 1960, when the King decided to ban all political parties in Nepal. However, the visit by the politicians at the site did ultimately have some influence on the changes in the design system.

There was significant opposition at the beginning of the project, mainly because the proposed canal system was going to integrate a larger portion of the traditional Raj Kulo that was the primary source of irrigation for the farmers in this area. The primary concerns of the farmers was that the proposed canal for electricity generation should not reduce the amount of water utilised for irrigation purposes, and that the acquisition of land for the project area provided a fair compensation according to local customary rule. After the mass meeting that was held during the visit of the political leaders, it was agreed that the design of the canal would accommodate the community's irrigation requirements and a fair compensation package would be included during the intervention period. The initial design did not include provision of water for irrigation[7] and in the heart of this valuable farmland this oversight by the designers appeared to be an anomaly.

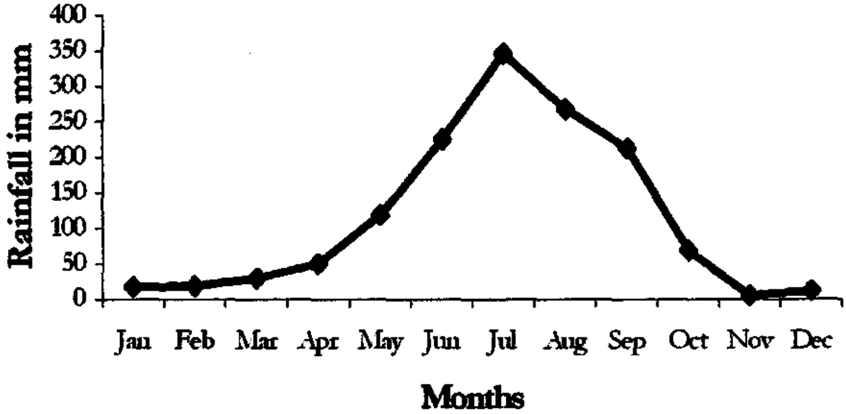
Roshi River Regime and Water Use

As with the other case study sites, the Panauti powerhouse site is fed by the Roshi River, which forms the main artery of a complex irrigation network in this district. One of the biggest irrigation systems within this sub-basin is the Power House canal of the Panauti small hydel power plant, which serves about 250 ha of irrigated land. The total catchment area of the offtake of the river is 87 km^2 and is mainly agricultural land.[8]

A diversion dam, located close to the confluence of Roshi and Punyamati Khola, near the main Panauti bazaar, channels the water for power and irrigation. This watershed area is exposed to longer sunshine hours as the river flows from South to North in this location. Subsequently, this area witnesses more evaporation and evapotranspiration. The gradient of this river is quite steep and a large discharge and sediment load is brought into the Roshi during the monsoon. This river remains almost dry outside the monsoon season. Figure 7.1 shows that over 80 per cent of the total annual rainfall in the catchment area occurs during the monsoon: the dry season accounts for about 4 per cent of the total rainfall.

Before the intervention of the state, the canal system formed a segment of an extensive traditional irrigation canal historically known as the Raj Kulo I (Joshi 1993; Theophile and Joshi 1992). A remnant of the Raj Kulo is still visible above the barrage of the new canal.[9] The new canal was built on this existing system by widening the canal to 1.5 m, and inter-linking the two large Panauti and Khopasi phant. The main canal that forms the artery integrates the two big phant, to support approximately 2710 households who are largely concentrated in Panauti VDC.

FIGURE 7.2 Mean monthly rainfall at Roshi watershed



Agriculture is the main occupation and major source of earnings for people living in and around this command area. The Panauti and Khopasi phant constitute of level terraces located in gently sloping terrain. In this area, irrigation is generally utilised for rice cultivation in both rabi (fall planted) and kharif (summer planted) crops. Cash crops, such as potatoes, are widely grown: farmers on average plant two crops of potato per year. With access to markets like Kathmandu and Banepa, potato is a major source of income in this area. Wheat is also grown to a lesser extent in the irrigated area. The dominant cropping pattern in the irrigated area is paddy and wheat; and paddy and potato. Table 7.2 shows the dominant cropping pattern of this area and water requirement for various crops. It can be seen that the paddy plantation and cropping season is the most water intensive, followed by the potato crop. The total water requirement for the irrigated area is about 1068 l/sec.ha of the command area.

Under rainfed conditions, maize and oilseed are the major crops grown in this area.

Water releases and design flows

The capacity of the Panauti canal is designed to supply 3.2 m^3/sec, the maximum potential from the river regime has been harnessed without other allowances.[10]

TABLE 7.1

Cropping pattern and water requirement: Panauti command area

Command area = 250 ha

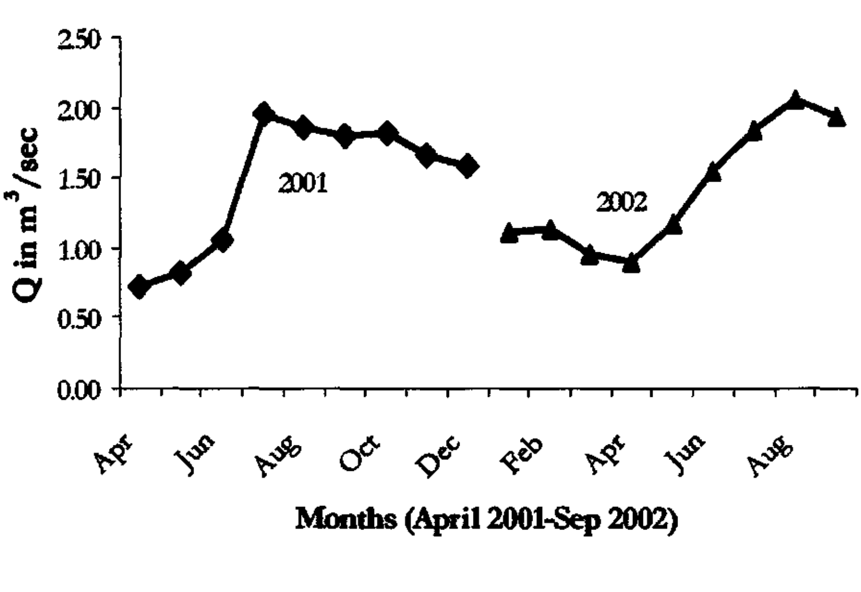
Soil type = Clay loamy

Kind of crop	*Season*	*Days*	*Base Period*	*Assumed Area for Harvesting (ha)*	*Duty (thousand ha/m^3)*	*Water Requirement (l/sec.ha)*	*Water Requirement (m^3/sec.ha)*
Paddy	July/October (Monsoon)	30	105	250	750	333.33	
Wheat	November/March	60	120	75	2000	37.50	
Paddy	Mid January/Mid February to April	30	130	125	750	166.67	
Potato	April	90	130	187.5	700	267.86	
Maize	March/June	45	105	150	2650	56.60	
Oil Seed	October/February	30	90	125	1750	71.43	
Soyabean	April-May/October	45	110	75	2650	28.30	
Vegetables	October to November/ March-April	45	110	75	700	107.17	
	Total water requirement in (l/sec.ha) for irrigation purposes					1068.83	
Total	Water requirement for 250 ha					267208.56	267.209

Water flows were measured at various points in the conveyance system, beginning with the hot season of 2001, using the float method.[11] According to the farmers, this area has witnessed an increase in rainfall for the year 2002. The other reason for the increase is also attributed to the fact that the powerhouse has not been in constant operation during the year 2002. This power station has been intermittently closed at various times due to the damages caused by Maoist attacks. The recent attack of September 2002 was the most significant one to have occurred at this station, as the plant remained closed for over 8 months. These attacks have not affected the irrigation system.

The measurements of water supply in the Panauti canal are shown in Figure 7.3.

FIGURE 7.3 Water Releases based on Field Measurements

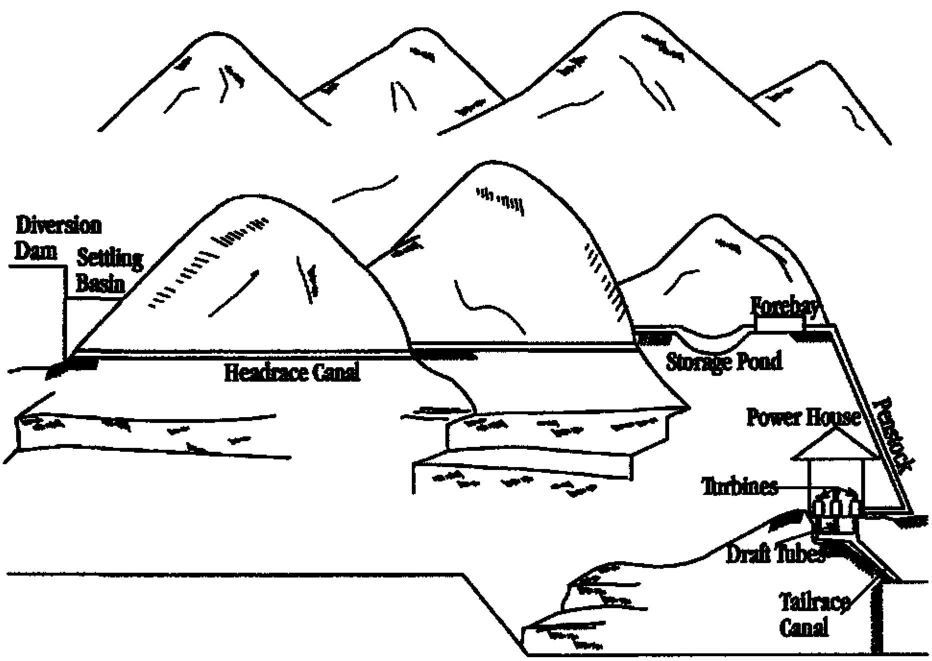


The dry season discharge averaging about 0.8 m^3/sec for 2001 and 2002 indicates that it is not able to meet the canal design capacity of 3.2 m^3/sec· A similar pattern can be observed on water releases at various points of the canal system. Figure 7.3 shows the average water releases in the main canal, measured over two dry seasons and one wet season, at the canal cross section between the third and the fourth gate. The data series for the years 2001 and 2002 indicate that the volume of water in the canal is high during the months of June, July, August, and September, and the low flow occurs during the dry season, as observed in other case study sites.

Hydraulic ensemble of Panauti plant

The outstanding feature of the Panauti hydropower plant at Khopasi is the long sturdy canal, with the provision of distribution outlets designed at intervals to supply water to the surrounding fields. The main design features of this station include a dam, an intake, storage pond, forebay, powerhouse, desilting and desanding control units, irrigation gates and a canal system. The length of the canal system from basin to barrage is 3721 m and ends at the forebay, which is situated at 463 masl. The main canal is designed to provide water for both irrigation and to run through the Powerhouse to generate electricity. Figure 7.4 shows the design and setting of Panauti Small Hydel System.

FIGURE 7.4 Design and setting, Panauti



The daily storage capacity of the pond situated right above the powerhouse is 50,000 m³ and its capacity is sufficient enough to store water for 3 hours of energy generation. The canal capacity is designed to provide 3.2 m³/sec of water. Six gates are placed at an interval of 465 m, with an additional gate at the outlet from the pond. The turbines located in the powerhouse are designed to function as three separate units, working simultaneously or as separate units with the discharge of each unit at 161 m³/sec. One wheel produces 800 kW of energy and is in continuous operation, while the second turbine is used during peak load hours. On average, 2 turbines run on this schedule and are rotated with the third one being idle for maintenance purposes. The water flow is insufficient for the three turbines to run in a simultaneous operation.

The plant is managed and run by a NEA Panauti Plant manager who has been assigned in this position since 1999. The plant manager's position is usually a short-term assigned position transferable from the Central NEA office in Kathmandu. Depending on a performance evaluation, the location tenure ranges anywhere from 2 years or more. At the time of study, the plant manager had an engineering background and came from Eastern Nepal. He was responsible for supervision of 32 operational, administrative and technical staff, out of which 22 were permanent employees and 10 on temporary assignment. There were 3 staff members to look after the administration, one dealt with the accounts and the rest are categorised as technical staff. They included two full-time paid canal guards and one chauffeur. Over 70 per cent staff members come from Kabhre Palanchowk district. Since its construction, there has been no major repair work undertaken and no electromechanical components have been replaced, except for emergency maintenance. The occasional breakdown of bearings is a common occurrence. One Francis Wheel turbine has been repaired locally. The equipment inside the powerhouse is outdated. The switchgear, control and protection equipment including the power transformer needs total replacement and the condition of most of equipment is said to be very dangerous (Upreti 2002). Civil works remain in fairly good condition, considering that construction took place over four decades ago. The canal structure and the irrigation gates also appear to be in good condition. Besides checking for routine leakage and seepage, NEA conducts 'overhauling' which indicate that the electromechanical components inside the powerhouse is greased, the surface cleaned, the mobile changed, and nuts and bolts are screwed and checked. This general maintenance is undertaken on a regular basis where each technician is assigned responsibilities to maintain and check certain components. For example, two mechanics are in charge of supervising the generators, one technician for the penstock, one for the storage pond, one forebay, four are assigned to check on the water conducting system, two are assigned at the dam, and so on and so forth. The storage pond is also maintained on an annual basis. Two separate step-up transformers are utilised to convert the electricity generated that separate electricity transmission for 33000 volts and 11000 volts distribution to Bhaktapur substation and Sangha substation respectively. Then electricity is distributed through the 11000 volts transmission lines within the surrounding areas including Panauti, Balthali, Dapcha, Khopasi and Dhung Kharka.

The major elements of this system include a diversion dam, conveyance canal, a forebay, a storage pond, penstock and a powerhouse. The details of the major elements are provided below.

Diversion dam

The diversion dam is adequately designed to ensure a regular flow of water, and is assembled with other control and filtering elements such as a trash rack before the water enters the two-chamber settling basin. The permanent structure of a diversion dam includes a sedimentation tank. From the left bank to the right, the structure measures 31.25 m in length. The dam is earth-filled with a concrete spillway. The capacity of the concrete spillway, built at the main canal, is 150 m^3/sec. The scouring particles such as silt, clay and gravel accumulating in the canal bed is controlled by a wash out valve that flushes into the river.

The NEA guard controls the releases of water flow from the Roshi River at the dam, through two vertical wheel gates operated by means of a chain pulley. This practise is maintained even during times when the powerhouse is not in operation. In this case, the canal guard releases water for irrigation and other uses. In this location, various activities of water use take place. The community, situated within this area, use this water for washing, bathing and for drinking purposes. Herds of animals are also brought here for grazing from the adjacent greener pastures along side the Roshi and also for bathing buffaloes near the dam site. The concrete spillway is quite large and therefore, children from the surrounding communities use this as a swimming pool and use this dam site during the hot season.

The NEA takes care of the major cleaning and maintenance of the headwork on an annual basis. As with other civil work maintenance, the NEA sub-contracts a civil overseer to undertake this cleaning assignment on a daily wage basis. Wherever possible, local manpower is used for these cleaning jobs. The construction of the diversion canal commences from the dam, which begins in Malpi area and crosses over the Roshi River to connect with Panauti Bazaar. The main headrace canal is designed to supply water to generate electricity and provide irrigation.

Conveyance canal

The original drawings provided by the NEA indicate that the canal is constructed of reinforced concrete flumes and rubble masonry flumes. At some places, gravel is used while at certain section rubble stone masonry and concrete are used. The canal is lined with cement paving. The ground slope of the canal is 0.00054. The canal incorporates several elements relevant to wider use, including six irrigation outlets, three storm overflow drains, and two passage bridges and nine rainstorm flow culverts. In the original design of the system, these culverts were meant for water releases to irrigate the fields of the farmers.

For irrigation facilities to the farmers, four double gates and two single gates are constructed at different places in the canal: the double gates are found at the downstream reaches of the conveyance system. The typical model for the gates is a heavy prefabricated slotted metal structure, winched mechanically through slots. Notches are provided at different levels to control the volume of water desired. Farmers manoeuvre the discharge from the main canal via these gates to open drop structures that lead into the network of earth channels in their terraced fields. The tailenders also use HDPE pipes to convey the water towards their fields. Due to water shortage in this area, communities located in Paanchthali and Sunthani also use the water from the canal for drinking purposes, in particular during the dry season.

The general cleaning and maintenance of this conveyance system, is undertaken by NEA on an annual basis using seasonal local labour. The farmers who own land and those who are located near the irrigation gates take care of any small, sporadic operational maintenance of the local system and gates. In this respect, there are no hard and fast rules that define the division of labour among water users but the rule of demand and necessity when irrigating their fields. Thus the rules for cleaning and maintenance also depend on the water users that use a particular irrigation gate to divert water into the sub-canals that serve their individual land-holdings. The headenders of the system, or those farmers who have land closer to the gates, also have the first priority to use water. These farmers are also seen as the first ones to respond to cleaning and maintenance.

As a State controlled system, the State-employed canal guards are responsible for the daily surveillance of the system. A common responsibility of the guards is to ensure that the irrigation gates remain closed when the water is not in use. Farmers tend to leave these gates open after releasing water through the outlets. Therefore, the guards are responsible for ensuring that unnecessary loss of water is avoided. The farmers had this traditional responsibility before the State intervention.

Forebay, storage pond and penstock

The adjoining structure, which is a permanent construction, continues from the canal to the forebay. The diversion ends at the beginning of the pondage area and runs underneath the passage-bridge to the forebay. The length of the forebay is about 30 m long and 4 m wide with a slope of about 1:300. The forebay structure consists of the overflow, desilting and desanding basin, and two control gates located towards the east and the southern part of the forebay structure. The gate located in the eastern section controls water flow towards the penstock, supplying water to run the turbine in the powerhouse located directly below the hill. The second check gate controls and monitors the discharge in the storage pond. Since 1998, this storage pond, one of the major features of the tailworks, has been fenced-in with a metal barbed wire and access to the public prohibited. Before the fencing, the pond was also being used by the local community for multiple uses. However the cleaning and maintenance was rendered difficult with the local use of this water. Also given the escalation of Maoist activities in the area, it was felt necessary to limit access.

The daily storage basin has a capacity to store about 50,000 m^3 of water, sufficient to run all the three turbines for three hours continuously. Other structures of this storage basin include a waste spillway pipe adjusted with an open chute and a concrete duct for cobbles. The water in the reservoir is channelled to the powerhouse via the penstock pipe. A trash-rack is fitted at the mouth of the penstock to filter foreign objects. A vertical gate is installed to control the flow of water into the penstock pipe, which is made of steel and is 370 m long. The internal diameter of the penstock is 1400 mm and carries water from the reservoir to the powerhouse to supply three sets of electricity generating machines. The effective head is designed at 60 meters.

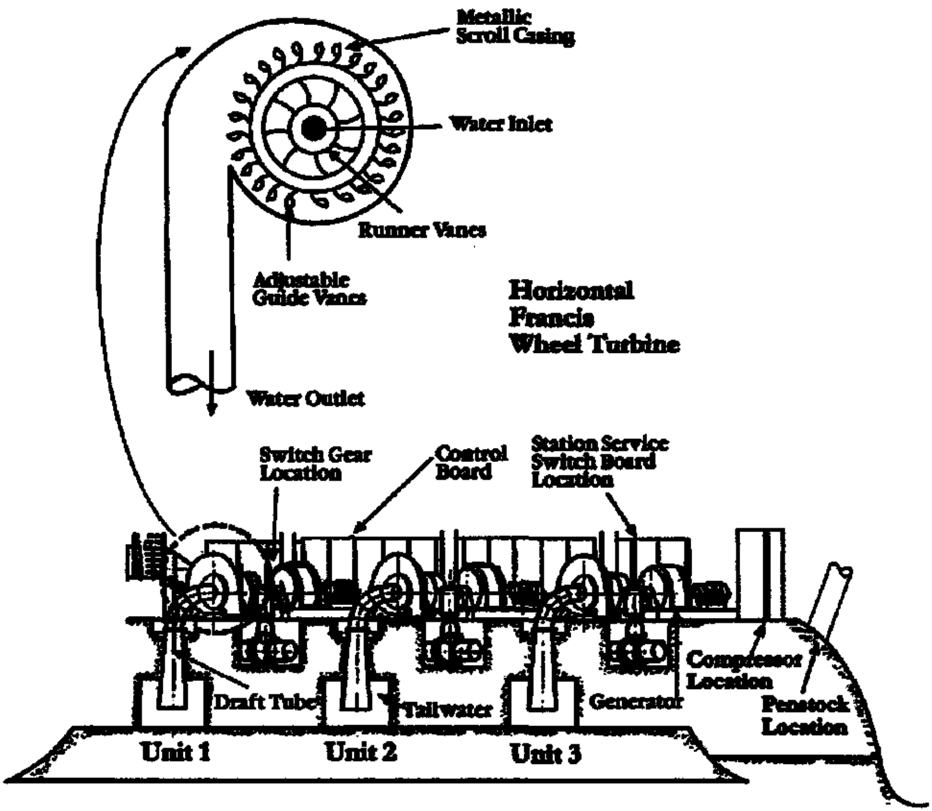
The storage pond is the last point in the design ensemble with interaction in social relations between power and other water uses. Up until this point, NEA and the local agency simultaneously and informally work together with the annual and general maintenance. Since, the pondage area is fenced, the access to the NEA facility also becomes limited from this point onwards. Hence, NEA undertakes cleaning of the pond, the forebay structure, and penstock and up until the powerhouse. Previously, the annual cleaning and draining of the pond was usually contracted out to a private company: however the last two years it is has been undertaken by using the local labour from the area. The NEA has one civil overseer assigned for this plant, who in addition to the supervision of cleaning and maintenance, is also responsible for sub-contracting jobs or mobilising local labour resources.

Francis Wheel turbine and generator at Panauti

The turbine utilised in this plant is of the reaction type. Therefore, energy conversion from water supplied mostly takes place in the form of pressure energy. As previously mentioned, three separate units of Francis Wheel turbines, which were designed and fabricated in Russia, have been installed at this plant. Three separate generators designed at a rated speed of 1,000 rpm are installed to generate power in a flexible manner, organising the individual units to function as independent units or as an integrated system. The turbines are of the horizontal type. The system can adapt to the hydrological situation, where according to water availability, the turbines are adjusted to produce power. The maximum power output from the three turbines is 2.4 MW with each turbine having an installed capacity of generating 800 kW of energy. The design discharge was estimated only for power generation, and not considering the multiple water use in the area.

Three separate generators, which were made in Germany, are assembled with Francis Wheel, each with an output of 6.3 kV. The turbines and the generators are in fairly good operational condition. Figure 7.5 shows the picture of the turbines installed in the powerhouse with other supporting systems.

FIGURE 7.5: Francis Wheel turbine



Source: Sketch adapted from NEA drawings (1965).

This life span of the machines has also been attributed to the fact that the various units are rotated for operation and hence not always simultaneously used for power generation. This schedule of power generation has reduced wear and tear on the machines in comparison to other components inside the powerhouse that are in constant operation.

The powerhouse and powerlines

The powerhouse is of permanent reinforced cement concrete

(RCC) structure, 25 m in length and 19 m in width. Other electromechanical units inside the powerhouse include equipment such as the switchgear, control panel, power transformer, energy meters, gate valves, runners and other components. This building also includes the electrical transmission. The technical operation is managed and co-ordinated at the administrative office of NEA Khopasi, a hundred meters away from the powerhouse. This main administrative office was damaged by a petrol bomb in January 2002 and is no longer in use. Since September 2002, the Panauti plant came to a standstill and was not functional for sometime. The NEA claimed that the damages were minor, and that changing the coils could repair the generators to resume power production again. However, given the current security situation in the area, repair work was undertaken only after the Maoists were brought into the peace process dialogue. The powerhouse again resumed operations mid-May 2003, after being shut down for over eight months. In the attacks, the administrative structure has been frequently targeted leaving the overall irrigation infrastructure intact. The NEA office in Khopasi is now operating from the guesthouse located within the premises.

The electricity produced is distributed in Khopasi and Sanga area via a 6.3/11 kV transformer and an 11 kV line. This transmission line is about 21 km long and wooden poles are used for the transmission line of this segment. The plant is further integrated with the Bhaktapur Central System via 6.3/33 kV 1.5 MVA transformers and a 33 kV transmission line. This transmission line is about 20 km long with steel towers erected for the transmission of this system.

The general maintenance of the electro-mechanical components is undertaken by the various mechanics under the employment of NEA. Each individual is responsible for the supervision of specific units, and hence cleaning and maintenance of the particular system as well. However, for five years now, routine maintenance of electrical equipment every five years has not been undertaken regularly or not at all with the attacks. Consequently, the operation of electro- mechanical components and other major machines are at risk. Wiring and power controls are also out-of-date or inadequate, under contemporary safety and reliability specifications. The absence of a synchro-check relay in the synchronising panel for parallel operation of electricity makes the convergence with the transforming national grid highly risky, if not eventually impossible (ibid 2002). Thus, both obsolescence and expected parts failure have affected the smallest parts of electrical generating forty-year old plant, while the canals and turbines continue to function. Options concerning these challenges are discussed at the end of the chapter.

Draft tube and tailrace canal

Three separate draft tubes link the turbines with the tailrace channel. After power generation, water from tailrace is released into the Salandhu River, which joins the Roshi River further downstream. The tailrace release from Salandhu Khola that connects with Roshi also feeds into some local irrigation network within the upstream reaches of the powerhouse. Some of the farmers expressed that when the powerhouse is not in operation, the upstream water users of the irrigation system, are affected as the tailrace release is reduced substantially. As mentioned previously, water control really begins at the dam where NEA regulates the supply in the canal. When the turbines are not in use, not all the water is released in the canals but only sufficient for irrigation and seasonal cropping pattern requirements. This control has impacted the upstream farmers that reside in the Balthali area, more than the downstream water users.

Farmer's Agency, Struggles and Adaptation at the Interface

Prior to state intervention, farmers in this area had difficulty in getting an adequate supply of water for irrigation uses. This farmland was a water scarce area. Several other smaller kulo that served as a network of irrigation system were impacted by the construction of the plant. The primary kulo known as the Raj Kulo had been serving as the main artery for irrigation purposes. The Raj Kulo originated at about 200 m above the present guardhouse, which is located adjacent to the headwork. This canal was much narrower in gauge hence could not supply water sufficient to fulfil requirements. Therefore, conflict and disputes over scarce resource were not unusual for the farmers in this area. The farmers planted more maize during the water scarce period, instead of planting water intensive paddy. Planting paddy was possible only during the high season flow.

As the Panauti Hydropower canal was built on the existing Raj Kulo, disputes and conflicts on water use and access were not surprising. The anxious farmers brought their irrigation concerns to the attention of the leaders and the designers. After the visit by the central level-political leaders, the initial design was modified to include the six gates for irrigation outlets. The drawings for these were finalised by the Russian designers in 1965. The farmers who benefited from access to these outlets were mainly from the downstream reaches of the powerhouse. The landholdings upstream of the powerhouse, leading upto Balthali area, were particularly at a disadvantage, because they depended on the secondary kulo that was integrated with the main canal. After the introduction of the gates, more than 300 farmers were still left affected. Disputes continued and with community pressure, which, at times included numerous petitions reaching up to the level of the royal courts, an additional seventh gate was also improvised to release water from the storage pond at the head end of the canal system. However, physical access to water did not ensure the actual right to use water.

From 1965 until 1992, the farmers from this area were in a constant tussle with the *dhal paale* (canal guards) from the state agency, who were stationed at the guard-post next to the dam. Until 1992, the canal operator and the guards from NEA made the daily rounds in the morning and evening locking the gates and regulating water, both for the farmers and the powerhouse. This central control over water release by the NEA proved to be disruptive, as irrigation needs were provided only after the energy requirements was fulfilled, with problems worsening with low flow, seasonal variations and transforming cropping patterns. Because of the large canal system it also became impossible for the farmer to monitor and judge the actual field conditions. Moreover, the farmers had access to water only if the locks in the gates were left open. The padlocks epitomised the formal establishment of control in the heart of a rich river and production regime. Water was controlled by the state, and the open-close gate system accommodated a flow variation depending on the volume distributed and notched by the hired operator.

This tightly controlled water distribution regime led to a major dispute in 1975 when angry farmers decided to perforate the canal. That year was also a dry year and the villagers made holes at night in different sections of the canal to steal water for their crops. During the day, the electricity authority staff would spend their time cementing and closing the holes. For a few years this hide and seek game of making holes and closing them continued, after which the staff stopped taking care of the maintenance of the canal. Finally, in 1992 the farmers decided to break the locks of the gates. Water from this canal was taken to as far as Sunthan VDC by means of big HDPE pipes. During this ensuing conflict, every house in Khopasi market near the canal was siphoning water from the canal by means of pipe for their household uses. The maintenance and inspection of the system was left in disarray and the powerhouse was running at a high cost and low efficiency.

In 1999, with the management change at Khopasi NEA, the inspection and maintenance work resumed. The management verbally conceded to release water for potato and paddy cultivation, provided the local community controlled water stealing. In actual practice, the system now operates on ad hoc adjustment, where water share depends neither on time or flow, but rather on field requirements and demand. Hence, the farmers now have the first right to use water and then water for energy comes as a second priority in use. Disputes have been minimised and the production in this area has significantly increased with changes in cropping pattern, improved seeds and fertiliser use. As such, the social struggle emphasised that actual water rights cannot be defined and designed in a drawing board or in a legal office (Boelens and Doornbos 2001). Access to water indicates control over resources and it arises amidst conflict, and has to be negotiated and enforced within normative structures.

The local action of the farmer's of Khopasi symbolises and reveals a preference through which the local society of Khopasi characterised their development path. The water distribution gates became the final pressure point where the push by the state and pull by the farmers allowed the pressure points to intersect. The gates became the symbol of not only the conflict, but also of conflict resolution and negotiation as outlets for intersection in water control. The priority of the farmers was to irrigate their fields. The canal system and access to water control, through the gates, is now under the control of the local communities. The maintenance of the structure and the main canal system is still undertaken and provided by the State. A verbal social understanding, that exists between the State and the community, allows farmers to utilise water, during and when required for production, leaving the allocation for energy production during peak load period. Subsequently, the *khet* (paddy field) owners now have open access to the canal and take their required amount of irrigation water. The NEA operator and canal guards, still make the daily round in the canal system to ensure that at least one wheel is able to run in the powerhouse and that other technical components remain functional. The farmers have the first right to use water for irrigation purposes, however water is still under the control of the NEA. The social and political influences of the Maoist movement in this area have also supported the local farmers' agency.

Evolution of local electricity supply

In rural Nepal, domestic lighting is foremost by the tuki, then micro-hydel and ultimately, for a few, by the grid connection. Unlike some rural areas, the development of electricity in the Panauti area has been a two-step process. In this area, this switch has occurred from tuki and *lalteen* (kerosene lantern) to the national grid connection. When the power plant came into operation in 1965, the Panauti office spent one year surveying the transmission network and electricity supply for the local farming area. After one year, as previously mentioned, about ten houses with permanent roof constructions were given access to grid-source electricity. At that time, the rule to provide access to grid electricity in the rural areas was nationally based on the nature of the roofing structure. The more traditional thatch of material such as *khar*, *shaulo* and *paral* (local weeds used for roofing and straw) was considered a fire hazard. Households with permanent roof construction also symbolised their ability to pay the tariff, as it was costly to have roof construction using tiles, aluminium sheets, bricks and slates; cement and RCC roofs were uncommon then. The Panauti office had a small section to facilitate tariff collection from the community members supplied in this area.

However, the farmers were not content and organised themselves in several groups to put forth a petition for access to the grid electricity. The minimum charge at that time was Rs.9 per month for 25 units of electricity, and above this use, 45 *paisa* (one hundred paisa make one rupee) per unit. However, most of the community households did not consume more than 25 units (one unit equals 100-W per hour) each. After pursuing the process for about ten years, the rest of the community was gradually integrated within the supply system.

However, to have a grid connection in this area, the NEA according to their national rule, requires a photocopy of a *lalpurja* (land title certificate), a citizenship card and the immediate three ancestral names, such as grandfather's name, father's name and the applicant's. An upfront deposit for connection fee is then required, after the approval for connection has been granted. Thus the rules for access, to grid-electricity, have not evolved substantially, despite the extension of grid-services in the surrounding area and provision of support structures. The requirement of a lalpurja indicates that evidence for a possible permanent or temporary roofing structure is still a prerequisite for electricity distribution. Lalpurja also indicates legal ownership of a home, which would further signify that the landless do not have the possibility of a grid connection through the national system.

From the bazaar area, local leaders assisted in organising the rest of the community to petition for access to grid-electricity. There was a strong local action in support of the farmers through the traditional *guthi* (formal association and trusts formed for special purposes)[12] system that strongly bound the community together. As certain segments of the guthi property were also affected by the construction of the hydropower plant, the voices for access to electricity resonated more effectively. The guthi members supported each other, and they could assert that the water resources that they collectively depended upon to support their livelihoods, was being used to generate electricity.

Gradually, more flexibility by the NEA, towards the rule and discretion of the type of roofing material used, was practiced. The members that belonged to their respective guthi were also assisted in paying the fees for electricity use. For this, the guthi exchanged agricultural produce for money, enabled farmers to avoid cash debt. Today, all the surrounding area in Khopasi and Panauti and the neighbouring settlements have access to electricity through the grid system. As more houses were being supplied with electricity, connection to electricity spread in the district around Sunthan, Sarada Batase, Sankhu and Kusha Devi as well. The NEA felt the need to expand its service through different sub-branches. In 1993, a separate distribution branch was opened up in Banepa to meet the requirements of the communities. This Banepa office is known as the district branch office for Kabhre Palanchowk. Excluding the hydropower plant office, four other sub-branch offices were set up in Panauti, Paanch Khaal, Dhulikhel and Dapcha, for fee collection and support services. Since 1996, a 'No Light Section' was established in south-west Panauti Bazaar sub-office, to assist with electricity failure and to organise service assistance at minimal charges for domestic repair and maintenance of individual households. Subsequently the tariff collection department was relocated from Panauti office located in Khopasi to this 'No Light' office.

Levers, gates and bombs: attacking symbolic technology

Currently, the Panauti hydropower plant is the only NEA-run power plant in the Kabhre Palanchowk district. As mentioned in Chapter 3 and elsewhere in this Chapter, the Maoists have attacked the Panauti plant several times. There have also been attempts to oppose the NEA establishment through attacks on other sub-stations in the district. The Panauti bazaar sub-branch was bombed for the first time on the afternoon of the 15 September 2003, after the Maoists shut down the entire market of Panauti Bazaar. The entire RCC structure and contents, including the documents inside, were destroyed. In 2001, the NEA office in Banepa also had a bomb lobbed within the premises, although no significant damage occurred.

In various acts of aggressions, against the NEA establishment, in particular at the power generating plant at Panauti, the attacks have included warnings. On one occasion, the NEA office was sent a letter cautioning them to await for an attack. They have also received warning notes to vacate the premises. The attack that destroyed the NEA vehicle in 2002, according to some community members, was allegedly because of over-expenditure on purchases of spare-parts of the vehicle itself. Other members have also expressed that the reason the Panauti plant has been attacked various times has been due to the dramatic public attention generated with the first attack in 2001, which was made to sound quite sensational. Since no employee, including canal guards or any average worker has been directly threatened to date, the attacks on the infrastructure appears to indicate, according to some community members, the broader Maoist opposition to hydropower development policies of Nepal. As Nepal lacks industries to consume surplus production, these attacks have served as explicit messages to the NEA to examine their internal policy matters. The NEA has functioned in an autonomous capsule, failing to integrate itself within the local and district governance structure. It has several offices in the district, however they have managed to operate, as a parallel structure of rural electrification, and the support for MHES from the NEA has been almost non-existent.

In many ways, the access to both electricity and water for local use, from the Panauti plant, depends on the management of NEA. The feeling of many who have access to grid-electricity is that the attitude of the NEA management has to change, and in fact some changes have begun at the plant since 1999. Irrigation supply now, not only depends on the flow through the irrigation gates, but on the condition that the turbine actually runs in the powerhouse. The lever to the dam with the chain pulley, controls water releases through the vertical wheel gates towards the canal. When the turbine is in operation, the volume of water also increases in the canal, as the canal guard releases a larger quantity of water for both power and irrigation use. However, the movement of the lever, which is controlled by the canal guards of the NEA, is now less important to farmers in this area. This is because the guards now comply with the prioritised needs of the local farmers, and the key to the irrigation gates is now in the possession of the farmers. This also symbolises flexibility in the operational arrangements, which can be a lesson learnt for many other centrally-controlled NEA plants. The continuing attacks of violence by the Maoist on the electrical systems also symbolise that the NEA should carefully examine its current hydropower policy issues regarding rights and access to power and other uses of water within local communities. The rights and access to urja also reflect the identity of a Nepali or collective members of a group, as rightful citizens.

Looking to the future

As mentioned, both obsolescence and expected parts failure bring questions about the viable continuation of operations at Panauti. Should the Panauti hydropower plant close in the near future, as it did for several months in the past, there would be absolutely no practical difference in the overall power output and distribution of the NEA, with its current existing national surplus (See Appendix 7.1). However, such a closure would affect local farmers, as water flow in the canal would still have to depend on the NEA's controlled release mechanism at the dam but it would not affect their electricity supply as the service is provided by the grid-centre. The NEA would benefit in monetary terms, by saving on the overhead and relaying the responsibility of operation and management to the community.

There are two feasible options for the future course for the Panauti plant, although a third less viable scheme has been mooted. First, the existing turbines could be replaced with lower capacity turbines to produce electricity for the local grid, using an 11-kVa-transmission line. This option would require the overhauling of all electro-mechanical components and use of the existing 11 kV transmissions. This option would require the NEA to hand over the management and operation to a local entrepreneur or DDC. The second option would be to abandoning the system entirely as a hydropower plant and leave it for irrigation use only. In this case, the management and operation, including the maintenance of the system, would be left in the hands of the community, who would nevertheless need specialised personnel to operate the lever and the gates.

Given the hydrological limitations, a third option currently proposed for upgrading[13] and, or continuing with the existing system could be catastrophic. In 1998, a Russian private company, called Techno Promexport, proposed to upgrade the powerhouse by installing higher capacity electricity-generating machines, at a budget of Rs. 130 million. This proposition, planned an installation of three sets of 1 MW capacity electricity-generating machines, increasing the capacity of the current system to enable production of 3 MW of power. Only part of the electro-mechanical equipment, such as the turbine and the generator was mentioned in the proposal and the NEA was expected to mobilise resources to fulfil the purchase of the remaining parts. Given the available data on water supply and releases, the implications of this suggestion, had it materialised, would have been quite unsuitable in the context of the wider agro-ecological conditions. As already mentioned in Chapter 5, a substantial volume of water is utilised at the Panauti plant and appropriated from the Roshi River. The downstream water users, that is located within this Roshi watershed are also affected by the volume available in the river and would be impacted by the activities that are undertaken upstream. The volume available for irrigation and other multiple purposes, for example in sites such as in Katunje Besi is also affected by water availability in the Roshi River. This suggestion, by the initial donor, to upgrade their 'baby' also suggests that planning for hydropower projects by external agents are still pursued following a techno-political aspiration and in total ignorance of the social conditions in which design systems have been placed.

Whichever recourse the NEA may eventually choose to follow, this plant shows how the evolution under a State intervention is closely linked to both local water and power control and to wider social, political and environment linkages, which in turn determine the design as well as, the efficiency of a plant. In this respect, these linkages become equally important in both centralised and decentralised systems.

Conclusion

The Panauti small hydel plant shows a complex telesis in the way it reflects the processes of nature and society to obtain certain goals. It has moved from being a site shaped by aspirations with little local concern, to a site where local concerns have reshaped it while under State control, but where the State can no longer maintain it properly or cope with the violence that its symbolism attracts. In relation to a life cycle of a technology, it has functioned well, although it has never been efficient in its power generating supply, and it came to perform well in irrigation for farmers once they gained control over the system. Its usefulness is clear, but its continuation will depend on the start-up of new local entrepreneurial action uncertain in the current local politics and economics of what is now almost a satellite village of Kathmandu. There has been growing consultation and recognition between frontine NEA staff and farmers, but no real democratic relationship has emerged, as shown by the lack of user consultation over the future of the Panauti plant. In considering this future, a technocratic mindset still persists among some donors, such as illustrated by the latest Russian proposal.

This chapter has shown that despite being a complete technocratic driven technology transfer; the Panauti hydropower system became a transformative unit. But it could not continue metamorphosis into an evolutionary system because of the misfits between state and community in representation and negotiation on policies for local water and power supply and management.

The emerging obsolescence of this small hydel system designed to supply the national grid, presented after the complex problems of the MHES, helps to show why decentralised grid systems are now becoming a new core focus for energy policy in Nepal. Even while interest for more democratic MHES continues for their possibilities to supply basic rural needs, the Panauti plant provides ample suggestions. This is discussed further in the concluding chapter.

Panauti has always been a field for growth, both in a physical and intellectual sense, and this recognition by the agents involved has been at a high political level, as well as from the local side. This dynamism is also being recognised by the Maoist movement, where the attacks on the Panauti plant and location have been symbolic and provided it much publicity. The attacks represent not only an opposition to the technical authoritarianism that was being imposed, but rather an opportunity for counteraction against the management and control in the power generation and supply itself, through the grid services. Power access is not open to all citizens of the country and the legitimacy of access of both electricity and water control firmly lies in the hands of the State.

The design of the system works, but never worked efficiently for power. The design is not a problem for irrigation, as farmers have been getting the performance they want. The control of water depends on the verbal commitment of the agents involved. However, this older grid model is becoming obsolete just like inappropriate technology of some micro-hydel sites, which provide a note of caution to the designers of micro-hydel. The Panauti example also indicates that MHES will inevitably also face this combination of obsolescence and life completion of parts. This could happen even more rapidly given the shorter life span of the MHES turbines and the more temporary nature of civil works, compared with the Panauti hydel system, which has proven to be a sturdy technological system for many decades. Furthermore, the chances of obsolescence increase, if the design is unable to interface adequately with local needs, and when a new design actually becomes constricted within technocratic networks.

The Panauti hydropower plant introduced a new technology in the form of hydel power and thus introduced a new control regime with new actors, even though the electricity generated was not intended for local use. The conflict to control water resources between formal and informal agencies took shape over twenty-seven years. The canal system moved from the hands of a traditional farmer-managed set-up to more of an agency-controlled system. This involved the formalisation of water rights for energy uses, even though use of water for irrigation legally preceded its use for energy generation. Such a process introduced new rules; norms and values, which contradicted those already well defined at the community level. The technical designers, in essence, did not recognise the community of Khopasi as an important central social actor. After both intervention by central-level political leaders, during the project development period, and protest and action before and after the installation of the plant, there was an alteration of the original design. Farmers also had to advocate through other civil society organisations to get electricity supplied, which was originally not addressed by the State agencies at VDC, DDC or NEA levels. As mentioned the state also subsequently took over these guthi organisations. Nevertheless, farmers could still organise to break the gates through other informal networking practices. Initially, community resistance, during the intervention was not anticipated, and it appears that local civil organisations that might focus this were also eventually taken over by the State. To get participation, the community had to stake out its claim to local resources and the services they supplied. Then, the 'gates' became the focus of negotiation between the two competing sets of actors, but the guthi became the means to ensure money to lobby for local electricity. Also like the MHES, getting access to power in Panauti, has been contingent on a 'moral' economy of responsible civil organisations, leaders and entrepreneurs. This also was never foreseen in MHES or grid interventions. The failure to include the social needs of the local community appeared as a mis-match with the natural dynamics of development processes (Cernea 1991). Furthermore, without a clear institutional role for water and power control, at both central and local levels (Pant 2000), the institutions created by the intervention itself were bound to be dismantled or stay in confusion. Now the Maoist movement acts as a third party, between the State and local community, taking advantage of opportunities to configure the power and technological development path of Nepal and of Panauti.

Notes

[1] There is some distinction between the terms Khopasi and Panauti. The term Panauti denotes the municipal administrative boundary of the area under which the administrative structure of NEA office of Panauti is situated. Khopasi is an older name, generally referred to the larger general locale. A small bazaar, which is called the Khopasi bazaar, is located near the Panauti hydropower plant, whereas the larger Panauti Bazaar is a bigger town where administrative municipal buildings and the "No-Light" section of NEA are located.

[2] There are various versions of how 'Khopasi' became named as such. In an ancient text found at the place where now Sri Ram High School stands, at one point in history this place was called *Kurpasi*: this text is thought to be of Mana Dev times. The word *Khurpasi* written in this script is believed to have changed to Khopasi. Yet another local version according to some elder Newars, explains that Khopasi is named after Newari word *Khnupasi*. According to them, in Newari language '*Khnu*' means thief and '*Pasi*' means pear. Some time ago, it is believed by some that some land with pear trees was associated with some kind of theft, and became known as Khopasi. Some non-Newars in this area believe that in ancient times this area was predominated by professional weavers. In Sanskrit language, weavers are called ***kupishak***, which later got changed to ***kuparshi*** and then to Khopasi.

[3] A text found at Mayalbot Ranganath temple indicates the prominence of this place as having flourished for its technological advancement. The coin found in a well in a garden VDC Ward-No.1 was gold plated written in Kutila script.

[4] Bhrikuti was the daughter of Amsuverma who ruled during the golden era of the Licchavi Period. The first documented history of Nepal starts from the Licchavi Period from 300 AD.

[5] History has indeed shown that civil society movements get constructed around particular themes. Pressure from civil society and environmental groups ensure that state agencies also adhere to the social and ecological norms of the external funding agencies, which may not always be useful in the local water use context. The current NEA policy in big hydropower projects such as in Khimti project, compensation was provided to the households that have poles installed in their land.

[6] The value of one US $ in October 24, 2002 was equivalent to Rs.78.00 and the prevailing value in 1959 was approximately 1 US $ = NRS 7.60. This rate prevailed for a decade. *Source: Nepal Rastriya Bank, Kathmandu*

[7] A set of drawings (*courtesy NEA*) completed by the USSR State Committee on Power Engineering and Electrification in 1965 bases the calculation for water discharge regimes and capacity separately for dry season, wet season and average season flow. The mean daily discharge is based as 3.0 m^3/sec. The calculation of water discharge requirement is

made based on two basic assumptions. First, the power from the station is to cover the evening peaks of daily load curves of the Kathmandu power station during 5 peak hours. Second, during interpeak hours (10 hours), which are in-between the peak hours of the power system load curve, the hydropower station has to separate the maximum number of hours but develop the capacity (of one unit only). The initial Russian designers have calculated the design discharge including irrigation as 3.2 m3/sec and there is no clarification as to how the allocation of 0.2 m^3/sec for irrigation has been calculated.

[8] The Roshi catchment area has been calculated through the graphical method. A topographical map from HMG-N, Survey Department has been used to define the catchment boundary and draw its area.

[9] The history of Raj Kulo date backs some 1000 years and demonstrates an advanced technological system for irrigation. This dynamic agricultural practice dominated the Licchavi and Malla period between 500-800 AD in the history of Nepal and extended to encompass the Newari kingdoms. The segment of the canal around Panauti area is believed to have started at Tikabhairav, some 11 Km. South of Patan.

[10] The Hydropower Development Policy of 1992 does not specify any quantitative limits for the diversion of water from rivers for hydropower purposes. Clause 5.25 of the updated Hydropower Development Policy of 2000 states: "the prevailing rules shall apply for environmental matters during the construction of hydropower projects. Ten per cent of the minimum monthly average flow or the amount of water mentioned in EIA study, whichever is greater shall have to be maintained in river/rivulet." However, according to the Environmental Protection Act 1996 and the Environment Protection Rule of 1997, which was later amended in 1999, environmental impact assessment (EIA) is required only for plants generating 5 MW or above of electricity. Hydropower projects above 1-5 MW require initial environmental examination. Similarly, environmental studies are required in the transmission sector. Only 132 KV and above transmission lines require EIA. Besides these studies, NEA is also bound through project documents to adhere to the environmental rules of external agencies.

[11] These measurements have been taken with the research assistance of Paras Mahat, a technical staff with the DDC. The NEA office in Khopasi had been keeping the records of the outflow and inflow in various points of the canal and the dam area. The data collected until November 2001 was destroyed in the fire caused by the petrol bomb during the Maoist attack.

[12] Guthi was a common form of social collective organisation within Newari communities. Guthi can be defined as organised associations that managed and served the community to run a civil society with a specific objective. Land and funds were assigned to run these traditional guthi. The traditional guthi had their agricultural land property donated by the

State and material support was also provided from the tenant (or members) from the Guthi land as well as those who belonged to a respective guthi. Different clans and caste groups had their separate local guthi. For discussion on guthi land tenure see Mahesh C.Regmi (1976). The State has now centralised most of guthi functions and funds since 1964 through a State Corporation known as the Guthi Sansthan. However, the guthi system of community organisations still exists in many Newari communities at an informal level.

[13] Upreti (2002), in his situation analysis of Panauti hydropower station, states that the current review of the equipment at Panauti plant demonstrates that the switchgear and the control system have been overused and need replacement. These parts were not even mentioned in the Russian proposal, whereas the focus remained on increasing the capacity of the turbines. Upreti further notes that there was substantial pressure by the relevant diplomatic agency to implement the proposal, which appeared to be motivated by 'acquiring' of a contract. NEA rejected the offer as it was expected to mobilise resources for other components. It is also revealing that the 'volume of water' and the issues of water supply and availability are rarely considered or discussed in a multiple use context in designing hydropower projects. The new Russian proposal solely focused on power generation, despite the irrigation use of water from the same source and the same technological system, and there were no discussions on with local users.

8

Making Micro-Hydel Energy Systems Work

Hamita chattyang samatera bijulee nikalchhan bhaneko ta paani bata po aundo raicha; gayera radio-ma phukidiau; yo dando-ko bijulee aba sabai herna aun. We thought that electricity was produced by capturing lightening, but it really comes from water; please go and announce it on the radio so that many people will come to see the electricity of this village now.

Maya Gurung, December 2000 Kumpur Village

Introduction

Managing the power supply and making MHES work is not just about the conversion of water into electricity, but also about design of governance systems, building the technical knowledge, managerial skills, rules, contracts and reshaping a gamut of related knowledge systems. The perception expressed in the opening quote, that electricity is generated by capturing lightening, not only suggests newer forms of knowledge systems that get embedded in the hydel technology, but it also provides an indication of the complexity the technology itself represents. The quote also highlights the symbolic value of the hydel technology and the power of water resources. It indicates not only the knowledge enhancement, but also the physical transformation of an area a hydel system brings about - representing acceptance, interest and pride in the MHES. These transformations require taking responsibility for technology through adequate measures that involve appropriate skills, rules, institutions, and management, tariff structures and other representative dimensions that contribute to make a technology democratic. This chapter examines these issues within the framework of accountability by looking at a broader governance landscape. The notion of accountability is elaborated on how they may apply in making micro-hydel systems work better, beyond just a hydraulic ensemble. The first section of this chapter provides a discussion on electrical services and the communities adaptation to these facilities at the local level. Then follows a discussion on the four levels of accountability domains by juxtaposing examples from the case studies and also from the RRA

The term 'accountability' in its simplest definition links the users of technology to producers of services. In the case of micro-hydel, 'accountability' links the community that use the technology with not just the designers and implementers, but also with the donor agencies, the state, the funding agency and the local governing structure. Subsequently, these actors are then also linked with the managers, the operators and the energy users committee. The processes, for accountability, can be built in a design system, but need to be given a 'political space' to evolve, as committees build their understanding and capacities. Kloezen (2002) uses the notion of accountability as a 'process and an outcome of negotiations' for a central analysis to study the viability of irrigation institutions. He examines the concept of accountability at three different levels: as *(i)* operational accountability, *(ii)* financial accountability and *(iii)* socio-economic and political accountability. At the first level, the term accountability is closely inter-linked with 'performance' where, management, operation and maintenance become part of a management organisation already discussed. At the second level, 'financial accountability' measures the extent by which users as consumers or buyers of services can monitor and control influence the financial management of the system. At the third level, the concept of 'socio-economic and political accountability' indicates the manner in which the arrangements (for decision-making, user representation and leadership selection) are negotiated. The 'political accountability' cannot be disregarded as representatives, as key actors have a great influence on how new institutions respond, which ultimately will have an impact on how the users themselves cope with new technology and systems in place. In addition to these three concepts of accountability, this thesis introduces the concept of 'constitutional accountability'. The term is described to signify governing mechanisms in relation to wider processes, and to the activities that provide the supportive legislative and constitutional framework that ensures access, rights and support structures in the provision of electricity supply to citizens. This notion of constitutional accountability can be strengthened in the development of MHES in Nepal.

Provision of Electrical Service and the Adoption of Electrical Goods

Providing a hydel service is seen as not just supplying electricity to a certain level, but also ensuring reliability of supply, repairing breakdowns and assuring safety. Electricity is supplied during the entire night, beginning from dusk to dawn, as is the normal practice at most micro-hydel sites. At the case study sites, the allocation of electricity varies from project to project; it ranges from a 25-W light bulb supply, to a combination of two or three units to reach a total of 100-W per household. The allowances per household at Pinthali were 100-W, Katunje-Besi was 80-W and Kusha Devi was 40-W. As a central-grid system, Panauti provided unlimited access. In some cases the benefits from a certain turbine seem circumscribed. Elsewhere, the demand for electricity is recognised to increase with the use of television and radio sets that have also been adopted in the process. These entertainment gadgets have also exposed the community to current affairs, including national and international news. Based on all these needs, around 80 to 100-W per household was considered sufficient supply of electricity[1] by some electricity consumers in Kusha Devi. The demand seemed to be much higher in both Pinthali and Katunje Besi, with some consumers indicating 300-W per household. During holidays and festivals and on special occasions such as weddings, electricity is supplied during the day primarily for operating television and music systems.

The adaptation of new technology is also constantly exposing the community to new knowledge systems, as well as dependence on other systems. A fixed light bulb of 25-W is considered too dim for children to study. Previously, with the use of *tuki*, the household members had the flexibility of moving this portable bottle around and placing it close to the study area. Unlike this traditional kerosene lamp, the light bulb, which is fixed in the ceiling, is placed at a distance from human movement. Most of the male members of the village are seen enjoying the benefits of technical knowledge whereas women get more work also. The reason for this is that the female members are involved in day-to-day household chores and the male members participate in the intervention and decision-making processes. The electric light in the kitchen has improved the visibility in the kitchen area for female members to do their household chores. Furthermore, the television placed in the kitchen area provides an opportunity to amuse oneself while cooking and for neighbours, without television-sets, to congregate and watch their favourite programmes. However, electricity in the house has also lengthened the work hours and the day for female members. For instance, whereas a typical day ends around 7 PM with kerosene lighting, the use of electricity extends the day and women tend to stay and work longer hours, at times until 11 PM, finishing up the household chores. The kitchen and the *angan* (courtyard) in most of the households are installed with light bulbs. The angan light bulb acquires more salience, as the light is visible from distance at night. The light bulb from the kitchen normally gets relocated to bedrooms after the kitchen chores are over.

Not all households, that use electricity, have entirely replaced kerosene with electricity. There has been no impact on deforestation. The people in the village still use firewood for cooking; those households that are using only 40 to 60-W partially use kerosene for household needs. The use of kerosene has been replaced by electricity in those households that are using more than the allocated wattage.

Rice cookers, which have been now widely adopted in the urban area, symbolise social status and mobility. These electric rice cookers have facilitated the process of preparing rice. It is not uncommon to seeing a rice cooker placed decoratively on a kitchen shelf even in a rural area. The electric rice cooker in rural Nepal provides a manifold of expressions. This utensil symbolises evolution, adaptation and awe from a manual utensil such as a *dekchi* or a *karai* (cooking pot), which requires constant stirring while preparing the meal. The rice cooker also shows the mobility of a rural dweller, the travel of a family member to Hong Kong, Thailand, Lebanon and Brunei and even indicates service in the international army. A rice cooker also represents the development of income level. However, the electricity supply in some of these areas has not been able to support these electric cookers nor electrical stoves. The use of diesel in villages by mills, kerosene for cooking stoves and for other uses has not abated. Both Pinthali and Katunje Besi sites have mills and refrigerators that run on diesel. In Katunje Besi, after the first few months of installation, it became quite evident that the 8 kW power was insufficient for the expanding community. The intervention was unable to integrate the existing economic activity in the area such as mills. Therefore, the prospects for initiating new interventions, such as a bakery, an ice-cream factory and milk chilling centres could not materialise.

Operational problems

With a new hydraulic regime, operation and maintenance (O&M) also introduces new adaptations. The most common problems related to O&M are with lightening, loose connections and breakdowns. The practice of routine proactive maintenance is a new technical concept; therefore, operators are mostly responsive to crisis or breakdown maintenance. Breakdowns are common in the conveyance system, such as with blockage of canals during water delivery and transmission of electricity, and with destruction of diversion weirs given the semi-permanent construction of these systems. Breakdowns due to lightening are also frequent, in particular during the monsoon period. During the first six months of the installation of the Pico Power Pack (PPP) at Kusha Devi, IGCs had burnt out due to a lightening strike and most of the CFLs installed in houses also burnt out. A lightening arrestor of 0.5 kV was provided by the donor agency, but due to its incorrect rating, it was damaged again.[2] Crisis management, such as protecting the system from lightening, is taken care of and fully understood by the technical operator of this plant. The operator in Kusha Devi has learnt to respond to the weather conditions. The problems related to lightening and adequate earthing installation seem to be common in most micro-hydel systems in Nepal.

As seen from the case study sites, it is not uncommon to find a cluster of houses or some times individual houses undergoing a blackout at least twice a month because of a short circuit due to overload. The operator is trained to handle the situation adeptly and, by replacing the fuse, he explains the cause. Some households use more than what is allocated to them, putting stress on the overall system. This was seen at Kusha Devi, Katunje Besi and Pinthali. Punishment for non-compliance are not very effective in a changing regime and the operator of Pinthali, as a penalty, disconnects, for a day, the houses that defy regulations. However, with consumption, demand increases and the stories of disconnection and over-consumption put greater pressure of responsibility on the operator. Non-compliance also increases when the volume of water in the canal is low; as a consequence, the light generated is dim. This takes place frequently during the wet season when sediment is carried into the canal and the flow is disrupted and blocked. These occurrences are also frequent during the hot season when the competition for irrigation use increases. When light is dim, the villagers seem to use more light bulbs to compensate for it. Legitimisation of rules and the capacity of the turbines pinpoint towards the linkages between skill building of technological systems and non-compliance among electricity users.

Households occupants do not have the practice of turning the electricity switch on and off in their homes. As a result, when the operator releases electricity from the powerhouse, light bulbs tend to burn out fast with surges of electricity when directly released in households. Community members in Kusha Devi, Katunje Besi and also from Kumpur village located in Dhading District, expressed that burnt light bulbs from the community filled a *'doko'* (woven traditional basket) in the first few months. Poor wiring was another cause for this. The plant in Kusha Devi closed down for over a month, as two ballast heaters and the Earth Leakage Circuit Breaker (ELCB) were also damaged; this time the NTU provided the required support. During the installation of the PPP, an ELCB was fitted directly after the generator for safety. However, the ELCB was bypassed due to an earthing problem, as the operator and some of the consumers were experiencing electric shocks. Improper wiring and overloading was identified as the causes for the earthing problem. Individual metering in households would encourage the users to switch the supply line off while not in use. However as already discussed in Chapter 4; this installation is considered costly for small capacity micro-hydel.

Given the hill and mountain terrain, the canal gets blocked with stone, boulders, sand, and even earthworks. There are also other reasons for the disruption of water supply. For example, in Kusha Devi non-users had blocked the canal and the nozzle leading to the turbine because the small capacity system had failed to include all the community members within the supply system. In such instances, primarily the mechanical operator undertakes the cleaning of the system under the supervision of the technical operator. The problems with the civil work, for example in Katunje Besi seem to have increased with the construction of a road, as sand and gravel were being excavated from the riverbed close to the dam. Six months after its installation, water started leaking from the turbine and puddles were perpetually being formed inside the powerhouse. In the seventh month, the bearing inside the generator broke down and the community had it fixed in Banepa. The primary belt has broken several times and the community prefers to shop around for better prices for repair, as the manufacturer often quotes higher than the market price. The community has discovered a shop in Kalimati, in Kathmandu, where they are able to buy a new belt that costs about US 75 cents per metre. Other mechanical breakdowns have occurred with the ballast, voltage controller, panel board and earthing.

The current provision of services and the practice at the local level shows the needs for operators skilled in technology but also social interaction. In this same regard, design of MHES has to be realistic about what they can supply. They may always really be for 'basic needs', but MHES do allow a community time to understand its energy needs and different ways to supply them. Various existing problems indicate that if the support structures for MHES are located closer to the area of installation, quality control and skill development could also be improved. In bringing the support structures closer to the community, the DDC and VDC could play an active role in providing these assurances.

Operational Accountability: Designing for Water-Power Interface

The case studies described in chapters 4-7 included a study to show whether the hydraulic ensemble delivered canal discharges equivalent to design flow initially calculated as necessary for power supply. This sub-section compares the actual flow with the discharges required for power generation, to understand how these fluctuate together, what causes discrepancies in power output - from design problems to social problems - and summarises the key design features that lead to these differences.

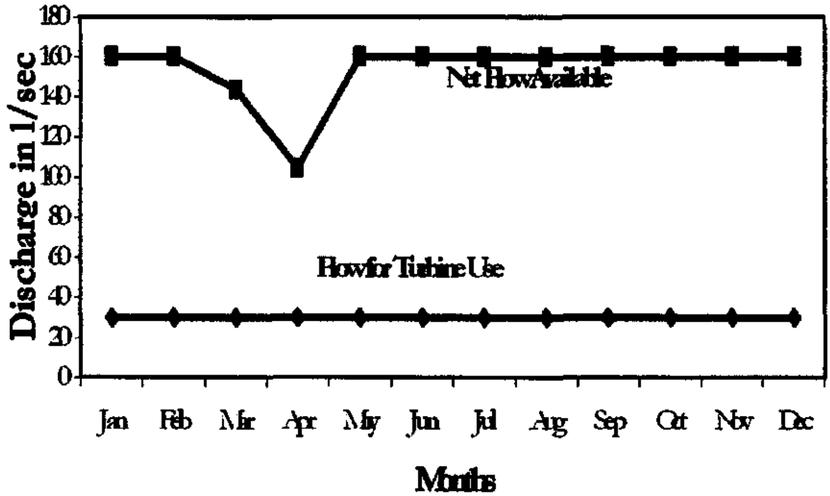
Ensuring water supply and availability

It is evident that the interfacing of power generation and water use is gradually being recognised as an important design feature in micro-hydel technology development interventions. However, this recognition is seldom fully incorporated into Nepali design perspectives. The more recent design systems of REDP, such as Pinthali and Katunje Besi, interfaced power generation and irrigation uses of water in their initial designs. Both these case studies indicate that the design flows and water releases have been adequately considered. In Pinthali, for example, the volume of water supply and release are sufficient for both uses. The water supply has increased after improvements were made in the original canal system. The Pinthali system maintained its initial design objective by focusing on 'lighting, agro-processing and irrigation'. There have been increases in production and convergence with the wider uses and functions of this technology. Most of the irrigation systems in and around the four case study sites are farmer managed. In all sites (excluding Kusha Devi), where provision is made for supplying water for irrigation, the existing irrigation canals were expanded, merged and modified to increase the volume of water supplied to generate electricity.

The Pinthali MHES

The water releases and design from the Pinthali case study also suggest that interfacing power generation and water use is not merely about adequate supply of water in the canal for both energy and irrigation uses, but also how canal conveyance losses affect the releases. These influences vary from the source to the point of transfer. For example, the hydraulic properties that result from Pinthali's long conveyance design system illustrate this. If we examine the canal capacity at the Pinthali plant, which is designed at 200 l/sec, the flow at the intake reaches maximum of 160 l/sec in August and minimum of 105 l/sec in April 2001. A cement and stone dam has replaced the temporary dam, increasing the width of the canal to 63 cm and the height to 1.35 m. Consolidated measurement of water of two dry seasons and one wet season indicates that the water availability in the canal near the forebay differs from the actual flow. The field data indicate that while 30 l/sec is diverted for electricity generation, some remainder is always available for irrigation. Figure 8.1 shows the discharge curve for irrigation and power uses of water.

FIGURE 8.1: Water supply for turbine and other uses

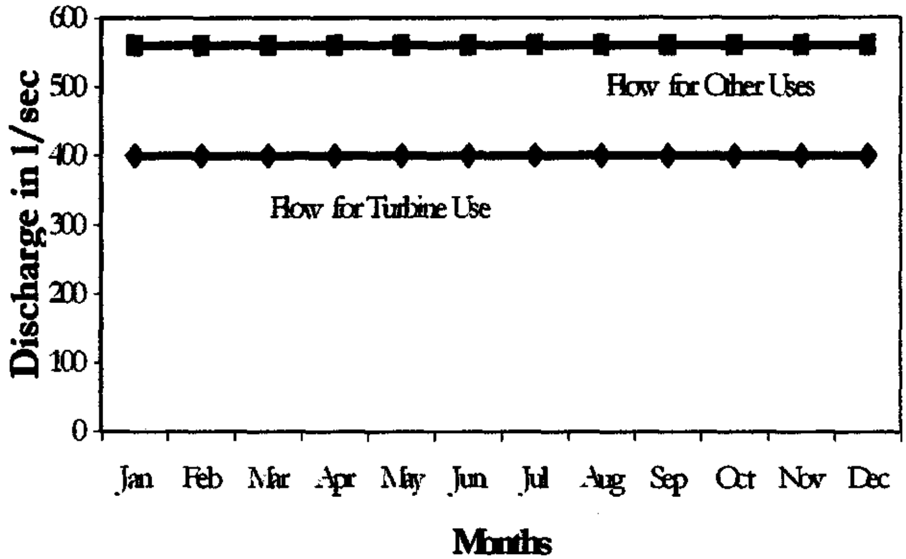


A comparison of the releases in the canal and at the source indicates that the available water supply varies from the design needs. The conveyance losses seem to be causing this discrepancy, where conveyance losses amount to as much as 44 per cent in August and 31 per cent in April. These losses occur because of the semi-permanent construction of the canal as well as the length of the system and the open outlets for irrigation. The graph indicates a low flow period, when water is diverted from irrigation to ensure power generation and run agro-processing machines during the day. The dip in the graph also indicates that while the flow is low during the dry season, the diversion for energy use decreases availability for other purposes. Thus, the design discharge of electricity has not taken into account daytime irrigation use during low flow months.

The Katunje Besi MHES

In Katunje Besi, a net flow of 560 l/sec water is available from the canal for irrigation purposes even during the low flow periods when the plant is in operation. The turbine, when in use, utilises a substantial amount of water, given the nature of the low head design. The canal is designed to supply 1200 l/sec of water: after deduction of the canal losses, about 960 l/sec is available. Figure 8.2 shows the discharge curve for power and other water uses, which suggests that there is no water scarcity for interfacing power and irrigation uses.

FIGURE 8.2: Water supply for turbine and other uses

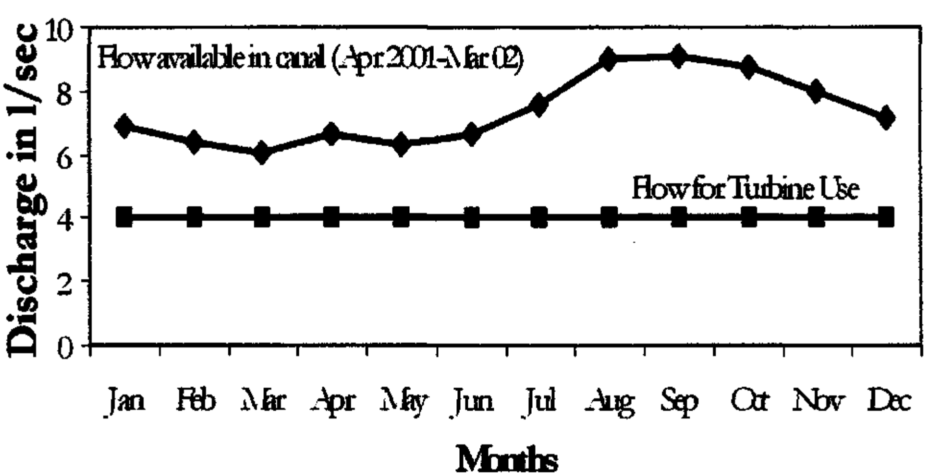


The release of water from Katunje Besi into the canal is also influenced by various ecological factors. Losses through leakage and seepage are not significant, given the short conveyance system, which also maintains a uniform-slope, unlike the one in Pinthali, which runs through high gradient. The major influence, as mentioned earlier, is through the upstream releases, in particular influenced by the Panauti Plant, which have significant influence on the volume available at this confluence of the Roshi Khola. Water is sufficient year round for both current electricity and irrigation requirements. However, Katunje Besi indicates that the convergence of domestic and rural economic sectors has not really taken place.[3] It was suggested that, with the available water resources, a higher head turbine could meet the growing electricity requirements as well as increase water use efficiency.

The Kusha Devi MHES

An experimental design, Kusha Devi had 'lighting and agro-processing' as its primary objectives. However, the system is used only for lighting purposes. The installation in Kusha Devi of an electric grinder has not converged with domestic needs, as the community's preference has remained in using the *paani ghatta* As already discussed, the system has not been able to adequately meet the local milling needs. The site indicates that water is not utilised to support other local livelihoods. The flow available in the canal ranges in average from 6.67 l/sec in the dry season of April to 9.02 l/sec in August against a canal design discharge of 9 l/sec. There is insignificant flow available for other uses. Figure 8.3 shows the water supply in the canal assuming a 4 l/sec diversion for turbine use.

FIGURE 8.3 Water supply for turbine use

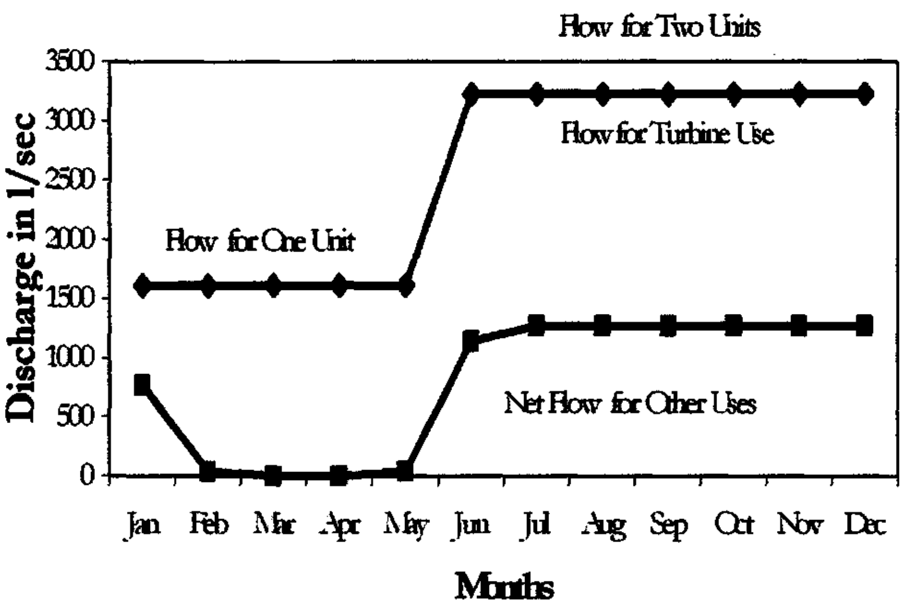


Socio-cultural struggles make this site complex, where class and ethnic conflict have played an important role in the divergence of water use and power generation. However, unlike in Pinthali, technology has not been able to bring the community together here, yet transformations have occurred in a subtle form as signposts of struggle and freedom. The refusal of the Tamang community to identify itself with the Pico Power Pack (PPP) represents a technical veto against the existing system and its governance, indicating that a system that fits with wider irrigation access is still not regarded as a democratic technology.

The Panauti small hydropower plant

The initial design of Panauti, a state-controlled system, put the emphasis only on lighting, for meeting a central need and not for local power use. The design was later modified to support local irrigation needs. This study suggests that water is not sufficient for meeting both uses, i.e. for running all the turbines at full efficiency. This site has shown that the contestation between the State and the local agency over the sharing of resources has led to devolution of more control over water to the local farmers where technology has been transformed to meet the local needs better.

FIGURE 8.4 Water Supply for Turbine and Other Uses



It was found that the canal flowing to the Panauti plant does not reach the maximum design capacity even during the high flow season. It can also be assumed that there has been a lot of eco-system changes from 1965 onwards, following population growth, deforestation around the Roshi watershed and climatic variability. For example, field data from Panauti indicate that there are many differences between the design discharge and the actual water releases. While the canal has been designed to carry a flow of up to 3.2 m^3/sec, the maximum flow in August 2002, a wet month is just over 2.04 m^3/sec. Available data shows that, even when one turbine is in operation, the net flows available for irrigation during

March and April is zero. The turbine discharge to operate one machine requires 1610 l/sec of water. Therefore, given the irrigation use, and after a conservative 10 per cent deduction for leakage and seepage, all three machines can never simultaneously operate in any given month. Figure 8.4 shows the water availability for irrigation and power uses, based on measured flows.

While the calculation assumes operation of one turbine from January to May, in reality it is practically impossible to keep the turbine running, given irrigation requirements. There may be sufficient water to run two turbines during the rest of the year, when the allocation of water for irrigation amounts to about 1270 l/sec. From the available flow and release data, it can also be assumed that pondage is an additional stress factor for irrigation water distribution, as the water entering the reservoir has to be diverted from the actual canal flow or the harvested rainwater. Therefore, design versus actual volume of water, available for meeting the dual need, i.e. power and irrigation, seems to be also shaping the performance of the local agency. The Table 8.1 shows the history of electricity generation of the Panauti plant.

This interrelatedness between the volume of water available and power efficiency suggests that inadequate design consideration of power generation and related water supply may minimise the efficiency of hydel systems.

If we examine the farming practice around the Panauti area, it can be observed that the production level has superseded all the past records, that farmers have replaced maize with paddy and farms have been connected to electricity. Consequently, the farmers are content, but NEA is not quite content for meeting their targets for electricity management.

An analysis of the past 26 years of the powerhouse shows that, despite a goal of annual electricity generation of 7000 MWH, the maximum generation has been less than 4600 MWH (NEA 2002b). Due to insufficient water, the machines operate, on average, less than 3500 MWH annually[4], currently operating at only 50 per cent of the estimated or planned capacity. After the first few years of the installation, only one machine operated, due to uncertainties on how the local farming community would react to the situation. The maximum production of this station was 65.7 per cent of the target in 1981: the minimum production reached about 28 per cent in 1999 - this was because only one machine was in operation in only part of the year. The cost of electricity generation for the year was

TABLE 8.1: Electricity generation history: Panauti power station

Year	Generation in MWH	Generation in % Target (7000 MWH)
1976	3895.19	55.64
1977	2848.58	40.69
1978	3062.96	43.76
1979	3338.75	47.70
1980	3721.35	53.16
1981	4599.00	65.70
1982	4484.16	64.06
1983	3826.99	54.67
1984	4539.06	64.84
1985	3838.34	54.83
1986	3360.34	48.00
1987	3249.72	46.42
1988	3964.50	56.64
1989	3782.70	54.04
1990	2721.89	38.38
1991	2371.86	33.88
1992	2501.11	35.73
1993	2600.02	37.14
1994	3123.53	44.62
1995	4007.52	57.25
1996	3727.08	53.24
1997	4349.16	62.13
1998	3859.38	55.13
1999	1976.41	28.23
2000	2437.92	34.83
2001	3891.24	55.59
Average production in 26 years	3464.56 MWH	49.49 %

Source: NEA, Khopasi.

Rs. 1.73 per unit (1000-W per hour), out of which more than 50 per cent was for staff salaries. If we compare the dry season and wet season generation, performance appears to be further pitiful. Since the Nepali fiscal year 2032/033[5], NEA Khopasi has been maintaining records of monthly energy generation in MWH.

The data in Table 8.1 illustrate that power generation range has been more or less constant, except during the early 1990s. This was also the period when the conflict between the farmers and the State was at its height because of padlocks being put on the irrigation outlets, the keys of which were kept by the NEA canal guards. As can also be understood from the data, electricity production from 1999 onwards, has not improved substantially; it averages about 31 per cent for the three years. The various attacks in the Maoist conflict have affected the operation of the plant.

The interfaces of a design system for power and irrigation, as discussed above, suggest that the development of an evolutionary system imply not only the capacity to operate within an agro-ecological setting, but also to involve electromechanical power-generating devices. Subsequently, in allowing to visualise the design fit, how the system relate and harmonise as 'technical' objects, within both agro-ecology and social processes. Part of the concept of an evolutionary system involves the capacity of technology to meet the local electricity demands and serve the potential for growth that provides allowances and capacity to converge from the domestic uses with the rural economic sector. Then encountering and resolving the various tenets of financial accountability becomes critical in envisaging a power-generating device.

Financial Accountability: Levying Charges and Managing Funds

Modalities of electricity use, rules and fee structure vary from plant to plant. While the concept of hiring a paid community member and remunerating him or her in cash every month to run a community service is new to rural areas in Nepal; the Kusha Devi site also indicates how adaptation to new institutional regime occurs with new technology. If fees cannot be collected in time and in an equitable manner, then salaries have to be compromised on. On the other hand, the community expects the manager and the operator to perform. Financial accountability not only shapes the provision of services for the salary structure but O&M. Financial accountability and contracts related to managing funds clearly dictates in the sustainability of the MHES.

Allocation, access and payment for electricity

The normal practice in Nepal is to charge a fee of Re.1 per watt consumption of electricity, which most of the REDP programmes seem to follow. Most hydel systems also require households to pay an upfront connection fee, which ranges from free services to Rs.1500 for the transmission and wiring costs. These rules can change and evolve over time, depending on the capacity available, the households connected, or the number of households that 'participate' during the implementation stage by contributing their time and labour.

Most of the hydel systems issue a 'tariff collection card' to each consumer household in the beginning, which is reviewed by the operator or the manager during the monthly fee collection. In most of the sites visited, the monthly cards were not used during the collection and the collection was done informally. In Pinthali village, the operator is responsible for fee collection. Fees are collected from individual households and a flexible oral understanding makes the collection easier. Penalties for late payment or for stealing of electricity are not always enforced.

All the households in Pinthali village are connected to the micro-hydel. The decision to formulate the connection charges and the tariffs to be paid is left with the committee members and is usually ratified in a village mass meeting. For example Pinthali and Katunje Besi collected Rs. 100 per household as the connection fee. Depending on what the committee decides, some plants also offer free connection. Not all of REDP programmes have instituted the connection fee and likewise both the Kumpur and Kusha Devi plant also did not include any connection fee. Sometimes, free connection services are also granted, based on the voluntary labour of household members during the implementation phase. Likewise, monthly payment of charges is also exempted to households that may have their livelihood affected by the infrastructure of the plant. This may include the installation of transmission pole in agricultural land, the relocation of a ghatta or even a canal running through an individual's property.

Those who were not able to provide the voluntary service are often times required to pay for the connection fee - as in the case of Kusha Devi where the Tamang community was invited to use the power at a later stage. In Pinthali, the tariff of Rs. 60 per 100-W consumption of electricity was also established. The same rule, however, did not apply in the case of Katunje Besi and Kusha Devi. In Katunje Besi for example, not all households participated by providing their services; some decided to provide land while others did not participate at all. There were some households who did not participate initially in the implementation process and did not make any cash, labour or material contributions. Some of these households were later connected to electricity supply. Therefore, two different tariff structures were established: Re.1 per watt for those who had contributed labour during the initial stages and Rs.2 per watt for those who had not contributed labour. In Kusha Devi, a monthly fee of Rs.50 per household was the established rate for consumption of 40-W electricity. There were no written rules and regulations, and practice changed and became more ambiguous as different actors were covered by the tariff structure. In addition, the donor agency intervened in the management process and recommended that the tariff be doubled for those consuming 80-W and above of power.

In the centrally managed NEA system, the connection charge for 1 house is established at Rs.1700. The minimum charge for 20 unit (one unit = 100-W per hour) of electricity consumption from NEA services is Rs.80 per month. The rate increments by Rs.7.30 per unit consumed up to 250: above 250 units, an additional fee of Rs. 9.90 per unit is then charged.

Payment structure

Different households seem to respond differently to the payment structure. This is seen, for example at the Kusha Devi site. There appear to be three sets of electricity consumers. First, those who claim that they have the responsibility and obligation to pay every month, to keep the system running. This group is usually not politically active in the village and also adheres to the maximum allocation to the household by following the rules that have been put in place. These households have either adjusted or are attempting to adjust within the techno-economic network that the new technology has introduced. The second group represents those households that claim that they have made their share of contribution, be it through labour or political representation, and therefore payment in cash is not obligatory. This group perceives that they deserve to consume electricity free; the external agency will take care of the problems and therefore they can consume electricity more than their allocation. This group in particular belongs to those households who were intimately involved in the intervention process of the system and are usually political leaders. The third group feels that water, as a natural resource is a common property that rightfully belongs to the consumers; hence, their entitlement to acquire electricity without a price is legitimate.

Among these various actors there exist households who have dues pending for over a year. This was found in both Kusha Devi and Katunje Besi. Some households consumed electricity more than allowed and yet paid only for the established allocation. Some houses were paying regularly. There was a fair amount of stealing of electricity in all the sites visited. Modalities and penalties for stealing and regulations for non-compliance are usually established at the initial committee and decision-making meetings. In Kusha Devi for instance, it was orally decided that a penalty of Rs.500 would be imposed on people bypassing the PTC (positive temperature coefficient thermistor), which indicates that the households were consuming more than their share of electricity. A second suggestion was cutting the supply for a definite period of time of those stealing the power supply. Legitimacy in instituting modalities for non-compliance is an important issue in the process of democratising technology. Furthermore, there is a moral connotation involved, as legitimacy also indicates voicing difference in the balance of power. Ironically, the chairman and the technical operator were the first two households to bypass the PTC. Similarly, those who failed to pay the tariff on time were to be disconnected for a month. However, these rules have merely been discussed and have not been endorsed.

Examples from other areas such as the tourist belt where projects under Annapurna Conservation Area Project (ACAP) are implemented, for example in the Ghandruk plant, the committee has not been successful in raising the fee structure above the 50 paisa per watt of electricity consumption set initially. Increasing this fee structure became quite a struggle and finally after more than 12 years, Ghandruk plant has been collecting a fee of Rs.2 per watt. This fee structure, which is 100 per cent more than what the new systems have instituted, was designed and enforced, finally after negotiation and discussion with the community, for a prolonged period. Even in newer systems, various sets of rules and charge structure have not been able to streamline tariff modalities and the need to raise charges is still not vocalised. But it is likely to be a problem for the future financial sustainability (Kloezen 2002). Financial and political accountability is much more problematic than operational accountability and financial accountability influences operational management.

The management contract and financial interface

A prototype intervention, the Katunje Besi plant was encountering a number of technical difficulties. As technical problems and breakdown of machines became more frequent, tariff collection became a problem. A private management contract was given by REDP to the manager of the Katunje Besi plant, which obliged the manager to pay Rs.1,500 from the collected tariff to the committee every month. During this period, the committee was dysfunctional and basically the manager himself represented the group. The private management contract raised a lot of questions in the village as the agreement was primarily done by the REDP during a socio-politically volatile situation, without involving all community members in the decision-making process. Furthermore, this contract made the 'manager' accountable not only for the management issues but also for technical breakdowns, which became a prevalent issue at this site. The manager said that he was unable to collect charges from the community and could not make his rounds to collect money every month as he was supposed to do. It had become a difficult task to collect money from the consumers, because the electricity supply had been intermittent and the system was rarely working. In addition, the police post had been consuming over 1 kW of electricity without paying, which caused a revenue loss of over Rs.2,000 per month to the community. Two views were expressed in this regard, but the management was powerless in confronting the situation. Some committee members felt that since the police force was guarding the community, they were rightfully entitled to this privilege. Others felt that it was unethical and the tariff exemption signified taking advantage of the community's resources, labour and time.

The manager was held accountable and responsible for all these numerous issues, and, with his private management contract, he was also held accountable for the O&M-related activities. On the other hand, with constant spare parts and fee collection problems, the committee was running at a loss. Households in this area had high demands for electricity and could easily absorb much higher amounts than the allocation; therefore, there was substantial stealing and use of more electricity than what was allocated. Ultimately, because of the manager's inability to revive the management of the system, some community members decided to resolve this issue and confront the manager at the police post with open account books. It was at this meeting that the management was reshuffled and the community was able to recoup partial funds from the police[6] post. The manager also agreed to return the project funds that were unaccounted for to the new committee.

Socio-Economic and Political Accountability

For this research investigation, and the framework of study of structures, systems and agents, three key actor domains for running an MHES have been noteworthy. These actor domains are committees, managers and operators. Within these domains, the variation in the composition and processes of committees, as well as modalities and objectives of management contracts had an impact in the forms and successes of such domains.

Building leadership and representation

The notion of decentralised processes in Nepal is very often linked to the creation of new institutions through group formation[7] whereby leadership and representation is built by including the politically knowledgeable agents. In this process, the political leadership is seen as an opportunity to sustain initiatives, whereas the traditional technical entrepreneur is perhaps perceived as a threat. Both Katunje Besi and Pinthali have a strong history of local technical innovation. Yet in Katunje Besi and Kusha Devi, the creation of *samiti* (committee) built up the representation of the existing political leaders, which alienated the citizens; however, it has made them more aware of their alienation. 'Participation' is expected to take place through these knowledge systems as new institutions of samiti and active members. Therefore, these local institutions become integral components in sustaining the intervention process. However, representation is more than promotion of the popular culture of development - for example the creation of samiti and *mandals* (groups) (Waghmore 2002) – which do not necessarily address the structural problems that exist prior to group formation.

In the movement towards decentralisation, building knowledge systems is also pursued through participation, and highlighted as an important part of development intervention. All REDP interventions focus on the mobilisation of community leaders and putting the quantity first through a number of collective groups. In most rural development projects in Nepal, participation is conceived through social mobilisation processes by forming community-based organisations such as COs, EUCs and FUGs.

The extent of representation is also judged in accordance with the membership size of a given committee. For example, REDP's achievements during five years of intervention in Kabhre Palanchowk district states that a total of 274 COs have been formed in 11 VDCs, out of which 136 are female COs. Similarly, a total of 2596 females and 2552 males from 2559 households have been mobilised for development initiatives through COs (Kabhre DDC/REDP 2002).

The notion of 'the more the merrier' seems to dominate these development approaches. However, extending the circle of social actors and groups by itself does not ensure participation (Hennen 1999) or representation, and can lead to the questioning of social and political legitimacy of technology-related development. Such questioning happened in both Kusha Devi and Katunje Besi sites.

Building management capacity: The committees, roles, rules and responsibility

With a new system, adaptation takes place at three levels and these are reified in the processes linking the roles, rules and responsibilities. Where previously the leaders and village elders had a substantial responsibility in making decisions, these powers have now shifted to a samiti, re-formulated by the intervening agencies. The roles are now more 'committee'-oriented, even though the power that is being exerted is still influenced by individual membership. Therefore, in a typical REDP model, the 11 and 16-member group, that comprises the Functional Group (FG), takes on shifting roles (see chapters 4 and 5). These models and representative numbers also vary from project to project. In the DANIDA supported Kumpur MHES intervention, for example, a 9-member Village Electrification Committee (VEC) that included one female representative was formulated. Where previously the farmers, as water users through Farmer Managed Irrigation Systems (FMIS), congregated at the village chautara to resolve conflicts, now the FG convenes a mass meeting. These groups have also introduced the offices of a manager and an operator, who are generally young, enthusiastic and committed members of the community. A hydel system now converts the manager and the operator into the local 'expert system'. While the farmers previously attended and supported the cleaning and maintenance of canals, this responsibility has now shifted to the technical operator where personal-orientation creates a more individualised role in performance.

In Pinthali, where the plant operates as a co-operative, the role of the farmers has also been changed from that of water users to that of clients or consumers of services. The responsibility for the maintenance of the irrigation system was undertaken, and managed collectively prior to power use. However, the village elders still yield a lot of influence and respect, which can also be detected in how various institutional rules of a hydel regime were followed, such as in electricity allocation, fee collection and tariff structure. At times, the overlap of the leadership between traditional and formal structure requires deeper discernment of social relations. At times traditional representatives have a way of influencing rules and regulations in various ways. The decision to establish the connection fee rate is usually undertaken at a mass meeting. It is also seen that the elders have a dominant voice in instituting these rules. In the REDP examples and at Kumpur, the committees are active during the initiation and implementation phase of the project, but the interest of the formal group wanes gradually after the electricity generation begins. The existing local governance structure of the respected, political and elderly representatives then also influences performance. However, the issues of operations and management in a formally created structure, such as the power management 'committees', do not remain as a collective responsibility. In practice, they remain only with the operator, although the decision-making in terms of rules and regulations is shaped collectively.

The initial composition of the Katunje Besi management committee included some members who had donated land for the installation of the plant. The selection of the committee members itself was done during politically volatile times. This area was undergoing rapid social and political changes and many of the committee members had left the village by the time the project was up and running. There were two young community members who had received formal training in operating the propeller turbine. During this period, the campaign by the State police to counterattack the Maoists and the presence of a police post in the community cast a dark shadow among the community members. As the insurgency intensified, the two police posts from *danda pari* (the other side of the Mahaharat mountain range) and the Kosi *pari* (the other side of the Kosi river) merged with the Katunje police post, increasing the state police's interference and surveillance in the area. While some youths were forced to go underground, others left the area to avoid unpleasant consequences and the security forces arrested some. These events were followed by the departure of the two youths that had received formal technical training in operating the propeller turbine. There were only a handful of members left from those actively involved during the implementation phase. An untrained person was designated as the operator of the machine. The rules and regulations instituted by the former committee were never adhered to. The management committee meetings, supposed to be held every month, did not take place regularly and did not meet until REDP intervened. Rumours of financial mismanagement and unaccounted expenditure for other activities that REDP was supporting (such as photography training, latrine construction and soap making), further fragmented the community and alienated the manager.

Kusha Devi and the manager

In Kusha Devi, the manager, as the primary agent of the management system, had twofold responsibilities: record keeping and tariff collection. Initially, in Kusha Devi, the manager was also responsible for the distribution of salaries to staff, tariff collection, tracking of expenses and allocation of budget for spare parts. A conflict emerged when the chairman decided to take partial authority for these responsibilities. With no formal rules in place, it was easy to make roles more implicit. At another decision-making meeting, it was further noted that the Energy User's Committee (EUC) members were responsible for collecting fees from their respective areas and passing them onto the manager. Therefore, it was not necessary for the manager to visit individual households door-to-door to collect the monthly tariff. These variations and conflicting rules made tariff collection even more ambiguous. The manager's discontent primarily arose from the fact that he was expected to provide his services free whereas he believed that he would have performed more effectively if he had been given a 'real job'. At a later stage, the committee, on the recommendation of the chairman, informally decided to provide a salary of Rs.300 per month to the manager. The manager took this as an insult as the powerhouse guard was getting Rs.700 per month and the technical operator Rs.800 per month. However, it was not certain if they were actually receiving their salaries, the operator had mentioned that he had not been remunerated for his services for several months.

An ITDG/PDDP-supported study tour had taken a group of EUC members from Kabhre Palanchowk district including Nayagaon, to study an 11-kW micro-hydel site in Parbat district in the Western region of Nepal. Numerous issues related to management and operations were discussed during this trip. The exchange visit had noted that one of the keys to the success of a plant is the efficiency of local operation and management. Similarly, the issues of governance and effectiveness of various ward-level committees were raised. It also became evident to the visitors that operators and managers in other plants got much higher salaries than they did. The salaries ranged from Rs.1500 to Rs.3000, depending on the effectiveness of tariff collection in the plant. As a result, they raised voices of discontent. This issue was also raised at the district-level monthly meetings of operators and managers organised by REDP.

Subsequently, the manager of Kusha Devi relinquished his job, stating that the committee needed to take the issue of management of the PPP seriously. The operator also expressed similar opinions. Hence, in a plural networking development field, agencies may not always promote the administration and management of technological systems; rather the interactive regulatory processes make the public more aware of their rights and existing regulations. An established, but weak formal procedure, again in Katunje Besi, indicates that the community will not always rely on and wait for committees to conduct business and represent their interests.

Building skills: the operator in the frontline

Micro-hydel has created a new generation of technical expertise in villages. Being a new technological leader in an evolving regime is not an easy task. Examples from Pinthali, Kusha Devi, Katunje Besi and even Kumpur suggest that adaptation of the manager and the operator to these new technical roles signifies a lot of changes and adaptations in their social and technical relationships. The operator becomes not only a technocrat of the village, but also a technical trouble-shooter. He is the one who is held entirely accountable for all breakdowns. The community feels that as a monthly salary earner, he is expected to solve problems, even if it is beyond the scope of his technical abilities.

The operator in Pinthali

In Pinthali village, the operator is constantly at work. He is expected to undertake umpteen tasks, such as fix the fuse, replace infested wooden poles, change nuts and bolts, wire houses, clean the canal, cool the ballast heaters and resolve the conflicts with farmers during paddy cultivation. Moreover, he is expected to figure out why light bulbs burn out so fast; why short circuits take place; why lightening disrupts electricity and is expected to solve earthing problems.[8] He is sought after during times of breakdown because he has technical knowledge as a trained person in the village to fix problems and ensure smooth supply of electricity.[9] The operator is expected to solve dilemmas such as 'why does electricity have to go off right when we take our hands to our mouth to eat at night?' or 'how will our children study in darkness?'

There is an equally challenging role for the operator to maintain his established social relations. It is difficult for him to turn the electricity on during the day for individual households. However, he cannot refuse the request to turn on electricity during the day if a political leader who, wishing to be a good host, decides to turn the fan on during a summer afternoon to cool his urban guest. They encounter other social dilemmas. For example, in Kumpur, the operator and the manager were forced to disconnect electricity from the village schoolteacher's house because the latter had refused to pay his monthly fees, claiming that, as a schoolteacher, he should be exempted from paying fees. The community was up in arms, not just because of his refusal to abide with the consensus decision, but also because his negative behaviour would be reflected in the education of their children. In Pinthali, Katunje Besi and Kusha Devi, the operators were aware that some of the households used more light bulbs than allocated. However, such deviation also reflected already established social relationships and cannot be uprooted easily. The operator from Pinthali commented that 'yes, they are my uncles and grandfathers, I can't really tell them that they are not following the rules.' In most cases the operators maintain a blind eye when the elderly or the politically powerful members use more than their allocation, in this respect these social relations also become important.

Building leadership and representation by reinforcing the existing political leadership within a conflict may or may not minimise performance. Autonomous structures do not solely represent political control. While Kusha Devi suggests that this 'political' leadership has disenfranchised the community, in Katunje Besi and Pinthali, it has brought the community together.

Given the nature of externally driven and guided interventions, micro-hydel also shapes the leadership in a given community. Those traditionally technologically aware – often already entrepreneurial agents – tend to take responsibility for directing innovation. Evidence from community initiatives led by Beli Lama, Nanda Raj Lama, Bajra Dhoj Lama, Subarna Shrestha and Sanga Bahadur Lama all suggest that being technologically aware also meant taking the responsibility for an adequate management structure. However, the convergence with new State regimes and interventions did not always build the initiatives taken by these village innovators. The case studies show that the operator has become a critical feature of the MHES, sometimes even replacing managers, committee members and the committee itself during insurgency periods. The success of the operational/management contract to run the agro-processing machines (see Chapter 4) by the operator in Pinthali also suggests this.

Negotiating Constitutional Accountability

With modern processes of intervention, diverse external agents and plural forms of networking, local formal institutions no longer represent the democratic interests of the rural citizens. Consequently, as indicated by the Kusha Devi site, a larger polity now controls the State and governance processes, where power is dispersed among various networking agencies, which render not only the State but also ordinary citizens powerless. Building leadership and representation also has to link with democratic local governance. As shown in Katunje Besi, the community acted to represent their own democratic interests. Both these examples indicate that modalities and procedures created by mediators through 'local governance and democratic' structures do not always represent nor legitimise the interests of the weaker sections of the community.

Inclusion, governance and representation

Governance is both a structure and a process, visualised between agencies and activities in skill building that entail contracts and organisations. In micro-hydel intervention, governance can be seen as interfaces within two distinct arenas. At the DDC level, (as seen in Chapter 2) the structure primarily functions to filter financial arrangements between the centre (Kathmandu) and the local level. As also seen (by Chapter 3) and the case study sites, the complicated governance structure also becomes redundant when power is disbursed among various networking agencies including the Maoist movement. Therefore, in reality the transaction that may directly be negotiated between the DDC and the VDC is not clear; rather the DDC seems to function as a pawn in the process of decentralisation. DDC is also seen as being powerless. If we examine the concept of governance as a process, the role of DDC again appears to operate in a vacuum. In order to understand this, the relationship between DDC and community organisations (CO) such as 'samitis and samuha' has to be examined. The case study sites show that these local level institutions have almost nothing to do with the DDC structure. Rather, negotiation on technology development issues is directly undertaken through interaction with the community organisation and the donor agencies. Contracts are negotiated at the central (Kathmandu) level in terms of manufacturing, installation, and technological training and other support structures. The social mobilisation contract is undertaken at the district level between the donor agency and the youth network as it involves in developing the capacity of a locally based non-governmental organisation. The role of these organisations and contracts are relevant and active only during the intervention process. After this, practical issues such as availability of spare parts, simple nuts and bolts and troubleshooting become inconsequential to the CO as they are not directly involved in the negotiation of these contracts. Therefore the 'community organisation' is seen rather as an activity, and not really as institution where the process that defines the relationship between DDC and the implementing/donor agency in reality shapes CO.

The group formation with its focus on representation visualises the community as an object, which is ready to accept development, regardless of it being good or bad. In most MHES, the basis of site selection is assessment of the co-operation of the community to accept a given technology, and the political capacity to oversee the intervention. Yet as seen in the case study sites the PRAs and PTAs, social mobilisation and social mapping are carried out after the decision to intervene in a given area has already been taken by the implementing and donor agencies. The next step then focuses on the process of participation, which in practice takes the form of selection of appropriate members through the formation of COs. The contributions of voluntary labour and cash and kind from the community and the formation of committees are viewed as indicators for accountability, users' involvement or participation. To stick to the political correctness of the development *mantra*, gender and ethnic diversities have to be represented in the committee regardless of who takes the decisions. The perception that seems to prevail is the larger the committee membership the better the quality of participation.

Negotiating governance as a structure and a process, at the CO level, is a challenge, highly dependent on skill building from external agents. However, what is also starkly visible from the case study sites is that both the local customary organisations (such as the existing network of respected elders and political leaders) and also the existing technological network greatly influence the new local structure created. For example, the previous technical background of the operator in Kusha Devi has also sustained his negotiation capacity in the technical governance of this system. Therefore, negotiating for governance at the CO level is a challenge in decentralisation efforts and in promoting autonomous structures. At this level, governance can be negotiated better, by allowing the customary institutions and networks as a focus of power building in a local intervention. In a similar manner, the DDC structure can be strengthened to provide support mechanisms in enhancing the skill building. The DDC structure could play an important role in linking traditional customary networks, new formal institutions and technical networks, to make the process of technology development more democratic. In this respect the local governance structures could proactively be involved in developing the district's energy sector by aspiring for technology that can move beyond just the 'basic needs' to include both the substantive and representative requirements of the local citizens. The non-functional District Energy Plan can be revitalised to include these aspects in planning, management and operational initiatives to emerge from the district and to be grounded within the district.

Gendering participation in governance processes

Gender - differing roles for men and women - in natural resource management, has been significantly raised in profile over the past few years (Zwarteveen 1994; Meinzen-Dick, et al. 1997; Koppen Van 1998). Accordingly, within the energy and micro-hydel sectors, gender issues get increased attention (Rai 2000; Rai 2003). However, gender gaps and disparity in Nepal are not just limited to property rights, access to water, energy, or representative and substantive participation in membership organisations. They are profoundly connected to and impacted by practical social and legislative constraints. These constraints are imposed and configured by the perception of Nepali women and their domestic versus their public role. Historically and socio-culturally, women in Nepal have had poor representation within the public sphere. This is also evident from the lack of female-led or groups in natural resource management or environmental advocacy coalitions, particularly when compared to those that are strongly emerging in India, such as those led by Vandana Shiva, Medha Patkar or Arundati Roy. In the domestic environment, particularly in urban elite homes, women have asserted powerful roles as matriarchs of the family, where the word '*ama*' (mother) has symbolised and exerted immense power and control as mothers or mother-in-laws. Thus the role of *ama* has also shaped social, political and constitutional life and has influenced the lives of daughters and daughter-in-laws, as seen from Chapter 5 and Chapter 3. The private and public life of women operate in two distinct perceived worlds. The systematic inequality and imbalance of this dichotomous representation and influence in the public and domestic spheres has generated two distinct responses. One response to this gender divide can be clearly observed from the radical feminist and militant role-played by subaltern women groups in Nepal, during the past few years. Within the Maoist movement the gender movement forcefully addresses the lack of recognition of women in Nepal as rightful, active and equal citizens. There has been a ground swell and urgency to reduce the gap that currently exists between the private and public, and urban and rural, lives of women.

Democratising technology is also about creating the political space and opportunities for women as citizens to balance both their private and public lives. Evidence from the case study sites reveal that the role of women in the rural area has not always been limited within the domestic periphery, as sometimes perceived by the urban dwellers and external development agents. In particular within the ethnic minority groups, women have long been active both within formal membership organisations, as well as through informal coalition groups and networks. However, there continues to be a lack of legislative recognition and support of the contribution and capability of women. Development intervention has seen the inclusion and struggle of marginalised groups and women as a solution to an existing problem, rather than a legitimate requirement merited in its own right. The creation of separate male and female COs also support this gendered condition of uneven citizenship for women. Chapters 3, 4 and 5 illustrate that female members have demonstrated and assumed technical knowledge and leadership roles and have worked equally with their male counterparts. However, the process of their acceptance and status as active and capable development agents is something yet to be built within constitutional accountability for recognition.

Legal restriction with lalpurja

The current mandatory requisite of depositing *lalpurja* (legal land title document) for bank loans does not ensure all community members access to electricity, nor does it respect the integrity of a citizen. While prior to hydel intervention, water as a natural resource, was used by the community for multiple of purposes; MHES technology changed rules, controlling and defining access and rights to water. However, one has to bear in mind that most of these interventions are supported through external assistance and the subsidy is granted to benefit an entire design system with the assumption that it will benefit an entire community. As an externally assisted development programme all the citizens of a given community have the right to enjoy the State provided subsidy. Chapter 6 shows how the landless and poor can get marginalised, and Chapter 5 illustrates that MHES policies and technologies can segregate a community. In order to ensure equitable rights to electricity, certain social criterion has to be developed prior to the intervention process to include the poor. It is also not a wise design practice to intervene when only a segment of the community can benefit from a given plant. Substituting the requirement to deposit lalpurja as collateral for community bank loan, with that of a submitting a voting card, would be an effective way of ensuring that the marginalised get included in the mainstream development process.

NEA support system at the district level

There are primarily four major challenges encountered in the management and operation of the MHES. The first deals with a lack of appropriate skill development to include technical and managerial training. As mentioned earlier, hydel systems introduce a new economic order. Therefore the simple accounting, financing and maintaining budget procedures that a hydel system introduces, contrast with those of older systems. Ledgers are introduced which formalises the budget system. The second problem deals with the availability and facilities of simple spare parts and replacement components. The third deals with formalisation and legitimisation of standard norms and procedures such as salary structure of the operator and manager, tariff rates, role and responsibility of the management committee or even the quality of spare parts. The fourth deals with constitutional democracy where representative elements become important at a substantive level where the basis of citizenship can be extended to include women, the landless and ethnic minorities to have a stake in governance. As seen from Chapter 2 and the case study sites, there is also a mismatch of district energy planning and the performance of the constitutional bureaucracy at the district level. Therefore the accountability of the DDC can be strengthened to respond to these needs.

There are several elements that are related to electricity access and benefits that are unaccountable and inequitable. Technological institutions and structures are typically shaped and configured around the state and the technology development sector through contracts and agreements. Technology options and choices are shaped by the manufacturers and donors from the central level. Neither the district energy plan, nor the systems for submitting requests for power systems appear to present options, or to enable debate or communicate advice about technology. Consequently, there is no space for people to exert technology choice, technology ownership or for knowledge to build up and be assimilated on 'best systems' for the district relative to what the community want. The *lalpurja* requirement is particularly un-democratic as it restricts people's access to power. There is mixed accountability with NEA: their local and accessible public offices have proven useful, but at regional and central levels, the NEA is perceived to be autocratic and non-consultative.

Conclusion

In summary, this chapter has revealed how the structure of VDC/regional entities and village entrepreneurs/leaders act and interface with other agents and structures in making MHES work. Various forms of accountability, both vertical and horizontal in nature influence the establishment of MHES. At its very fundamental configuration, MHES work in Nepal as hydraulic ensemble within the domain of an operational and financial accountability framework. External interventions for a typical hydel system appear to be guided and controlled by intervening and directive agencies where rules, regulations, institutions and skills are in place as templates awaiting to be imposed. In this respect, the technical dimensions of a 'modern' technology also shape an agency's involvement to construct representation and how the needs of the people are perceived and responded to. However, for the systems to work and evolve, MHES needs in accountability move beyond operational and financial domains, to include socio-political accountability in the design of processes. The concept of democratic management structures also relies on the rights, understanding, engagement and awareness with the process of the community. Further, how these technological notions are assimilated and adapted at the local level is critical to achieving a successful outcome, rather than adopting, regulating or developing their knowledge systems to a standardised approach. For a system to evolve into transformative units, all the four domains of accountability becomes important, in particular the constitutional accountability domain. Therefore, the social dimension also influences the technical dimensions of 'democratic' structures, and technology adapts to show both the aspects of transformation. As the case study sites suggests, there are various forms of dominant forces, which demonstrate that challenges towards leadership and finances can only be minimised where supply is adequate to meet popular demand. Democratic ownership and control is much more difficult to achieve with just the corresponding operational and financial accountability of the physical infrastructure and water supply. The evolution of detailed governance (i.e. management organisation, contractors, and tariffs) and representation also have to be recognised as a sequential struggle within the socio-political and constitutional domains, and be incorporated as critical elements of accountability.

Notes

[1] To augment electricity production in the village, some villagers explored the possibility of a new plant with REDP. However, REDP has not intervened in exploring this possibility in this area. The community was also connected with a research institute and to support their request, a group of students from the Kathmandu University studied the feasibility of a new plant from downstream reaches of the Gudgude outflow.

[2] This seems a common cause for breakdown of micro-hydel plants in Nepal during the monsoon period. In Taplejung district in 2001, seven houses were destroyed by lightening in a micro-hydel plant and killed two community members. A locally-made IGC costs about Rs.30,000 but the

villagers expressed that they had no funds to purchase one.

[3] The number referred to and often quoted, as the 'installed capacity' is always a deceiving one as the efficiency of these plant are always 20-40 per cent lower than the installed capacity. For example, most reports of achievements, annual reports and inventories use the installed capacity to measure kW or MW electricity produced, as there is no method to calculate actual production of electricity that measure the efficiency of these turbines. Therefore, it is assumed that the number installed is the number produced, which is never the case in any of the plants. For example, the Katunje site has been non-operational for about six months a year since installation. Similarly, other micro-hydel plants have experienced breakdown and temporary closures due to various technical problems. In all the sites that were researched and appraised, electricity disruption of more than three weeks has taken place.

[4] Data obtained through personal communication with Nur Bahadur Karki, Manager, NEA, Khopasi, 2001.

[5] The Nepali calendar, known as the Bikram Sambat (BS) is 57 years ahead of the Gregorian calendar. The year starts with the Nepali month of Baisakh, which begins around April 15. There are 12 months and each month begins around the middle of a Gregorian month. For example Bikram Sambat 2058 would be AD2001/2002.

[6] As the insurgency escalated and security forces started disbanding from rural areas, the police post in November 2001 moved to the nearest town of Bhakunde Besi. Many of the young police officers earlier involved in the surveillance of Katunje bazaar were massacred in February 2002 in Bhakunde.

[7] In Nepali, the word *samiti* (committee) does not originate from *samuha* (group), although in the social mobilisation process, samuha formation (group formation) precedes samiti formation. Samuha, which also means *mandala* in Nepali, is an informal and loose gathering of people, which may not necessarily be constituted, whereas samiti is formally constituted to achieve specific objectives.

[8] If it is a question of minor repair of nuts and bolts, the operator usually takes care of them. For major spare parts, depending on the extent of problem, the operator brings up the issue before the users committee and the committee takes decision. If spare parts and repairs involve purchase, the committee can also call for a village mass meeting for decisions. The manufacturers' warranty for the electromechanical components, according to a verbal understanding, is 1 year from the period of operation. The life-span of a hydel plant is normally accepted at a 10 year operational period.

[9] In two of the three micro-hydel sites, the operators indicated that they had worked hard and were ready for a change. They also expressed their desire to look out for better job opportunities in the same sector, preferably with the State agency, the NEA.

9

Building Democratic Power Supply

Conclusion

Hyammar ra dhunga bokeka kisan-harule, sabai talcha phode ra sinchai-lai chahine paani lage; aba, saancho uniharuko haath ma chha: 'The farmers pounded padlocks with hammers and stones, and took as much water as they needed for irrigation; now they have the key to the gates of the canal.

Bishnu Bhakta Gochhe, Khopasi July 2001

Introduction

The case studies presented in this thesis indicate the limited progress made in the rural electrification sector through MHES, despite four decades of intervention. It is evident that reform and a revamp of the hydel sector in Nepal is a necessity. However, this thesis has demonstrated that community-oriented hydel technology is a sociotechnical system that possesses adaptive properties and is capable of manifesting democratic values but is a product of the interplay between structures, systems and agents. It has illustrated that democratising hydel technology signifies that certain 'creative' design criteria have to be embraced, in order to visualise the system as an evolutionary system rather than a hydraulic ensemble. This study argues that designers and policies should aim for more democratic technology and reduce the prevailing authoritarianism that is pervasive in hydel technology and energy policies in Nepal. This authoritarianism has given rise to systems that often face all the design limitations – in habitat, human use and longevity - mentioned by Papanek (1997).

This chapter concludes by revisiting the three premises of the study and the symbolic play of Maoist violence in the hydel sector, in rural politics and against rural governance structures. It ends with an agenda for reform for MHES design and policies, and the rural electricity sector of Nepal.

This study has shown the interpretative capacity of the Actor-Network Theory, which has served as a useful approach in studying interactions between structures, systems and agents. Furthermore, this network theory brings to bear the entire focus of the 'relevant agents' on the community as the users of the technology who are the key focus of this thesis.

The methodology of multiple case studies applied to this investigation has been useful in sketching a technography of different designs. This has shown how systems were embedded, through intervention and participatory processes, within the backdrop of design and implementation of the system. There is limited scope to the village community on the choice of technology. The approaches applied in this study furthermore, reveal how the internal and salient communicative and adaptive dynamics are regularised and adapted by various group members and actors in pursuit of social and technical transformations. The case studies have shown that there is always scope for expansion and improvement of REDP technology and system. The current practices indicate that the coverage of technology has not been effectively deployed to embody the local dynamics and technical needs.

On Technology and its Adaptive Properties

In its first stage, micro-hydel is often approached as a hydraulic ensemble, and may or may not be shaped and re-shaped by users. Katunje Besi is an example of such an ensemble, which was unable to move beyond this stage because of difficulties in its component parts and the relationships that bind technology with people and water. Secondly, micro-hydel can develop, as a transformative unit where the technology design grants reappropriation to users to meet both domestic and productive power needs through water management such as seen from the case study of the small Panauti hydel system. In this respect, the relevance to design micro-hydel technology with irrigation systems cannot be overemphasised.

These connections further illustrate that where technology is used for irrigation, the technology also serves as a cohesive collective factor that binds the community together. Thirdly, micro-hydel is envisaged as an evolutionary system where technology is democratic in governance and access and continues to evolve in relation to tangible and intangible benefits and processes. An evolutionary unit further emphasises the role of evolving local level democratic institutions that can both control and manage their own resources and benefit from national level programmes which has been visible also at Pinthali. Where MHES technology is not accessed equitably for livelihood support, such as seen from Kusha Devi site, it becomes a breeding ground for increasing conflict. New coalitions are needed to become new intermediaries within the public sphere to help build these new design debates.

Currently, the community-oriented micro-hydel systems available encourage subsistence provision of electricity and the services are studded with development anomalies. As most of the case study sites have shown, the current allocations of 80-100-W or low capacity turbines encourage disparities in access. This low capacity consumption characterises Nepal's energy poverty, which is described by Banskota (2000) as the 'inability to meet one's own energy needs' and is basically reflected by a community's lack of choice to adequate and safe source of energy.

The argument that the community cannot afford to pay for more electricity or end-use provision has to be revised and tariff and service better considered and integrated in institutional design, to sustain the operation and management of the plants: these concerns are not reflected in current design systems and implementation processes. The current policies do not encourage and provide scope for the convergence of the local domestic and enterprise sectors. The current social and technical design configuration does not permit the community sufficient lighting, nor enable them to run simple popular gadgets. Furthermore, the currently used small-capacity turbines do not provide sufficient energy to run the local mills, promote milk chilling centres, recharge batteries and support emerging small businesses such as saw mills, bakery, ice cream and yoghurt parlours, dairies and refrigerators in small shops and health centres. Irrigation and agricultural linkages in community-oriented designs should focus on improving livelihoods through increased and efficient production rather than in installing larger industries. Small-scale industries will emerge, if electrical infrastructure is able to provide the community with a stable, reliable and sufficient supply of power. The current focus on meagre lighting alone is not a sufficient criterion to promote the micro-hydel sector in Nepal.

Isolated decentralised micro-hydel technology does provide much scope to meet some of rural Nepal's energy requirements, as Kusha Devi has shown. However, the rural electrification sector has to get out of the mindset of 'low-cost' and 'low-wattage' concept as also seen not suitable from the Katunje Besi study. The segregation of rural versus urban and grid versus non-grid policies will not develop a sustainable electricity supply sector in Nepal. Currently, grid and non-grid systems are perceived as a mutually exclusive, as demonstrated at Kusha Devi. Micro-hydel as a typology will continue to demonstrate mediocrity if it is visualised as an 'alternative' system. Micro-hydel in rural and remote area is not an alternative system. In these areas, this technology is the only source of electricity. However, too often a community is expected to 'adopt' a given system rather than be given the chance to adapting a design within their given community context, and their future interests in 'scaling up' supply for productive power uses.

Technological Democracy Can Be A Unifying Focus

This study has shown that transformation of hydel systems, as democratic self-governing units, is inherently linked with wider socio-natural, political and cultural processes. Adaptation of technology is not only through experiment, but also forged by desires for recognition, and people's capacity to engage in changes and collective action through various ventures of local forces. Technological democracy encompasses these dynamics, where inclusive institutions, representative and accountable agents and evolutionary systems become core processes for change.

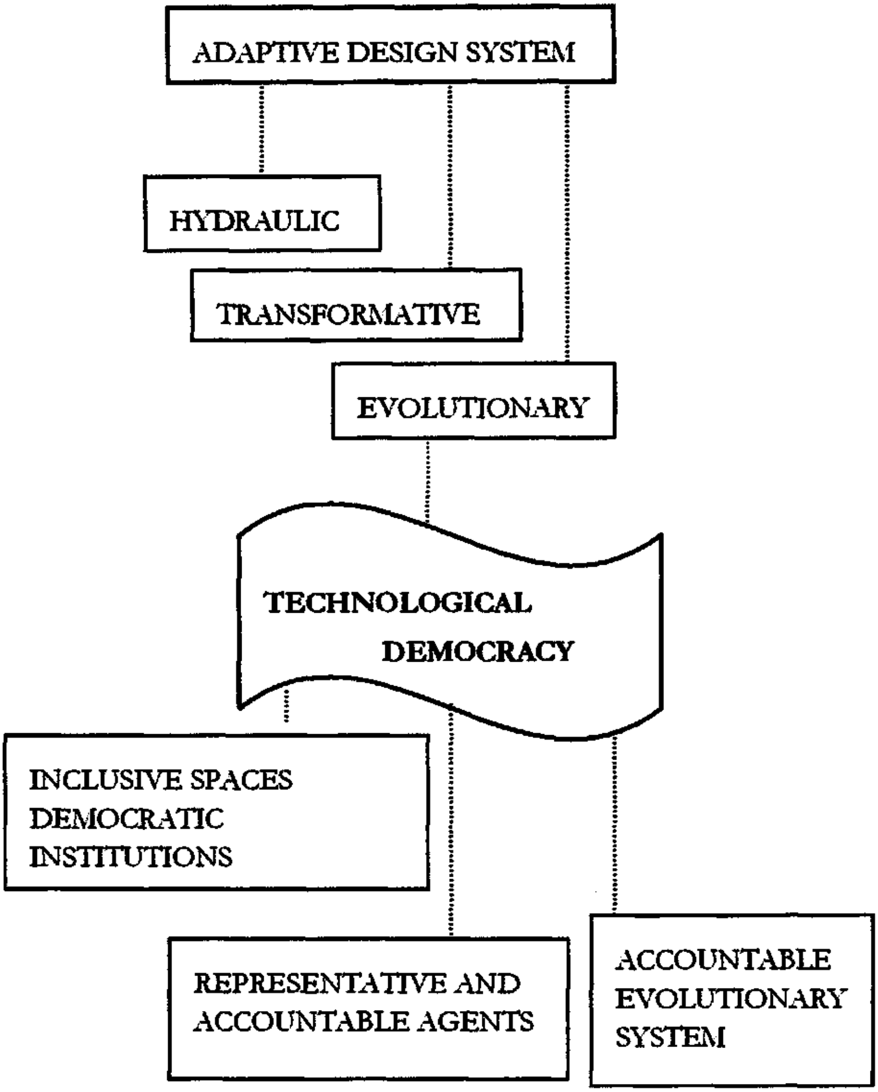
The 'democracy' emerging in Nepal reflects a deficit in the 'democratisation of democracy' - the process of continual negotiation and renegotiations between the citizens and the state (Castañeda 1994). This illustrates that there is always a space and scope for democratic reform. Therefore, democracy is no longer a mirage to local people, and the struggles discussed here represent an aspiration by various collective groups within the community to attain democratic technology within wider constitutional democracy. It is evident that both constitutional engineering and inclusive politics, as currently practised, make a difference in access to benefits and power at the local level. This is shown at Pinthali. It is also evident that structures - as policy, institutions and governance - combine with systems and agents in crafting the degree of technological democracy. Technological democracy as a system is embedded in the field of democracy and democratic institutions, which in turn produce, reproduce and shape democratic technology. A variety of factors including human and society, politics and institutions shape technological democracy. Democratic technology has strong design outcome because technology can be moulded to configure how democratic or authoritarian it is designed to be. Technological democracy is shaped by organisations, institutions and policies, where technology acts as a mechanism of control or liberation. Democratic technology is practical for users, operated in their interests, with their representation, then, relevant choices become available without restriction.

Process of change and collective action

In chapter 1, the term 'democracy' has already been suggested for use as a better recast of the term 'participation', as it expresses the wider choices and voices of people. In espousing the claims of inclusive development, *samuha* and *samiti* are created to manage power supply in promoting the concept of self-governing systems. Such neo-institutional structures by themselves do not become democratic without wider support from the VDC and DDC levels and sufficient focus from central-level agencies. The spread of democratic institutions does not necessarily bring democratic technology (with equitable access, social justice, and redistribution of power, electricity, water, access and rights). Nonetheless, technology becomes evolutionary through democratic institutions. Figure 9.1 shows how technological democracy is situated within the overall framework of democratic design and how it emerges from an adaptive design system.

As seen from the Pinthali and Panauti case studies, institutions are also designed systems, a socially constructed ensemble of arrangements, people, practices and rules. As seen from the research area, violence also acts upon people's capacity to engage in

FIGURE 9.1 Design for democratic technology



collective action. In contrast, Katunje Besi and Kusha Devi highlight that these routinely implemented institutions also have to be accepted at the societal level. The examples demonstrate that local processes have also occurred outside the periphery of samuha and samiti and those members who have taken action are not those who have formal membership on the committee. The Kusha Devi and Katunje Besi sites also show that subsidies granted to a 'community' do not always permit the entire community to benefit from them. Other examples may be when the landless cannot 'participate' in a hydel project because they do not possess the legal entitlement to land; as a result water use is compromised.

Therefore, local action suggests that adaptation takes place, not merely to represent actions within the committees, but to search for more democratic institutions and practices. Democratic institutions are an arena designed and arranged to organise political competition, legitimise rulers and implement rule (Luckham et al. 1999), as well as recognising conflict and diversity.

Because institutions are politically driven, democratic institutions emphasise methods and procedures for legitimising rule and assuring political contestation Therefore, the need for democratic institutions and democratic technology cannot be much clearer. Like democratic institutions, democratic technology also emphasises participation, equality of access, and emancipation in the realm of representative and substantive democracy. This is where the accountability framework, as discussed in chapter 8 becomes important.

In popular technology, such as MHES, it is pre-requisite to investigate in what ways and whether the contemporary design approaches foster the kind of technological democracy that can express popular demand for participation, social justice and equity. In this context, it is also important to ask 'how does MHES, as democratic technology, relate to a system that can meet the demands of ordinary citizens, particularly the poor, as well as fulfil or reconcile conflicting expectations regarding social justice and economic equity?'

Advocacy, activism, coalitions and politics

Democracy includes the recognition of collective action and needs in a polity. This thesis recognises that the political contestation is a particular form of communicative and collective force. This research has shown that there are two distinct and contrasting positions associated with political contestation and collective action in Nepal. First, at the supra level where contestation of democratic rights and freedom is confined to the political or public sphere. Second, at the subaltern level where contestation on behalf of women and minorities and freedom from poverty and gross social inequality are considered basic entitlements of democratic citizenship. In the latter case, democracy involves the notion of political and socio-economic power redistribution. Therefore, the legitimacy of coalition groups depends on their capacity to deliver these transformations and be able to redirect resources to address inequalities. This study has shown that advocacy groups are currently active only at the supra level. The popular elite culture of Nepal also strongly hinders the interface of these two forms of contestation that are centred within the public and the subaltern spheres. However, as in other South Asian countries, the spread of civil society activism and the interests of the donors strengthen local organisations and collective groups. The NGO base has considerably expanded in Nepal where networking power is now pluralised in the spread of activism. Yet, a shared agenda is still lacking, without identification of a common ground where advocacy groups can interface with the macro and micro policy levels.

Implementing planned change with wider democratic linkages

As mentioned previously, the notion of decentralised processes in Nepal is very often linked to the creation of new institutions through group formation, whereby the astute and politically active agents get included in the process of participation, whereas the traditional technical entrepreneur is perhaps perceived as a threat. Nepal has been inundated with development aid and the contemporary mantra of participation is, therefore, being seen as the panacea to development. However, there is an enormous difference between the conceptual and empirical postulations. The paradox of participation is that it is becoming a political, financial and developmental game. The thesis has focused on cases under REDP and shown that, together with DANIDA models, a plethora of policy initiatives, committees and texts has emerged, beyond what is easy to access by local debate. The REDP and the DANIDA model indicate that donor identification with certain programmes and sectors also give rise to newer forms of institutions accompanied by a reincarnation of texts, acronyms, redundancies, confusion and overlap. The required mechanism for budget control further creates extra layers of institutions within the central organisations

The link between the currently practised concepts of 'participation' in reality is a 'process of institutionalisation' not directly linked with the local governance structure. The connection between the local governance structure and the planned implementation in villages is fulfilled by the role of three persons. These are the chairperson, manager and the operator. In Pinthali and Kusha Devi, the chairperson functions as a political representative. In most of the sites the manager is designated as the financial administrator. In Pinthali it is a joint task: the operator collects tariff, and the manager administers the finances. As also seen from Pinthali and Kusha Devi, the operator is also the technical representative. The rest of the members attend meetings whenever required. The manager and the chairperson often represent the position of elected political leaders. The chairperson further has standing political power; this is maintained always in discretion, but he or she does not get involved in day-to-day management of the plant. If any links exist between this structure and the DDC, it can again be traced back to the elected political leader as a 'manager' or as a 'chairperson' who provides the link with the DDC, which is also headed by an elected position. If we examine the intervention processes at the national, district and community levels, various dynamics of these 'governance' linkages in implementing a planned change reveals that operations and management yet depend on the central level institutions.

The Interplay of Structures, Systems and Agents

Applying the structure-system-agent framework has generated a number of findings. Hydel technology illustrates significant characteristics of authoritarianism in design.

There exists different scope for design intervention of REDP depending on whether a chosen 'core' site or is transferred along the process for various reasons. Diverse prototypes are possible and can be taken up under REDP, which is often times shaped, by other donors involved, but also Kathmandu manufacturing associations. MHES manufacturers have usually shown only a narrow interest in the hydraulic conditions for the choice and operation of technology, and limited interest in long-term facilitation and feedback over design.

There is little understanding in the design process of how micro-hydel fit institutions for other uses and users (like irrigation), and thus indicative of also how previous interventions in these areas may have shaped community dynamics. Conversely, the lavish attention given to group formation and participation at local level is in stark contrast to the non-consultative, donor-driven development of networks and agencies for policy-making, planning and implementation found in MHES and energy policy at national level.

The concept of electricity 'grid' and the understanding of what service a capacity of system is being developed for locals are often unclear. Rural electrification needs to focus on VDC giving possible enmeshing with wider politics bearing in mind the linkages with other participatory models in use.

The typology of 'Renewal Energy Technology' and the 'Basic Needs' approach is not espousing an energy vision or social justice in the progress and development of rural electrification. The users want an accessible, safe and adequate service electricity supply.

Hydel technology is easily co-opted as a political symbol for identity, violence, and oppression, as well as for emancipation. The concept of 'constitutional accountability' is important to study wider linkages with both national and district levels and focus on new means to include the poor, the marginalised and the ethnic minority in the sharing of power resources, both in representative and substantive forms. These findings form the basis of the agenda for reform given in the next section.

The Dark Face of Authoritarianism: Identity, Conflict and Violence

Identity-based conflict, politics and violence provide a conduit to demonstrate resistance and the emergence of such conflict is not unusual in the absence of democratic institutions. Violence has also created a new political geography dividing social spaces into 'violence prone' and 'peaceful' zones (Das et al. 2000). Therefore, when dialogue fails, violence also becomes a co-opted tool of resistance. Violence can also be easily mobilised among both the powerless and the powerful. Identity-based conflict can also be easily co-opted by political leaders, to become part of the process of political contestation, between those who are included and those that are excluded. Chapter 3 illustrates that violence has become so embedded in Nepal, that rules and practices of the social movements, minority groups, the army and the state have also been rewritten. There is a distinct polarisation between the state, the palace, bureaucracy, the army, the community and the militants. Violence becomes further embedded, and destruction of infrastructure and hydel systems can become endemic, when democratic institutions fail to produce and reorganise democratic technology. Various attacks on hydel power by the Maoist movement and the accompanying political violence make rules and practices of democratic institutions and technological democracy translucent, normalising violence as a way of allocating power and resources and increasing the political power of the actors who control violence. The legitimacy and even the effectiveness of the state and of the so-called democratic institutions are being questioned and challenged. Democracy will remain meaningless to ordinary citizens if they do not enjoy rights and entitlements as citizens. Constitutional and legal arrangements have to be accountable, to do away with the 'pacted' exclusion of the citizens, as a consequence of gender, societal inequalities, cultures of intolerance or intimidation and violence. Responsive governance implies effective accountability of the government to a broad range of societal groups and not just a narrow and selective section of the society.

An Agenda for Reform

The post-1990 democracy era has provided a space to increase the voices and choices from the public, private and social spheres of society for a pluralistic approach to hydel policy formulation. However, this pluralistic approach has remained confined within macro-level policy issues. It requires widening the horizon within the rural electrification sector. The figures are astounding and paradoxical. Out of a population of 22 million, only 1.1 million rural people have access to electricity and the majority of those through the romanticised 'renewal-energy' small capacity micro-hydel. Yet, Nepal is sitting on a national power surplus from central grid-line of about 112 MW in flood season and about 50-60 MW in dry season. Considering that 17.6 million people are rural dwellers, the energy sector policy in Nepal requires addressing this significant rural power deficit.

This study shows the need for a reversal in the policy direction, by moving away from 'micro-hydel' technology to adaptive 'hydel' systems that generate power to address a broad range of community needs. In this respect, adaptive technology is defined as a democratic design of choice that can gradually bring a community to benefit from the mainstream national energy plan and the energy policy process.

Macro-micro policies and new interfaces

The current energy policies and practices reflect neither the optimum interest of the rural people, nor the complete aspiration of technological democracy, in rural electrification interventions. The energy sector of Nepal is totally financed with the assistance of international financial institutions and donors. The Alliance for Energy and Arun Concern Group have been successful in expanding private sector involvement in power generation by the modification of the original Arun III plan through dispersed activities, primarily at the macro level. The next step for these policy entrepreneurs will be to expand the arena of public debate, so that a coherent policy strategy allows electricity benefits and access to services to be made available to the local community for local needs. Stakeholder coalitions, and their composition, agendas and member representation and platforms need to be studied in terms of new possibilities and realities among elite, activities and government action. An increasing number of stakeholders with their own agendas - and technological options from micro, mini, small, and pico to traditional wheels - are further shaping and re-shaping rural electrification strategy. These new coalitions require further expansion, grounded within the knowledge that over 1,200 micro-hydels implemented in the country have been identified as being 'sick' (DMFA/ESAP 2000). A rehabilitation subsidy of 50 per cent of the actual system cost within the subsidy policy affirms the gap between policy proposals and the implementation process. Therefore, coalition movements and efforts should not focus on the choice between large and small, but rather seek alternative links and focus on developing the overlap between macro and micro policy links. New coalitions have to drive the technology and institutions for better rural electrification and for better hydropower, and, indeed, the power of better policymaking.

From grid versus non-grid to an equalising policy agenda

While the concurrent models do encourage isolated systems to feed ultimately into the national grid service, these are only feasible for larger capacity units. Given the various existing problems in this sector, in particular with lower capacity systems, it is highly unlikely that Nepal will reach the stage where community-oriented smaller systems (5-100 kW) get connected within the grid service. The existing problems from various micro-hydel sites indicate a broad range of deficiencies related to design and quality control, operational management, spare parts, technical capacity and institutional linkages. For a central agency such as NEA to oversee the administration of numerous small isolated grids is financially unrealistic. However, if private companies manage such smaller plants, the focus on energy generation would take precedence over local water use, such as irrigation. Panauti provides such an example - if it were to be privatised, the farmers would lose the key to the canal and their control of water resources for irrigation use. Therefore, privatisation of small-scale grid-connected systems requires an operational framework that continues to allow the immediate surrounding community to have access to electricity and maintain their water access, to avoid conflict.

The structural reform plans of NEA have already begun (The Rising Nepal, 2003), and the focus has been in the privatisation of smaller systems. In the ongoing structural reforms, the option of providing grid services to communities within the minimum distance of 50-kilometres of the grid line should be considered. Energy development to meet the rural power needs has to be done in close co-ordination with NEA, taking into account the expansion plans of NEA to avoid rural duplication of efforts in future of the kind shown by the Kusha Devi site. In this respect, a community close to the grid service line should always have the option of access through a national grid service. Micro-hydel is promoted only in areas where the national grid possibility remains limited - but this should still be part of a longer-term energy plan for the village. In order to do this; the typology of micro-hydel has to be redefined

Clarifying the local benefits of micro-hydel systems

In evolutionary systems of MHES, the technology moves beyond the generation of electricity alone, as power and water is being used for other purposes. However they are not yet as ecologically beneficial as assumed. The existing micro-hydel has not really made any impact, in terms of reduction of fuel-wood consumption or reduction of carbon emission. Additionally, kerosene is still used by some community members to substitute for poor lighting generated, due to low flow or insufficient allocation of electricity. In this respect, the current subsidy policy described has made very little impact in providing a long-term solution for Nepal's rural electrification or environmental degradation. It is recommended that, micro-hydel technology be taken off the category of Renewal Energy Technology (RET) and impetus be given to adaptive 'community-oriented hydel systems' that provide an opportunity for local sociotechnical evolution. By removing micro-hydel from the RET category, this study also suggests that this technology be removed from the AEPC structure and put under the district level energy planning structures.

Community-oriented systems have to be spearheaded by the central energy structure working at the 'decentralised' level and the district level, in terms of planning for the people and by the people. At the district level, both non-grid and grid supply have to be included in a comprehensive district plan that can work together with NEA at the district level and DDC as a mainstream energy implementation structure, by widening the choices, for both the grid and non-grid structure. The administrative and technical turf of NEA has to be made permeable to create a space for the district level interventions and adapting innovation.

Review of the subsidy policy

The subsidy policy can be reformulated to support both the grid and the non-grid systems, where the subsidy for 'rural electrification' should be emphasised and not categorically be for 'micro-hydel' only. In situations where grid access is feasible and the preference of the community is for grid access, a subsidy could be offered to a community to substitute for initial high fees for transmission connection. In systems also used for irrigation purposes, the technology design should emphasise secure civil structures and support the linkage with agriculture. The current practice has often been to improvise on the civil structures as a cost-saving measure with a design discharge focusing on water supply for electricity generation. Subsidy could also be targeted to converge with the productive use sector.

Adaptive application: technical and social configuration

An adaptive micro-hydel technology is one that meets the productive and consumptive needs of the community and provides opportunities for scaling up of electricity use. There are three specific recommendations suggested here to move progressively forward with this technology. First, the definition of the technical capacity of micro-hydel for community use requires a revisit. With a typical system of 20 kW installed capacity, 20 per cent (4 kW) could be kept aside for productive usage such as for milling purposes and for convergence with other local economic sector activities. Then, an allocation of 200-W power distribution (five 40-W light bulbs) for each household should also be set as a national minimum standard when calculating design capacity. This would indicate that the remaining 80 per cent allocation is set-aside for domestic lighting purposes. Therefore an installed system of 20 kW capacity could provide coverage of 80 households (16 kW) with a 200-W distribution of electricity for domestic power use and also encourage convergence with the local entrepreneurship with the 4 kW of power. Anything below this norm and category for community lighting purposes is not recommended. Second, as previously mentioned, considering micro-hydel as power generating devices and not necessarily as renewal energy systems will provide a broader vision, scope and expansion for innovation and creativity within the rural electrification network. As power generating devices, the convergence of the domestic and economic sector could occur at a faster rate. Where diesel-operated mills exist, the integration of these systems in the initial power plan is important not only in converging domestic and economic sectors but also in recognising local technological entrepreneurship. Third, micro-hydel systems will continue to fail in Nepal if the knowledge building process does not include the local community as proactive agents.

For further research

Moving beyond the essential reforms as already suggested in revamping the hydel sector, there is a need for future research in understanding the dynamics of the rural electrification sector of Nepal. This future research could be directed in investigating comparative models of grid and non-grid systems and also designs of rural hydel models, water supply sources and systems for multiple uses. There is also a scope for further research in understanding and documenting the experiences of expanding electricity generation and use within communities; as rural communities, the village dynamics and their locales change. Another area for potential research could focus specifically at non-REDP models and approaches of rural power supply intervention.

Beyond hydel technology biases and models: The last word

Nepal has the potential, with its abundant water resources, to generate hydel power through a significant number of high head systems. However, this thesis has shown that within the backdrop of this bounty, there has been quite an extraordinary authoritarianism in actual choice of hydel design. MHES have been orchestrated as the common model for rural electrification and even promoted as part of the 'new' village identity and rural movement. As a centralised intervention, the various grid and combined grid-system models differ somewhat from the micro-hydel intervention, as the state is directly involved in the intervention. The political conflict between the state and the Maoists has also succeeded in building a coalition, from the grassroots where micro-hydel is 'protected' for its supposed technological democracy. This research has shown that it is not technology or frontline worker per se that attract attacks from anti-government or security forces. It is the corrupt, chaotic and authoritarian actions and motivations hiding behind the image of modernity and enlightened rationality of hydel infrastructure and policy-makers (O'Neill 1974) that is being attacked with the destruction of the physical infrastructure and its representatives.

Contrasting MHES to general larger-scale hydel technology, micro-hydel has been perceived to meet rural needs and efficiently utilising ecological conditions. On one hand, *urja* is clearly linked with *bikas*, both in terms of electricity services and politics of power visible in the various models of electricity generation in Nepal. On the other hand, *khukuri* and violence are also linked with identity, which act as symbols and forces together in social action to oppose authoritarianism in governance and technology. Technology, therefore, in the hill terrain of Nepal not only represents illumination and development but is also a focus for identity, power, control and democracy.

Hydel systems have introduced new technology in the community; therefore, a new regime with new actors. This new technology also requires new support structures, and development of new skills and knowledge systems. The internecine fighting between the State and the Maoists, with the large hydel technology systems as symbolic targets, also reflects the inadequacies of local administration efforts in power generation and the power of local governments. By democratising micro-hydel technology, more effective conditions can be established for equalising policies in electricity provision, access to services and management of water resources.

Appendices

APPENDIX 1.1 RAPID APPRAISAL AND RATIONALE FOR SITE SELECTION

In November 2000, I undertook a rapid appraisal of community hydel technology systems in three districts of Nepal, namely Rasuwa, Kabhre Palanchowk and Sindhupalchowk including Kumpur village in Dhading district. The appraisal was undertaken with five specific objectives.

- First, to assess technology and development options through hydel (mini, micro and traditional turbines) and energy (diesel-operated generators, car batteries, wind, biogas) systems.

- Second, to observe communities' needs and level of interaction in the choice of technology for water control.

- Third, to consider the existing systems in a preliminary framework of clustering technology into design prototypes.

- Fourth, to assess the institutions involved and approaches used in promoting and influencing hydel technology at the district level.

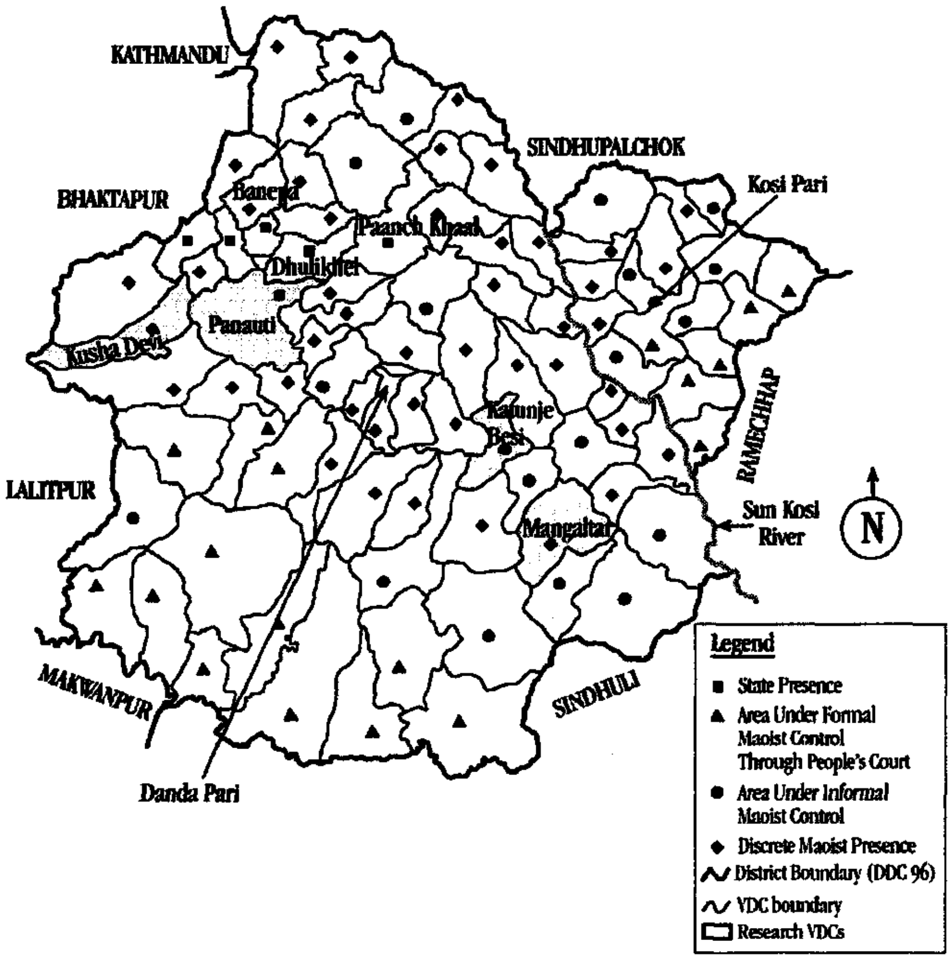
- Fifth, to select one district or one focused hydro-legal space for further in-depth study and research.

A checklist was used in the rapid reconnaissance of technology choices for water control both for electricity and irrigation uses within the community, which I have termed in this thesis as 'productive and consumptive uses'. The checklist also covered data collection on land, water, environment and people, such as hydrology and engineering requirements, water supply, irrigation and design aspects of systems, social structure of the community. Observations were also made on the extent of community interaction, the influences of these on design systems and choices, in terms of both technology and artefacts. Personal walk-through observation of the social, economic, political and agro-ecological implications of technology were made on the uses and functions of technology. Informal discussions were held with key district and village level officials, representatives of non-government organisations, donors, entrepreneurs, village leaders and end users. In Kathmandu, discussions were held with key individuals such as government functionaries, policy planners, water and energy professionals, researchers, non-government agencies, manufacturers and implementers, involved in the hydro development sector in Nepal. In total, twenty-five different sites were visited in the above mentioned, four districts.

Having visited different sites in different districts, Kabhre Palanchowk district was selected for in-depth research. Since my investigation centred on the design of technology and the adaptive characteristics within the local operating environment, I selected three micro- hydels and one small hydel system for further study.

Rasuwa district was not selected for further study because of the low number of hydro systems present in the district. The NEA-implemented Chilime project was a potential alternative for investigation of State run systems. However, because of the harsh geo-physical setting and scattered communities, it would have been almost impossible to cover other smaller micro systems, as it involved traversing by foot, for days from one site to another. After initial discussions with the district authorities in Chautara, it became quite evident that Sindhupalchowk district would not be easily accessible for further study because of the ongoing conflict with the Maoist insurgency. The visit to Kumpur micro-hydro plant in Dhading district was enlightening and this site has been referred to in this thesis in many instances for wider comparative inferences.

APPENDIX: 3.1 MAP SHOWING AREA UNDER THE INFLUENCE OF THE MAOIST MOVEMENT



Note Well: This map was plotted with the assistance of two local youths from the Kabhre Palanchowk district in April 2002. The area under the influence of the Maoist movement represented in the map therefore reflects that particular timeframe.

APPENDIX 3.2 THE FORTY-POINT DEMAND OF THE MAOIST MOVEMENT

Demands of the *Samukta Jana Morcha*, CPN-Maoists of Nepal submitted to the Coalition Government of Sher Bahadur Deuba on February 17, 1996.

I. Demands related to nationalism

1. All unequal treaties and agreements, including the 1950 Nepal-India Treaty, should be annulled.
2. As the so-called Mahakali Treaty, concluded between Nepal and India on 15 Magh 2052, is even more anti-national and dangerous from a long-term perspective, it should be immediately nullified.
3. The open Nepal-India border should be controlled and systematised. Vehicles with Indian licence plates should not be allowed to ply in Nepal.
4. Gorkha recruiting centres should be closed and provision of decent jobs within the country should be made for Nepalese.
5. Priority should be given to Nepalese workers in different sectors, and a system of work permit instituted when special manpower have to be employed for special jobs.
6. The dominance of foreign monopoly capital in Nepal's industries, trade and finance sectors should be stopped.
7. A customs policy should be determined and enforced for the development of a self-reliant national economy.
8. The imperialist and expansionist cultural pollution and invasion should be stopped. Immediate ban should be imposed on the import and distribution of vulgar Hindi films, videos and newspapers and magazines.
9. The infiltration of imperialists and expansionists in the name of non-governmental organisations (NGOs) and international non-governmental organisations (INGOs) should be stopped.

II. Demands related to democracy

10. A new Constitution should be drafted by the people's representatives elected for the establishment of a people's democratic system.
11. All the special rights and privileges of the king and the royal family should be abolished.
12. The army, the police and the administration should be under the people's control.
13. All repressive Acts, including the Security Act, should be scrapped.

14. All prisoners implicated in false cases out of political vendetta, including those of Rukum, Rolpa, Jajarkot, Gorkha, Kabhre, Sindhupalchowk, Sindhuli, Dhanusha and Ramechhap districts, should be immediately released and all false cases withdrawn.
15. Armed police operations, repression and state terrorism taking place in different districts should be immediately stopped.
16. Independent investigations should be held into the disappearances of people from police custody at different times, which include Dilip Chaudhary, Bhuvan Thapa Magar, Prabhakar Subedi and others; the culprits should be handed out severe punishments and suitable compensation given to the suffering families.
17. Those dying in the course of the people's movement should be declared martyrs; the families, wounded and the disabled should be given suitable compensations; and strong action should be taken against the killers.
18. Nepal should be declared a secular state.
19. The patriarchal exploitation of women should end. Daughters should be given equal property rights like sons.
20. All kinds of exploitation and repression based on ethnicity should be ended. In areas predominated by ethnic groups, provision should be made for ethnic autonomous governance.
21. The discrimination against *dalits* should be ended. The system of untouchability should be ended once and for all.
22. All languages should be given equal opportunities and facilities. Provision should be made for imparting education in mother tongue up to higher secondary school level.
23. Full guarantee of freedom of speech and freedom of press should be made. The government communication media should be completely autonomous.
24. Intellectuals, litterateurs, artistes and others engaged in cultural activities should be guaranteed academic freedom.
25. The discrimination between the terai and hilly regions should be ended; backward areas should be should be granted regional autonomy. Balance should be established between villages and cities.
26. Local bodies should be granted rights and resources.

III. Demands related to the question of people's livelihood

27. Those who cultivate the land should own it. The land of feudal elements should be confiscated and distributed to the homeless and the landless.
28. The property belonging to commission agents and bureaucratic

capitalists should be confiscated and nationalised. The capital lying idle in unproductive sectors should be invested for industrialisation.

29. All should be guaranteed work. Dole should be given until jobs are found for them.
30. Minimum wages of labourers working in all sectors, including industry and agriculture, should be determined and strictly enforced.
31. Suitable provision should be made for the settlement of the homeless. The work of evicting the homeless should at once be stopped until alternative arrangements are made for settling the homeless.
32. Poor farmers should be completely freed of debt. Loans borrowed from the Agricultural Development Bank by poor farmers should be completely written off. Small industries should be given loans.
33. Fertiliser and seeds should be cheaply and easily available. The farmers should be given proper market prices for their production.
34. Appropriate relief should be provided in flood and draught affected areas.
35. All should be given free and scientific medical service and education. Commercialisation prevalent in education should be stopped.
36. Inflation should be controlled. Wages should be raised in proportion to the rise in prices. Provision should be made for making available items of daily consumption cheap and easily available.
37. Arrangements should be made for drinking water, roads and electricity in villages.
38. Cottage and small industries should be granted special facilities and protection.
39. Corruption, black marketing, smuggling, bribing, the taking of commissions should be stopped.
40. Provision should be made for the proper protection of orphans, the disabled, the elderly and children.

Source: High-level Recommendation Committee for the Resolution of the Maoist Problem

Appendix 7.1 Hydropower projects in Nepal: Existing, under construction, planned and proposed

No.	Existing	kW Capacity	Under Construction	kW Capacity
1	Panauti	2400	Puwa Khola	6200
2	Trisuli	24000	Khimti (HPL)*	60000
3	Devighat	14100	Modi Khola	14000
4	Sunkosi	10050	Chilime (CPC)*	20000
5	Gandak	15000	Bhote Kosi (BKPC)*	36000
6	Kulekhani 1	60000	Indrawati (NHPC)*	5000
7	Kulekhani 2	32000		
8	Marsyangdi	75000	Total Under Construction	141200
9	Andhi Khola	5100		
10	Jhimruk (BPC)	12300	Manma (Kalikot)	500
11	Kali Gandaki A	144000	Gamadi	200
			Heldung	250
			Dolpa	160
	<u>Total Major Projects</u>	394450	Total Under Construction	1110
12	Pharping***	500	Planned and Proposed	kW Capacity
13	Sundarijal	640		
14	Phewa (Pokhara)	1088	Middle Marsyangdi	61000
15	Dhankuta	240	Seti West	750000
16	Tinau (Butwal)	1020	Arun 3	402000
17	Jhupra (Surkhet)	340	Budigandaki	600000
18	Baglung	200	Kaligandaki No. 2	660000
19	Doti	200	Lower Arun	308000
20	Phidim	240	Upper Arun	335000
21	Gorkhe	64	Karnali (Chispani)	10800000
22	Jomsom**	240	Upper Karnali	300000
23	Jumla	200	Chamelia	30000
24	Dhading	32	Pancheshwar	6480000
25	Syangja	80	Thulodunga	25000
26	Seti (Pokhara)	1500	Tamur/Mewa	100000
27	Helambu	50	Dudh Kosi (Storage)	300000
28	Salleri*	400	Budhi Ganga	16000
29	Darchula**(1+2)	300	Rahughat Khola	24000
30	Chame	45	Likhu-4	44000
31	Taplejung	125	Kabeli A	35000
32	Manang	80	Upper Marsyangdi	121000
33	Chaurjhari	150	Upper Modi	14000
34	Syarpudaha	200	Kulekhani No. 3	14000
35	Khandbari**	250	Andhi Khola (Storage)	176000
36	Terathum	200	Khimti II	27000
37	Bhojpur**	250		

38	Ramecchap	150	Total Planned	21622000
39	Bajura	200		
40	Bajhang**	200	Dailekh	300
41	Arughat (Gorkha)	150	Lamangthan	65
42	Tatopani (1 + 2)	1000	Khotang	2300
43	Okhaldhunga	125		
44	Rupalgad	100	Total Planned for Small	2665
45	Surnalyagad	200		
46	Namche*	600		
47	Achham	400		
	Total for Small Hydro Projects	11 468		

Nepal's total grid hydropower installed capacity is 592 MW.
Power demand forecast for 2003 is 482 MW or 2110 GWH.
Power surplus is 112 MW in flood season and 50-60 MW in dry season.

No.	Existing Diesel Power Stations	kW	Solar Power Stations	kW
1	Mahendra/Kathmandu	1728	Simikot	50
2	Biratnagar	1028	Gamgadhi	50
3	Hetauda	12750	Kodari Tatopani	30
4	Marsyangdi	2250		
5	Duhabi Multi Fuel – 1	26000	Total for Solar Power	130
6	Duhabi Multi Fuel – 2	13000		
7	Ilam	200	Existing Sub-Station	
8	Salyan	100	Capacity MVA	
	Total for Diesel Power	57056 kW	132/11 KVA	28.5
			132/33 KVA	175
	Existing Transmission Lines Length	KM	132/66 KVA	149
			66/11 KVA	273.3
1	132 KV Single Circuit	1178	66/33 KVA	12.5
2	132 KV Double Circuit	43	132/33/11 KVA	10
3	66 kV Single Circuit	179		
4	66 kV Double Circuit	153	Total MVA	648.3
5	33 kV Single Circuit	1348.70		

Note: * Private and others; ** Leased to the private sector; *** Not in normal operation.

Source: Nepal Electricity Authority, NEA 2003.

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SUMMARY

Hydel technology in Nepal is shaped by macro and micro power policy models. While the state-controlled grid system supplies energy nationally, micro-hydel have been romanticised and perceived as 'community-oriented' alternative system of rural electrification. The system has been designed with the premise that this is the 'appropriate' form of power supply, often overlooking the existing power bases and the 'adaptive' features of these hydraulic, transformative and evolutionary ensembles. Significant development of micro-hydel in Nepal has placed this technology in the forefront of these alternative forms of power supply. However, very little research has been done on the evolution of the micro-hydel sector or on the impact of this technology in the rural areas of Nepal. Out of the country's total population of 22 million, only 1.1 million rural people have access to electricity, the majority of them through the 'renewal energy'-based small capacity micro-hydel.

This study documents micro-hydel technology realities and hydropower policy in Nepal through an inter-disciplinary field study of four hydel systems in the Kabhre Palanchowk district, in the central hills of Nepal. Most of the plants were implemented under the Rural Energy Development Programme (REDP), supported by UNDP. Three of these systems are in the micro-hydel category for supplying electricity to local communities and one is in the medium category, which also feeds the national grid. The sites studied range from State-run to community-run 'decentralised' systems involving a number of institutions and a variety of institutional approaches. These sites also show interesting interface with irrigation and energy water users. Each of these four studies looks at how technology can be designed, and evolves, to provide the wanted output and accepted governance. These case studies reflect how and why different levels of technological adaptation have come into being beyond a 'hydraulic ensemble' and whether 'technological democracy' is achieved through these adaptations. The study focuses on 'community-oriented micro-hydel systems' to study the systems that not only generate electricity for a community but also are shaped by it. This study examines the interface between local power provision and water resource management. This thesis is divided into nine chapters. Chapter 1 sets the stage for the analytical framework of the arguments presented. Chapters 2 and 3, analysing at the societal

level, provide broader historical and political policy perspectives and the social actions surrounding them. As the research area exploded into local action generated by the Maoist movement during the field research period, Chapter 3 particularly looks at these social changes and responses. This chapter shows how identity and violence become embedded and inter-linked with rural politics and hydel technology ~~to reinforce the struggles~~ for equity and development.

Chapters 4 to 8 present the case studies and examine the different trajectories of micro-hydel technology choice, implementation and adaptation by studying the interactions of structures, systems and agents in the materialisation of designs. Chapter 4 shows how communities have innovated and adapted to maintain a 12 kW capacity cross-flow turbine, a design developed by a national manufacturer. Chapter 5 examines the interfaces of 8 kW capacity propeller turbine installed and implemented under an R and D initiative and the adaptation of the community around this design. Chapter 6 examines the various networks, agents and actions in the materialisation of the Pico Power Pack (PPP) of 4.2 kW capacity developed by a foreign designer and manufactured locally. By studying the historical shaping of the early intervention of State hydropower plant that uses Francis Wheels to generate 2.4 MW electricity, designed and implemented by Russian technical assistance, chapter 7 provides insights on comparative design choices, both on grid versus non-grid intervention and on grid-system evolution. All these four case study sites are linked to the Roshi River system. The structure-system-agent linkages in the case study chapters are scrutinised to show different coalitions and sequences of actions around and within the technology, to transform the original devices and establish working practices. By charting an interdisciplinary technography of hydel systems, these chapters examine how the sociotechnical knowledge systems have been built, embedded, adapted and shaped within the community by various design networks. The case studies specifically look into the materialisation of the design and its functionality by looking at structures, systems and agents. In all these chapters, this research juxtaposes why and how things transform. Subsequently, Chapter 8 explores the extent to which hydraulic, transformative and evolutionary mechanisms interface, adhering to the basic levels of operational, socio-political and financial accountability. This chapter introduces the concept of constitutional accountability, one that is guided by moral and political responsibilities and shows that this level can be strengthened in Nepal.

The final chapter, Chapter 9, revisits the key concepts discussed in the preceding chapters, bearing in mind that democratic technology is shaped by society and humans where technological democracy adapts, transforms and evolves within the field of 'democracy'. This chapter discusses the key messages and contributions of this research to policy, practice and theory, and concludes with a suggested agenda for reform for Nepal.

This thesis is based on the central argument that design of technology is an outcome situated within the triadic interfaces of structures, systems and agents. The study shows that hydel technology in Nepal illustrates significant characteristics of authoritarianism in design. The thesis further expresses that society and humans shape 'technological democracy'. Against a backdrop of myriad design networks influences by donors and private manufacturers, this thesis shows that the spread of democratic institutions does not necessarily signify the spread of democratic technology. This study suggests that 'democratising technology' require creation of required political spaces for discourse, recognising contestations and building and re-building of democratic institutions by adhering to the basic principles of accountability.

Curriculum Vitae

Amreeta Regmi was born in Kathmandu, Nepal. She graduated from St. Mary's High School in 1976. After doing a preliminary course in architectural engineering from Pulchowk Campus, Tribhuvan University, Nepal, she pursued higher education in India, Peru and the USA to obtain BA and MBA degrees. She has worked with NGOs in Nepal involved in trail and bridge development, and has also undertaken work in Africa, Latin America and other parts of Asia primarily in the water sector. She is currently based in Jakarta, Indonesia.