Waters of Life

Perspectives of Water Harvesting in the HKH

Mahesh Banskota
Suresh R. Chalise

ICIMOD

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Perspectives of Water Harvesting in the Hindu Kush-Himalayas

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Editors
Mahesh Banskota
Suresh R. Chalise

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Cover

Background	Waterfall close to Khasa near Nepal-China (Tibet) border
Top Right	Water brings life to the cold desert, Ladakh, India
Centre	An elderly lady walking uphill to fetch water, Bajrapare village, Kabhrepalanchok, Nepal
Bottom right	Little girls with a big burden: children fetching daily water supplies, Tehri Garhwal, India
Back page	Rara Lake, 3,000 masl

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Editorial Team: Greta Mary Rana (Senior Editor)
Dharma R. Maharjan (Technical Support and Layout Design)
Asha K. Thaku (Cartography and Design)

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Foreword

Water is fundamental to the material basis of both life and livelihoods in rural Asia. Water serves a variety of purposes: it is used not only for irrigating the main field crops, but also for domestic needs such as drinking, washing, and bathing and for home gardens, livestock, trees, and other permanent vegetation. Other productive uses include aquaculture, transportation, and small rural enterprises such as brick making. The environmental benefits of water resources include direct uses such as the harvesting of aquatic plants and animals and the immeasurable benefits of biodiversity and maintaining natural ecosystems. Many of the traditional water-harvesting systems have fallen into disuse or have been forgotten, replaced by 'modern' structures and systems that have failed to meet the expectations and demands of growing populations. Water scarcity affects the rural household, economy, and environment in multifarious ways, resulting in hardships such as the necessity of carrying heavy pots of water several kilometres every day to meet household needs; the destitution of farmers and their families who lose their lands, or of the landless who lose their jobs because of lack of water for irrigation; the loss of wetlands and estuaries because of water depletion upstream; and increasing health problems caused by water-borne diseases and pollution. Inequitable access and a distribution system skewed in favour of the urban, rich and powerful further compound the problem of absolute scarcity, especially for the poor and the disadvantaged.

Concomitantly with growing scarcity, competition over water among various uses and users is intensifying, both within and between sectors. Demands for water supplies for agriculture, households, and industry have escalated dramatically in recent decades. Increasingly, wetlands, rivers, and estuaries that support wildlife and vegetation are being threatened by water transfer and shortage. While water for irrigation remains critical for food production and rural incomes, farmers must compete for the resource among themselves and with rapidly growing industrial, domestic, and urban demands for water. In the competition for water, industrial and urban needs typically receive priority over agriculture and irrigation, which in turn are favoured over domestic uses (generally considered the domain of women) or ecosystem needs. 'Environment versus development' dilemmas over water have led to conflicts and struggles related to large dams, industrial pollution, chemical runoff from agriculture, and aquaculture, among other issues. Often, as water resources have fallen under centralized and state control through bureaucracies, policies, and legal instruments, communities have had to struggle to maintain their rights, customary local practices, and livelihoods. With towns and industries making more and more claims on the water currently used in rural areas, the rural poor and marginalised groups have little means to defend their rights to water and are unlikely to even gain a seat at the table in discussions about the best way to manage diminishing water resources.

Simultaneously, a better understanding by the public and policy-makers of resource limits and the urgency of taking effective action to meet the challenge is needed. In the face of increasing water scarcity and competitive demands on water, water security will be increasingly linked to poverty eradication, governance, and conflict resolution. In the meantime, rapidly evolving water markets are establishing their own means of rationing water in many parts of Asia. Water is increasingly being treated as a commodity to facilitate mobility between competing demands and purchasing capacities; in short, going to those who have the ability and willingness to pay. But treating water as a commodity may only further marginalise the weaker sections of society who have minimal purchasing capacity and are unable to defend their prior use of water. Water is imbued with deep cultural significance all over the world, especially in rural Asia. Conflicts over water evoke meanings and images that go beyond the physical attributes of water. After all, denial of access to water is ultimately denial of life itself.

ICIMOD must be commended for bringing out these two volumes on the significance and the diversity of water-harvesting technologies and institutions governing them. Apart from the publication of these volumes, ICIMOD has been instrumental in bringing people and institutions from different countries together to share their experiences of the dynamics of policies and practices revolving around water-harvesting structures and the local economy. In pursuing this interest on a vital resource for livelihoods in the Hindu Kush mountains, we hope that the further research and programme activities of ICIMOD will seek to enhance and sustain the role and voice of local communities in governing these community assets and also continue to identify policies, practices, movements, and institutional capacities that increase disadvantaged people's access and control over water resources.

Ujjwal Pradhan
Ford Foundation
New Delhi

March 2000

Preface

A commonly held notion about mountain areas is that these are all plentifully endowed with water, and mountain communities should not be facing too much difficulty in accessing needed water supplies. These two volumes, discussing efforts by local communities to harness water resources for drinking and agriculture, show clearly that plentiful endowment does not necessarily mean it is readily available. Water for the settlements and fields of mountain households had become increasingly scarce. Tapping more distant sources has many technical, environmental, and socio-institutional implications as the discussions in these two volumes indicate.

ICIMOD's main objective in bringing out two volumes on water harvesting is first to close some of the continuing knowledge gaps about the use of resources by mountain communities. It is hoped that by a better understanding of prevailing practices it will contribute towards the development of sustainable systems in the future. Another important reason is that this is also the year of the World Water Vision and it would be a gross oversight if mountain communities did not have a place in this vision. We hope this small contribution will help in this direction.

ICIMOD is very grateful to the Ford Foundation for supporting the water harvesting programme of the Centre which has made this review work possible. The contributions of all the national and local organisations, including the authors of the various papers and case studies, are also highly appreciated. Dr. M. Banskota, Deputy Director General and Professor S. R. Chalise, Water Resources' Specialist, planned the outline and contents of these documents and ensured that all critical issues were covered. Obviously much more can be said about important topics like water and mountain communities. This is only a small step forward towards improving our understanding about water harvesting at community level in the Hindu Kush-Himalayas. ICIMOD is looking forward to taking the next steps that should include, in particular, capacity building in local planning and management of water-harvesting systems.

Abstract

The Hindu Kush-Himalayas (HKH) are the largest storehouse of the fresh water in the lower latitudes and as such are important water towers for nearly 500 million people. They are the source of major river systems: the Indus, the Ganges, the Yarlung-Tsangpo, the Brahmaputra, the Nu-Salween, the Yangtze, and the Mekong. Also called the 'Third Pole' they contain the largest mass of ice and snow outside the earth's polar regions. Located at the highest elevations on earth, with the permanent snowline at about 5,000 m, the mountain peaks of the HKH extend close to 9,000 m. These peaks contain many glaciers, including some of the longest outside the polar regions. Availability of water at such great heights has also made human life possible at higher elevations than elsewhere, with human settlements beyond even 4,000 m and temporary and seasonal settlements with unique cultures and traditions even close to 6,000 m. The extreme variability of climate and precipitation and patterns, as well as extremely inadequate knowledge on the hydrology of the HKH rivers and streams and the complex interrelationships between ecology and hydrology in the region impose serious scientific and technical limitations on the development of HKH waters. This two-volume document discusses the methods of harvesting water throughout the HKH mountains amongst a wide variety of human groups, focussing on the efforts being made by local communities for harvesting water. Many of the older systems are breaking down while newer ones supported by government and development organisations are limited. A concerted effort is needed to improve existing systems through community participation while at the same time expanding new systems.

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Suresh R. Chalise
Mahesh Banskota

Acronyms

ADB/N	:	Asian Development Bank, Nepal
ARWSP	:	Accelerated Rural Water Supply Programme
AZRI	:	Arid Zone Research Institute
BOARD	:	Rural Water Supply and Sanitation Fund Development Board
BWMP	:	Bagmati Watershed Management Project
CAPART	:	Council for Advancement of People's Action and Rural Technology
CBO	:	Community Based Organisation
CDO	:	Chief District Officer
CGI	:	Corrugated Galvanized Iron
CIDA	:	Canadian International Development Agency
CSWCRTI	:	Central Soil and Water Conservation Research and Training Institute
DDC	:	District Development Committee
DPAP	:	Drought Prone Area Programme
DSCWM	:	Department of Soil Conservation and Watershed Management
DWRC	:	District Water Resources Committee
DWSCC	:	District Water Supply Coordination Committee
DWSS	:	Department of Water Supply and Sanitation
FIFO	:	first-in-first-out
FINNIDA	:	Finnish International Development Agency
FMIS	:	Farmer Managed Irrigation System
FRIEND	:	Flow Regimes from International Experimental and Network Data
FYP	:	Five Year Plan
HYV	:	High Yielding Variety
GIS	:	Geographic Information Systems
GLOF	:	Glacial Lake Outburst Flood
HDPE	:	High density polyethene
HH	:	Household
HKH	:	Hindu Kush-Himalayas
HKH-FRIEND	:	Hindu Kush-Himalayan Flow Regimes from International Experimental and Network Data
HMG/N	:	His Majesty's Government of Nepal
HYV	:	High Yielding Variety
ICARDA	:	International Centre for Agricultural Research in Dry Areas
ICIMOD	:	International Centre for Integrated Mountain Development
IDE	:	International Development Enterprise
IHP	:	International Hydrological Programme
IIDS	:	Institute for Integrated Development Studies
ILO	:	International Labour Organisation
INGO	:	International Non-Governmental Organisation

INSAN	:	Institute for Sustainable Agriculture
IRDP	:	Integrated Rural Watershed Development Programme
IP	:	Irrigation Policy
IPCC	:	Intergovernmental Panel on Climate Change
IWDP	:	Integrated Watershed Development Programme
JRY	:	Jawahar Rojgar Yojna - A centrally-sponsored rural employment generating scheme
LDPE	:	Low Density Poly Ethylene
lps	:	litres per second
LWHS	:	Local Water Harvesting Systems
MLD	:	Ministry of Local Development
MOWR/DOI	:	Ministry of Water Resources/Department of Irrigation
NGO	:	Non-Governmental Organisation
NWDPRA	:	National Watershed Development Programme for Rainfed Agriculture
NWFP	:	North West Frontier Province
NWSC	:	Nepal Water Supply and Sanitation Corporation
O and M	:	Operation and Maintenance
PARAG	:	A Cooperative Dairy Development Organization
PARK	:	Pakistan Agricultural Research Council
PCRWR	:	Pakistan Council of Research in Water Resources
PIM	:	Participatory Irrigation Management
R and D	:	Research and Development
REFRESHA	:	Regional Flow Regime Estimation for Small Hydropower Agreement
RWHU	:	Rain water Harvesting and Utilisation
RWSSP/F	:	Rural Water Supply and Sanitation Project/FINNIDA,
SAARC	:	South Asian Association for Regional Cooperation
SAPPROS	:	Support Activities for the Poor Producers of Nepal
SAPROS	:	An NGO based in Kathmandu
SC	:	Scheduled Castes
SLR	:	Standard lactometer reading
ST	:	Scheduled Tribes
SWC	:	Social Welfare Council
UDLE	:	Urban Development through Local Efforts
UG	:	User Groups
UNESCO	:	United Nations Educational Scientific and Cultural Organisation
VDC	:	Village Development Committee
WARM	:	Water Resources' Management
WECS	:	Water and Energy Commission Secretariat
WHS	:	Water-harvesting Systems

WHO	:	World Health Organization
WMO	:	World Meteorology Organisation
WUA	:	Water Users' Association
WUC	:	Water Users' Committee

Glossary of Local Terms Used in This Case Study

bares	:	A system in which families take turns to graze cattle.
bari	:	sloping terraces
bazar	:	Market, commercial centre
bes	:	sharing of labour
Bhotia-Gurung	:	People of Tibetan origin
bijuli dekchi	:	Low wattage cookers
bolla/rolla/gadni	:	ephemeral lower order streams
chakluth	:	manure from the latrine
chaksa	:	traditional dry latrine
chartung	:	A Buddhist festival
chhrupon	:	village irrigation overseer
ching	:	A small reservoir or tank
chowa	:	The title of a person who assists the *gempa* in the traditional village organization
chu	:	water
chumik	:	spring
chyangra	:	A kind of mountain goat
chyure	:	measure of water for sharing
cropping intensity	:	percentage of gross cropped area to net cropped area in a year
dhar	:	ridge line
dhara	:	a spring of freely falling water
diggi	:	tank plastered with cement
dolchu	:	first irrigation of a field when seedlings have appeared.
dzo	:	male cross between a yak and a cow
dzopa/dzo	:	cross-breed between yak and local lulu cow
gad	:	higher order perennial streams
gempa	:	Chairperson
Gram Sabha	:	Village assembly
guhl	:	small water channel
hauzi/hauz	:	water storage tank
Jhuma	:	Buddhist nun
ka (rka)	:	sluice, a gap in the *yura*
ka-do (rka-do)	:	boulder to open/close the sluice
Khampa	:	Tibetan refugee, followers of the Dalai Lama from the province of Kham in Tibet
kharif	:	rainy season
kharka	:	Alpine pasture
khet	:	irrigated level terrace land
khola	:	stream

la	:	a pass on a mountain or road
lah	:	deity
lah-lchang	:	tree dedicated to lah
lang-de	:	sharing of dzo for ploughing
la-tho	:	structure in which a lah is believed to reside
lekh	:	high altitude area (cliff)
lorapa	:	village official who prevents animals from damaging crops
Losar	:	New Year
Lo-shar	:	Tibetan Buddhist New Year festival, celebrated also in this area
lu	:	serpent, nag
lu-bang	:	structure in which a lu is believed to reside
lulu	:	local breed of cow
masyang	:	a kind of local bean
naula	:	Shallow subterraneum water source
pakho	:	(rainfed slope lands).
Panchayat (village)	:	Assembly of elected rural representatives
Pani Panchayat	:	Water users' society
para	:	A dice marked fron one to six
pathi	:	A measure of volume
Pradhan (Village)	:	Head of village assembly
rabi	:	winter season
satwara	:	mutual exchange of land
soyam	:	forest land with open access resources, it is no-one's property.
Swajal Yojna	:	drinking water and sanitation scheme
thok	:	joint ancestral landholdings.
yura	:	water channel
Yuwak Mangal Dal	:	Village youth welfare group
zamindari	:	feudal landlord system

Contents

Chapter 1
Water Harvesting Policies and Institutions in Bhutan

K. Tshering

1. Background

Bhutan is a mountainous country, covering a total area of 40,500 sq. km. To the north it is bounded by the Tibetan Plateau of China and the rest of Bhutan's borders are contiguous with those of India. Bhutan is classified into three geographical zones as follow.

- The foothills, a 20 km wide strip in the south adjacent to India that rising to an elevation of 1,500 m
- The middle or intermediate range, rising to an altitude of 5,000 m
- A high mountain area, with altitudes exceeding 7,500 m

Flat land is limited to a relatively few broad river valleys in the mid-country and a small area immediately below the foothills (Figure 1.1)

The population of Bhutan was estimated at 600,000 in 1993. Crop production and livestock rearing are the main occupations of 86% of the people and contribute some 41% of the Gross Domestic Product (GDP). Labour is limited and hence intensified agricultural production is difficult. The traditional, self-sustaining farming system integrates crop and livestock production and the use of forest resources.

Upadhyay (1995) comments on the fragile geology and immature soils in Bhutan. In the foothills, factors such as steep slopes and loosely consolidated bedrock lead to severe surface erosion in spite of thick vegetative cover. In the high mountains, rocks are resistant to weathering, and, because of low rainfall and temperature, chemical weathering is also slow. Soil formation is therefore slow, leading to shallow soil depths with high percentages of rocks and stones. In the middle mountains, most rock types are extremely weathered.

The country is dissected by fast, south-flowing rivers running through deep, narrow gorges and steep-sided ravines. The high mountain areas, which are snow-bound throughout the year, are the source of the main rivers. The rivers, fed by perennial snow and summer rains or both, form four separate drainage basins: the Amochu (Toorsa), the Wangchu (Raidak), the Puna Tsang Chu (Sunkosh), and the Dangmechu (Manas).

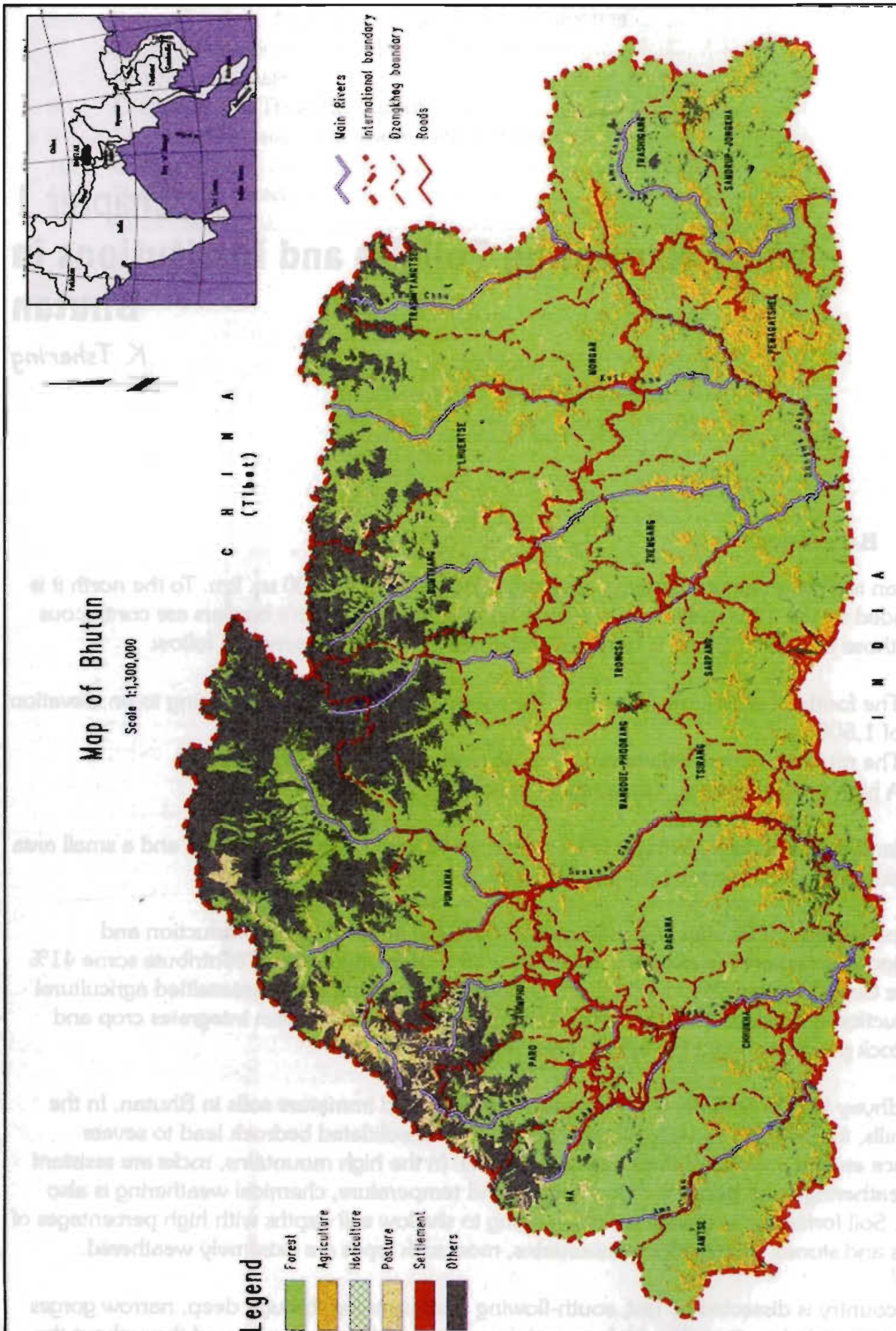

Figure 1.1: Map of Bhutan

Bhutan has a wide diversity of climates compared to other regions of similar size, ranging from hot and humid sub-tropical in the south to perpetual snow and ice in the high Himalayas. Because of the wide variations in physical features within short vertical as well as horizontal distances, each valley can have unique climatic characteristics from differences in altitude, rainfall, and exposure to radiation and wind. The predominant climatic feature is the southwest monsoon which sweeps in from the Bay of Bengal during June, is intense in July and August, and finally fizzles out by the end of September. Occasionally, post-monsoon rains occur in October. They last for a few days only but can be severe. Precipitation decreases as altitude increases and from west to east. Average annual rainfall ranges from 2,000 to 5,000 mm in the foothills, while the middle mountains receive between 500 to 1,000 mm, and precipitation is less than 500 mm in the high mountains.

Mean temperature logically follows altitude. Temperatures range from the subtropical belt at about 15-30°C, to middle altitudes of 1,500 m where the climate becomes cool and misty much of the year, to the high mountains at 3,500 m and above where the climate becomes increasingly severe with limited precipitation, short cool summers, and long cold winters.

Given the climatic and topographical diversification described above, exact delineation of agro-ecological zones is problematic. Nevertheless, six major agro-ecological zones have been identified from north to south, based on altitude, rainfall, and temperature: alpine, cool temperate, warm temperate, dry sub-tropical, humid sub-tropical, and wet sub-tropical (Table 1.1). The warm temperate and dry sub-tropical zones have been subdivided into east and west dry sub-tropical zones because of differences in cropping patterns in the two parts of the country.

Table 1.1: **Agro-ecological zones of Bhutan**

Agro-ecological Zones	Altitude Masl	Temp Max	Temp Min	Temp Mean	Rainfall mm
Alpine	>3,500	12	-1	5.5	<650
Cool Temperate	2,500-3,500	22	1	10	650 – 850
Warm Temperate	1,800-2,500	26	1	13	650 – 850
Dry Sub-tropical	1,200-1,800	29	3	17	850 – 1,200
Humid Sub-tropical	600-1,200	33	5	20	1,200 – 1,500
Wet Sub-tropical	150-600	35	12	24	2,500 – 5,500

Source: FAO (1990)

Agricultural production is largely governed by altitude and climatic factors. The most important crop is rice which is grown in irrigated or rainfed bunded fields throughout the country at altitudes ranging from 150 to 2,600 masl. National yields average between 2.0 to 2.4 MT/ha with the highest yields in the mid-altitude ranges (1,200 to 2,500 masl) and lower yields in the southern districts. Maize is another popular crop and is found mainly in the eastern and southern parts of the country. While most of it is used as a substitute for rice, considerable amounts are converted into an alcoholic beverage. Wheat has traditionally been an important part of the diet in various parts of rural Bhutan. It is mainly grown on dry land and to some extent as a relay crop after paddy in a wide range of agro-ecological zones.

2. Review of Policies on Water

In the early days, the Land Act was the only legislation that laid down the statutes on water use, mainly for agriculture. As explained below, it is mainly confined to rights and responsibilities involved in the process of construction and/or rehabilitation of irrigation channels. At the time of its formulation, it embodied the government policies on the principal uses of water at the national level. However, since the clauses are specific to individual channels, it serves at all levels. Likewise, the National Irrigation Policy has been formulated to cater to the local level while meeting the national objectives. Micro variations of water availability are not unknown but have not been documented as yet.

As in most other countries, the government has a predominant role in water use. The state is the owner of all water bodies in the country. The government has the responsibility of providing safe water for domestic use. Thus, in its Health For All programme (RWSS 1998) a key objective is to provide universal access to safe drinking water and sanitation facilities by the year 2000. Similarly, in order to meet the food self-sufficiency goal, irrigation development has been a key component of the government's drive to boost agricultural production. A strong role for the state has also become necessary for environmental reasons to control pollution of surface and groundwater and maintain aquatic eco-systems (Meinzen-Dick 1998).

Because water is necessary for life, the private individual has long been using it with or without government support. In fact, government involvement started only with planned development, long before this individuals or groups managed water for their daily requirements. Water for domestic purposes has mostly been organised through individual efforts and still continues to be so. For irrigation, due to its communal nature, groups were mobilised to construct and maintain channels and the tradition has been passed down to modern times.

The 'Land Act'

Traditionally, water use in Bhutan was limited to domestic and agricultural uses and, to some extent, as a source of energy. Irrigation was and still is the prime user of water resources in the country, as a consequence of which national policies on and programmes for water relate only to irrigation. Prior to the adoption of the National Irrigation Policy, the Land Act (1979) was the only document dealing with water.

The Land Act is based on the *'Thram Martham Chenm'*, a register maintained by the rulers of the Kingdom containing land records of every tax-paying household. The sizes of land holdings were measured in units called *'Sondrey and Langdo'*. This register was started in the 17[th] century and reviewed in 1919 during the reign of the first King, His Majesty Gongsa Ugyen Wangchuck (MoHA Guidelines1998).

In keeping with the needs of planned development, the Act has been supplemented by several resolutions of the National Assembly and orders issued by the government. At the same time, the system of calculating land-holding sizes also underwent changes from chain to cadastral surveys.

The Land Act grants permission to harvest water for irrigation provided that the person doing so does not cause damage to other's landed property, house, and plantations. The Act empowers him/her to maintain an existing channel and its related structures even if these affect somebody who does not benefit from the system. However, if a new construction is proposed and this affects another party, it must be cleared by a local court. In case of default, the offender will be fined and his/her activities treated as null and void. For the purpose of avoiding ambiguity, a channel that has not been used for the last five years is non-existent and any work proposed on the system will be considered to be new.

Use of water that is jointly harvested is to be shared among the beneficiaries of the system, by either mutual understanding or by existing practices. Otherwise the water is divided among the land-holders according to the land-holding size and the amount of water in the system. Likewise, the system maintenance responsibility in labour terms is also based on the size of the holding.

The Act bars individuals wanting to increase their share of water from a system unless it has been upgraded to carry more water. Water sufficiency must be considered before staking a claim for an additional share of water, notwithstanding the individual's labour contribution. However, if the water supply is adequate, any new member, whosoever he/she is, can become a beneficiary and the older members cannot object. The new member (s) will share the maintenance responsibilities along with the others.

Neglecting one's channel with the intent of acquiring water from another channel closer to one's fields is strongly discouraged. This is only permissible if there is sufficient water in the other channel and the users' own cannot be made functional.

Having devoted a whole chapter of the Land Act to irrigation channels elucidating the rights to and responsibilities for them, it is only logical that paddy land is protected. The Act prohibits conversion of terraced wetland to other forms of use. Until recently, the government also provided a nominal subsidy to farmers for terracing land.

The 'national irrigation policy'

In 1992 the government approved the National Irrigation Policy to lay down the procedures for irrigation development. The policy was formulated based on inputs from field; experiences drawn from model schemes and from the results of the farmer-managed irrigation systems' study. The evolution of the National Irrigation Policy thus emerged through testing procedures, programmes, and as a result of a number of interactions at the local and national levels (Pradhan 1998).

The policy outlines the procedural requirements for farmers requesting government assistance for construction and/or rehabilitation of irrigation channels. Pradhan (1998) concludes that many components of technical and social interventions for irrigation development have been streamlined. The National Irrigation Policies covers the range of activities beginning with selection, survey and investigation, construction and operation and maintenance. Farmers are required to form Water Users' Associations (WUAs) and encouraged to take the leading role in the entire process.

One of the basic premises of the policy is that irrigation is a complex activity with interacting physical, agricultural, and social aspects. Assistance to irrigation development, therefore, calls for a multidisciplinary approach combining the concerted efforts of engineers, agriculturists, sociologists, and others. Another key feature is the emphasis on long-term sustainability which allows the implementing agencies more time to iron out the problems with the policy and expand them as appropriate. At the same time, the process takes into account development of the institutional capacities of the different agencies involved.

Drinking water supply

There is no formal policy to guide the development of drinking water supplies. However, the Rural Water Supply and Sanitation Unit of the Health Division has formulated several guidelines to facilitate their activities. The overall goal of this programme is to improve public health by reducing the incidence of water borne and filth borne diseases through provision of safe drinking water and adequate sanitation facilities (RWSS 1998). Other objectives include the provision of universal access to safe drinking water and sanitation facilities by the year 2000; improving the understanding of beneficiaries regarding relationships between water-borne diseases, hygiene, water quality and sanitary conditions; and institutionalising implementation and maintenance procedures and human resource development.

3. Critical Analysis of Impacts

The Land Act legalised the water rights of an individual vis-à-vis the community. He/she is entitled to draw water from a source provided it does not adversely affect others. It favours rights of priority on disputable matters. Membership of irrigation channels is well defined. Water sharing is to be based on principles of equity irrespective of social and gender considerations.

The Act recognises the existence of beneficiaries (groups) for management of irrigation systems. It confers authority on the group to take decisions regarding construction, operation and maintenance, and system management. The group can resolve internal conflicts, failing which the affected party can go to court to redress their grievances. However, the court cannot force its ruling in all circumstances. Then, the decision of the beneficiaries is final in such cases.

While the intra-system rights of a channel are defined, a system's right to a water source is only implicitly addressed. Clause Ka. 7.5 of the Land Act states that, for new constructions permission of the court must be sought. This implies that water rights have to be secured prior to construction. Again, the water rights of one system vis-a-vis the others in the same watershed are indirectly defined in Ka. 7.4, where it states that if a new construction affects others, this can be stopped by the court. It would simplify matters if the Act contained specific clauses on a topic like water rights.

The National Irrigation Policy (NIP) has succeeded in institutionalising the participatory approach in government assistance to community irrigation systems. The policy premises are that development should be demand-driven, promote active beneficiary participation, enhance the institutional and managerial capabilities of the beneficiaries and be sustainable (IAP 1994).

In the foreword of the NIP, it is mentioned that 'although it is the core document around which the national policy has been developed, it is not a book of rigid rules and regulations. " Again, the policy measures herein are relevant only to irrigation as it relates to cereal crop production, mainly rice. " That too is only applicable to gravity-fed irrigation systems, suggesting a narrow focus on one crop and a limited range of technology. The policy has not considered the requirements of other types of irrigation technologies and cropping systems.

It is the contention of this paper that the National Irrigation Policy is not fully comprehensive enough to cover the whole gamut of irrigation development. The scope of the policy needs to be broadened from assistance to rehabilitation and/or renovations to irrigation sector development. It appears that one of the objectives is to make government assistance more cost-effective by minimising government expenditure on construction and subsequent operation and maintenance of irrigation channels. Another objective that might be added is *"to ensure that sustainable and productive use be made of scarce labour, land, and water resources"*. Amongst others, the policy could stress the need for protecting watersheds to ensure sustained water supplies. The policy would also be strengthened if appropriate measures to avoid environmental degradation, occurring as a result of irrigation development, are included (IAP 1994).

The principle of equity is not specifically mentioned in the policy document. It is elementary to the success of a participatory approach that water users contribute to the development in proportion to the gains they stand to make. It would mean that resource contributions are in accordance with the size of their land holdings; that the positions of men and women are strengthened equally, and that water users in all schemes contribute proportionally (IAP 1994).

Pradhan (1998) points out that as irrigation diversifies from cereals to high-value cash crops, the policy will have to incorporate appropriate modifications. These will include other methods of irrigation, the role of the Irrigation Agency, and the capital investment strategies.

For another couple of years, the government will still remain the sole donor of assistance. Given the implementation capacity of its Irrigation Agency, the number of schemes receiving assistance will not be high. The figures will be lower as the inventory did not include all of the innumerable, small indigenous schemes (Figure 1.2). However, the policy does not provide for priority setting based on a certain rationale. In order to provide equal opportunities to all, options must be made available for farmers to pursue other venues for assistance or choose different types of technology.

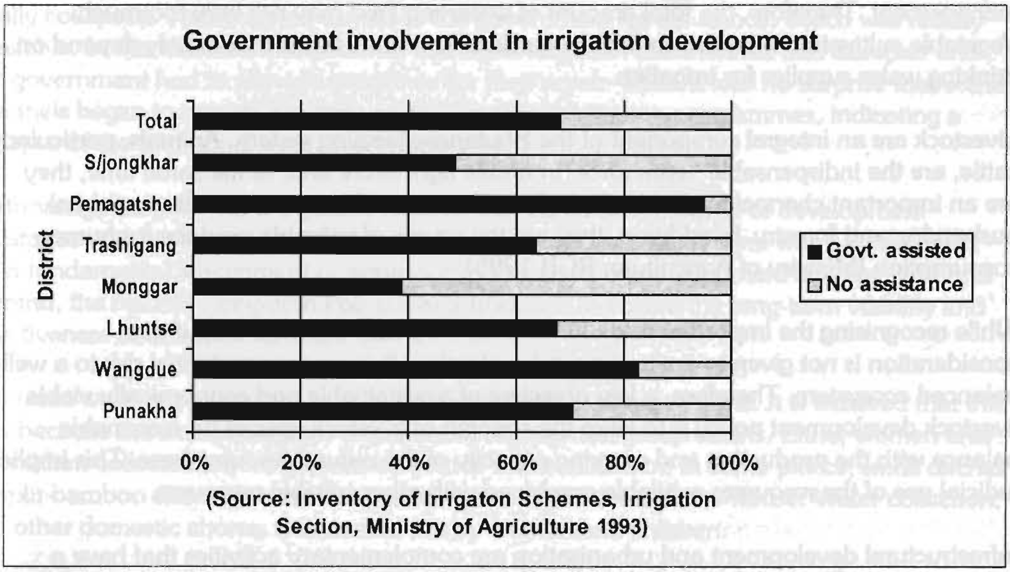

Figure 1.2: **A random sample of districts showing percentage of government assistance received**

One of the biggest problems in the water supply programme is the spatial distribution of communities benefitting from it. Villages are spread far apart from each other and, in the village itself, houses are scattered all over the place making it very difficult to build common supply points. Drinking water supplies that have traditionally been organised individually are new to community management and are yet to receive the support required, as is the case with irrigation, and hence, there is no management system. This has led to a high percentage of non-functioning schemes. Where such schemes have either failed or are non-existent, the individual has had to resort to his/her own means. In the past, this would have meant using split bamboo pieces laid end to end and supported on wooden stakes to form an open 'pipeline' drawing water from a stream or a spring. Others would have simply made a ditch in the ground. Nowadays, most of these bamboo structures are being replaced by plastic pipes.

4. Review and Analysis of Other Policies and Programmes

Of the other policies and/or legislation, the Forest and Nature Conservation Act of Bhutan, 1995, and the Livestock Development Policy and Strategy, 1995, contain topics related to water. The Forest Act stipulates that water is the property of the state and individuals or groups must acquire rights by obtaining permits from the Ministry of Agriculture. It prohibits felling of trees within 100 feet of the bank of a water body. Pollution control measures are also specified in the Act.

The Forestry Division is given the responsibility of managing government forest in keeping with the policy of maintaining about 70% of the country under forest cover. Timber extraction is allowed on a limited scale based on a sound management plan. Thus forest destruction is not a big problem except for in certain pockets where shifting cultivation has led to clearing of patches for food production.

Demand for water for agriculture has gone up with rapid expansion of plantation crops, viz. , apples and oranges. However, if one were to assess the quantity of water used in traditional wet land cultivation, substantial quantities could be saved with proper management. Therefore, the total amount of water required may not vary too much. Vegetable cultivation is limited to kitchen gardens and small farms that mainly depend on drinking water supplies for irrigation.

Livestock are an integral component of the Bhutanese farming system. Animals, particularly cattle, are the indispensable 'work force' in arable agriculture and, at the same time, they are an important channel for the multiple flow of nutrients between agriculture, animal husbandry, and forestry. In addition, they are the source of valuable produce for human consumption (Ministry of Agriculture, RGB 1995).

While recognising the important role of livestock, the policy cautions that, if due consideration is not given to environmental protection, it can pose a potential risk to a well-balanced ecosystem. Therefore, a key objective of a sustainable and economically viable livestock development policy is to keep the strength of livestock species, in reasonable balance with the production and carrying capacity of the natural resource base. This implies judicial use of the resources available combined with other suitable measures.

Infrastructural development and urbanisation are complementary activities that have a direct bearing on water utilisation. Land is buried under the sprawl of urban and industrial development, hampering groundwater replenishment. Competition for water between agriculture and other uses leads to shortages in supply. Roads open up access into watersheds, which more often than not leads to human settlement. Eventually, there is a rise in demand for social services, increasing the pressure on resources.

Even projects for harvesting water have similar consequences. Power projects require huge quantities of water, which, unless the water can be used for other purposes as well, does not necessarily optimise water use. Then, with the increase in available power, growth of industries takes place rapidly, further aggravating the supply situation. Similarly, big irrigation projects are plagued by problems of low water use efficiency, inequitable water distribution and undesirable environmental effects. Thus, there is a strong case for proper design of infrastructure complemented by good management for water harvesting.

Urbanisation is an inevitable consequence of economic progress and development. While it has its own merits, its impact on the environment is far from desirable. Rapid and unplanned urbanisation is a strain on the natural resources. Competition for land and water increases dramatically, further widening the gap between the resource-poor and the well-endowed.

5. INSTITUTIONS IN WATER HARVESTING

In the context of an agrarian society, the farmers, either singly or in groups, are the key players in water-harvesting. The Land Act empowers every citizen to make arrangements for the rational utilisation of water for his/her benefit. On the strength of this legal fillip, farmers took the initiative of building channels. Given the nature of the local terrain, farmers were compelled to organise themselves into groups to put their collective efforts to good use. However, in certain cases, individuals built private channels with their own resources. There was no or very little support from the government.

With the onset of planned development programmes, the Government took up new construction as well as rehabilitation of farmer-built irrigation channels. As the number of such schemes climbed steadily, the farmers began to see it as an easy way out of a demanding task. Routine operation and maintenance were neglected until the channel finally collapsed. Then farmers turned to the government for assistance, which was readily available. In this manner, many farmer-managed irrigation channels fell into disrepair and the government had to provide assistance for their repair. Thus, it was no surprise that some channels began to appear regularly on the list of rehabilitation programmes, indicating a collapse of the traditional institutions responsible for their upkeep.

Fortunately, the government quickly realised that the chosen method of development assistance was having a negative impact. It became apparent that there was a strong need for a fundamental realignment of approach in the irrigation development strategy. With this in mind, the National Irrigation Policy was introduced to ensure the long-term viability and effectiveness of investments made.

Domestic water supplies were usually arranged through private efforts. It is believed that this was because the small quantities required did not warrant group efforts. Either women and/ or children collected it from a common source in containers or, in some places, small ditches or split-bamboo channels were used to bring the water closer to the house. Water collection, like other domestic chores, was carried out by women and children.

Although the quantities involved were not significant, provision of safe drinking water was seen as a key element in the socioeconomic development of the people. Thus, the Public

Works' Division of the Ministry of Communications launched the Rural Water Supply project and many villages were provided with piped water. Tanks were built and tap-stands installed at central locations. It is estimated that 58% of the rural population and 75% of the urban population have access to water supplies (RWSS 1998). Of the over 1,700 schemes built, 30% or so fell into disrepair because farmers were not used to the idea of working collectively for repair and maintenance.

6. CONSTRAINTS AND OPPORTUNITIES

Sustainable water harvesting at the local household level can be achieved with the right blend of policies and programmes. However, such a conducive environment can be offset by a lack of resources. Shortage of funds and lack of appropriate technology are constraints to water harvesting. Technology, *per se*, is available, but it either comes at a high cost requiring continuous government support or it is relatively inexpensive but unsuitable from an environmental and/or managerial point of view. Irrigation development in the highlands faces mounting pressure from declining economic justification.

Another constraint is the geo-physical environment of the country. The young Himalayan mountains are vulnerable to erosion hazards. Landslides are a natural phenomenon in the fragile ecology of young mountains. This is further accelerated by human activities. Slopes that have attained some degree of stability are disturbed by construction of channels and clearing of land for cultivation. Natural drainage patterns are changed and the additional water introduced into the area causes in erosion and eventually landslides.

There is a tendency to favour infrastructural development over institutional building. While infrastructure is essential, it has to be complemented by adequate support mechanisms in the form of functional institutional arrangements. This is commonly ensured through training local government staff and farmer organisations, either to promote new local organisations, or to improve the way existing ones work. Formally constituted local organisations are the means by which the state and farmers assign rights and responsibilities to each other.

Different training techniques, *inter alia*, use of social organisers and farmer-to-farmer training, can be adopted. However, training should not be confined to operational management of infrastructure but should also highlight concerns for resource mobilisation for their maintenance (Vincent 1995).

Almost all the development policies and programmes are intended for the country as a whole. Therefore, there are no special programmes aimed at marginal farmers, though these would be desirable from the perspective of ensuring social equity among all users. Marginalised farmers are on the fringe of society and need special attention to draw them into the mainstream.

It is taken for granted that water will always be available in limitless quantities. Adequate quantities of good quality water are no longer freely available in quite a few places. There is growing competition for water, and it is inevitably the marginalised farmers who feel the brunt of such developments. It is essential to adopt appropriate technology to increase the efficiency of water-harvesting systems.

Considering that women are the ones directly involved in water collection and/or use, gender concerns need to be addressed in a proper light. Policies and programmes must be gender-sensitive so that women have equal opportunities to participate in planning, execution, and monitoring and evaluation of water development programmes.

In Bhutan we are fortunate that the population is still within manageable limits. Most of the problems associated with water in more populous countries are absent. This and the bountiful water resources have ensured that there is no crisis at the moment. However, with a high rate of population growth and expansion of industries, the situation may quickly change to an unfavourable one if appropriate measures are not taken. It is more or less accepted that, in view of the limited land resources available, horizontal expansion is not an easy option. This means that the increase in food production has to come from vertical expansion or by intensifying use of the available land. Efficient use of land and water has to be stepped up; improved seeds and modern irrigation techniques need to replace the present lot.

People's participation is the underlying principle of the decentralization policy of the government. Thus, there is active involvement of stake-holders with the *Gewog Yargye Tshokchung* (GYT) or Block Development Committees and *Dzongkhag Yargye Tshokchung* (DYT) or District Development Committees in all policy and programme formulation, providing the forum to voice their wishes and aspirations. This has been reinforced by the government's commitment to strengthen their institutional capacity. It has launched the 'Gewog' (Blocks) Development Fund (GDF) programme to make limited funds available for the Gewog to enable farmers to plan and implement projects prioritised by themselves. These would, if required, receive assistance from the districts and central agencies (Kammeier 1998).

With devolution of power to the village and block level, farmers can now choose where to invest their resources. The GYT has the authority to decide on the utilisation of resources available within the Gewog (Block). If, however, resources have to be mobilised from outside the block, then it should be addressed at the DYT at the district-level for their equitable distribution and allocation. Again, any change in the utilisation of a shared resource requires the consent of the other party (s) or can be taken up by the DYT.

7. RECOMMENDATIONS

Since all surface and sub-surface water-related activities are closely interlinked through upstream-downstream relations, the whole river basin or the watershed must be considered in all water development policies and programmes (Abernethy 1996). In order to achieve this goal there is a need for a central organisation to coordinate such activities. This can be achieved by setting up a National Water Resources' Authority to conserve, develop, and allocate water resources.

Although water may not be a scarce resource, the cost of its abstraction is becoming increasingly more expensive. Cheaper alternatives like rain water harvesting, mulching, and collection of runoff need to be promoted for use. Mulching as a substitute for irrigation in apple and orange orchards is already being studied. More research is required on this and other methods of water supply.

Notwithstanding the present efforts initiated to promote stake-holder participation in the allocation and management of water resources, this has to be strengthened. The participatory approach can be used to reconcile multiple or contradictory objectives and to reduce conflicts over ownership and control of water.

Poor management of water can have devastating effects on the environment. Introduction of irrigation has led to large-scale clearing of natural land, pollution from intensive fertilizer and pesticide use, and introduction and spread of water-borne diseases (Oi 1996). Landslides caused by irrigation channels are a common sight in many mountain areas.

Schemes for conservation and delivery of water should take into account all ecological and societal considerations. Studies must be initiated to determine the choice of technology. Where appropriate, modern techniques like drip and sprinkler irrigation should be promoted by providing technical support.

The key objective for all policies and programmes should be sustainability. Relevant institutions and livelihood strategies must be promoted while protecting the environment.

Improving the capacities and capabilities of personnel involved is a prerequisite. Farmers need to be trained in operational management as well as resource mobilisation. Cost-sharing of infrastructure and their maintenance should be mandatory for farmers. Agency staff should be equipped to carry out proper planning, monitoring, and evaluation and to work more effectively under the user- participatory environment. Policy makers can also be sensitised to issues concerning water rights, equity, service improvement, and user participation.

Development activities for water supplies require substantial resources. Funding is required to develop programmes, set up and evaluate water databases, and provide support to user groups. Local resources may not be sufficient to cover the entire range of activities, necessitating recourse to external assistance. Some of the funds can be raised by involving the private sector in domestic water supply systems, for example; and these efforts could be supported by the government by providing subsidies and technical cooperation.

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Annex 1

Relevant Organisations/Institutions/ Programmes

1. Land Record Division, Ministry of Home Affairs, Tashichodzong, Thimphu
2. Research, Extension and Irrigation Division, Ministry of Agriculture, Thimphu
3. Forestry Services Division, Ministry of Agriculture, Thimphu
4. Crops and Livestock Services Division, Ministry of Agriculture, Thimphu
5. Rural Water Supply and Sanitation Unit, Health Division, Ministry of Health and Education, Thimphu
6. Division of Power, Ministry of Trade and Industries, Thimphu
7. Gewog Yargye Tshokchung *(GYT), or Block Development Committee for each of the 202* Gewog *(blocks) in the country*
8. Water User Associations (WUA) ; formally constituted for government-assisted schemes and informal ones for the rest.

Chapter 2

Water Harvesting in the South Western Mountains of China

Changming Liu and Li Cheng

1. Overview

Water harvesting plays a vital role in mountainous areas, especially in the alpine regions where mountain inhabitants live on sloping lands and have agricultural land at higher elevations where water supplies a are less than required. In this situation, people have to travel long distances to fetch limited amounts of water. In many cases, water scarcity is widespread in the high mountains because poor water retention capacity. Hence, water harvesting is necessary to provide sufficient water for people, livestock, and agriculture in the mountain regions.

In order to provide water to people dispersed over difficult terrain for their animals and crops, water harvesting has been promoted rapidly in arid and semi-arid mountains of China and has also been actively promoted in the alpine regions of southwest China. For example, the southwest mountain areas in the middle reaches of Yaluzangbu River in Tibet have more than five thousand storage structures for water harvesting. Notwithstanding, there are still 250,000 people for whom water supplies are insufficient and for whom none of these structures are in place.

On the other hand, water harvesting has been successful in the Hengduan Mountains of Yunnan and meets the needs of 98,100 people and 69,000 animals in Nujiang county. However, another 58,400 people and 40,100 animals still do not have sufficient water.

In the alpine regions of southwestern China, water harvesting practices consist of collecting rain water runoff from very small or small catchments, the extraction of subsurface flows or interflows, digging of superficial wells to draw infiltration rain water or spring water, and roof rain catchment. In the absence of conventional irrigation systems, rain water is used to irrigate farmlands and ranches.

The mountainous regions in China account for 70% of its territory, and water harvesting is both very useful and also holds promise for the future. Besides the alpine areas, all the arid and semi-arid regions, which occupy two thirds of Chinese territory, including the rain shadow belt of the Himalayas and 6,600 or more islands along the sea coast, are introducing water harvesting to overcome water shortages.

2. POLICY AND PLANNING

Policies on water harvesting

According to the Chinese constitution, water resources, like other resources, belong to the state. Without water harvesting, high mountain areas would suffer from water shortages. This would result in loss of productivity and immense difficulties in developing and managing mountain areas; in addition to insufficient water. Hence, the Chinese government has promoted water harvesting and introduced many relevant policy measures and codes with the following six characteristics.

The Chinese government advocates water harvesting in the mountains, and gives priority to investments in water-harvesting projects. For example, the government offers more than 70 million yuan annually to develop "**One Jiang Two He**" regions: the Yaluzangbu River, Lhasa River, and the middle and lower reaches of the Nianchu River. These regions cover eighteen counties and cities. Out of the total investment, 50% is used to build water facilities to provide Tibetan counties and townships with engineering facilities to establish water-harvesting structures. Up to the end of 1996, the total fixed assets of irrigation works in Tibetan project areas was 12.9 billion *yuan*, and two hundred irrigation areas had been established. These areas have 5,000 or more water storage projects, 34 reservoirs with capacities greater than 100 thousand cubic metres, and 14 thousand water extraction projects. Owing to such water harvesting installations, two thirds of the cultivated land along with some grasslands are irrigated properly and urban water supplies are sufficient. On the other hand, water supplies are insufficient in some farming areas, and 250,000 people are still short of water.

Water harvesting and poverty alleviation

The harsh natural environment exacerbates poverty in these regions. The Hengduan Mountains are a prominent example. Blocked by high mountains and deep canyons and situated in a remote belt where the upper reaches of the Nujiang River, La-chang River, the Jinsha River, it contains more than 40 underdeveloped counties where 20 minority groups live. Insofar as harsh natural conditions prevail on the Qingzang (Qinghai-Tibet) plateau, poverty also prevails here: for instance there is no electricity in 21 countries, a situation that prevails in only 28 counties in China as a whole.

The most effective way to alleviate poverty is to build irrigation systems and roads. Therefore, the Chinese government drafted a notification about how to eradicate poverty from poor and disadvantaged regions in September 1984 and has been carrying out a plan for replacing aid with labour since that time. The plan includes building roads and irrigation works and developing water resources and so on. To improve the living conditions of mountain inhabitants is seen as the ultimate policy and aim of the government. Nowadays, the plan has promoted seven projects, all of which have a connection with water harvesting. Five of them are in quite similar and involve establishing water-harvesting facilities.

The funds for water harvesting come not only from the government's poverty assistance programme and the appropriation of small irrigation works, but also the aid donor's consortium. Since the inception of China's 'open door' policy, the total amount of international loans directly used by poor and underdeveloped regions in China is approximately 1.5 billion U. S. dollars, most of which has been spent for water-harvesting systems. For example, the World Bank loaned 0.25 billion U. S. dollars to assist the southwestern poor mountainous regions of China.

From the report of World Bank and its subsidiary, IDA, people in the poor regions of developing countries can benefit most from assistance for water harvesting, transport, education, and hygiene.

In China, local governments and water users conjoin to draw up extended plans for water harvesting, and these are supported by local government finance and to a certain extent from the consumers themselves. Local governments provide most of the funds especially if a plan is for poverty eradication, while local people mainly provide labour to build the system. Because water supplies can lead to improvement in local economies and increase in local living standards, there has been an increase in systems built on a voluntary basis by local people. MangKang County, located in the southeast of Tibet in the parallel flow belt of three rivers (Jinsha River, La-chang River and Nu-jiang River) in the Hengduan Mountain region has had a water-harvesting policy based on its needs and conditions since 1965. Different methods are followed and, depending on diversion projects, indigenous methods and miniature hydraulic works were used involving voluntary labour. These have irrigated 1,380 hectares of farmland, built 84 pools with a total capacity of 35,600 cubic metres and improved a further 4,000 hectares of land by controlled irrigation.

Increasingly, provincial governments and many local governments in mountain regions have encouraged households to construct water harvesting systems for drinking water supplies and to develop yard economies.

In 1995, Ganshu Province government began its rain water catchment policy to put its **'1-2-1 rain water harvesting project' into operation**. This means that **each household** in the project area makes use of the house, roof, and yard to catch rain water by forming a **one hundred square metre compressed surface** with poor permeability to collect rain water. The collected rain water is stored in **two cisterns or tanks** separately for drinking and production uses. **One** of them is projected to supply water for **one *mu* (15 *mu* per hectare) of land so that cash crops can be planted in the yard around the house. So** this is called a **'1-2-1 project'**. Up to the end of 1996, rain water cisterns reached 525,600 and the total area of yard economies extended to 7,813 hectares and 11,700 or more yard economy units were involved in livestock breeding and processing. At the same time, the project provided drinking water for 267,300 households with 1,310,200 people and for 1,187,700 livestock. Now, in the Ninth Five-year Plan (1995-2000), Ganshu Province has planned to expand water-harvesting areas to 266,667 hectares. Obviously, this illustrates the important role government policy plays in developing water harvesting.

Taking advantage of water cisterns, Shanxi Province started to implement a so-called 'nectar project' to encourage water harvesting in all the mountain areas of the Province in 1996.In accordance with the project proposal, Hengshan County in the Province proposed a '**21211** project' to carry out the 'nectar project'. The '**21211** project' means **two cisterns**, **one** '**mu**' (0.0667 ha) of garden, **two mu** (**0.1334** hectares) of water-saving cropping, **one thousand** '**Jin**' (500g) **per capita** with earnings of **one thousand** '**yuan**'. Counties like Hengshan and Wuqi have achieved **21211**'s aim initially and made appreciable progress in agricultural development by using rain water cisterns.

Combining rain water catchment systems with other miniature water development projects, the water-harvesting policy for southwestern China has adopted an integrated approach. In the mountain areas of this region, the high mountains and deep canyons hinder movement of local commodities and, as a result, the local economy. Additionally, both the predominant natural economy and bad infrastructure (facilities) make the economic basis weak and productivity low. Furthermore, cultural diversities also make local management complex. All these factors augment the disadvantages from which the area suffers. Although sources of water are plentiful enough in the mountains, cultivated land is impoverished and cereal production limited, making it difficult for people and their livestock to survive let alone develop the economy. Only by conserving water can the current situation be improved. As everyone knows, besides illumination, hydropower can be used to process grain, feed stuff, and food, employ labour off-farm, and provide alternatives to herding in industry and associated sectors. Moreover, since firewood can be replaced with hydropower, forest and grass can be protected, conserving an environment that is conducive to agriculture and animal husbandry by preventing soil and water loss.

A demerit of hydropower establishment is the substantial investment needed for construction and the amount of time it takes compared to thermal power plants. However, when hydropower is associated synthetically with flood control and water supplies for irrigation, the investment is worth carrying out with higher benefits compared to costs. Therefore development of miniature water structures should be encouraged, so that water resources can be exploited in an integrated manner to provide a big economic benefit from such policy.

Water-harvesting planning

Sustainable development must be considered as the final goal. So far as water resources exploitation are concerned: firstly, the development and use of rain water should support water resource systems to be continuous and sustainable; secondly, the developm.ent and use of rain water resources should be associated with meeting the requirements of social and economic development at local level. These two factors are mutually dependent, so that rain water harvesting is of great significance and must be integrated with sustainable development.

Harmonious development of human activities, rain water resources, ecology, and the environment should be the principle for planning. It is well known that water is one of the most important resources for human survival. This resource has two attributes. While the positive attribute of water is that it is a useful natural resource essential for human production and survival, the negative attribute is its association with disasters that threaten and harm human beings such as floods, water logging, and drought. Rain water harvesting should be organised in such a way that water can be supplied to people who are living on high mountain slopes away from streams.

Based on the hydrological cycle, rain water should be seen as an original source transforming into surface water, soil water, groundwater, and water contained by vegetation. So harvesting rain water involves integrated development of all water sources for use.

Priorities for increased water-harvesting activities are planned over the long term in accordance with objective of meeting the growing needs of the population growth and increased production by mountain inhabitants. Water harvesting has to be planned in accordance with the availability of rain water in time and space through careful investigation and survey. This work requires technical assistance from government and relevant institutions.

Planning for water harvesting should follow the sequence outlined below.

- Analysis of basic conditions such as the rainfall regime, topographical conditions for water harvesting, and the socioeconomic situations

- Planning objective, necessity and feasibility analysis for harvesting water, its storage, and use
- Determination of the demand for water for drinking, livestock, and agricultural use in terms of water needed for field crops based on water-saving farming techniques
- Place and scale of water collectors (water harvesting, place and scale) should be planned on the basis of analysis of the balance between water demand and water supply
- Planning of storage techniques by establishing storage structures for water harvesting and storing according to water requirements in mountain communities
- Planning water supplies according to irrigation needs and optimum use of water by proper selection of irrigation systems and facilities
- Budgetary planning and cost-benefit analysis so that funds can be provided to build storage facilities.

The investments for construction should be shared by national and local governments, and water users should provide the labour to implement the plan, to provide water harvesting facilities, and to manage water-harvesting systems.

Four case studies from different mountain regions of China are discussed briefly to illustrate the impacts of water-harvesting policies on the lives of local people.

Case 1: Water harvesting in the southern high mountains of Tibet

Background information

The rain shadow area of the southern high mountains of Tibet, the southern area of Lhasa City, Shanpan prefecture and some counties of Xigaze prefecture are the main agricultural areas; population density in these areas is greater than in other parts of Tibet. Unfortunately, precipitation is only between 300 and 400 mm and the climate is semi-arid. Influenced by the monsoon, about 80% of the annual precipitation is concentrated in the summer season from June to September. Shortage of water is a serious problem in these regions.

Policy and development of water harvesting

In order to solve the problem of the shortage of water for drinking and irrigation, people are usually organised into natural village units to build ponds and storage for harvested water. Methods used include the tapping of subsurface water, the storage of cataracts, the collection of rain water, and diversion of water from storage and creeks, ponds, and others. Such sources are important areas of supply in the dry season.

Mainly, along the banks of creeks and at elevations between 3,500 and 4,200 m, these ponds have different sizes, from tens of cubic metres to millions of cubic metres. Almost every village possesses one or several ponds. In some cases, the ponds are distributed along the low-lying slopes or at the foot of slopes to collect the intermittent flow from gullies and sub-surface water. In such situations, they usually do not dry-up, but it is difficult to fetch water from them due to their distance from the village. In other cases, the ponds are located on the plains to collect cataracts and rain water for people and livestock. However, the quality of the water is poor and the ponds often shrink after the rainy season.

There are nearly sixty small ponds in the five administrative villages lying along the Zhanang channel in Zhanang County, Shannan prefecture. The biggest one can supply water for fifty households, about 300-350 people. However, the ponds are small, and can only supply water for three to five households with about 20-35 people. Owing to the collection of subsurface water and rain water, and even some collection from cataracts, the ponds upstream of the Zhanang channel do not dry up in a normal year. In the dry season, water can only be collected during the night. These ponds can only supply drinking water for people and livestock with a little water for irrigation. On the other hand in the downstream areas of Zhanang channel, the ponds collecting rain water and cataract water are only sufficient for drinking water not for irrigation. They usually dry up in the dry season. In such case, it is difficult to get sufficient drinking water, and furthermore, the quality of water is relatively poor.

Water harvesting and hydropower development

With the improvement of small hydropower schemes in recent years, the government has developed successions of wells for drinking water supply in association with these. Zhanang channel, for example, has twenty wells, but some of them, such as those in Shajia in Xigaze prefecture and others in counties in the Xietongmen region have water that is not suitable for drinking. So there is still a long way to go for drinking water as these wells need to be checked and the water analysed. Nevertheless, water harvesting is still an efficient way of supplying water for rural farmers and herdsman.

Case 2: Water harvesting in the Hengduan Mountains of Yunnan

Background information

The West Hengduan (Traverse) Mountain areas of Yunnan are unique geographically. There are three mountain range systems, viz. , the Gaoligong, Nushan, and Yunling mountains. They extend from south to north and the highest peaks are all above 5,000 metres. Among the peaks, the elevation of the highest peak, Cagert Peak in Yunnan Province, is 6,740 metres high. From these high mountains and snow peaks, the Nu jiang (Salween), Langcang (Mekong), and Jinsha (upper part of the Yangtze) rivers flow southwards.

The Hengduan Mountain areas in Yunnan Province include Diqing Prefecture and the Lijiang area of Nujiang prefecture, accounting for a total land area of 38,000 sq. km. the population is 800,000 and the population density is 21/ km^2, differing widely between sub-areas, with a high of 62/ km^2 and a low of below 8/ km^2. Eighty-two per cent of the population are from minority ethnic groups such as the Tibetan, Lili, and Naxi.

Survey of water resources

The main source of water in Yunnan is rainfall and small amounts of snowmelt in the warm season. So the distribution of water resources in space and time is basically according to the rainfall distribution pattern. Consequently, water allocations throughout the year are in accordance with rainfall conditions. The weather conditions vary depending upon the south current of the dry-hot west wind from November to April; and the weather is mainly sunny with strong sunshine and few clouds. However, when the warm-moist Bengal air current influences conditions from May to October, there is plentiful moisture and thick cloud, causing abundant rainfall on the windward slopes of the three mountain ranges. The densest annual precipitation, for example, reaches 4,000 mm on the leeward slopes and valleys. Because of the orographic influence and rain shadow effect, rainfall decreases gradually from the western to the eastern slopes, and the rainfall increases from the valley bottom to the mountain peaks. Since the river courses are long, the runoff waters from the Nujiang, La-chang, and Jinsha rivers are very plentiful. On the headwaters of these rivers, the flows mainly come from snowmelt and groundwater, and, in the lower reaches, the flows mainly come from rainfall recharge. Furthermore, there are many tributaries and stream networks, with almost one tributary every two to four kilometres.

Development of water-harvesting projects

In the Hengduan Mountains, the rainfall reaches even the highest peaks, but because of the topography and the neglect the area has suffered throughout history, there is a perennial shortage of drinking water for both people and livestock For example, drinking water was provided for 98,100 persons and 69,000 head of livestock by the end of 1988; 58,000 people and 40,100 draught animals in Nujiang Prefecture are without water. There is also another problem in terms of water quality. In this area, water is deficient in iodine and contamination has caused endemic diseases; and these cause serious health problems. Although there are plentiful hydro resources, the current water conservation projects can only control 200 million cubic metres and only 150 million cubic metres are used: about 6.9% of the total water, available (below 0.14% if all available water resources are taken into consideration). The established hydroelectric capacity is 31.9 MW (16.9 MW from the Nujiang River and 15 MW from the Diqing River). Moreover, each county has a mainstay hydropower station, and the townships have mini-structures and small hydropower stations.

Existing problems in technology and institutions

Water harvesting is a very old method of resolving the shortage in supply of drinking water for people and livestock. The technology needs improving, but this is not a major problem. There have been quite a few good examples of yard-economy development through use of water-saving technology. Sufficient input and good instruction are the essential conditions. In the mountains, additional attention must be paid to the hydrologic complexity and adequate policy measures for water harvesting management must be established.

Challenges for water-harvesting technology

Hydrologic characteristics in mountain areas differ greatly from those in the arid and semi-arid plains. The main arguments are as follow. The immense difference in precipitation on windward slopes compared to leeward slopes is caused by the topography and by the rain- shadow effect. The rainfall on the leeward slopes is quite sparse. For example, the annual rainfall in the middle reaches of the Yalu River is only from 300-600mm. Only a small amount of the rainfall converts into river runoff and supplies groundwater, most of the rainfall is lost by evaporation. The evaporation and stream water that flows out can cause a shortage of water. If 10% of the water lost were to be collected, it would provide benefits for 33,682 sq. km land. For windward slopes, the rainfall is plentiful. For example, the annual rainfall on the windward slopes of three mountain ranges (Gaolingong, Nushan, and Yunling) in Hengduan Mountain areas can reach 4,000mm, while precipitation in the arid and semi-arid areas is too low, from 300-600mm. However, because the area has a monsoon climate, precipitation is concentrated between July and September. In addition, on the high mountains and steep slopes, rainfall runs off rapidly. Flooding in the valley-belts provides abundant water in the rainy season. So, these areas are not suitable for habitation and people in this region live on the slopes away from water courses and hence drinking water supplies are short during the dry season. Furthermore, geological formation in these mountain areas is very intense, and the rock patterns are crushed and folded. All these serious conditions have restricted the efficient use of water-harvesting technologies.

Examples of the above problems can be seen in the parallel belts of three rivers (the Nujiang, Langlang, and Jinsha) where as a result of insufficient hydrological investigation by certain gravity flow water projects, site selection was not optimum and resulted in excessively circular channels; and thus water supplies could not be assured. An added problem was serious leakage. All this and bad maintenance have resulted in many projects being out of order. In short, the utility of the projects is poor. In another example, paucity of large storage projects along the Nu-jiang River in Diqing Prefecture, has led to extraction of water by pumping it out from hydroelectric stations. The stations are, however, short of regular supplies of water and the output of hydropower is poor and generation of electricity unstable. A lot of water is wasted during the seasons of abundance, whereas power generation is poor during spate. This has resulted in widespread shortage of electricity. Shortage of electricity consequently affects the development of agriculture and industry in mountain regions. So, water harvesting should be an engineering system based on adjustment of water storage and collection of surface runoff.

General problems in managing water harvesting

Water-harvesting management consists of designing, implementing, and operating activities as well as their social implications. Hence, water-management problems should be considered in an integrated context. Generally, the first problem is that each office for managing water resources does things in its own way and takes little care of the mutual relations and cooperation among government organisations and administrative divisions. For example, separate departments administrate water supply, irrigation, hydroelectricity, aquatic ecology, and transportation. Water quality, quantity, and the environment of water bodies are the responsibility of different offices or agencies. So, comprehensive planning of water development does not take place.

The second problem is lack of systems supporting maintenance supporting. In general, after a mainstay project is finished and some irrigated areas begin to profit from a project, the project is no longer listed in the budgetary plan associated with maintaining project structures. The maintenance of structures and associated project systems are neglected for a long time because of the poverty of the local people who are unable to bear the costs of irrigation. In the end, many irrigation systems cannot attain their projected goals Furthermore, after the irrigation systems are transferred to the administrative office, water fees are needed to operating it. This includes the costs of salaries and welfare of the administrative staff. Therefore a certain subsidy should be provided to mountain people by the government. The third problem, however, is that the project, when combined with poverty alleviation, is less concerned with the costs of water. Thus projects emphasise the economic benefits and ignore the accounting aspects, assigning a lower price for water than its actual economic value. The direct results are insufficient maintenance and poor service; insufficient measures to ensure sustainable development. The fourth problem is that water quality and water-related environmental management are not considered to be critical issues and the end result is endemic diseases.

Case 3: Harvesting rain water in eastern Qinghai Province

Background information

The Qinghai Province is a part of the Qing-Zang Plateau and is located in north Tibet. It has a total area of 720,000 square kilometres. The average annual precipitation is 286 mm.

About 350 mm of precipitation occurs in the eastern area of Qinghai; a semi-arid mountain area There is a population of almost four million people, mainly living on cistern water. Most of these cisterns are clay-cisterns, and the rain water collection system uses natural ground or yards, resulting in poor hygiene, contaminated water, and bad construction causing seepage and even collapse of the cisterns.

Development of rain water harvesting

Since August 1996, a rain water harvesting project for 2,300-2,700 metre high mountains in eastern Qinghai has been constructed by rebuilding and replacing old clay-cisterns with brick-cisterns. Each house built two 30-cubic metre round brick-cisterns and 100 square metres of brick-catchment to collect water in every yard. One cistern collects rainfall from the roof and yard for drinking water. Rain water harvested from the road and ground outside is stored for irrigation. At present, this kind of structure can be found in Huangzhong County, Pingan County, Ledu County, Minhe County, and Hualong County in Qinghai Province. The structures serve 190,000 households reaching nearly one million people, if one estimates five persons per house. At the same time, some old clay-cisterns were lined with brick inside, to establish 400,000 brick cisterns that collect up to 11 million cubic metres of water. Nearly eight million cubic metres of harvested water were stored after autumn in 1998 and were ready to provide drinking water during the winter and water for irrigation the following spring.

Experience in institutions and diversified use

During implementation of structures, the government was responsible for providing cement and a subsidy of 1,000 yuan per one household as well as transportation costs. In addition, counties were provided with technicians to guide construction work. The beneficiaries prepared the sand and stone, and built the cisterns themselves. After one year of operations, the water of these new cisterns provided drinking water of relatively good quality in terms of PH value, total amount of bacteria, colicin count, and so on. Now, have an assured supply of drinking water and furthermore they have been able to grow vegetables in gardens and irrigate some of their fields since 1997.

Along with the building of plastic greenhouses, vegetables are grown in gardens using drip irrigation and micro-spray irrigation. Water is extracted by electric pumps, hand pumps, and manually from the cisterns.

Use of harvested water for irrigation through financing schemes

Field irrigation mainly depends on pressure in drip irrigation and seeping irrigation. Using a drip irrigation system introduced by the Luyuan Company in Beijing along with plastic film, wheat and corn were planted in strips at regular intervals in Zhongbao Haiyugou village, Huangzhong County in 1998.Drip irrigation was carried out six times and the amount of water was 534 m^3/ha. A bumper crop was seen that year. Planting only corn from the Corn Department of the Chinese Ministry of Agriculture, up to 6,667.5 kg was produced per hectare. It was the first time in record that a yield such as this was harvested in the high, frigid (reaching an elevation of 2650 m) and arid mountains.

Using perforated pipes from Huayuan Henan, a seeping drip irrigation test for spring wheat was carried out watering the crops three times and using 370.5 cubic metres of water per hectare. As a result, 4,470 kg of spring wheat per hectare was harvested. Neighbouring lands without seeping drip irrigation produced only 3,045 kg per hectare, hence seeping drip irrigation can increase production by 46.8%.

Today, facilities for field irrigation are financed mostly by the government and are usually managed by water stations in each county. Some of them are administered by the farmers themselves. In 1999, beneficiaries were provided with facilities for field irrigation, aided partly by the government and paid partly by the farmers themselves in order to extend the scale of rain water harvesting. According to the funds budgetted, 20-25 thousand households will benefit, which means about 100-120 thousand people.

Case 4: Water harvesting in the southwest mountains of Sichuan Province

Background information

This is a case study from Liangshan Yi Autonomous Prefecture in the southwestern part of Sichuan Province. The Prefectures covers a territory of 61,000 square kilometres and has a population of 3.8 million. About 40% of the population belong to the Yi minority ethnic group. The prefecture is a typical mountain region and mountains account for 91.7% of its total area. The high mountains are cut deeply by the Jinsha River and its tributaries. Elevations in the prefecture vary from 305 to 5,958 masl. Most of the areas in the Liangshan Prefecture lie in the subtropical zone. Climatically it has a wet season from June to October and a dry season from November to May. Annual precipitation is about 1,000 mm, of which 90% is concentrated in the wet season. Annual pan evaporation is much higher than precipitation. For example, in Ningnan County, annual pan evaporation is 1,939.6 mm while precipitation only amounts to 960.5 mm. In the dry season in April and May evaporation is twice precipitation. In the dry and hot valley of Jinsha River the lowest yearly precipitation and the highest yearly pan evaporation are 600 and 3,000mm respectively.

Presently, in Liangshan Prefecture, 592,000 ha of cultivated land are under irrigation. The rest is rainfed land and prone to drought. Since 1952, a number of water conservation projects, such as reservoirs, irrigation canals, and ditches, have been constructed in the prefecture. The irrigated land has increased by 6,440 ha. Most of the land in the prefecture has no irrigation facilities. Four hundred and twenty-five thousand people and 913,000 cattle are short of drinking water. It is difficult to construct water conservation structures to provide sufficient water to all the mountain regions in Liangshan. The landscape is deeply dissected and people live in scattered settlements. Since 1983, micro-engineering work has been carried out to provide water storage facilities in areas suffering from drought.

Development of water harvesting

In Tongkuan village, Huidong County, Liangshan Prefecture, water-harvesting techniques have been introduced to provide sufficient water in times of drought. In the history of the village, there are even stories about residents fighting with wolves over drinking water. In 1983 people dug a few simple water storage ponds to collect runoff. The ponds had no sedimentation hollows or covers. The walls were not lined with concrete or brick and by Spring of 1984 one third of the collected water was remaining in the ponds. This was due to heavy water losses caused by seepage and evaporation. Such problems should be taken care of in future because, after 1983, a lot of ponds were built in the village. Only with proper care can people harvest water efficiently.

Experience in managing water harvesting ponds in Tongkuan Village drew the attention of leaders and engineers from both the county and prefecture. They realised the significance of the village's experience for the county and the prefecture. The simple ponds needed to be improved to overcome shortcomings such as heavy losses of water through evaporation and seepage, sedimentation, and collapse of the earthen walls of the ponds. A research project on water-harvesting techniques supported by the government of Liangshan Prefecture and the Bureau of Water Conservancy and Electricity of Liangshan Prefecture was carried out in the middle of the 1980s. Huidong and Huili counties were selected as experimental regions for demonstrating water-harvesting techniques. Great improvements have been made in water-harvesting techniques and in applying and transferring the experience from these counties to other counties. A simple ground pond has been converted into a standard underground cistern. In the winter of 1991, a regional working meeting on micro water conservancy works in Sichuan Province was held in Huili and Huidong counties. Since then, water-harvesting works have been applied and have spread widely.

Progress and problems to be solved

Up to August 1996, 163,854 underground cisterns had been built with a total storage volume of 594 million cubic metres in Liangshan Prefecture. Water from the cisterns had irrigated 1,530 ha of farmlands. Drinking water was supplied to 60,000 people and 90,000 cattle in the during dry season. Thanks to the establishment of water harvesting works, the value of agricultural output from the Prefecture had increased by 89 million yuan. The farmers' yearly income totalled 64 million yuan (about 8 million U. S dollars).

Through water harvesting, great changes have taken place in a number of villages in the Prefecture. Tongkuan Village has 450 underground cisterns for drinking water. The area irrigated has reached 100 ha. In 1995, per capita grain productivity was 544 kg and the per capita income averaged 2,921 yuan. The village has become rich thanks to water harvesting. Chanxian village of Huidong County is a typical mountain village which in the past frequently suffered from drought. Although farmers worked very hard, the yearly grain production was no more than 1,350 tonnes before 1991. The poor harvest was because of water shortage. Since 1991, water harvesting has led to a yearly grain production increase to 1,600 tonnes. Farmers have produced more than 400 kg of grain per capita per annum. There was an increase in per capita income of 402 yuan on an average in 1992. In 1995, 1,210 underground cisterns were constructed and now each household has its own cistern. Farmers produced 450 kg of grain and earned 900 yuan in cash per capita in 1995.

Lessons from water harvesting

The above case studies have shown that water harvesting has made three principal breakthroughs, has three criteria for suitability, and provides three benefits. Firstly, as a strategy micro water harvesting can be carried out in association with large water conservation projects. Secondly, it can be carried out easily by local people. Thirdly, the underground cisterns only lose a little water through evaporation, transportation, and seepage.

As to the three criteria of suitability, firstly, the underground cisterns are suitable in the climatic conditions in terms of overcoming the problems of uneven distribution of water between the wet and dry seasons. Secondly, the cisterns are suited to the scattered farm lands and households, because underground cisterns can be set up almost anywhere. Thirdly, support is easily found because construction costs can be borne locally.

In terms of the three benefits, firstly, water harvesting is a convenient way of providing irrigation in the mountains. For example, one underground cistern can serve one or two *mu* of dry farmland. During sowing in Spring water is available from the cisterns when it is needed. Secondly, water from cisterns is reliable as drinking water during the dry season. Thirdly, water cisterns are ecologically compatible as they do not take up space on the surface of the land.

3. SUGGESTIONS FOR DEVELOPING AND MANAGING WATER-HARVESTING SYSTEMS

The importance of water supplies cannot be overestimated in terms of long-term development of agriculture and a sustainable increase in productivity in mountain areas. Hence the importance of water harvesting and a long-term plan to develop and manage water harvesting and auxiliary systems. A comprehensive strategy that takes ecological and environmental conditions, socioeconomic implications, user participation, water prices, and cost recovery into consideration is essential. The objective is to assure sustainable development of water harvesting.

Systematic and intensive studies on water harvesting development should focus on the features of mountain hydrology. Perhaps water harvesting can be used as a supplementary technology for irrigation in mountain areas? Can an optimum system of technology and management that will ensure water balance and water and soil conservation be found? What are the economic benefits of water harvesting in the mountains? Only by answering these questions can the position and function of water harvesting in mountain areas be assessed. Such answers can help determine national investment and design for water technology and management.

An integrated management framework should be worked out based on a series of laws: Water Law, a Law for Water and Soil Conservation, and so on. Measures for a permit system for water extraction should be strictly implemented. At the same time, by using economic, legal, and administrative measures, integrated management to assure scientific allocation of water resources should be implemented. Administrative integration for planning, maintenance, operation, permission for water extraction, levy of water fees, and quality and quantity control should be ensured.

Proper budgetary allocation for investment in poverty alleviation in the mountains is necessary. This means rational pricing and a policy for cost return and cost recovery. In turn this will lead to efficient use of water. Otherwise, wastage will continue.

Training officials and technicians in good water-harvesting techniques is advisable. Such knowledge should be passed on locally as soon as possible to raise consciousness about the importance of water harvesting. It is more important to train administrators who can comprehend water harvesting policies and who have a long-term view of sustainable development as they will be instrumental in promoting and developing water harvesting.

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Chapter 3
Policies, Programmes, and Institutions in Promoting Local Water Harvesting in the Indian Himalayas

V.S. Saravanan

1. Introduction[1]

The Himalayan mountain system is both fragile and dynamic, and is one of the principal sources of fresh water in the Indian sub-continent. In fact, increasing erosion and loss of topsoil, leading to downstream flooding and general environmental degradation have been subjects of debate, uncertainty, and confusion (Ives and Messerli 1989) from the 1980s. Since then, restoration of the ecology through community-based initiatives received considerable attention in policies, especially in the 1990s. However, many of these policies fall short of expectation because of lack of understanding of the community and environment. This report calls for a contextually relevant policy that promotes joint activities between the community and state by facilitating community-based initiatives to restore the fragile ecosystem.

The study builds on the extensive study of traditional water-harvesting structures in the Himalayan region by the Centre for Science and Environment. From the case study literature from Himachal Pradesh, Mizoram, Jammu and Kashmir, and Uttar Pradesh and based on field visits to the Uttar Pradesh (UP) hills, the study recommends a thorough investigation in order to formulate an appropriate policy for the region. It provides a framework for debate about the nature of its implementation in a particular region.

The following section broadly describes the dynamic nature and the dichotomy of the development that needs to be considered in promoting water harvesting in the region. The third section provides a detailed review of the traditional water-harvesting systems in four ecologically categorised areas in the Himalayan region and the factors that have led to their deterioration or decline. Current policies and programmes are critically reviewed in the fourth section, and the relevance of water-harvesting technologies promoted by the government, NGOs, and communities examined. In addition, the paper calls for an understanding of the functioning of community-based institutions and the role of development agencies in promoting participatory governance. The study calls for a policy

[1] The author wishes to thank Anil Agarwal, Director, CSE, New Delhi, for his comments

that combines the efficiency of traditional communities with that of government institutions through joint activities promoting efficient water harvesting in the Himalayas. It concludes by discussing implications of policies on the Himalayan region.

2. The Diverse and Dynamic Himalayas

The Himalayas constitute a unique and complex system of fold mountains that is geologically active and dynamic. The mountain range stretches about 2,800 km and are about 380 km wide. The Himalayas cover a total area of about 5, 94,437 sq. km with a population of 30.5 million: the population has increased by about two thirds since 1971 (Bandyopadhayay 1999). The range in India stretches from the river Indus in the West to the river Brahmaputra in the East, broadly encompassing the Trans-Himalayas (Ladhak, Lahul, and Spiti), Western Himalayas (Jammu and Kashmir, parts of Himachal Pradesh, and Uttar Pradesh hills), Eastern Himalayas (Darjeeling district of West Bengal, Sikkim, and Arunachal Pradesh), and the North Eastern hills (Mizoram, Manipur, Tirupura, and Nagaland, and Meghalaya) (Table 3.1).

Table 3.1: **Area (sq.km) and population (in '000s) of the states in the Indian Himalayas**

State/ Sub-region	Area (sq.km)	Population 1971	Population 1981	Population 1991
Jammu and Kashmir	222,236	4,617	5,982	7,719
Himachal Pradesh	55,673	3,460	4,238	5,171
UP Hills Districts	51,125	3,822	4,780	5,926
Sikkim	7,596	210	316	404
Arunchal Pradesh	83,743	468	628	865
Nagaland	16,579	516	773	1,216
Manipur	22,237	1,073	1,434	1,837
Mizoram	21,081	332	488	686
Tripura	10,186	1,556	2,060	2,745
West Bengal (Dargeeling)	3,075	782	1,016	1,300
Meghalaya	22,489	1,012	1,328	1,775
Total	579423	12848	23043	29644

Source: Bandhyopadhayay1999

The Himalayan mountains are a critical determinant of the climate in the Indian subcontinent. In the winter, they serve as an effective barrier to the intensely cold continental air blowing southwards towards India, to keep it comparatively warm. . During monsoon, they force the rain-bearing winds from the south to deposit moisture on the Indian side. The rainfall pattern demonstrates a decreasing trend along the Himalayan arc from east to northwest; matched by a general decrease from south to north with each successively higher topographic alignments from the Siwalik foothills to the Greater Himalayas producing windward maxima and leeward rain shadows. The climate within the Himalayan region varies considerably. On one hand, cold deserts in the Trans-Himalayas and, on the other, dense rainfall in the north-eastern Himalayas resulting in unusually low flows or superabundance of water. However, this does not always remain the same. For instance, in 1992, there was no rainfall in Nepal, it was sparse in the eastern Himalayas, but the Indus basin in the west was ravaged by floods (Bandyopadhyay and Gyawali 1994). At the micro-level it varies to a great extent. Local mountains strongly influence its distribution. With minor ranges, spurs, and valleys running in different directions, rain-bearing winds often enter only through narrow gaps. The northern slopes and east-west oriented valleys usually receive less precipitation because of the rain-shadow effect than southern slopes or north-south oriented valleys. Rainfall also varies with altitude (CSE 1991).

Water supplies are affected by the geodynamically active mountain system. It is estimated that the upliftment of the Himalayan region at the rate of seven mm per year is accelerating the rate of erosion from 0.13 mm per year in dry season to 0.91 to 3.38 mm per year during the rains (Valdiya 1997). This has resulted in voluminous production, sometimes 500 to 1,000% of the suspended bedload that fills valleys and reservoirs (Valdiya 1997). It is estimated that sediments from the Himalayan rivers contribute a quarter of the ocean's sediment (Valdiya 1997). Over this massive landscape, human activity has wrought enormous ecological changes over the last few centuries. Large areas have been deforested, agriculture has expanded, vast road networks have been built, and numerous dams have been constructed or are under construction.

This complex mountain system consists of high mountains, intermontane valleys, and plateaux that produce one of the largest renewable supplies of fresh water to more than a billion people. However, this life-giving ecosystem brings misery and deprivation to a large number of people caused by climatic, physiographic, geologic, and man-made factors.

The dichotomy of development in the Indian Himalayas

The water resources in the Indian Himalayas are estimated (CSE 1991) to be about 1,20,700 million cubic metres in average annual flow. Of the three major rivers in the Himalayan region, the Brahmaputra, Ganges, and Indus have an average annual flow of about 606.7,390, and 210 million cubic metres per year, respectively. This water has the potential to generate 28,150 megawatts of electricity and to contribute about 2,46,000 million cubic metres of water for irrigation (Valdiya 1997). However, the complexity of the region makes one question the reliability of using this potential. For instance, Valdiya estimates that 15% of the rain water is able to percolate down through the ground of treeless slopes to recharge the springs, the remaining 85% flows as surface runoff and causes floods (Valdiya 1997). On the contrary, Kumaon University scientists reveal that most of the rains become subsurface flows and only 0.3 to 1.3% of rainfall flows as surface water. The non-forest area has more surface flow but with less magnitude (CSE 1991). This is corroborated by scientists in Nepal who have argued that, even during heavy storms, surface runoff is rare and of small amounts, the presence or absence of forest makes little difference (CSE 1991). However, the Himalayan glaciers that cover about three million hectares or about 17% of the terrain are a unique reservoir that supports the mighty river systems. Controversy notwithstanding, the evidence shows that there is enough water in the Himalayan region; a 'too-little-too-much-water' syndrome.

It is this syndrome that helped human societies in the Asian uplands as well as those in the plains to flourish for generations. Traditionally human societies have developed the means to use the mechanical energy of water for micro-hydel power and intricate local institutions have developed to use water for irrigation and domestic needs. In the lower basins, fine silt deposited by the annual floods created new land and improved the fertility of the soil. However, in recent decades there has been increasing outside interest in the Himalayan environment. One of the foremost is manifest in the increasing accessibility made possible by building roads. This not only led to the beginning of pressure on water resources in the region, but also neglected the importance of traditional irrigation systems causing an increased threat of natural disaster in the region (CSE 1991).

One of the prime motivations for large-scale intervention into Himalayan water supplies was the demand for irrigation, flood control, and hydro-electricity from the people in the Himalayan plains and, more recently, the demand for water supplies to major cities. All these have combined to promote construction of large dams to ensure the necessary modulation of water flow. It enhanced political acceptability, while undermining economic and technical feasibility (Singh 1997). Underestimation of flood flow and inadequate understanding of hydrogeology and man-made floods were serious limitations to these programmes. The strong plea to intervene in the region, to build large dams as a basis for fighting the poverty of the lowland population was derived largely from the economic interests of the plains. This is clearly visible in the 1950s and 1960s when extensive canal networks were built in the Gangetic plains of Uttar Pradesh, the Punjab, and Haryana, while there were no interventions in the Indian Himalayan states apart from Jammu and Kashmir. On the other hand, investments that are directly in the interests of mountain village economies were far too marginal (Bandyopadhyay and Gyawali 1994).

Environmental problems in the region emerged as a result of the negative effects of the very process of development and of the conditions of poverty and underdevelopment of the mountain village communities. This 'dichotomy of development' assumes importance in considering water harvesting in the Himalayan belt for use in space and time. Any effort in this direction must not only integrate the social and environmental conditions of the region, but also understand the geodynamically active mountain systems.

3. The Study Area

The complex Indian Himalayas encompass diverse physiography, geohydrology and rainfall patterns. These diverse environmental settings can be dealt with in four homogeneous ecological regions; the Trans-Himalaya, Western Himalaya, Eastern Himalaya, and Northeastern Hill ranges.

Trans-Himalayan region

The Trans-Himalayan region, consisting of Ladakh in Jammu and Kashmir and Lahul and Spiti in Himachal Pradesh, characterises the cold desert area of the region. The average annual rainfall decreases from 279 mm in Lahaul and Spiti to 140 mm in Ladakh on the edge of the Tibetean Plateau. In this wild and desolate region it is surprising that in Lahul and Spiti about 84% of the total work force is engaged in agriculture and about 0.2% (3,007/1,220,000 mha) of the land is under cultivation. In Ladakh, a major proportion of the precipitation is in the form of snow, and it is difficult to use for irrigation. However, a large area of cultivable land depends on irrigation from snow and glaciers. Snow and glaciers melt slowly throughout the day and water is available for irrigation only in the evening, too late for cultivation. In addition, the demands of farmers at the same time and for a short time period also influences the water supply.

In this arid land people have developed intelligent ways of using water. People divert the melting water from glaciers towards evening, with the help of guiding channels, to a small tank, locally called a *zing*. The stored glacier water is then used the following day in the fields. To ensure equity in distribution, villagers elect a water official known as a 'churpun'. The churpun ensures that each farmer gets an adequate supply of water in proportion to the area of land he owns and disputes are rare. The community maintains the canals. Such a system is prevalent in the Ladakh region. In Lahul and Spiti, the community largely depends on traditional diversion-based channels. For instance, in Spiti, the people have devised an ingenious system of tapping glacier water from a distance through kul. This system is over a century old. The water rights in this system are exclusively owned by the members of 'bada ghar' (big houses). This hierarchical system distributed water on the basis of the demand for labour being spread over the entire harvest season. This spacing of the need for labour does away with the danger of demand peaking at the same time throughout the valley and provides a firm basis for community labour. However, during water shortages, water distribution creates tension. This system of sharing water is renewed and adjusted every season according to need.

The western Himalayas

In contrast, the western Himalayas that stretch from Kashmir to Uttarkhand in Uttar Pradesh receives an average annual rainfall of about 1,000 mm and, because of its moderate temperature, has been a favoured belt for habitation. The soil is fertile, and the abundant water on the gentle sloping terrain has been tapped through ponds to support the staple crop; viz. , paddy. The abundance of water has led communities to largely depend on the streams, springs, and ponds, for drinking and for agriculture. In the Uttarkhand region of the Uttar Pradesh hills, the abundance of water has resulted in diversion of flowing streams through channels called 'guhl' or 'khul'. These systems were managed by community-based regulations that ensured sustenance for the people.

Jammu, lying in the sub-Himalayan hills, and the adjoining plains have ponds that have been one of the main sources of water supply. However, after Independence investments were made to provide drinking water by installing dug wells in the beds of rivulets. However, water is supplied only two to three days a week in the so-called 'covered' villages and still 20% of the villages are not covered (Singh 1997). During summer, people resort to the ponds for water. Unfortunately, most of these ponds are in disuse and neglect and village institutions have since collapsed.

One of the impressive experiments in water harvesting was in Jagti village in the dry Kandi region. A long concrete dam, called Jagti reservoir, was constructed across the Bilani *nullah* at low cost and in a short span of time by the local community. This reservoir is an improvement over the ponds in terms of checking excess surface runoff, erosion, and floods and has already revived the dried springs and wells in the region. The 'khul' in Himachal Pradesh have met with a similar fate.

The new economic opportunities, introduction of 'Panchayati Raj' institutions, and community development programmes have, however, led to adverse effects on community-managed water-harvesting systems (Gopinath 1997). In the changed settings, traditional institutions are rapidly becoming formal with cash as a medium of exchange. With the introduction of 'Panchayati Raj', Block Development Officers have an option of 'ad hoc' grants for repair and maintenance of these systems, if the community can muster up the contributions. Generally, the repair work costs more than the grant amount, and the community is unable to mobilise such large amounts. This increasingly encourages the community to hand over the community system to the authorities. In addition, deforestation in the catchment areas and increasing withdrawal of water supplies have exacerbated the situation.

The eastern Himalayas and the northeastern hill ranges

This forms an intense rainfall zone of the Himalayan region. However, the water resources are rarely tapped because of the rugged nature of the terrain. Hence, the living standards of the people depend on rainfed agriculture through 'Jhum' cultivation. However, the community has developed an indigenous water-harvesting system for settled agriculture. This is practised in the form of irrigated terrace cultivation in parts of Nagaland and a few villages of Meghalaya. Channels are dug to irrigate these fields. Some of these systems involve use of bamboo pipes to irrigate the fields. Apart from this, natural springs are also used for drinking purposes. The spring water is brought through bamboo pipes or collected at the source itself. Another most recent practice is roof-top water harvesting in Mizoram.

Irrigated terraced paddy cultivation is predominant on the gentle and sometimes on steep sloping terrain. The region has diverse kinds of irrigated terraced cultivation: the Angami system, practised by the Angami tribes and the 'Zabo' system practised by the Chakhesangs. The Angami system of terraced cultivation depends on seasonal or perennial streams, natural springs, and, in rare cases, ponds where rain water is harvested. The system is comprised of a protected forests on the hilltop; well-planned water harvesting tanks and cattle yards, one below the other, in the middle, and paddy fields in the foothills.

The bamboo drip irrigation system is prevalent and so perfected that about 18-20 litres of water enters the pipes per minute and is transported over several hundred metres and finally dimishes to 20-80 drops per minute. This 200 year old system is practised by the tribal farmers in the Khasi and Jaintia hills to water betel leaf plants or black pepper crops. In Mizoram, because of deforestation and soil erosion, people either tap the springs, locally known as 'tuikhur', or depend on rooftop water harvesting for drinking water. Although the people in Arunchal Pradesh have similar patterns of terraced cultivation called 'Apatani', the striking feature of this system is the partial flooding of rice fields and the intricate designs of the contour dams dividing the plots. These traditional systems have something in common: use of local materials and resources to harvest water, all community managed. The systems are managed and maintained by rules and procedures commonly agreed upon by the villagers, as the problem of water supplies is the effect of the cumulative actions of many.

Increasing state-controlled policies

These traditional systems, though prevalent in pockets of the region, have undergone considerable change since colonial rule. The rulers with their doctrine of 'colonial logic' and 'increase in wealth' invaded 'private rights'. The mid -19th Century witnessed consolidation of state control over water resources. Although many different water-harvesting systems were recognised by the colonial rulers (Siddiqui 1992), civil engineers were employed to control and design highly diverse irrigation systems, while the Revenue Department executed the work (Vani 1991). This not only led to creation of a Public Works' Department to supervise and control public works in the country, including irrigation and other water-related work, but also fixed and rendered standard measures for an extremely diverse irrigation system amenable to administrative manipulation. To support the revenue department, the process of 'settlement' was undertaken. This involved two related tasks, one for the assessment of revenue to be collected and, second, for creation of a record of rights (Coward and Walter 1990). These documents were called 'Riwaj-i-abpashi' (Book of Irrigation Customs) and are extant even today in many parts of the Himalayan region and also in various parts of the country, under different names.

To overcome the unequal distribution of rainfall, the colonial rulers introduced a regulated system of canal irrigation, facilitating centralized control. The water laws were formulated by giving the upper hand to the government. In the Kumaon hills of Uttar Pradesh (Vani 1995) the then state government formulated 'Rules Relating to Water Mills and Use of Water in

Kumaon' in 1917 and then again in 1930. This laid down in clear terms the proprietorship of the colonial government over all water resources, declaring that:

> "the water of all rivers and natural streams and of all lakes, natural ponds and other collections of still water within the hill tracts of the Kumaon division are the property of and subject to the control of the state."

Although the rules recognised the customs relating to water use in the region, they brought in certain changes. The rules provided the right to take a water channel through measured and assessed land of another on payment of an amount of compensation fixed by the revenue court. In addition, all disputes relating to water rights were to be decided exclusively by the revenue court. In fact, the courts replaced the customary rules in practice. In addition, the interest in land revenue brought the colonial rulers in direct contact with the farmers; or with the 'ryot', and this was known as the 'ryotwari' system, or through intermediaries (landlords) for the 'zamin' lands, and this was known as the 'zamindari' system throughout the country. These developments resulted in ownership and moral responsibilities being vested in the state, while the communities were at the receiving end.

Independent India, through its fundamental rights, gave prominence to free access and use of water to citizens; the right to life, extending to any issue involving a threat, or likelihood of the same, that involved water resources. The rights applied to both individuals or groups and imposed on the state the duties of equitable distribution of the resource and of ensuring ecological and environmental improvements and preservation. In contrast, the Constitution of India listed water as a state subject, with access and use by beneficiaries being subject to statutory procedures with the state having a final say. These contradictory statements are a complete departure from the pre-colonial practice of treating water as common property. In fact, Independent India followed the colonial legal structure of state control until altered, repealed, or amended by a competent legislature or authority.

In the initial phase of Indian planning, policies for water harvesting were in the form of grand schemes for major and medium-sized projects to achieve agricultural development on the same pattern as that of the western world; using modern methods of farming, fertilizers, and animal husbandry to increase irrigation potential and areas under command. The planning emphasised the need for a 'stable irrigation' system. There was little mention of the specific context of the Himalayan region (Planning Commission 1993). However, the disappointing performance of the large-scale projects became clear in the 1970s.

The Sixth Irrigation Commission (1973) reports (Singh 1997) :

> "The era of irrigation planning, which has witnessed a phenomenal increase in the investment in irrigation projects, has however been unfortunately marked by sharp and progressive deterioration in the working results."

It points out that between 1955-56 and 1967-68, the area irrigated by these projects had doubled, but losses from investments had increased 11-fold. The gross receipts had doubled, but the working expenditure had increased three-fold (Singh 1997). In addition to the large- scale interventions, there was consolidation of state control over water resources. The latest of all the 1975 water laws enacted by the Uttar Pradesh, Kumaon, and Garhwal Water (Collection, Retention, and Distribution) Act 1975, applicable in the Kumaon and Garhwal divisions, and the Uttar Pradesh Water Supply and Sewerage Act 1975, applicable in the whole state, abolished all existing rights over water use, took up the entire responsibility for regulating water and vested in the state the sole authority to regulate and control water.

The importance of comprehensive planning of water resource use in Independent India emerged in the Fourth Plan period. However, a broad policy for development of water resources in the Himalayan region emerged only in the Sixth Five Year Plan. The plan proposed multi-directional treatment of water: conjunctive (multiple and simultaneous) use of water resources, efficient management of irrigation projects, emergence of command area development programmes that take ecological aspects into consideration. One of the significant developments in the Sixth Plan was the importance of developing the hill areas of the country. This led to establishment of the North Eastern Council for integrated development of the North Eastern states. In addition, hill area development in the composite states of the Himalayan and sub-Himalayan regions was promoted through assistance from the centre with the state having primary responsibility. Protection of the fragile and irreplaceable ecosystem of the Himalayan and Western Ghats received considerable attention in the Seventh Plan. Another significant programme in the plan period is the Drought Prone Area Programme. The main thrust of the programme is to restore the ecological balance, through efficient use of scarce resources and conservation of scanty rainfall by arresting its runoff and ensuring farmers' cooperation for management and distribution of water.

The importance given to small-scale water harvesting was limited. The state became a modernising agent by extending its own legal and administrative control. This has changed the traditional production practises and social pattern profoundly. They introduced a number of technical and physical innovations as part of maintenance and repair work. For example, the kul were reinforced with cement or concrete and some complemented with rubber pipes. In addition, many of the hill irrigation systems of the Kumaon region in northern Uttar Pradesh have been formally converted from farmer-managed to Irrigation Department-managed systems (Agarwal and Narain 1997). These interventions, along with the market economy and alternative sources of employment, have adversely affected the traditional social mechanisms to maintain the system, and this has led to a decline in small-scale irrigation systems, referred to in Table 3.2 as other sources. Informal rights were replaced with formal legal rights, cash became a medium of exchange, and this resulted in

Table 3.2: **Net area irrigated (in '000 ha) by sources in himalayan states**

States	Government Canals	Private Canals	Total	Tanks	Wells (including Tube wells)	Other Sources	Total
Jammu and Kashmir	130	159	289	3	3	15	310
Himachal Pradesh	-	-	-	-	11	88	99
UP Hill	108	-	108	5	118	592	1506
Arunachal Pradesh	-	-	-	-	-	32	32
Nagaland	-	-	-	-	-	56	56
Manipur	-	-	-	-	-	65	65
Mizoram	-	-	-	-	-	8	8
Tripura	28	-	28	2	7	6	43
Meghalaya	-	-	-	-	-	50	50

deterioration in community-based institutions. Nonetheless, in the interior, inaccessible remote regions traditional community-managed water-harvesting systems are still operational (Pande 1995).

The study in the background of these complex regions aims to evolve contextually relevant policy in the Himalayan region by reviewing:

1. The technologies to promote water harvesting in the complex and sensitive mountain system;
2. The relevance of community-based resource management in the present context; and,
3. The role of the government and non-government institutions in promoting such participatory mode of resource management.

4. Policies, Programmes and Institutions

In recent decades, there has been a growing interest in reviving community-based water management in government policies. The National Water Policy (1987) is a landmark in this respect. The policy for the first time aimed at planning, developing, and conserving scarce water resources in an integrated and environmentally sound basis. Learning from the success stories of various watershed development programmes carried out by NGOs and by committed individuals, the Policy recognises the importance of people's participation in the development programme. One of the formal moves towards this was introduction of decentralization governance through 'Panchayati Raj' in the early 1990s. It assumes that by formalising community-based 'social' institutions, grounded traditional organisation, collective interests will be represented and activities undertaken on their members behalf. These institutions are also seen as the main vehicle for community-based resource management.

One of the outcomes of the 1987 policy was the National Watershed Development Programme (NWDP) that was introduced in 1994. It emphasised the importance of people's participation in planning and management through Watershed Associations. The NWDP combined the features of the Desert Development Programmes, Drought Prone Area Programme, and Integrated Watershed Development Programme. Although the focus of the programme differs, the prime objective remains land and water resource management (GOI 1994).

The 9th plan identifies 'eco-preservation and eco-restoration' as the main objective of the HADP. These documents view the economic backwardness of mountain communities as being mainly caused by environmental degradation, especially of land and water resources, and that development programmes need to be undertaken with lease damage to the environment. Whether this occurs or not will depend on a more integrated understanding and analysis of mountain ecology and the natural resource potential (GOI 1994).

In addition to forming Watershed Associations, the significance of this programme is that it has set up various institutions to coordinate the work of the Watershed Development, Implementation and Review Committee at state level, the District Rural Development Agency (DRDA) or 'Zilla Parishad' at district level, and Project Implementation agencies (government or non-government organisations) at project level. The project implementing agency is expected to be a multidisciplinary team (plant sciences, animal sciences, civil or agricultural engineering and social sciences) designated as watershed development team. The Watershed Association was set up as a formal institution to ensure participation, and its task is to prepare watershed development plan, monitor and review its progress, solve any problems that arise, mobilise funds and operate and maintain the assets. To ensure effective participation, the project called for training of project staff and the village community in various techniques. The techniques include record keeping, conducting meetings and liaison with other agencies. The programme has been implemented in the Himalayan states through different funding agencies such as the World Bank, the European Economic Community (EEC); and the government. In addition, the Minor Irrigation Department promotes water users associations to modernise and rehabilitate minor irrigation structures through Farmer Managed Irrigation Systems (FMIS) programme.

In 1992 the Planning Commission of India decided to constitute an expert group to formulate a national policy for integrated development in the Himalayas. The expert group recognised the importance of local NGOs in evolving appropriate technologies and in understanding the felt needs of the people, the importance of institutional restructuring, and the need for establishment of a Himalayan Development Authority (Planning Commission 1993). In response to the expert panel recommendations, a working group was constituted on the Hill Area Development Programme (HADP) for the Ninth Five-year Plan (1997-2002) (Bandopadhyay 1999).

The Ninth Five-year Plan (GOI) emphasises the importance of community-based water harvesting in addition to watershed management in its various programmes. The agriculture programme (GOI) mentions the importance of soil and water conservation to enhance and sustain the productivity of the available land stock, degradation caused by soil erosion, deterioration of hydrologic balance and increasing competing demand for land. The irrigation programme, (GOI) stresses the importance of using water more efficiently by progressive reduction loss of water in conveyance and application, restoring and modernising old irrigation structures, introducing water rationing and promoting Participatory Irrigation Management with full involvement of water users. In terms of minor irrigation, the plan calls for restoration and improvement of minor irrigation systems as part of micro-watershed development, involvement of the community, awareness about judicious use of groundwater, and promotion of crop diversification in favour of crops that need less water than others. To implement and review policy issues in Participatory Irrigation Management (PIM), a high level committee was established in Himachal Pradesh and Uttar Pradesh. These programmes should be adequately funded by the Command Area Development Programme. These community - based initiatives are likely to be given legal status under the irrigation acts of the states. The significance of the ongoing and current policy is the emphasis on minor water-harvesting systems, involvement of the community, and concomitant use of surface and groundwater.

Water harvesting has assumed importance in recent years in India, with the growing recognition of the scarcity of water and emergence of many community-level efforts.

Although NGOs have actively promoted water harvesting through various schemes, in recent years a separate programme for water harvesting has been promoted by government and funding agencies. The Council for Advancement of People's Action and Rural Technology (CAPART), a funding agency under the Ministry of Rural Areas and Employment, has been supporting individuals and NGOs in rain water harvesting under the Advancement of Rural Technologies' (ARTS) programme (CAPART 1999). CAPART has been promoting ferro-cement tanks to harvest water from rooves through NGOs working in mountain communities. An evaluation of CAPART's work pointed out that rain water harvesting is useful and cost effective for mountain areas (CAPART 1999). Although ferro-cement tanks provide storage for water (other than rain water also during the dry months), a systematic approach to promoting them on a large scale has not yet become part of policy measures.

State governments also realise the problem of water scarcity. In the Himalayan region, the governments of Mizoram (Dunglena 1998) and Uttar Pradesh have promoted rain water catchment systems from roof-tops and springs as one of the main methods of solving water supply and sanitation problems in rural and urban areas of the hills (Dunglena 1998). The Government of Mizoram through the Accelerated Rural Water Supply Programme (ARWSP) and Technology Mission Programme has provided as many as 5,993 rain water tanks in individual houses of 198 villages at a cost of Rs 60 million. The grants are provided by the government and individual households are expected to carry out the maintenance. The programme is encouraging in that it is providing drinking water in rural areas where there is a scarcity. Apart from government efforts, the state has about 10,000 rain water tanks built by communities at their own expense (Dunglena 1998). The government of Himachal Pradesh has gone beyond the programme stage by making water harvesting mandatory. The State Cabinet of Himachal Pradesh recently decided to make rain water harvesting mandatory for all new existing buildings in the state (Max 1999). Himachal Pradesh is the first state in the country to do so, close on the heels of a similar directive limited to the Chennai (Madras) metropolitan area.

At the central level, the Central Groundwater Board (one of the nodal agencies for groundwater development) of the Government of India recently called for efforts to recharge groundwater basins through artificial methods (Central Groundwater Board 1996). The Board's recent National Perspective Plan for Recharge of Groundwater calls for about 59.06 million ha of available subsurface storage space on the basis of hydrogeological study. It proposes storage of monsoon runoff in the unsaturated vadose zone up to three metres below the ground.

A case from Uttar Pradesh Hills

The UP hills are spread over the Himalayan areas of the state, which constitute nine per cent of the Indian Himalayas. They are home to 13% of the population of the Indian Himalayan region (Prasad 1994). An important feature of this hill region is that about 65% of the region is forest and only 13% net sown area (Bandopadhyay 1999). The density of population based on net sown area in the region works out to about 20%, which is much more dense than in the state of UP overall (Bandopadhyay 1999).

The region is increasingly plagued by water shortages compelling a reduction in domestic water consumption, leading to consumption of unhygenic water, and bringing about social conflicts. In March 1993, 75% of the villages were reported to have drinking water. However, whereas pipelines exist, water flow is either inadequate or absent during the summer months. The poorer families suffer the most (Bandopadhyay 1999). A survey of 135 households of seven villages in Garhwal revealed that the drinking water consumption was 1.5 litres per day per person and the total water consumption per capita was only 29 litres per day (Negi *et al.* 1998), which is much less than the WHO standards of 135 litres per capita per day (lpcd). This problem is exacerbated by problems of access to water. Women and children suffer most because they spend about 32 minutes fetching one load of water (19 minutes in rainy season and 56 minutes in summer). Drinking water is collected from springs, and these springs in turn are managed by mountain communities. However, in recent times, increasing centralized control by the state and increasing demand has made drinking water a scarce resource in mountain regions. The responsibility for establishing piped water supplies in rural parts of the UP hills rests with UP 'Jal Nigam' and maintenance with the UP 'Jal Sansthan', a state sector corporation. However, the institutional structure of these programmes is entirely supply oriented and they lack interface with and the participation of local communities, incorporating few incentives to maximise economic efficiency and social benefit with the resources at their disposal (Bandopadhyay 1999).

The situation is no different for irrigation. With large numbers of people dependent on agriculture and 70-80% of them having an average landholding of 0.8 of a hectare, community- managed irrigation has been the predominant water supply system for agriculture. About 52% (791/ 1506) of the net irrigated area receives water from canals, and two thirds of these are private canals that are community managed. Irrigation from other sources accounts for 42% of the net irrigated area, which is also community managed. With the acceptance of a planned approach to development, creation of state irrigation works began in Uttar Pradesh. A series of Acts in the 1950s and again in 1975 affirmed state ownership of water-harvesting systems. Even though these brought about major changes in legislation, existing users have not been affected in most cases. However, changing water rights has influenced the behaviour of farmers served by new state irrigation systems (Pande and Singh 1997). As in the case of the institutional structure for drinking water, irrigation institutions are also centralized and undermine the community-managed systems.

In 1996, a new drinking water project was introduced in the UP hills with the financial assistance of the World Bank. The new project, named SAWAJAL, has a comprehensive approach to water supply and associated aspects of rural infrastructure. The project is accountable to the local community and, when completed, it becomes their property. One of the significant things about this programmes is that NGOs are considered to be central to the success of this community-based project. NGOs coordinate with the community, follow up on the activity, and promote its capacity for maintaining the project. Discussions with the District Project Management Unit in Almora revealed that the project had covered 775 villages since 1996.

In recent years, government agencies and NGOs have prepared a massive programme to implement community-based water harvesting for irrigation and drinking water. The following sections review the water-harvesting technologies relevant to community-based institutions and the role of the state. It becomes clear that an institutional approach to policy formulation is needed by understanding the dynamic role of the communities and the environment.

Review of water-harvesting technologies

Water-harvesting technologies are of special importance to the people in the hills where traditional services can no longer meet the present day needs of a rapidly growing population. The technology has to protect and meet the needs of mountain communities and of the downstream population, as well as protecting and conserving the environment The technology used for water harvesting varies according to the available sources and supply. Although there are various technologies in use, in mountainous regions of the Himalayas, water can be harvested from the rooves, from catchment area runoff, and by diverting flowing water.

With increasing demand and centralised control, government departments, as for example in the 'Swajal' Project or in watershed development programmes, promote technologies that create assets, generate employment, prevent soil loss, and improve soil productivity. Though these projects have a participatory approach, participation is mostly seen as a way of getting the work done.

The designs for water-harvesting structures promoted by the government are based on ideals of permanency and financial returns. Although the United States Agency for International Development (USAID), which sponsors the Hill Areas Land and Water Development (HALWD) project in Himachal Pradesh, recognises the importance of temporary designs, the conditions imposed in terms of Financial Internal Rate of Return (FIRR) and Benefit-Cost Ratio call for stable structures (Pande and Singh 1997), and, in most of these cases, this is not possible. This has led to investment of 63 million US dollars. In addition, the Farmer Managed Irrigation Systems (FMIS) implemented by the Uttar Pradesh Irrigation Department (UPID) along with Minor Irrigation and Soil Conservation wing of the Department of Agriculture aims to "chase the illusive and unattainable ideal of permanency in a system and its components and proceed to design the systems accordingly. " (Pande and Singh 1997)

The approach of the government agencies in terms of permanency of technology arises not only from the perspective of financial returns, but also from the perspective of reversing and slowing down the process of environmental degradation. In addition, these designs, such as stream bank protection, stream alignment, check dams, and others, mostly treat the symptoms of environmental problems by some form of reinforcement and resistance and are often prone to failure or outflanking (Hemphill and Bramley 1989).

In contrast, the technologies promoted by communities are temporary, simple, less expensive, and require regular maintenance and management by local people. The 'zing' and 'man-made glacier' (Norphel 1998) in Ladakh, 'kul' in Himachal Pradesh, 'bamboo drip irrigation' in Meghalaya, and roof-top water harvesting in Mizoram are technologies devised by the communities. These technologies are simple, prove to be environmentally friendly, and meet the needs of mountain communities (Table 3.3). However, what makes these systems complex in terms of their revival is the incorporation of water rights of user groups (Pande 1995).

The NGO approach largely seeks to harvest water by promoting indigenous methods that cost less and are efficient despite constraints. Such methods are appropriate on a small scale and can meet the needs of the local population. The Sri Krishna Charitable Trust, a religious group, introduced roof-top harvesting for drinking water supplies projecting it as a cost-effective method, yet there was limited replication of this even within the community (Maikhuri *et al.* 1998). In harvesting surface water for irrigation, as in the Uttaranchal region of Uttar Pradesh, harvesting is mostly based on water allocation and general engineering and many a time, it is a miniature design of a large-scale system (Pande 1995). The objective of water conservation for Doodhatoli Lok Vikas Sansthan (DLVS) in Garhwal region of Uttar Pradesh "goes much beyond soil and land management to magnify the sustained endeavours of the mountain communities, to nourish and revitalise the thinning headwaters of the Himalayan rivers and recharge, and augment water in the upper watersheds. " (Sheena and Sharma 1998) The NGOs' (good organisations) approach in most cases makes community technology sound better than it really is.

Technologies in the past were more localised. However, in recent years, the population explosion, land degradation, deforestation, increasing erosion, floods and droughts (sometimes claimed to be due to global warming) have exacerbated environmental problems from

Table 3.3: **Implication of water-harvesting technologies**

Agency	Wh Technologies	Implications
Government of Jammu and Kashmir: World Bank assisted Integrated Watershed Development Project of the Kandi Areas of the State (Govt. of J and K 1996) SWAJAL Project in UP Hills	1. In situ moisture conservation through vegetative barriers 2. Drainage line treatment to reduce stream and bank erosion through earthen bag check dams and stream bank protection 3. Harvesting the surplus runoff through storage structures.	1. Permanent engineering design 2. Cost of construction and maintenance high 3. Controls the river systems
Doodhatoli Lok Vikas Sansthan (DLVS) (Sheena and Sharma 1998) (an NGO). Sri Krishna Charitable Trust.	1. In situ moisture conservation through tree plantation to recharge groundwater and anchor soil formation 2. Construction of small water ponds in the middle of the watershed augment soil moisture and replenish water. 3. *Gul* or irrigation channels to irrigate terraced fields	1. Semi-permanent structures 2. Innovation from community effort 3. Cost effectiveness
Community Effort (Agarwal and Narain 1997).	1. Zing 2. Kul 3. Terraced Cultivation 4. Man-made glacier 5. Roof-top water harvesting in Mizoram, Uttar Pradesh and Himachal Pradesh	1. Temporary structures 2. Designs in harmony with the natural flow of streams 3. Less costly 4. Requires regular maintenance or rebuilding of the system

the local to the global. This means that technologies balancing the economic needs of the people and protecting them from natural hazards, in both the Himalayan and the downstream regions are required. An understanding of the functioning of river systems and enforceable regulations are needed for this.

To devise a technology and regulations to harvest water, it is important to understand stream management problems by:

classifying the streams or rivers into components with ecological emphasis;

1. understanding the interconnectedness of river systems in terms of continuity of sediment transport systems and the aquatic terrestrial ecotone;
2. identifying the ultimate and controlling factors that determine the stream behaviour in different time and space scales; (to help define the sensitivity of the system to disturbance and the recovery period needed following disturbances) ; and
3. careful consideration of the natural time scale of fluvial adjustment.

Such an understanding of the river systems may not be feasible in most inaccessible and complex terrains. However in accessible regions, information could be derived from the knowledge of local resource users through an interactionist approach. Certain studies (Guha 1989) have pointed out that this information may be of significance for impact assessment and monitoring of environmental change. This knowledge if tapped, along with scientific and geomorphic study, will enhance the integral part of policy planning.

Lessons from traditional community-based institutions

The growing concern about poverty, population growth, and environmental degradation calls for a pervasive policy for community-based resource management. Communities are closely associated with the natural resource base (NRB). Their closeness and their diverse interest in these resources enable to accumulate knowledge to monitor resource sustainability, allocate resources, and resolve any conflicts that may arise (Duffield *et al.* 1998). Thus, strong dependence on the local NRB promotes a collective stake in these assets. However, superficially the approach is based on the assumption that a distinct and autonomous community exists apart from 'outsiders' in a local administrative unit of a cultural or ethnic group in a valley; and therefore these homogeneous groups can be used to promote institutions on the principles of participatory governance.

The experience of participatory watershed management in the dynamic Himalayan region indicates that the resources are managed through hierarchy and authority. Community institutions in the Himalayan region, similar to other parts of the country, are often characterised by caste, class, and gender differentiation in access to resources. An assessment of European-assisted Watershed Development Projects in Doon Valley indicates that the projects have been disproportionately beneficial to the dominant caste and interest groups (Ninnan 1998). Despite targetting underprivileged groups (scheduled castes and tribal groups, women, and so on), institutional and social barriers, apart from other constraints, have come in the way of helping those who rank very low on the social scale and poverty profile (Ninnan 1998). In the Kulu region of Himachal Pradesh (Berkes *et al.* 1998) it is no different. The Rajputs in the Kulu village of Goshal and Chichoga are economically predominant and also have social and political control in relation to the scheduled castes (SC), the lower group on the social ladder. Although various structural changes (like land reforms) and participatory modes of watershed development have been introduced, the basic distinction between upper and lower castes has remained, and control of common lands and local politics rests with the dominant castes. Despite the fact that village institutions are formed, as in the Doon watershed project, to empower subjugated groups, they either remain silent or play a secondary role in these fora. The domination of the upper castes and interest groups continues. It is the same situation in water management in kul where water rights are exclusively owned by the 'bada ghars' (big houses) who are in adominant position and suffer the least compared to other secondary users (Agarwal and Narain 1997). Although these community institutions had a flexible approach that suited the local people in the context of earning a living, the hierarchy and monopoly over the resource were characteristics of them.

Traditionally these communal institutions have been part of the larger political process in facilitating their domains of control over the resources and not as autonomous entities, as widely assumed, through which effective resource management can be established. In Uttaranchal, records of the Katyuri Kings (9^{th} to 15^{th} century A. D.) indicate that a large number of 'naula' (small tanks for collection and storage of subsoil flow) and 'dhara' were built during wars against the Muslim rulers (Pande 1995). These heterogeneous authoritative power structures were often challenged and this led to political struggle or sometimes demand for equitable use of resources, rendering them dynamic and promoting ingenious methods of using and conserving environmental resources.

The conventional approach of forming user groups through a participatory programme, as with watershed management and the Swajal project is thought to be representative of the collective interests of the community, and these organisations are expected to undertake activities on their members' behalf. Although such institutions are new, frequently they are believed to represent the traditional wisdom of collective action. Indeed, they are expected to be a focus of the strength of community-based institutions for effective resource management. Many of the programmes use the community to implement programmes rather getting them to participate in the full process.

In this respect, it is important to understand how users access resources through various claim-making strategies over common property resources (CPR) (Mearns *et al.* 1998) like water. How does the informal community-based institution function? and how effective is it in resource management in modern terms of sustainability?

Water resource systems, like other CPRs, have multiple uses and competing users. For instance, the Ladakhi's revere their streams to maintain their cleanliness. Water, for the people of Ladakhi, is not just important from the economic perspective alone, but also from the social and religious perspectives and hence sanctions and incentives are used in its management. In Ratura, farmer-managed irrigation systems, the farmers gather before the Goddess Chandi's image at the head of the canal to determine maintenance chores and rotation sequences. Any violation of the rules fixed in the temple is unimaginable (Pande 1995). Inherently, temples as institutions enforce water allocation rules. In fact, water is collectively managed by multiple regimes of institutions. In these multiple regime, rights to CPR use have been a social process in which rights are part of socially legitimised claims to a benefit stream (Vira 1995). The claims over resources through rights are not static or stable, but are negotiated through a combination of social, political, and ecological claim-making strategies. In an effort to untangle these complex institutions, studies (Saravanan 1998) elsewhere have indicated that it is important to identify the informal user groups who have major claims. These groups are said to possess sufficient knowledge and skills in resource management. However, it is important as well to identify the relevant characteristics of the users in terms of leadership qualities, homogeneity, heterogeneity, educational characteristics, and others in relation to sustainable management of common property resources.

Another challenge to reviving traditional institutions is the informal existence of these institutions. They do not function by a set of rules in use. Studies elsewhere (Adams *et al.* 1997) indicate that behind every formal set of rules for water rights allocation in place, there is a complex network of 'working rules' to allocate water through stealing and selling. Although, to some extent this makes water allocation more equal by providing the means for those with limited rights to obtain more water and, in some instances, makes this system more flexible, it leads to reconstitution, renegotiation, and redefinition of socially acceptable forms of equitable access.

One of the misunderstandings about community-based resource management is that it was an efficient means of managing resources; meaning that it followed rules and patterns of behaviour that led to self-sustainability (Baland and Platteau 1996). This means that traditional communities evolved mechanisms to address the issues of environment and development—for instance, kul irrigation in the Spiti region of Himachal Pradesh. The community evolved techniques to divert melting water from glaciers into a village tank. This water is shared among users who have been allocated water rights. However, notwithstanding the decreasing or increasing availability of water, there have been no improvements in water harvesting techniques, control of the increasing population, or diversification of economic activities. In fact, these societies do not conceive of their natural environment nor of their own relationship with it as modern societies do. They perceive that natural resources are provided as an act of kindness by some supernatural agent and shortage of resources is perceived as a temporary phenomenon (Baland and Platteau 1996). Pande, questions the efficiency of these systems (Pande 1995). Sometimes, the resource management practices are coincidental, as with terraced paddy cultivation in Nagaland, but there is no motive of ecological conservation.

In the past, environmental problems were localised and suited traditional institutions. The environment acted as a sink for absorbing the potential inputs. However, in recent years, the population explosion, land degradation, deforestation, increasing erosion, floods, and droughts (sometimes claimed to be due to global warming) have rendered these seemingly localised problems global in nature. The complexity of and limited knowledge about environmental change make uncertainty about the environment inevitable. However, understanding the uncertainty is critical in solving environmental problems. Other studies have indicated that this requires not only that local people become managers of nature, but that the state and other actors manage it also. Wherever it is important, locally based practice should be explored, at the same time taking into account the role and interest of the state as an environmental manager.

The community institutions possess various positive aspects that are advantageous for effective resource management (Baland and Platteau 1996).

1. They are well informed about the dynamic nature of ecological conditions, although they may possibly misjudge recent changes in the environment or ascribe wrong causes to visible ecological processes.
2. They are well informed about the local technology and economic and social conditions, as well as the problems or constraints that characterise their society. Consequently they are able to devise location-specific rules that are acceptable to resource users and well-suited to local conditions, if effective local leaders are available.
3. They have a low-cost customary regulation of resource use that can be tapped and self-monitoring can be organised by local users.

To form community institutions as a primary base for resource management in the Himalayas, it is important to understand the following.

1. How the resource is used? How the resource is allocated between different users? How do different users make claims over the resources?
2. What are the rules governing the use of and access to resources? What are the motives behind them? How are they formulated?
3. What different water-harvesting technologies are used by the community? What is the purpose behind selection of the technology? How is it maintained?

Such an understanding helps to see how responsibilities can be devolved to the users based on the principle that 'the weaker the social group in terms of collective action, the more it requires centralized control' - 'the stronger the collective action of the community, the more power it can channel into resource management'. Where decentralization and active participation of the communities are the key to resource management, a critical role can be played by the state through a flexible approach that suits and facilitates community institutions. This joint activity will enable genuine power sharing between the state and the community to check potential excessive control by either side (Pinkerton 1989).

Role of the state and other institutions

The policy environment in the 1990s has been dominated by participatory environmental management and decentralization of the development process. The increasing interest has in these is largely guided by the recognition of past failures, mounting costs, enforcement of the participatory approach by the international aid community, and the manifold achievements of NGOs (Thompson 1998).

The Government's National Watershed Development Programme (NWDP) and Farmer Managed Irrigation System (FMIS) programme have been significant in that they moved from traditional bureaucratic functioning to a participatory mode. However, this static functioning has to interact with more dynamic local institutions. The European funded Doon Valley Project (Sheperd 1998) has already run into problems. The project authorities assumed that government bureaucracies are sufficiently familiar with participatory approaches, that they could play their parts, and that training only needed to be provided to user groups and project implementing staff. One of the significant features of the World Bank's Swajal project is that it has established a single agency for implementation (unlike UP's 'Jal Nigam' and UP's 'Jal Sansthan') and tries to promote an interface between government officials and the people through NGOs. This interface is expected to provide information about field conditions and enable project monitoring. Although this is one of the significant initiatives, the project authorities need to have flexibility and creativity to offer a variety of technical and managerial possibilities so that individuals, groups, and communities can choose what suits them best. Training alone will not facilitate participatory functioning, rather reversals in attitudes and practices are needed. In addition, contemporary programmes call for involvement of NGOs in building community institutions. This has led to the emergence of new NGOs in the UP hills to support the World Bank supported Swajal Project.

To evolve a participatory approach to development institutions need to change from being static to being flexible, need to build on their analytical abilities, and need to share information on a wide range of options. One of the common problems faced by government institutions is their target-oriented functioning. This has led to a premature process of implementation that is meaningful in terms of statistics, but meaningless in terms of development. In addition, the field staff need the commitment to implement the programme, and this has to be promoted by the government departments through incentives. The implicit logic of institutional development underlying the participatory approach in the Doon Valley indicates that a significant change in the functioning of the organisations (both government and non-government organisations) is required. Comparatively, the NGO programmes have been successful because of their flexibility, their adaptability to local-level changes, as less target-oriented approach, and small-scale operations.

For wide-scale implementation of the participatory approach, the government and non-governmental agencies have to restructure their internal systems: their structures, procedures, and values to suit participatory governance. Institutionalisation of participation not only depends on exogenous policy factors, it involves changes in the organisational characteristics of development organisations. It also requires the ability to respond rapidly to changes in development needs with procedural flexibility and commitment to devolution of management tasks and responsibilities to proposed beneficiaries. The development organisation needs to be flexible and evolve a coordinated approach that supports the subordinate groups, increasing their access to and control over resources by taking operational clues from ongoing struggles, knowledge, and strategies. Such operational clues should form part of the broader learning process approach, whereby new skills are acquired by development professionals. This calls for re-orientation of development agencies (both government and non-government) in terms of structural and normative changes (Uphoff 1991). The former involves a change in organisational functioning, creating interdependence between different institutions, and enabling user groups. The latter calls for normative changes that target the people working in the departments through value commitment, organisational culture, and organisational development.

In fact, the government and other institutions can play a complementary role to that of community institutions (Baland and Plateau 1996) by doing the following.

1. Processing crucial information on village resources and their external impacts, providing technical assistance to users (Disseminating crucial information will help to assess the environmental changes taking place, to promote remedial measures and new practices, and to monitor and evaluate the effectiveness of action programmes.)
2. Promoting economic incentives for users to move towards the path of conservation
3. Providing a flexible legal framework that facilitates users by clarifying their territorial rights and by protecting them from outside intruders
4. Devising formal conflict resolution mechanisms to settle disputes at the local level
5. Providing financial and technical support to decentralise monitoring and facilitate local users
6. Improving efficiency of users through diffusion of best practices and working rules
7. Promoting a 'learning organisation' of the government departments through changes in value systems and attitudes

5. Implication for Policy

An institutionalist approach is needed for holistic, realistic, and flexible water-harvesting policies for the Himalayan region; an approach in which both the state and community jointly manage the water resource. The holistic policy should focus on diverse institutions with social differences.

In a region where uncertainty and complexities are part of the ongoing ecological process, understanding environmental changes makes it difficult to devise strategies for management. To understand these complexities the social sciences need to understand the characteristics and dimensions of environmental problems. To devise a strong environmental policy, dialogue between science and the community to generate future visioning, networking, truth telling, and learning is needed. Given the uncertainties prevalent in the environment, water management policies cannot be fixed, they must be responsive, adaptive, and open to the unexpected—continuously testing, examining, and monitoring the unknown implications of different trajectories of environmental change.

Thus, the policy for the Indian Himalayan region has to provide a framework within which a debate, both scientific and political, takes place about the nature of its implementation in a particular region (Trudgill and Keith 1997). It is important to understand that such a policy might work well in one place, at one time, and on one scale, but might not be relevant or true for other times, places, or scales. In addition, such a policy should not extrapolate beyond the period for which it was initially meant.

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Chapter 4
Policies and Institutions for Water Harvesting in Nepal

M.M. Sainju, S.K. Malla, and J.P. Thanju

1. Introduction

Nepal has a population of about 21 million with 7.5% and 42.6% residing in the mountain and hill regions respectively. The mountain region is rugged and remote, and its people face great hardship. Tibeto-Burman speaking people dominate the north; whereas Nepali speaking people dominate in the mid-hills. Ninety per cent of the population live in rural areas and are engaged in agriculture, which is the basis for subsistence. Nepal is a poor country with a per capita annual income of US $ 210.

Ecologically, Nepal is divided into three regions: the high mountains, the hills, and the flat land (Terai). The Terai is the bread basket of the nation. With the variation in altitude from the high Himalayas in the north to the flat plains of the Terai in the south, the climatic change across the country is dramatic. The Terai region close to the Indian border receives about 1,500 mm of rainfall per annum. In the hills, the average rainfall is around 1,800 mm a year, but varies from place to place. There is a significant temporal variation in the amount of rainfall. About four fifths of the annual rainfall occurs during the monsoon season which lasts from mid June to September.

The high mountain ecological belt receives quite light rainfall, and some of the districts are rain shadow districts. The eastern region receives heavy rainfall compared to the Far Western region. The meeting point between the Churia hills and the flat lands of the Terai is called the Bhabar zone and the soil is porous and the water table quite deep. The water scarcity areas in Nepal are the mountain/hill tops, rain shadow hill districts, and the Bhabar zone (due to the deep water table). In the hills and mountains, there is usually excess water in the monsoon season, creating havoc with landslides and soil erosion, and no water in dry seasons.

2. Review of National Policies and Programmes on Water with Particular Reference to Water Harvesting in Mountain Areas: Evolution and Present Status

Water harvesting in mountain areas: evolution and present status

The traditional water-harvesting system is based on conservation of rain water where it falls and its utilisation to meet the diverse requirements of the local people. There is evidence of such systems all over the country, in general, and in Kathmandu Valley in particular. These systems met the basic domestic and irrigation water requirements of the local population. These systems used low-cost, user-friendly techniques and were kept in good operational condition by local communities. These facilities not only served the minimum requirements of individual households but also fostered social cohesion and self-reliance.

Rain-water harvesting and utilisation (RWHU) is not a new technology; it is an ancient legacy. On top of the hills and mountains of Nepal, ponds were dug in ancient times to collect rain water mainly for livestock use. At present, significant numbers of ponds are filled and put to other uses. Stone spouts were constructed in the hills and also in urban areas. The ancient people had a good knowledge of the hydrological cycle, and they constructed ponds to collect water for the dry season and also to recharge the springs and increase soil moisture. Springs and stone spouts were constructed; and these were the main source of water before the introduction of piped water supplies. At present, such springs and stone spouts are still being used. For example, the intricate system of the traditional water supply for Patan, which consists of a network of 'Rajkulo(s'), ponds, and stone spouts is centuries' old. As a result of urbanisation, it has fallen into neglect and disuse; however, ample facets of this system are still working.

Trusts ('guthi') were established to maintain some stone spouts and several ponds properly. However, most of the systems have been neglected and most of the ponds are encroached upon for other uses.

Managing and making available drinking water are considered religious acts. In the old days, people used to construct ponds for the benefit of the public as a noble act. These types of ponds are prevalent in the Terai region, and they are sources of groundwater recharge. These ponds at present are a good source of income for the VDCs which contract them out as ponds for fish farming. Some people provide drinking water near 'chautara' (resting places below big trees) for trekkers especially in summer.

Spring sources in the hills have a special meaning for the women of Nepal. They are places to meet fellow women, to socialise, or just to relax for a while from the drudgery of household chores. Due to social norms, opportunities to meet with the opposite sex are limited. Normally, springs are also places where rural girls and boys can meet.

To capture rainfall runoff from the sloping hills, the farmers of Nepal construct terrace lands with bunded fields to accumulate rain water for irrigated agriculture. Terracing the sloping land and using for paddy cultivation are efficient ways of using otherwise excess rain water which would have washed away the nutrients and eroded the topsoil. Many visitors to Nepal are impressed by the beauty of the series of contours of the terraces, ingenuity, and hard work of Nepalese farmers.

Historically, the communities in Nepal have used local water resources successfully for centuries. Nepali farmers irrigate their fields by diverting water from streams and to a lesser extent from small ponds. About 70% of the irrigated area in Nepal is covered by farmer constructed and managed systems called farmer managed irrigation systems (FMIS). These FMIS have survived and continued to function over the centuries. Even though the technology is at a low level and simple, the system functions well due to its strong institutional base and adequate networking in the organisation. The FMIS vary in size from a few hectares to a more than 10,000 ha and are still functional. There has been considerable research and documentation in institutions on the management of these FMIS. Valuable lessons can be learned for application in agency-managed irrigation systems. Some of the important FMIS are Chhattis Mauja Kulo, Rupandehi (3,000 ha); Raj Kulo Argeli, Palpa (48 ha) ; and the Budi Kulo system, Bardia (12,000) ha (several kulo in the area combined). These FMIS have been in existence for 160,110, and 160 years respectively. The Rajkulo of Patan, which divert water from the Naldu and Lele rivers, is said to be 1,000 years old. HMG/N has recognised the importance of FMIS. It has made provisions for rehabilitation and improvement of FMIS. Large numbers of FMIS are still functioning without any support from HMG/N.

Before public sector initiation in irrigation systems' development, several Rajkulo (canals) were constructed through state patronage. In the 17th Century King Ram Shah declared that irrigation and its management were community responsibilities (Riccardi 1977).

The modern development process gradually undermined these innovative systems. Ancient RWHU systems are dying out and are gradually losing their importance. Currently, there are some efforts to revive this dying wisdom. Rapid population increase, urbanisation, and improved quality of life have increased the demand for water. This means that RWHU systems need to be revived. Slowly, efforts are being made to revive and promote RWHU. The modern approaches to RWHU are collection, storage, and use of rain water from the rooves of houses. Ponds lined with plastic are used for small-scale sprinkler irrigation. Small earth dams are used to create small reservoirs for irrigation and other uses. In Kathmandu, a project to pilot test groundwater recharge is being introduced.

In the early 1960s, the mission Hospital in Tansen, Palpa, constructed a Rain water Harvesting System (RWHU) system and it is still functioning well. The major ongoing work of RWHU at household level are undertaken by the Rural Water Supply and Sanitation Project, FINNIDA (RWSSP/F) in the two districts of Palpa and Gulmi in Nepal. This project involves user participation. It is considered to be a successful programme. The Department of Water Supply and Sewerage (DWSS) has also undertaken some RWHU at community level in Syangja, and Tanahu districts through its district offices with little or no cost sharing. Peace Corps, Nepal, constructed some RWHUs with ferro-cement tanks. Some NGOs, with support from INGOs, have built small RWHUs mostly with plastic-lined tanks for small irrigation for marginalised farmers. Some agencies have constructed RWHUs for their own use. ICIMOD has constructed small, plastic-lined tanks in Kabhre and Godavari. In Ramechhap district, a pond with a capacity of 3,300 cubic metres with plastic lining for use in irrigation is being constructed by the users with assistance from the Canadian International Development Agency (CIDA). The Department of Soil Conservation and Watershed Management (DSCWM) also undertakes establishment of RWHU systems through its district and project offices. Ponds are constructed without lining to allow seepage to recharge springs and increase soil moisture downstream. Under the DSCWM, there are several watershed management projects that are being implemented with assistance from donor agencies.

Most of the houses in the hills and mountains have thatched rooves, and they are not suitable for collecting rain water for domestic use. It is a great constraint.

The present status of RWHU is given below.

About 30% of the erodible land in the hills, covering 365,000 ha in Nepal, has been terraced (Yadav 1998). The majority of traditional systems are dying out because of a number of reasons. Many traditional ponds have been encroached upon, especially in urban areas. Slowly, attempts are being made to revive the systems. For example, in Patan and Kathmandu, a few ancient stone spouts are being rehabilitated. The following is a list of the work undertaken in recent times.

- RWSSP/F constructed 478 jars of ferro-cement by March 1998.At the household level ferro-cement jars of two cubic metres in capacity are used to collect water harvested from CGI rooves.
- Plastic-lined small tanks/ponds along with sprinklers are being used in several dozen places for very small-scale irrigation by marginalised farmers.
- Ponds have been constructed by government departments, but they are very few in number.
- For drinking water, small community-level RWHU schemes have been successfully constructed, mostly by the DWSS.
- About 40 small ponds have been constructed without lining by the Bagmati Watershed Management Project (BWMP) in and around Kathmandu Valley to increase soil moisture and spring flow downstream.
- Peace Corps Volunteers have constructed ferro-cement tanks for RWHU.
- The existing, traditional water-harvesting systems have not been documented yet. However, their numbers are substantial. There are numerous stone spouts in urban and rural areas. Judicious use of such sources can augment domestic water supplies.
- Large numbers of ancient ponds have been filled in and put to other non-water-related uses.
- With the assistance of the Asian Development Bank (ADB/Manila) a pilot project is being introduced to use water from the Manahara River to recharge groundwater by injection through the tubewells.
- The lakes and ponds, which are 637 in number, have been documented along with the location, size, and so on by the Department of Hydrology and Meteorology. However, its present use and potential for use have not been described.
- FREEDEAL, a legal firm/NGO, organised a seminar on Water Rights' Law Study in March 1998.

The progress up to date in RWHU has been quite insignificant. However, an encouraging effort is being made and activities in RWHU are moving ahead slowly. INGOs, NGOs, and some government departments are slowly entering into this field. A boost will be required to accelerate these activities. RWHU needs to be promoted in water scarce areas, considering its potential to free women from the drudgery of fetching water for drinking and other domestic uses.

Review of national policies on water with particular reference to water harvesting in mountain areas

The country has promulgated various acts and policies in the water resources' sector. These include irrigation policy, water resources act, water resources' regulations, national policy on water supply, and sanitation policy. Some of these acts and policies have indicated the importance of RWHU in the hills and mountains. There is no separate policy on RWHU. Most of the topics, such as institution building and gender/children's issues, mentioned in the above policy statement are also relevant to RWHU. However, the lack of strong commitment is clearly observed. The following is a relevant quote from Dhungel and Bhattarai (1997).

"Governmental and non-governmental agencies involved in water resources, agriculture, forestry/soil conservation and road construction have not given rain water conservation the due recognition and priority it deserves in relieving the drudgery of mountain people, particularly women and children. Sparse reference to rain water conservation, direct or implied, is found in some policy statements of intent. However, direct commitment has been conspicuous by its absence, a situation which is exacerbated by an acute lack of data and research into the appropriate technologies to be adopted."

The necessity for promoting RWHU in water scarce areas of Nepal has been recently recognised and several agencies are engaged in this endeavour with the support of different promoters.

The HMG/N policy has shifted from an agency-managed system to a user-managed system and promotion of the private sector in the water sector. Recently, it has been the thinking that the government should be acting as a supporter or facilitator instead of a provider or implementator. At the implementation level, RWSSP/F, in its first phase, worked as an implementator or more like a contractor. Now, in the second phase, it is working as an advisor and as back-up support; whereas the district development committees (DDCs) and user groups are the actual implementators.

The government departments began development/management of the water-related systems. Agency-managed irrigation systems were caught in the vicious circle of construction, deterioration, and rehabilitation. To make it sustainable, the concept of users' participation in planning, construction, and operation and maintenance (O&M) was considered vital. This vision is reflected in the Irrigation Policy (IP) which has been revised twice. Similarly, a water supply policy has also been formulated. This concept of users' participation is also introduced in the water supply sector. In actual practice, there are various levels of users' participation; in most cases, the participation is less than required. Continuous efforts are required to entice users to participate.

The Water Supply Policy establishes a service fee to cover full O&M costs and capital cost recovery from urban users. However, this policy has not been implemented in practice. Previously, sanitation was not given much importance in water supply schemes; however, at present, both these aspects are considered together during scheme planning, design, and implementation.

NGOs were promoted to deliver efficient services. NGOs usually out-perform government departments. In the eighth and ninth Five-year Plans (FYPs), emphasis was given to the promotion of NGOs. A Social Welfare Council (SWC) was established to regulate/facilitate NGOs and the activities of INGOs. However, the SWC itself has not been able to function effectively. The DWSS has prepared a policy for the participation of NGOs in the drinking water/sanitation sector. There are encouraging results and performances of NGOs operating under INGOs, Rural Water Supply and Sanitation Development Board (BOARD) and the World Bank Funded Project 'Janatako Khanepani Tatha Sarsafai Karyakram' (JAKPAS). Secondary data on the status/performance of NGOs under the Development of Water Supply and Sanitation (DWSS) are not available.

The Associations' Act - 2034 prescribes registration of NGOs and user groups/associations to give them legal status. As per this Act, user groups/associations and NGOs were registered at the Chief District Officer's (CDO) Office. At present, all the water user groups/associations are required to register with the District Water Resources' Committee (DWRC). This committee also issues licenses to use water resources. There have been some reservations about the ability of DWRC to process applications and issue licenses.

On the initiative of the World Bank, the Rural Water Supply and Sanitation Fund Development Board (BOARD) was established as an autonomous institution within the government framework for delivery of services in the water supply sector through service organisations, (NGOs, Community Based Organisations (CBO), and so on). BOARD has proved to be an efficient and really autonomous institution without a government bureaucracy. In the water supply sector, there are more than 19 INGOs providing services through NGOs.

The following is a list of related acts and policies.

1. The Ninth Five Year Plan (1998), NPC
2. Water Resources' Act (1992)
3. Water Resources' Regulations (1993)
4. National Water Supply Sector Policy (1998)
5. Irrigation Policy (2053-1996-97)
6. Soil and Water Conservation Act (1982)
7. Village Development Committee (VDC) Act (1962)
8. Association Registration Act (2034-1987-88)
9. National Environment Impact Assessment Guidelines, IUCN (1993)
10. National Code Act (*Muluki Ain*) (1964)
11. Nepal National Sanitation Policy and Guidelines for Planning and Implementation of Sanitation Programme (1994)
12. Social Welfare Council Act (1992)
13. Fishes, Aquatic Birds, and Animals' Conservation Act (2017-1970-71, revised in 2021-1974-75).
14. Policy on the Participation of NGOs in Water Supply and Sanitation Programme (1996)
15. District Water Supply Coordination Committee: Guidelines for Work Implementation

The following are some of the provisions in the above policies that are applicable to RWHU as well.

National policy on drinking water

- The policy has considered different aspects, such as legal, institutional, human resources, technology level, user participation, and so on, for overall development and management of water supplies in the Kingdom.
- In very remote areas and places where alternative viable sources of drinking water are not available, RWHU will be used.
- Communities will be enabled to take up leading roles in all aspects of water supply schemes.
- Sanitation programmes will be made part of water supply programmes.
- Appropriate technology, such as rain water harvesting, will be promoted.
- Research and development (R&D) will be undertaken with regard to development of appropriate and sustainable technology.
- A minimum of 10% of costs is to be met by users in cash/kind or volunteer labour. After completion of the schemes, full O&M responsibility is to be given right away to the users.

- Traditional sources, such as stone spouts, wells, and springs, will be rehabilitated, conserved, developed, and protected and promoted.
- Technology should be simple, affordable, sustainable, and replicable by users.
- Small gravity water supply systems for less than 500 persons will be the responsibility of VDC.

Policy on irrigation

- The Irrigation Policy (IP) -2053 (1996-97) mentions use of RWHU. This IP has given a lot of emphasis to the active participation of the users. Irrigation schemes smaller than 25 ha in the Terai and 10 ha in the hills are considered private schemes and are not usually undertaken by the Department of Irrigation. These small projects are usually constructed with ADB/N assistance and users have to meet 40% of the cost. IP emphasises that at least 20% of the members of the executive committee of the user group should be women.

The 'ninth plan'

- Water-harvesting techniques will be tested for small-scale irrigation. Irrigation facilities will be provided through RWHU in areas where surface and groundwater are not available.
- Studies will be undertaken by the bank in order to extend loans for sprinklers and drips for small-scale irrigation for high-value crops in hilly and remote areas.
- Institutional and procedural arrangements will be made for appropriate management and conservation of ponds, lakes, and wetlands.
- To counter negative impacts, watershed management will be implemented along with water resource development and conservation.
- Pricing is to be based on realisation of costs based on investment and O&M from urban users and recovering O&M costs only from rural water users for drinking water supply.
- O&M, rehabilitation, and extension of the water supply system in the 58 municipalities will be undertaken to improve the system with active involvement of the municipalities.
- Local institutions, NGOs, CBOs, and private operators will be given the responsibility of water supply schemes for less than 500 persons
- Subsidies will be gradually phased out for sprinkler/drip irrigation systems.

The 'water resources act', 2049[1]

The Water Resources Act, 2049 has given the highest priority to drinking water and water for domestic use. This Act has specified that the ownership of water lies with the State. However, most of the planners and people in the villages are unaware of this provision, and there would have been less conflict had they known. Any water resource developer has to get a license from the DWRC. However, for household and community-level domestic use no license is required.

The 'water resources' regulations, 1993

The Water Resources' Regulations, 1993 prescribes registration of consumers' (users) associations, formation of a DWRC, arrangements for conflict management, and a licensing procedure for the use of water resources.

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[1] The Water Resources' Act – 2049 (1992) deals with rational use, conservation, development, and management of water resources in the country in an environmentally sound manner, with provision for mitigating the adverse effects and preventing pollution. It has made legal provisions for formation of users' groups, establishes priority for different uses, and outlines requirements for licenses to use water resources.

An environmental impact assessment (EIA)

An Environmental Impact Assessment (EIA) is not required for RWHU at household or small community level. An Initial Environmental Examination (IEE) is required for systems with water impoundment/development in a catchment area.

The 'VDC Act'

This Act authorises the VDC to construct, repair, and maintain the water resources in common use in the village. It can organise volunteer labour for such work. It has the power to frame bye laws - on pollution of drinking water/spring water, disposal of dirty water, and blockage of drainage.

'Soil and Water Conservation Act'

In protected watersheds permission is required from the Watershed Conservation Officer to use water resources. This Act prescribes land use according to the prescribed land-use plan. An interview with a senior officer in the DSCWM revealed that this Act has not been put into practice. For example, it is impractical, for various reasons, to advise people not to farm steep hill slopes. This Act is now in the process of being updated.

'Fishes, and Aquatic Birds and Animals Conservation Act – 2017'

This Act defines 'Private Water' as ponds/reservoirs on personal land for which land taxes are paid. HMG has prohibited capturing or hunting of certain species of fish and water-loving birds and animals. Even the owner of 'Private Water' is not allowed to kill fish by poisoning them.

'Muluki Ain - 1964'

This Act prescribes that those people who constructed or invested in the canal system to bring water for irrigation shall have the right of first use. Further, no one shall obstruct the flow of water to the fields. It prohibits the pollution of water and the blocking of natural drainage.

Policy on the participation of NGOs in the water supply and sanitation programme, 1996

This policy recognises the importance of local-level NGOs and advocates their promotion. It describes the possible areas for involvement of NGOs, provides selection criteria, and specifies the support to NGOs (honorary remuneration), including monitoring/ evaluation. A format is provided for the NGO to provide information on its capability and experiences. Interviews with senior officers (SOs) of the DWSS reveal that NGOs are not available in sufficient numbers. This is quite opposite to the experience of the BOARD who have no problem mobilising SOs. It means that the provision of this policy is not attractive to the NGOs compared to that applicable to INGOs funded and other programmes.

District water supply coordination committee, guidelines for work implementation – 2053 (1997)

HMG/N has established a Central Drinking Water Coordination Committee at the national level. These guidelines have been prepared for creation of district-level committees. The Local Development Officer (LDO) is the chairperson of this Committee. This committee also includes representatives from nationally recognised political parties. The overall objective is to promote and coordinate the rapid expansion of water supply services/schemes and to resolve the problems. In schemes to be implemented in participation with NGOs, this committee has the responsibility of selecting NGOs. It prescribes the duties and responsibilities of user groups. Further, it has the responsibility of establishing user groups where there are no user groups. The provisions in these guidelines are excellent. However, interviews with senior officers from DWSS indicate that this committee has not been effective. This Committee meets only twice a year and is almost defunct. This conflicts with the provisions made in the Water Resources' Regulations specifying a committee under the Chairpersonship of the CDO to look into the conflicts over water sources or use of water.

The national sanitation policy

The National Sanitation Policy prescribes mandatory participation of 50% for women and formation of the District Water and Sanitation Coordination Committee.

It is observed that the existing policies do not provide and adequate framework for the promotion of RWHU in mountain areas. Analysis of the findings about traditional water-harvesting systems is extremely limited. Recently constructed schemes are very few and their impact has not yet been studied. Under the circumstances it may be desirable to introduce some changes based on the suggestions made above. These primarily relate to resolving confusion, streamlining inconsistencies, and improving effectiveness of institutions at local level.

3. Institutions Involved in Water Harvesting at Various Levels

Central-level institutions

At the central level, the institutions involved or with the potential to be involved in water harvesting are the following.

Department of water supply and sewerage (DWSS)

The DWSS, a government agency under the Ministry of Housing and Physical Planning, is responsible for providing drinking water and promoting sanitation and sewerage. It has offices in all the 75 districts of the country. The DWSS provides services to 22 small towns. It has plans to prepare district profiles of all districts, each covering the water resources and water supply sanitation situation. The DWSS has undertaken RWHU in three districts: Tanahu, Syangja, and Gulmi. The National Policy on Water Supply stipulates that a minimum of 10% of the costa should be shared by users, but this is not applied (by DWSS) in practice in the case of RWHU as it is considered to be a test case. The DWSS has a community NGO Mobilisation Section and has prepared a policy to promote NGOs. Further, the DWSCC has a branch in each district for smooth implementation of water supply schemes. All district-level schemes need approval from the District Development Committee.

A World Bank Report on the Rural Water Supply and Sanitation Project (1996) indicates that the success of NGO schemes contrasts noticeably with the performance of many DWSS schemes.

The DWSS has not given much importance to RWHU, possibly due to its tendency to cater to large communities. The DWSS may take greater interest in RWHU in future, especially in those places where alternatives prove to be extremely costly. A sum of Rs 0.5 million each for the districts of Tanahu and Sankhuwasabha had been allotted for RWHU in the 1998/99 budget. The JAKPAS[2] evaluation indicated that a share of 40% of the total cost by users is no problem, whereas in the DWSS, the percentage of the share in costs is quite low. The Fourth Rural Water Supply and Sanitation Project with ADB/N assistance is being implemented in three regions and is being executed by the DWSS. Some of the DWSS engineers (when interviewed) involved in RWHU are not too enthusiastic about RWHU systems.

Water and energy commission secretariat (WECS)

The WECS advises the government on policies and strategies for environmentally sustainable development/management of the water and energy sector. The WECS undertook a feasibility study (FY 1997/98) in Tansen Palpa for rain water harvesting and use. A programme to pilot test the RWHU system in Tansen Palpa in partnership with the DWSO and Tansen Municipality has been initiated. The three agencies will share equal costs with 10% contributed by users and their active participation. It intends to undertake construction of about 20-25 RWHU at household and community levels in Tansen. The WECS intends to promote the construction of RWHU at household, community and agency levels. The WECS has undertaken the formulation of a Water Resources Strategy for Nepal. It intends to formulate a national policy on RWHU in consultation with stakeholders in the near future. It has reviewed the Water Resources Act (2049) with a view to reformulation. Now, to make it active and to provide leadership, a revised mandate is in the final stages of approval.

Ministry of local development (MLD)

The MLD oversees integrated rural development projects: usually water supply components. Rural water supply is a local function. The MLD is the line ministry for local authorities such as VDCs, DDCs, and municipalities. In the Rural Water Supply and Sanitation Field Testing Project (RWSSP/F), 50% of the costs are borne by this ministry.

Department of soil conservation and watershed management (DSCWM)

The objective of the DSCWM is to conserve soil and water for beneficial use. The DSCWM promotes water harvesting as one of the important elements in its overall policies and programmes on water and soil conservation. These policies and programmes are, in general, expected to positively influence RWHU works at local level. The main activities are to protect spring sources, gully protection, protection from erosion by collecting rain water in ponds, afforestation, and watershed management. Under this Department, the implementing agencies are the District Soil Conservation Office, which has offices in 55 districts, and six watershed management projects are being implemented with donor assistance. Out of the six, four projects are centrally managed by the DSCWM. Several donor agencies are assisting the DSCWM. It seems that soil conservation and watershed management are of interest to the donor community in Nepal. In all the watershed management projects, ponds are used to conserve water. Most of the ponds used are rehabilitated ones rather than new constructions. The DSCWM publishes a newsletter, 'ASIAN WATMANET' on watershed management.

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2 Nepali acronym for Rural Water Supply and Sanitation Field Testing Project (a World Bank assisted programme which has completed its mission and has been closed.)

Department of irrigation (DOI)

The Department of Irrigation has the responsibility of developing and providing irrigation facilities. It has offices in all 75 districts. It has not yet undertaken any RWHU for irrigation purposes. The Ninth Plan stipulates that research is to be undertaken in RWHU for irrigation. However, the DOI has not taken any initiative in this respect. The DOI has made an increasing effort to encourage users to participate in its programmes and to transfer completed, small projects to users. However, efforts need to increase even more for positive results.

Rural water supply and sanitation fund development board (BOARD)

BOARD, with assistance from the World Bank, is an agency independent from the DWSS, and is responsible for undertaking rural water supply schemes for small communities in the Central and Western Regions of Nepal, mostly in rural areas. It will spend US$ 21.25 million over a period of six years, ending in 2002. The programmes are implemented through support organisations (NGOs, CBOs) with users' participation and cost sharing. Because of the regular monitoring and evaluation activities and care in selection of sub-projects, the programmes have been successful. No water-harvesting work has been undertaken yet. It is learned, however, that on request RWHU will also be undertaken. It has great potential as a capable institution to undertake RWHU work. The cycle of the scheme is estimated to be 36 months, which seems quite long for small schemes. It has set an example of creation of an autonomous body within the government framework. It has opened a possibility for private sector service delivery which was not there before.

INGOs

INGOs activities have been significant, both quantitatively and qualitatively. There are at least 19 INGOs (1996) involved in the water supply and sanitation sector. The main ones are the International Red Cross, Water AID, CARE, Save the Children, HELVETAS, Redd Barna. HELVETAS is the largest INGO effort in this sector. UNICEF has been a catalyst in starting community-oriented programmes. The INGOs have shifted from direct services to assisting NGOs in providing services. In most cases, the performance of NGO-INGOs is better than that of the DWSS. User participation and cost sharing is greater in INGO-assisted programmes than in HMG-funded programmes. Peace Corps volunteers have undertaken establishment of some RWHU systems with users sharing costs. Their feeling is that the system is more successful at household level than at community level.

International development enterprises (IDE)

IDE, an INGO, is promoting drip irrigation and treadle pumps for small and marginalised farmers with low incomes. The target groups for IDE are (a) small farmers with less than one of ha land; (b) farmers who have small and scattered landholdings; (c) small entrepreneurs for technology development and sales; and (d) technicians who install the systems. It has developed a simplified low-cost drip irrigation system and is pilot testing the system in Gorkha, Tanahu, and Kathmandu districts. The treadle (foot-operated) pump, which can irrigate 0.33 ha land, is suitable for the Terai areas. IDE has field offices in Gorkha and Tanahu

Agricultural development bank (ADB)

The ADB has been promoting sprinklers and drip irrigation systems, and it provides loans and technical advice for their installation. It has promoted small-scale irrigation systems with users' participation and cost sharing of up to 40%.

Nepal water supply corporation (NWSC)

NWSC is responsible for supplying water to 13 large municipalities and sewerage systems to the three municipalities of Kathmandu Valley. NWSC has not undertaken RWHU work except in one or two isolated cases.

District development committee

This is one of the institutions most likely to undertake RWHUs for rural areas, as demonstrated by the experience of RWSS/F in Lumbini Zone. This system is functioning well with some support from the project. It has contributed its share to the cost of the RWHU. The Local Development Officer (LDO) stationed in the DDC is the disbursing Officer handling all the expenses of the project in the district. Further, the LDO has an important function in the DWRC and DWSCC. All water supply/sanitation schemes require the approval of the District Development Committee.

Implementing agencies at local level

The following are the local-level agencies providing services for RWHUs.

- Rural Water Supply and Sanitation Project, Lumbini Zone (RWSSP/F)
- District Water Supply Offices (DWSO), Gulmi, Syangja, Tanahu, and Palpa
- District Offices of Soil Conservation and Watershed Management
- Bagmati Watershed Management Project (BWMP) and other Watershed Management Projects
- NGOs – SAPROS, INSAN, and others.
- Service organisations (SOs recruited by the BOARD)
- District offices of ADB/N
- User Groups (UG) – some of the agencies mentioned above encourage user group formation and they involve the UGs in construction of the system. Recently, greater importance has been given to user groups than before, so that all the schemes are conceived, planned, designed, and executed with the active participation of users and who take responsibility for the organisation and management.
- The Bagmati Watershed Management Project (BWMP) is under the DSCWM and has also established RWHUs by constructing about 40 ponds without linings. The rain water stored in the ponds is allowed to seep away slowly to increase soil moisture and spring flow downstream. Its field of operation lies in Bagmati basin.

Critical gaps in institutional capacity development

There is no policy focus on the development of RWHUs, except for some reference in the Ninth Plan. The sub-sectoral policies on water supply and irrigation deal marginally with this issue. The focus is inadequate when viewed in the context of the potential of this resource. The following constitute some of the gaps identified during the course of the study.

i) There are no specific policies and programmes related to RWHU development in the country.
ii) Several institutions, such as DWSO, RWSSP/F, and NGOs, are carrying out RWHU activities in different districts of the country in their own way with varying degrees of user participation and cost-sharing.
iii) There is a lack of coordination among these institutions. This has resulted in the institutions developing their own criteria for implementing RWHU projects, and these need to

be harmonised for the sake of uniformity, efficiency, and effectiveness.

iv) Schemes undertaken by the DWSO do not have an adequate mechanism for strengthening water user groups (WUG) through a systematic training programme.

v) The ability of DWRC to process and issue licenses to water users is in doubt. The provision needs to be revised in the light of the limited ability of the DWRC.

vi) The inherent weaknesses in the government department, mainly because of bureaucratic processes, result in everything moving very slowly. NGOs, on the other hand, can be efficient and can produce results in a short time. There have been some criticisms about high expenditure on NGOs. This can be checked with proper monitoring systems. The Ninth Plan Document says NGOs will be mobilised. However, in practice, HMG has to take some concrete steps in this respect. For example, INGOs can only engage local NGOs through the Social Welfare Council (SWC). For amounts of up to Rs 2,00,000, permission of the SWC is not required to receive funding from an INGO or donor agency. However, notice has to be given to the SWC. This amount is small for social work and needs to be increased. The SWC was established to facilitate, promote, and coordinate the activities of NGOs. However, this institution is not yet effective. The policy concerning participation of NGOs in the water supply and sanitation programme (1996) has not attracted NGOs. It requires revision.

vii) The Soil Conservation and Watershed Management Act and the DWSCC - Guidelines for Work Implementation are not effective and need revision.

viii) The BOARD and NWSC have not undertaken any RWHU work. The relevant agencies have not persuaded these agencies to take up RWHU work.

ix) There has been no clear-cut demarcation between the functions of local institutions and government agencies regarding water supply work.

x) There is no clear process for the registration of users' groups and NGOs.

xi) There are still many small water supply and irrigation systems which have not been handed over to users' groups.

xii) VDCs and DDCs have not been persuaded to bear the costs of additional investments in the water supply and sanitation sector.

4. Critical Analysis of Impacts of National Policies and Programmes on Mountain Households (in Particular on Women, Children and Marginalised Farmers)

The main area of focus has been the collection and use of rain water for drinking purposes, domestic use, and also for small-scale irrigation—especially for marginalised farmers. Fetching water for domestic purposes is the responsibility of women. The children also help. The national water supply policy indicates that great importance should be given to gender issues and to involving women in user groups. It is observed that the required numbers of women do not participate in the process. Due to social norms and illiteracy, it is difficult to involve women in community activities. It is expected that the RWHU systems will benefit women, children, and men equally. Time saved from the drudgery of water collection would help improve the quality of life. Increased household income from irrigated farming will help to send children to school. Women will have an opportunity to cultivate vegetables, and hence improve family nutrition. Increased crops mean increased fodder and less fodder to collect from the forest.

Even though the FMIS have been in existence for many generations, the government recognised and began to consider assisting them only in 1981. The Irrigation Policy-2049 (1991-2) and its revision 2053 (1996-97) consider assistance for rehabilitation of FMIS. The second irrigation sector programme in the eastern and central regions and National

Irrigation Sector Programmes in the three western regions are continuing with ADB/Manila and World Bank assistance respectively. These programmes include generous assistance for rehabilitation and improvement of FMIS. These rehabilitation works are undertaken through close participation of and cost sharing with users. After completion, the schemes are operated by the users themselves. In the IP 2049 (1992-93), the requirements for user participation and other requirements were simple. Due to non-compliance and non-seriousness on the part of the users and implementing agencies, more demanding requirements were added to make users' participation more active. IP 2049 (1992-93) has made provision to include a minimum of women's representation of 20% on the executive committees of user groups. However, very few user groups met such provisions.

Incentives

There are no general policies to provide incentives for RWHU, except in some specific RWSSP/F programmes.

The RWSSP/F has given an attractive incentive to start the programme. Each household is required to provide Rs 300/- in cash plus collect and transport local materials, provide unskilled labour, provide water for construction, and supply transport for construction materials from the nearest roadhead. For a household with a thatched roof, provision is made for a two cubic metre tank and 180 sq. ft. of CGI sheet to replace the thatched roof.

In the small pond type RWHU established by NGOs, the NGOs provide plastic sheets, high density polyethylene (HDPE) delivery pipes, a gate valve, and one sprinkler to each household for high-value vegetable farming. Unskilled labour costs are borne by the users.

The incentives packages offered by the DWSO and donor-supported projects differ to a great extent. The NGOs to be selected by the DWSCC and administered by the DWSO do not have adequate attractive incentives.

In DWSS implemented RWHU schemes, users do not share the costs but are usually responsible for O&M.

Schemes implemented by the BOARD require that users contribute unskilled labour and local materials for water supply schemes. In irrigation schemes, the users are required to pay a minimum of 10 and 15% for new and rehabilitation schemes respectively. The percentages are more for sprinkler and drip irrigation systems. Further, for schemes smaller than 25 ha in the Terai and 10 ha in the hills, the users are required to pay 40% of the costs.

Impacts

The advantages of RWHU are:

- time saved from collecting water,
- improved health because of use of clean potable water,
- less drudgery and hardship,
- adoption of irrigated agriculture on a small scale, and
- improvements in the environment and arresting soil erosion.

The major impact has been the reduction of time needed to collect water and improvement in health and sanitation. In the hills where there are no nearby water supply systems, a family spends an average 126 minutes per day fetching water. A minimum of 30% of the total time saved can be used for other economically productive activities (NPC 1998). In communities where RWHU has been installed, it has saved time normally used to fetch water and thus helped to lessen drudgery and hardship.

The RWSSP/F have not provided sufficient jars for year round use. They have provided two jars and one jar where thatched rooves have been converted into CGI roofs, against a requirement of sic jars. When the rain water collected is finished, the households are forced to use their usual water source, with a very high probability of contamination, thus defeating the very purpose of the programme.

It has been reported that, due to traditional water-harvesting from ponds, land terracing, and use of water from trails, the yield of maize increased by 50% in the BWMP. Similarly, a 35% increase in yield has been reported in the hills of Lalitpur and Kabhre as well as a reduction in loss of manure as a result of runoff management.

The small farmers have benefitted from sprinkler irrigation from plastic-lined ponds constructed by some NGOs, making vegetable farming possible.

The traditional water supply system in Patan not only increases domestic water supplies, but also provides a beautiful and artistic monument admired by many.

Case Studies

Case studies have been grouped according to the type of rain water-harvesting systems such as (a) rain water collection from roofs, (b) RWHU systems from ponds, (c) springs and stone spouts, and (d) sprinkler and drip irrigation system. Further examples are given of integrated approaches to water management. The case studies are presented below.

Rain water-harvesting from rooves

Daugha[3] VDC, Gulmi

Daugha VDC in Lumbini Zone, situated at an altitude of 1,400 masl in Gulmi district is a hardship area in terms of water scarcity. It can be reached by walking for three hours after a two-hour drive from the district headquarters Tamghas. It has about 500 households, out of which 150 have CGI rooves. The population totals 4,000. Most of the people have to spend three hours for one round trip to fetch water. Children also help. Livestock are taken down to the stream for water every alternate day. Diarrhea and dysentery are common. A diarrhoea epidemic in 1995 caused five or six deaths, and a large number of people suffered from it. About 10 rich households have constructed stone masonry tanks of from 10-25 cubic metres in capacity. The DWSO has constructed nine tanks, each of 20 cubic metres in capacity and out of which six are reserved for weddings, religious festivals, and funerals, and the remaining three are for the VDC, health post, and schools. A procedure was established to mobilise the community, form and register water users' groups/ water users' committees (WUG/WUC), enlist support for cost-sharing from the VDC and DDC, and train WUCs in keeping accounts and O&M. Local NGOs were used to mobilise, coordinate, monitor, and supervise the construction.

It was proposed that two jars be kept by each household with a CGI roof and one jar and 180 sq. ft. of CGI sheeting for each household with a thatched roof. The system costs

[3] This case study is based on Mr. R. Bohara's article on Rain water: Potential Source Drinking Water and Sanitation, A Case Study of Daugha VDC, Gulmi and reference to this is duly acknowledged.

Rs 9,000. The Local Development Officer in the DDC operates the fund. The WUC maintains accounts of purchases and expenditure. Savings of Rs 2,000 out of Rs 9,000 were realised, and it was proposed that they be used to start a revolving fund. Each ward will have a WUC and thus, taking 50 households into consideration, a fund of Rs 100,000 as a revolving fund should be realised to purchase more jars in future. The proposed revolving fund did not materialise, however, because of the reluctance of His Majesty's Government (HMG) to use it as a revolving fund. Fifty per cent of the programme funds belonged to HMG. However, FINNIDA has no objection to its grant being used as a revolving fund.

Cash: An investment of Rs 1,500 (US $ 22) per capita was needed to start the programme. A household of six members would require a contribution of Rs 9,000 (US$132) follows.

- Rs 300 (US $4.41) per capita from VDC contributions
- Rs 300 (Rs 50 per capita) from each household
- Rs 1,150 per capita contribution from the RWSSP/F and the Ministry of Local Development

Contribution in kind by beneficiaries

- Collection and transportation of local materials
- Transportation of construction materials from the road head to the programme site
- Unskilled labour for construction and for fetching water.

As reported by the RWSSP/F officers, the programme in Daugha is very successful. By March 1998, 369 jars have been constructed against a total target of 834. This success was replicated in other places in Gulmi and Palpa also. Thirty additional VDCs in Palpa have requested to take part in this programme.

The RWSSP/F undertakes other water supply and sanitation works besides RWHUs. In the first phase of the RWSSP/F, the project was the implementator and worked like a contractor. Now in this second phase, the project has changed the strategy, and it works like an advisor and the user groups are asked to purchase the materials required and increased responsibilities are given to the DDC. The project works as a back-up support system. It has given a lot of importance to gender issues. In all the user groups, women representatives are always present. In some cases, there are women Chairpersons of user groups/associations.

Before the project is taken up, all disputes are settled. However, if some dispute arises the local community tries to resolve it. If they are not successful, the matter is referred to the Chairman of the DDC.

Manungkot Vyas Municipality (Ward No. 7), Tanahu

This scheme consists of rain water collection from the roof of a school building and storage in a tank with a capacity of 350 cubic metres to be used by 30-35 households. Initially, the tank was built with black soil with a lining of plastic sheets at the bottom and sides of stone. The cost was Rs 0.55 million. This tank leaked and was subsequently rebuilt by the users (with DWSS funds of Rs 168,000) with 20-centimetre (cm) stone soling (cm), topped with 10 cm of concrete in bed and cement plaster and punning in the existing stone walls. A slow sand filter has been installed and the users are advised to boil water for drinking. Occasionally, the users demand and take bleaching powder from the DWSO. According to the staff of the DWSO, the scheme is successful and there is sufficient water all year round.

As this scheme was constructed as a sample case; users did not contribute anything towards the cost. However, they have taken full responsibility for O&M. Further, RWHU schemes are planned in two more places in Jamuni VDC, Tanahu, and Rs 0.5 million has been allocated in the 1998/99 budget.

RWHU constructed by the DWSO, Syangja District

RWHU systems were constructed three years ago in Kharikot village, Kichnas VDC, Ward No. 6, Syangja by the DWSO. This place is 12 miles from the district headquarters and a day's walk from the nearest road head. Four ferro-cement tanks of ten cubic metres in capacity were constructed. There was no cost sharing. Each tank cost about Rs 0.1 million (Rs 0.125 million at present prices), which is expensive, and hence this system was not continued in subsequent years. The users are satisfied with the system according to the DWSS officials.

Rain water harvesting system at the UMN hospital, Tansen

The United Mission to Nepal's hospital in Tansen Palpa started constructing an RHWU system for its own use in the early 1960s. Rain water collected from the CGI roofing is stored in the tanks in the basement of the buildings of the hospital complex. About six to seven tanks with a total capacity of 950 cubic metres have been constructed for rain water storage. Water from these tanks is pumped to a central tank where the municipal water supply and other fresh water supplies (hospital's own system) are also stored and sent to the main distribution system. For drinking purposes, the water is filtered before use; whereas, for other uses, no filtration treatment is carried out. As the hospital is a located in a water scarce area; this RWHU system has been quite useful. This is an excellent example of a successful RWHU system.

RWHU system built by the Peace Crops in Tansen and Syangja

A ferro-cement tank of with a capacity of about four to five cubic metres and a collection system were constructed with Peace Corps' assistance near the motor garage of the Tansen municipality. The driver and family live in the garage. Even though it was nicely built, this facility has not been used, probably the actual user was not involved in the construction. In a school in Syangja, Peace Corps' volunteers have constructed an RWHS system with two underground ferro-cement tanks with a capacity of 20 cubic metres each for a total cost of about Rs 0.3 million.

RWHU systems from ponds

Small plastic lined ponds

SAPPROS, an NGO, has established (with INGO funding) 23 small ponds (community-level) lined with 300-micron thick plastic sheets for marginalised farmers for vegetable farming in four districts based on their experience with such systems in Kashmir in India. The distribution of ponds is as follows: Gorkha-eight; Lamjung- two; Chitwan – five; and Dailekh – eight. The scheme involves a group of users digging regular-shaped ponds in sizes of from 25 to 50 cubic metres. SAPPROS provides plastic sheets, 150 – 200 m of delivery pipe, one gate valve, and one sprinkler for each household. A users' committee is formed and registered with the District Water Resources' Committee. In one typical scheme, the tank had a capacity of 42 metres, served 12 households, and commanded 1.6 ha of land. According to SAPPROS, these systems are quite successful.

Similarly, another NGO called INSAN claims to be a pioneer in construction and promotion of RWHUs using plastic-lined tanks and sprinklers for small-scale irrigation.

Horticultural farm, Panchkhal, Kabhre

There are two ponds, plus one newly-constructed pond for collecting rain water for use on the farm. The site was visited at the beginning of August 1998.The ponds were not well maintained. One pond was completely covered with grass and the other was covered more than half by grass. The new pond, recently constructed with stone masonry walls, has not been put into operation. Some earthwork remains to be done. The new wall construction and the system do not appear to be robust enough to serve their purposes. These three ponds are in one line; the spill over from one is used by the other and so on and so forth. When fully rehabilitated and operational, these three ponds will help substantially to fulfill the water needs of the farm. One pond is about 1,200 sq. m. in area and the other two are about 700 sq. m. each.

Gajurang village, Makawanpur

Garjung Village, in Khairang VDC, Makwanpur district is a very water scarce area, where water is costlier than milk. It is one of the remotest areas in the district. The sixty households suffer greatly from scarcity of water. It takes a person six hours for a round trip to fetch two pitchers of water. Rain water from rooves collected from gutters made of bamboo/ banana trees is collected in ditch dugouts near the households and used for livestock.

Rain water harvesting from a plastic lined pond for irrigation, Ramechhap

A pond with a capacity of 3,300 cubic metres is being constructed in Ramechhap VDC, ward No 2, Babiyakharka, Ramechhap district. The catchment area is 2.12 ha to irrigate 3.5 ha land. The VDC, DDC, local MP, beneficiaries, and CIDA have contributed to its construction and a local NGO is implementing this construction and management. The beneficiaries and local institutions are contributing to the pond construction, whereas CIDA has contributed the plastic film and support for the NGO. The plastic film is 250 microns' thick and is called 'Agrifilm', a tough wide, black, and low density polythene (LDPE) material; which is of Indian make. It is proposed to plant trees around the pond to reduce evaporation. The total project cost is NRs 1.172 million.

Traditional ponds

Collection of rain water is large and small ponds in an old tradition in Nepal. They are mostly used for livestock, fire fighting, and also for irrigation, in some places. However, such traditional ponds are gradually disappearing due to disuse encroachment and breakdown of local institutions which in the past took care for their maintenance.

For example, a pond of covering one third of a bigha, (1 bigha in Nepal = 0.65 hectares) located at the southeast corner of the Tundikhel (playground) in Tansen was used for livestock and also for irrigation. The pond was filled and a building was constructed by the army barracks.

Similarly, Kamal Pokhari in Kathmandu is another example of this kind of pond. It is about to lose its identity because of pollution. There are hundreds of examples of disuse of, neglect of, and encroachment on once beautiful ponds in urban and rural areas.

Stone spouts and ponds

Stone spouts and ponds: traditional water supply system of Patan City[4]

The traditional water supply system of Patan has an intricate system of Rajkulo (canals), ponds, and stone spouts that were constructed centuries ago. The Rajkulo bring water from the Naldu and Lele rivers to Patan along a distance of about 16km to irrigate agricultural land and also to feed the ponds that recharge the groundwater and feed the stone spouts. The Rajkulo have a capacity to irrigate 1,250 ha. Before the introduction of piped water supplies to Patan in 1869 A. D. , these stone spouts, ponds, and wells were the only sources of domestic water supply. Some of the stone spouts date back to the Licchavi period (500-800 A. D.) and the sunken paved ponds are from the Malla era (1420-1769 A. D.). The Rajkulo system is said to be about 1,000 years old (Joshi 1993).

These stone spouts and their surroundings are artistically made with beautiful carvings: part of Nepal's artistic heritage. This system is a living example of the ingenuity of ancient artisans and craftsmen. It is quite surprising that the intricate system of Kulo, ponds, and, spouts are still working despite centuries of use. However, as a result of urbanisation, piped water systems, and neglect the ponds are subject to encroachment. Most of these ponds and spouts are in disuse and not functional. The Rajkulo system is at present functional up to a few kilometres only. Some agencies have carried out excellent research and documented this traditional system of Patan.

There are 40 stone spouts: of which four are not functional, about of half of them just trickle, while the other half are in good working condition. Three stone spouts were rehabilitated through the joint efforts of the Patan Municipality, the Rotary Club of Patan, Urban Development through Local Efforts (UDLE), and the local people. Further, a proposal has been prepared to rehabilitate four stone spouts, namely, Tusahiti, Bhanderkhalhiti, Saugahiti, and Sethuhiti at a cost of US$ 32,000. In 1991, the Rotary Club of Patan rehabilitated Nahity in Ward No. 6, with contributions from the local people and the NWSC. Before rehabilitation, this was a neglected stagnant pond with blocked drains. New pipes were laid and choked outlet drains were cleared. The present discharge of two litres per second is sufficient for more than 1,000 people. The rehabilitation of spouts involves locating the source of water, clearing the pipes (from source to spout), relaying a new pipe if found necessary, clearing the blocked drain outlet, and relaying a new drain if necessary and rehabilitating the spout's surroundings.

Local people believe that spout water is clear and good for drinking. However, water quality tests have shown that substantial numbers of spouts have bacteriological contamination caused by groundwater pollution. Since the community has survived for centuries drinking the spout water, it can be concluded that previously the water was potable and at present its deterioration is due to rapid urbanisation.

The stone spout in Dhobighat, situated at the western side of Patan is being used by the NWSC to augment the municipality's supply, by storing (night time) the unused water from the stone spout and pumping it to the mains. The water is stored in about a tank with a capacity of about 100 cubic metres. This system was constructed with the cooperation of the local people. Similarly, on the eastern side the NWSC tried to tap another stone spout, but

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[4] The information for this case study is borrowed heavily from the works of Eric Theophile and P. R. Joshi (1992) ; Mr. P. R. Joshi (1993) ; and N. G. Halwai (1998) and this is gratefully acknowledged.

the local people did not allow it to do so, fearing they would not be able to use the stone spouts. The NWSC thinks that such augmentation of water supplies is not economical because of the high cost of pumping. To avoid the high O&M costs, pumping would need to be substituted by a gravity-flow system.

The users' group for Dhobighat's stone spout are doing a good job in operation and maintenance. They collect one rupee from those taking bath from the spout and charge for Rs 10 for manual water collection and Rs 40 for collection with a small pump for household tanks. The surrounding area is kept clean. This process is suitable for replication in other places.

The Sundhara stone spout, a famous spout in Patan is neglected and water flow has drastically decreased. Because of poor maintenance, the drain is choked by plastic and garbage. Replicating the system in Dhobighat may be a good idea for Sundhara.

In ancient times, most of the traditional water-harvesting systems were managed by Trusts. Still, today, some stone spouts, including the one at Sundhara, and large numbers of ponds are under Trusts. A royal edict in 1887 B. S. allocated 25 *ropani*[5] and 8 *anna*[6] (1.32 ha) of land to this Trust to manage Sundhara. A person is deputed for its maintenance, and he is entitled to the produce from five *ropani* (0.25 ha) of land. Despite these arrangements, Sundhara today is in great neglect.

Most of the big ponds and tanks in Patan as well as in other parts of the country were maintained and run by religious, private or public trusti. Several ponds in Kathmandu and Janakpur are also under public Trusts. The 'Guthi Sansthan', a corporation of HMG is in-charge the of all public and religious Trusts, but has failed to manage the system properly. If cash is deposited in a Trust, then 70% of the interest can be spent of which 25% is added to the principal, and 5% is set aside for the overheads of the Guthi Sansthan.

Ponds ('pokhari')

There are 39 ponds and 218 dugwells *(kuwa)* in Patan. Out of 39, 18 are linked to Rajkulo. At present, there are only 26 ponds; one only is in good condition and the others are subject to encroachment. Retaining water in the ponds is one effective way of recharging groundwater and of supplementing recharge with rainfall.

Sprinklers and drip irrigation

Irrigation uses the most water in Nepal. Because of wide temporal variations in rainfall, substantial storage units are essential, and this makes storage costly. Sprinklers and drip irrigation systems are useful water-saving technologies and should be promoted. Sprinklers and drip irrigation systems operate by pressure and are useful in the hills where headwater is available without pumping. However, sprinklers and drip irrigation systems both require new technology with special O&M and may be unsuitable for Nepali farmers in the remote hills. For example, to avoid clogging in the drippers in the drip irrigation system, the water intensive filtration. Similarly, pipelines for fixed sprinklers can be expensive to establish. All these things have to be tailored local needs. The Agricultural Development Bank (ADB/N) has been promoting sprinklers and drip irrigation systems. SAPPROS, an NGO, is

5 One *ropani* = 0.05 hectare
6 One *anna* = 1/16 Ropani = 0/003 hectare approx.

promoting sprinklers together with plastic-lined ponds. International Development Enterprise (IDE) is also pilot testing a simplified drip irrigation system. The government policy to gradually phase out subsidies for sprinkler/drip irrigation is not justified at a time when promotion of these systems has not yet commenced.

Integrated approaches

Pilot project of the self-reliant drinking water support programme (SRWSP) of Helvetas/Nepal in Bajung VDC of Parbat district[7]

The SRWSP has developed an approach to integrated Water Resources' Management (WARM) based on local participation and in accordance with national legislation (VDC Act, Water Resources' Act). The project has developed a chair model (Figure 4.1) The chair model in the figure is self explanatory.

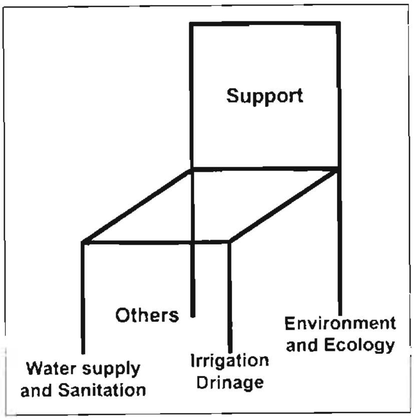

Figure 4.1: **The WARM chair**

According to the Luitel (1998), "the frequent source disputes observed by most of the organisations in the water sector necessitate a different approach to the selection and use of water sources in Nepal. For sustainability of a drinking water programme, the issue of water should not be tackled from a sub-sectoral perspective, but also with a broader approach in order to overcome the increasing water scarcity. The SRWSP has piloted a new approach to Integrated Water Resources' Management (WARM) in Bajung VDC of Parbat district to address the multidisciplinary dimension of water resources' development. The main goal of WARM is to ensure that water sources are used optimally and sustainably for economic and social development. "

5. Critical Gaps

The coverage of present RWHU, whether for drinking water or irrigation purposes is extremely limited. Besides, a systematic assessment of the impact/performance of these schemes has yet to be carried out. The validity of the gaps identified below needs to be viewed in the light of the limitations mentioned above.

i) There is a tendency to use water sources for a single purpose, say domestic water supply or irrigation. Planning should properly integrate the different uses. This will also reduce conflicts over use of the source. In this respect, there is insufficient awareness about the legal provisions stipulated in the Water Resources Act 2049 (1996-97).
ii) There is no clear-cut policy relating to planning and implementation of RWHU, although its potential to serve the needs of mountain households is quite promising.
iii) In general RWHU projects undertaken so far have been managed at both the government and non-government levels and incentive packages relating to sharing of costs and users' participation differ considerably. The effectiveness of these incentives need to be examined and a uniform standard adopted as far as possible.

[7] This case study is taken from the paper entitled Need of Integrated Water Resource Management at Village Level by Achut Luitel, Team Leader SRWSP/Helvetas (9) and is gratefully acknowledged.

iv) Against a requirement of six cisterns per household (in RWSSP/F), two ferrocement cisterns are constructed as per the programme and for the rest it is assumed that the users will construct them with assistance from the revolving fund. Water from two jars lasts only about 1.5 months, after that the household will continue the old practice of using unsafe water, defeating the aim of the programme. Due to poor socioeconomic condition, it is difficult for the hill people to add jars from their own resources. Use of the revolving fund to complete the scheme as planned needs to be revived in the RWSSP/F project.

v) One survey has shown that 13.6% of the water samples from jars in the RWSSP/F system had faecal coliform. Despite the popular belief that spring water is safe and potable, tests have shown some bacteriological contamination, especially in urban areas. This means that distribution of RWHU as safe water should be undertaken with caution. Various technology options such as first flush, use of a slow sand filter, and chlorination may need to be examined and adopted to make the water potable.

vi) There is almost no information on RWHU in the mountain ecological zones. Some pilot testing may be necessary.

vii) The Ninth Plan indicates that HMG subsidies for the schemes undertaken with loans assistance for sprinkler/drip irrigation will gradually decrease. For the RWHU system, the temporal variation in rainfall pattern requires a huge storage capacity for use in the dry season. This means that water-saving technology is a necessity and, hence, sprinkler/drip irrigation is important. Phasing out of subsidies needs to be seriously examined at this stage when promotion of these schemes is not yet complete.

viii) Many of the plastic-lined tanks/ponds constructed under the RWHU system are quite small in capacity, ranging from 30 to 50 cubic metres. The water is used mostly for irrigation of high-value vegetables. Considering a general water requirement (supplement to rainfall) per hectare of area for wheat to be 4,200 m^3 in the Terai and 2,900 m^3 in the inner Terai, (HMG/DOI 1994), the tank provided is quite small. It seems that the NGOs implementing the programmes have not given due thought to this aspect. This aspect has to be considered in terms of both increasing tank capacity and promoting more efficient drip or sprinkler irrigation systems. The drip irrigation system requires a very good filtration system to avoid clogging the emitters. In this respect more research on the suitability of collected rain water is necessary.

ix) There are successful examples of integrated watershed management in India such as schemes based on the Sukhomajri concept. In the Sukhomajri concept of RWHU, the scheme is to create small reservoirs by construction of low height dams, along with programmes such as control of soil erosion, afforestation/fodder, fish farming, and irrigation use. This type of scheme has not been adopted in Nepal, although six watershed management projects are being implemented. Such schemes deserve promotion in the light of their potential to raise the economic status of rural people.

x) The BOARD in drinking water supply and the RWSSP/F in RWHU call for input of unskilled labour, local materials, transportation of materials from the nearest road head which amounts to 30-40% of cost sharing by users, against a minimum of 10% as required by the water supply policy. Most of the schemes constructed by the DWSO require about 10% cost sharing on the part of users. No effort is seen to minimise such a wide variation.

xi) Since the late eighties, development efforts in Nepal have been increasingly directed towards users' participation and cost-sharing in local works. The poor rural dweller is pulled by different departments/agencies for cost sharing, and it becomes a burden to him/her. The idea should not be to maximise cost-sharing by users; but to let the users participate and share the cost to such an extent that the users feel that the schemes are their own and O&M their responsibility. As drinking water is the basic need for sustaining life, the schemes should not be denied to users merely on the grounds of their capacity to pay.

xii) The Soil Conservation and Watershed Management Act is yet to be implemented effectively. Similarly, the DWSCC is not effective; and the policy on the participation of NGOs in water supply and sanitation programmes has not been able to attract NGOs. All these acts and policies need revision.

xiii) Even though trusts were established centuries ago, the stone spouts and ponds under the trusts are not well maintained. The system needs to be revived with a view to bringing about improvement in the services.

6. Other Sectoral Policies and Programmes Influencing Water Harvesting at Local Level

The policies and programmes of other sectors of the economy have a varying influence on water harvesting and are summarised in the following sections.

Forest

Forests are related to watershed management. There are interrelationships between forestry, agriculture, livestock, water, and land resources. The watershed of the Siwalik region, which is quite fragile, is deteriorating rapidly due to population pressure. The Ninth FYP Plan pledges to undertake forest/soil conservation and watershed management programmes the in Siwalik range to augment groundwater recharge. A watershed management project is being implemented in the Churia hills in the three districts of Saptari, Siraha, and Udaypur with GTZ funding. The destruction of forest has adversely reduced the stream flow. The peak floods of the Bagmati and Kankai rivers have greatly increased over the predictions. These may be attributed to the reduction in forest cover in the catchment areas. At present, the community forestry programme in Nepal is showing encouraging results. Increased crops from irrigated farms means increased fodder. This will reduce pressure on the forest.

Agriculture and livestock

High-yielding varieties of crops, such as paddy, wheat, and others, need more water than local varieties. As a result of increased irrigation facilities and extension services, use of high-yielding varieties (HYV) seeds is increasing. The high doses of fertilizer required for HYV seeds also mean more water is needed. Modern agricultural technology places heavy demands on water. Lack of water/irrigation has prevented use of HYV varieties. Traditional water harvesting, such as use of ponds, terrace levelling, and use of trails to bring runoff water to places where it is needed have resulted in a 50% increase in maize production over the previous years. Soil moisture in the water use area lasts two months longer than in the untreated area (Upadhyaya 1998). Similarly, in the hills of Lalitpur and Kabhre, the increase in yield is reported to be 35% by runoff management (Shrestha 1995). The impacts of such agricultural practices on RWHU at local level have not been widely documented, because of the very small area covered by the existing RWHU. The RWHU will increase the supplies of water for livestock. In hill areas, ponds make it sprinkler irrigation possible.

Fodder deficits in the mountains, hills, and Terai account for 49, 34, and 28% respectively (DSCWM 1993). Under heavy livestock pressure most of the pastures are overgrazed. The soil loss from overgrazed grassland is estimated to be 34.7 tonnes/ha. /yr.; whereas it is around 9.4 tonnes/ha/yr. from pasture land. (DSCWM 1993).

In Daugha VDC, Gulmi, before RWHU construction, livestock were taken down to the stream every alternate day; that is, livestock used to go without water for 48 hours. After implementation of RWHU, livestock received water more frequently.

Infrastructural development

Because of very small coverage of existing RWHU, the impacts of infrastructural development on RWHU have not been documented. Roadside drains can be a good source of water, and this is widely practised in China. Hence, road/highway construction, especially the side drains, can support the RWHU system.

Infrastructural development in general influences settlements, thus exerting pressure on the use of all resources, including water. Construction of the foundation of the Sanchaya Kosh Building near Sundhara, Kathmandu, has drastically reduced eater flow to the traditional stone spouts of Sundhara. HMG/N has decided to relocate a community close to a wildlife park to the watershed area of Khageri River. This has caused great concern to the farmers drawing water from the Khageri River for irrigation in Chitwan District. Promotion of water-harvesting systems can help to ease the pressure to some extent.

Urbanisation

Cities such as Butwal, Pokhara, and Birgunj have grown very fast. Kathmandu, the capital, has undergone tremendous growth, paralysing amenities such as water supply, drainage, and others. The daily demand for drinking water in Kathmandu is 145 million litres compared to an availability of 115 million litres in the wet season and 80 million litres in the dry season. At the end of the Ninth Plan, the demand is projected to increase to 182 million litres/day (Ninth Plan Document). Acute water shortage in the Kathmandu Valley has led to excessive groundwater withdrawal, causing a significant drop in the groundwater table. The annual withdrawal greatly exceeds the annual recharge. RWHU has the potential to contribute to meeting the water requirements for at least some months each year.

In ancient times, traditional water-harvesting systems, such as stone sprouts, wells, and ponds, were constructed in urban areas, i.e., in Kathmandu, Bhaktapur, and Patan. Even though some of them are in disuse, the majority of these systems are still being used by the community, but most of them are in a state neglect. A survey by the Kathmandu municipality indicated that out of 103 stone spouts in Kathmandu, 85 are functional and most of them are in neglect. A joint project of the Kathmandu Municipality and a UN agency is rehabilitating Tamsi Pakha Ga Hiti stone spout. Even though, the water from the stone spouts is not potable, it can be used for washing clothes and bathing. A case study on the traditional water supply of Patan is given in the Appendix. The traditional water supply systems of ponds and stone spouts in urban areas in the past were potable; however, at present laboratory tests on spout water indicate that faecal coliform is present in a number of samples. There is no concerning evidence of potability in the old days; however, the community has survived for centuries on drinking water from stone spouts. This is an indication that in the old days the stone spouts were not contaminated. Therefore, a systematic study of the traditional water- harvesting system in Kathmandu Valley should be carried out to arrive at a better understanding of the system and devise ways and means to rehabilitate it in a planned manner. This would provide some support to the valley's water supply system.

Urbanisation of the Kathmandu Valley has made the rivers virtually sewers and adversely affected the environment. One example is that urbanisation has increased the demand for sand for construction. This has resulted in large-scale sand mining with very undesirable effects. Sand mining in and near the rivers might have decreased the water retention capacity of the soil. Because of the heavy demand, sand is also quarried from agriculture land near the rivers of Kathmandu Valley. About 0.60 m of the topsoil is removed and sand is quarried. This has resulted in loss of agricultural land, the danger of river erosion, and meandering and reduction in groundwater (sand is a good aquifer).

Theophile and Joshi (1992) have pointed out the complexities of issues concerning rehabilitation of traditional stone spouts and ponds. According to them:

> "This rehabilitation nevertheless raises complex questions about how to fully exploit the potential water supply through large-scale interventions. In an urban environment as in Patan, there is[sic] conflicting demands of development and conservation. The traditional water supply system of ponds, spouts can augment[sic] to reduce the domestic water shortage in Patan. "

In urban areas, there are usually buildings with very large, CGI roofing suitable for collecting rain water. Hence, it is possible to use RWHU systems in urban areas. Agencies such as Nepal Water Supply Corporation (NWSC) should consider this aspect.

7. CONSTRAINTS AND OPPORTUNITIES IN POLICY AND PROGRAMME FORMULATION AND INSTITUTIONAL DEVELOPMENT FOR SUSTAINABLE WATER HARVESTING AT LOCAL HOUSEHOLD LEVEL FOR MARGINALISED FARMERS

Constraints

The following are the main constraints to establishing RWHU:

- The Trust established centuries ago for the maintenance of traditional RWHUs are not effective, mostly because of negligence.
- Lack of awareness about legal provisions such as giving highest priority to water for drinking/ domestic use, and state ownership of water.
- Despite the policy to recover full investments and O&M costs from the urban water supply, only nominal charges are recovered. Hence, there is no incentive for the household to invest in RWHUs. Further, most people in Nepal regard water as a free commodity instead of an economic good.
- The ubiquitous thatched rooves in the hills are not suitable for maintaining the quality of rain water collected for drinking.
- HMG's policy is not strongly committed to RWHU establishment.
- Monsoon rainfall is concentrated in a three to for month period, and this means a lot of water needs to be stored to meet both domestic and irrigation requirements. Large storage systems require substantial investments. It seems that NGOs and other agencies have not given sufficient attention to this fact.
- Impact evaluation of the existing RWHUs has not been undertaken to draw lessons learned.
- The socioeconomic condition of the hill/mountainous people is quite low. The monthly rural household income in the hills according to 1996 estimates is Rs 1,240, Rs 2,560, and Rs 3,230 per household per month (The World Bank 1996: 35-36) for the lowest, median, and average household, respectively. Several communities surveyed indicate that they are willing to pay Rs 13 - 30 per household per month (1993 prices) for water

supplies, whereas the estimate for organisation and management for the gravity system is Rs 19 per household per month. (The World Bank 996)

- To ensure involvement of women in the users' groups requires their constant persuasion and motivation.
- Though the importance of NGOs in community mobilisation has been well-recognised and is also acknowledged by the Ninth Plan document, government agencies have yet to promote NGOs. The SWC is not effective. INGOs have to get permission to engage NGOs even for small jobs for more than Rs 2,00,000/- of support.
- At the implementation level, difficulties were encountered in using HMG money in the revolving fund (i.e., RWSSP/F).
- VDC/municipalities have not been successfully (except RWSSP/F) persuaded to put additional investments in this sector.
- The Ninth Plan stipulates that the subsidy or loan will be reduced on the irrigation schemes based on the sprinkler/drip systems. This merits reconsideration at a time when these systems need extensive and intensive promotion.
- Remoteness makes transportation of construction materials difficult.

Opportunities

Widespread use of RWHUs will result in improved quality of life by bringing about the following favourable changes.

- Reduction in the drudgery of carrying water from long distances in the mountains and hills. RWHU mean that drinking water is available on the doorstep, thereby reducing drudgery. In the hills, where there are no nearby water supply systems, a family spends an average of 126 minutes per day fetching water. The time saved (estimated to be 30%) could be used for other beneficial economic activities.
- Improved health and improved sanitary conditions result from an increase in water Supplies. Every year about 45,000 children below the age of five die in Nepal from sanitation related problems, which is related to inadequate supplies of and poor quality of water. RWHUs with good treatment systems can improve sanitation, reducing the number of infant deaths.
- Some of the hill towns have costly high-lift pumping systems for water supplies. Widespread augmentation in supplies of water by RWHU work will reduce the quantity of water to be pumped and hence the costs of O&M cost will decrease. For example, in Tansen, a hill town, water is pumped to a height of 500 metres at a cost of seven million rupees per annum in O&M (Rs 5 million for electricity charges alone). Large percentages of water from stone spouts go to waste in Tansen. Judicious use of water from stone spouts will reduce pumping costs.
- Use of water for irrigation will result in increased agricultural production—including high value vegetables. Marginal farmers in the hills/mountains of Nepal do not eat many vegetables Widespread use of RWHUs for small-scale irrigation in vegetable farming will help to improve this situation. Increased production of vegetables will increase their use, resulting in better nutrition. Vegetable farming is more profitable than conventional paddy, wheat, or maize cultivation. Hence, their production will increase the incomes of farmers.
- In Nepali communities, there are problems of social interaction between 'high' and 'low' castes. The occupational castes (tailors, blacksmiths, and shoemakers) are disadvantaged and they are usually deprived of the benefit of facilities. As 'low caste' people are supposed to be 'untouchables', they have problems using community taps. Use of RWHUs at household level will ensure water also for the disadvantaged groups.

- There is a good opportunity to augment domestic water supply through judicious use of spring, stone spouts, and also for agricultural use with the waste water from these sources.
- Construction of ponds will increase soil moisture and spring flow downstream due to seepage from the unlined ponds. This will result in increased greenery and increased productivity in agriculture. Further, in the monsoon, too much rain causes soil erosion and washout of nutrients from the sloped fields. Collection and storage of water during monsoon can decrease soil erosion, thus improving the environment. The problem of excessive rainfall in monsoon and little or no water in dry season can be mitigated to some extent by the RWHU.
- Integrated watershed management, which includes the components of afforestation, growing fodder, soil conservation, fish farming, and irrigation, has great potential for increasing socioeconomic conditions.
- In the hills, water head is usually available freely for use of sprinklers and drip irrigation; and hence costly pumping is not required.
- In the Bhabar zone, the groundwater table is quite deep and hand pumps cost more than 0.15 million rupees each. RWHUs may be a good alternative if other sources are not available nearby.
- Some public buildings in urban areas have very large rooves which are suitable as rain water collecting surfaces, . This opportunity needs to be tapped in cities and towns like Kathmandu where water is scarce.
- The World Bank funded BOARD is observed to be an efficient institution. If this institution undertakes RWHU, it would result in promotion of the same.
- Traditional stone spouts and ponds looked after by Trusts can be better maintained by reviving the old management system.

8. Recommendations for Future Action

The following recommendations are suggested for the development, better management, and promotion of RWHUs:

- Provisions in the Water Resources' Act – (2049-1992-93) that stipulate that the source of water belongs to the state and drinking/domestic water receives the highest priority are not known by many planners and people, mostly those in rural areas. Awareness should be raised about them.
- *"A simple, affordable, replicable, and sustainable design of water supply projects should be developed for rural areas which will at the same time conserve and protect local, traditional water supply sources"* (Ref -9).
- Ineffective Acts and Policies need to be revised to make them practical and attractive, i.e., Soil Conservation and Watershed Management Act, Policy on Participation of NGOs in the Water Supply and Sanitation Programme, and DWCC – Guidelines for Work Implementation.
- An integrated approach should be developed for exploitation of water sources for different uses instead of for single uses. For example, waste water from stone spouts might be used for irrigation. This concept may help to reduce conflicts.
- Related key stakeholders should be encouraged to team up and draft a national strategic policy on RWHU so as to give it the importance and priority it deserves.
- Research and pilot testing should be undertaken, especially in high mountain areas, with flat rooves and in areas where thatched rooves are predominant.
- Women should be encouraged to play a greater role in RWHU activities.
- The WUGs should be strengthened through the development of an appropriate training

programme aimed at development, use, and dissemination of local skills and indigenous knowledge.

- The BOARD should be persuaded to take up RWHU in hill/mountain places where other viable alternatives are not available.
- Where thatched rooves are predominant, it may be necessary to launch RWHU at community level by using CGI rooves of schools, community buildings, and others.
- Arrangements should be made to permit HMG funds to be used as revolving funds similar to guthi (trust) arrangements.
- Policies on RWHU should take into account the unique characteristics of the regional nature, rain shadow areas/high mountains, and other hill areas.
- Impact evaluation of the ongoing and completed RWHUs needs to be undertaken to assess their impact on the community and draw valuable lessons for feedback.
- As drinking water is the basic essential for sustaining life, maximising users' cost sharing should not be the sole criterion for launching RWHU programmes.
- A suitable agency should evaluate the RWHU works and introduce awards for excellence in micro-conservation of water.
- Policies should be formulated so that the government acts as a facilitator, or supporter instead of a provider or implementator. HMG/N needs to create an enabling environment so that user groups, the private sector, and service organisations can implement small schemes. Rain water harvesting at household level and small community level should be entrusted to NGOs, CBOs, user groups, and so on with HMG agencies playing the role of facilitators.
- Effective policies for regulating, facilitating, and promoting NGOs need to be formulated. It is necessary to make the SWC an effective institution. The limit of Rs 200,000 on grants from INGOs to local NGOs, under which amount the permission of SWC is not required needs to be increased to promote NGOs. As NGOs are expected to increase their activities, this policy will facilitate increased small-scale use of water resources. Similarly, other service organisations such as user groups and Community Based Organisations should also be promoted. Further, a clear and easy registration process should be established.
- RWHUs should be promoted first at household level, with users sharing a small amount of the costs. When people see the importance of RWHU, then cost sharing can be increased. In the later stages, pond construction at community level can be promoted for irrigation. In the final stage, emphasis should be given to micro- catchment by integrating watershed management. Hence, the policy should include short-, medium-, and long-term strategies.
- As directed by the Ninth Plan, the Department of Irrigation should undertake research work on RWHU-based small-scale irrigation using the sprinkler/drip system.
- There is a need for legislation to encourage the use of RWHUs in all new houses (urban areas) to be constructed in water scarce areas, i.e., Tansen Palpa, and Kathmandu (Chennai City of South India and Bermuda (a coastal country) have similar legislation).
- Provision should be made so that households that are too poor to contribute to the costs are not denied access to community facilities.
- Even though the drip irrigation system can be very efficient to an extent of about 90%, it requires very good filtration to avoid clogging. It is a high-tech system and its appropriateness for marginalised farmers needs to be assessed. Further test and research are required on the simplified drip irrigation system before it is promoted widely.
- Traditional water supply systems, such as ponds and stone spouts in urban and rural areas, need to rehabilitated to augment the existing water supply. To the extent possible augmentation from these systems should be by gravity (without pumping) to minimise O&M costs.

- A systematic study of traditional water-harvesting systems in Kathmandu Valley needs to be carried out to have a better understanding of the system and to devise ways and means to rehabilitate it in a planned manner. Such an approach would provide meaningful support to the inadequate drinking water system in the valley.
- The ability of the DWRC to process and issue licenses to water users has been in doubt. The provision needs to be revised in light of the limited ability of the DWRC.
- Despite the popular belief that water from springs and stone spouts is safe for drinking, laboratory tests have indicated that bacteriological contamination is present, especially in urban areas. Some agency needs to monitor the water quality frequently and the users need to be advised accordingly.
- Related agencies should persuade VDCs and DDCs to bear the additional investments in the small-scale water sector.
- Since traditional ponds and spouts looked after by Trusts are in a state of neglect and are being encroached upon, Guthi Sansthan (Corporation for Royal Trusts) should be persuaded to act effectively.
- The Water Resources' Regulations – 1993 and the DWSCC have nominated different committees for conflict resolution over water sources and their use. This needs to be resolved to avoid confusion.

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Chapter 5
Water Harvesting Policies in Mountain Areas of Pakistan

S.M. Zia[1] and T. Hasnain[2]

1. Introduction

Pakistan is situated in the arid and semi-arid region of the world between 24°N and 37°N latitude and between 61°E and 77°E longitude. Average annual precipitation ranges from 2,000mm in the north to 100mm in the south (PCRWR 1994). Pakistan has two mountain ranges in the Hindu Kush-Himalayas (HKH), namely, the western mountains and northern mountains. The climate in Pakistan virtually allows all kinds of crops and trees to grow. Irrigated agriculture provides 90% of the country's food and fibre production, and the use of water for irrigation (see Annex 1) is still on the increase (Mulk and Mohtadullah 1992).

Pakistan's agrarian economy is predominantly dependent on irrigation. Pakistan operates the world's largest gravity flow irrigation system. The Indus River and its main tributaries, i.e., the Kabul, Jehlum, Chenab, Ravi, Bias, and Sutlej, together form one of the largest river systems in the world. The principal water resources available for agriculture in Pakistan include rainfall in cropped areas, surface water from rivers or canals, and usable groundwater from aquifers (see Annexes 2 and 3).

Although a vast area has been brought under irrigation through a network of barrages and canals in the lowlands and plains of Pakistan, mountain agriculture is still mostly rainfed. Several indigenous water-harvesting methods in mountain areas, such as the Rod Kohi system (water from hill torrents collected in reservoirs and used for agriculture) in the southern North-West Frontier Province (NWFP); the sailaba and khushkaba systems in Balochistan; and groundwater mining through tubewells in both the NWFP and Balochistan, are in place.

This study reviews Pakistan's water resources in mountain areas and their development potential for improving agricultural production. It explores water-harvesting techniques and analyses the impacts of policies on the local community.

[1] Research Fellow, Sustainable Agriculture Programme, Sustainable Development Policy Institute (SDPI), Islamabad

[2] Research Associate, Sustainable Agriculture Programme, Sustainable Development Policy Institute (SDPI), Islamabad

Physical characteristics

Pakistan is divided into seven broad land-resource regions: the Northern Mountains, *Barani* Lands, Irrigated Plains, Sandy Deserts, Sustainable 'Rod Kohi', Western Dry Mountains, and Coastal Areas. Ecologically speaking, great biotic, physical, cultural, and ethnic diversity is found in mountainous areas. Wide variation in topography, rainfall, vegetation, and farming systems in the mountains is also evident and permits the growth of almost all kinds of crops. However, diversity makes it difficult to generalise or to make comparisons. Public sensitisation is needed to overcome social taboos. Further, planned government interventions in line with fragility, marginality, and human adaptation mechanisms are required to transform mountains into agriculturally productive areas.

In mountainous areas, arable farming, pastoralism, and social forestry are the common land uses. It is generally the altitude, climate, physiography, soil moisture, and socioeconomic conditions that determine the use of land. Over 90% of the area is comprised of steep slopes with shallow soils. These slopes are unstable and support patchy natural vegetation. Large tracts between the altitudes of 900 to 3,300 metres support coniferous forests. At elevations of up to 1,500 metres, pastures are grazed around the year. Small ruminants cause stress on the vegetative cover. With increasing population pressures and demand for landholdings, the vegetative capacity has been substantially reduced. Higher elevations between 1,500 to 3,000 metres are grazed only during summer; the pastoralists moving with the snowline.

The Northern mountains include Malakand Division, Hazara Division, the Northern Areas, and Murree- Kahuta Tehsil in Rawalpindi District covering 96,340 sq. km. and hosting a population of 7.82 million (1993 figures). The average literacy rate is less than 20%. Agricultural land is privately owned in smallholdings and most farmers are engaged in subsistence farming. There are also communal and state-owned lands. Income levels are relatively low and overseas' remittances play an important role in the local economy.

The Western dry mountains are the core of the arid land and cover, to a great extent, the major parts of Kohat and Bannu districts of the NWFP and tribal areas/agencies of Kurram, Northern Waziristan, South Waziristan, Bannu, and Kohat. The average rural population density of 12/km^2 makes the region, by far, the most thinly populated in Pakistan. The low population density is attributed to lack of water resources and scarcity of economic opportunities.

The western dry mountains face even harsher conditions. The population density is very low. The environment is impoverished by development interventions. This area is rich in minerals and natural gas, but these are exploited by the more affluent and powerful. Water is scarce and the resources that are available are ill managed. Several resources still remain untapped.

Inefficient water use has led to wastage of tapped water resources. The water table in some areas of Balochistan is going down by more than a metre every year as a result of over pumping for irrigation. The runoff, flash flood waters are allowed to escape to the Arabian Sea, leaving soils in upland areas exposed and degraded. Soil erosion, it is believed, is the principal cause of desertification in upland areas. Check dams can help reduce runoff and, thus, erosion.

Socioeconomic conditions

Mountainous areas in Pakistan skim the north west of the country forming a formidable barrier. The ecology of these areas varies and their capabilities can be severely limited due to the lack of natural resources. This is reflected in the culture and social norms of the area. The social system can be very collaborative with the extreme harshness of tribal systems. Harmonious living in the Northern areas, on the one extreme, is contrasted by tribal conflicts in the south west. The tribal system follows its own codes of conduct and justice. The tribes are very tightly organised. Tribal leadership is still intact and codes are rigidly implemented. The social structure of certain tribes has been modified in some cases by their proximity to settled areas. Efforts made previously by successive governments have been unsuccessful because physical power has been used as an intervention. Evidence is available that it is possible to modify the social structure through simple economic interventions. However, these interventions have not been used in Pakistan. They may have come about by accident and not as a matter of conscious government fiat. The way of life and the compulsions in these areas are different from those of the plains. Cultural aspects provide security and subsistence under very harsh conditions. It is easy to condemn a given social system because it no longer conforms with a given model of a system. Where living conditions are harsh and production systems nomadic or non-existent, there may be no other option but to be part of a given system. So far, modern economic opportunities have not been introduced into the area. Conflicts between the government and the tribes are a common occurrence and, as a result, the areas are closed to development of resources. Education and health facilities are unheard of and road construction is not allowed. Electricity infrastructure is frequently vandalised. Given this scenario, development is decades behind. The will and the right of the federal government is virtually non-existent. A more participatory approach, especially in the western dry mountains, is required to change the existing conditions. The profile of food security in this area is given in Table 5.1.

Table 5.1: **Profile of food security and natural resources in Pakistan**

Food production per capita 1993 1980=100	118
Food imports per capita 1993 1980=100	114
Cereal imports per capita 1994 (1,000 tonnes) 1980=100	201
Food aid in cereals per capita 1994 (1,000) 1980=100	19
Food aid 1992 ($ million)	190
Land area (1,000 ha) 1993	79,610
As % of land area 1993 - forest and woodland - arable land	
Irrigated land (as % of arable land area) 1994	80
Deforestation (1,000 ha per year) 1980-9	9
Annual rate of deforestation (%) 1981-90	2.9
Reforestation (1,000 ha per year) 1980-9	7
Production of fuel wood and charcoal (1,000m^3 per year) - 1980 - 1993	 16,683 25,021
Internal renewable water resources per capita (1,000m^3 per year) 1995	3.3
Annual fresh water withdrawals 1980-9 - a % of water resources - per capita (m^3)	 33 2,053

Source: IIED 1998

2. WATER HARVESTING PROGRAMMES IN PAKISTAN

The small, isolated communities in mountain areas use several novel techniques to store rain water for domestic as well as agricultural use. Among the examples of water harvesting methods developed for agricultural purposes in mountain regions that have been documented are the 'diversion system' and the 'dam system'. In the diversion system, a long channel diverts the flood water to plantations adjacent to the valleys. In the dam system, a large reservoir behind the dam is filled with flood water. The reservoir water is then pumped through pipes to numerous sprinklers that distribute the water to the winter crops.

As far as water harvesting for domestic needs is concerned, two major approaches are applied: the 'community-owned approach' and the 'household approach'. The communities in mountainous and arid regions collect rain water in large reservoirs located inside or adjacent to the localities and villages. These reservoirs may be open ponds or underground, concrete water tanks which keep water for varying periods of time according to their size. People also practise different household techniques for harvesting and storing water.

Lack of information about invaluable indigenous practices is one major hurdle to the acceptance, adaptation, and replication of these techniques on a broad scale. We have compiled two case studies in this document. These case studies cover the water-harvesting practices developed by the indigenous people in southern NWFP, called the Rod Kohi system; and the sailaba and khushkaba systems practised in western Balochistan province to address the domestic and agricultural needs for water. The agricultural and domestic needs of these regions are met by rain water harvesting.

The rod kohi water-harvesting system of Southern NWFP

The southern most regions of the NWFP province, comprising the D. I. Khan and Tank districts, are bounded by the Suleiman range in the west, the Bhittani range in the north, and Marwat range in the east. The area between the Suleiman range and the Indus River, *inter alia*, constitutes a huge wasteland locally known as the 'Damani Area'. This area is frequently subjected to flooding by hill torrents. Five major hill torrents, called 'zam'(s), along with a number of small ones, traverse the Damani area. Flash floods of shorter duration but large magnitude hit the area generally during monsoon. Some of the water from these flash floods is used by the locals in a traditional system of irrigation called the Rod Kohi System. The zam(s) bring large quantities of water laden with high silt charge, eroding soils from the gorges. The water is used by landowners through a network of earthen temporary dams ('gandi/sad') constructed across the bed of the torrents in the piedmont area en route to the Indus River. There water is led into the embanked fields, through shallow channels ('khula') and trail-dikes (*pala*). The high embankments used to divert water into terraced fields are generally filled with water up to 1 to 1.5 metres, after which the water is released to the next field and so on. This system of diversion continues till the flood flows are either completely exhausted or all the fields are filled. The major zam have some perennial flows aggregating to about six cubic metres per second, and they are used for cultivation of about 28,000 hectares (or about 70,000 acres). The monsoon flows are used for winter ('rabi') cultivation in September and October. Various components of the spate irrigation practices in the area are elaborated upon in the following the figure.

The Rod Kohi (hill torrent) Irrigation System in the area is more than a century old and is a vital component of the local economy, social set-up, and environment. The Chashma Right

Bank Canal, currently under construction, is to command the area located on the right bank and will continue to depend on the traditional Rod Kohi System. The total dam area under the Rod Kohi Irrigation System covers 263,730 ha. This is inclusive of 23,500ha irrigated by Chasma Right Bank Canal (CRBC) under gravity flow conditions. The area irrigated through 205 cfs of perennial supply available from different zam is about 24,300ha. The remaining 239,430 hectares are irrigated by flood irrigation. The Rod Kohi System consists of 11 flood channels originating from the Kohe-Suleiman range through different gorges (*darrah*). Out of these, five are major hill torrents (zam) and six are small hill torrents (*rod*). Major zam: the Tank, Gomal, Sheikh Haider, Daraban, and Chodwan, further fan out into 17 *rod*. The *rod* are further divided into minor distributors (*wah*) that take the water into the fields. This network aggregates to 1,168 km in length. In addition to this, diversion weirs/ distribution structures have been constructed on different *rod* to divert flow to different channels. A zam can be broadly divided into mountainous area, sub-mountainous, and plains. The five major zam are rainfed and perennial. These zam have a considerable discharge in which sediment concentrations are enormous, and the damming of flood flows in some cases is not economically feasible. Thus, these zam require systematic planning for effective management.

The Rod Kohi System is governed by rules and regulations called *Kulyat and Riwajat-i-*Abpashi (rules and regulations for irrigation) established more than a century ago by the local people. These rules and regulations provide detailed information regarding distribution of flows to the riparian community. However, the settlement officers have made minor changes, modifications, and adjustments from time to time without violating the basic governing principles or the established rights of different villages and their people.

The farmers also have problems with the Rod Kohi System. The gandi/sad, when built improperly, usually breach under the rush of flood water before the required amount of irrigation is accomplished. Quite often these are not completely constructed and, when the rains set in and the torrents are flooded, irrigation becomes impossible. The flood water continually cuts out new channels and ravines. Consequently, the whole area is affected by flood flows. Sometimes the floods of different torrents accumulate in certain ravines, rendering the flow unmanageable and causing a lot of damage to lands, villages, and property, besides paralysing the communications' system. The embankments surrounding the fields, which play a vital role in the irrigation system of the area, are generally weak and get washed away, releasing most of the impounded water. The fields, therefore, sometimes do not retain sufficient moisture to make cultivation possible. The other main problems that farmers face in the Rod Kohi System are the lack of the earth-moving machinery at the appropriate time and inadequate labour for constructing temporary diversion dykes during the hot months of June and July when water, shelter, and fodder are insufficient. This leads to high mobilisation costs for the farm labour and machinery. The short-lived high peaks and flows of flood water do not conform to the crop water requirements of the area. The flood flows are generally impregnated with a high siit charge, precluding the possibility of economical management through reservoirs. The banks of the channels are irregular in height and width, creating flooding over the banks in various reaches of the channel. Generally, the major zam have a number of tributaries and offshoots out falling into each other and complicating the entire management system. Furthermore, on account of the bilateral slope and highly variable flows laden with silt charges of different amounts during various seasons of the year, the channels frequently change their course to make the location of cross-drainage structures on canals and roads unpredictable.

Advantages and disadvantages of the Rod Kohi System

The Rod Kohi System is facing many problems. Some of the main drawbacks are outlined here. The Rod Kohi channels become silted up in different places because of continuous neglect and improper maintenance, and are thus unable to accommodate the full water discharge. This results in overflowing of banks and formation of new ravines. These ravines ultimately join the ones scoured out by neighbouring torrents to aggravate the flood situation. The water, thus, does not flow along its proper course on which dams (gandi) are erected. The flood water continues to flow unchecked and is wasted instead of being put to good use. In addition, it causes damage to the lands and property. The time, location, and mode of construction and the quality of the dams are important factors determining their efficacy in diverting flood waters for a meaningful purpose. Sometimes, when the dam is not constructed before the onset of a flood, or if it is imperfectly built and the shallow channels are not prepared and maintained to withdraw water from the dams, they are washed away under the pressure of impounded water.

The hill torrents keep on changing their course due to varying amounts of discharge and sediment. The diversion of flow in one channel above its carrying capacity causes flood problems in the area leading to crop damage, infrastructural wreckage, land erosion, and ravine formation; ultimately resulting in social problems. Cross drainage structures are constructed to control the situation, but because of unpredictable channel behaviour and the amount of flow, there is every possibility of damage to the irrigation system. At present, the Rod Kohi System is working under the supervision of the Deputy Commissioners in both D. I. Khan and Tank districts. The existing administrative set-up is facing serious constraints such as paucity of maintenance funds, insufficient transport facilities to facilitate staff supervision, inadequate office buildings, scarcity of engineering staff, scarcity of earth-moving machinery and mobile workshops, and inadequate extension services from the department of agriculture for training of and bringing about awareness to farmers.

Water harvesting in Northern Balochistan

The Pishin district lies in northern Balochistan. The general characteristics of the district are mountainous. The northern half of Pishin district is covered by the Topa plateau. The hill ranges are fairly uniform in character and consist of long central ridges from which frequent spurs descend. The spurs vary in elevation from about 1,500 to 3,300 metres. The main occupation is agriculture together with forestry, hunting, and fishing. The principal agricultural crops in the district are wheat, tobacco, potatoes, apples, grapes, and barley. Sheep and goat activities are also common in the district because of the extensive pasturelands; and this is an important source of income. The local people manufacture blankets and rugs and embroidery is carried out as a cottage industry.

In Pishin rainfed farming is practised widely. There are two important water-harvesting techniques applied: i) building embankments and bunds to divert the stream and flood water in the rainy season known as the Sailaba system and ii) the Khushkaba, system which depends upon direct rain. The farmers sometimes develop a small catchment area on the upper side of a field and the rain water is harvested for farming on the lower side. Sometimes no catchment area exists and the water is directly harvested on to the cultivated fields.

The climate of the district is generally dry and cold, because it lies outside the range of monsoon currents. The rainfall is irregular and scanty and the precipitation varies from year to year. There is very little rainfall in Spring and Summer. Rainfall and snowfall usually occur in January and February. Sometimes snow falls even in March, and the winter rains continue throughout April. The mean annual rainfall in the district varies from 200 to 300mm. Pishin's elevation from sea level ranges between 1,200 to 2,000 metres (Anees and Baluch 1980). Its climate is mild in summer. The maximum temperature rarely goes beyond 35°C. The winters in Pishin are extremely cold with snowfall and sub-zero temperatures.

Water sources and need for rain water harvesting

The main sources of drinking water in the district are wells, springs, rivers, streams, and ponds. Three quarters of the population use these sources to meet different needs. Piped water is supplied to 15% of the households. Piped water is available mainly in urban areas. The rural population depends upon springs, streams, and pond water (Census 1981). Farming in the district is mostly rainfed (*barani)*. In some areas, agriculture is carried out with the help of 'karez'. Karez is a centuries' old system developed by the local people (Pithawalla 1952). These are underground waterways linking water from various wells and then bringing the water to elevated places from below. The use of tubewells has become common in recent years, but both tubewells and karez are unable to meet agricultural and domestic water needs, and these have to be met through rain water harvesting.

Pishin, like other upland areas of Balochistan, is a water scarce district. In spite of being a major source of water for downstream plains, the mountain region itself is short of water for irrigation and needs water harvesting for sustainable crop and plant production. There are many important factors responsible for shortage of water in the district such as temporal distribution of water flows, incompatibility between mountain terrain and conventional approaches to irrigation systems, and failure to develop irrigation designs suited to mountain situations. The scarcity of water in the district calls for adopting comprehensive water-harvesting and management strategies in order to meet the demands (Ashraf and Anwar 1995).

Water-harvesting system for rainfed farming in Pishin

In the centre and north east of Balochistan province seven districts are defined as highland rainfed areas. These districts, namely, Quetta, Kalat, Pishin, Loralai, Zhob, Kachi, and Khuzdar, have a total geographical area of 14.9 million hectares, a little less then 43% of the total geographical area of the province. The area under crops in the rainfed highlands of Balochistan in 1985-86 constituted 37% of the total cropped area of the province (Buzdar *et al.* 1989). The main characteristics of rainfed farming systems is that it is dependent on erratic and uncertain rainfall causing frequent crop failures. The farmers try to diversify crops and enterprises to minimise risks and ensure continuous subsistence. The farming community's cooperative mechanism also works as insurance against personal economic disasters.

Most of the cultivable lands in Pishin district lie in valleys surrounded by mountain ranges or hills. The most predominant soil types are clay loam, loam, and sandy loam. Generally, the soils are deeper towards valley centres. Fertility is adequate in areas where rain water deposits new layers of silt each year. These characteristics of soils in Pishin are quite favourable for rainfed farming. Two main farming systems are common in the district, and they are known by the farmers as sailaba (flood) and khushkaba (rainfed) farming systems. These systems are different from each other due to the nature of moisture supply systems practised under each of them. The details of both systems are described in the next section.

3. POLICIES THAT INFLUENCE WATER HARVESTING AT LOCAL LEVEL

The network of irrigation in Pakistan consists of canals, dams, tubewells, and rain. The national policy on water is developed by the federal government in consultation with the provinces. According to the constitution of Pakistan, water is a concurrent or shared resource between the centre and its four provinces. The latest agricultural package announced by the government provides the following relief to boost irrigation facilities in mountain/rainfed areas (GOP 1998).

The water from hill torrents will be harvested through diversions and used for rabi (winter cropping season) crops in a sizeable area throughout the Suleiman Range in the Northern Areas, North West Frontier Province (NWFP), part of the Punjab, and Balochistan. For *barani* (rainfed) areas, schemes for small dams, sprinkler, and drip irrigation projects will be introduced.

The federal government has published five-year plans ever since the late Fifties. Eight plans have been published so far and the latest one (1993-98) was completed in 1998.Both federal and provincial ministries and their allied institutions prepare their annual public sector development plans for delivering policy impacts. The principal national projects are managed at the federal level; however, the provinces are also encouraged to plan and undertake projects.

Water policy in Pakistan is synonymous with irrigation policy and its main objective is to increase supplies of water for irrigation consequently increasing irrigated areas through augmenting investments in irrigation systems. There are other policies that may have an indirect impact on water harvesting and thus on water supplies at farm level. These are discussed below.

Deforestation and water supplies

In general, deforestation affects water supplies in two ways. One, it alters the micro-environment of the area and can have a negative impact on the annual rainfall. Second, deforestation can accelerate soil erosion, resulting in silting of dams, streams, and water channels downstream and, thus, decreasing water supplies at farm level. Deforestation in Pakistan is estimated to be somewhere between 7,000 to 9,000 hectares per annum and that equals an annual decline of 0.2% in forest vegetation according to the National Conservation Strategy of Pakistan 1992.

New farming systems and demand for water

New technological developments, together coupled with strenuous public and private sector efforts, have made it possible to shift from traditional crops to high-value crops in mountain areas. Large areas have shifted from traditional crops to vegetables like potatoes, turnips, carrots, and radishes. Vegetable crops require more water and more regular irrigation than other crops (maize). Additional water has to be provided either through additional supplies or through demand management. On-farm water management techniques, developed by several development projects like Provincially Administered Tribal Areas (PATA) help to increase efficient use of water on the one hand and to develop or improve water-harvesting techniques on the other. As vegetable crops, particularly off-season vegetables, generate more income, this encourages investments to improve in situ water harvesting.

Subsidies and water resources

Substantial subsidies for machinery and fuel have encouraged construction of wells. This quite often leads to inadequate or careless maintenance of other water resources. For instance, in Balochistan, availability of water from subsidised tubewells has resulted in poor management of the traditional karez system (Jassra *et al.* 1998). As a result, many karez are not in operation.

Also, in Balochistan, farmers do not pay their electricity bills. As a result, they run tubewells round the clock. This over-pumping has two implications. One, overmining of groundwater results in a lower water table. With almost no recharge, the groundwater falls more than a metre every year. Two, due to the availability of free water for irrigation, farmers do not apply indigenous in situ water-harvesting techniques. Thus, rain water, a very scarce resource, is used inefficiently. There is evidence that, with proper in situ water harvesting techniques, cultivated areas can receive substantially more (up to 300%) rainfall than is currently the case.

Research policy and water harvesting

It has frequently been advocated that, for arid lands in Pakistan receiving insufficient rainfall, proper harvesting of rain water can provide a cheaper source of water for crop production than other methods of imigation. Some of the simplest indigenous water-harvesting systems can collect 20 to 40% of the precipitation for later use. In the Eighties, the Pakistan Agricultural Research Council (PARC) began research, in collaboration with International Centre for Agricultural Research in Dry Areas (ICARDA), to generate viable technologies for water harvesting in rainfed areas. As a result, the Arid Zone Research Institute (AZRI), Quetta, developed an on-farm water-harvesting technology that could increase water storage in the cropped area. Yields in the cropped area were also considerably high (Rees *et al.* 1989a). In another study (Rees 1989b) it was found that cleaning and compacting of the upper parts of gently sloping valley-bottom fields, to form a catchment area, could result in considerable increases in water and, thus, crop yields could be doubled.

These technologies are in use at various levels and are being refined. The on-farm water harvesting project-III of the Ministry of Agriculture and Livestock receives assistance from the World Bank. It aims to maximise infiltration and storage of water from rainfall in cultivated areas. Water-harvesting strategies have been developed for catchment and sub-catchment areas (Table 5.2).

Watershed management

Increased demand for forest products and a rapidly growing population put further pressure on natural resources in upland areas, resulting in degraded watersheds. Though watershed degradation continued to receive attention, the need for large-scale watershed management projects was felt only after the construction of large dams. Since 1962, watershed management recommendations have emerged as key components of forest policies. Strategies proposed to improve watersheds include large-scale afforestation, soil and water conservation through check dams, gully plugging, and terracing of fields. These steps help increase in situ water harvesting.

Table 5.2: **Summary of alternative water harvesting development strategies**

1. Steeply Sloping Land
1.1 Erosion Protection
1.2 Forestry Plantations on eyebrow and reverse terraces
1.3 Range Development
2. Gently Sloping Land
2.1 Contour Terracing
2.2 Waterways grassed to control flow
2.3 Pasture Development
3. Terraced Land
3.1 Field levelling (level or graded)
3.2 Improvements to field bunds
3.3 Field spillways and waterways
3.4 Ridge and furrows or contour furrows
3.5 Improved tillage practices
3.6 Development of micro-catchments (where annual rainfall is less than 750 mm)
3.7 Improved farming systems--including development of rotations, improved varieties and others.
4. Rainfall Regimes
Annual rainfall:
< 250 mm } Developed micro-catchments:
250-500 mm } in field-field-hill runoff-alternate
500-750 mm }
> 750 mm No additional catchment required.
5. Eroded Land-Gullied
5.1 Check structures and other erosion protection structures
6. Small Streams
6.1 Diversion weirs and channels
6.2 Check dams for storage
7. Depressions
7.1 Storage ponds
7.2 Reservoirs
7.3 Check dams

Source: Information from the Government of Pakistan

4. INSTITUTIONS INVOLVED IN WATER HARVESTING

Institutions are quite often defined as simply government agencies and private organisations. More broadly speaking, it is in fact the institutions that set the 'rules of the game' within which economic systems operate. For instance, the property rights' system is considered to be a water institution because it determines access to land and water, thus influencing the decision to make investments in the farm. Property rights help define the structure of incentives and disincentives, rules, rights, and duties that guide human activities and encourage conformist behaviour (Bromley 1989). Farmers with secure property rights tend to invest more in improving in situ water harvesting and in *ex situ* water harvesting than the farming with short-term rights on land use.

Institutional structures are also important for allocating water to different users or to define rights for harvesting rain water. Communities in Balochistan, over time, have developed an institutional structure within the community to allocate the water they harvest through the karez system. This is similar to water users' associations, a concept that is popular with water policy specialists and practitioners.

Research institutions are involved in finding ways to improve efficiency of use through institutional performance. For instance, the AZRI has developed water-harvesting techniques that are efficient at field level. The On-Farm Water Management Programme of the Ministry of Agriculture is now testing and adapting these technologies in more than 40 sites in hilly areas of Pakistan. There are a host of institutions involved directly or indirectly in influencing water-harvesting techniques in Pakistan (see Annex 4).

The Water and Power Development Authority (WAPDA) is the principal federal institution in the water sector and operates throughout the country. However, the Federal Planning Commission is the supreme body for overall planning of economic development in Pakistan.

5. Recommendations for Future Action

Both systems in D. I. Khan, the Rod Kohi Irrigation System and the 'Talai' System can easily be replicated in other areas with similar geophysical conditions. The Rod Kohi System is typical of hilly areas that have flash floods/hill torrents. Development of the Talai System on an artificial basis is possible but catchment areas can only be created at high cost. The National Engineering Services of Pakistan (NESPAK), the Irrigation Department of NWFP, and the Department of Agriculture have the potential and skills to provide institutional support for replicating these systems in other areas.

The technology applied for rainfed farming is very simple and cheap, and it can be adopted easily. The 'Sailaba' farming system is like the Rod Kohi system in NWFP province, but here the sizes of streams/torrents are smaller than those of hill torrents in NWFP. Sailaba harvesting is dependent upon the collective efforts of the community. Khuskaba farming is practised by individual farmers, with household catchments but with the support of community members. The Khushkaba farming system is very important for those areas where no irrigation system, streams, or hill torrents exist. Institutional support to replicate and strengthen rainfed agricultural technology in Balochistan is available at AZRI in the public sector. Many non-government organisations like the Balochistan Rural Support Programme (BRSP) and Strengthening Participatory Organisation (SPO) are actively involved in agricultural development and can play a very effective role, particularly in promoting the Sailaba harvesting system where community participation is important.

More reliable water supplies are certainly the most favourable option for development interventions. However, without development of fresh water resources to the maximum possible extent, even of water resources from the highly irregular rainfall of the arid zone, would be to neglect a significant potential for domestic use and agricultural production. Therefore, this water resource potential should not be dismissed from development strategies for arid zones. Nevertheless the development of a reliable water supply system must depend on the economic feasibility of such a scheme and on criteria acceptable to both communities and policy-makers alike.

Provision of quality water for domestic and agricultural purposes all year round needs to be a part of all development strategies. Local communities could be trained in water-harvesting. There is evidence that people are completely convinced about adopting such strategies and techniques which, through ensuring the availability of water, could reduce droughts, famine, and forced migration. Yet they are not aware of the methods. They also lack essential skills for implementing such strategies. The government departments concerned, such as the Pakistan Council of Research in Water Resources (PCRWR) in Cholistan and Sind Arid Zone Development Authority (SAZDA) in Thar, have invented many techniques to increase the runoff for pond and tanks. These techniques should be introduced to the people and replicated on a wide scale.

The development of micro-catchments and micro-watersheds can increase water supplies for farming substantially, which, in turn, through increasing agricultural output, will enhance the potential for dry areas to absorb the growing number of people. The cover of small grasses may be left on the soil to reduce the erosion effects from the watershed. A runoff of 20 to 25% can be expected from untreated watersheds of loam and sandy loam soils. Wide areas with regular slopes may be developed into bench terraces for water harvesting. The terraces are constructed with bunds across the slope of the land on a contour to cut a long slope into small ones, and each contour bund acts as a barrier to the flow of water.

Embankments, bunds, and small dams constructed for water harvesting through the Rod Kohi System and for Sailaba as well as Khushkaba cultivation do not seem to be good quality structures. Close to 80% of farmers' labour and power is spent on construction, reconstruction, and repair of the bunds. Because of the poor quality and non-durability of the bunds and dams, water and soil losses are high. There is a need to provide more resources for compaction of these structures and to improve the defects in the location, height, breadth, and design of the spillways, resulting in frequent breaches of the bunds. Both institutional and financial support would be needed to build up the capacities of the communities involved.

The development of low-cost water reservoirs can play an important role in sustainable mountain agriculture. The topography of the mountains provides ample sites for construction of medium and small-sized reservoirs by blocking ephemeral streams. The water stored can be used for supplementary irrigation of crops and plants.

Introduction of some Distribution Management Systems (DMS) could be beneficial in ensuring the longevity of the resources available. This would need in-depth study of the socioeconomic aspects of the respective communities. The study, through facilitating understanding of social dynamics, would help to develop community-based institutional arrangements to introduce the water allocation practices essential to ensure proper water use.

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Annex, Table 1: **Area irrigated by different sources**

(million hectares)

Year	Canals	Wells	Canal and Wells	Tube-wells	Canal and Tubewells	Others	Total
1990-91	7.89	0.13	0.08	2.56	5.87	0.22	16.75
1991-92	7.85	0.16	0.11	2.59	5.93	0.21	16.85
1992-93	7.91	0.18	0.10	2.67	6.23	0.24	17.33
1993-94	7.73	0.14	0.09	2.78	6.22	0.17	17.13
1994-95	7.51	0.17	0.10	2.83	6.41	0.18	17.20
1995-96	7.60	0.18	0.11	2.89	6.58	0.22	17.58
1996-97	7.81	0.18	0.11	2.88	6.61	0.26	17.85

Source: Economic Survey 1997-98,pp 62

Annex, Table 2: **Monthly average rainfall in mountain areas of Pakistan in 1996**

(millimetres)

Area	Jan	Feb	Mar	App	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rawalpindi	82	122	130	47	32	145	299	328	72	60	3	6
Peshawar	29	74	76	38	15	12	18	110	51	203	42	0
Abbottabad	74	112	256	144	0	162	164	160	89	120	19	14
Kohat	35	43	60	17	31	50	34	107	9	55	1	0
D.I. Khan	15	15	50	0	15	37	19	45	21	10	0	4
Quetta	34	34	30	1	8	2	0	0	0	3	0	9
Zhob	15	19	27	27	28	15	81	114	90	0	0	5

Source: Agri. Statistics of Pakistan 1996-97, pp 143

Annex, Table 3: **Overall water availability in Pakistan**

(million acre feet)

Year	Surface Water	Ground Water	Total Water Availability
1989-90	176.26	42.98	117.14
1990-91	185.24	43.98	119.62
1991-92	186.85	44.90	122.05
1992-93	176.60	46.00	124.70
1993-94	180.56	47.45	128.01
1994-95	181.23	48.42	129.65
1995-96	192.59	38.26	130.85
1996-97	192.82	39.23	132.05

Source: Agricultural Statistics of Pakistan 1996-97, pp 142

Annex, Table 4. **Institutions Involved In Water Harvesting**

Government Agencies
1. Ministry of Water and Power (MWP)
2. Federal Water Management Cell (FWMC)
3. Central Engineering Authority (CEA)
4. Water and Power Development Authority (WAPDA)
5. Provincial Irrigation Departments (PIDs) of each province
6. Irrigation and Power Department of each province
7. Pakistan Council of Research in Water Resources (PCRWR)
8. Small Dams' Organisation, Irrigation and Power Department of each province
9. Ministry of Food and Agriculture
10. Pakistan Agricultural Research Council (PARC)
    - National Agricultural Research Centre (NARC)
    - Arid Zone Research Institute (AZRI)
11. Department of Public Health Engineering and Irrigation in each Province
12. Agriculture and Engineering Universities
13. Irrigation Research Institute, Lahore
14. Agency for *Barani* Areas Development (ABAD)
15. Soil Survey of Pakistan
16. Geological Survey of Pakistan (GSP)

International Agencies
1. International Irrigation Management Institute (IIMI)
2. United Nations (Tech. Assistance Programme)
3. United Nations Development Programme (UNDP)
4. Food and Agriculture Organisation (FAO)
5. World Bank
6. USAID
7. Japan International Cooperative Agency (JICA)
8. Asian Development Bank (ADB)
9. The World Conservation Union (IUCN)—Pakistan
10. International Centre for Agricultural Research in Dry Areas (ICARDA)

Private Sector
1. National Engineering Services Pakistan (NESPAK), Islamabad
2. Halcrow Rural Management (HALCROW), Islamabad
3. Hazara Engineering Consultants, Lahore
4. National Engineering Services, Lahore
5. Enterprise Development Consultants (EDC), Islamabad

Non-Government Organisations (NGOs)
1. Pakistan Institute of Environment Development Action Resource (PIEDAR), Islamabad
2. Agha Khan Rural Support Programme (AKRSP), Gilgit
3. Action Aid-Pakistan

International NGOs
1. Action Aid-Pakistan

Annex Table 5: **Comparative efficiencies of farms with and without supplementary water supplies from private tubewells**

	Non-user of water from tube wells	User of water from tube wells	Increase in yield
Cropping intensity	113	157	
Per cent of gardens in cropping pattern	2	11	
	(tonnes per ha)	(tonnes per ha)	(per cent)
Crop yields			
Sugar cane	29.0	54.7	88.6
i) Wheat	1.7	2.4	41.1
Rice (Irri)	1.9	2.9	52.6
Rice (Basmati)	1.7	2.2	29.4
	(Rupees)	(Rupees)	
Net value per hectare	2,470	3,137	27.0

Source: Pakistan National Conservation Strategy (Table 2.9)

Chapter 6

Water Harvesting Technology and Management Practices in Garhkot Watershed of Tehri Garhwal, U.P. Hills, India[1]

R. Babu, J.S. Samra, P.B. Joshi, B.L. Dhyani, R. Singh and C. Prakash

1. Introduction

The Kumaon and Garhwal Himalayas and the hills of Uttar Pradesh (UP) are geologically young, seismically active, fragile, inaccessible, and marginalised areas with biotic and ecosystem diversity. In spite of heavy rainfall and the fact that they are the source of perennial rivers, there is acute scarcity of water for domestic and agricultural uses as well as for wild- life during most of the year. These areas exercise a tremendous off-site effect by determining weather and being the source of floods and sediment deposition in the plains, reservoirs, and natural water bodies.

The UP Hills lie between 28°60'-31°28'N latitude and 77°49'-80°60'E longitude and are comprised of twelve districts, six in Garhwal Division: Dehra Dun, Pauri Garhwal, Tehri Garhwal, Rudra Prayag, Uttar Kashi, and Chamoli and six in Kumaon Division: Almora, Bageshwar, Champawat, Nainital, Udham Singh Nagar, and Pithoragarh; altogether covering a geographical area of 5.11 million ha. The population density in 1991 was 115/km^2 with a literacy percentage of 55.7 (Table 6.1). About 64% of the working population are engaged in agriculture and nearly 78% of the population live in villages. The average holding size in the region is 0.94 ha. Out of the total area, 64% area is under forest and only 12.4% is under agriculture. Orchard and other vegetation account for four per cent. Agriculture is largely rainfed making it especially prone to the vagaries of weather. Only about 11% of the net sown area is irrigated and that too is mostly confined to lower altitudes.

The most alarming development in the populated Lesser Himalayan belt is the drying up of springs and their increasing seasonality. A study in the catchment of Gaula River in lesser Himalayan River in south central Kumaon in UP demonstrated that in 40% of the villages, the extent of decline in spring discharges in the last five to 50 years ranged between 25 to 75% (Bartarya and Valdiya 1989). This clearly indicates that the Himalayan villages are heading for a serious water shortage. The soils of the area are shallow, gravelly, and

[1] The views expressed in this report are those of the authors and not those of the Central Soil and Water Conservation Research and Training Institute.

Table 6.1: **Development indicators of the hill region of UP**

S.N.	Item	Unit	Year	UP Hill Region
1.	Area	sq.km.	1981	51125
2.	Population	million	1991	5.874
3.	Density of population	per sq.km.	1991	115
4.	Decennial growth rate of population	per cent	1981-91	21.49
5.	Literacy rate	per cent	1991	55.67
6.	Female per thousand males	no	1991	974
7.	Percentage of rural population to total population	per cent	1991	78.00
8.	Percentage distribution of main workers			
	1. Cultivators	per cent	1981	63.78
	2. Agricultural labourers	per cent	1981	5.54
	3. Household industry	per cent	1981	1.49
	4. Others	per cent	1981	29.19
9	Average size of operational holdings	per cent	1990-91	0.94
10.	Percentage of small and marginal holdings to total holdings	per cent	1980-81	78.50
11.	Area under forest	per cent	1992-93*	63.95
12.	Area under agriculture	per cent	1992-93*	12.36
13.	Area under orchard and other vegetation	per cent	1992-93*	4.10
14.	Net sown area	per cent	1992-93*	12.9
15.	Irrigation (%) of net sown area	per cent	1992-93*	11.1
16.	Total cropped area	'000 ha	1987	1102.80
17.	Cropping intensity	per cent	1987	164.27
18.	Fruit production	'000 tonnes	-	398
19.	Food grain production	million tonnes	-	1.53
20.	Average yield			
	a. Wheat	kg/ha	1989-90	1465
	b. Rice	kg/ha	1989-90	2116
	c. Potatoes	kg/ha	1989-90	18380
21.	Total number of problem villages suffering drinking water shortages	no		11642
22.	Percentage of village having drinking water facility to total problem villages	per cent	1990	90.90
23.	Employment per lakh of population in organised sector	no	1987	4712

* Agricultural Report, UP, 1995

** Agricultural Census, UP, 1990-91

Source: 'Rumbling in the Mountain' by Chand Joshi. The Hindustan Times, August 22, 1992

impregnated with unweathered fragments of parent rock, occurring within a few centimetres at elevated spots to within about two metres in the valleys. The soils are brown to greyish brown and dark grey in colour, generally non-calcareous and neutral to slightly acidic in reaction.

The region is difficult to approach because of its unique topographical features, and this has resulted in poor impact of development programmes. The people of the region, although primarily depending on agriculture, are relatively unaware of modern crop production and forestry and pasture management practices. Application of modern crop production, animal husbandry, fruit and vegetable production, and forestry and pasture management practices is needed. Application of modern technological methods are indispensable for maximising production per unit area. Due to the mountainous nature of the terrain with steep slopes, coarse and shallow soils, denuded vegetational cover, and heavy precipitation, the zone is extremely vulnerable to landslides, soil erosion, and runoff. Thus ecologically sound innovative development approaches need to be adopted for sustainable development of the area with the least deleterious impact on the mountain ecosystem as well as the foreland.

The climate of the UP hill region is extremely varied, ranging from sub-tropical to temperate and hosting diverse flora and fauna. The area has a different rainfall pattern from the rest of the country. There are two distinct rainfall seasons: July-September and December-March. The isopleths for these two periods are given in Figures 6.1 and 6.2. The variation is great in the monsoon and ranges from 500 to 2,000 mm, but most of the area receives between 750 and 1,500 mm (Srivastava *et al.* 1998). In addition to the normal monsoon precipitation, the region also receives about 200 mm of rainfall in winter with the exception of some pockets near Chakrata and the hills near Uttarkashi. Thus, the region receives plenty of water during the monsoon season. However, during the rest of the period drought prevails. During winter and summer, there is a scarcity of water for drinking purposes as well as for livestock consumption. The average annual rainfall of the Garhwal Himalayas varies from 826 to 2,115 mm, out of which 80% is received during the monsoon season (Table 6.2). Weekly rainfall and rainfall received at probability levels of 70 and 50% (7 and 5 years out of 10 years) for 16 stations in the UP Himalayas are given in Tables 6.3a and 6.3b. During the monsoon (July-September), most of the stations received weekly rainfall of 50 mm or more. During October to December, scanty rainfall is received. However, from January to March, the region receives winter rainfall of about 25 mm per week. The average temperature in the valleys varies from 3° to 30°C, while the higher hills (more than 3,000 masl) are covered with snow in winter.

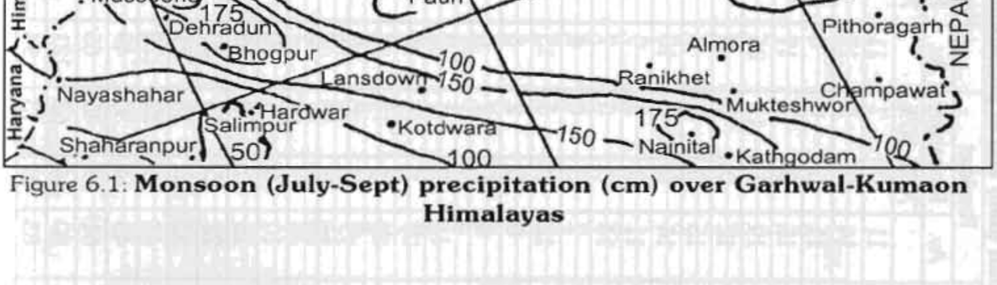

Figure 6.1: **Monsoon (July-Sept) precipitation (cm) over Garhwal-Kumaon Himalayas**

Table 6.2: **Average monthly and annual rainfall (mm) in the area**

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Pauri	61	67	55	32	52	132	326	360	148	34	8	28	1303
Srinagar	55	56	37	22	43	118	244	223	97	25	6	22	948
Devprayag	39	54	50	22	37	89	204	208	89	4	3	27	826
Bironkhal	63	72	44	31	63	166	316	264	132	37	5	27	1220
Lansdown	67	73	45	29	53	202	624	628	316	45	6	27	2115

Source: Compiled from various sources, 1998

Table 6.3a: **Weekly rainfall (mm) and at probability levels of 70 and 50% for selected stations in the UP Hills**

Week	Almora			Ranikhet			Kausani			Nainital			Mukeshwar			Champawat			Pithoragarh			Berinag		
	Av.	Probability		Av.	Probability		Av.	Prob.Level		Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability	
		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%
1	9	0	0	11	0	1	11	0	0	17	0	0	10	0	1	15	0	0	10	0	0	11	0	0
2	10	0	0	14	0	5	17	0	0	15	0	0	12	0	3	14	0	0	10	0	0	11	0	0
3	8	0	1	11	0	0	6	0	0	17	0	0	11	0	3	12	0	0	10	0	0	12	0	0
4	13	0	4	15	0	7	17	0	0	16	0	0	15	0	6	18	0	6	12	0	2	15	0	4
5	16	0	7	19	1	11	26	0	0	23	0	0	20	1	9	23	0	10	19	0	7	20	0	12
6	11	0	4	12	0	3	9	0	0	16	0	0	13	0	4	15	0	4	13	0	3	13	0	2
7	12	0	7	16	0	7	6	0	0	18	0	0	16	0	7	18	0	6	13	0	5	17	0	7
8	11	0	3	14	0	3	10	0	0	18	0	0	13	0	5	15	0	0	12	0	0	13	0	3
9	8	0	2	11	0	2	9	0	0	9	0	0	10	0	3	9	0	0	8	0	0	10	0	3
10	12	0	4	14	0	5	7	0	0	12	0	0	13	0	5	13	0	3	11	0	3	13	0	3
11	8	0	0	7	0	0	8	0	0	10	0	0	9	0	0	10	0	0	8	0	1	9	0	0
12	10	0	4	12	0	5	13	0	0	11	0	0	13	0	6	14	0	6	11	0	4	15	0	8
13	8	0	2	8	0	2	8	0	0	10	0	0	10	0	4	7	0	0	7	0	0	10	0	0
14	6	0	2	8	0	2	0	0	0	7	0	0	0	0	3	10	0	0	7	0	1	9	0	3
15	5	0	1	7	0	1	4	0	0	6	0	0	9	0	2	8	0	2	7	0	1	8	0	1
16	7	0	0	8	0	1	7	0	0	6	0	0	8	0	2	6	0	1	5	0	0	8	0	0
17	5	0	1	6	0	1	8	0	0	6	0	0	7	0	2	5	0	0	7	0	1	8	0	2
18	7	0	1	8	0	3	6	0	0	9	0	1	10	0	3	10	0	3	11	0	5	15	0	5
19	15	0	8	15	1	8	9	0	0	20	0	9	15	0	8	14	0	8	16	0	9	23	0	13
20	10	0	4	10	0	5	7	0	0	22	0	7	13	2	7	13	0	6	13	0	7	14	0	5
21	8	0	3	10	0	5	10	0	0	17	0	6	11	1	5	11	0	8	15	0	6	14	0	8
22	17	1	8	15	1	8	18	0	0	30	0	18	19	0	13	24	6	17	27	0	16	34	3	20
23	22	3	12	22	5	15	20	0	0	43	10	31	21	4	12	21	4	14	27	7	21	40	7	29
24	25	5	14	33	5	18	21	0	10	70	14	40	33	3	19	33	9	22	40	9	28	62	19	43
25	43	13	29	48	16	32	29	0	9	125	55	89	49	8	32	61	25	40	58	25	42	90	42	70
26	42	18	30	43	14	30	49	9	28	135	60	97	48	20	33	53	22	36	54	24	38	79	35	55
27	51	24	37	61	29	45	65	35	59	142	67	106	65	16	49	65	30	47	65	33	53	100	51	81
28	64	32	53	80	44	63	121	73	114	178	90	143	78	30	56	81	38	60	68	35	57	103	63	96
29	61	30	51	83	49	73	94	53	83	185	100	170	74	36	65	84	42	69	69	40	60	118	68	102

Table 6.3a: Cont....

Week	Almora			Ranikhet			Kausani			Nainital			Mukeshwar			Champawat			Pithoragarh			Berinag		
	Av.	Probability		Av.	Probability		Av.	Prob.Level		Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability	
		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%
30	64	30	47	84	43	70	113	87	96	164	88	150	72	43	57	77	36	55	76	41	70	132	78	117
31	60	32	53	86	46	80	110	59	96	197	113	168	70	35	61	73	44	67	71	42	62	124	75	115
32	61	30	49	89	45	75	101	81	90	169	91	157	79	41	73	77	39	65	74	39	66	134	81	123
33	56	26	42	85	45	76	95	47	78	165	82	136	69	42	55	61	31	51	74	38	62	120	64	110
34	56	26	42	75	35	54	73	47	66	184	87	137	75	34	52	72	32	51	64	28	45	110	54	87
35	29	12	20	46	21	32	61	12	44	102	45	70	45	33	32	45	15	30	46	20	33	82	38	63
36	37	12	25	50	22	35	55	24	43	99	45	69	50	21	35	43	18	30	42	19	32	78	37	58
37	33	10	24	44	14	30	56	16	37	94	25	66	54	22	36	54	13	38	40	17	29	56	23	40
38	23	3	13	33	4	16	27	5	18	80	11	39	34	22	20	43	1	16	26	2	14	41	8	29
39	31	0	11	34	2	14	34	0	8	57	4	26	43	7	17	36	0	10	24	0	11	34	7	24
40	14	0	0	19	0	1	75	0	35	42	0	3	24	3	4	27	0	0	21	0	3	21	0	7
41	5	0	0	5	0	0	96	0	0	12	0	0	6	0	0	11	0	0	7	0	0	11	0	0
42	6	0	0	7	0	0	4	0	0	6	0	0	4	0	0	11	0	0	8	0	0	8	0	0
43	1	0	0	2	0	0	4	0	0	1	0	0	2	0	0	3	0	0	2	0	0	1	0	0
44	2	0	0	2	0	0	0	0	0	5	0	0	3	0	0	1	0	0	3	0	0	2	0	0
45	1	0	0	2	0	0	0	0	0	2	0	0	1	0	0	1	0	0	2	0	0	1	0	0
46	2	0	0	2	0	0	0	0	0	4	0	0	3	0	0	5	0	0	3	0	0	3	0	0
47	1	0	0	1	0	0	1	0	0	2	0	0	2	0	0	2	0	0	1	0	0	2	0	0
48	1	0	0	2	0	0	0	0	0	2	0	0	2	0	0	2	0	0	1	0	0	2	0	0
49	1	0	0	2	0	0	0	0	0	3	0	0	2	0	0	1	0	0	2	0	0	2	0	0
50	7	0	0	8	0	0	3	0	0	8	0	0	7	0	0	10	0	0	7	0	0	7	0	0
51	6	0	0	6	0	0	7	0	0	7	0	0	7	0	0	8	0	0	7	0	0	7	0	0
52	5	0	0	6	0	0	1	0	0	6	0	0	7	0	0	6	0	0	4	0	0	7	0	0
Total	1026			1311			1531			2604			1286			1351			1238			1879		

Table 6.3b: **Weekly rainfall (mm) and at probability levels of 70 and 50% for selected stations in the UP Hills**

Week	Pauri			Srinagar			Bironkhal			Joshimath			Karanprayag			Rudraprayag			Dehradun			Mussoorie		
	Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability	
		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%
1	10	0	0	8	0	0	10	0	0	7	0	0	8	0	0	12	0	0	11	0	0	14	0	3
2	13	0	6	10	0	2	13	0	0	17	0	7	11	0	4	12	0	2	12	0	1	14	0	4
3	14	0	5	12	0	3	14	0	5	13	0	5	14	0	0	11	0	0	15	0	1	14	0	4
4	16	0	7	16	0	5	19	0	4	17	0	7	17	0	7	21	0	9	14	0	1	18	0	2
5	19	0	9	20	1	7	20	0	7	23	0	10	21	0	10	22	0	9	20	0	6	26	0	12
6	15	0	6	11	0	3	18	0	2	17	0	7	16	0	5	16	0	5	16	0	1	16	0	7
7	16	0	8	12	0	4	16	0	5	16	4	11	14	0	5	16	0	9	14	0	0	19	0	6
8	16	0	4	13	0	0	18	0	4	20	0	8	19	0	7	23	0	7	17	0	0	17	0	4
9	12	0	2	8	0	0	12	0	0	21	2	11	14	0	6	12	0	5	9	0	0	11	0	1
10	13	0	4	8	0	0	12	0	2	22	2	10	14	0	5	16	0	5	10	0	0	17	0	4
11	9	0	0	9	0	0	7	0	0	16	1	9	7	0	2	10	0	0	5	0	0	9	0	1
12	14	0	6	10	0	3	12	0	4	23	4	13	19	0	9	16	0	9	6	0	0	13	0	7
13	11	0	4	6	0	0	6	0	0	16	1	9	10	0	4	11	0	3	7	0	0	12	0	3
14	8	0	3	6	0	0	6	0	0	14	1	7	10	0	4	12	0	7	5	0	0	11	0	3
15	7	0	0	4	0	0	7	0	1	11	0	5	8	0	3	9	0	4	2	0	0	6	0	0
16	7	0	0	4	0	0	7	0	0	11	0	6	9	0	2	10	0	6	5	0	0	5	0	0
17	6	0	0	4	0	0	7	0	0	6	0	1	8	0	0	9	0	3	3	0	0	5	0	0
18	8	0	2	4	0	0	12	0	3	7	0	3	9	0	2	12	0	7	4	0	0	8	0	1
19	14	0	6	10	1	3	15	0	9	12	0	6	12	0	6	14	0	7	8	0	0	15	0	6
20	10	0	4	8	0	3	12	0	4	7	0	2	12	0	7	18	0	8	8	0	0	10	0	4
21	11	0	4	7	0	2	10	0	0	6	0	2	11	0	6	14	2	7	5	0	0	11	0	4
22	15	0	8	13	0	5	19	0	10	7	0	4	21	2	11	19	2	11	18	0	3	19	0	10
23	19	2	10	13	0	7	21	2	12	10	2	7	18	0	10	26	7	18	19	0	6	24	0	11
24	22	6	16	20	3	14	34	6	19	18	5	12	29	5	20	47	16	32	34	0	13	39	5	21
25	37	9	26	34	10	23	54	17	37	27	9	18	47	19	32	62	26	42	48	12	31	54	11	30
26	51	16	35	38	10	27	55	18	38	28	12	19	58	25	42	80	41	70	68	28	53	87	26	58
27	57	25	40	42	14	29	58	25	41	34	16	26	66	31	50	94	44	71	118	60	97	142	77	121
28	74	37	59	50	21	34	75	35	55	36	21	32	92	46	75	107	64	90	136	88	123	156	85	133
29	79	42	70	58	27	43	80	38	61	43	21	35	86	52	60	127	88	107	153	98	135	198	121	174
30	82	41	68	60	28	45	75	35	54	49	24	39	105	53	87	163	95	140	150	88	130	179	101	154

Table 6.3b: Cont....

Week	Pauri			Srinagar			Bironkhal			Joshimath			Karanprayag			Rudraprayag			Dehradun			Mussoorie		
	Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability		Av.	Probability	
		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%		70%	50%
31	97	48	77	66	31	49	68	37	54	50	26	40	119	61	92	156	115	141	174	115	157	210	136	190
32	83	40	66	50	23	38	66	34	56	49	26	40	112	56	90	141	102	125	163	95	140	179	88	143
33	95	56	84	47	22	36	69	32	51	38	21	30	81	40	65	138	95	124	170	88	135	176	101	153
34	74	40	68	48	23	37	54	25	41	36	19	28	77	40	60	127	76	107	145	78	123	176	110	158
35	58	26	40	36	11	25	34	11	24	33	15	24	74	33	51	109	59	86	116	58	94	126	57	100
36	40	17	28	23	5	16	34	9	24	25	11	18	60	24	41	74	40	69	94	37	68	95	37	70
37	43	11	30	29	5	21	33	3	20	21	8	14	49	21	35	71	31	51	77	28	56	90	30	63
38	22	1	10	13	0	6	19	0	5	15	3	10	28	6	16	35	14	24	41	3	21	45	4	19
39	24	0	10	15	0	4	21	0	5	17	1	8	26	0	14	29	6	20	35	0	7	52	0	19
40	12	0	0	8	0	1	16	0	0	10	0	2	13	0	33	15	0	4	23	0	0	22	0	3
41	4	0	0	7	0	0	12	0	0	4	0	0	5	0	9	6	0	0	14	0	0	6	0	0
42	6	0	0	5	0	0	7	0	0	5	0	0	4	0	0	9	0	0	6	0	0	6	0	0
43	2	0	0	1	0	0	2	0	0	2	0	0	1	0	0	3	0	0	7	0	0	4	0	0
44	2	0	0	2	0	0	1	0	0	4	0	0	2	0	0	3	0	0	2	0	0	3	0	0
45	2	0	0	1	0	0	2	0	0	2	0	0	2	0	0	1	0	0	2	0	0	4	0	0
46	2	0	0	1	0	0	2	0	0	3	0	0	2	0	0	2	0	0	2	0	0	2	0	0
47	2	0	0	2	0	0	2	0	0	3	0	0	1	0	0	2	0	0	2	0	0	2	0	0
48	2	0	0	1	0	0	1	0	0	2	0	0	1	0	0	4	0	0	2	0	0	3	0	0
49	2	0	0	2	0	0	3	0	0	3	0	0	1	0	0	3	0	0	2	0	0	6	0	0
50	7	0	0	6	0	0	8	0	0	6	0	0	6	0	0	5	0	0	7	0	0	10	0	0
51	7	0	0	7	0	0	10	0	0	8	0	0	5	0	0	6	0	0	7	0	0	8	0	0
52	9	0	0	6	0	0	7	0	0	9	0	0	8	0	0	8	0	0	7	0	0	10	0	0
Total	1280			894			1195			899			1462			1968			2038			2404		

Source : Indian Meteorological Department (IMD) 1995

The runoff data from three experimental watersheds (with areas ranging from 286 to 370 ha) in Garhwal Himalayas (Table 6.4) reveal that runoff volume under different land uses varies from 15 to 42% (Dhyani *et al.* 1997 and Joshi *et al.* 1998).

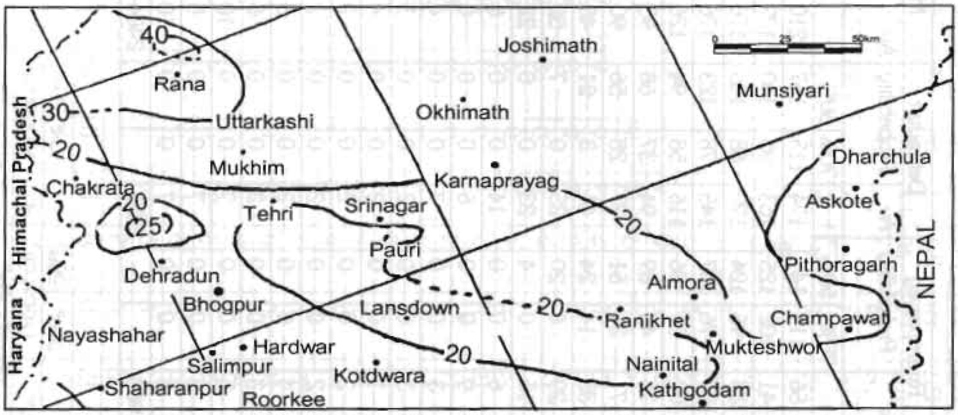

Figure 6.2: **Winter (Dec-March) precipitation (cm) over Garhwal-Kumaon Himalayas**

Table 6.4: **Runoff volume in small watersheds in Garhwal Region of the UP Hills**

	Name of the Watershed		
	*Fakot (Tehri Garhwal)	**Dugar Gad (Pauri Garhwal)	**Srikot Gad. (Pauri Garhwal)
Location	23°13'N and 78°20'E	30°11'N and 78°48'E	30°5'N and 78°46'E
Watershed area (ha)	370	306	286
Elevation range (m)	650 to 2015	1460 to 1900	1060 to 1980
Av. annual rainfall (mm)	1900	1698	2365
Land Use (%)			
Cultivation	22	38	38
Forest	36	9	50
Wasteland	42	53	12
Runoff (%)	42 (Before treatment)	41.3	18.1
	15 (After treatment)		

* Dhyani, et al. (1997)
** Srivastava, et al. (1998)

The hill economy predominantly operates on a subsistence level and is mostly self-contained. Women contribute more than 80% of labour input every day, whereas males migrate elsewhere to supplement family incomes. About 50% of the male population migrate from the area in search of employment. About 74% work in agriculture (82% in crop activities and 69% in livestock activities) is performed by female workers who have little decision-making power (Singh and Sharma 1987). In addition, collection of fodder, fuel, and water is generally considered as women's work and women are subjected to extreme drudgery in carrying out these tasks. Farm equipment suitable for women farmers is non-existent. At the same time, farm mechanisation is not possible because of topographical constraints and a preponderance of marginal and scattered operational landholdings. Bullocks are the main source of draught power.

Transport and communication systems are rudimentary. The marketing and institutional infrastructures are grossly inadequate. There are tremendous potentials for floriculture, off-season vegetables, mushroom production, and Angora rabbit rearing, but they remain unexploited because of the communication constraints. The amount of rich inherent diversity also results in slow adoption of improved technologies.

The UP Himalayas gained popularity as a tourist attraction because of pilgrimages, natural beauty, and recreation and adventure sports. During 1990, more than 15 million tourists (Swaroop 1991 and 1993) visited different places in the UP Hills. The number is increasing rapidly. This is going to aggravate the problem of acute water shortage in the region.

2. Water Problems in the Hills

Despite the fact that the Himalayas are the largest storehouse of fresh water at lower altitudes, for the bulk of people inhabiting these mountains, water is extremely scarce all year round. They receive either too much during the few months of monsoon or too little for the rest of the year (Chalise 1996). This is also true for the UP Hills. Therefore, the following issues need to be addressed and appropriate methods of and techniques for water harvesting and management of local water resources in the region assessed and identified.

- The water requirements of mountain communities in the region need attention and the inhabitants should be provided with a fair share of local downstream benefits from harnessing upstream mountain resources.
- The wide variations and seasonality in water supplies need to be considered and matched with the ever-increasing year round demands for water.
- The systems for harvesting and sustainable management of local water resources need to be better understood.

3. Selection of the Study Area

In the UP hills, the largest population (more than 60%) residing in 55% of the villages is concentrated in the middle altitude zone (1,000-1,500 m) where there are 15°-30° (27% to 60%) slopes, 0-5 km of road accessibility, southern and eastern aspects, and where it is most suitable for habitation with the maximum amount of land under all types of land use. As a result of the heavy population pressure, the region is short of water (for drinking, domestic, and irrigation purposes) all year round except for the four months (July to October) of the south-west monsoon. The Garhkot watershed (elevations range from 840 to 1,700 m) in Hindolakhal block of Dev Prayag 'tehsil' sub-district in Tehri Garhwal district was selected for the study (Figure 6.3). The Garhkot watershed is short of water for drinking, domestic uses, and irrigation. The watershed also has all possible land uses and associated problems for land, water, and vegetation. The watershed is situated on the Devprayag - Tehri road and is easily approachable for the purposes of survey and investigation. (Plate 1)

4. Methodology

The study was based on an intensive field survey and investigation. The investigation covered six 'gram sabha' having five villages and seven hamlets. Forty-five households comprising of 15 families in each altitude zone (upper - greater than 1,500 m, middle – 1,000-1,500 m, and lower - below 1,000 m) were selected randomly. All the families

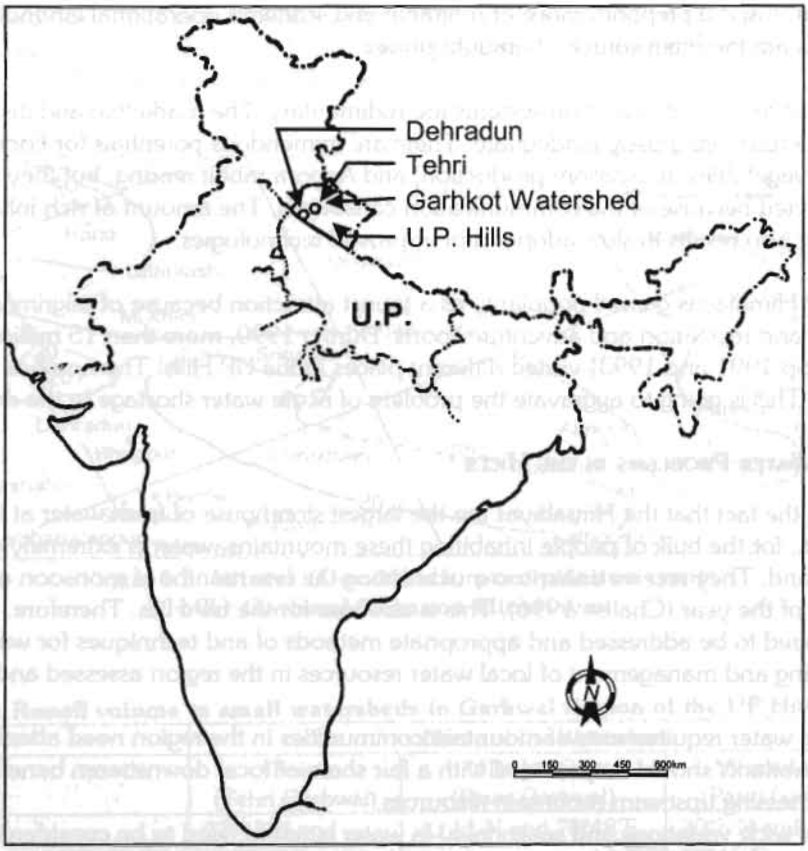

Figure 6.3: **Location map of Garhkot watershed-Tehri Garhwal**

selected were interviewed and an inventory made using a well-structured schedule designed for the study to understand the socioeconomic structure, productivity of land, and arrangements for management of existing water resources in the watershed. Much of the information, both quantitative and qualitative, was gathered using the diary method; thus a mixed approach was used as suggested by Jodha (1995). This was necessary in order to record cross-sectional information linked with water resource issues such as local history, farmers' perspectives and strategies, their perceptions of public policies and programmes, and future vision. Information was generated through group discussions involving farmers of all age groups and from both sexes. The opinions of the village 'Pradhan' (headman), President of the Watershed Association, social workers, and key persons regarding various aspects of local water-harvesting technologies and management systems were also taken into consideration. Various public departments and NGOs were contacted to learn about their different programmes.

A multi-disciplinary team comprising of social scientists, water resource specialists , and a soil scientist extensively carried out a transact survey in each village to collect the actual observations on various aspects pertaining to water resources, socioeconomics, soil, and vegetation. Actual measurements were recorded at each site.

Participatory Rural Appraisal (PRA) was carried out with the villagers. Further, vein diagrams of water resources in the villages were also prepared by a group residing in the village. Water samples from various springs were collected and analysed for physio-chemical characteristics using the 'Standard Method' to monitor water quality. The statistics on humans, livestock population, revenue records, and other related information were obtained from published records, The Tehsil headquarters at Devprayag and the Block Development Office, Hindolakhal, were also visited.

5. Background and Information on the Study Area

Location

The 348 ha watershed is situated on the south-eastern aspect of the Alaknanda River catchment between 13.6 to 16 km from Dev Prayag and two km before Hindolakhal (Block Office). The ridge line forming the boundary of the watershed is well defined and drains into the 'Garhkot Gad' stream. The mean elevation of the watershed is approximately 1,200 masl. The highest ridge point of the watershed is at 1,690 m and the lowest is at 840 m near the bridge below Garhkot village. There are two well-defined drains that join at 'Garhkot Gad' (Figure 6.4).

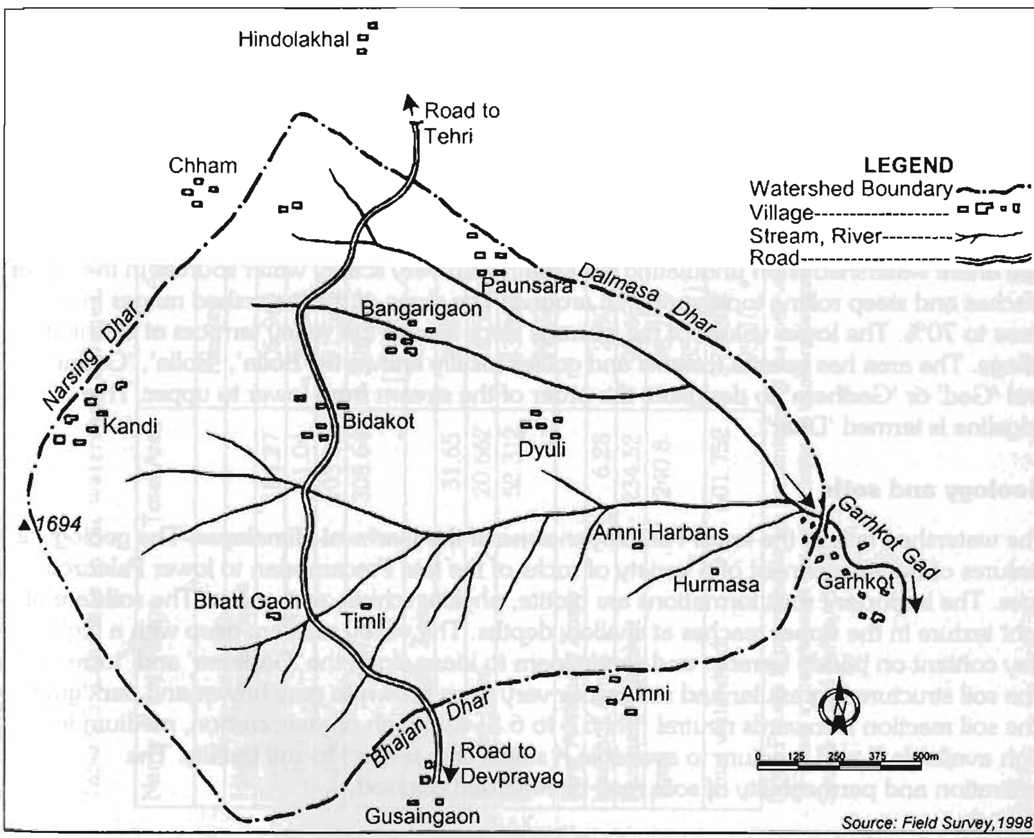

Figure 6.4: **Map of Garhkot watershed, block-Hindolakhal, District-Tehri Garhwal**

The watershed is located at 78°-30'E longitude and 30°-15'N latitude. The area consists of a cluster of twelve hamlets: Kandi Bagri, Chham, Bidakot, Pausada, Bangarigoan, Dyuli, Bhat gaon, Timli, Amni Harbans, Hurmasa, and Garhkot.

Climate

The watershed has a variable climate because of the variation in altitude (840 to 1,690 m). The maximum temperature during summer ranges from 25 to 38°C, while in winter it rarely exceeds 20°C. The minimum temperature touches freezing point when snowfall occurs around the highest peak adjacent to Hindolakhal village. The average rainfall in the area varies from 826 to 2,115 mm (Table 6.2), 80% of which is confined to the three months of the rainy season brought by the south-west monsoon. Winter rain is received as a result of the western disturbances and sustains the meagre rabi (winter) crops. Because of the rolling topography and steep slopes the runoff is rapid, resulting in soil loss (> 18 t/ha/yr) exceeding the permissible limit of 7.5 t/ha/yr and scanty infiltration (Singh and Gupta 1982). This results in poor soil moisture and little recharge. The runoff data; from three identical watersheds (Fakot in Tehri Garhwal and Dugar Gad and Srikot Gad in Pauri Garhwal) located in the vicinity having identical areas, latitudes, altitude variations, and aspects; revealed that runoff volumes vary from 18 to 42% (Dhyani *et al.* 1997 and Srivastava *et al.* 1998) depending on the amounts of annual rainfall (Table 6.4).

Area

The gross area of the watershed is 348 ha. The cultivable, non-arable lands, wastelands, and forest lands in and around the village have been listed in Table 6.5. Although the main motorable road crosses the middle reaches of the watershed, all the villages (except Bidakot) are accessible through trails ranging from 0.5 to 3 km. across the fields. During inclement weather, accessibility from one village to another decreases.

Topography and physiography

The entire watershed is on undulating hill terrain with very scanty water sources in the upper reaches and steep rolling topography all around. The slope of the watershed ranges from three to 70%. The lower values of the average slope are on the valley terraces at Garhkot village. The area has several torrents and gullies locally known as 'Bolla', 'Rolla', 'Gadni' and 'Gad' or 'Gadhera' to designate the order of the stream from lower to upper. The ridgeline is termed 'Dhar'.

Geology and soils

The watershed falls in the lower Himalayan zone of the Garhwal Himalayas. The geological features of the area consist of a variety of rocks of the late Precambrian to lower Paleozoic ages. The important rock formations are biotite, phyllite schists, and gneiss. The soils are of light texture in the upper reaches at shallow depths. The valley soils are deep with a high clay content on paddy terraces and sandy loam to loam along the 'Gadhera' and 'torrents.' The soil structure is granular and soil colour vary from brown to gray brown and dark gray. The soil reaction is towards neutral (pH 6.5 to 6.8) with high organic carbon, medium to high available P, and medium to available K status with respect to soil fertility. The infiltration and permeability of soils may be regarded as good.

Drainage

The drainage in the watershed area is characterised by a number of small seasonal streams flowing along the south-east slope which ultimately form the main flowing stream called

Table 6.5: **Land use in the watershed villages, 1998**

(in ha)

Name of the Village	Total Area	Agricultural Area			Civil Soyam	Forest Panchayat	Water Covered	Wasteland
		Rainfed	Irrigated	Total				
High Altitude Zone								
Kandi Bagri	154.27	105.961	-	105.961	47.145	-	0.015	-
Chham	51.04	30.664	-	30.664	8.828	10.620	0.069	-
Bidakot	103.33	91.527	-	91.527	11.051	-	0.018	-
Total	308.64	228.152 (100*)	-	228.152 (73.92)	67.024 (21.72)	10.620 (3.44)	0.102 (0.03)	-
Mid Altitude Zone								
Pausada	31.65	26.8	2.0	28.8	1.014	-	0.036	0.60
Bangari goan	20.662	16.592	0.760	17.252	0.243	-	0.026	3.143
Total	52.312	43.392 (94.02) *	2.760 (5.98)	46.152 (88.22)	1.257 (2.40)	-	0.052 (0.1)	3.743 (7.16)
Low Altitude Zone						-		
Harbans Amni	6.28	2.30	3.12	5.42	-	0.86	-	-
Hurmasa/Garhkot	234.52	96.463	13.17	109.633	34.728	30.601	0.248	58.10
Total	240.8	98.763 (85.84*)	16.29 (14.16)	115.053 (47.78)	34.728 (14.42)	31.461 (13.06)	0.248 (0.1)	58.10 (24.13)
Total watershed	601.752	370.307 (95.10) *	19.05 (4.90)	389.357 (64.64)	103.009 (17.12)	42.081 (6.99)	0.402 (0.07)	61.843 (10.28)

Note: Figures in parentheses are percentages of the total village area
* Figures in parentheses are percentages of total arable area.
Source : Field Survey (1998)

'Garhkot Gad'. This 'Gad', after flowing about four km towards the south-east merges with the River Alaknanda. These small seasonal streams play an important role for the natural springs, locally known as naula. The drainage pattern is generally of the Dendritic type.

Local water sources/water bodies

Surveys and discussions with the inhabitants of all the villages situated in the project area revealed that there is a scarcity of water in the entire upper reaches, and people have to fetch water from remote springs even for drinking purposes. Although the ridge is a dividing line between two prominent snowfed rivers–the Bhagirathi and Alaknanda, the people and the fields remain thirsty during the rainless period. These perennial rivers with abundance of water are far below (1,400 to 1,500 m vertically). Most of the villagers insisted on the need for some water-lifting device to pump the water from the Bhagirathi to the highest point on the ridge to supply water to the dry tracts and to humans and cattle. Whatever small quantity of rain water or snowmelt recharges the underground aquifers, it emerges in natural springs or streams in the lower reaches. The streams (Dhara), springs (Srot), and covered percolation tanks (naula) are the main sources of water for drinking and minor irrigation purposes. The streams are either perennial or ephemeral depending upon the source and location of the recharge area. Lakes and ponds are few in the region. On the advice of certain development agencies, a few dugout ponds were established in the middle reaches below Garhkot village along the side of a natural drain, but these were silted up in the very first season due to heavy debris flow and suspended sediments. On the rocky terrain in Kandi Bagri village, an embankment type runoff storage pond, shaped like a horseshoe on three sides with a wall constructed on the downstream side, contains water for livestock use and other consumption (Plate 2). A similar tank exists in Chham village. Collection of low discharge spring water into tanks through unlined channels ('Ghul') for irrigation purposes is an old practice in the area. The existing water resources and those dried up in different years have been depicted on the Water Resource Map of the area (Annex I).

Availability of water

In most of the villages situated in the upper reaches of the watershed, there is an acute shortage of water, whereas in certain pockets in the valley, stream water flows in abundance. The drinking water source situated between the two villages is shared on a roster system all twenty-four hours. For example, Bidakot village receives water up to 10 p. m. and Amni village receives it from 10 p. m. to 3 a. m. A watchman paid by the Village Panchayat is engaged to supervise water distribution.

Rain water collection from roof tops through sheet metal gutters and down pipes with funnels has already been adopted by a few progressive farmers in the villages of Chham and Hindolakhals (Plate 3). One resident from Chham village has constructed a cement lined tank of 1.7 m x 1.2 m x 1.0 m to collect about two cubic metres of runoff at a time from the roof; the area of the roof is 18 m x 8 m, i.e., 144 sq m. Because of the undulating topography the underground water table is not uniform and there are perched water tables in certain pockets: the sources of natural springs oozing out the recharged rain water. Details are given in Chapter 3.

Natural vegetation

The natural vegetation in the watershed presented is variable because of variations in altitude and landscape. Lower altitudes have sub-tropical vegetation species, while higher altitudes are dominated by pine (*Pinus roxburghii*) in patches. Because of human and biotic interference, vegetation is poor and far below the desired density (50%) of the area in the hilly region. In general multi-purpose trees (MPT) are grown on risers in the fields by the farmers themselves. Civil 'Soyam' land (Forest land - an open access resource : no one's property or everyone's property) is devoid of shrubs and trees. The characteristic species of forest trees, shrubs, and grasses found in the watershed are *Toona ciliata* (Tun), *Grewia optica* (Bhimal), *Melia azedaragh* (Bakain), *Ficus religiosa* (Pipal), *Acacia catechu* (Khair), *Ficus roxburghii* (Timal), *Embelica officinalis* (Aonla), *Ficus palmata* (Bad), *Pinus roxburghii* (Chir), *Quercus incana* (Banj), *Dendrocalamus strictus* (Bans), *Arundo donax* (Narkul), *Celtis tetrandia* (Kharik), *Punica granatum* (Anar), *Juglans regia* (Akhrot), *Berberis asiatica* (Kilmora), *Ricinus communis* (Arandi), *Agave americana* (Ram Bans), *Lantana camara* (Lantana), *Rosa sinensis* (wild rose), *Urtica parviflora* (suin), *Artensia vulgaris* (Hill bamboo), *Juniperus macropoda* (Dhup) ; *Solanum indicum* (Bhat kataiya), *Cyperus rotundus* (Motha), *Cynodon dactylon* (Doob), and *Panicum spp*.

Fruit trees and plants

There are no systematically planted orchards in the watershed. However, fruit plants are scattered throughout the area. Some farmers have planted fruit trees near their homesteads as well as in the fields. Among the fruit plants, *Mangifera indica* (mango), *Psidium guajava* (guava), *Citrus spp* (Nimbu), *Punica granatum* (Pomegranate), *Musa paradisica* (Banana), and *Carrica papaya* (Papaya) are mainly grown in the valley (lower altitudes); while *Prunus persica* (Peach), *Citrus spp* (Nimbu), *Juglans regia* (Walnut), and *Prunus communis* (Plum) are grown at higher altitudes on the upper ridge of the watershed. Most farmers in the area prefer plantations of mango and bananas in the lower reaches and walnuts in the upper reaches because of favourable soil and climatic conditions.

Land use

The total area of the villages is 602 ha, out of which about 348 ha fall within the watershed and the rest outside the watershed. Land-use statistics for whole villages within the watershed are presented in Table 6.5. The watershed is a dry-land agricultural watershed where 64.6% of the total watershed is under agriculture and nearly 95% of arable land is rainfed. In the high hills, all the arable land (228 ha) is rainfed. In the middle altitude zone, about six per cent of the area is irrigated out of total agricultural land of 46 ha. In the low altitude zone, 14% of the area is irrigated out of agricultural land of 115 ha (Table 6.5). Civil soyam land constitutes a second important land use (17%), followed by wasteland (10.3%). Forests constitute only seven per cent of the total geographical area of the villages; and this is far below the requirements (60%), as per the New Forest Policy, (1988) and a matter of great concern. The land use map of the study area indicating the land-use pattern in different villages is appended to the report (Annex II). A sharp decline in the vegetation cover decreased the recharging capacity of acquifers on the one hand and high intensity storm floods caused a lot of soil and water erosion on the other. Similarly, observations were recorded in various studies conducted in the middle altitude zone of the UP hills (Dhyani *et al.* 1997). Consequently, the area is suffering from severe shortages of water for drinking as well as for irrigation for more than six months in a year. The problem becomes acute during summer when people have to pay a high price for water, about one rupee per litre in the case of water transported from Devprayag, and when they have to wait for long hours (1-4 hours) to get 20-25 litres of water. Although the watershed lies between two big rivers – the Alaknanda and Bhagirathi—joining at Devprayag and forming the sacred River Ganges, the area has acute water shortage.

Agriculture (crops and cropping pattern)

Only 4.9% of agricultural land in the watershed area is irrigated and the remaining area is rainfed. The agriculture in the watershed is limited to cultivation of a few crops. It has a low cropping intensity of 140% (normal-200%) due to small landholdings, lack of irrigation, the vagaries of the weather, and lack of modern technology, and all these lead to uncommercial and unremunerative types of farming. Fertilizer consumption is very low, resulting in poor crop yields. The main problem for agriculture is the lack of water and sloping land, as a result of which crops suffer from inadequate moisture. Agricultural fields are not well terraced on the high slopes and are subjected to soil erosion. The lower area of the watershed in the valley is irrigated and terraces have been constructed scientifically.

Agriculture is mainly looked after and governed by women, except for ploughing the fields which is carried out by men. All packages of practices for agriculture are carried out by women for the most part. Because of the lack of locally-based income- generating opportunities, difficult accessibility, and low productivity, young men move to the cities in search of jobs.

The watershed is vulnerable to soil erosion (>18t/ha/yr) and this creates ecological imbalances caused by a decline in productivity, water scarcity, and floods downstream. Therefore, a watershed management approach needs to be followed and soil conservation measures on agricultural land should be adequately supported by infrastructure to make agriculture more productive and sustainable on a long-term basis.

The main crops grown in the watershed are *Elucine coracana* (*mandua*[a millet]), followed by *Oryza sativa* (paddy), *Glycine max* (soybean), *Zea mays* (maize), *Paspalum scorbiculatum* (jhingora), *Vigna mungo* (black gram), *Phaseolus mungo* (green gram), and *Cajanus cajan* (pigeon pea) in *kharif* (summer) and *Triticum spp* (wheat), *Hordeum vulgare* (barley), *Brassica nigra* (mustard), *Pisum sativum* (pea), and *Sessamum indicum* (til[sesame]) in rabi (winter).

In addition, seasonal and off-season vegetables are also grown under rainfed as well as irrigated conditions. The vegetable crops grown are *Solanum tuberosum* (potatoes), *Brassica spp* (cauliflowers and cabbages), *Lycopersicum esculentum* (tomatoes), *Allium cepa* (onions), *Allium sativum* (garlic), *Capsicum spp* (chillies), *Solanum melongena* (aubergine), *Phaseolus spp* (beans), *Hibiscus esculentum* (okra[lady fingers]), *Zingiber officinale* (ginger), *Cucumis spp* (cucurbits) *Spinacia oleracea* (spinach), *Amaranthus spp* (amaranths), and *Raphnus sativa* (radishes).

The present cropping pattern in the watershed is generally monoculture, and double cropping is carried out in a year. The main crop rotations are given below.

Paddy - wheat - one year (irrigated)
Pigeon pea - fallow - one year (rainfed)
Mandua - fallow - one year (rainfed)
Maize - fallow - one year (rainfed)
Soybean - lentil/pea - one year (rainfed)
Ginger - vegetable/potato - one year (irrigated)
Potato + soybean - one year (irrigated)

Wildlife

The watershed and surrounding area is suitable only for a few wildlife species because the forest is not dense. The wild animals found and reported to be seen in the area are the fox, jackal, boar, monkey (black mouth and red mouth), panther, mongoose, wild cat, and porcupine. The birds found are the owl, pigeon, cuckoo, crow, eagle, vulture, sparrow, parrot, bat, kite, partridge, magpie, and nightingale.

Socioeconomic aspects

Garhkot watershed covers six Gram Sabha (a village-level political body) with five villages and seven hamlets. The details are given below.

Gram Sabha, Villages and Hamlets in Garhkot Watershed

Gram Sabha Covered	Villages	Hamlet
Kandi Bagdi	Kandi Bagdi	-
Durogi	Chham	-
Bidakot	Bidakot	Bangarigaon
Pausada	Pausada	-
Amni	-	Hurbansamni, Bhatt gaon, Amni Timli
Garhkot	Garhkot	Hurmasa, Dyuli, Lwadla

A detailed survey of 45 farmers comprising of 15 members from each altitude zone (high, middle, and valley) was conducted with a pre-designed schedule in order to understand the socioeconomic structure, productivity of land, and arrangements for management of various water resources in the watershed.

The total human population of the watershed is 1,958 and it is distributed in 415 households (Table 6.6). Thus the average family size is about 4.71. However, average family size was maximum (5.20) in the middle hills followed by 5.04 in the low altitude zone and at least 4.4 in the high altitude zone. More than 54% of the total watershed population reside in the high altitude zone, while the corresponding figures for the middle altitude zone and lower altitude zone are 19 and 27% respectively. The female population is higher than the male in the watershed with a sex ratio of 1,075 women to a 1,000 men. The literacy rate is quite low (36.6%). There is a wide gap in the literacy rate of men and women. About 56% of men are literate while the figure is only 19% for women.

Social structural analysis revealed that the watershed is dominated by Rajputs who account for 78.7% of the total human population, followed by Brahmins 12.7%, and Scheduled Castes and Scheduled Tribes (SC and ST), 8.6%. In all the villages it was observed that the upper castes, i.e., Brahamins and Rajputs, are clustered in parts, while the SCs are settled in a separate group. Both upper castes had common traditions and mingled together, except for marriages. Most of the inhabitants are cultivators and follow the same agricultural practices. There are a few caste-based traditions, e. g, . worshipping of a god and goddess by the Brahmins and blacksmith work still carried out by Scheduled Castes. No other distinction is prevalent with respect to job opportunities. One common point that unites the whole village, however, is the worship of the village deity ('Gram Devta'). All the villagers worship this deity and perform their duties as per their caste traditions.

Land distribution

The land distribution pattern in the villages and watershed as a whole is presented in Table 6.7.The overall holding size in the watershed is 0.94 ha. The majority (63.3%) of farm

Table 6.6: **Basic information about villages in the watershed (1991)**

Name of Village	Altitude Range (m)	No. of House holds	Average Family Size	Human Population			Literacy			S.C and S.T. Population		
				Male	Female	Total	Male	Female	Total	Male	Female	Total
High Altitude Zone												
Kandi Bagri	1500-1690	100	3.91	181	213	394	99	43	142 (36.0)	22	16	38 (9.8)
Chham	1500-1600	27	5.11	62	76	138	39	28	67 (48.5)	8	4	12 (8.6)
Bidakot	1380-1500	99	4.65	238	222	460	119	19	138 (30.0)	10	10	20 (7.4)
Total		226 (54.5)	4.39	481	511	992	257	90	347 (34.5)	40	30	70 (7.1)
Mid Altitude Zone												
Pausada	1180-1380	52	4.92	118	138	256	81	54	135 (52.7)	7	9	16 (6.25)
Bangarigoan	1180-1340	27	5.74	71	84	155	45	15	60 (38.7)	Nil	Nil	Nil
Total		79 (19.0)	5.20	189	222	411	126	69	195 (47.4)	7	9	16 (3.89)
Low Altitude Zone												
Harbans-Amni Hurmasa	890-1180	6	4.5	15	12	27	10	8	18 (66.67)	Nil	Nil	Nil
Garhkot	860-1180	104	5.08	247	281	528	128	28	156 (29.5)	46	36	82 (15.5)
Total		110 (26.5)	5.04	262	293	555	138	36	174 (31.35)	46	36	82 (14.7)
Total Watershed	840-1690	415	4.71	932	1026	1958	521 (55.9)	195 (19.0)	716 (36.56)	93	75	168 (8.6)

Note: Figures in parentheses are percentages of the total population of the village.
Source: District Statistical Report of Tehri Garhwal, U.P. (1991).

families have marginal landholdings of less than 0.5 ha with an average holding size of 0.38 ha. No farmer has large holdings (> 10 ha) in this watershed. The number of small (> 2 ha), medium (4-10 ha), and semi-medium (2-4 ha) farmers has declined. Further, the average holding size varies significantly between altitudes. The lowest average holding size was 0.55 ha in Pausada (in the mid-altitude zone) and the maximum 1.13 ha in Chham village (in the high altitude zone). Thus the analysis revealed that there are disparities within as well as between the villages with respect to distribution of arable land.

Fragmentation

Scattered smallholdings pose severe problems to adoption of improved technologies, on the one hand, and have rendered agriculture uneconomical on the other (Table 6.7a). The watershed villages also exhibit the same characteristics in which smallholdings are distributed over five to nine locations situated from 0.4 to 1.5 km apart (Table 6.7b). Thus, the effective operational holding in one place ranges between 0.09 to 0.21 ha. Fragmentation consumes maximum time in travelling from one place to another for both humans and livestock. Realising the curse of fragmentation, farmers have tried to consolidate their landholdings by either legal sale purchase or the *Satwara* (a barter system comprising of exchange of land for land) system. *Satwara* land transactions have no legality as the land is not transferred in the records. People adopted the *Satwara* system to avoid the payment of duty for legal transfer and save their meagre financial resources.

Livestock

Livestock are an integral and vital part of the hill economy and the number of livestock is more or less equal to the human population. Garhkot watershed is no exception. The total livestock population in the watershed is about 1,900, almost equal to the human population in 1958 (Table 6.8). Cows constitute about one-third of the livestock population, followed by sheep and goats (32%). Buffaloes constitute about 24% of the total livestock population. Sheep, goats, and hens are kept primarily for commercial purposes, female buffaloes and cows for milk, and oxen for draught purposes. Increasing livestock population on the one hand and shrinking vegetative cover on the other compell farmers to travel as far away as eight km from the villages to collect grass from the forest (Plate 4).

Time-line analysis of watershed villages

The historical event analysis of villages in the Garhkot watershed is presented in Table 6.9.It is evident from the table that all these villages were settled by migrant people from far away places during the 9th - 10th centuries. It is further evident that settlements started in the higher reaches and slowly moved towards the lower altitude zone. Titles of land were given to the cultivators in 1951 after abolition of the feudal landlord system. Water harvesting in dug-out ponds is quite an old practice in the area, and the oldest existing one was built in 1945. Roof-top water harvesting, although a normal casual practice in the area, has been adopted into regular practice only in one village (Chham) since 1970. A water mill was established in Garhkot village in 1940. Other development activities started very late. All the villages and hamlets have electricity except for the hamlets of Hurmasa and Dyuli.

Women's dairy development cooperative society

To boost farm incomes from livestock, PARAG-a cooperative dairy development organisation in Uttar Pradesh started a Women's Dairy Development Cooperative Society in Bidakot during 1996-97.It is run completely by women. The Society is headed by the

Table 6.7a: **Distribution of farmers as per holding size (1991)**

Name of Village	Marginal < 0.5 ha			Small 1-2 ha			Semi- medium 2-4 ha			Medium 4-10 ha			Av. Holding Size (ha)
	No.	Area (ha)	Avg. holding (ha)	No.	Area (ha)	Avg. holding (ha)	No.	Area (ha)	Avg. holding (ha)	No.	Area (ha)	Avg. holding (ha)	
High Altitude Zone													
Kandi Bagri	50 (50)	8.22	0.164	23 (23)	24.389	1.061	23 (23)	55.27	2.40	4 (4)	18.082	4.52	1.06
Chham	15 (55.6)	6.678	0.445	9 (33.3)	14.667	1.629	3 (11.1)	9.319	3.106	-	-	-	1.13
Bidakot	57 (57.6)	18.625	0.327	32 (32.3)	38.192	1.194	8 (8.1)	19.826	2.478	3 (3.0)	14.889	4.963	0.925
Total	122 (54.0)	33.523	0.275	64 (28.0)	77.248	1.207	34 (15.0)	84.415	2.48	7 (3.0)	32.971	4.71	1.01
Mid Altitude Zone													
Pausada	48 (92.3)	23.6	0.49	4 (7.7)	5.2	1.3	Nil	-	-	-	-	-	0.55
Bangari goan	20 (74.1)	7.252	0.36	7 (25.9)	10.00	1.43	Nil	-	-	-	-	-	0.64
Total	68 (86.1)	30.852	0.453	11 (13.9)	15.2	1.38	Nil	-	-	Nil	-	-	0.58
Low Altitude Zone													
Harbans Amni	3 (50.0)	1.32	0.44	3 (50.0)	4.10	1.37	-	-	-	-	-	-	0.90
Hurmasa Garhkot	70 (67.3)	34.83	0.49	31 (29.8)	61.5	1.98	2 (1.9)	5.803	2.902	1 (1.0)	7.50	7.50	1.05
Total	73 (66.4)	36.15	0.49	34 (30.9)	65.60	1.93	2 (1.8)	5.803	2.902	1 (0.9)	7.50	7.50	1.05
Total Watershed	263 (63.3)	100.525	0.382	109 (26.2)	158.048	1.45	36 (8.6)	90.218	2.506	8 (1.9)	40.471	5.05	0.94

Figures in parentheses are percentages of respective totals
Source : Revenue Records (1991). Devprayag Tehsil, Tehri Garhwal District, U.P.

Table 6.7b: **Fragmentation of arable land**

Name of Village	Number of Fragments in Each Family	Av.Size of Fragment (ha)	Av. Distance between Fragments (km)
Kandi Bagri	5	0.21	0.5
Chham	9	0.12	1.0
Bidakot	7	0.13	0.4
Pausada	6	0.09	0.8
Bangari gaon	4	0.16	0.5
Hurbans Amni	6	0.11	1.2
Hurmasa Garhkot	8	0.13	1.5

Table 6.8: **Livestock population (No) of selected villages in the watershed (1997-98)**

Name of Village	Ox	Cow	She Buffalo	He Buffalo	Sheep	Goat	Hen	Dog	Total
High Altitude Zone									
Kandi Bagri	102	20	71	1	-	93	29	9	325
Chham	70	81	128	9	26	55	46	9	424
Bidakot	60	27	91	1	-	81	21	9	290
Total	232 (22.3)	128 (12.3)	290 (27.9)	11 (1.1)	26 (2.6)	229 (22.0)	96 (9.2)	27 (2.6)	1039 (100)
Mid-Altitude Zone									
Pausada	-	51	-	-	-	37	-	2	90
Bangari gaon	24	30	29	-	17	67	2	3	172
Total	24 (9.2)	81 (30.9)	29 (11.1)	-	17 (6.5)	104 (39.6)	2 (0.8)	5 (1.9)	262 (100)
Low Altitude Zone									
Harbans Amni	12	8	2	-	-	12	16	1	51
Hurmasa Garhkot	102	35	122	1	36	184	55	13	548
Total	114 (19.0)	43 (7.2)	124 (20.7)	1 (0.2)	36 (6.0)	196 (32.7)	71 (11.9)	14 (2.3)	599 (100)
Total for Watershed	370 (19.5)	252 (13.3)	443 (23.3)	12 (0.6)	79 (4.1)	529 (27.8)	169 (8.9)	46 (2.5)	1900 (100)

Source : Agricultural Census, UP, 1997

honorary President (elected from among the members), assisted by a paid secretary (nominated by the members) and a board of members (five). PARAG has deputed a woman worker from their organisation to assist in monitoring the day to day progress. Payment of Rs 300 per month is given to the Secretary by PARAG. Membership is open to all the women on payment of a one time membership fee of Rs 11 only. Each member is entitled to sell milk at the milk booth close to the road within a specified time, twice a day. The Secretary inspects the quality of milk in terms of fat percentage and records it in the presence of the members. The minimum criterion for accepting the milk is that it should have a fat content of more than six per cent, and milk having more than 6.9% fat receives a higher price. The milk collected is transported by the PARAG dairy people to the processing plant. The Village Women's Society has a joint account in the names of its President and

Table 6.9: **Historical timeline analysis of selected villages**

Events	Time period of their first occurrence					
	Kandi Bagri	Chham	Bidakot	Bangarigoan	Pausada	Garhkot
Establishment	9th Century	9th Century	9th Century	9th Century	9th Century	10th Century
Water mill	No	No	No	No	No	1940
Abolition of landlord system	1951	1951	1951	1951	1951	1951
First *Kuchha* pond dug out	1948	1948	1972	1960	1945	1965
Roof-top water harvesting	No	1970	No	No	No	No
High unprecedented rainfall	April, 1978	April, 1978	April, 1978	April, 1978	April, 1978	April, 1978
Kachha road to village	No	No	1960	No	No	No
Electrification	1985	1985	1985	1985	1986	1983
Primary school	1989	1898	1973	No	1973	1940
Junior High School	-	-	-	-	-	1995
Tap water facility from Bagwan-Alaknanda (42 km away) through lift	1986	1986	1986	1986	1990	1994
SWC works started	1982	1982	1982	1982	1982	1982
Cooperative Dairy	No	No	1996	1996	1996	No
Telephone	1997	1997	1997	1997	1997	1997
Distance to Hindolakhal	4 km	3 Km	3 km	3.5 km	3 km	5 km

1962 Block Development Office shifted from Devprayag to Hindolakhal where various facilities were developed

1948	Co-educational Private Junior High School	Collectively developed by all the villagers of nearby villages and headed by board of management - an elected body
1970 1972 1974-75	Co-educational High School Co-educational Intermediate Public School	Collectively developed by all the villagers of nearby villages and headed by board of management - an elected body Adopted by Govt. of U.P.
1965	Primary Health Centre and Veterinary Hospital	
1960	Post Office	
1982	Mettalled Roads	
1964	Cooperative Society	
1973	Nationalised Bank	

Secretary in the bank, and PARAG makes monthly or bi-monthly payments to the Society by cheque. The amount is then distributed to its members according to the quantity and quality of the milk. PARAG also provides free medical or health consultancies to its members for animals and also supplies feed on the basis of payment. There has been a positive growth in the number (increased from 18 to 50) of members, quantity of milk, and income for members. The quantity of milk sold daily depends on the season. It is highest (about 250 lit/day) during the rainy and lowest (60 lit/day) during the summer season.

Workforce

From the field survey it was fond that about 60% of the total watershed workforce is available within the watershed and 40% migrate outside in search of employment. This is because of the lack of off-farm employment opportunities in the area and predominance of rainfed farming. It was also found that the work force available in the villages is dominated by women. About 97% of the total women's work force is found in the village itself, while the corresponding figure for men is 29%, indicating that about 71% of men of working age migrate outside the watershed. It can be concluded that hill agriculture is predominantly dependent on women and the policy implication is that women extension workers may provide quick and better results than men (Plate 5).

Income generation

Family income includes return over variable costs from agriculture and net amount of remittances contributed by family members who have out-migrated. Contributions made by a permanent employee ¶are called income through service, while contributions made by seasonal migrants are called labour income. Average annual family income in the watershed is calculated on 1998 prices and ranges from 41,000 to 43,700 per annum with an average of Rs 42,500 (Table 6.10). The highest per family income is obtained in the high altitude zone (Rs 43,700) followed by the mid-altitude zone (Rs 42,823) and the least in the agriculturally dominant part of the watershed, i.e., the low altitude zone (Rs 41,016). Per capita average annual income is highest (Rs 9,925/) in the high altitude zone followed by 8,235 in the mid-altitude zone, and by 8,138 in the low altitude zone with an average of 9,043 for the watershed as a whole.

Table 6.10: **Annual net income (Rs/family) pattern of sample farmers at 1998**

Attitude Zone	Agriculture			Off farm			Total income
	Crop	Livestock	Sub total	Service	Labour	Sub total	
High-altitude zone	6000 (13.7)	3200 (7.3)	9200 (21.0)	24000 (55.0)	10468 (24.0)	34468 (79.0)	43668 (100)
Mid-altitude zone	5000 (11.7)	2500 (5.8)	7500 (17.5)	19600 (45.8)	15723 (36.7)	35323 (82.5)	42823 (100)
Low-altitude zone	14600 (35.6)	1000 (2.4)	15600 (38.0)	15200 (37.1)	10216 (24.9))	25416 (62.0)	41016 (100)
Overall for whole watershed samples	8533 (20.0)	2233 (5.3)	10766 (25.3)	19600 (46.1)	12136 (28.6)	31736 (74.7)	42502 (100)

Note: Figure in parentheses are percentages of the total
Source : Field Survey 1998

Composition of family income presented in Table 6.10 shows that the economy of the watershed is totally dependent on remittances received from family members who have out-migrated. Contribution of remittances varied significantly in the three zones. It is lowest (62%) in the low altitude zone and highest in the mid-altitude zone (83%) with an average of 75% for the watershed as a whole. Remittances made by seasonal migrants, i.e., labour, contribute about 29% to family incomes, about 17% less than the contribution made by the service group in the migrant population (46%). The agricultural sector contributes only one fourth of the family income in the watershed. Its contribution is lowest in the mid altitude zone (17.5%) and highest in the low altitude zone (38.6%). Thus, agriculture in the hills, particularly in the high and mid-altitude zones, is not profitable under current conditions. An efficient land-use management system with diversified enterprise combinations and improved technology packages are required. This will lead to economic prosperity and environmental security in the area.

Expenditure pattern

Annual family expenditure of the sample watershed was studied for different altitude zones for 1997 and is presented in Table 6.11. Farmers consume about 97% of their total family income in meeting their family's subsistence requirements. Thus, they are left with about Rs 1,120 per annum for investment activities. However, there is a marginal difference in expenditure/savings at different altitudinal zones. Mid-altitude zone farmers consume all their family income (99.5%), while farmers from lower altitudes save about 4.5% of their income. Most of the expenditure is on food (65%). The proportion of expenditure on food items was maximum (70%) in the mid-altitude zone, followed by 65% in the high altitude zone and a minimum (59%) in the lower altitude zone. Clothes are the second major item of expenditure, and their share varied from seven to nine per cent with an overall average of eight per cent. Lower altitude zone farmers spend about 50% more on medicine and treatment of their families. This is primarily due to topographical aspects and inaccessibility of the village. Education expenditure ranked fourth in family expenditure and it ranges from 4.7 to 8.2% with an average of 6.8%. Expenditure for improvement of land is least in priority and constitutes about 1.3% of the total expenditure.

Table 6.11: **Annual expenditure pattern (Rs/family) of sample farm group at 1998 prices**

Altitude Zone	Food etc	Clothes	Ceremonies	Medicines	Education (fee+book+rent)	Land Treatment and Agril. Dev.	Others	Total
High altitude zone	27440 (64.7)	3567 (8.4)	3860 (9.0)	2415 (5.7)	3500 (8.2)	40 (1.1)	1200 (2.8)	42432 (100)
Mid altitude zone	27900 (70.2)	3930 (9.2)	2750 (6.5)	2215 (5.2)	2000 (4.7)	300 (0.7)	1500 (3.5)	42595 (100)
Low altitude zone	22960 (58.7)	2879 (7.4)	3261 (8.3)	3620 (9.2)	3000 (7.7)	900 (2.3)	2500 (6.4)	39120 (100)
Overall	26767 (64.7)	3459 (8.4)	3290 (8.0)	2750 (6.6)	2833 (6.8)	550 (1.3)	1733 (4.2)	41381 (100)

Note: Figures in parentheses indicate per cent of total expenditure.
Source : Field Survey 1998

It is interesting to note that lower altitude zone farmers invest twice more than high altitude and thrice more than mid-altitude zone farmers in land improvement. This is attributed to the fact that high and mid-altitude zone farmers receive less income from agriculture and, therefore, do not care much about land improvement.

Temporal distribution of water resources

Temporal distribution of available water resources was studied through transect walks with elderly villagers. It was observed that the upper reaches of the watershed were worst affected. About 83% of the natural water resources in the area had dried up by 1976.Kandi Bagri village was worst affected and the village shifted from a lower elevation to a higher elevation because of the availability of drinking water on the other side of the ridge forming a catchment of the Bhagirathi River. In the middle portion of the watershed about 35% of the total water sources dried up between 1978 (a year of unprecedented heavy rainfall in the month of April) and 1991 (the year of the Uttarkashi earthquake). However, there was a significant reduction (two to three times) in other water sources compared to the situation in 1950. In the valley portion, only one water source (dhara) had dried up near Hurmasa hamlet in 1991, otherwise all others were intact. In some cases, however, displacement of water courses towards the lower side was observed. It was generally observed by all the villagers that there had been a significant reduction in the quantity of water from these sources over the past twenty years.

The capacity of the water mill was initially about one quintal/hr (q/hr) and this had decreased to 0.6 q/hr in 1988.This is supported by the fact that tail-ender farmers do not demand water for their wheat crops because of acute shortage and high seepage losses.

Major problems in the watershed

To assess the severity of problems faced by the farmers in different altitude zones in the watershed, the Venn diagram technique of PRA was used and the results are presented in Figures 6.5 to 6.7.The size of the circles indicates the severity of the problem, while distance from the village indicates the degree of accessibility for villagers to the department concerned.

Drinking water is the prominent problem in high and mid-altitude villages, while scarcity of fuel and fodder ranked second at high altitudes. Food shortage was the second major problem in the mid-altitude zone, owing to small holding sizes and low productivity. In the lower altitude areas, shortages of fuel and fodder are the main problems, followed by lack of human health facilities and water for irrigation. Most of the big problems faced by farmers are primarily due to the remoteness of the government department that is supposed to solve them. Implementation of the soil and water conservation programme by the State Soil Conservation Department had a positive impact on farmers' attitudes. Most farmers felt that this programme helped to increase productivity of arable and non-arable land and augment lean period water flow. The analysis revealed that the watershed suffered from problems related to soil, human, and animal health in total. Most of the villages are remote and have little accessibility to various facilities (Table 6.12).

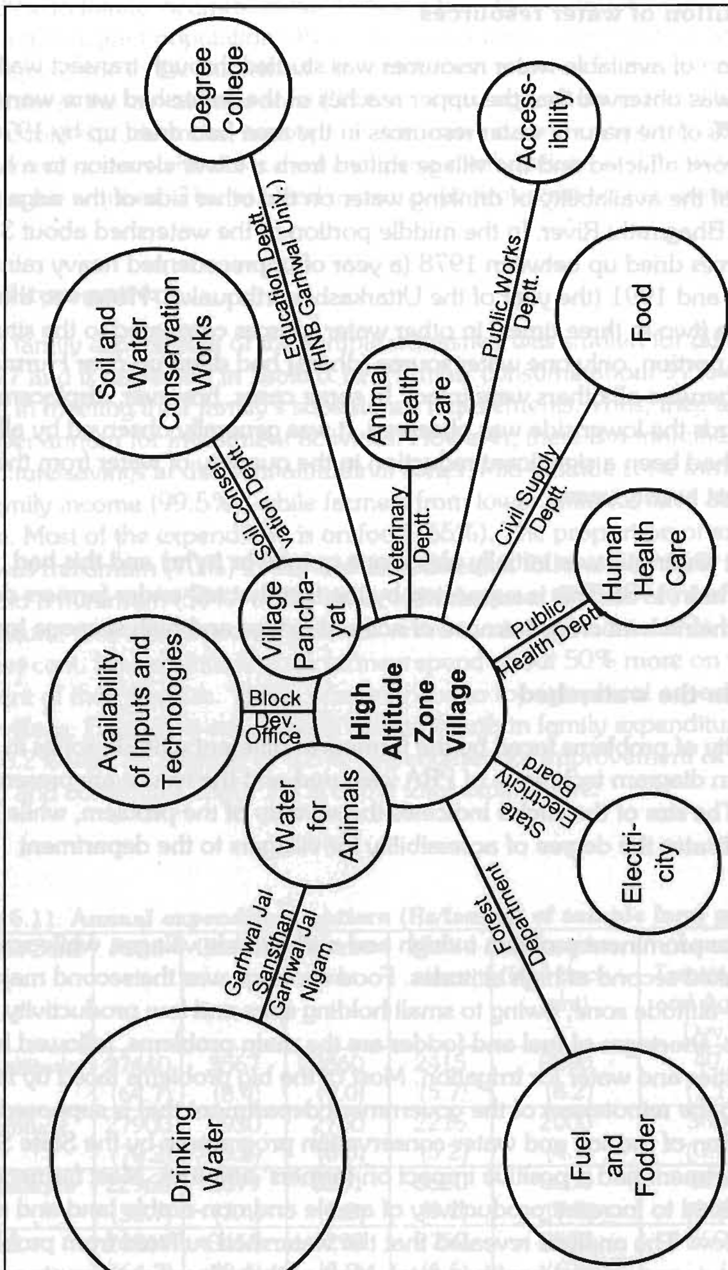

Figure 6.5: **Venn diagram showing problems and accessibility to the related Institute in the high-altitude zone village**

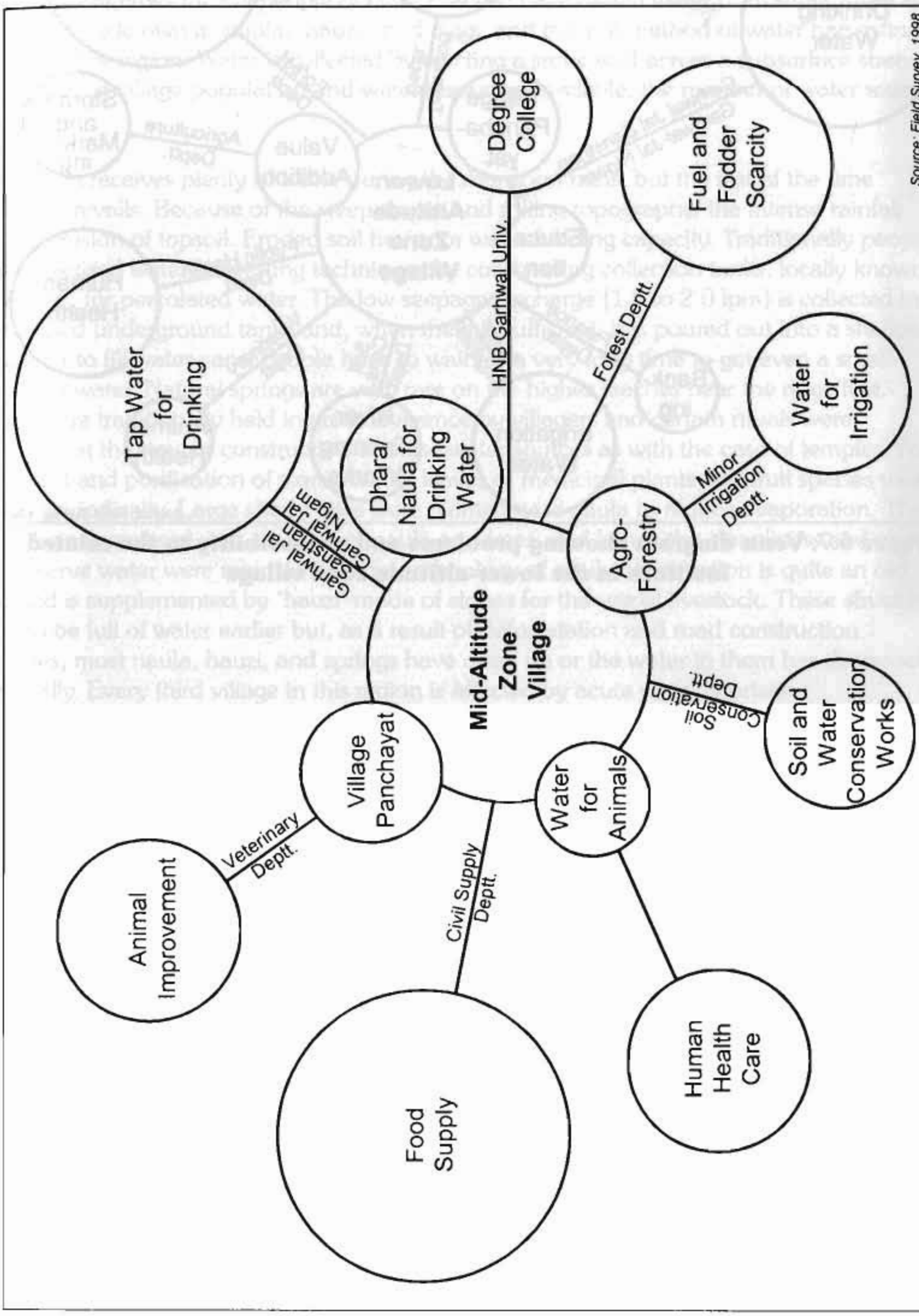

Figure 6.6: **Venn diagram showing problems and accessibility to the related Institute in the mid-altitude zone village**

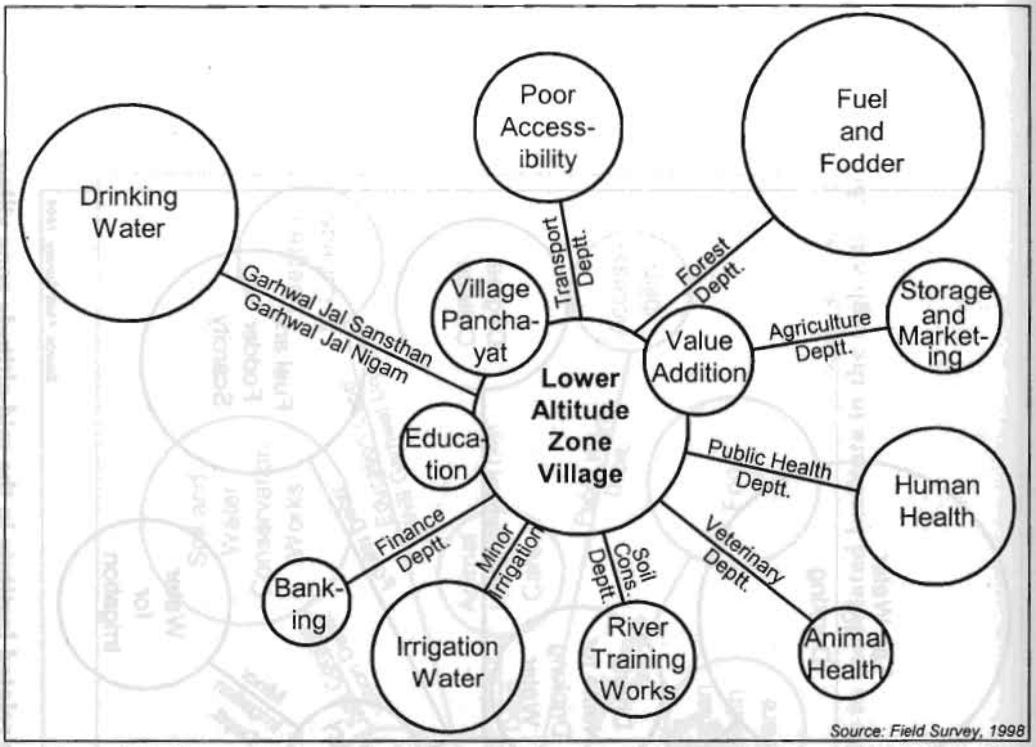

Figure 6.7: **Venn diagram showing problems and accessibility to the related institute in the lower-altitude zone village**

Table 6.12: **Accessibility of selected villages from nearest infrastructure distance from the village**

Facility	High-altitude Zone		Mid-altitude Zone			Low-altitude Zone	
	Kandi Bagri	Chham	Bidakot	Banga-rigaon	Pausada	Hurmasa	Garhkot
Electricity	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Distance from motarable road (km)	3	1.5	0	0.5	0.5	3	3.5
Fair price shop (km)	4.0	3.0	3.0	3.5	3.0	3	3.5
Primary school	0	0	0	0.5		0.5	0
Junior High School	4.0	3.0	3.0	3.5	3.0	0.5	0
Inter College	4.0	3.0	3.0	3.5	3.0	4.5	5
Degree College	28	27	26	26.5	26.5	26	26.5
Bank	4	3.0	3.0	3.5	3.0	4.5	5
Post Office	4	3.0	3.0	3.5	3.0	4.5	5
Water mill	No	No	No	No	No	1.0	0.5
Flour mill	4	3	3.0	3.5	3.0	3.0	3.5
Primary health centre	3	1.5	1.5	2.0	1.5	4.0	4.5
Block Development Office	4.0	3.0					
Veterinary							
Source: Field survey, 1998							

6. Local Water Harvesting Technology, Practices and Knowledge : Status and Critical Review

Traditional/indigenous knowledge, methods, and practices for assessing and using water at the local level

Since ancient times the hill people of Uttar Pradesh have drawn water from small, shallow ponds locally known as naula, 'hauzi', and *diggi*, and this is a method of water harvesting typical of this region. Water is collected by erecting a stone wall across a subsurface stream. Based on the village population and water resources available, the number of water sources varies.

The region receives plenty of water during the monsoon rains, but the rest of the time drought prevails. Because of the steep slopes and rolling topography, the intense rainfall causes erosion of topsoil. Eroded soil has poor water-holding capacity. Traditionally people have practised water-harvesting techniques by constructing collection tanks, locally known as 'naula', for percolated water. The low seepage discharge (1.5 to 2.0 lpm) is collected in stone-lined underground tanks and, when there is sufficient, it is poured out into a shallow container to fill water cans. People have to wait for a very long time to get even a small bucket of water. Natural springs are very rare on the higher reaches near the ridge line. Naula were traditionally held in great reverence by villagers and certain rituals were observed at the time of construction of these water sources as with the case of temples. For treatment and purification of stored water, leaves of medicinal plants and fruit species were added periodically. Large shady trees were planted near naula to reduce evaporation. This is still being practised, i.e., worship of naula and trees, and hence the cleanliness and effort to conserve water were maintained. The technology of naula construction is quite an old one and is supplemented by 'hauzi' made of stones for the use of livestock. These structures used to be full of water earlier but, as a result of deforestation and road construction activities, most naula, hauzi, and springs have dried up or the water in them has decreased drastically. Every third village in this region is affected by acute water shortage.

In the middle reaches, the availability of water improves slightly as the recharge area increases, resulting in longer concentration time for runoff water. Consequently, the opportunity for infiltration time increases, and there is an increase in the number of streams and discharge in Pausada, Amni, Harbans, Dyuli, and Garhkot villages. The discharge from dhara (springs) during the summer peak is from five to 20 litres per minute depending on the recharge area and the location. The residents in the area state that many water sources dried up and disappeared after the disastrous Uttarkashi earthquake in October 1991.

Ponds are very rare in this area and most of the water storage structures are cement-plastered tanks constructed in stone masonry. Almost 60-70% of these tanks are defunct as a result of sub-standard construction or wrong site selection or because cracks have developed following soil subsidence/settlement in the filling area. Ms Shakuntala Raturi, Pradhan of Pausada; stated that out of 12 cement tanks constructed in this area, only four are storing surplus water from springs and the eight remaining are defunct as the water sources have dried up in some cases and the tanks need repair also. This situation is prevalent not only in the study area, but also in the entire hilly region. Since water sources are Common Property Resources (CPR), no one looks after their maintenance and upkeep. However, during scarcity, a roster for water distribution is prepared based on family units: a practice going back three generations. On the outskirts of the village on the north-eastern ridge. there are two springs locally called *Magron Ka Dhara,* one giving a lean period discharge of 10 litres per minute (lpm) and the other, on the left side of the village school, discharging 18 litres of clean drinking water per minute. The overflow from the second spring is being diverted through a 193-metre long, unlined eastern channel with an approximate cross-section of 50 cm x 20 cm, locally called a guhl. The excess discharge of overflow from the spring is conveyed through the channel in a stone masonry, cement-plastered tank of 10 m in length, 6 m in width, and 2 m in depth (inside dimensions), i.e., with a capacity of 120 cubic metres. Another similar tank with less capacity (80 m^3) is positioned near the other spring.

On the other side (south-east) of the ridge below Pausada village, two springs with a lean season discharge of 5 lpm and 9 lpm are also used to collect drinking water. In addition to these, one spring at Bangarigaon village has a discharge of 18 lpm and one at Dyuli village has a maximum discharge of 6 lpm; the overflow from this is untapped and it flows into the Garhkot Gad to be finally used in Mulyagaon village situated outside the watershed on the downstream side.

The former Pradhan of Bangarigaon village stated that there are five water sources in this village and only one in the lower village, Hurmasa. Water is primarily used for drinking purposes and the overflow is collected in cement tanks overnight to irrigate small vegetable plots. Rotational distribution of water was fixed family-wise in 1946 and prior to that, before independence, when this was a part of the kingdom of the then Maharaja of Tehri. One villager (Mr. Bihari Lal Bhatt) stated that many streams had dried up as a consequence of the 1991 earthquake. An old perennial water source called *Amni Ka Dhara* had dried up eight years previously. This was feeding surplus water to a cement-lined tank of 12 m x 4 m x 1.25 m: i.e., 60 m^3. This tank has no water at all now. Most of the existing tanks have been constructed under the National Watershed Development Programme for Rainfed Agriculture (NWDPRA). Through the Watershed Development Project, the renovation of naula (percolation water storage tanks) has been carried out by the state soil conservation unit of the Department of Agriculture. Water channels, locally called guhl, have been constructed to channel the overflow from streams of runoff water from seasonal torrents for aquatic crops, e. g. , rice in the rainy season. A small reach of these channels is lined and the remainder is left unlined. This has resulted in a drastic reduction in efficiency (approx. 30%). The Pradhan of Garhkot village (Mr. Hukam Singh) is presently constructing lined channels by assigning jobs to village people on a daily wage basis of Rs 60. The total length of the channel is 250 metres with a cross section of 30 cm x 20 cm.

Gender aspects

Women are the hub of all activities in this neglected and backward region. Apart from routine household chores, all the agricultural and livestock raising activities are being carried out primarily by women. Only ploughing with bullock pairs is carried out by men. Collecting or fetching water for domestic use is the sole responsibility of women. In the case of irrigation, women take charge in the absence of men. Women are totally responsible for collecting fuel and fodder from distant places. They have to travel up to 12 km up and down to do so. Thus most of the time women are kept busy in routine duties. Drudgery is a way of life in this difficult and backward region, irrespective of caste or economic status. Women hardly get time to participate in meetings about water or forest management. Most adult women are illiterate and unexposed to water management activities. Consequently, they simply carry out routine work as dictated by their spouses.

Ethnicity and indigenous knowledge about water and water harvesting

The importance and utility of water has been understood by the inhabitants of hilly region since time immemorial. Originally the habitations were settled near and around the sources of perennial water, e. g. , springs, water falls, seepage/percolated water or streams or rivers. With the increasing population (human and cattle) and better standards of living, the demand for water increased. Biotic interference, environmental degradation, and increase in roads and buildings have led to a dwindling away of natural water sources.

The survey team observed that people in remote areas were very conversant with water-harvesting techniques as these were very much a part of their adaptation to life in the mountains. Rain water was collected in rocky natural depressions for miscellaneous and livestock needs; naula were constructed to collect low discharges through seepage/percolation; and in the upper reaches roof-top water harvesting had been practised for a 100 years as a means of supplementing supplies from springs and erratic tap water supplies. Rain water is free and can be stored in the house and used for domestic purposes, livestock, and kitchen gardening. This was the practice during British times. These same practices were carried out in Champawat district of Kumaon hills as far back as 1917.

Local water-harvesting technologies (indigenous and recent)

While selecting the watershed, the survey team visited various locations where different water-harvesting techniques were already practised in line with the availability of water, the location, and the requirements of the people.

On the way to Srinagar, about 29 km from Dev Prayag, there is a village called Maletha where a large waterfall can be found at the side of the road. The villagers told the team that, about 300 years ago, a village chief named Mr. Madho Singh Bhandari made personal efforts to construct a guhl diverting water to this site from a water source at Dangchaura village about 4.5 km away. The guhl is almost three kilometres long and has a lined stretch of 1,650 m beyond the second tunnel. Prior to this, there is yet another tunnel through which water crosses the ridge of the hillock. Details are given in Figure 6.8.Hydraulic observations were recorded outside the lower tunnel and the following data were recorded.

- Cross section of lined channel (beyond 2nd channel = 0.60 m x 0.375 m or 0.225 sq. m.
- Flow depth = 0.25 m
- Velocity of flow = 0.625 m/sec or 37.5 m/minute
- Discharge available outside the lower tunnel = 0.09375 cumec. or 94 litres per sec.
- Outlets in the channel length of 1,650 m = 7

Observations recorded at the last outlet on the roadside.

- Cross-section of the tail end of the channel = 0.60 m x 0.25 m or 0.15 sq. m.
- Flow depth = 0.15 m
- Velocity of flow = 0.77 m/sec or 46.2 m/minute
- Discharge available of the road side = 0.0693 cumec. or 70 litres per sec.
- Area irrigated (Approx.)
  (i) Rice/*Cheena*
  (ii) Wheat/Potato = 50 ha = 70 ha

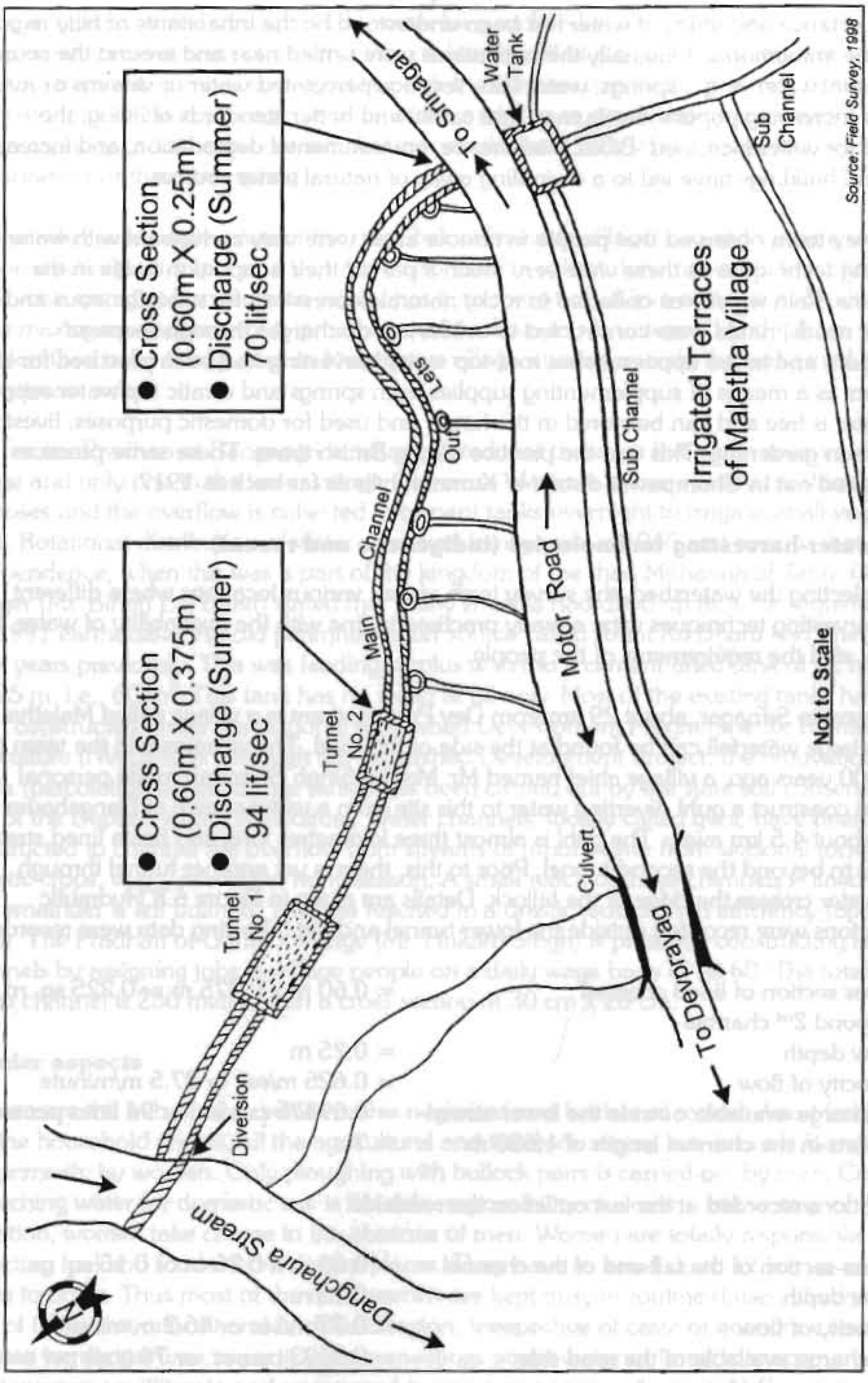

Figure 6.8: **Local water harvesting techniques, Maletha village (Tehri Garhwal district)**

On the same road at Bagwan (16 km from Dev Prayag) towards Srinagar, there is yet another perennial water source with a discharge of approximately 35 litres per second. This discharge is diverted to irrigate crops of rice, potatoes, wheat, and onions. This practice of constructing lined channels is adopted at several locations in the region.

In the middle reaches there are several dhara and naula which primarily supply drinking water and the excess water, i.e., overflow, is diverted to cement-lined tanks for small-scale collection; and the water collected in this way can be crucial in times of drought. Renovation of naula and construction of small unlined ponds have been carried out by the State Soil Conservation Unit, while tanks and channels, locally called hauz and guhl, have been constructed by the Watershed Development Project.

In the upper reaches, embankment-type rain water collecting ponds could be seen in natural depressions where the bases were rocky. One was observed in Kandi Bagri village and another was observed just below Chandrabadni temple in Naukhari village at an altitude of almost 2,500 masl.

The specifications of the two rain-water collection ponds in the vicinity of the watershed are as follow.

- **Location** : **Kandi Bagri Village**
  - Elevation : 1,650 masl
  - Dimensions : Average observations
    - Length - 60 m
    - Width (embankment) - 35 m
    - Depth - Maximum- 4 m, minimum-1.5 m
  - Inlet : Runoff collection
  - Surplussing arrangement : Yes
  - Use of water stored : Livestock and washing
  - Year of construction : 1986
- **Location** : **Naukhari Village (below Chandrabadni Temple)**
  - Elevation : 2,480 masl
  - Dimensions : Average observations
    - Length - 100 m
    - Width - 30 m
    - Depth - Variable (1.5 to 2.5 m)
  - Inlet : Runoff collection
  - Outlet : Seepage flow
  - Use of water : Drinking water for animals and groundwater recharge
  - Year of construction : 1975

This kind of pond is usually found at high altitudes (beyond 1,500 m).

In the same upper reaches, it is the practice to collect rain water from slanting roof tops by diverting the flowing rain water through sheet metal drains placed horizontally across the roof and diverting it into a tin funnel and a vertical drainpipe opening into a water container (tank/drum). Even in recently constructed houses with cemented rooves, villagers place pipes to collect rain water. Twelve households are collecting water from the roof in cement tanks. On average, a roof of 150 sq. m. is enough to provide about two cubic metres of water with one hour of moderate rainfall (15 mm/hr). The local people think that this water can not be stored for a long period, and they avoid using it for human consumption.

Bench terraces are constructed for soil and runoff conservation. Cultivation on benched terraces is predominant in the region and steep slopes are transformed into relatively level, narrow steps across the slope. The cultivators in the hills use irrigated, level bench terraces and attain a high rate of productivity. The vertical interval between two adjacent bench terraces should normally not exceed two metres to maintain stability; the width should not be less than three metres to facilitate farming operations and uniform distribution of water. Water moves down from terrace to terrace. The excess water from the last terrace is usually safely disposed of through a well-vegetated grass waterway. Specifications for bench terraces in the UP hills have been calculated by Juyal and Katiyar (1990) and are given in Table 6.13.

Table 6.13: **Specifications for irrigated bench terraces in the hills of UP**

Land Slope (%)	Vertical Interval (m)	Bench Width (m)	Soil Depth (m)
10	0.8	7.5	0.7
20	1.0	5.0	0.8
30	1.2	4.0	0.9
40	1.5	3.7	1.0
50	1.8	3.5	1.2

Source : Juyal and Katiyar 1990

Quality of spring water

In the Garhwal Himalayas where a large population is dependent on natural springs for drinking water, the importance of spring water quality cannot be neglected. The main problems confronting the users of spring water are chemical and biological contamination through infiltration. In the watershed area, almost all the springs discharge water under gravity and the groundwater is in unconfined aquifers. This means that there are increased possibilities of leaching out of surface water into the springs through percolation. If surface water receives sufficient treatment within soil layers, the quality of water will not be poor. But, in the hills, cracks and joints present in the rock can cause short-circuiting and untreated waste water can enter the groundwater body and pollute it. Therefore, to ascertain the degree of subsoil water contamination, the quality of spring water was assessed.

Methodology

The methodology followed during the study included a preliminary survey, in depth monitoring, and data analysis. A preliminary survey was conducted in the watershed to monitor the springs. After surveying, twelve springs/ naula situated in the watershed were selected for water sampling to determine the physico-chemical characteristics. Water samples were collected during the summer of 1998.These samples were analysed by standard methods.

Physio-chemical characteristics

The water samples collected from different springs were colourless; transparent without any turbidity. No specific taste and odour were observed, indicating that water samples were odourless and unremarkable with respect to taste and odour.

The various parameters with respect to water quality are presented in Table 6.14. The pH of spring water ranged between 6.7 to 7.3. The minimum pH value (6.7) was observed in spring water from Kandi Bagri and Pausada and the maximum value (7.3) was observed in spring water from Bangarigaon, Amni Dhara, and Garhkot. Such a slight variation in pH may be ascribed to the varying chemical composition of underground rocks from where water passes out to form springs. Considering the standards for pH laid down by the World Health Organisation (WHO) for drinking water, the spring water is well within permissible limits. Electrical Conductivity (EC) is considered to be a direct indicator of concentration of total dissolved ions in water. In the watershed, spring water had a wide range of EC from 28.3 to 290 micro mhos/cm (Table 6.14). The water from Garhkot had the highest EC of 290 micro mhos/cm followed by Kandi Bagri (200-230 micro mhos/cm) and Amni springs. A possible reason for the high EC could be the dissolution of salts from the bedrock. The water could be taken as safe for drinking purposes as far as EC is concerned.

Sulphates in groundwater are found naturally due to dissolution of calcium sulphate from bedrock. The concentration of sulphate in spring water ranged from 8.4 to 52.21 ppm. The highest value of 52.21 ppm was observed in the Garhkot spring, followed by Amni Dhara (13.66 ppm) and Bidakot spring water (11.25 ppm). The other spring water had the same value of 8.4 ppm. The concentration of sulphate in spring water is within desirable limits (250 ppm) for drinking water (as specified by WHO in their guidelines). Concentration of chlorides was observed in traces and therefore cannot be quantified, and thus there is no fear of chloride toxicity in using spring water for drinking purposes. The carbonate and bicarbonate ions ranged from 1.5 to 15.0 ppm and 73.20 to 147.92 ppm respectively in the water samples analysed. The lowest value of carbonate (1.5 ppm) was obtained in Bidakot and the highest value (15 ppm) in Bangarigaon spring. Similarily, bicarbonate was also minimum (73.20 ppm) in Bidakot and maximum (147.92 ppm) in Bangarigaon springs.

Nitrate is one of the important criterion for the quality of drinking water. Its high concentration is toxic for infants and creates lethal effects (Steel and Meghee 1984). Concentration of nitrate in watershed springs ranged from 17.3 to 47.0 ppm (Table 6.14). About 60% of water samples were found to have a concentration of nitrate as high as 30 ppm. These results are in line with those reported by Kumar and Rawat (1996) who observed that concentrations of nitrate ranged from 11.6 to 68.4 ppm (60% of the samples had more than 50 ppm) in the natural spring water near Almora in the UP hills. Considering an upper limit of 10 ppm as a criterion fixed for nitrate concentration in drinking water by the World Health Organisation (WHO), and 30 ppm as laid down by the Ministry of Health, Government of India, 60% of the spring water in the study area is not suitable for human consumption. However, no case of blue babies (children born with rhesus negative blood) caused by nitrate toxicity has been reported so far. It is, therefore, suggested that these springs be protected against further contamination if they are used for drinking as there is no other option for the villagers.

Calcium and magnesium salts in the water make it hard. In domestic water, hardness is not desirable as it results in excess soap consumption. The concentration of calcium and magnesium in spring water in the watershed ranged from 16.0 to 30.0 ppm and 6.0 to 43.2 ppm, respectively. The minimum concentration of 16.0 ppm calcium was observed in Bangarigoan and Bidakot and the maximum value of 30.0 ppm was found in Garhkot and Kandi Bagri springs. The concentration of magnesium ions was minimum (6.0 ppm) in Kandi Bagri spring (A) and maximum (43.2 ppm) in Bangarigaon spring. This could be due to variation in baseflow conditions through the bedrock. The concentrations of both calcium

Table 6.14: **Physical and chemical characteristics of spring water of Garhkot watershed**

Characteristics	Springs											
	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}
	Kandi Bagri	Kandi Bagri	Pausada	Pausada	Pausada	Dyuli	Bangari gaon	Amni Harbans	Hurmasa	Garhkot (Dhara Aam)	Amni Dhara	Bidakot
	(A)	(B)	(A)	(B)	(C)							
1. Colour	----- Permissible Colourless ----											
2. Taste and Odour	Nothing and No*	No	No	No	No	No	No	No	No	No	No	No
3. Ph	6.7	6.7	6.7	6.8	6.8	6.8	7.3	6.8	6.9	7.3	7.3	6.8
4. Ec (micro mhos/cm)	230	200	73	200	200	140.3	128.3	28.3	66.3	290	210	164.3
5. Cl (ppm)	-	-	-	-	-	-	-	-	-	-	-	-
6. SO_4 (ppm)	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	52.21	13.66	11.25
7. CO_3	6.0	6.0	4.5	13.5	6.0	6.0	15.0	9.0	4.5	7.5	9.0	1.5
8. HCO_3 (ppm)	99.12	99.12	96.07	134.20	94.55	76.25	147.92	108.27	83.87	102.17	94.55	73.20
9. NO_3	37.10	17.30	32.10	29.00	29.70	17.30	39.60	37.10	26.00	32.10	42.10	47.00
10. Ca (ppm)	30.0	26.0	22.0	26.0	24.0	26.0	16.0	26.0	20.0	30.0	20.0	16.0
11. Mg (ppm)	6.0	26.4	18.0	13.2	9.6	8.4	43.2	8.4	19.2	18.0	42.0	10.8
12. Fe (ppm)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
13. Cu (ppm)	0.003	0.001	0.003	0.002	0.003	0.004	0.001	0.002	0.002	0.004	0.003	0.002
14. Mn (ppm)	Nil	Nil	0.001	0.004	Nil	0.002	Nil	Nil	0.002	Nil	Nil	Nil
15. Zn (ppm)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.004	0.001

*No - Not objectionable

Source : Field Survey 1998

and magnesium were well within the permissible limits laid down by the World Health Organisation (WHO) for the quality of drinking water.

The concentration of copper ranged from 0.001 to 0.004 ppm, zinc from nil to 0.004 ppm, manganese from nil to 0.004 ppm, and iron was not found in the spring water. Thus, the water was found to be within safe limits of 0.1 ppm for iron, 0.05 ppm for copper, and 5.0 ppm for zinc as per the guidelines of the WHO for drinking water. Thus, spring water in general can be stated to be quite suitable and fit for use by aquatic plants and other life forms. However, these springs must be maintained and protected to collect quality water on a sustainable basis.

Efficiency of the local water use system

Most of the local water conveyance systems are unlined over a highly permeable soil mass. Only about two per cent of the channels, locally called guhl, are lined with cement plaster over local stone masonry work. The condition of lined guhl was not satisfactory, mainly because of the ignorance of villagers and apathy of the department. In some villages, it was also found that guhl were constructed and lined with concrete and cement, but there was no water to flow in these guhl.

The storage tanks in most cases are cement lined, otherwise they would not be able to hold water. The siltation rate in the tanks was found to be quite high (1.2 to 3.2 $kg/m^2/yr$). The main losses are during conveyance from the source to the field and during application and storage in the soil profile. As much as 70% of the water is lost and only about 30% is made use of in this already water-starved region. Even if the channels *(guhl)* are lined, they become defunct as a result of debris slides from above, disruption caused by toe-cutting, and gravelly sediment in naturally flowing water. The unlined channels (guhl) are most inefficient in conveying water. The dhara are fed by natural springs. They are a common and popular source of drinking water, but yet huge amounts of scarce water get wasted through inefficient water use.

7. Local Water Supply and Management Systems

Water sources

The study area is situated between two major snowfed river systems, namely, the Bhagirathi in the North-West and the Alaknanda in the South East. The rivers join together at Dev Prayag and thereafter are known as the Ganges. Both rivers flow 800-900 m vertically below the highest point in the watershed. The watershed selected is a catchment of the River Alaknanda. The elevation range is far below that of the permanent snow line. Thus, all the water sources available in the watershed depend on rainfall and groundwater recharge. Chham and Kandi Bagri villages are in the upper reaches and experience few snowfall events. When snow does occur, it melts within a week. Groundwater potential in the watershed has not yet been assessed. Thus rainfall, surface flow, and oozing out of groundwater in places locally called dhara (if water is available in larger quantities and used as a fountain) and naula (if trickling or oozing water) are collected in a very small ditch protected with stone or a wooden roof). Unlined dug-out ponds for collection of excess runoff during rainy season are common in the upper reaches. At mid-altitude the lean base flow is channellised through earthen diversions and carried to cement-lined water storage devices—tanks or hauz— through unlined small channels, guhl. The valley areas had plenty of water in the past, and it was used directly by constructing earthen or cement-lined guhl.

With the increase in demand, on one hand, and declining water availability in the stream on the other, farmers have been forced to line the guhl and tanks with cement as far as possible. In order to avoid excess withdrawal of water from a guhl at its head, resulting in less water for downstream users, a simple inexpensive device can be adopted. At the opening of a turn out, a small boulder is placed with clay sealing it so that the largest stone obstructs the mouth of each but the last turn out, the sizes of the stones obstructing successive turn out mouths become progressively smaller. Some measure of equity in water distribution is thus ensured.

In the region twice a year, the villagers jointly undertake the cleaning and repair of the irrigation system of tanks and channels by removing silt and obnoxious weeds. Those unable to take part in the work provide hired labour. Widows, the infirm, and handicapped persons are exempted. Most of the villagers are of the opinion that the irrigation department and government agencies need not interfere in their arrangements. They believe that if a guhl were to be handed over to the government, it would be destroyed. Even if a new guhl were to be made, there would be no one to maintain it.

Water is diverted at the head of each system by means of a temporary embankment through which enough water is permitted to flow into the system. As per the typical cross sections reported, limited capacity of the guhl ensures that only a certain quantity of water can pass into it. The diversion structure is washed away frequently during monsoon, but it is promptly repaired by the beneficiaries who act collectively. Maintenance and cleaning of the channel within one's field is the responsibility of each farmer. For paddy irrigation, water is allowed to flow from the higher to the lower fields, and establishment of an extensive network of field channels is avoided.

Overexploitation of available vegetation in the region and faulty land-use practices together with natural disasters such as earthquakes and landslides, have contributed significantly to a decrease in water supplies. Time-line analysis of water sources in the watershed showed that a lot of water sources in the area have dried up during the past 20 to 30 years (Annex I). Kandi Bagri villagers shifted to the upper reaches because of the dhara in the old village were drying out and hence water was scarce. Diminishing availability was observed at many water sources. All the villagers of the Hindolakhal Development Block and Dev Prayag Tehsil joined forces to agitate against the government, demanding provision of soft drinking water. The State government established a lift scheme from the Alaknanda River for drinking water, and tap water was provided to the villages.

The tap water system

Water is lifted from the Alaknanda River near Bagwan village on the Devprayag-Srinagar road at government expense. Garhwal Jal Nigam, a state government organisation, is responsible for construction of water collection and distribution systems. The system is handed over to another sister organisation, namely, Garhwal Jal Sansthan, for distribution, minor maintenance, and collection of revenue. The system has been in operation since 1980. It reached the selected watershed villages in 1986, 1990, and 1994 only. The total length of this lift system is about 30 km and water reached the highest point near Chandrabadani in three phases. At the end of each phase, there is a water collection tank, a pump for lifting water, and a distribution system. Distribution of water from a tank at lower elevation reduces the discharge and water pressure at higher elevation. The whole distribution system is practically managed by a water-box man. Each water-box man covers about 60-80 villages within a radius of 20 km. Inaccessibility and paucity of maintenance funds are the main constraints faced by the water-box man in maintaining the system.

Drinking water supplies

Various drinking water supply systems are present in the villages selected. Dhara are the most prominent sources of drinking water and are found in all elevation ranges followed by the tap-water supply system. There is only one naula present in the watershed and this is situated in the mid-altitude zone. People in the low-altitude zone are forced to drink polluted stream water owing to the scarcity of other sources of drinking water. Seasonal distribution/ availability of water from these revealed that there is no scarcity of drinking water during the rainy season. In the winter, water scarcity occurs in high altitude villages and villagers queue for water. On the other hand, at mid-altitude and in the valley plenty of water is available. During summer, drinking water is scarce in all three zones and common in the whole Development Block. People have to travel long distances to fetch water (Table 6.15).

Table 6.15: **Distance travelled and waiting time for drinking water during summer by the villagers**

Parameter/Source	High-altitude Zone	Mid-altitude Zone	Low-altitude Zone (Valley)
Dhara			
Distance travelled (km)	3 to 3.5	0.5 to 1.0	0.5 to 1.0
Waiting time (hour)	2 to 4	2 to 3	0.3
Tap Water			
Average frequency observed			
Rainy season	Twice a week	Daily	Twice a week
Winter season	Once in a week	Once in a week	Once in a week
Summer	Not available (not sure)	Fortnightly	Not available
Waiting time (hours) winter	4 to 6	4 to 6	6 to 8
Waiting time (hours) summer	8 to 10	6 to 8	Not available
Water transported from Devprayag			
Average price paid (Rs/lit)	0.75	0.50	Not purchased
Availability	Erratic	Erratic	-

Source: Field Survey 1998

Water supplies for domestic purposes and cattle

Pond and roof-top water harvesting are prevalent in the high altitude zone, while tanks and guhl are used widely in the mid-altitude and valley (Table 6.16). Water availability from them decreases with the advancement of time from rainy season to summer. Animals have to travel four to eight km for water, particularly from high and mid altitudes. Three continuous ponds constructed on the other side of Kandi Bagri provide drinking water for animals and water for washing. Chham villagers have to travel four to six km away. Mid-altitude farmers travel downstream about two to three km away to get water for their animals.

Irrigation

Water is not available for irrigation in the high-altitude zone. Tanks and guhl are the common water-harvesting and recycling devices at mid-altitude and in the valley. Water from these sources is sufficient during rainy season. During winter, discharge decreases drastically and the command area is reduced by 70% in the mid-altitude zone and 40% in

Table 6.16: **Water sources and availability of water for human uses**

Sources	High Altitude				Mid-altitude				Low Altitude			
	Pre-sence	availability during			Pre-sence	availability during			Pre-sence	Availability during		
		R	W	S		R	W	S		R	W	S
Drinking purposes												
Tap	Yes	L	M	M	Yes	L	M	M	Yes	L	M	M
Dhara	Yes	A	M	M	Yes	A	A	M	Yes	A	A	A
Naula	No	-		-	Yes	L	M	M	No	-	-	-
Stream	No		-	-	No	-	-	-	Yes	A	A	A
Other purposes (washing & cattle)												
Pond	Yes	A	L	M	No	-	-	-	No	-	-	-
Tank	No	-	-	-	Yes	A	L	M	Yes	A	L	L
Roof top water harvesting	Yes	L	M	No	Yes	L	M	No	Yes	A	L	No
Guhl irrigation	No	-	-	-	Yes	L	M	No	Yes	L	M	M
Stream irrigation	No	-	-	-	No	-	-	-	Yes	A	A	L

R= Rainy season, WS= Winter season, S = Summer, L = Low, M = Meager, A = Adequate
Source : Field Survey 1998

the valley. All the farmers have realised this and, by mutual agreement, tail-ender farmers do not ask to share the water. The normal irrigated crops are wheat and potatoes in winter (rabi) and paddy in the rainy ('kharif') season. During winter, one to two waterings are available rather than three to four during the rainy season, along with adequate rainfall from July to September. For winter crops, water is required in October for pre-sowing irrigation and again between December to February based on the availability of winter rains. During rainy season, two waterings are needed in July and August for transplanting and thereafter continuously up to the end of September.

Water mills

The steep gradients of hill rivers provide ample scope for generation of electricity through micro-hydropower generation techniques. Local people are using this potential for water mills. Water mills have been used for more than a hundred years in the region. There were many water mills in the UP Himalayas in the past. Some of them have been replaced by diesel/electric motor engine mills. Yet, at present, there are more than hundred thousand operational water mills in the region. Most of the water mills are owned by higher caste people belonging to low-income groups. Ownership of a water mill is restricted because one has to own land near a potential site for hydropower. There is a complete, cohesive interdependency between various ethnic groups. People of all castes use the mill on a first come first served basis and pay equally for milling. The mill owner pays only a nominal amount of revenue (Rs 16 per year) for setting up a mill. Uniform charges of Rs 0.80/kg or 12% of input is charged by the mill owner from all customers irrespective of caste and religion. Technological improvements in water mills have increased their efficiency by a 100%, one water mill owner stated at a meeting of the UP Hill Water Mill Association held on 2nd November 1998 in Dehradun. It was also observed that the number of water mills is decreasing over time because of scarcity of water (Bartarya and Valdiya 1989). A water mill owner (Mr. Hukum Singh) in the selected watershed revealed that there is about a 40% reduction in grinding efficiency of his mill compared to 1970. This is because of decreased water flow. Downstream from Garhkot Gad, there were four water mills within a span of four km until 1970, and today there is only one. This is partially due to the lack of water for generating the power required and partly to the replacement of water mills by electric/diesel motor mills that are more efficient.

Traditional water-management systems

The water scarcity in the region is acute during summer. Discharges from dhara and naula decrease significantly. Tap water supplies are erratic and insufficient. The seriousness of the scarcity can be seen from the fact that one man was killed in the summer of 1998 over a water dispute. People have had to devise their own methods of water distribution from available sources.

Traditional water-harvesting systems still continue in this region and are managed by the village communities themselves. The Gram Sabha (village assemblies) manage their own water resources. Based on the population and on water requirements, rosters for water use are maintained.

Most of the area in these hills is rainfed, however a small percentage of cultivated area is irrigated. Wherever a perennial source of water is available, streams are harnessed by temporary diagonal obstructions, made of boulders, trees, or logs, diverting the flow into contour channels along the hillsides. Well construction is very rare except near perennial streams. Canals receive supplies from local springs or streams. Masonry canals, unless lined with lime and stone, deteriorate very rapidly. Large tracts are infested with land crabs which, to get to the water, bore through the ordinary boulder masonry set in white lime. This causes extensive damage to canals.

Some canals are built from hill torrents and from perennial streams and rivers by individuals. Usually the streams almost sink underground on reaching the base of the hill. Large rivers are torrential in nature and follow very steep slopes in descent. The irrigating capacity of the canals varies according to the extent to which they are lined and also according to the type of soil used to build them. A tract of good quality land may not produce as much as one of poorer quality with irrigation facilities. Availability of water also determines the cropping pattern.

Hill farmers harness even the most insignificant water sources that can be diverted to the field. The water source may not carry enough volume outside the monsoon period to support a good winter crop but farmers will still harness it. Villagers who own sufficient irrigated land do not migrate to the plains. Development of irrigation in the hills has been left to the cultivators and has not been considered a government responsibility. After independence, the irrigation department in the hills modernised some of the traditional irrigation systems in the early 1950s and created a few new ones. Some experts are of the opinion that farmer-managed irrigation systems are on the verge of extinction in this region. In fact, there is not enough data about their existence (being small-sized systems), and they are so simple in design that they may go unnoticed by someone looking for sophisticated engineering structures.

Management of drinking water

Locally available water sources, i.e., dhara or naula are cleaned by villagers once a year through *'Yuwak Mangal Dal'* (Village Youth Welfare Groups) without any payment. Sometimes (once in five years), these dhara require major repairs, and these are carried out by all the villagers/beneficiaries on a voluntary basis. All the beneficiary families contribute equal amounts of labour and money to accomplish the job. Sometimes they receive the funds needed from the Block Development Office. Farmers believe that the amounts sanctioned are less than required and beneficiaries have to contribute to maintenance. Maintenance of the tap-water system is the responsibility of the state government department, the Garhwal Jal Sansthan. The present management situation is inadequate. Distribution of drinking water is by roster. The first-in-first out (FIFO) rule is followed in distribution. All the sources of drinking water are busy for 15 to 20 hours a day, particularly during summer. In cases of acute shortage, no family can fetch more than 40 litres at a time and this restriction is imposed in the high and mid-attitude zones especially. If water is available, it is used according to the same rules (Plate 6).

For special ceremonies like marriages, each family contributes its first quota of water to the family in question. In case tap water is available, the whole amount will be used by the family celebrating the marriage. Conflicts about distribution of water often arise between villagers. Most of these are resolved by the village elders on the spot, but, if an amicable solution is not reached, the Village Panchayat, with the advice and cooperation of elderly villagers, will resolve the conflict. Most resolutions are modifications in norms or suggestive in nature. Financial or other restrictions are not within the purview of these committees.

Drinking water is common property between two villages also and managed by a water users' society ('Pani Panchayat') consisting of both villages. For example, a dhara between Amni and Bidakot villages is a common source to both villages. The Pani Panchayat decided that Bidakot villagers can fetch water between 3a. m. and 10p. m. and the rest of the time, i.e., from 10p. m. to 3a. m. Amni village folk will fetch water. The first-in-first-out (FIFO) rule is followed. For efficient functioning of the system, a paid watchman is engaged by the Pani Panchayat. For this, the Pani Panchayat collects a nominal amount of Rs 20 per family per month to pay the watchman. For repair and maintenance, all the beneficiary villagers contribute one day's labour or equivalent wage payment to the Pani Panchayat. The water source between Pausara and Bangari gaon is jointly shared in a similar by both the villages without fixing any time schedule, but the FIFO rule is followed. Maintenance is carried out through voluntary contribution of labour by all the beneficiaries once a year.

Ethnicity and drinking water sources

Drinking water sources, either dhara or tap, are separate for upper caste and lower caste people. Every village is caste-based, i.e., upper caste consisting of Brahamins and Rajputs and lower castes. Scheduled caste clustering is a common feature. Upper castes have different drinking water sources than lower castes (Plate 7). No-one can use the water sources of another caste, particularly for drinking. If water is available from other caste sources, generally from the lower caste sources, it is used by higher castes for washing and animals. The FIFO rule is followed in all cases. Maintenance of these sources lies within the purview of each group. However, in some cases, the village *panchayat* gets a special grant for socially weaker sections for rehabilitation of water sources and to accomplish the job with the cooperation of that community. In very adverse situations, particularly in high altitude villages like Kandibagdi and Chham, when water scarcity is faced by socially weaker sections, they are given water by the upper castes to drink at the source. In this case also, they have to wait in a queue (though separately) for their turn. The upper caste person in the corresponding position in the queue next to them will fetch water and supply it to them.

Gender aspects

It is normal practice in the hills that all jobs, such as collection of water, fodder, fuel, animal grazing, and washing, which require continual and persistent labour for maintenance of the household and farm, are carried out by women. Men do engage in hard labour such as ploughing and construction as well as in conflict resolution, but these are occasional in the agricultural year and do not represent continual drudgery. However, no hard and fast distinction is followed. Most of the work is carried out by women. Women's representation in the Pani Panchayat is a new concept only after reservation of seats for women under the new Panchayati Raj Institution Act (PRI Act). Women hardly contribute to planning, managing, and decision-making with respect to water sources. They simply carry out the decisions made by the male-dominated Pani Panchayat.

Irrigation management system

Water for irrigation is available at mid altitude and in the valley only. Surplus water, either as surface flow or base flow, i.e., oozing out, is diverted through a water channel guhl and collected in a cement-lined tank. It is distributed through a number of unlined guhl. Each water collection tank has a defined command area and all the land owners of the defined area prior to 1950 are members of informal groups for the tank or irrigation system. All those who owned land at the time of abolition of kingship, i.e., 1950, are known as 'thok'. Any subsequent division of land within the thok is not considered as an independent unit. Only the head of the thok is a member of an informal group.

Water-harvesting structures and conveyance systems were initially constructed by local people through contributions in cash as well as in kind based on the area to be irrigated. Regular repair and maintenance of the system is done collectively, prior to the onset of the monsoon and wheat sowing by the beneficiaries as per thok and area to be benefited. Members can contribute in the form of labour or cash. If there is no major breakdown of the system, routine cleaning of guhl and the system is carried out by the person watering the fields. The informal group mainly consists of men from each thok, but there is no restriction on women participating.

Each informal group prepares its estimates for repair/maintenance and extension of irrigation facilities in order to seek financial assistance from government financial sources. All these estimates are checked and prioritised by the village council or Gram Sabha decisions are made on the basis of considerations of social justice and the needs of the people. Projects receiving high priority are then submitted to the Block Development Office, Hindolakhal, by the Head of the village council, the Pradhan. The Minor Irrigation Department prioritises all the applications and allocates the budget for sanctioned projects after completing formalities. The sanctioned budget finally allotted to the village Pradhan to accomplish the job. Since the probability of approving the project from the minor irrigation department is very poor, many times the village Pradhan diverts the 'Jawahar Rojgar Yojna' (JRY) funds for this purpose with the approval of the village council. All the work is completed under the supervision of the village Pradhan. Since funds available to the village council are limited, most of the work cannot be done. Many times there are technical as well as financial lapses in such programmes. Thus the village Pradhan becomes the contractor for all the programmes financed by the government. This has eased the social ties, on one hand, and resulted in poor cooperation and mistrust in village-level institutes on the other. Therefore, local institutions have a more adverse impact on social attitude, behaviour, and community development programmes than before.

Distribution of water for irrigation

All the beneficiaries from a water distribution system form an informal group. The number of beneficiaries is determined as the number of families at the time of abolition of the landlord or kingship system, i.e., in 1950. Paddy is the major kharif (rainy season) crop grown under irrigated conditions. Paddy nurseries are raised close to the water source in the month of May. Each thok is allotted water for 24 hours. If there are sub-divisions within a thok the distribution of water for 24 hours among themselves is the responsibility of the head of the thok as the representative of the water users' group. Thok owning fields closest to the water source receive water first followed by the next owner and so on. This is carried out with minimum seepage and conveyance losses. During summer, water is very limited and, to make efficient use of it, people raise paddy nurseries close to the water sources by mutual consent without payment. Lean flows of water are first collected in a tank and opened for irrigation only after it is completely filled. In most cases, early morning or late evening irrigation is followed to minimise evaporation losses. The same practice is followed when paddy is transplanted. Normally paddy is transplanted jointly by all the beneficiaries from the source. In the remaining area water for irrigating paddy increases, and there are no shortages when annual precipitation is normal. Bartering for water within the group is permitted, but not outside the group.

After harvesting paddy, all the farmers receive water once through the same roster system prior to planting wheat. From the month of December onwards, water supplies decrease drastically and nearly 70 and 30% of the beneficiaries at mid-altitude and in the valley do not get water. Tail enders are well aware of the scarcity and do not demand water. They do not contribute to the maintenance of the system during this period. In the valley people cultivate potatoes and onions. These activities are mostly restricted to those who have landholdings very close to water-harvesting structures or water sources. Thus locational advantages are used to good advantage by the farmers. All farmers have equal rights to water for irrigation, and it is distributed without any disparity based on caste, sex, or economic status. Disputes are resolved in informal group meetings involving all the beneficiaries, and group decisions are strictly followed. Thus formulation of norms for water use, contributions for upkeep of the system, and so on are subjected to revision from time to time depending on the availability of water and the amount required for maintenance.

Civil soyam and forest panchayat management system

Civil soyam land (owned by the forest department and managed by villagers) and Forest panchayat ('Van Panchayat' - owned and managed by villagers) are the two main categories of common property resources in the study area. These two categories of forest land are given to local people primarily to strengthen local institutions and ensure that they have a stake in it so that local demands for fuel, fodder, and timber for agricultural implements will be met. All the villages in the selected watershed have civil soyam land except Harbans and Amni villages. Van Panchayat(s) are limited to Chham, Harbans, Amni, and Garhkot. Civil soyam land is not managed by any set rules or norms. These lands are used by everyone without a management system. In fact, all the civil soyam land is turned into open access resources and ultimately this land becomes wasteland, devoid of vegetation.

The Van Panchayat in the study area has been in existence since 1958.It is managed by a Committee headed by the village Pradhan. There are four to five elected members on the Committee. No effort has been made to rejuvenate the degraded Van Panchayat by the local people. The only restriction currently in place followed strictly in Garhkot and Chham

Van Panchayat is a complete ban on cutting down trees. The State Soil Conservation Unit, Kirtinagar, implemented a watershed management plan in the selected watershed during 1992-95 under the National Watershed Development Project in Rainfed Areas (NWDPRA). Efforts were made to rejuvenate civil soyam as well as the Van Panchayat by adopting soil conservation measures, e. g. , trenching, planting, and loose boulder and gabion check dams. Due to the open grazing practices adopted by villagers and the low participation of local people, these measures have been not been very successful. Therefore, people's participation is an important element in making these CPRs self sustainable.

Recent demands for increased water supply

As the population of both people and livestock increased in the watershed the demand for water also increased. Human population figures for the three altitude zones were collected for the years 1981, 1991, and 1998 from secondary sources and converted into standard human population units. The human population for the next 22 years in the watershed was projected through fitting a trend equation and this is presented in Table 6.17.Daily water requirements for the human population were worked out at two rates, i.e., 150 lit. /day and 175 lit/day per standard human units (Tables 6.18 and 6.19). The estimated water demand is presented in Tables 19 and 20. Based on the recorded discharge from various drinking water sources in each altitude zone, the supply of water from these sources will be enough to cater for human needs even in summer, provided water is collected 24 hours a day. The remoteness of water sources and lack of infrastructural facilities to store water during the night have created a shortage of drinking water in the region.

Table 6.17: **Standard human population of Garhkot watershed**

	Year	Standard Human Population (No)			
		High Altitude	Mid Altitude	Low Altitude	Total Watershed
Actual	1981	72	77	70	219
	1991	96	111	88	295
	1998	120	130	103	353
Projected	2000	124	137	106	367
	2010	152	169	126	447
	2020	180	200	145	525

Table 6.18: **Water requirement (00 lpd) for human consumption @ 150 lpd (litre per day)**

Year	Standard Human Population (No)			
	High Altitude	Mid Altitude	Low Altitude	Total Watershed
1981	108	116	105	329
1991	144	167	132	443
1998	180	195	155	530
2000	186	206	159	551
2010	228	254	189	671
2020	270	300	218	788

Table 6.19: **Water requirements (00 lpd) for human consumption @ 175 lpd**

Year	Standard Human Population (No)			
	High Altitude	Mid Altitude	Low Altitude	Total Watershed
1981	126	135	123	384
1991	168	194	154	516
1998	210	228	180	618
2000	217	240	186	643
2010	266	296	221	783
2020	315	350	254	919

Source : Field Survey 1998

The standard livestock populations for 1987 and 1997 were used to estimate livestock populations for 2000 and 2010 by fitting a trend line (Table 6.20) and water requirements were estimated as per the technical coefficient observed in the area and presented in Table 6.21.By comparing the requirements for people and livestock, it became clear that twice as much water is needed for livestock in the high altitude zone, nearly half in the mid-altitude zone, and almost equal in the valley.

The total water requirements for people and livestock in the watershed are presented in Table 6.22. Past experience and available statistics suggest that the water shortage can mainly be attributed to the poor structural and management system rather than availability in gross terms.

Table 6.20: **Standard livestock population in different zones of the watershed**

Year	Standard Human Population (No)			
	High Altitude	Mid Altitude	Low Altitude	Total Watershed
1987	813	120	340	1273
1997	913	198	434	1545
2000	943	222	435	1600
2010	1043	300	439	1782
2020	1143	378	533	2054

Table 6.21: **Water requirements (00 lpd) for livestock purposes @ 50 lpd**

Year	High Altitude	Mid Altitude	Low Altitude	Total Watershed
1987	407	60	170	637
1997	457	99	217	773
2000	472	111	278	800
2010	522	150	220	892
2020	572	189	267	1029

Table 6.22: **Total projected water requirements for human and livestock in the watershed (00 lpd)**

Year	Water Requirements (00 lpd)
2000	1443
2010	1675
2020	1948

Source : Field Survey 1998

Local water supplies: the main problems

Water scarcity in the region is attributed to many factors. These factors can be grouped into biophysical and socioeconomic aspects and as such have been presented in Figure 6.9.Under the biophysical factors, erratic rainfall, topography (steep slope, gravelly soil), heavy runoff, and soil erosion caused by ineffective vegetative cover are listed. As far as socioeconomic factors are concerned, faulty land use, low adoption of soil and water conservation techniques, and poor water-harvesting and management systems are the main constraints to augmenting water supplies. Increased human and livestock populations, poor economic conditions, the land tenure system, the fact that women are alone in carrying out most of the agriculture, over-grazing, and subsistence agriculture are the major socioeconomic constraints.

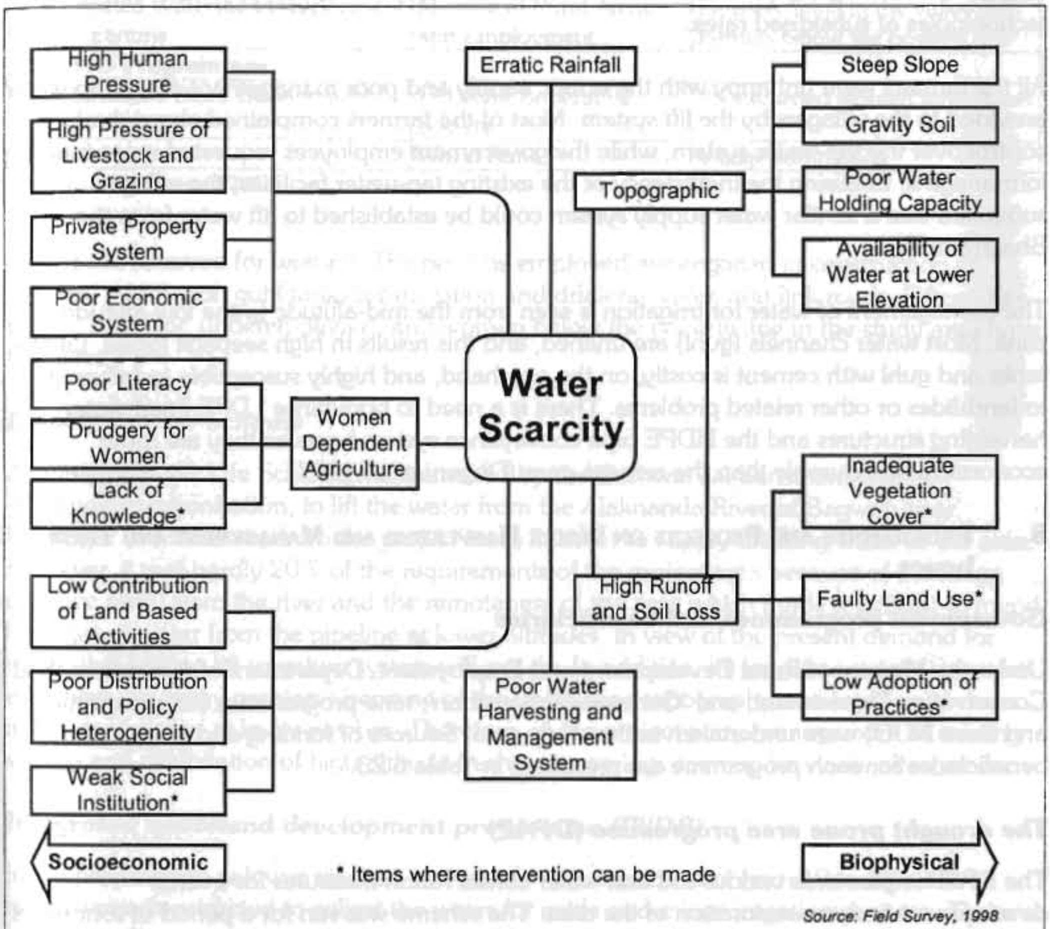

Figure 6.9: **Problems caused: diagram of water scarcity**

Critical issues

Analysis of the watershed and discussions with inhabitants revealed that there were areas in which government intervention (financial or technical or both) could increase water supplies and prosperity in the region. These interventions include creating awareness about the water-management system among the rural masses through various extension methods, improving the economic status of local people through improved crop production technologies, and establishment of agro-based cooperative industries.

All the inhabitants in the watershed realised that denudation of the area caused by ineffective vegetative cover, faulty land-use systems, and lack of proper soil and water conservation measures are the main reasons for depletion of water resources. Mid-altitude and valley zone farmers have perceived a significant increase in the water supplies after implementation of a watershed management programme by the state government in the area. Absence of proper water-harvesting and recycling structures and poor management of available structures are the key issues and require government intervention. Most farmers want to fence in the common land and carry out large-scale plantation of fuel and fodder species with staggered contour trenching on these lands. High-altitude farmers favoured construction of dug-out ponds on common land and adoption of roof-top water harvesting technologies at subsidised rates.

All the farmers were unhappy with the erratic supply and poor management of the tap water provided to the villagers by the lift system. Most of the farmers complained about dual control over the tap-water system, while the government employees requested more funds to manage it. Realising the inefficiency of the existing tap-water facilities, the villagers suggested that a similar water supply system could be established to lift water from the Bhagirathi River.

The management of water for irrigation is seen from the mid-altitude to the low-altitude zone. Most water channels (guhl) are unlined, and this results in high seepage losses. Lining tanks and guhl with cement is costly, on the one hand, and highly susceptible to failure due to landslides or other related problems. There is a need to popularise LDPE-lined water-harvesting structures and the HDPE pipe conveyance system because they are more economical and durable than the cement ones (Dhyani *et al.* 1997).

8. PROGRAMMES AND PROJECTS ON WATER HARVESTING AND MANAGEMENT AND THEIR IMPACT

Government programmes and beneficiaries

Under the Ministry of Rural Development and Employment, Department of Agriculture, Soil Conservation Department, and 'Garhwal Jal Sansthan', nine programmes (six government, and three NGO) were undertaken in the study area. Sources of funding and target beneficiaries for each programme are presented in Table 6.23.

The drought prone area programme (DPAP)

The DPAP implements various soil and water conservation measures for overall development and eco-restoration of the area. The scheme was run for a period of four years (1988-92) with development costs of Rs 4,000 per hectare. The Soil Conservation Department, Govt. of Uttar Pradesh, carried out in situ moisture conservation, construction and repair of ponds and guhl, and construction and renovation of terraces. A large number of families benefited from this programme.

Jawahar rojgar yojna (JRY)

The JRY scheme is totally financed by the Government of India. It provides employment to poor and underemployed villagers who live below the poverty line. Under the scheme, 30%

Table 6.23: **Projects, programmes and target beneficiaries in the area**

Programme	Source of Funds	Target Beneficiaries
A. Government Programmes		
1. Drought Prone Area Programme (DPAP)	Ministry of Agriculture	All cultivators
2. *Jawahar Rojgar Yojna* (JRY)	Ministry of Rural Area and Employment	Community resource, rehabilitation, and weaker sections
3. Drinking Water Scheme	*Garhwal Jal Sansthan* (Govt. of U.P.)	All farmers
4. Integrated Rural Development (IRDP)	Ministry of Rural Areas and Environment	All villagers
5. Million Well Scheme	World Bank	Small and marginalised farmers
6. Integrated Watershed Development Programme	Ministry of Rural Areas and Employment	Farmers living in the valley. All farmers below the poverty line
B. NGO Programmes		
1. Cooperative Dairy Development	PARAG Cooperative Society	All interested women inhabitants
2. *Swajal Yojna*	World Bank	Village community

Source : Field Survey 1998

of jobs are reserved for women. The persons employed are engaged in construction of schools, *panchayat*, guhl tanks for irrigation and drinking water, and link roads. Fifteen per cent of the poor, underemployed, and women below the poverty line in the study area have benefited.

Drinking water scheme

A Drinking Water Life Scheme was launched by the Garhwal Jal Sansthan, a State government organisation, to lift the water from the Alaknanda River at Bagwan near Kirtinagar (35 km away from the project area) in order to supply drinking water to the area. However, it met hardly 20% of the requirements of the project area because of the long distance away from the river and the remoteness of the area which made it difficult to mend leakages of water from the pipeline at lower altitudes. In view of the present demand for water, the existing lift irrigation system will not do. In addition, lift irrigation is cost intensive and there are many problems because of the undulating topography and location of rivers in the deep valley at lower reaches. Therefore, in the project area, management of existing springs and exploitation of high-altitude fresh water springs seem to be viable alternatives.

Integrated wasteland development programme (IWDP)

In the project area at lower reaches, two ponds with capacities of from 10 to 20 cubic metres were constructed to collect the water for cattle and minor irrigation purpose. These tanks have been constructed under the IWDP by the Soil Conservation Department of the government of Uttar Pradesh. These tanks are maintained by the local people. During 1996-97, 12 hectares were planted by the Forest Department in the denuded catchment area of the pond near Kandi Bagri village. A 25% survival rate was observed in the area.

Million well scheme

The million well scheme is meant to create employment for small and marginalised farmers living below the poverty line. Preference is given to bonded labourers for employment. The main objective of the scheme is to create irrigation facilities by constructing ponds, irrigation channels, water-harvesting structures, and bio-engineering measures, thereby reducing runoff and soil loss. The work is strictly carried out through muster rolls and not by contract under any circumstances. Under the schemes, two masonry structures and a half kilometre channel was constructed to benefit the villagers in the watershed.

Integrated rural development programme (IRDP)

The IRDP provides loans and subsidies to those farmers whose annual income from all sources is below Rs 10,000. This money is to be used for establishment of any subsidiary enterprise to boost farming income without adversely affecting the ecology of the area.

NGO Programmes and beneficiaries

PARAG: the cooperative dairy development organisation

A Cooperative Dairy Development Society (named PARAG) is working in the study area to collect milk, process, and distribute it. PARAG provides loans for purchase of good quality animals. The organisation also provides free medical or health consultations for animals to the members of the society and also supplies feed on a payment basis. One such Women's Dairy Development Cooperative Society was started in Bidakot village during 1996-97.It is totally run by the women of Bidakot and nearby villages. Membership increased from 18 in 1996-97 to 50 in 1998-99.

Swajal yojna

Swajal *Yojna* (UP Rural Supply and Environmental Sanitation Project) was started with the assistance of the World Bank in 1996-97 in 650 villages in the UP hills at an approximate cost of Rs 2.5 billion (US $ 60 million). The project was implemented over a period of five years (1996-2000) in four batches (100,150,200, and 200). The scheme is implemented by NGOs only, with the following main objectives.

i) To assist the government of UP to develop and implement a long-term strategy to improve overall water resource management in the state
ii) To deliver sustainable health and hygiene benefits to the rural population through improvements in water supply and environmental sanitation
iii) To improve rural income through time-saving and income-earning opportunities for women
iv) To test alternatives to the current government-led service delivery mechanism

The scheme is functioning in a participatory fashion. Ten per cent of the contribution comes from the beneficiaries (in cash or kind) and 90% is met by the government. *Shri Bhubaneshwari Mahila Ashram* (SBMA) and *Anjanisen* (an NGO) have taken five villages near the study area in which to develop drinking water supply systems. In the near future, it is hoped that the scheme will be extended in the villages in Garhkot watershed.

Water-harvesting measures

The 'Himalaya Paryavaran Evam Gram Vikas Sangathan' has taken on an ambitious programme for developing water-harvesting measures in 22 villages in Khirsue Development Block of Pauri Garhwal district close to the study area.

Impact of programmes on the local ecology and economy

The various government and non-government programmes in the project area have resulted in favourable as well as undesirable impacts on the ecology, economy, and equity in the study area. Impacts as perceived by the beneficiaries and the villagers are summarised in Table 6.23. All rural development programmes in the hills focus primarily on eco-restoration and economic upliftment of the weaker (social or economic) sections of society. Thus, most programmes include soil and water conservation or income-generating activities. All the development programmes have had a favourable impact on the local ecology. Farmers perceive that all the programmes have helped to increase water supplies, reduce runoff, and increase natural vegetation. However, farmers believe that the IRDP programme has had an adverse impact on ecology. This is thought to be primarily because of the increase in livestock in the area, consequently an increase in demand for fodder; and hence reduced vegetative cover. Marginal improvements in the economic status of target families have been realised through these programmes, with the exception of the drinking water scheme. The JRY and IRDP helped to reduce economic disparity.

Some of the programmes described have helped to increase the incomes of small and marginalised farmers (43% of the total population) (Table 6.24).

Table 6.24: **List of Organisations/Institutions Presently Working in the Study Area**

1. Soil and Water Conservation Unit, Deptt. of Agriculture, Govt. of UP
2. Department of Agriculture, Govt. of UP
3. Department of Horticulture and Food Processing, Govt. of UP
4. Department of Animal Husbandry, Govt. of UP
5. Department of Rural Development, Govt. of UP
6. Department of Health and Family Welfare, Govt. of UP
7. Department of Minor Irrigation, Govt. of UP
8. Department of Rural Engineering and Survey, Govt. of UP
9. UP Jal Nigam, Govt. of UP
10. Garhwal Jal Sansthan, Govt. of UP
11. Public Works' Department, Govt. of UP
12. *Garhwal Mandal Vikas Nigam*, Govt. of UP
13. Department of Education, Govt. of UP
14. Department of Forest, Govt. of UP
15. Department of Revenue, Govt. of UP
16. *Parag* Cooperative Dairy Development Organisation
17. *Shri Bhubaneshwari Mahila Ashram, Anjani sain* Tehri - Garhwal (NGO)
18. *Himalaya Paryavaran Evam Gram Vikas Sangathan* (NGO)
19. Central Soil and Water Conservation Research and Training Institute, 218, Kaulagarh Road, Dehradun (UP) (ICAR)

Under the DPAP and IWDP programmes, soya beans were introduced into the high and mid altitude zones, while improved varieties of paddy and wheat were introduced throughout the watershed. These crops are cultivated in the area. Soya bean has become an important cash crop. An afforestation programme undertaken in the area also helped to increase vegetative cover. Stall-feeding practices are being adopted by members of the cooperative dairy project in the area. Increases in vegetative cover and the productivity of natural grass land were observed in the area where social fencing has been established and stall feeding is practised. A list of all the organisations and institutions presently working in the study area is provided below.

Impact with reference to women and marginalised farmers

The impact of the Cooperative Dairy Development Programme financed by PARAG (a Cooperative Dairy Development Organisation of UP Govt.) increased the average family income of each member to Rs 1,400 per month. This programme was taken up exclusively by women. Further investigation revealed that, on average, 20% of this income is kept at the disposal of the women of the family as their personal money and the rest is used for family purposes. The society has thus shown a path of self-help and awakening to the women.

With 20-30% tap water availability in the villages through lifting devices, the pressure of work on women has been reduced to a considerable extent and women are devoting more time to other meaningful activities.

Comparison of modern and traditional systems

Traditionally, the villagers were meeting their drinking and other domestic requirements directly from natural springs, naula, and, perennial streams as well as river water by carrying water as head loads. Besides this, water collected in earthern ponds was also used for domestic purposes and cattle. During monsoon, rain water was also used. One of the methods that involved connecting *kuchha guhl* with streams located at higher reaches was also adopted to meet water needs.

Considering a minimum consumption of 15 litres only per capita per day (which is much below the standard consumption of about 150 litres/day fixed by the Ministry of Health [GOI]) in view of the scarcity of water in the area, women (on average a family has five members) were using 115 days of work to carry water from springs located one kilometre away. These days could have been used for other work if water had been available on the doorstep. Thus, these traditional methods are energy consuming.

In the recent past, tap water was provided to the villages at some point by lifting water from the River Alaknanada located at about 35 km away. The tap water, however, hardly met 20% of the requirements and people are still dependent on natural springs (naula and dhara). Under the Village Development Programme, a water tank (from 10,000-12,000 litres in capacity) was constructed during 1990-91 to collect the spring water and supply it to the villagers. However, this pond was not in use because it was not properly maintained. In view of the current demand for water to meet drinking and domestic requirements, it is not possible to meet the needs from the existing lift water supply and natural springs. Therefore, management of existing springs and exploitation of new springs seem to be viable alternatives.

9. HUMAN AND INSTITUTIONAL CAPACITIES AT LOCAL LEVEL : TECHNOLOGY, OPERATIONS AND MANAGEMENT

Considering water supplies through existing water resources in the study area, drinking and domestic water needs can be met by proper management of water resources as well as by regulating water supplies properly. Awareness needs to be created among the villagers concerning the importance of conserving water by not leaving taps running, by not putting it to unnecessary use in building construction, and so forth. This will reduce the pressure on the ongoing supply of water to distant locations. Thus water will be conserved by avoiding such activities, particularly during dry season, with the help of local people and the authorities.

Though the River Alaknanda, flowing to the south-east, and the River Bhagirathi, flowing towards the north-west of the study area, are located deep inside the valley, it is difficult and expensive to develop lift systems for water supplies that will meet the demands of future populations; and this is because of the undulating topography. Therefore, in the study area, management of fresh existing springs and exploitation of springs in the upper reaches seem to be along with the measures given in the following passages, viable alternatives.

Water-lifting scheme

A water-lifting scheme is already in operation, but it meets only 20% of the demand because of tampering and leakage on the way. Further, whatever water supply is available to the villagers is lavishly used by head-reach villagers, without considering the needs of others. Therefore, the villagers' cooperation should be solicited.

Rejuvenation of natural springs

Most of the natural springs in the study area are of the open type and very unhygienically maintained. Therefore, the water in them is not used by villagers for drinking. Such springs need to be managed properly by constructing covered tanks and providing pipe outlets to ensure hygienic water supplies for drinking. In addition, the algae and bacteria in the springs should be cleaned and water should be treated with a suitable disinfectant. Similarly, water tanks and ponds should also be maintained and protected to avoid contamination. Proper distribution of water should be undertaken with the help of the local people.

Construction of tanks for capacity building

It was observed during the survey that some of the natural streams are perennial. Water from these streams could be diverted to the tanks if they were constructed along the streams. Water collected in such tanks could be used for domestic purposes as well as for a limited amount of irrigation by connecting them with a pipeline to the lower reaches.

Roof-water harvesting

During winter (December - March) about 200 mm of rainfall is expected in the area. Therefore, during these months water from the roof can be collected and used for cattle and domestic purposes to supplement water needs.

Improving spring discharge

Since spring water is an important source of water to meet the demands of people in the study area, decline in spring discharge is one of the main problems and needs immediate action due to increasing demographic pressure. Discharge in springs can be improved by developing 'spring sanctuaries' in the recharge area along with their protection from degradation. Infiltration of rain water can be increased through engineering and vegetative measures. A series of shallow, saucer-shaped dug-out ponds could help to recharge the springs.

Table 6.25: **Impact of Various Programmes on Local Ecology, Economy and Social Equity**

Programme	Major Works	Perceived Benefits by Farmers on		
		Ecology	Economy	Social Equity
Government Programme				
DPAP	All watershed management related works	1. Marginally reduced runoff through construction of terraces 2. Perenniality of water in stream/pond increased due to rejuvenation and soil conservation works	About 5-10 per cent increase in crop yield	No change
JRY	All rural development works as approved by Village Panchayat	Improvement in water quality through improvement in existing water resources	Increased employment opportunities to weaker sections	Disparity in income between weaker and upper sections of society decreased
Drinking Water Scheme	Construction of drinking water facility	Availability of quality drinking water	No change	No change
IWDP	All watershed management works	1. Availability of water is increased 2. Marginal increase in the vegetative cover 3. Increase in crop diversity	Productivity, production and income from agriculture enhanced upto 20%	Sharing of resources increased harmonious relations between different ethnic group
Million Wells Scheme	1. Water resource development 2. Soil and water conservation works	Yet to be realised	Employment opportunities enhanced	Income of weaker sections increased
IRDP	Institutional subsidised financial assistance to improve income of the weaker sections	Ecology was adversely affected by increase in livestock population	Nutritional status and income of families increased	Economic disparity decreased
NGO Programme Cooperative dairy development	Formation of outside assistance to voluntary organization to boost milk production	Ecology improved through adoption of stall feeding practices	Economy improved	Women's status and independence increased.

Source : Field Survey 1998

10. Policies on Water Harvesting and Their Impacts

The water supply situation in hilly areas is quite different from that in the plains because of the undulating topography and rugged geological formation. Groundwater is available only in the form of natural springs in these areas, and it is used as the main source of water for drinking and domestic purposes by the local population. Rivers flowing in deep valleys can hardly serve the purpose as far as domestic water supplies are concerned. The scarcity of water in the area was felt long back, and policies on water were made and modified from time to time to suit the local requirements.

The water rules of 1917 were modified in 1930 and the traditional practices prevalent in the region were codified. The rules confirmed the then prevailing practice of allowing development of irrigation without the government actively participating in the process. Water rights remained largely with the irrigators, and the principle of prior water use was safeguarded by the rules. Later, it was found that these rules sometimes prevented the government from implementing irrigation and drinking water schemes in the hills. The need to provide drinking water to the hills was considered to be a matter of priority.

Enactment of the *Zamindari* Abolition Act of 1950 confirmed that ownership of private wells (i. e., ponds, naula and hauzi) was vested in the owner of the land on which it was located. The rules established this by giving the right of transfer of the pond to the owner of the land who would not be liable to eviction and should have the right to use the site of the water body for any purpose. The act also envisages that tanks, ponds, ferries, and water channels belonging to the state should be managed by the Gram Sabha (Village Assembly) or any other local authority.

The state government enacted the Kumaon and Garhwal Water (collection, conservation, and distribution) Act of 1975 which terminated the current and customary rights of individuals and village communities. The state took over the power to frame the rules for collection, conservation, and distribution of water and control of water sources. There was, however, provision for giving priority to such village communities from whom the powers had been withdrawn. The state also empowered itself to create a water system, pond, or reservoir and establish a pump set or pipeline on land belonging to any person. One was allowed, without receiving prior written permission of the competent authority, to set up an irrigation system.

The Act of 1975 took away the jurisdiction of individuals and village communities over all water sources and vested these in the government. Thus, there is a conflict between the legislations of 1950 and 1975 and this has not been settled even today. New irrigation systems serving a moderately large area cannot be planned and constructed by village communities because of several reasons. In this region, the irrigation department has expanded at a rapid pace. Private minor irrigation works, which are generally created by individuals and cater to areas of less than one hectare, are supported by the department of minor irrigation which itself has grown substantially.

The Act has not made any difference to the overall picture of irrigated agriculture in the area. Even though a major change was introduced in water rights in the 1975 legislation, the users have not been affected in a majority of cases in which individual or community irrigation systems were already operative. Changing water rights has, however, influenced the irrigation behaviour of farmers served by some new state irrigation systems.

11. Critical Issues and Recommendations

Issues and recommendations

From the point of view of critical issues the following aspects need consideration.

- This area is hydrologically a 'high rainfall and a seasonally dry region' resulting in surplus water during three months of the monsoon and acute scarcity during the remaining nine months of the year, except for a brief spell of winter rain.
- Practically there is no vegetative cover in the whole watershed. From the point of view of sustainability, massive efforts should be made to increase vegetation (trees, shrubs, and grasses) in combination with engineering measures (staggered contour trenching).
- Livestock population (5 animals per hectare) is high and beyond the carrying capacity of the area as well as uneconomical. Therefore, a shift in livestock composition from local to high-yielding breeds, in combination with management techniques, is required along with provision of concentrates and feeds.
- In the upper reaches water scarcity is acute compared to the middle reaches and valley areas.
- All unprotected springs need to be covered with regulated outlets and continuous monitoring of water quality is needed to prevent the outbreak of epidemics.
- Plantation of broad-leaved (*Quereus incana*) species around naula and the sources of springs will help recharge good quality water in future.
- It is also important to explore the possibilities of locating new sources of water.
- Roof-water harvesting should be encouraged in view of the heavy rainfall in winter and during monsoon.
- In situ and surface runoff and underground (seepage and percolation) water need scientific as well as judicious storage and use.
- People's participation was more effective in the past and is almost absent at present, particularly in planning and management; nevertheless people play an active role in water distribution.
- A Water Users' Society needs to be created and made functional in each micro-watershed giving due representation to all inhabitants.
- Low Density Polyethylene (LDPE) sheets, 1,000 gauge thick and High Density Polyethylene (HDPE) pipes could be useful for arresting seepage losses and for laying out in difficult/unstable reaches.
- Most of the spring water is not suitable for human consumption because of a high concentration of nitrate (NO_3). It is suggested that precautions be taken in using it as there is no option for the villagers.
- Women are the main work force. Efforts should be made through women extension workers to motivate them to take an active part in planning, implementation, and management of the system.
- Considering the important role played by women in the hills, their training and participation need to be ensured.
- The UP hills have a great potential for development of tourism for pilgrimage, recreation, and adventure sports. It is obviously expected that additional quantities of water will be needed to boost tourism in the region.

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Plates

Plate 1: A general view of the Garhkot watershed

Plate 2: Rain water-harvesting pond built through the 'Self help' programme by the villagers of 'Kandi Bagri' with a provision to collect the seepage flow in another pit at the lower end

Plate 3: Roof-water harvesting being practised by the farmers in a traditional way from the slanting slated roof of a house

Plate 4: The topmost portion of the watershed under reserved forest is devoid of vegetation and cattle are grazing freely

Plate 5: Women are the main workers in the villages and are engaged in agricultural activities apart from all household chores

Plate 6: Village people waiting for a long time in a queue to collect drinking water in brass cans—measurement of water discharge during the lean period is in progress

Plate 7: Twin sources of water (dhara) earmarked on a caste basis-water quality samples are being collected

Chapter 7
Local Water Harvesting Technologies and Management Systems in Cha Khola Micro-watershed of Kabhrepalanchok District, Nepal

J. Lohani and K. Banskota

1. Background and Information on Study Area

Introduction

The hills and mountains of Nepal, which are a part of the Hindu Kush-Himalayan range, are endowed with abundant water resources. However, most of the resources exist in situ and are yet to be harvested for human and other uses. Consequently, most people in the mountainous region do not have year-round access to water to meet their ever-growing needs for drinking, washing, irrigation, livestock, and other essentials. In many places, households have to walk a long distance to fetch water for drinking. Agricultural productivity and cropping intensity are similarly constrained by the unavailability of an assured water supply. This is a serous problem, especially for the communities who are heavily dependent on agriculture for their survival.

Much of the water available is contributed through precipitation, and as much as 75% of the precipitation occurs from June–September. Such non-uniform precipitation over time makes the withdrawal or consumptive uses of the water resources available that much difficult. However, in spite of the apparent difficulties, the local people have used their ingenuity to harvest and store rain water for productive uses within the limitation of their technology and financial wherewithal. Several indigenous water-harvesting systems dot the landscape of the hills and mountains and are the mainstay of the local people's survival and well-beings.

The indigenous water-harvesting systems are many and varied. They are generally small-scale, site-specific, and depend, among others, the water-holding capacity of the soil, topography or slope of the land, climatic factors, the availability of materials, and the skill and experience of the local people. Moreover, they are deeply rooted in the local milieu. A systematic analysis of the evolution and dynamics of these systems would greatly help to understand the underlying critical factors and processes, crystallising a more balanced view of the indigenous management systems, technologies, and their interfaces. The lessons learned from such an analysis would enable the formulation of more flexible and constructive external interventions and better informed policies and legislation to improve and sustain local water-harvesting systems (LWHS).

This is one of the six case studies commissioned by ICIMOD on local water-harvesting technologies and management systems in micro-watersheds of the Hindu Kush-Himalayas as part of its programme activities in water harvesting (1997–98) under the first Regional Collaborative Programme (enclosed terms of reference). This case study from the mid-hills of Nepal discusses the key findings of the field inquiry into the techniques and methods practised by the people of Cha Khola micro-watershed of the Kabhrepalanchok district for harvesting and management of local water resources, highlighting the critical issues for the sustainable development of LWHS.

The case study begins with a detailed description of the micro-watershed, in terms of its physical as well as socioeconomic characteristics. This is followed by a discussion on local water supply and management systems and on comparative analysis of different systems. The next chapter outlines the status of human and institutional capacities in the area. The final chapter examines relevant policies, tracing their implications for water harvesting. The focus of the study is on local experiences with water-harvesting practices, with reference to the broader issue of policy intervention.

Study methodology

This case study broadly followed the methodological guidelines provided by ICIMOD. Accordingly, the study has introduced the concept of a micro-watershed as a unit of enquiry. This is because the watershed concept enables the assessment of temporal and spatial water balance in a watershed as well as its water contribution downstream. Out of the three micro-watersheds identified for the purpose in the given district, the Upper Cha Khola micro-watershed was finally selected. The overriding consideration in the selection of the watershed was its all-weather accessibility because the survey work was scheduled for the monsoon months.

A field survey of the water sources and individual LWHSs (also the micro-hydel project being implemented) and discussions with the local people on various aspects of LWHS, including the performance of the prevailing institutions,[1] were undertaken. For socio-economic information, Participatory Rural Appraisal (PRA) of three wards, one each falling in the top, middle, and bottom of the watershed, was carried out. A further probe into the socioeconomic dynamics of the identified LWHSs, including the history of the resource, was undertaken by using a detailed checklist in Nepali (the copy translated is attached as Annex 1) with the assistance of a local NGO.

After receipt of the data collection report from the NGO, discussions were held with the key informants (Messrs. Krisna P. Bagagain, Sher B. Tamang, and Lal B. Tamang) to cross-check the NGO's findings and for further clarification. A short field visit was also undertaken during the winter months to assess the seasonal differences in water supply and management practices. In addition, photo-interpretation of aerial photos (1996) of the study area was carried out, and the results were compared with the 1978 LRMP map to determine the changes in broad land-use patterns. Secondary information of the two VDCs, with dominant portions falling into the watershed, were collected from different sources, among which were the relevant VDCs and wards and other institutions in Dhulikhel, and, wherever relevant, this information was used to characterise the socioeconomic situation in the watershed.

1 Because of a very limited number of intervention schemes within the watershed, two nearby schemes, Chhap Raniban and Lapsekhola Chainpur Water Supply Scheme, were also visited to get a feel of the existing organisations and their performances, but these schemes are not specifically discussed in this report.

The study area

The study area–a micro-watershed representing the mid-hills of Nepal, is located in the north-east edge of Kabhrepalanchok (the given district), which is a district adjoining Kathmandu. The area was selected within the frame of the guidelines provided by ICIMOD and taking into account the definition of a micro-watershed of the Department of Soil Conservation and Watershed Management. A comparative method of selection was adopted based on ten characteristic features of the micro-watersheds. Table 7.1 provides some information on the three micro-watersheds identified, from among which the Upper Cha Khola micro-watershed was selected as it met more closely the conditions set out in the guidelines.

Table 7.1: **Basic features of the upper Cha Khola micro-watershed**

	Upper Cha Khola Micro-watershed
Area and Shape	12.2 sq. km.; bat-shaped
Inhabitant	Thickly populated with 438 households
Accessibility	Close to an all-weather road (Nagarkot)
Climate	Warm temperate (15-20 C) and humid
Stream Types	1st, 2nd and upper reaches of third order streams
Vegetation	Cultivated land 82%; shrubland 6%; forest land 12%
Slope and Aspects	NE-SW with >60% slope dominant and well drained
Altitude	1,000 to 2,151 (masl)
Weather Station	One at Nagarkot
Agency for Collective Work	Rural Energy Development (UNDP)

The Upper Cha Khola watershed (UCKW) adjoins Nagarkot–a popular tourist resort some 20 km east of Kathmandu. Its proximity to Kathmandu was advantageous to the study in that it enabled consultants to make repeat field visits. With the upper boundary lying along the ridge at Nagarkot, the watershed is partially accessible by motor vehicle. However, despite a fair weather road that is being built in some parts, a large part of the watershed is accessible only by foot.

The UCKW lies between latitudes 27°41' 28" to 27' 43' 21" and longitudes 85° 31' 25" to 85° 33' 28" and covers an area of 12.2 sq.km. (Figure 7.1). It falls into two VDCs: Naldung and Nayagaon. Included are ward 2 and a substantial portion of wards 7, 8, and 9 of Naldung VDC and ward 4 and parts of wards 2 and 3 from Nayagaon VDC. Wards 7, 8, and 9 are in the upper reaches, ward 2 of Naldung in the middle (in fact, elongated across the watershed from the uppermost ridge to the lowest basin), and the remainder of 2, 3 and 4 wards in the bottom of the watershed. The three wards in which PRA was undertaken are 8 and 2 of Naldung and 2 of Nayagaon.

Background to study area

Geology and soil

Within the watershed, the land form is dominated by alternating ridges and valleys. The main valley runs along the Cha-Khola draining from SWW to NEE, more or less dissecting the watershed into two halves. A dendritic (tree-like) drainage pattern is widespread along the outskirts of the micro-watershed, while core parts tend to exhibit a sub-parallel drainage pattern (Figure 7.2).

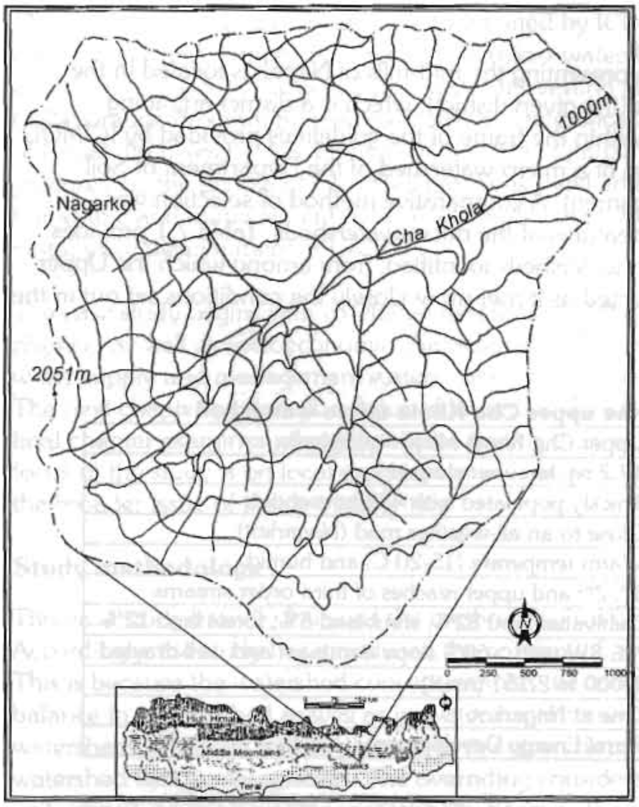

Figure 7.1: **Topographic map of Cha Khola Micro-watershed contour interval: 100m**

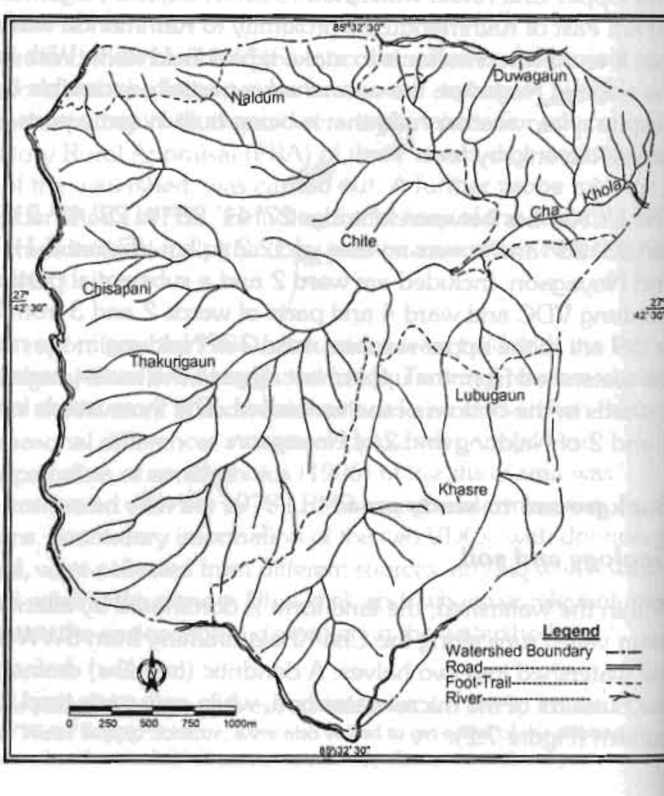

Figure 7.2: **Drainage map of Cha Khola Micro-watershed**

Three broad types of sloping face are recognised, namely, East, North, and South. In conformity with the aforementioned drainage pattern, islands of moderately sloping (15–30% slope) hills are encircled by steeply sloping (30–60%) hills (Figure 7.3). Over 90% of the watershed is covered with hill slopes falling into the categories of slope class III and/or IV. The remaining 10% are covered by centrally located patches of scarp of slope class V. Normally, hill slopes in classes III and IV are used for agriculture (growing rice during monsoon) by developing level terraces, while scarp land is left for natural shrub.

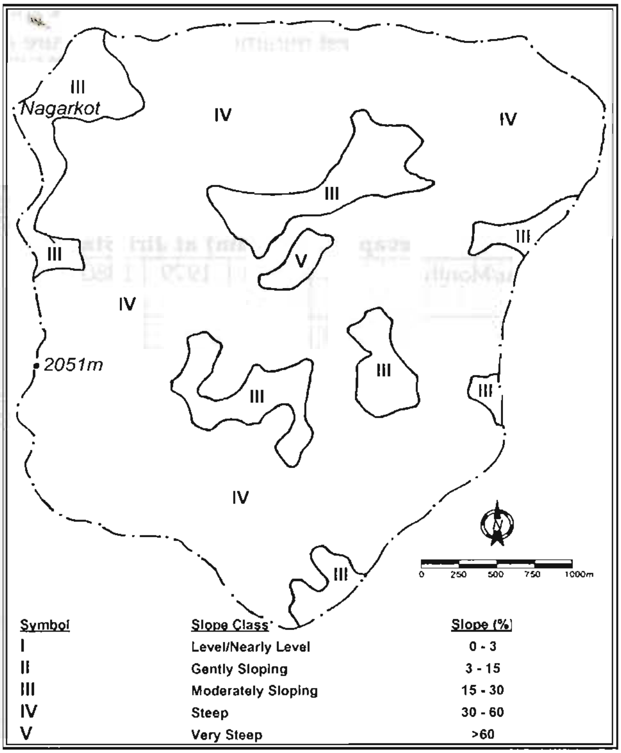

Figure 7.3: **Slope map of Cha Khola Micro-Watershed**

Broadly the watershed has a medium-class drainage texture. The average distance between first-order streams varies between 125 to 300m. On the periphery, surface runoff is of high speed while in the central parts it slow downs to medium speed. Soil textures and underlying rocks are typically neither fine nor coarse but contain mixtures of particle sizes.

There is no geological map of the UCKW. Hence inferences had to be drawn from the photo geographical map (1" = 1 mile) of the Dhulikhel-Dolalaghat area (sheets 72E/10, 72E/14). This indicates that the rock formation of the Kulekhani formation, consisting of micaceous quartzite and biotite schists, would continue in western parts of the micro-watershed while the lower portions of the Cha Khola would be comprised of a variety of crystalline rocks ranging from gneisses to biotite schists to garnetiferous quartzites and marbles.

A major thrust fault separating the Nuwakot Group of rocks from the Bhimphedi Group of rocks is exposed near the confluence of the Cha Khola and Asi Khola would probably continue further to the north. Some cross-cutting minor faults seem to exist along parts of the Cha Khola and Asi Khola.

Local geomorphology, geology, and soil tend to favour the water-holding capacity of the watershed. The heterogeneous nature of soils and sub-soils, along with low porosity and permeability, help reduce infiltration or deep percolation of water. The surface configuration also provides an opportunity to develop local depressions for water harvesting and storage with little cost.

Climate and precipitation

The elevation of the watershed ranges between 1,000 to 2,051 masl. As in other mid-hill areas of Nepal, a warm temperate and humid climate prevails over the watershed area.

Temperature records from Nagarkot station indicate that the highest average maximum air temperature and the lowest minimum air temperature are respectively 23°C in August and 2°C January. Within this temperature range, the mean annual pan evaporation and mean daily pan evaporation at Jiri station (this is the only station near the watershed measuring evaporation) are recorded to be 37.6 mm and 3.1 mm respectively (Table 7.2). Farmers have also reported hailstorms, wind, and frost as climatic problems sometimes encountered.

Table 7.2: **Pan evaporation (mm) at Jiri Station (elevation- 2,003 masl)**

Year/Month	1977	1978	1979	1980	1981	1982	1983	1990	Mothly Mean
Jan	3.1	2.5	1.8	1.9	1.5	3.0	3.1	1.9	2.35
Feb	2.1	2.6	3.9	2.4	2.7	3.1	3.8	2.1	2.84
Mar	3.6	3.2	3.7	3.2	3.0	4.9	4.0	2.9	3.56
Apr	3.4	3.0	4.1	4.3	4.1	9.0	5.0	3.7	4.58
May	4.1	2.4	4.4	4.1	3.7	6.9	5.0	3.7	4.29
Jun	2.9	2.4	4.4	4.2	4.0	5.3	5.0	3.8	4.00
Jul	2.2	2.0	3.4	3.6	4.2	5.2	5.6	3.3	3.69
Aug	1.5	2.0	NA	4.3	4.7	4.8	4.7	3.1	3.59
Sep	2.4	1.9	3.1	3.3	3.8	3.4	3.6	2.7	3.03
Oct	2.0	2.5	2.6	3.3	3.3	3.3	NA	2.9	2.84
Nov	1.8	1.8	2.4	2.4	2.6	2.1	2.5	2.2	2.23
Dec	1.6	1.8	2.0	1.8	3.5	2.0	NA	1.4	2.01
Average day	2.56	2.34	NA	3.23	3.43	4.42	NA	2.81	
Annual	30.7	28.1	NA	38.8	41.1	53.0	NA	33.7	

Mean Daily Pan Evaporation at Ziri =3.13 mm/day
Mean Annual Pan Evaporation at Ziri =37.57 mm
Source: DHM

A substantial amount of precipitation occurs within the micro-watershed. Monthly precipitation records over a period of twelve years from 1987–99 at Nagarkot station and at Panchakhal station (given here for comparison) are shown below in Table 7.3. Average annual precipitation at Nagarkot and Panchkhal are 1,814.1 and 1,093.2 mm respectively, monsoon months (June to August) alone accounting for nearly 75% of the precipitation.

Table 7.3: **Precipitation data from the upper hills (Nagarkot) and the lower foothills (Panchkhal)**

	Monthly Precipitation (mm) at Nagarkot (Elevation 2,163m)							
Year/Month	87	88	89	90	91	92	93	94
Jan	0.0	0.0	32.8	0.0	40.3	24.0	NA	28.1
Feb	0.0	17.3	15.8	31.7	1.6	24.5	NA	29.8
Mar	0.0	28.6	24.2	56.3	21.9	0.0	45.2	21.0
Apr	0.0	87.8	6.6	168.2	66.7	20.8	27.8	10.8
May	0.0	142.4	NA	146.9	189.1	132.8	250.9	192.6
Jun	279.7	387.6	NA	282.2	278.7	267.3	333.8	402.8
Jul	494.6	156.3	366.7	551.1	330.9	387.0	327.1	416.4
Aug	454.2	420.6	567.1	465.4	537.1	582.9	543.5	620.8
Sep	242.9	177.6	375.3	308.9	261.2	302.0	238.2	256.6
Oct	152.6	11.8	10.4	112.9	0.0	21.7	91.2	7.8
Nov	0.0	10.2	3.5	5.5	0.0	28.7	0.0	53.2
Dec	21.2	71.0	0.0	2.9	14.3	7.4	0.0	15.1
Annual	1645.2	1511.2	NA	2132.0	1741.8	1799.1	NA	2055.0

Average Annual Precipitation at Nagarkot =1,814.1 mm

Table 7.3: Cont....

	Monthly Precipitation (mm) at Panchkhal (Elevation 865m)							
Year/Month	1987	1988	1989	1990	1991	1992	1993	1994
Jan	0.0	0.0	51.5	0.0	23.0	8.0	10.5	NA
Feb	16.0	25.3	7.4	34.7	8.9	23.5	18.5	NA
Mar	16.0	91.2	16.9	36.1	62.3	0.0	27.1	8.0
Apr	123.5	47.2	2.5	51.5	10.7	9.8	54.1	11.0
May	48.5	111.3	121.8	177.7	140.5	21.6	27.5	79.0
Jun	NA	173.4	116.0	190.9	172.6	125.0	187.2	239.3
Jul	NA	228.8	311.7	267.1	183.3	223.9	265.1	283.4
Aug	NA	341.1	266.4	268.7	290.1	260.5	291.5	306.2
Sep	NA	152.1	254.5	143.5	163.9	144.1	80.8	226.4
Oct	NA	10.5	2.4	42.3	0.0	33.7	16.0	0.0
Nov	NA	8.8	0.0	0.0	0.0	24.0	7.6	15.2
Dec	NA	69.6	0.0	0.0	13.0	8.0	0.0	1.0
Annual	NA	1,259.3	1,151.1	1,212.5	1,068.3	882.1	985.9	NA

Land resources and use

The total land area of the watershed is 1,220 hectares, of which 145.1 hectares (11.89%) are forest, 67.2 hectares (5.5%) shrub, and 1,007.4 hectares (82.5%) terraced land with 50–75% cultivation (Figure 7.4). The cultivated land is predominantly level terraces interspersed with sloping terraces; only 13.1 hectares of land near the flood plain of the Cha Khola is purely level terrace. On the level terraces (locally known as *khet*), rice in monsoon and cereal in winter/dry season is the dominant cropping pattern, while maize is the main crop on sloping terraces *(bari)*.

Compared to 1978 (Figure 7.5), the current land use has undergone significant change. As seen in Table 7.4, the shrub area has decreased by 83.1%. This is accompanied by a 907.6% increase in forest area and a 24.6% increase in cultivated area (the seemingly extraordinary growth in forest area in percentage terms is largely due to the low base). Evidently, a substantial part (198.7 ha) of the shrub area has been brought under cultivation while another similar lot (130.7 ha) has gone to afforestation, mainly under community forestry, over the review period. Partly because of this reduction in common shrub land, combined with the regulated access to community protected forest, the local farmers have switched over to stall-fed buffalo rearing. Local people also confirmed that the encroachment on public land (mainly conversion of adjoining public land into private during land registration surveys) is widespread in the area. Such complaints are more commonly heard in the Nagarkot area.

Forest resources

There has been a noticeable change in the attitudes and interests of local people regarding the value and significance of forest cover to their economy. This was primarily induced by

Figure 7.4: **Land utilisation map, 1996 of Cha Khola (Interpretation of aerial photos from Department of Survey**

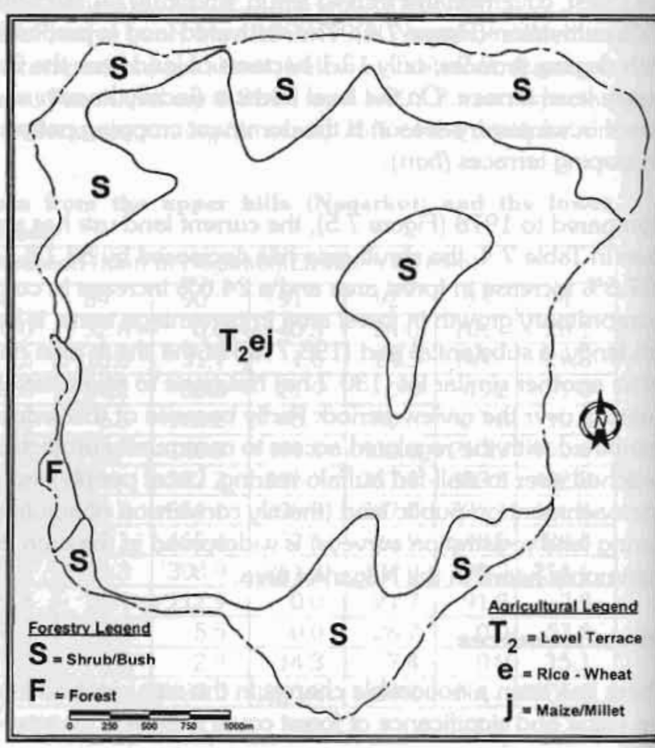

Figure 7.5: **Land utilisation map, 1978 of Cha Khola Micro-watershed (as per LRMP map)**

Table 7.4: **Land use change in the watershed, 1978–1996**

(Area in ha)

Land Use Type	1978 LRMP	1996 Photo Interpretation	Difference	Per Cent Change
Forest	14.4	145.1	+130.7	+907.6
Shrub	396.9	67.2	-329.7	-83.1
Cultivated (50-75%) :	808.7	1007.4	+198.7	+24.6
Level Terrace	*808.7*	13.1		
Level/Sloping Terrace		994.3		
Total	1,220	1220		

the reduction in shrub land (i.e., brought under cultivation) and the restriction on entry to natural forests imposed by the government in different locations of the watershed, on the one hand, and the need for green grasses and fodder for the thriving animal husbandry in the area for milk production, on the other. Local people have also responded by gradually reducing grazing animals, such as cows, and replacing them by buffaloes, primarily a stall-feeding animal (green grasses and fodder, however, are needed even for stall-fed animals)

These developments and changes motivated people to engage in afforestation and preservation of the existing community forest land. The introduction of a community forestry programme has also contributed to this process. Currently a total of 83 hectares of land (not included as government protected forest) has been either preserved as forest or afforested. The area under preserved forest and afforestation in three different locations (not in the total area) of the watershed are presented in Table 7.5 below. *Sallo,* (pines: *Pinus roxburghii), Dhupi,* (juniper: *Juniperus recurva), Masala,* (eucalyptus: *Eucalyptus camaldulensis), Painyu,* (prunus: *Prunus cerecoides), Lapsi, (Choerospondias axillaris)* and *Uttis* (himalyan alder: Alnus nepalensis) are the plants grown on afforested land. Preservation and afforestation activities are carried out through different users' groups.

Table 7.5: **Preservation and afforestation area (ha)**

	Naldung	Chitte	Nayagaun
Preserved Area	-	50	12
Afforested Area	12	7	2

Source: Field Enquiry

Water resources

With an average annual rainfall of 1,800 mm, the watershed is endowed with abundant water resources. The watershed has a network of the first, second, and upper reaches of the third order streams. The Cha Khola and its four tributaries: the Satipani Khola, Dandebhare Khola, Rohini Khola, and Ghyampe Khola are perennial streams traversing the watershed. Dividing the watershed into near-equal segments, they feed numerous springs/water sources in the area. During monsoon, the number of such springs and tributaries multiplies many times. Sketch maps of major streams and their tributaries during rainy and dry seasons are presented in Figures 7.6 and 7.7 respectively. Largely due to the favourable geology and soil condition, the water sources are quite uniformly spread throughout the watershed area. This is one reason why the land in the watershed is extensively terraced and intensively cultivated. Overall, the watershed appears to be water surplus in relation to the current land use. This observation is also corroborated by a simple calculation based on evapotranspiration. Using the rainfall data from Nagarkot station and pan evaporation data from Jiri station, the exercise shows that there would be a surplus of 447 mm of rain water even based on the assumption that the entire watershed is under actively growing green grass cover (Table 7.6). There will, however, be seasonal fluctuations in the magnitude of such surplus. Furthermore, the fact that the watershed is continuously contributing to

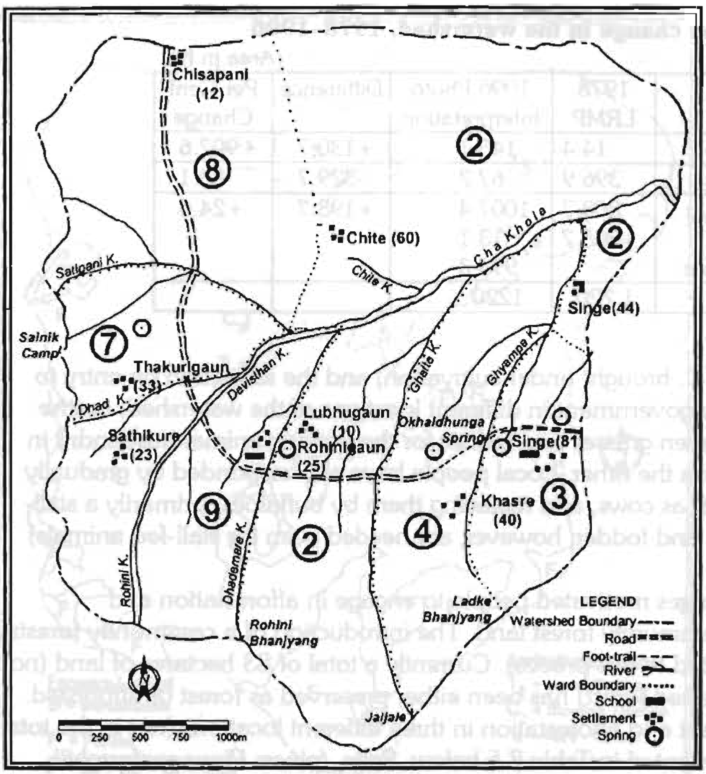

Figure 7.6: **Field sketch map of Cha Khola Micro-watershed (during rainy season)**

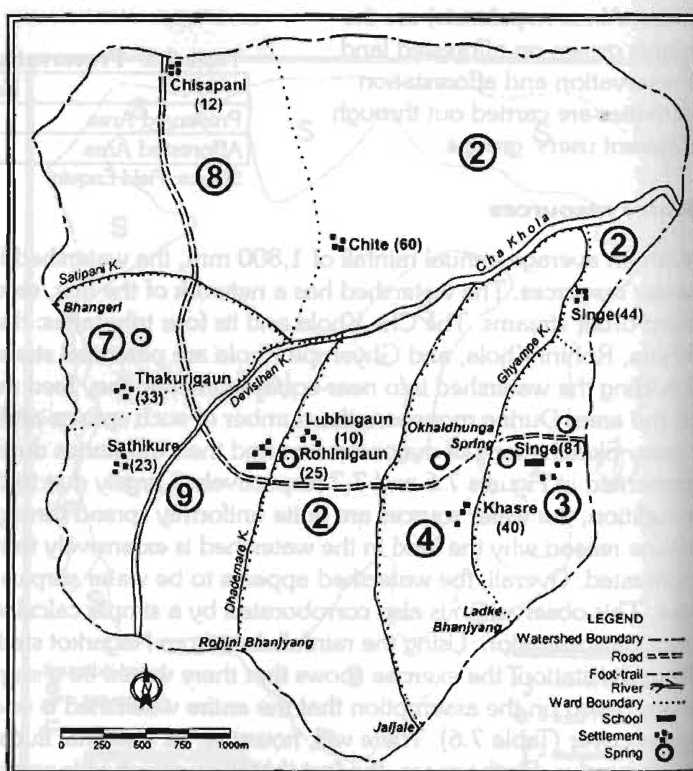

Figure 7.7: **Field sketch map of Cha Khola Micro-watershed (during dry season)**

Table 7.6: **Calculation of total evapotranspiration using rainfall and pan evaporation data**

Station	Mean Annual Rainfall (mm)		Annual ETO (mm)	Water Surplus (+) /Deficit (-)
	P	Pe (effective)	Kpan*Epan	Pe–ETO
Nagarkot				
	1827	1246	799	(+) 447

Note : Annual Pan is derived from Jiri station.

downstream flow is another indication of its surplus status. The minimum flow or discharge of the Cha Khola at the outlet point of the watershed is measured at around 65 lt/sec.

Mineral resources

There are no reported economic mineral deposits in this area. However, abundant slag is found in the vicinity (Bhimsendanda) of the study area. The carbonate rocks exposed in Bhimsendanda and lower parts of the Cha Khola (probably equivalent to Bhainsedobhan marble) contain chalcopyrite (copper sulphide), malachite (copper hydroxide), and magnetite (iron oxide).

People and communities

Cha Khola Watershed is constituted of whole or parts of seven wards of the Naldung and Nayagaon Village Development Committees of Kabhrepalanchowk district. All three wards, namely, ward nos 2, 3, and 4 of Nayagaon VDC, are situated at lower elevations of the Upper Cha Khola Watershed, whereas three wards, namely, ward nos 7, 8, and 9 of Naldung VDC, are situated at upper elevations. Ward no 2 of Naldung is rather uniquely situated, as it is elongated across the watershed encompassing the uppermost ridge to the lowest basin of Cha Khola. There are 10 major settlement clusters, some having two to three smaller satellite settlements comprising five to six households. The distribution pattern of settlements by elevation and administrative units is presented in Table 7.7.

The total number of households in Cha Khola Watershed is 438 with an average estimated household size of 7.72. The total population of the watershed is estimated to be 3,381. The distribution of households by Ward is presented in Table 7.8.

Table 7.7: **Distribution pattern of settlements by elevation and administration**

Naldung VDC			
Ward No.	2	Luha, Rohini	Chitte
	7	Thakuri Gaun	
	8	Chisapani, kafling, Danda Thumko, Gorung	
	9	Sathipure	
Nayagaun VDC			
Ward No.	2		Nayagaun
	3		Singe
	4		Khasre

Source: Field visits

Table 7.8: **Distribution of households by ward**

Naldung VDC		
Ward No.	2	138
	7	33
	8	130
	9	23
Nayagaun VDC		
Ward No.	2	44
	3	70
	4	40
Total		438

Source: Field enquiry

The ethnic composition of the study area is characterised by predominance of the Tamang ethnic group. Out of 438 households, 358 households belong to the Tamang ethnic group, the rest are Brahmins, Chhetri, Newar, and some minor ethnic groups. Settlement clusters are ethnically also homogenous. Even smaller ethnic groups are not living together with other groups. As for example, Rohini, belonging to ward no 2 of Naldung, is a Brahmin village and Chisapani, a major settlement in ward no 8 of Naldung, is a 100% Newar. Similarly, in settlements situated at lower elevation also, the ethnic composition within the settlement is homogenous.

The Cha Khola Watershed area has only one primary school. Children attend schools in neighbouring VDCs and in Bhaktapur district. The average adult literacy rate of Naldung and Nayagaon VDCs as presented in the Kabrepalanchowk DDC document is around 33%. Field enquiries and impressions provide a varied scenario of literacy in different settlements within the watershed area. As for example in Brahmin and Chhetri settlements, such as Nayagaon of Nayagaon VDC Ward No 2, the average literacy rates of men and women are 85 and 70% respectively. This extraordinary achievement in literacy, as reported by the local people, is due to extensive literacy programmes run by the Red Cross, Rural Energy Development Project, and other NGOs. The literacy levels in other settlements are far lower. In some Tamang settlements, such as Chisapani of Naldung VDC Ward No. 8, the literacy rate for women is less than five per cent.

Cultural practices related to water harvesting are not explicit. The demand for water among Brahmin and Chhetri groups is more pronounced than among the Tamangs and is consistent with their agricultural and animal husbandry practices. Water harvesting for irrigating *khet* (irrigated level terraces) is a prime preoccupation among the Brahmins and Chhetris who own and operate most of the *khet* in the watershed. Harvesting water for irrigation needs collective action which, culturally and traditionally, has induced local people to form informal social groups. Harvesting drinking water also demands collective action, although on a smaller scale. Depending upon the proximity to water sources from individual houses, smaller groups of households are formed to maintain and clean *kuwa* (wells). Larger (user) groups are being formed presently, mostly motivated by the introduction of a piped water system supported by occasional external assistance.

Watershed economy

The Cha Khola Watershed communities are primarily dependent on farming supplemented by animal husbandry for their livelihood and employment. A small percentage (less than 10%) is employed in off-farm occupations.

As estimated from the latest photo map of 1996, the total cultivated area in the watershed is nearly 995 hectares. The average size of holdings differs from settlement to settlement. For example, the average size of holding per household in three locations of the watershed is reported as follows (Table 7.9).

Table 7.9: **Size of holding per household (in ha)**

Naldung W. No –8	0.65
Naldung W. No–2 (Chitte)	0.50
Nayagaun W. No –2	1.00

Source: Field Inquiry and Estimates

The proportions of *khet* (level terraces) and *bari* (sloping rainfed terraces) vary from location to location depending upon availability of water from streams feeding the Cha Khola River. At higher elevations, such as in Naldung Ward No 8, the proportion is 12:88%, whereas it was reported to be 50 : 50% in Chitte, the lowest elevation of watershed area in Naldung VDC Ward No 2. It was reported to be 40 : 60% in Nayagaon VDC.

The cropping pattern in the watershed area is paddy and maize planted respectively on *khet* and *bari*. The main cropping patterns on *khet* and *bari* at different locations by elevation are presented as follow (Table 7.10).

Table 7.10: **Cropping pattern in Cha Khola**

(in % of paddy area)

Khet	Naldung	Chitte	Nayagaun
Main Paddy-Wheat	70	100	75
Main Paddy-Potato	5	-	insignificant
Main Paddy-Fallow	25	-	-
Early Paddy- Main Paddy	-	-	25
Paddy-Mustard	-	-	10
Black Gram and Soyabean crops are	-	-	-
grown on bunds with main Paddy	-	-	-
Avg. Cropping Intensity	-	-	-
	160	195	200

(in % of maize area)

Bari	Naldung	Chitte	Nayagaun
Maize /Millet relayed	30	95	75
Maize –Mustard	20	-	-
Maize – Potato	insignificant	insignificant	20
Maize- Radish	5	-	-
Maize /Soyabean /Masyan	5	insignificant	5
Avg. Cropping Intensity	175	200	210

Source: Field Enquiry and Estimated

The cropping intensities for both *khet* and *bari* are lowest in areas situated at higher elevations of the watershed. The average productivity of principal crops also differs from area to area. The average yields of various crops grown in the watershed area are as follow (Table 7.11).

Table 7.11: **Crop yields (MT/ha)**

Crops	Naldung	Chitte	Nayagaun
Early Paddy	-	-	5.96
Main Paddy	1.50	4.50	5.96
Wheat	0.95	1.39	2.53
Maize	5.05	5.05	2.53
Potato	2.50	-	4.79
Mustard	1.44	-	-
Millet	2.18	2.91	2.91

Source: Field Estimates

Two major cropping patterns were observed in the watershed and the cropping pattern on *khet* and *pakho* are different. Main paddy, early paddy, and vegetables are grown on *khet,* whereas maize, millet, and different types of pulses, beans, and potatoes are important crops grown on *pakho* (rainfed slope lands).

Agricultural productivity is directly related to the availability of water and application of chemical fertilizer. Traditionally, much of the farm nutrient was supplied through farmyard manure, but, with growing scarcity of fodder, reliance on chemical fertilizer, especially for paddy, is increasing.

The present volume of chemical fertilizer used, as reported by local farmers during the field visit, however, appears to be far lower than properly required. Paddy, wheat, and maize are crops that receive chemical fertilizer. Maize is treated with compost also. The average applications of chemical fertilizer on paddy, wheat, and maize, as estimated by the local people, were 200,100, and 200 kg per hectare respectively. The total estimated consumption of chemical fertilizer in different areas is presented in Table 7.12.

Table 7.12: **Chemical fertilizer use (kg/yr.)**

Naldung	400
Chitte	500
Nayagaun	750

Source: Field Enquiry

Animal husbandry is becoming one of the significant sources of cash income for local farmers. The pattern of livestock holdings in all locations and at all elevations was not reported to be significantly different. She-buffaloes are the principal livestock raised. The number of cows is insignificant. Except in Rohini and in Nayagaon villages where the communities are Brahmin, a couple of cows are raised for religious purposes, cattle raising is virtually absent from the entire watershed. The average numbers of different livestock raised by the local people are estimated as follow (Table 7.13).

Table 7.13: **Type of livestock (No./household)**

She Buffalo	2-3
Goat	4-5
Chicken	5-6
Cow	insignificant
Oxen	Not permanently raised

Source: Field Enquiry

The case of oxen is quite unique. Local farmers on an average keep a pair of oxen for ploughing. These animals are bought at the beginning of the ploughing season and are sold after the ploughing is completed. Oxen are bought and sold in seasonal livestock bazaars held in neighbouring areas. One of the principal reasons for this strange practice is reported to be because of its cost effectiveness and shortage of grazing area.

Milk production and sales have become a dominant feature of the watershed economy. As reported by the local people, the daily average sale of fresh milk is four litres. The average annual milk production has been estimated to be nearly seven per cent. Sale of goats is also an important source of cash income for local people. Most of the goats are sold locally to nearby military barracks and traders from Bhaktapur. The average annual household income from the sale of goats was reported to be Rs 5,000.

There are altogether eight rice and flour mills in the watershed area. With the growth of Nagarkot as a tourist resort, local people have gained easy access to market for a few local vegetables. With the cash income from the sale of milk, the village economy is gradually transforming into a cash economy. Currently a micro-hydroelectric project is under construction as a cooperative enterprise.

2. LOCAL WATER SUPPLY AND MANAGEMENT SYSTEMS

Introduction

As in other areas of the Nepalese mid-hills, the pattern of water use in the watershed area is confined to drinking and irrigation. In Nagarkot, where drinking water sources are at lower elevations than the township, local people were observed harvesting rain water from the slanted rooves of their homes. The water is collected through pipes to containers or ditches dug in the homestead for later use. Such water is generally used for cleaning pots, washing clothes, and for livestock and vegetable farming.

The Cha Khola Watershed features a system of big and small streams and springs (*mul*) feeding the Cha Khola River. During the rainy season there are altogether 15-16 major streams and small rivulets that drain rain water into Cha Khola River. During the dry season, only five major streams contain some water. These are the Satipani, Devithan, Dangore, Rohini, and Ghyampe streams. All other streams and rivulets become dry. The general pattern of rain water harvesting for irrigation is dependent on the availability of water in existing streams during different seasons. For drinking water and other domestic purposes, local people are dependent on nearby *mul* (springs) or *kuwa*. As observed during the field visits in both rainy and dry seasons and reported by the local people, most of the drinking water requirements are met through tapping water from the *mul* and drawing through polythene pipes to settlements. This way of tapping drinking water is not specific to any settlement located at any elevation. This is the general method of harvesting drinking water in the entire watershed. The technique for tapping water is very simple. Pipes are inserted into the *mul*. No reservoir is constructed.

Water supplies for domestic purposes

The principal sources of water for general domestic uses are wells (*kuwa*) and taps. Before the introduction of piped water for domestic (mainly drinking) purposes, almost the entire population was dependent on *kuwa* for drinking water. With the funds for drinking water made available through government and philanthropic non-government agencies and organisations over the last several decades, there has been a shift from *kuwa* to piped water supplies. However, as explained in an earlier paragraph, the piped water systems installed are not constructed with a commonly specified technique. In all such systems installed by the local people, there are no provisions for intake reservoirs and/or distribution reservoirs. Polythene pipes are inserted into *mul* and pipes laid to bring water to settlements. There are three distinct patterns observed in privately tapping *mul* with pipes to bring drinking water to settlements. In some settlements a well-to-do household might buy the pipes and bear all the costs of tapping the *mul* and allow neighbours to use the water also. The second pattern is that a well-to-do household puts the most money into the venture and others contribute smaller amounts. In the third pattern, all interested households contribute an equal amount of money and, depending upon the settlement pattern, two to three outlets are built. In Naldung area, the first two patterns were reported. The third pattern of contribution was reported in Chitte. This privately-owned and operated piped water system is widespread throughout the settlements in the watershed. In a very few small settlements at lowest elevations, where sources are either not nearby or simply do not exist, local people rely on *kuwa* as sources of drinking water. Dursable is one such settlement located at the lowest elevation in Ward No. 2 of Naldung VDC.

The second form of tapping *mul* for drinking water is formal, as the official budget of the DDC or NGO is involved. The number of such officially-aided piped water schemes is very small though; as such there are only two schemes. The oldest is located in Nayagaon Ward No. 2. The scheme is called *Muldharo* Simikhet Nayagaon drinking water scheme. The then District Panchayat donated Rs 6,000/ for the purchase of pipes and fittings. Local people contributed labour on an equal basis. The said *mul* is located on the fringe of the settlement. Local people added to the external fund and developed a more permanent structure to protect the water source to regulate water supplies through the pipes. There are three water taps built at equal distances in different locations. A formal committee for construction and or management purposes was formed. However, occasional repair and maintenance work is carried out by users on their own initiative. Until now, no cash has been required for repair and maintenance. No conflicts have been reported regarding use of this scheme.

Over the last 20 years, this has remained the sole source of drinking water for 36 households of Nayagaon village. Last year the Nayagaon villagers finalised a plan for constructing a new drinking water scheme to augment the volume of water from the existing scheme. The water source would be the Chhote Dando *Mul*. For this, the Red Cross has agreed to provide funds and local people will be contributing five per cent of the total cost. Villagers have organised themselves into a formal group which is participated in by women on an equal basis. The group is also formally registered.

The other externally funded drinking water scheme in the watershed was built in 1998.A sum of Rs 30,000/ was provided by the District Development Committee (DDC) through Naldung Village Development Committee. The scheme was previously planned to serve three settlements of Ward No. 2 of Naldung: Rohini, Luha, and Chitte. However the funds were insufficient for all the settlements. Accordingly, the plan was revised to supply drinking water to Rohini and Luha only. A Users' Committee was formed consisting of households from Rohini and Luha. The chairman and secretary were both local inhabitants of Rohini village, a predominantly Brahmin village. Currently, 35 households in Rohini and Luha villages are said to have been provided with piped water. Unlike in the Nayagaon scheme there is no intake reservoir. Instead the pipe has been directly inserted into the *mul*. However, according to the people from Luha, and as reported by the Chitte Ward chairman, the size of the pipe from the *mul* to Rohini village was bigger than from Rohini down to Luha village. This discriminates against Luha as water is in shorter supply by the time it reaches them. In addition, the committee has also been unable to properly present the expenses of Rs 30,000 to the VDC. As the reaction of the committee leaders could not be solicited, no definite conclusion can be drawn from the said allegations. It is a fact, nevertheless, that a serious conflict arose right from the commencement of the scheme.

Although there has been a decline in use of *kuwa* in some settlements at lower elevations because of the popularity of piped water, they are still a source of drinking water. During the monsoon, the quantity of water in the *kuwa* is abundant with overflow. With the onset of the dry season, most *kuwa* start to dry out and the quality of water deteriorates. The surroundings of *kuwa*, which are usually filthy, become a fertile breeding ground for organisms that are harmful to humans as well as animals, as some of the larger *kuwas*, which do not completely dry out, become overcrowded. Increase in the frequency of collecting water is the cause. Other than *kuwa* and piped water, a few local people use *kholcha* (rivulets) to compensate for the shortage of drinking water for livestock. Bunds are built to check the meagre water flow.

However, *kholcha* are used more for filling small earthen ponds built subject to proximity to the settlement for the purpose of supplying water for livestock. Building ponds is a common method of water harvesting in the watershed. This has become a necessity because of the rising number of stall-fed buffaloes. As reported by the local people, there are on avcrage five buffalo ponds per settlement. Ponds are filled by rain water during the wet season. During dry season, however, ponds are filled in different ways. In some villages, where *kholcha* still contain water, people were observed building bunds to create ponds. Ponds were observed built close to *mul* (springs), and seepages are diverted to fill the pond. Some ponds are filled with piped water. In Chitte, a lower evaluation settlement in Naldung VDC, local people made ponds in the middle of the irrigation canal. They said that it is healthy for animals to use flowing water.

Generally ponds fed by small rivulets, irrigation canals, and *mul* and built on public lands are common property. Such ponds are cleared through collective labour twice a year. Other ponds on private lands are used individually.

Collection of rain water from rooves was observed in Nagarkot, a popular tourist resort. The local people said the water collected is used for domestic purposes other than drinking. Small tea shops and local households fetch drinking water from *kuwa or mul* several metres (sometimes 7-10 minutes' walk away) down the slope. All tourist hotels meet their daily water requirements by pumping water from personal reservoirs built around a number of *mul*.

Water supply for irrigation

The other principal use of water is for irrigation. Similar to other mid-hill areas of Nepal, people in the watershed area are dependent on agriculture for their livelihoods. The quality of life in these areas has always remained proportional to agricultural productivity and production. Irrigation influences production. Rice and wheat are the main crops grown on *khet*. Rainfed non-irrigated *bari* produces corn, millet, and different kinds of pulses and potatoes. It is the productivity and cropping intensity of *khet* that matter most in the economy of the farm household.

Cha Khola watershed features nearly 15 major streams (*khola*) and smaller rivulets (*kholcha*) that feed the Cha Khola, which drains the watershed. During the dry winter season hardly five streams contain water that can be used for irrigation of crops—mainly wheat. Regardless of elevation there are numerous indigenous irrigation systems built by the local people. The size of the system, in terms of the number of households involved and/or area of land irrigated, varies greatly. The micro-systems involve two to five households and irrigate not more than one hectare of land, whereas the largest irrigation system irrigates 20-25 hectares of land and involves 15-20 households. There is only one externally funded irrigation system in the watershed. This system, namely, the Cha Khola Irrigation Scheme, irrigates more than 150 hectares of land operated by more than 400 households in Nayagaon VDC.

Locally built irrigation systems are operated through oral, collective agreement among users. The technology is simple to the extent that the flow of streams and/or *mul* are diverted through dug channels to fields. No permanent structure of any form is built, Every season when irrigation is required each of the user households participates in cleaning channels and fixing diversions generally by diverting water by blocking the flow of the stream with boulders. Almost all, locally-built irrigation structures are at least two to three generations old. During rainy season when intake and low earth-lined channels wash away in the floods, local users collectively, usually at a rate of one person per user household, repair the system. With all such locally built and operated irrigation systems, the code for sharing water is the same. Upstream farmers irrigate the fields first then lower stream farmers are allowed to irrigate their fields in turn.

In the rainy season, as the volume of water at the source is abundant, the adequacy of water usually does not become a problem. But, during winter when the primary source of irrigation water, i.e., streams, dry out, farmers supplement the water from streams with water from several *mul*. In Naldung VDC Ward No. 8, dependence on *mul* to irrigate wheat crops has given rise to direct conflict with the hotels in Nagarkot that tap and pump out *mul* water in large volumes.

As stated in the earlier paragraphs, none of the locally built irrigation systems has a formal management committee to look after repair and maintenance and operation of the systems. No cases of conflict in sharing of either efforts to maintain the system or use of water were reported during the field enquiry. Cases of cheating on irrigation schedules were resolved with as tern warning from fellow users. There are two principal ethnic groups residing in the watershed. These are Tamangs and Brahmins, but no variation in technique and/or management system was reported between these two ethnic groups.

Other than numerous mini- and micro-sized, locally built and operated irrigation systems there is only one large and externally funded irrigation scheme in the watershed.

Cha Khola irrigation scheme was previously (before 1986) locally built from a set of smaller irrigation systems. Later, users of fragmented systems came to an understanding to join the different systems into a single big system that would assure an increase in flow of water and also reduce the cost of maintenance. With the promise of procuring external support from Mr. Sailendra Kumar Upadhaya, a politician, local people initiated this new venture. An international Non-Government Organisation, CARE Nepal, was approached. However, a conflict about local contributions arose between upstream and downstream (of the canal) farmers that could not be resolved. Upstream farmers refused to contribute to construction of the entire length of the canal and claimed that water from the existing system was adequate for them. However, downstream farmers badly needed the water, especially for winter crops (principally wheat and vegetables). Owing to the long distance (nearly 9 km) between the intake and the water available for downstream farmers from the existing system, the supply was extremely inadequate. They were, therefore, willing to contribute to the entire length. As the said conflict about the contribution issue could not be resolved, CARE Nepal withdrew. Later the Government gave the money through SINKALAMA for construction of the scheme. All expenses were borne by the Government. Local users did not have to contribute. The conflict was thus resolved. The total budget spent on the scheme was Rs 1.4 million. Currently, the scheme irrigates mote than 150 hectares of *khet* belonging to 400 households in Ward Nos. 1, 2, 3, and 7 of Nayagaon VDC. The total length of the earth-lined canal is nine kilometres.

In 1995, the scheme was formally registered as a users' group. The name of the scheme is Singe Chainpur Irrigation Water Users' Organisation. The 400 user households elect, from among themselves, nine members for the executive committee every second year. The committee has fixed water charges at Rs 600 per hectare for *bari* and Rs 1,200 per hectare for *khet*. The entire length of the canal is cleaned twice a year for the rice and wheat crops. The committee has hired two permanent watchmen to guard the canal and regulate distribution of water to individual fields. Conflicts arising in the operation of the scheme are resolved at committee meetings. So far no conflicts have been reported after formation of the group.

In the watershed, water harvesting in the fields was not a major activity. However, the problem of protecting lower terraces from overflowing water drained from upper terraces was a major activity. This problem is managed by making small outlets at the corners of the fields and on each layer of terraces to maintain a constant level of water in the paddy fields. Usually the water retention bunds for paddy and wheat fields are 15-16 cm and 10 cm respectively. In addition to regular bunding of paddy and wheat fields, local farmers clean the weeds from the terrace walls every year. This unusual practice is carried out to prevent rats from making holes in terraces and hence to check water from seeping out of the fields. The height of the weed-free terrace walls is kept less then 90 degrees to prevent them from collapsing under heavy rain. As new terracing has became prohibitively expensive, farmers are giving more attention to maintenance of existing terraces.

Bunds are also used for crop plantation. Different kinds of legumes and beans, such as soyabeans and black gram, are grown on the bunds of paddy fields. Similarly peas, soyabeans, and masyang (a kind of local bean) are planted on the bunds of *bari* (sloping terraces) with standing maize crops.

Changes in Water Supply and Diversification of Uses

There has been a general increase in demand for water as a result of population growth and increase in farming owing to net addition to cultivated land. Consequently, new water sources are being tapped to harvest water. Also, hotels and resorts in Nagarkot compete with local people for drinking water. Also, because of escalating land prices, many local farmers have sold their land to hoteliers and moved to settle at lower elevations. This movement of people has also changed the demand pattern for water and many of the settlements of Naldung VDC have reported difficulty in obtaining an adequate amount of water all year round. The most noticeable change has been observed in the tendency of people to tap *mul* through polythene pipes. This practice has greatly helped increase the supply of water to homes.

The current effort to build a micro hydroelectric plant is the first major attempt to harvest water on a large scale by the people in the watershed. This project is being constructed with partial assistance from the Rural Energy Development Project of UNDP and with inputs from the local people. After completion, a total of 20.25 kilowatts will be generated. About 125 households (55%) will benefit from this project. Water from the Cha Khola has been diverted to generate the power. These beneficiary households have collectively raised about 40% of the total investment required for the project. This project has been implemented through a participatory approach, and the local community has the final say in all matters pertaining to the project.

Resource Mobilisation in Water Harvesting Management

Generally, in the past, most water-harvesting projects have been developed through the Government or grants made available through foreign-supported projects. One problem with such projects has been poor maintenance. Within the last few years, a new approach has evolved in which beneficiaries have been greatly involved in project design and implementation as well as in sharing the costs of the project. This new partnership approach is showing promise. However, there are variations in the nature of projects developed through the partnership approach, especially in sharing resources between the beneficiaries and the supporting agency.

Maintenance is usually carried out by local people or the beneficiaries who regularly clean, repair, and maintain drinking water sources and irrigation canals. In such cases, local contributions are generally in terms of the labour supplied and generally do not involve any form of cash payment. However, in the case of piped water systems, which not only demand regular maintenance but also require cash to replace pipes and pipe fittings, a management body that is able to raise the funds required for regular maintenance becomes essential.

In the watershed, the source of water to Nayagaon piped water scheme is an old *mul*. The *mul* is well protected and over time people have developed a permanent structure to control seepage and maintain a clean supply of water. Pipes were laid to supply water through three taps to the settlements. The pipes were provided by the Village Development Committee

(VDC). The cash expenses were borne by the people themselves through equal contributions. To oversee the regular repair and maintenance of the scheme, a maintenance committee is also functional. Members of the committee are chosen among the water users. The other piped water scheme is located in Ward No. 2 of Naldung. It serves Rohini and Luha villages. A sum of Rs 30,000 was provided by the DDC through Naldung VDC. A formal committee was formed for its construction. There was no local contribution.

Resource mobilisation and local people's participation in community irrigation systems is similar to drinking water schemes. During cropping seasons, when irrigation is needed, farmers collectively dig small earth-lined channels to divert water either from streams or from *mul* to their fields. Every farmer participates through equal contributions of labour, but there is no permanent body or committee formed in the case of irrigation. Collective labour is solicited as and when needed.

However, in the case of the permanent irrigation scheme (Cha Khola Irrigation Scheme), there is a committee for the regular maintenance and distribution of water for irrigation. This committee consists of members elected from the users of irrigation facilities. Annual water charges of Rs 1,200 per hectare for *khet* and Rs 600 per hectare for *bari* are collected from each user. The committee uses the fund for paying the salaries of two watchmen. Water distribution is based on agreed rules and is monitored by the committee. Upstream farmers get the water first. The scheme was initiated by a politician who was also able to organise the financial resources (through CARE Nepal) necessary for its construction. But the scheme could not take off as local contributions to be shared between upstream and downstream (of canal) farmers could not be agreed upon by the beneficiaries. Later, when a government grant (Rs 1.4 million) was made available, the system was constructed.

Resource mobilisation in the current micro-hydel project is different. The UNDP Rural Energy Development Project (REDP) is guiding local people to enable them to make decisions by themselves on every aspect of project planning, implementation, and operation and management, including fund raising. The guiding principles of the project are based on organising the local beneficiaries, initiating savings, developing skills, encouraging women's participation, and protecting the environment.

After the project's technical feasibility study was completed in July 1997, the DDC chairman, the manager of REDP, and the ward chairman from the project area (Nayagaon VDC) agreed to propose that the local people take over ownership of the project. This ownership involved making decisions about project implementation, distribution, and maintenance and formation of an organisation to undertake the entire implementation of the project. Subsequently, eleven community organisations, (COs), of which six had male membership and the remaining five female membership, were formed in the project area. Each CO looks after a particular type of community concern identified in the REDP principles. All members of the community organisations are involved in some aspect of the project. A management committee, constituted of members of the COs, has also been formed. This committee is the final decision-making authority. The role of local bodies, such as the VDC, is advisory only. The VDC chairperson is invited to the management committee meeting. In CO and management committee meetings, political and personal matters are strictly not entertained. The committee chairperson has no discretionary power whatsoever. Issues, however minor they may be, are brought up in the meeting for discussion. Community mobilisation work is facilitated by a local NGO, stationed in Dhulikhel, under the REDP contract and approved by the local people.

As provided for by REDP policy, 50% of the project cost is provided by the REDP, five per cent each by the DDC and VDC, and the local people have to provide the remaining 40%. Local people have borrowed collectively from the Agricultural Development Bank (ADB) using land as collateral. Landless households have participated by contributing cash or labour. Households' contributions are not perceived differently as contributions by rich or poor or small or big farmers. There is equal participation by all. Landless households who cannot put collateral for the ADB loan have been asked to contribute cash or labour equal to the amount of an individual share of the loan.

Every household will receive an equal number of watts of electricity and will be allowed to purchase a fixed share (but equal) in the project. It is envisaged that income will be generated by selling electricity to the diesel mills, saw mills, poultry farms, milk chilling plant, cheese factory, and households outside the project area.

Institution Building and Conflict Management

The practice of forming organisations to carry out development work is recent in the watershed as in the case of the Nayagaon piped water scheme, the Cha Khola irrigation system, and the ongoing micro-hydel project. Beneficiaries have formed permanent bodies of elected members, developed their charter, and formulated rules. Conflicts arising are generally resolved according to the rules. Special problems are sorted out in periodic committee meetings. Offenders are warned.

There were some cases of conflicts arising in the past even in those schemes that had committees of local users to supervise the construction and distribution of water among participating users. Therefore, what the method of committee formation also matters. As stated earlier, the conflict arising about local contributions between upstream and downstream farmers in the Cha Khola Irrigation Scheme was not resolved, rather the case of conflict itself became redundant when the Government later took care of all the expenses for the scheme. Currently, the scheme has been properly organised. It is now a registered users' group. All 400 user households elect the committee, pass the rules of operation, and resolve conflicts through a previously agreed upon set of rules.

The latest case of conflict was reported in a piped water scheme built in 1998.The DDC through Naldung VDC had provided a grant of Rs 30,000 for the construction of piped water to serve three settlements: Rohini, Luha, and Chitte. As the funds were insufficient to serve all of them, Chitte withdrew from the scheme voluntarily and a committee was formed for construction. The chairman and secretary both belong to Rohini village. The other seven members were chosen from Rohini and Luha. There was no participation of all the potential users. The chairman established the committee and forwarded the names to the VDC. The VDC gave the money to the committee chairman. No permanent reservoir has been made as the intake. The pipe has been inserted into the *mul* located in Rohini village. Two types of pipe were bought – bigger pipes were laid in Rohini and smaller pipes extended down to Luha. The people from Luha report that there is no water flowing to Luha. The committee has not yet presented the statement of expenses to the VDC. There is no formal committee responsible for operation and management of the scheme. As this scheme was officially launched, as per the rules a users' committee was formed, but the transparency was absent.

The other case of conflict reported was about the increasing use of water by hotels and shortage of water for irrigation. There are 37 standard tourist hotels, all pumping copious amounts of water from nearby *mul* up to the hotels. As reported by local people, this has greatly reduced the flow of water from the lower *mul* once used extensively for irrigation in winter. Besides open drainage of waste water people complain that the hotels have polluted the *mul* used for drinking water. Naldung VDC has formed a Public Property Protection Commission and has sent written complaints to hotel owners. There has been no response yet. Hotel owners claim they have pumped water from *mul* that belong to their property. Local people disagree. They argue these are public lands encroached upon by the hotel owners. The conflict has not been resolved.

Some years back, a conflict had arisen about the right of way to lay pipes for bringing water to a lower elevation settlement above Singe Village through a village. Pipes were laid across private land and the owners opposed this. As this village had its own drinking water source, owners had no incentive to allow the use of their land. Users of the intended scheme had not devised any compensation mechanism, from our impressions, they did not have any intention of doing so either. In addition, the money spent on construction was also not collected from users. It was provided by the Government. The project was abandoned in the absence of a resolution to the conflict.

The ongoing micro-hydel project is the most elaborate and transparent undertaking in the watershed. Its managing committee foresees likely areas of conflict and ways to resolve them through its eleven community organisations. Transparency and accountability are the necessary preconditions to minimising chances of conflict, and both are pronounced in this project.

Women's Empowerment

Of the 11 community organisations, five are women's organisations in the hydropower project. Women's participation in this project is direct, and they are involved in decision-making, according to both the men and women contacted during our field visits. In other schemes, women's participation was limited to fetching water, and their opinions and judgements were seldom heard. Recently, the Red Cross has provided money to construct another piped water system in Nayagaon. In this scheme women participate on an equal basis.

Issues

If properly harvested, the supply of water in the watershed should be adequate to meet the needs. During the rainy season, a number of *mul* spring up from which water is harvested. In higher elevation settlements, such as Naldung, water scarcity is relatively more pronounced, but it cannot be said to be in short supply. The problem with these settlements is that villages are scattered. However, with proper management, supplies can be improved.

Nagarkot, the popular tourist resort, is located at the highest point in Naldung VDC. All the settlements and agricultural fields are located below Nagarkot. There are presently 37 tourist hotels in Nagarkot. This is the development that has taken place over the last 15 years. All hotels have installed their own water pump-sets to lift water from privately built water reservoirs located on the slopes above the settlements and agricultural terraces. Most of the reservoirs are fed water from *mul* located on land owned by the hotels. During the field visits, pump-sets were observed to be running for more than 12 hours a day. Heavy pumping of water up to the hotels has given rise to complaints from the local people.

People complain, for instance, that owing to the large volume of water pumped up from the *mul*, the lower *mul* used by local people as sources of drinking water and irrigation either completely dry out or the volume of water decreases significantly during the dry season. The case of Chandra Surya Tole, a settlement just below Nagarkot, illustrates this claim. A stream called the Danda Thumka Kholcha is the principal source of water for irrigation for the winter wheat crop grown on 20-25 hectares in Chandra Surya Tole. Local people reported that, 10 to 15 years ago, the flow of water from Kholcha was sufficient to irrigate the wheat crop. Now the flow of water has decreased greatly creating a shortage of water for irrigation.

The other complaints against hotels concern the waste water discharge from hotels to open slopes, polluting drinking water sources located along the lower slopes and their illegal encroachment on public fallow land, depriving local people of use—particularly for grazing livestock.

Local people formed a body through Naldung VDC in 1997 called the Public Property Protection Commission. It wrote letters to hotels to draw their attention towards rampant pumping of water, open discharge of raw sewage on to slopes polluting drinking water sources, and encroachment on public land. The Ward Chairman of the settlements concerned stated that they have not received any response from the hotel owners yet.

3. External Interventions and Impacts

Interventions

Chronologically speaking, the history of external intervention into local water-harvesting systems in Cha Khola watershed dates back to 1977/78 when the then District Panchayat provided a small grant to construct a piped drinking water system for 36 households in Nayagaon settlement of Nayagaon VDC as reported in the earlier section. This system is working well to date even without a formal management committee, without any conflict. A bigger scheme for irrigation, which was initiated in 1986, failed as a result of conflict about local contributions from upstream and downstream farmers. As mentioned earlier funding was promised by CARE Nepal, but the conflict could not be resolved. CARE Nepal withdrew from the venture and, after a couple of years, the Government bore the entire cost of the scheme (which made the conflict redundant) and the scheme is now operational.

The other government scheme for piped water supply for the people of Rohini, Luha, and Chitte of Ward No. 2 of Naldung VDC in 1998 was another example of government intervention giving rise to local conflicts, as mentioned already.

The latest outcome of external intervention, as mentioned earlier, is a UNDP aided micro-hydro electricity project located in Nayagaon with local contribution of 40% of the total project. The remaining 50% has been provided by the UNDP and the remaining 10% by local bodies. As the local people were consulted extensively right from the planning stage and involved in decision-making at all stages, it has been successful and the plant is now operational.

Impacts of Intervention

External intervention in local development areas has both desirable and undesirable impacts. There is no denying the fact that know how and materials to build infrastructure are most often beyond the reach of the local community. Over a couple of decades, a significant number of people in rural areas gained access to piped drinking water. This could not have been possible in such a short period of time without injection of external funds. Similarly, external assistance in small-scale hill irrigation schemes has made a significant impact on agricultural productivity and cropping intensity in irrigated areas. These changes have had direct benefits on the local economy. Similarly, due to external intervention in Cha Khola irrigation scheme, where two rice crops and one wheat crop are grown, the tendency of the local farmers to keep buffaloes for milk production is growing. Buffaloes are stall-fed and need plenty of rice straw as feed. Currently, the Cha Khola irrigation command area has the greatest number of buffaloes. Although favourable markets and accessibility also matter, there appears to be a noticeable impact of irrigation schemes on the local economy.

Government and, lately, non-government organisations have played a major role in building infrastructure and providing public services - education, health, and agricultural inputs. External interventions in local water harvesting have focused on developing piped drinking water and irrigation systems.

Such external intervention in local water harvesting has reduced significantly the amount of time needed to fetch water. Previously it used to take on average 30 minutes to fetch a bucket of water in Nayagaon, whereas now the time taken is five minutes.

Such impacts are not reported and observed in other settlements, as these settlements do not have either piped water or irrigation systems. Again, local topography and ratio of *khet* to *pakho* area might have played an important role, besides the lack of these services.

The most undesirable impact of intervention is an increased dependency on external support for local water harvesting. In settlements located in Naldung there are potential sources of water for piped schemes. As external agencies have not come up with the funds, such schemes have not been implemented.

Although it is premature to evaluate the impacts of the micro-hydel project, the likelihood of undesirable impacts is minimal. External interventions and community initiatives and efforts are neatly blended to dispel undesirable impacts. Women's empowerment has been fully promoted in this project.

Comparative Analysis of Different Systems

External interventions through government and NGO involvement in water harvesting in the watershed area have played different roles. Although the end product may be the same, the *modus operandi* adopted in carrying out the work appears to have influenced local attitudes and knowledge. Most of the government undertakings have been in the pattern of 'come, build, hand over and go' Local people's interests and capacity to assume responsibility were seldom incorporated into the planning process. The Cha Khola irrigation and Rohini piped water schemes illustrate this. Success in terms of physical completion of the project sufficed with little regard paid to operation and maintenance. The Government avoided resolving disputes between farmers, as the dispute about cost sharing did not arise since funding was given entirely by the Government. Government line agencies and personnel were insensitive to the local people's needs. In other words, on the one hand, inherent issues were left unattended and, on the other, dependency on external interventions further deepened.

Non-government organisations are recent entrants on the scene. Equipped with increasing support from international agencies the NGOs are intervening in rural work, including harvesting of water for domestic as well irrigation uses. Their approach was observed to be different from that taken by the government agencies. Local people were involved in identifying their needs and preparing them as partners in all aspects of projects, right from the very conceptual stage. Local people are asked to contribute only after their needs are identified and, furthermore, they are assigned the task of managing the project, including operation and regular maintenance work. NGOs do not compromise on these principals. The withdrawal of CARE Nepal is an example.

The success or failure of schemes supported by NGOs thus correlate with the degree of institutionalisation taking place. The UNDP supported micro-hydel project in the watershed area is making efforts in this direction. The whole community has been made responsible for making this project a success. Despite the fact that a significant proportion of the costs has been funded by the UNDP, it has succeeded in remaining in the background.

4. HUMAN AND INSTITUTIONAL CAPACITIES

Human Capacity

Human capacity is positively correlated to knowledge and skill, which emerge when proper opportunities are afforded to them. In this respect, basic education is the fundamental precondition. Although the average literacy rate in the watershed is above the national average, the distribution of literate population in the area is extremely skewed. For example, the literacy rate in Nayagaon and Rohini is unusually high at 85% for men and 70% for women. Yet, in Naldung VDC the literacy rate for men is as low as 15% and 2% for women. In this VDC the total number of high school graduates does not exceed 10. In Chitte, a large settlement in Naldung VDC, the Red Cross began to run literacy classes for local women in 1998.According to their rules, the Red Cross wanted to hire a local SLC graduate teacher for the class. It could not find one in the whole of Naldung VDC.

When opportunities were made available to local people they demonstrated their capacity for development. As a matter of fact, external interventions in terms of technology and financial assistance in local water harvesting are also concentrated in a few localities. Out of four externally aided schemes, three of them have been introduced in Nayagaon and the fourth, which received a grant in 1998, is being implemented in Rohini. As stated in the previous paragraph, these two Brahmin communities have an unusually high literacy rate.

In Naldung VDC, even given a low literacy rate and absence of external assistance, local people have developed piped water schemes with their own money. Most of the homes at higher elevation have piped water for domestic uses. There are also numerous indigenous irrigation systems where coverage varies from four to five to 20-25 households. The people of Naldung have demonstrated their skills in tapping springs to bring piped water to their homes.

When opportunities are given local people have demonstrated their ability to exploit and get benefit from them. With the opening of a market for milk, local people have raised milk production to the extent to which they can afford to do so and in line with access to the resources required. Milk production is becoming one of the dominant features of the local rural economy. How people perceive the value of harnessing or exploiting any given opportunity largely determines and demonstrates their willingness and capacity for change or development.

With respect to institutional capacity, the Cha Khola irrigation scheme has been managed over the last few years by the local people through a user group. Local people have been able to demonstrate their capacity to organise and manage themselves to carry out tasks that will benefit them. The case of the micro-hydro project is by far the best demonstration of local people organising themselves to carry out a complex task of implementing the entire hydropower scheme. There has been external support in this context. Through UNDP-REDP, motivators were provided to interact with the local people to begin the process of organisation. After lengthy interactions, local people were motivated to organise themselves. Without their active participation, the hydropower project would not have been forthcoming. This case demonstrates that, with some external help, local people have the capacity to not only organise themselves, but also to execute a complex project such as the micro-hydel project.

Group Action and Management

Group action is part of local culture, as demonstrated by the building of canals and small irrigation schemes that generally do not involve cash investments and are manageable through local skills. Users were made to contribute labour. Rules are made and a system for regular repair and maintenance is established. Usually, some kind of managing body is also established which is dominated by the village elite and, lately, by members of the local political body.

Over time, however, beginning with government initiatives in local development, local contributions and active participation of the local people were gradually minimised as projects were funded and developed by the government. This situation eroded active, local involvement in development activities. More recently, with a change in the political system, NGOs have attempted to rebuild the old group culture. Modern concepts of management, particularly formation of committees, election of committee members from among users or beneficiaries, record keeping, decision-making, preparation, and finalisation of operational rules have been introduced. This is not to say that the modern system of management was imposed upon the local people. More or less informal methods adopted through group mobilisation have been formalised and recorded. Introduction of newer procedures of management are intended to streamline group actions, and these appear to be gaining ground, as witnessed in the case of the ongoing micro-hydel project. Local people's support to and cooperation in this style of management reaffirms their old attitudes about group action.

5. LOCAL EXPERIENCES AND IMPLICATIONS FOR POLICIES ON WATER HARVESTING AND THEIR IMPACTS

Impact of Policies on Water Harvesting

There are no government policies on water harvesting as such,[2] but several policies with a bearing on water harvesting are in existence. They are sector specific and are codified in Acts and policy statements. Some of the key policies are discussed below, tracing their impacts on water harvesting at local level, wherever relevant.

[2] The Ninth Plan has stated in its irrigation policy that water-harvesting techniques will be tested on a pilot basis to irrigate areas where surface water and groundwater are not available, by storing rain water. The latest policy statement issued by the Ministry of Housing and Physical Planning has also included, under its working policies, the use of water-harvesting methods for supplying drinking water.

Water Rights

The Water Resources' Act, 2049 (1992), which governs the use and development of water resources throughout the country, has established that water is state property, and individuals and community groups will have usufructory rights. Only in the broader national interest can the State revoke users' rights. Three top priority uses prescribed under the Act are drinking water/domestic uses, irrigation, and agricultural uses for livestock and aquaculture. The Act does not require the registration of the customary rights of the existing users. Largely, the Act is favourable to local water harvesting. Although the Act has not resulted in the expected behavioural responses in terms of tangible action (except the micro-hydel scheme being implemented) in the watershed, the local people, particularly those who frequent district headquarters/capital and interact with officials, are gradually becoming aware of the provisions of the Act.

Water rights are an area of concern for local people. This is because, in particular, they have small schemes based on local water sources in the watershed, and these small schemes are not normally taken into account by government development agencies. With external intervention, small schemes are often destroyed and their interests are subordinated to the requirements of large-scale development. [3] Indeed, the local people had problems in the past when an external agency (Department of Irrigation through the ADB-financed SINKALAMA project) tried to reallocate water with a project intervention. They, therefore, value the provisions contained in the Act relating to the protection of the customary use rights and exemption from registration of such rights. Their willingness to invest in the micro-hydel project in the watershed reflects the measure of confidence that the local people now have in their use rights.

Conscious of the difficulty of resolving water-related disputes in the past, they were also appreciative of the provision for a formal dispute settlement mechanism. The Water Resources' Committee at the district level, consisting of a Chief District Officer as chairman and a representative of district irrigation, district water supply, District Development Committee, and so on can decide in the cases of water-use disputes, on the basis of the priority order, the beneficial use or misuse supported by necessary enquiries and investigation.

Water Users' Association/Local Participation

The Water Resources' Act 2049 (1992-3) provides for the formation of the Water Users' Association (WUA) as a legal body: Individuals interested in using water resources in an organised way for communal benefits can form a WUA, as prescribed. The Irrigation Policy (1992) prescribes that the structure of WUA as a legally recognised body, with perpetual succession established and managed by the user farmers for irrigation, with due recognition under the Water Resources' Act 2049, shall be based on the nature and extension of the irrigation system. There shall be at least 20% female users in all the executive units of the WUA. The formal registration of such a WUA should be carried out before the implementation of a project (the Water Resources' Regulations 2050 have laid down a procedure for registration). Similarly, the Water Supply Policy 2054 (1997) has spelled out

[3] There are no cases of destruction of small schemes as such. However, the local people are fully aware of and apprehensive about the potential dislocation that can be caused to their systems by intervention. In course of the discussion, they narrated how protracted the negotiation among the stakeholders was that preceded the co-option of a series of small schemes at the head reach on to the Cha-Khola irrigation as part of system consolidation and extension.

the need to involve autonomous WUAs and local agencies in the planning cycle as well as in the operation and maintenance of water supply schemes. There is, however, no such provision in the case of micro-hydel schemes.

It is increasingly recognised that WUAs/community organisations are a viable institution for the management of common property resources. Empowerment of WUAs by conferring legal recognition would greatly help these organisations to grow institutionally, enabling them to establish formal relations with government agencies, donors/INGOs, and financial institutions. A strong and functioning WUA attracts the direct representation of local people, motivates them to actively participate in decision-making, distributes benefits equitably in a transparent and participatory way, generates a sense of ownership, and eventually produces improved system performance.

In the watershed, there are a number of community organisations (of very informal nature as discussed earlier), and only a few of them are organised. The more organised ones are Cha Khola Irrigation Association, Cha Khola Micro-hydel Users' Association, Rohini Water Supply Users' Association, and Nayagaon Piped Water Supply Users' Association. They have been operating and maintaining local water-use systems, mobilising resources (cash to pay for watchmen and labour for cleaning canals, removing landslides, and so on), settling disputes among members, and holding elections and conducting meetings of members for decision-making. However, the local people reported that the performance of community organisations is not satisfactory, more so in the externally-assisted schemes (the micro-hydel scheme is an exception).[4] Except one (Cha Khola Irrigation Association), these organisations are not legally recognised as they have not been registered with any agency. In the micro-hydel project, the functional group is readying itself for the registration as a cooperative/NGO (because, as noted earlier, legislation has not prescribed any mechanism to register the micro-hydel group). They have already prepared/drafted a memorandum of understanding and bye laws required for registration.

Policy Incentives

The Hydropower Development Policy 1992 has exempted micro-hydel schemes (defined as having a capacity of up to 100 kW) from the licensing and notification requirements. According to the policy document, no license shall be required to operate a hydroelectric project with a capacity of up to 1,000 kW and only for projects in the capacity range of 100 – 1000 kW; and a notice with necessary particulars should be given to the agency concerned before commencing work. The government has also extended financial incentives to micro-hydel schemes, through financial institutions, in the form of a capital subsidy of 50% of the electrical and mechanical costs of a scheme.

[4] When asked to elaborate, the farmers explained that, despite the existence of groups, the members with locational advantage receive precedence over others, and they also have to guard personally, even during the night, against water theft. However, they admitted that such is the case only during water scarcity or drought, which, incidentally, occurs infrequently in the area. Water scarcity in the area mainly connotes delayed rainfall, which reportedly occurs once in three or four years. Still farmers are sensitive to it because, due to intensive (three crops) cultivation, the timing of rainfall is very important for them. So, in point of fact, because of it being an infrequent event with uncertainty of occurrence, there is no incentive for the groups to establish elaborate organisational rules and practices. As reported, they sometimes even resolve disputes by resorting to altercation and muscle power. However, members in small schemes normally being from the same clan, it does not leave lasting impact or bitterness. In the assisted schemes, on the other hand, performance of community organisations has suffered largely due to i) lack of transparency, ii) absence of democratic decision-making, and iii) no users' contributions.

Similar incentives are also provided to irrigation and water supply schemes. The current subsidy rates, as laid out in the Irrigation Policy 2049, range between 60–95% of capital costs depending on irrigation types and development modes (excluding private schemes). In the case of rural water supply, the government policy is to recover at least 10% of capital costs (i.e., the capital subsidy is not to exceed 90%). The government has also been providing subsidies to individuals/groups for the construction of dug-wells and ponds/ storage tanks. As a policy, however, the government intends to phase out or gradually reduce the level of subsidies. The expectation is that the reduction/removal of subsidies could improve, among other things, resource allocation at both the budgetary level and at the local level.

To a certain extent, the policy incentives are instrumental in arousing local interest in the micro-hydel scheme and stimulating active participation of the local people in the planning and implementation of the scheme. This scheme is, indeed, an example that demonstrates that subsidy, when combined with other essential elements of project intervention, can make a difference. It can be an effective means of leverage on community resources for local development.

In the other assisted schemes (e. g. , Cha Khola Irrigation Scheme, Rohini Water Supply Scheme, and Nayagaon Piped Water Supply Scheme) however, where the agencies had borne almost the entire cost of construction, excessive subsidy has had rather dysfunctional effects. Strong users' associations have not evolved in these schemes and, as a result, these schemes suffer from the problem of free riding, upstream and downstream conflicts, and the issue of sustainability. Lack of proper maintenance is showing in low levels of service and system breakdowns. What is worse, the people seem to have developed a dependence on the external agency. All this indicates that the beneficiaries have not attached any substantial economic value to these services/schemes. Probably economics did not enter into selection decisions about these schemes. With subsidies covering full costs, agencies and users will not be concerned with the financial viability of a scheme.

Local Experiences and Their Implications

Water Harvesting Practices

As discussed earlier, some simple water-harvesting technologies are in use in the watershed. They include the rooftop harvesting system, terracing/bunding of farms,[5] ponds/tanks, ponds/tanks with pumping,[6] dug pit, spring development, collection/re-use of runoff from field drains, piped water supply, canal irrigation, and micro-hydel schemes (the latter three

[5] In the watershed, farmers have employed terracing techniques very extensively to harvest available water; even steep hill slopes are level terraced. Narrow terraced strips of from 6–8 ft, with a terrace height as high as 8–10 ft, are commonly found. Taking advantage of widespread water sources, farmers have converted sloping terraces (*bari*) into bunded fields for the cultivation of paddy, one of the crops that requires most water. Bunded terraces have proven to be an efficient way to capture runoff/rain water, and they are, in effect, the indigenous structural techniques for soil and water conservation in the hills and mountains. However, because of the high cost of terracing, farmers have not been constructing new terraces and are only maintaining the existing ones. If terraces are not properly maintained, particularly those that accumulate a high concentration of water, structural failure can take place. It also must be recognised that the cost of maintaining terraces too is high.

[6] To give a few examples, a resort hotel (out of some 37) in Nagarkot with 34 beds consumes, on the average, around 5,800 lt of water daily. It has constructed a concrete tank of 25,000 lt in capacity to collect water from a spring inside its own compound, and the water collected is pumped to an overhead tank. According to the hotel management, the water supply is sufficient to meet the guests' demands for eight months, and they face water shortage only during four months: September–December. In these deficit months, particularly when occupancy rate exceeds 80% or if there is a large conference, they even have to buy water in tankers from

based on diversion of rainfed rivers and springs). All these systems tap rain water and store it in drums, tanks, farms, and also within the soil profile on an hourly, daily, or weekly basis (long-term or interseasonal storage was not seen). The catchments of these systems are rooftop, agricultural farm, and defined areas from which rain flows into the springs. The Cha Khola and its tributaries up to the point of extraction; catchments of most of the springs, and rivulets are reportedly small and largely common property areas.
Barring a few externally-supported ones, these water-harvesting systems are low cost, simple, and extremely easy to manage and maintain. As reported, the majority of the systems are seasonal, and the externally supported ones run all year round. However, alternative sources further afield are available for drinking water. Drinking water is collected mostly by women/girls from springs or other sources in Gagri and takes on average, half an hour (varies seasonally). Wherever possible, individuals or groups of households have used polythene pipes extensively to bring water to their homesteads. Water is only sold in the market area (local shopkeepers reported paying Rs 10–15 for a 40-litre container; and these small shopkeepers harvest water from their rooves). The local people, in general, and those on the Naldung side, in particular, are not sanitation conscious. In fact, a water supply scheme aided by UNICEF[7] mainly to create awareness of sanitary practices had failed to accomplish the intended objective (it is learned that the services of two female workers employed in the initial stages to keep the surroundings of the water source clean were terminated after six months because of lack of local financial support, and recently the *Samaj Sewa Samuha* of Kuntabesi is becoming involved in activities in sanitation awareness).

Clearly, the local people's choice of water-harvesting technologies is basically driven by economics; unless they perceive real value for their efforts, they will not go for it. External intervention to be successful should, therefore, create value, as perceived by the local people. In point of fact, local people in many places do not see much value even in the intervention that seeks to provide assured water supplies. [8] This is mainly for two reasons: availability of alternative local water supply and general lack of awareness about sanitation. So it is more a question of costs (maintenance and organising costs only because investment is free any way) in relation to perceived/realised benefits. Nevertheless, the micro- hydel project appears to have succeeded in creating a perceived value for its product. The measure of the value can be judged from the fact that people really fear the prospect of

Kathmandu (a 12,000 lt tanker costs around Rs 5,000). When asked why they are not considering roof-top water harvesting or runoff harvesting instead of paying such a high price for imported water, the management explained that they have surplus water during June, July, and August in the existing spring itself, which they can store by having bigger or additional tanks. It is not necessary for them to go for other alternatives. However, they have not been doing so because the hotel occupancy rate during those months has not steadied at the threshold level, and therefore outsourcing of water is still a better option to bridge the occasional demand-supply gap. Similarly, one other hotel is meeting its water needs by constructing a water tank on public land (actually, there is confusion as to the exact status of ownership of this piece of land, and the hotel owner has reportedly not paid any royalty to the government) and pumping water from the tank to the hotel situated uphill. The current arrangement is that water is collected from the spring during the night and in the daytime the spring water is used by local inhabitants for washing and other purposes. As reported, there has been no conflict over water use.

7 This scheme was not discussed earlier because the scheme falls outside the watershed though it is in Naldung VDC.

8 For example, with regard to the water supply rehabilitation/augmentation scheme recently initiated by the Red Cross in Ward 2 of Nayagaon VDC, a number of sceptics were found who genuinely believe that people may not participate and hence the scheme is not worth the effort because the targeted beneficiaries already have access to drinking water. The Red Cross has reportedly multi objectives including improvement of sanitation.

exclusion from the beneficiary group. [9] It is to the micro-hydel project's credit that it managed to identify and cater to the local people's felt needs. Local people are seen to have attached greater importance to electricity for lighting houses (saving of kerosene), viewing TV/movies, listening to radio (replacement of battery), and for children's education, i.e., reading/writing during the night. They also see earning opportunities by selling electricity to grain and saw mills, cheese factories, or any other industry.

It is also a fact that apparent abundance of water does not preclude the use of water harvesting; it simply demands as much additional effort to find sites/techniques that create value. Neither water shortage or seasonal gap is automatic justification for water harvesting. The downstream farmers of the Cha Khola irrigation system, for example, found it more remunerative to maintain the system by themselves rather than having their own separate water-harvesting/storage scheme to meet the water shortage during the season. [10]

To many in the watershed, water harvesting means making full use of 'available' water in the most cost-effective way. Given the choice, they also seem to prefer small catchments or local sources for water harvesting to be able to exercise collective/individual control over the entire system (seen were cases of afforestation, to protect catchments of water sources, and preventing people from defaecating near sources used for drinking water). This preference for 'local' is also a manifestation of their desire for low costs, predictability of supply (source fully understood), and ease of management. The micro-watershed approach to the study and promotion of water harvesting at the local level thus seems to fit in well with the local concept of water harvesting.

Local Management Systems

The management systems prevalent in the area range from simple household collection arrangement in case of rooftop harvesting system to a rather elaborate system managing interpersonal relations (among 121 beneficiaries households) and agency-users' coordination in the micro-hydel scheme. However, the dominant pattern is 'informal' management or working arrangement. [11] The key characteristics of such management practices, as understood from the field interview, are flexible organisational arrangements, a committee style of decision-making, management control largely reflective of local social hierarchy/relations, rules and sanctions grounded in customary practices and local values, information flow by contacts/word of mouth, coordination by mutual understanding and interaction, work allocation/delegation by convenience and capability, overlapping/ multiple responsibilities of members, voluntary nature of work, seasonal or intermittent activities,

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9 To give one instance, recently, when the ADBN local office declined to release a loan (and associated subsidy) to the project on the grounds that some of the beneficiaries had overdue personal loans, the users' association issued a notice to the defaulting members that they would be denied electricity unless their dues were cleared by the stipulated date, and they reportedly cleared them.

10 The farmers at the tail-end of the Cha Khola Irrigation Scheme frequently face difficulties in channelling water to their area and also have to bear a disproportionate share of system maintenance. Technically speaking, they can have their own alternative system to irrigate their *bari* by, say, constructing a community pond to capture rain water. They have not done so, however, and instead preferred to stick to the Cha Khola Irrigation Scheme. They must have found the *status quo* more cost effective.

11 These organisations are visible and activated only when there is action or a purpose to be accomplished. There is no set rule for regulating the relations between members and their activities, and working procedures can be changed with mutual understanding to suit the new needs and conditions. Even the more organised Cha Khola Irrigation showed flexibility by co-opting new members and becoming a larger association than the original small group. That these organisations, in whatever forms, have endured the stress and strain of time indicate their strength and adaptability.

dominance of interpersonal relations, preponderance of group action, leadership by performance or political/external links, and social accountability.

While this management style has its own strengths, it has some in-built disadvantages. As reported, these organisations do not always operate fairly and in a participatory mode; some are actually monopolised by the local elite. Given the local environment characterised by social and cultural heterogeneity and rife with political rivalries and caste conflicts, [12] local disputes frequently spill over into organisational performance and outcomes. To a great extent, the local politics is an extension of the rivalry among political parties and interest groups at the national level. It is basically a quest for grass-root control over resources, institutions, and vote banks to wield political power for their own or group ends. More often than not, deliberate actions are required to break the existing nexus and to steer clear from local politics. The micro-hydel project has done this tactfully, [13] through an extensive programme of training, consultation, and exposure, as seen in its success in bringing local leaders of rival political camps together in the organisation (one as chairman and another as manager). The project has also managed to make the organisation broad-based and transparent through, among others, a deliberate process of one-and-all participation, inclusion of female members, and regular mass meetings.

Another weakness of these community organisations relates to their unfamiliarity with accounting, record-keeping, and banking practices. For that reason, they often face difficulties in handling large amount of funds and, sometimes, also in maintaining financial integrity[14]. They also find it difficult to meaningfully interact with a formal system or external agency (notwithstanding the fact that they treasure near-complete information about the local environment). While this emphasises the need to impart fresh skills to the local people, this also calls for a different management style and intervention strategy on the part of the development agency. In fact, the apparent success of the micro-hydel project can be attributed to the fact that they internalised this reality, tailored their approach to the local needs and capabilities, and oriented their field staff, particularly the group organisers, to be people-friendly.

Customary Water Rights

The local people have been exercising their customary water rights over a very long period of time. The customary rights in the area are based on the principle of prior appropriation which means that older established rights have precedence over new rights. This is normally operationalised by denying the right to extract water from any point within 500 metres

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[12] To give an example of the extent of political rivalries, an ailing Tamang teacher was socially ostracised by a section of his community loyal to the rival political party on the grounds that he took drinking water from a lower caste Damai, and this dispute went to the supreme court. This also indicates the strength of social sanctions in the area.

[13] Strict adherence to the REDP organising ground rules: 'no personal matters and no political matters', 'no scheme unless all-inclusive organisation' and the leadership and political neutrality of an NGO as a group mobiliser stand out as the key factors for bringing the rival political factions together. High perceived value of the project output, REDP's demonstrated success in other parts of the district, and waning political interest (a local leader stated that the people are gradually realising the futility of local in-fighting as no parties are seen to deliver the goods) also facilitated creation of the right atmosphere for concerted action.

[14] In the Rohini Piped Water Supply Users' Group, for example, it is partly because of unfamiliarity with the accounting that the only statement of expenses the group has maintained is a pipe purchase bill for Rs 12,000 (out of Rs 30,000 of reported total expenses). Similarly, for the same reason, a sense of misgiving is brewing in the group savings' scheme under the micro-hydel project regarding the use of members' deposits when the total has not even exceeded Rs 10,000.

upstream from the existing water diversion point/delivery system. [15] In the case of Cha Khola, a dispute arose in 1992 between the upstream and downstream farmers even beyond the above limit. [16] The dispute was finally resolved after the upstream farmers agreed to replace the permanent structure with a temporary diversion, assuring the existing lower system of adequate water during the dry months. This dispute was basically arbitrated by local people: senior/respected citizens and community groups. This case goes to show that local people have indigenous dispute settlement mechanisms (which at times may seem unnecessarily protracted).

Investment normally entitles a person to customary water rights. Irrespective of social status, if someone has contributed to the creation of assets, he/she will have access to the assets or the benefits resulting from the assets thus created (though access may not be equitable). The farmers downstream in the Cha Khola irrigation system, for example, have the social legitimacy to direct the canal flow to their area (of course with night watchmen in different places) because they have been investing in the maintenance of the system. Part of the confusion over the Chhap Raniban water supply scheme (this scheme is not within the watershed) is also investment-related: the ownership of the system is not clearly defined. The agency left after completing the project without handing it over to the District Development Committee or the local beneficiaries. The lessons that can be learned from these cases are that (i) users' contributions should be encouraged in the broader context of reinforcing their right to benefit or to broad-based benefit sharing and (ii) transfer of ownership or handing over of systems should be an integral part of the project cycle.

Interdependency of Resources

The local people are increasingly appreciative of the interdependency of resources. It has dawned on them that depletion of one resource has corresponding negative effects on others, and that managing the links across resources and property regimes is essential for sustainability of benefits. This was, indeed, a time tested wisdom which they have relearned in recent years. They learned from their recent bitter experience of the seasonal drying up of water sources caused by deforestation of catchments (as mentioned before, drying up of water sources in Naldung is also partly due to overexploitation by hoteliers in Nagarkot). To recharge the springs again, they have now afforested and protected large parts of the catchments; and this is the case particularly in the small catchments feeding their main drinking water sources.

15 Such customary rights, however, do not exist in relation to subsurface water. It is therefore the downhill farmers of Naldung who are dependent on seepage water fed by springs uphill that are finding themselves helpless in protecting their interests in the face of a score of hoteliers in Nagarkot trapping and using up almost all the nearby springs for commercial purpose. The seriousness of the situation can be gauged from the development of the Public Property Protection Commission under the aegis of the Naldung VDC formally protesting against the hotel managements' misuse and monopolisation of water.

16 The dispute started when the Department of Irrigation came to develop/extend the Cha Khola Irrigation system with a permanent diversion structure. As the stakeholders, the beneficiaries of the Cha Khola Irrigation, the users of an existing downstream scheme (which does not fall within this watershed), and SINKALAMA project staff were directly involved in the dispute. The downstream farmers were against the complete damming of the Cha Khola insofar as it would adversely affect the flow feeding their system, particularly during the lean season. This dispute lasted for over a year and was finally resolved through several rounds of negotiation after the Department of Irrigation and the farmers of the Cha Khola Irrigation agreed to build a previous construction across the Khola for water diversion. Many influential people, including the local politicians and departmental staff, contributed to the resolution of the dispute. The spinoff from this dispute is the reinforcement of customary water rights, even in the modern context, through agency intervention.

On a broader level, this new development represents the revival of the tradition of maintaining common property. There were examples of local people giving up their private property for common goods. A landholder in Nayagaon VDC, for example, had contributed a piece of farm land on which a spring was located for community water supplies and had instructed his family members not to cultivate that portion of land. This water supply system has been running for several years, serving more than 30 households in the vicinity. In general, the local people believe in common property management regimes, partly because the local community schemes are small and membership boundaries can be well defined and cost of cooperation for individuals is not high. Capitalising on such rooted local values, the micro-hydel project is promoting functional groups for different resources (e. g. , a forest functional group, energy functional group), with the long-term view of creating interlocking institutional arrangements for managing interdependent resource systems.

Development/Change as a Process

Though seemingly risk averse, the local people are not wary of change. They have been taking initiatives and also cooperating with external agencies (though in varying degrees). They, however, go through rather a long process of consultation, evaluation, internalisation, negotiation, and adoption before taking action or participating actively. This process can be facilitated by external inputs, particularly of hardware, but cannot be drastically shortened. External intervention that seeks to cut short this institutional process does so at its own cost. The case of Cha Khola Irrigation illustrates this point.

Originally, Cha Khola Irrigation was a small community-managed scheme. CARE Nepal (INGO) had tried to extend the system in 1985. After protracted negotiations, this attempt was, however, aborted because of the lack of consensus between the upstream/headreach and downstream/tail-end farmers about the amount of their contribution. Upstream farmers were opposed to a uniform rate of contribution by all farmers and some of them even refused to contribute at all. As an acceptable formula could not be determined, CARE Nepal, which places great emphasis on farmers' participation, withdrew its support from the project. Subsequently, a government agency (the Department of Irrigation) intervened with a large amount of donor funding to finance the project almost entirely. The financial incentive or gift that the agency provided helped all the differences disappear, cutting short the project development time. But the project could not reap the desired benefits, and it is being sustained largely by the downstream farmers (made possible by the fact that the system is reasonably stable, entailing low maintenance cost). The lessons from this kind of example appear to have been learned by the Micro Hydel Project which does not have time-bound disbursement or physical completion targets.

Assimilation of External Inputs

The local people have demonstrated their capacity to assimilate external inputs and technologies. The degree of assimilation, however, depends largely on the value of inputs. If the people perceive value, they are ready even to accept the apparently complex schemes as micro-hydel. By and large, there is willingness to contribute and acquire skills for managing the innovations. In fact, 'people's contribution' is invariably the true measure of the economic value of intervention for the local community. The agency-financed water supply schemes in the watershed, for example, are not being properly maintained (even the one implemented by a NGO outside the watershed) largely because they are not demand-driven and, consequently, local people have made virtually no contribution to their implementation. On the other hand, there are instances (in the district) of local people taking over agency implemented schemes in which they see tangible gains (but such a take-over may not be equitable compared to the managed hand-over).

Coping with Emerging Adversities

Although the assessment is preliminary, it appears that the local people have been coping with the emerging adversities reasonably well. They seem to have indigenous coping strategies, both at the household and community levels. The local people have generally exploited available opportunities, managing whatever limited productive assets they have for securing and stabilising income. There may be a variation in the strategies of the poor from those of the non-poor in that the former makes use of inferior options most. But the point is that even the poor have all along been coping with the problem of scarcity and deprivation through household adjustments (in terms of consumption, savings, and employment) and community actions.

Some people reported that they resort to seasonal migration and dis-saving or sales of assets to make ends meet. The reporting households have large (above average) family sizes and high dependency ratio. As mentioned earlier, the local communities embarked on collective action to protect their water sources. In fact, some of the local water-harvesting practices can be traced to the local people's quest for survival in the harsh hilly environment. It is reported that urbanisation and proximity to Kathmandu have created some difficulties for the local people in managing the community assets and resources. While growing attraction for service relegated farming in some families to a secondary occupation, the problem of retention of trained manpower prevented them from undertaking technological innovations. The 'competition' for water between commercial and domestic/agricultural uses is also a problem emerging which is attributable to urbanisation.

Critical Issues and Recommendation

Lack of a Distinct and Precise Definition of Water Harvesting

The concept of water harvesting is not understood fully by the local people. For some, it is simply trapping rain water in an artificial pond, tank, or drum. For others, it means all kinds of productive use of water. Even government officials and development agencies appear to be confused; but quite a number of them tend to interpret water harvesting narrowly as collection of rain water from hill slopes or man-made catchments to provide low-cost water supplies for domestic uses. Some also include runoff agriculture under water harvesting. While all this may indeed be true, it is useful to have a distinct and precise definition to facilitate meaningful operationalisation of the concept in the field. Based on field observations, one way of looking at water harvesting could be as something that empowers local people, i.e., a means of conferring on households the control over water and its uses.

Lack of Awareness of Cost Effective WH Technological Innovations

Local people are not aware of new WH technologies or innovations. Whatever they have accomplished thus far is largely based on their own indigenous knowledge and skills. What they need now is fresh solutions that are superior to the traditional ones. As technology, management, and capital are the things that the local area is generally deficient in, they need to be offered a menu of promising technologies from which they can choose a cost-effective one. In addition, local people need awareness about WH technologies that are already available. What seems to be lacking is a communication system to disseminate information to them.

Lack of Catalytic Agency to Promote Local Water Harvesting

A major problem in the way of promoting water-harvesting schemes is the lack of 'appropriate' institutions. Although various agencies are involved in the water sector with varying degrees of effectiveness, most of these agencies, including NGOs, follow a conventional approach, which is not normally suitable for promoting sustainable local water harvesting. Small-scale water-harvesting schemes, which seek to empower individual households and build as well as sustain local initiatives, entail a different development approach and organisational orientation. An action research agency that operates in an 'informal' mode following a process approach, and that is sensitive to local subtleties and constraints, should fit the bill. Such an agency normally specialises in social intermediation and would be effective in spreading local WH schemes if adequately supported by, say, a 'social fund' administered by an 'enlightened' NGO. Based on experiences in other countries, the essential characteristics of the fund are autonomy, transparency, and participatory and in-built monitoring.

Protection of Customary Rights and WH Systems

The Water Resources' Act, 2049 has recognised customary water rights, granting legal status to indigenous water-use systems. Nevertheless, this is not communicated to the local people who are generally unaware of the provisions of the Act. While well coordinated dissemination of legal and policy information is necessary, equally essential is the strengthening of institutional arrangements to enforce the provisions of the Act, particularly to extend the reach of the enforcement system to local areas. Whenever disputes cannot be settled through the customary informal ways, local people should be able to take recourse to the formal system at a minimal cost. Only then can the legal status conferred by the Act carry real meaning and local WH systems be protected. Another issue with the Act is related to the water users' groups. The Act does not recognise the groups unless they are registered with the designated office. Given that casual groups of households are involved in the small-scale local WH schemes, this provision of the Act may pose some problems to development agencies that cannot deal with informal groups.

Information Gap

The government (including local government) officials in the district do not acknowledge the repository of knowledge that exists at the local level. It is typical of policy-makers and implementers in Nepal to ignore indigenous knowledge and systems. In fact, failure of many of the development experiments in the past can be traced to this information gap. Research agencies have a better appreciation of local information. However, they too have not been effective in communicating the information available to the implementers, tracing their implications. Nor have they come up with innovative ways of grafting institutions on to local structures and practices. The project management cycle practised by donor agencies as well does not incorporate learning from the local people as an essential stage of the management cycle. While bridging this knowledge gap is essential, documentation of local resource management practices, resource dynamics, skills and capacity, and changing preferences/expectations of local people are not sufficient. Effective linkages have to be established between the providers of indigenous knowledge and programme implementers for action in the field.

Lack of a Focal Point at the Local Level

There is no focal point at the local level to direct and coordinate diverse activities and act as a reference point of contact and information dissemination centre. A UNDP-financed

Participatory District Development Programme is making efforts to create/update the information base in each Village Development Committee (VDC) of the selected districts—including Kabhre. However, of the two VDCs falling into the micro-watershed of this study, only Nayagaon has maintained a database on socioeconomic aspects of the VDC. While this data management effort should proceed, ways and means must be found to enable VDCs to take a more proactive role in local development management.

Next Course of Action

As follow up, the following activities should be initiated: i) development of a Water Harvesting Framework, ii) preparation of Water Harvesting Guidelines and Technological Manual, and iii) creation and management of a Water Harvesting Network/Site with special reference to the Hindu Kush-Himalayas.

Annex 1
Check List

Case Study on Local Water Harvesting Technologies and Management Systems in Micro-watersheds of HKH

Rapid Participatory Rural Appraisal

I. LWHS Type (irrigation, watersupply and others)

- Name of the System
- Location

II. History of the System

1. Original Construction
   - When?
   - Who initiated and directed?
   - Amount and sources or resources invested: cash, labour, materials?
   - Basis for internal resource mobilisation: household, landholding?
   - External resources?

2. Improvements/rehabilitation/expansion
   - When have major inputs and improvements been made?
   - Who initiated it? When? What was done?
   - Internal or external resources?
   - Basis for internal resource mobilisation?
   - Are regular external resources given?
   - Area or beneficiaries increased?

III. Description of the System

1. The Physical System and Hydrology
   - Source Type (*mul*, *nala*, ponds, rivers, wells, others?
   - Name of water source?
   - Catchment area (approx)?
   - Rights to water in the source: upstream and downstream systems?
   - Seasonal variation of water source?
   - Discharge in canal at extraction (if applicable)?
   - Flood frequency?
   - Water quality: salt, lime, etc?
   - Water constraints to expansion/intensification of irrigation?

2. Size of the System
   - Number of beneficiaries?
   - Types of benefit/use (irrigation of crops/vegetables, drinking, bathing and washing only, for livestocks, fisheries, recreation, cottage industry, mixed)?
   - Quality and seasonality of benefits (min. and max. benefits or beneficiaries, water quality, min. and max. fetching time, adequacy with this system)?

3. Technology of LWH (artificial pond, river-based canal/river harvesting, subsoil storage, spring development, stone spouts, bamboo or plastic piped water supply, hydraulic rams, water wheels, sprinklers, dug-wells)?

4. Water Conveyance and Distribution (canals, pipe, standpost, sprinkler, or no conveyance system)
   - Type of construction, materials, quality, and condition?
   - Intake/diversion/drop structures/measuring devices (exist?)
   - Distance from source to first field/household?
   - Capacity of canals (if applicable)?
   - Density of canals (high, low, reasonable)?
   - Condition of rock and soil along the alignment (chances of disruption)?

5. Drainage/Sanitation Condition?

6. Soil Fertility and Suitability for Irrigated Agriculture: Head, Tail and Middle (if applicable)?

Operation and Maintenance

1. Operational Tasks (frequency and magnitude of effort)
   - Basis of water allocation (number of persons/livestock, land area, soil type, investment)?
   - How allocation changes during scarcity?
   - Method of water distribution for each or group of households, or in the case of irrigation, for each crop and variation during each crop: rotation (who and how initiated, frequency of turn); continuous flow; contract; turns (head to tail), water trading?
   - Distribution during water shortages: rotation among outlets, among field neighbours within outlet, rationing among households in the case of drinking water?
   - Match between water distribution and allocation: method of matching, proportioning weir, timed rotation?
   - Relationship of water distribution to physical infrastructure?
   - Who is responsible for water distribution activities, particularly at the time of scarcity?

2. Routine maintenance
   - What work is done?
   - Frequency?
   - Purpose: improve performance, preventive>
   - How long does it take?
   - Who initiates and directs work?
   - Who pays, in what form and how much?

3. Emergency maintenance
   - Reasons?
   - Frequency ?
   - How long does it take?
   - Who determines it is an emergency?

- Who organises and leads the work?
- Who pays in what form and how much?

4. Extent of agency involvement in this communal system
   - What agency is involved?
   - What inputs are provided and how frequently?

V. Institutions and Social Environment

5. Social structure
   - Landholding pattern?
   - Nature of tenancy (criteria: owner, tenant, sharecropper)?
   - Ethnic and religious composition of the beneficiaries?

6. Organisation for irrigation operation and maintenance

   a) *Membership*
   - Criteria: land, water share, crop, tenancy, official position, contractual, ethnic (exclusions), gender, age, labor, investment input?
   - Membership in other system?
   - Absentee members?
   - Free?

   b) *Roles and positions*
   - For each position: method of nomination, appointment, tenure. remuneration (cash, in kind, labour exemption)?
   - Appointed functionaries?
   - Chairman?
   - Vice-chairman?
   - Secretary?
   - Treasurer, and so on?
   - Water supply and/or system damage monitor?
   - Crier?
   - External communications?
   - Moderator of meetings?
   - Tool keeper?
   - Number of women among the functionaries?
   - Committees: regular and ex officio?
   - Informal leaders?
   - Relationship of political leadership to system?

   c) *Tiers of organisations*
   - Federation/unitary?
   - System/distributory?
   - Village/farm channel (*mauja*)?

   d) *Meetings*
   - Regular: time, place, who calls or ad hoc?
   - Extra/emergency?
   - Purpose: resource mobilisation, accounts, maintenance, conflict?

- Attendance: landlords, tenants? Only beneficiaries? women? landless?
- Penalty for not attending?
- Leadership: moderator, minute keeper, how selected?
- How are resolutions passed? vote, consensus?
- Records of meeting?

7. Conflict and conflict management
    - Cause, nature, frequency of conflict?
    - Specific to benefit-sharing (equity related issues) or making contributions or free rein?
    - Internal or external to the system (with local government)?
    - Among systems/water rights?
    - Non-water issues?
    - To whom is the first appeal for conflict resolution and what is the step-by-step procedure for difficult cases?
    - What is handled within the organisation and what is taken outside?
    - Police cases?
    - Court cases?
    - WDDC involvement?
    - Rules and sanctions?
    - Records of conflict resolution?

8. Water Rights
    - Sharing with other system?
    - Permit, rent, prior appropriation, riparian?
    - Customary rights?

9. Internal Resource Mobilisation
    - Purposes for resource mobilisation?
    - Basis: same as water allocation?, household, preferential treatment for women-headed household, less benefiting member, lower caste member or landless?
    - Type of resource: cash labour, in kind (remuneration, etc), animal, bullock cart, local knowledge?
    - Annual quantity of each type of resource?
    - Sanctions for not contributing?
    - Annual amount realised from fines, how collected and used?
    - Where are funds and in-kind resources held? Is there intermediate (short-term loans) use?
    - Discrimination against contribution: caste, sex, age?
    - Contractual arrangements for maintenance: method, reason?
    - Resource generating activity: mill?

    External resources
    - Purpose?
    - Source: connections, contacts?
    - Who (person) initiated contact with outside agency, incumbent or previous experience in government position?
    - Frequency?
    - Type: cash, food-for-work, cement, gabion wire, technical advice?
    - Equipment: bulldozer, jackhammer?

10. Organisational development

- Changes over time in: rules, resource mobilisation, processes for electing functionaries, and so on?
- Changes in decision-making process, incorporation of women, democratic and transparent?
- Terms and conditions of external agency for providing aid and resolving conflict and its effects (positive or negative)?
- Changes in relationships with other systems, agencies: water sharing when temporary?
- damage in canal, sharing resources for maintenance?

Chapter 8
Battal (Mansehra) Water Harvesting Technologies and Management Systems

M.J. Khan

1. Introduction

In the Northern part of South Asia, the long mountain chain covers an area of 45,000 sq. km. and consists of the Himalayas, the Karakoram range, and the Hindu Kush. The Sanskrit term *Himalaya* means the abode of snow and the peaks of these mountains are covered with perpetual snow. Inhabitants of the mountainous regions are faced with the dilemma of water shortage or excess. During monsoon they receive excess rainfall and too little for the rest of the year. For centuries, these people have been struggling to live in the harsh environment.

Local communities in these mountains have developed indigenous techniques and skills for harnessing available water resources. With an increase in population, the demand for water has increased several fold; the competition for water for domestic and agricultural use has also increased. Given the scarcity of water, its proper management has become more critical to provide relief to the suffering of the inhabitants in mountains regions.

The NWFP

The main land uses in the North West Frontier Province (NWFP) are agriculture, forestry, and rangelands. The total cultivated area of the NWFP is 1.92 million hectares (19% of the total area): forest land—1.72 million hectares (17%), rangeland–1.78 million hectares (18%), agriculturally unproductive—2.97 million hectares (29%), and unclassified—1.74 million hectares (17%) (Mian and Mirza 1993). Given the vast area under forests, grazing, and rangeland, it is imperative to develop an effective management programme for these resources. Forests play a vital role in protecting the country's fragile watersheds, which yield power and water for the large agricultural economy of the rest of Pakistan.

The NWFP has a rich heritage of wildlife and plant resources which is diminishing as a result of population pressure and other human interventions. The number of people residing in the forested mountain regions is increasing rapidly. Increase in human population has increased the pressure on forest resources to meet the local needs for timber and fuel. It has resulted in the extension of cultivation on to steep slopes, and this has augmented losses of soil and water. Sustainable development of the watershed is, therefore, essential for conservation of natural resources.

This report is partially based on a case study of a micro-watershed in Battal, Mansehra district (NWFP), Pakistan, undertaken for the Water Harvesting Project of the International Centre for Integrated Mountain Development (ICIMOD). The duration of this study was 12 weeks, the field work started on August 1, 1998. Data were collected until the end of September 1998.The background information about the project area, i.e., information about climate, soil, vegetation, and so on and the socioeconomic conditions of the households in terms of landholding, tenancy status, and per capita income are discussed in the Annex to this paper.[1] Local drinking and irrigation water supplies are also dealt with in the Annex. Specific attention has been given to gender issues and management of the water supply system. Indigenous methods of water harvesting are presented in Section 2. Water harvesting practices in other parts of Pakistan are discussed in Section 3. Section 4 describes the role of different government agencies and NGOs in the development and management of local water-harvesting systems. Section 5 deals with institutional capacities and local experiences in water harvesting. National policies on water harvesting, water resource management, and implications on water harvesting and the problems are discussed in Section 6.Critical issues and recommendation are presented in Section 7.

2. LOCAL WATER HARVESTING TECHNOLOGY, PRACTICES AND KNOWLEDGE

The villages in the area were representative of the region of Pakistan in terms of the different types of water- harvesting techniques practised. Details of the different water-harvesting practices are given below.

Local Water Harvesting Practices

Check Dams

Check dams are made of earth and stones, built across the natural streams to pond water upstream. The water collected in the reservoir is used for irrigation, drinking, or other household uses. Usually, these dams are small in size and are erected in the foothills. The dams are temporary structures, mostly built in the dry season. Small dams are constructed by individual families, while bigger structures are erected jointly by community groups.

Level Terracing on Gentle Slopes

Level terraces are common in the Battal watershed (Figure 8.1). These terraces are wider than others and have little or no slope and are effective in retaining rainfall water on different levels of terrace. This practice serves the dual purpose of controlling runoff and preventing soil erosion. The terraces are mainly constructed for raising field crops and fruit trees.

Terracing on Steep Slopes

Because there is limited land for cultivation of crops, some farmers construct narrow terraces on steep slopes (Figure 8.2). These terraces are 1.2 to 1.5 metres wide and one or two rows of plants are cultivated on them. Since they are not properly designed, they have further accelerated land degradation in the watershed. This practice is mostly adopted by poor farmers in the area.

[1] Editorial Note : Details of the study have been kept almost in their entirety in the Annex.

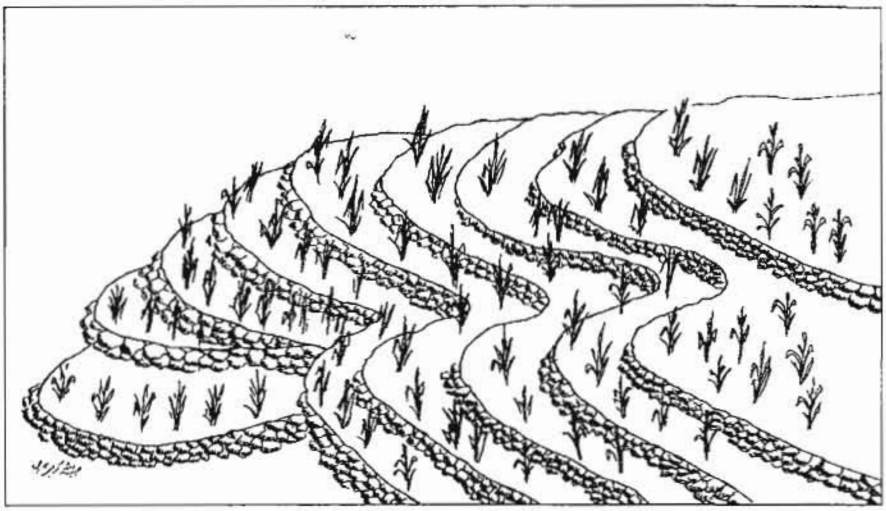


Figure 8.1: **Terraces on gentle slopes**

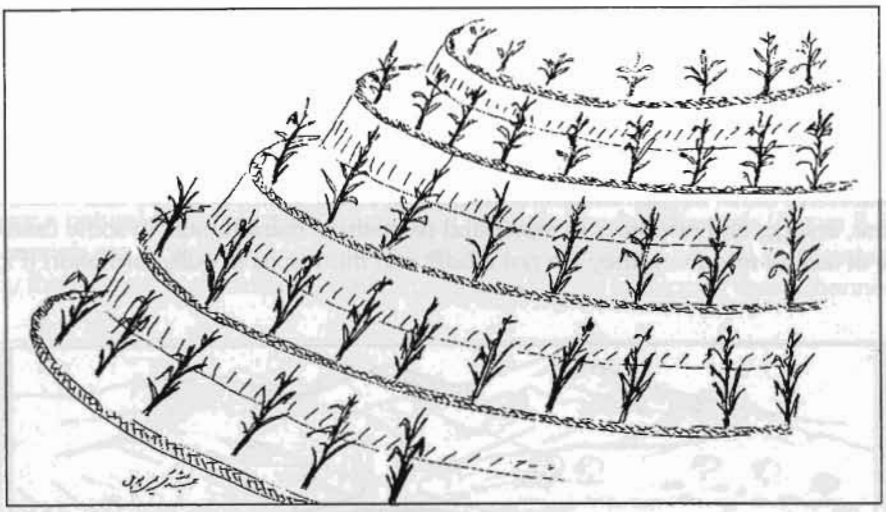


Figure 8.2: **Terraces on steep slopes**

Earthen Ponds

Small ponds are constructed to store water for irrigation of cultivated fields (Figure 8.3). The dimensions of the pond depend upon the amount of water needed for irrigation. Earthen bunds or large stones are placed around the bank of the pond to stabilise it. These ponds are usually located uphill and are used for irrigation of fields downhill. Runoff and rainfall water are collected in these ponds. In some cases, water from these ponds is used for both irrigation and domestic needs. This practice is common in all the villages in the watershed.

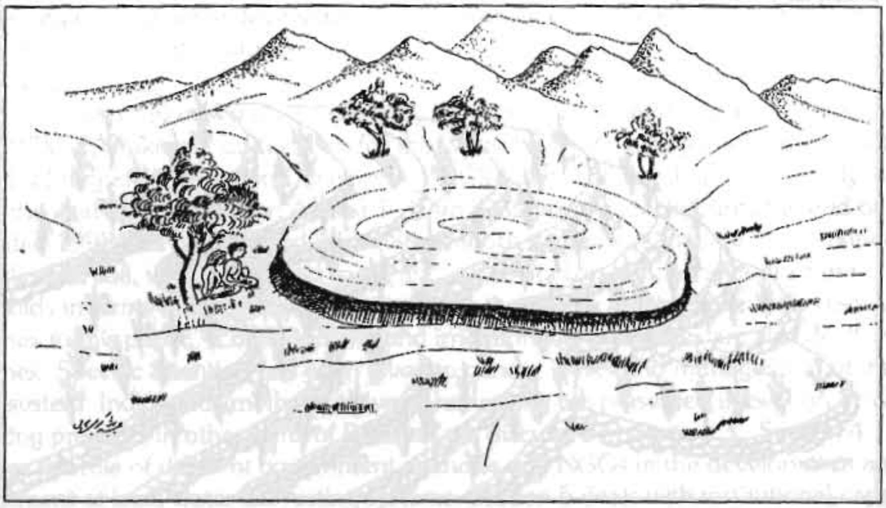


Figure 8.3: **An Earthen pond for irrigation and domestic needs**

Field Bunding

Earthern or stone bunds are constructed around the field boundary to retain runoff water and to prevent overflow into the fields. This method has been found to be very effective in controlling runoff and erosion. It is practised widely by farmers in the watershed. Sometimes, when there is heavy rainfall, these bunds are eroded and farmers have to reconstruct them. The height of these bunds ranges from 0.30 to 0.60 m and the width from 0.60 to 0.90 m. In some places, where there is a danger of bank erosion, stone walls are constructed instead. Although field bunding is a popular practice for retaining water in the field, sometimes the bunds overflow and are undermined or completely washed away during excessive rains. In such situations farmers face serious losses of soil and water, and it takes time, energy, and resources to repair and reconstruct these bunds. In some cases, because of lack of resources, they are not rebuilt and this results in gully formation (Figure 8.4).

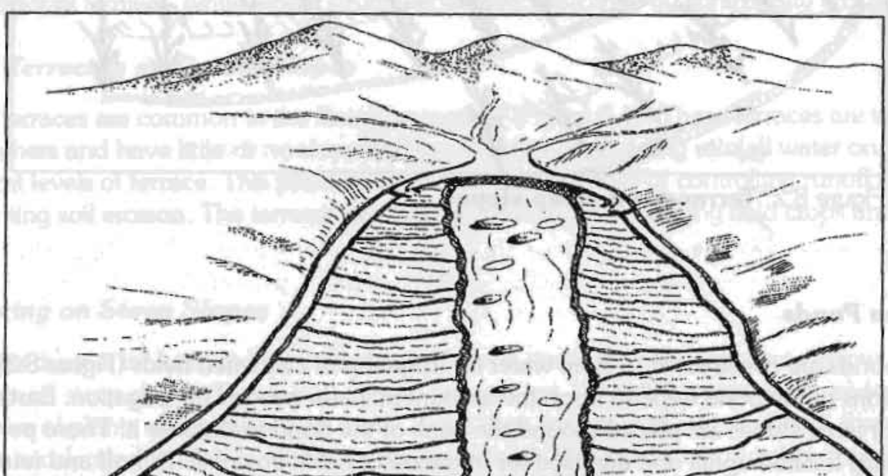


Figure 8.4: **Typical spring irrigation system with field bunding**

Water Wells (Kua)

A hole is dug in sedimentary rock where groundwater oozes naturally to the surface. The quality of this water is good for drinking as it is free of sediment, debris, and other impurities. This practice is also common in all the other villages in the watershed. A potential site for digging a well is identified by the elders of the community. Usually, these wells are dug near the foothills and close to the houses. Some people have constructed *kua* in their homes to meet domestic water needs. The depth of these wells is about one metre and widths range from 1 to 1.5 m.

Diversion Structures

Diverting floods coming from natural streams and gullies is an efficient method of harvesting runoff. Walls made of earth and stones are constructed to divert runoff to the terraced fields. These structures are temporary and farmers construct them on the spot to divert water to their fields. The diversion walls are four to six metres high and one to two metres wide. The efficiency of such structures depends upon the location of the area (upstream versus downstream), timely construction of the structures with respect to seasonal flooding, and on their strength to embank the flood water.

Spring Galleries

There are many springs in the watershed, although their number and capacity have decreased due to deforestation. In order to meet drinking water requirements, the government-constructed community water supply schemes. Under these schemes, water from small springs is channelled through G. I. pipes and collected into bigger storage tanks from where it is supplied to the local community by gravity flow. Pipes commonly burst in winter when temperatures are frequently below freezing.

Wooden Channels

Water over a natural stream or gully is conveyed through wooden channels (Figure 8.5). These channels are rectangular in shape and about 0.30 m deep. They are constructed locally by the farmers from cuttings of tree trunks. Pillars used to support these channels are

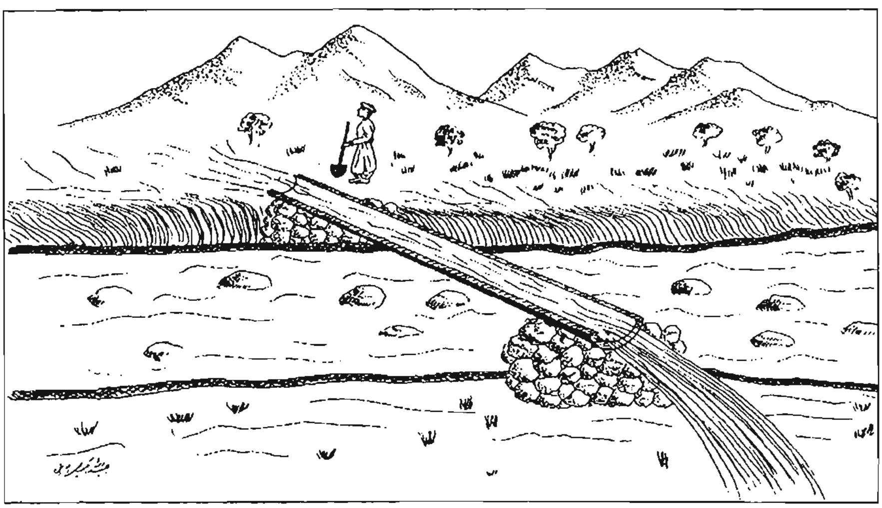


Figure 8.5: **A wooden channel**

also made of wood. This is a very simple, cheap, and effective method of carrying water over streams to cultivated land.

Gender Role in Water Harvesting

Water harvesting is generally carried out by men (Table 8.1). One of the reasons why men do this job is the risk involved in the control and diversion of fast flowing water to the fields. Women help to harvest runoff water, but their contribution is relatively small (4%). About one-third of interviewees did not respond to the question, because they did not own much land in the selected micro-watershed.

Table 8.1: **Gender role in water harvesting**

Name of Village	Women	Men	Individual House hold	Local Bodies	Govern-ment	No Response
	% Respondents					
Malokra	0	73	5	0	0	22
Palai	3	60	6	0	0	31
Kandi	5	52	5	0	0	38
Overall Avg	3	62	5	0	0	30

Management of Water Harvesting

Management of water harvesting for irrigation is normally carried out either by individual households (34 to 41%) or by communities (23 to 32%) as shown in Table 8.2. One-third of the households have no landed property and did not respond to this question. During snowmelt in April they construct earthen bunds to divert water to the fields. The role of the Government or NGOs in the development of water-harvesting practices in the selected watershed is negligible. However, the Government and NGOs have introduced various projects on water harvesting in other parts of the country.

Table 8.2: **Runoff water management system**

Name of Village	Community Management	Government	Individual	Other	No Response
	% Respondents				
Malokra	32	0 .	41	5	22
Palai	23	0	34	3	40
Kandi	24	0	38	0	38
Overall Avg	26	0	38	3	33

Organization of Farmers for Water Harvesting

In the watershed selected there is no formal organization for water harvesting. However, whenever they have a common irrigation channel or a water supply system, they do get together for its maintenance and repair in an informal manner (Table 8.3). About two-thirds of the people were not sure about any organization for water harvesting. It seems to be that farmers are organized for water harvesting, either by influential individuals or by landlords, for a specific task. Table 8.3 suggests a degree of leadership qualities ranging from 9 to 29% in individuals who organize farmers for water harvesting with no inputs from the Government.

Table 8.3: **Organization of farmers for water harvesting**

Name of Village	Individual	Community	By Land Lords	Govern-ment	No Response
	% Respondents				
Malokra	27	0	5	0	68
Palai	9	9	6	0	77
Kandi	29	10	5	0	57
Overall Avg	22	6	5	0	67

Distribution of Runoff Water

There is no proper method of runoff water distribution in the watershed area, but the natural general rule of upstream to downstream distribution is practised in the selected micro-watershed. Those land owners/farmers who are in the upper reaches of the watershed consider it their right to use the runoff water first, as no formal water users' association for distribution of water existed in the area. In the absence of a formal water users' association, it is but natural to follow the principle of the first opportunity by virtue of location along the stream.

Changes in Runoff Water Harvesting Practices

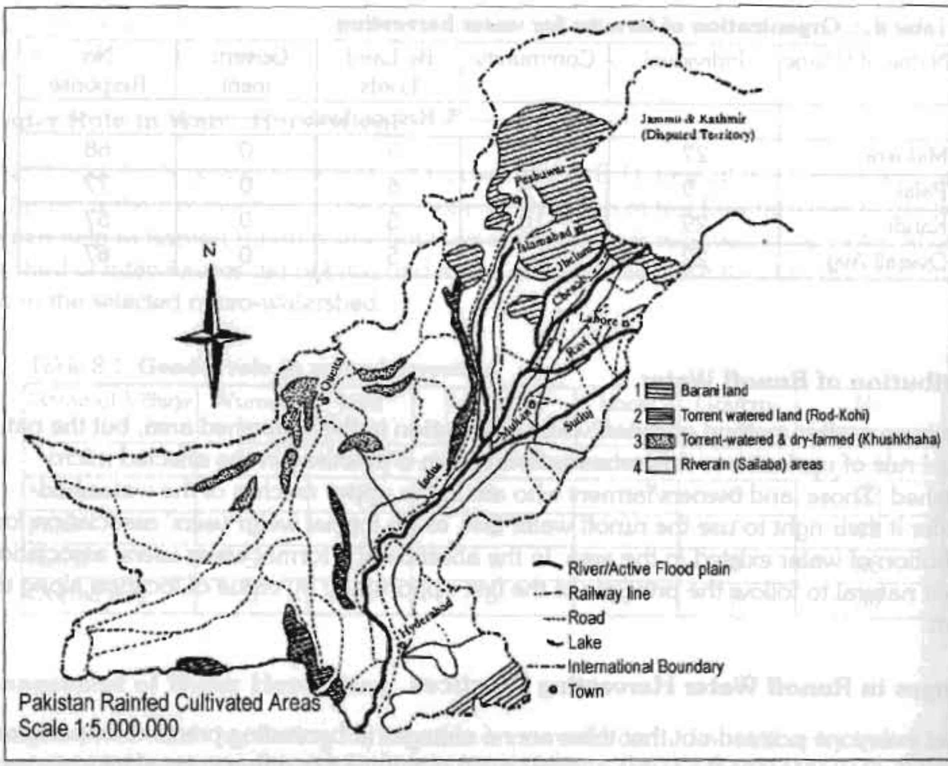
Almost everyone pointed out that there are no changes in harvesting practices or patterns for runoff water. Most of the farmers interviewed mentioned that there was always a scarcity of water during cropping season and that they would like to have more water for irrigation from the adjacent micro-watershed. This would mean major changes in the existing runoff harvesting system to satisfy crop requirements.

Critical Issues Related to Harvesting Runoff

About 10% of the farmers who harvest runoff use structures of mud and stone for diversion of runoff water to their fields for irrigation, and most of the time these bunds are washed away by floods. Harvesting runoff takes place only during cropping season. Runoff collects in some of the terraced fields from the upstream macro-catchment and in the case of heavy rainfall there is no adequate or safe drainage disposal system through which excess runoff can be removed. Because of inadequate storage capacity and a poor surface drainage disposal system, severe soil loss and, in some cases, even complete loss of cultivated land occur.

3. WATER HARVESTING PRACTICES IN OTHER PARTS OF PAKISTAN

Water harvesting is mainly practised in rainfed areas of Pakistan. The term rainfed means agriculture with controlled irrigation. It includes Rod Kohi, Sailaba and *Khuskhaba* cultivation (Map 1). Rod Kohi cultivation is carried out by diverting and spreading the intermittent flow of hill torrents. *Khuskhaba* cultivation is practised in the western cool, semi-arid region where crops are sown with a minimum of pre-cultivation either immediately after the first rains in winter or in expectation of precipitation in mid-December to early March. Sailaba cultivation refers to areas where production of crops depends on residual moisture from summer floods and rains.



Map 1: **Map showing rainfed cultivated area in Pakistan (Adopted from PARK, 1990)**

Khuskhaba

Khuskhaba cultivation is mainly found in Balochistan province (Figure 8.6). *Khuskhaba* cultivation is merely chance cropping with successful crops being raised on an average once in five years. Locally, the availability of moisture for crops is enhanced by water-harvesting

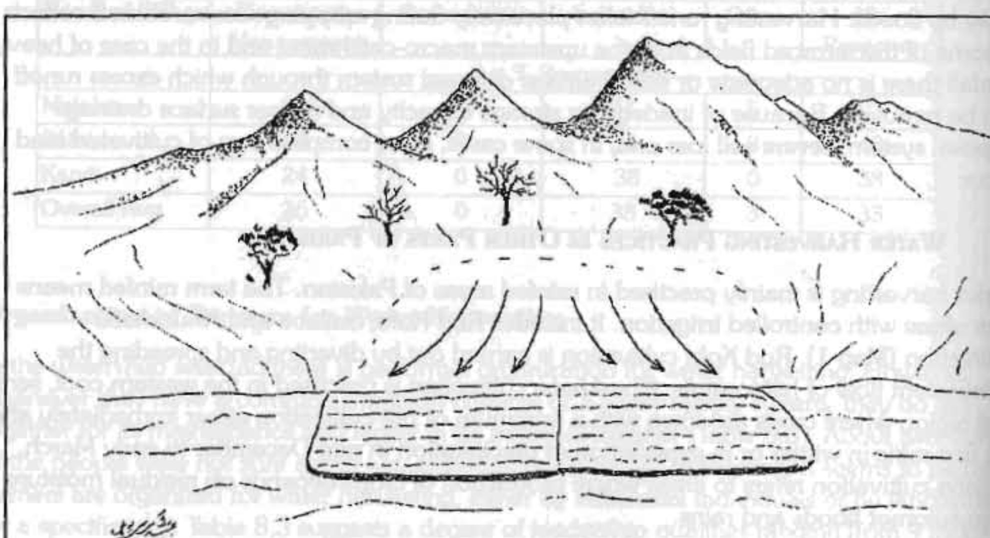


Figure 8.6: **Khuskhaba in Balochistan**

techniques in which runoff from large uncultivated blocks of land is diverted and carried to cultivated fields by means of ridges. *Khuskhaba* is mainly practised in the Quetta-Sarawan and Zhob-Loralai areas.

Rod Kohi

The Rod Kohi system of irrigation is known as the *Wandhera* system and uses flood water from mountainous streams (Figure 8.7). The flowing seasonal streams or *Rod* are blocked by earthen bunds, rain is fed into the bed and flood water is diverted to cultivated lands that have strong embankments built according to the rights framed through settlement. Manual and bullock labour are provided free of charge by farming communities to construct bunds to divert the flood water and this practice is called *Kamara*. The Rod Kohi system is largely practised in D. I. Khan (NWFP), but is also found on a small scale in other parts of Pakistan (Kohistan, Karak, Lasbela, Kachhi plains, the Salt range). In D. I. Khan district, it is under the overall control of the government /district administration (Revenue Department)

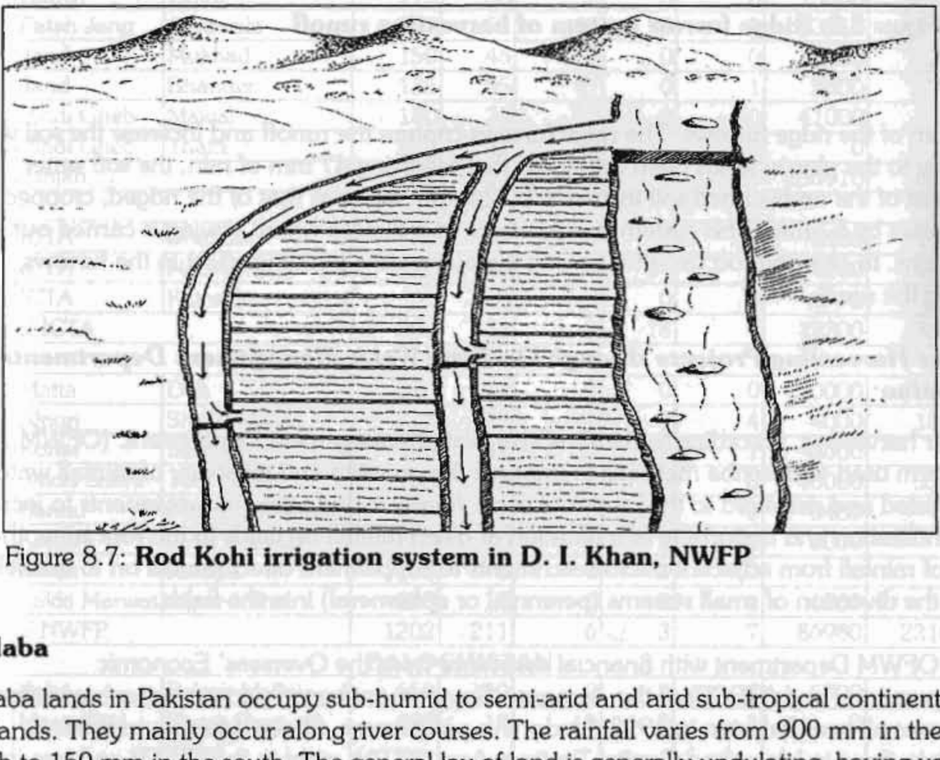


Figure 8.7: **Rod Kohi irrigation system in D. I. Khan, NWFP**

Sailaba

Sailaba lands in Pakistan occupy sub-humid to semi-arid and arid sub-tropical continental lowlands. They mainly occur along river courses. The rainfall varies from 900 mm in the north to 150 mm in the south. The general lay of land is generally undulating, having young floodplain features of sandy levees, silty flats, and clayey depressions. The silty flats covering 70 to 80% of the area are used for unirrigated cultivation of wheat crops using residual moisture from summer floods. Because of flood hazards, little cropping is carried out in summer. It is practised mainly in the Indus floodplains. Crops are grown after monsoon season is over. It is usually winter cropping.

Ridging

In ridging an indigenous plough is used by the farmers (Figure 8.8). The instrument is made in such a way that when ploughing it pushes and loosens the soil to either side making ridges from 8 to 15 cm high. Farmers place the seeds four to six centimetres below the

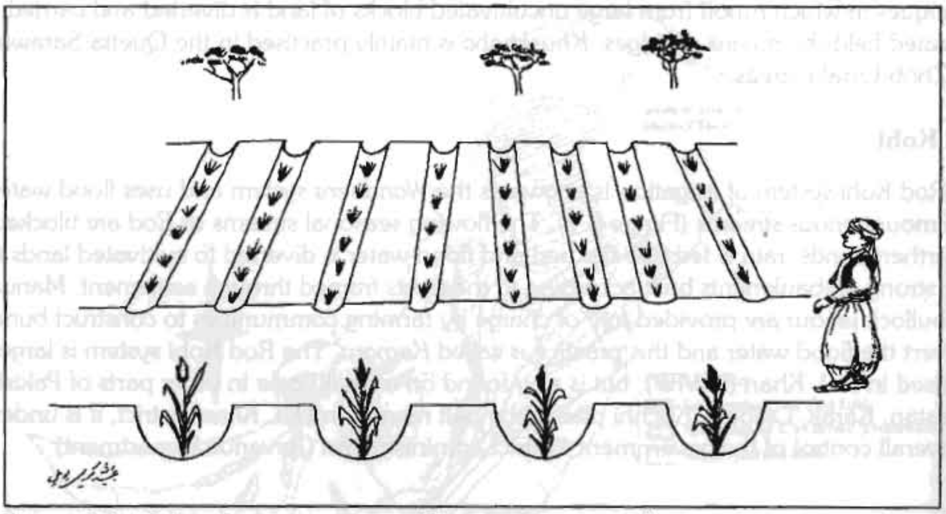


Figure 8.8: **Ridge furrow system of harvesting runoff**

bottom of the ridge furrows. The ridge furrows capture the runoff and increase the soil water supply to the plants. It has been estimated that following 47 mm of rain, the soil water content of the undisturbed soil increases by 24 mm, whereas that of the ridged, cropped soil increases by 57 mm. This system is only viable in a climate where sowing is carried out after the rains. In case rain occurs after sowing it may create a ponding effect in the furrows, killing the seeds.

Water Harvesting Projects through On-Farm Water Management Departments in Pakistan

Water harvesting, according to the On-Farm Water Management Department. (OFWM), is the term used to describe methods to improve the quantity and reliability of rainfall water harvested and delivered to the crop root zone. It may include field improvements to increase the infiltration and uniformity of infiltration of direct rainfall on fields to the root zone, the use of rainfall from adjacent micro-catchments to supplement direct rainfall on to the fields, and the diversion of small streams (perennial or ephemeral) into the fields.

The OFWM Department with financial assistance from the Overseas' Economic Cooperation Fund (OECF) of the Japanese Government began various water-harvesting schemes all over Pakistan in 1993. Under this programme, fifteen schemes in Barani Punjab, three in Islamabad Capital Territory Area (ICTA), eight in the NWFP, and two in Balochistan were completed. The goal of these water-harvesting projects was to manage water directly from rainfall for the production of field and tree crops and range grasses for livestock and human consumption in order to maximise farm income through improved sustainable productivity. The current status of these water-harvesting projects is summarised in Table 8.4. The principal activities undertaken in these schemes are forest and fruit tree plantation on steeply sloping lands, contour terracing, field spillways and waterways to control flow, and field bunding on gently sloping lands, storage ponds, and reservoirs and check dam construction in topographic depressions.

Table 8.4: **Status of water-harvesting projects implemented by the OFWM in Pakistan (1993-98)**

S. No.	Location	Name of Water Harvesting Site	Command Area (ha)	No. of Terraces	No. of Spillways	Water-ways (km)	Ponds/ Dams	Forest Trees Planted	Fruit Trees Planted
PUNJAB									
1	Rawalpindi	Kot Kolian	350	170	46	0	2	10000	1400
2	Kahuta	Sehale Ferozai	175	50	2	1	2	1000	0
3	Gugar Khan	NegialPur	100	37	3	0	1	7000	0
4.	Gugar Khan	Chehri Bangial	150	30	1	0	1	5000	0
5.	Jhelum	D. M. Waris	354	60	35	0	2	27400	2000
6.	Chakwal	Sirral	175	85	249	0	2	40000	500
7.	Chakwal	Koka Dakhli	170	44	0	0	0	7500	700
8.	Talagang	Mial	120	80	48	0	0	7100	0
9.	Talagang	Dher Moond	161	110	20	0	1	30000	0
10.	Attock	Golra	175	38	2	0	0	15000	500
11.	Fateh Jang	Ajoowala	257	52	62	0	0	13910	1000
12.	Jand	Mukhad	150	45	12	0	0	30000	300
13.	Jand	Bhander	135	65	47	0	1	2000	200
14.	Pindi Gheb	Makial	180	70	94	0	0	41000	0
15.	Pindi Gheb	Thatti	285	21	0	0	0	0	0
Total Punjab			2937	957	621	1	12	236910	6600
ICTA									
16.	ICTA	Dhahala	100	39	0	4	0	8100	1900
17.	ICTA	Nazirabad	200	14	0	14	0	4200	1450
18.	ICTA	Katreel	60	0	0	0	0	0	0
Total of ICTA			360	53	0	18	0	12300	3350
NWFP									
19.	Matta	Dub	200	24	0	0	0	30000	18000
20.	Alpuri	Shwar Maira	73	36	0	0	4	4000	1800
21.	Kohat	Bamma	100	31	2	0	1	3000	0
22.	Saido Sharif	Toot Shah	168	72	0	0	0	40000	3330
23.	Bannu	Danda Azimabad	95	11	0	1	0	6480	36
24	Kulachi	Gara Bakhtiar	200	25	4	2	1	2000	0
25	Karak	Karapa	138	0	0	0	0	0	0
26	Lakki Marwat	Ahmed Khel	228	12	0	0	1	1500	0
Total of NWFP			1202	211	6	3	7	86980	23166
BALOCHISTAN									
27	Kalat	Pulseir Malki	650	50	0	0	1	5700	0
28.	Musa Khel	Khosa Rara Sham	490	18	0	0	1	0	0
Total of Balochistan			1140	68	0	0	2	5700	0

4. Programmes and Projects on Water Harvesting

The Department of Forests, Fisheries and Wildlife, Department of Irrigation, Department of On-farm Water Management, Soil Conservation, Agricultural Engineering Department, Public Health Engineering, and Department of Rural Development are the major government agencies involved in the development of water-harvesting projects. The main activities of these departments related to water harvesting are described in this section.

Department of Forests, Fisheries and Wildlife

The mandate of the Department is sustainable and integrated development of natural resources. Some examples of the forestry sector projects on integrated watershed management are as follow.

Title	*Basic Concept*
Watershed Management Project	Watershed Protection through Afforestation
Social Forestry Project	Reforestation through Community Involvement
Siran Valley Forestry Project	Natural Resource Conservation through Community Participation
Flood Rehabilitation in the Himalayan Jungle Project	Community Participation
Environmental Rehabilitation in Malakand Division	Participatory Watershed Management
Protection, Conservation and Management of Migratory Bird Species in the NWFP	Sustainable Use of Wildlife

Department of Irrigation

The Department of Irrigation is generally dealing with major irrigation infrastructure and its operation and maintenance in Pakistan. However, under the Irrigation Department the Directorate of Small Dams is responsible for water-harvesting projects on a relatively large scale. The Directorate of Small Dams is constructing small dams for harnessing runoff water. Several small dams are being constructed throughout Pakistan. The Irrigation Department extends help to farming communities in the development of large spring irrigation projects in hilly areas. Besides that they also help in some places in the use of flood runoff water.

Department of On-Farm Water Management

The main task of the Department of On-farm Water Management is to line water courses and level land in the main irrigation system command area of Pakistan. However, recently they have also been working on water-harvesting projects. The main water-harvesting projects involve water tanks for collection of spring water in the hilly areas of Pakistan and small ponds for harvesting rainfall runoff. Recently the Department has been working on integrated watershed development projects in eight locations in the NWFP. Similar projects are being executed in other provinces of Pakistan with financial assistance from the Overseas' Economic Cooperation Fund (OECF) of Japan.

Department of Soil Conservation

The Department of Soil Conservation is mainly responsible for protection of cultivated land from erosion. The Department constructs flood protection structures to safeguard cultivated lands in the flood zones or from concentrated flow. The Department also constructed check dams, spurs, gabion structures, and ponds for water harvesting.

Agricultural Engineering Department

The Agricultural Engineering Department is mainly responsible for levelling uncultivated and cultivated land also for constructing tubewells for irrigation. In addition, the Department is also helping farming communities to construct diversion structures for runoff water harvesting.

Public Health Engineering Department

The Public Health Engineering Department is responsible for development, operation, and maintenance of drinking water supply schemes in both rural and urban areas. Mostly they construct tubewells for water supplies. In addition water supply schemes consist of construction of underground galleries, small dams on perennial springs and to check flood water, and storage reservoirs. In hill areas they collect spring water directly from the source and supply it to rural communities through galvanized iron pipes. Some drinking water supply schemes were completed about 10-20 years ago by the Public Health Engineering Department.

Local Government and Rural Development

This Department is responsible for providing different infrastructure and maintenance of the same and development projects (roads, schools, health, and drinking water supply) in the rural areas. In hill areas they collect spring water for drinking water supplies and also construct tanks/ponds for domestic use.

Other government agencies that are working in the rural areas on different development projects are given below.

- Communication and Works Department
- Water and Power Development Authority
- Health Department
- Livestock and Dairy Department
- Agricultural Extension Department
- Forestry Department
- Mansehra District Council
- Industries, Labour and Manpower Department
- Agricultural Research Universities

NGOs

Several NGOs are working in Mansehra on rural developments projects. However, in the selected micro-watershed, NGOs did not contribute much to development. A few of the important NGOs helping in the development of rural communities in Mansehra district are listed below.

- National Rural Support Programme
- Sarhad Rural Support Corporation
- SUNGI Development Foundation
- International Union for the Conservation of Natural Resources (IUCN)
- Mansehra Village Support Programme

Community Organizations (COs) in Mansehra

The rural communities are organizing themselves to change their destiny and get out of the chain of poverty and misery. At present there are more than a thousand community organizations that have emerged during the past decade in the NWFP. The names of the two village-based community organizations (VOs) are the

- Social Welfare Society and
- Harori Youth Club, Battal.

5. HUMAN AND INSTITUTIONAL CAPACITIES

Institutions play a vital role in the development of nations/communities. For stable regulation of important processes in societies, certain structures and patterns are established that are commonly called institutions. Institutions can be defined as those stable regulatory organizational principles and rules that govern interactive processes between the people themselves and the environment in which they are living. In societies social changes are induced by a multitude of exogenous and endogenous influencing factors. Most of the population in Pakistan lives in rural areas where economies are based primarily on agriculture. Important factors that induce institutional changes and lead to socioeconomic changes in the remote mountainous regions are as follow.

- Rapid population growth
- Increased expectations among the population
- Changes in demand
- Commercialisation tendencies
- Technological changes and advancement
- Government policy

The above-mentioned factors can produce endogenous social and economic tensions in the communities if the rate of development is not maintained by human and institutional capacities. No system, policy, or development activity can be successfully maintained and operated without the support of the local population. The support of local populations can be obtained in an effective manner provided the human and institutional capacities are sufficiently flexible and capable of accommodating changes in the cultural and socioeconomic norms and patterns. To introduce such changes in an area, literacy, learning aptitude, and economic needs are interdependent. Some of these aspects are briefly discussed in the succeeding section.

Technical Skills for Operation and Maintenance of a Water-harvesting System

There is no formal water users' association for operation and maintenance of water channels and drinking water supply schemes in the area studied (see Annex). However, informally they do construct and clean the irrigation channels as well drinking water supply schemes The farmers do have rich experiences in an informal tradition of collaborative work in such activities as the construction of mosques, irrigation channels, and the maintenance of both, besides farming activities such as weeding. This system of informal organization has been prevalent for a long time.

People definitely have the aptitude and tendency to cooperate and work jointly. There is great scope for development of human and as well as institutional capacities with respect to technical skills for operation and maintenance of WHS.

Role of Group Action in Use of Water Resources

The NWFP population is growing rapidly, widening the gap between consumption and availability of the resource. Therefore, pressure on the limited available natural resources and competition for the use of land and water resources increase. The role of group action is confounded by several factors such as small landholdings. However, construction of check dams, afforestation, and management of grazing land will increase the supply of spring water for irrigation and drinking water supplies. Since people were interested and showed a keen interest in development of such projects, it suggested that there is a need to organize them to be able to handle some of these projects through working and acting in groups.

Local Experiences and Implication for Policies on Water Harvesting

In general the farming communities living in the mountains have rich experiences in water harvesting. By participation of these local communities with the Government/NGOs their living standards can be improved. At present, because of poverty and small landholdings the spirit of cooperation is missing. Natural resources are shrinking and, as a result of overexploitation of these resources beyond their limits, severe problems have been created for local communities. A lack of committed local leadership because of the diversity of ethnic groups living in the selected watershed and low literacy rates are the main constraints to development activities. Poor coordination of efforts on the part of the Government and the rural communities is another cause behind degradation of natural resources.

6. POLICIES ON WATER HARVESTING/WATER RESOURCES

The world faces severe and growing challenges to maintaining water quality and meeting the rapid growing demand for water resources. New sources of water are increasingly expensive to exploit, limiting the potential for expansion of new water supplies. Water used for irrigation, the most important use of water in developing countries, will likely have to be diverted to meet the needs of urban areas and industries, but must remain the principal engine of agricultural growth.

New strategies for water development and management are urgently needed to avert severe national, regional, and local water scarcities that will depress agricultural production, parch the household and industrial sectors, damage the environment, and escalate water-related health problems. This chapter describes existing government policies on water harvesting, water management, flood protection, and their implications and strategies and institutional reforms to meet the mounting challenges now and in the future.

Harnessing of Hill Torrents

Food shortages have necessitated development of additional resources of land and water in Pakistan, as the gap between food production and the growing demand has been widening. In the circumstances, improvement of irrigation supplies to *barani* (rainfed) areas and cultivation of wastelands by proper management of hill torrent flows are considered inevitable. Proper management of these hill torrents can also help to protect people and infrastructure from devastating flood damage.

Depending upon the varying physiological and demographic conditions, five different types of strategy can be adopted for harnessing hill torrents: (1) dispersion structures, (2) diversion structures, (3) detention dams, (4) storage dams, and (5) channelisation. In addition to these structural measures, non structural measures in the form of vegetation and watershed management practices can also be adopted. The Government of Pakistan is keen to harness the flood flows of these hill torrents since they are located in the most backward areas of Pakistan and the tangible losses are tremendous. Moreover, management of these hill torrents is bound to stimulate other development activities in the area. The economic internal rate of return from the development of hill torrents is estimated to be over 25%.

Flood Protection Programme in Pakistan

Destructive floods, both large and small, have been taking a heavy toll on life and property in Pakistan. Monetary losses during major floods since 1950 amount to billions of rupees, including loss of land due to erosion along the banks of main and tributary rivers. In order to safeguard lands from inundation 5,550 km of embankment have been constructed along major rivers and their tributaries in Pakistan.

By proper planning, effective means can not only help to minimise flood losses but can also conserve surplus flows to increase water supplies for productive use and to promote the welfare of the community. This can be accomplished through construction of flood storage mechanisms.

Institutional Reforms

The present national policy is to establish a programme of participatory water management. The policy of participatory water management will bring about positive changes in water supply and management systems by achieving the following.

- Increasing irrigation efficiency, equity in water distribution, agricultural productivity, and service equality
- Increasing participation of farmers and mobilising the community, giving them a sense of ownership
- Reducing conflicts and political inference
- Using O&M funds effectively and promoting better cost recovery
- Better linkages since the farmers have been represented on Provincial Irrigation and Drainage authorities and Area Water boards.

The criteria for selecting locations for pilot projects includes easy accessibility of the system, positive attitude of farmers, a broad-based concept so that all aspects of water management can be addressed, canal/channels with representative ownership, and guarantees that withdrawal of government financial assistance can be effected without undermining the sustainability of the project/system.

Current Status of National Policies on Water Harvesting/Water Resources' Management

The ordinance for creation of Provincial Irrigation Development Authorities (PIDAs) has already been enacted by the provincial assemblies. The existing secretaries of Irrigation Departments are to act as managing directors for meaningful management of the authorities. However, it is essential that farmers should be given training in basic literacy, O&M of channels, water harvesting/management, assessment of water rates, accounting/book-keeping, election procedures and byelaws, and maintenance of equipment; whereas the Provincial Irrigation Department (PID) and on-farm water management development (OFWM) staff should be trained in the concept of PIM, improved role of institutions, research and development, and monitoring and evaluation.

7. Critical Issues and Recommendations

Natural resources are limited and there has to be a balance between their use and replenishment. The increasing population further aggravates the fragile ecosystem of the mountains through increasing demands for food, shelter, and jobs. Some of the critical issues to be addressed in future planning are listed here.

- Scarcity of agricultural land, water, forests, and other natural resources
- High rate of deforestation, desertification, and loss of biodiversity
- Food security-the immediate need is for food security at both household and community level. This can be achieved by increased agricultural productivity through efficient and wise use of the available land and water resources.
- A serious timber deficiency for fuel, construction, and so on
- The mountain economy is crippled and needs immediate attention.
- Slow pace of human resource development for management of natural resources
- Lack of educational opportunities
- Lack of employment opportunities
- Lack of adequate allocation of funding

The following recommendations are proposed to alleviate poverty and to conserve natural resources.

- Existing local water-harvesting technologies and management systems should be critically evaluated before any external technology is introduced.
- All watershed resource users should be involved in identifying problems.
- Training programmes that develop leadership attitudes, knowledge, and skills in local users should be organized.
- Women should be approached to identify their problems. For work with women, women motivators should be hired locally.
- The national policy should be to implement those water management and soil conservation activities that generate quick income and create an environment for sustainable development.
- An awareness campaign and assistance are needed to promote the awareness of rural communities about the efficient use of natural resources.
- The institutional capacity for natural resource management at the local level must be strengthened.
- New crops such as tea and fruit trees should be introduced to improve household income.
- Regeneration of watershed resources for strengthening infrastructures such as roads, health facilities, drinking water, and irrigation supplies with the participation of rural communities
- There is a need for greater efforts to strengthen farmer organizations/village communities in order to improve the operation and maintenance of the irrigation and water supply system.
- In general, there ought to be benefits from an improved extension programme addressing water requirements for different crops and assurance that farmers are fully aware of the problems of both over-irrigation and under-irrigation in obtaining good yields.

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Annex 1

Objectives of the Study in Battal, Mansehra District

The specific objectives of the case study were as follow.

- To assess and analyse the socioeconomic conditions of the communities in the micro-watershed command area
- To develop a better understanding of technical, organizational, and managerial aspects of Local Water-harvesting Systems (LWHS)
- To examine the gender and environmental considerations in LWHS
- To assess the policies for LWHS
- To investigate the existence of water users' associations and community- based organizations
- To formulate recommendations for the efficient use of natural resources in the watershed and measures to strengthen human and institutional capacities.

Selected Micro-Watershed

Site Selection Criteria

Certain criteria were kept in mind while selecting the watershed: the main points were as follow.

- The watershed and its inhabitants should be typical of the social and economic environment of the surrounding areas of the HKH.
- The watershed should have agricultural, forest, and rangeland.
- It should be easily accessible for the research team.
- The size of the watershed should be preferably between five to 50 sq. km.
- Rainfall and runoff data for the watershed should be available or easily estimible.
- The local people should be willing to cooperate with the research team.

The micro-watershed selected is representative of the surrounding northern mountains of Pakistan in term of socioeconomic conditions, cropping pattern, local water-harvesting practices, water supplies, and management system. It should be noted, however, that people residing in the southern mountainous areas of the NWFP have developed their own indigenous technologies and practices.

Information provided by the local people about the watershed during the rapid appraisal survey enabled us to estimate the area to be over five square kilometres. However, when the size of the watershed was determined from the Survey of Pakistan it was found to be about three square kilometres.

The Battal micro-watershed is located in the District of Mansehra in the North West Frontier Province of Pakistan. The total area of the district is about 439,423 ha, with an arable area of about 80,747 ha (18% of the total area). The average altitude is about 1,082 metres. Mansehra District has three tehsil(s) or sub-districts (Mansehra, Battagram, and Balakot) and a village council in (Union Council) Battal. Most of the area is hilly and agricultural land is in the form of terraced fields on the slopes of the hills (NWFP Development Statistics 1997).

The sampled population of the watershed totals about 900 inhabitants, giving a population density of about 300/km². It is located 25 km towards the north-east of the Silk Route (Karakoram highway) which leads to China and passes through Mansehra. It is located between latitudes 34.67° to 34.70° and longitudes 73.16° to 73.17°. The altitude of the watershed ranges from 1,500 to 2,000 metres.

Climate

The long-term average annual rainfall in the selected micro-watershed is well over 1,000 mm. Most of this rainfall (> 600 mm) occurs during monsoon (July-August) and during the month of March. The monthly average rainfall values are shown in Figure A1. It is obvious that September, October, November, and December are the driest months of the year. The selected watershed receives up to one metre of snow from December to March. Winter is quite cold, the temperature is below zero during the months of January and February, while the summer is pleasant with an average maximum temperature of about 25°C. The mean annual relative humidity at the selected site is about 59%.

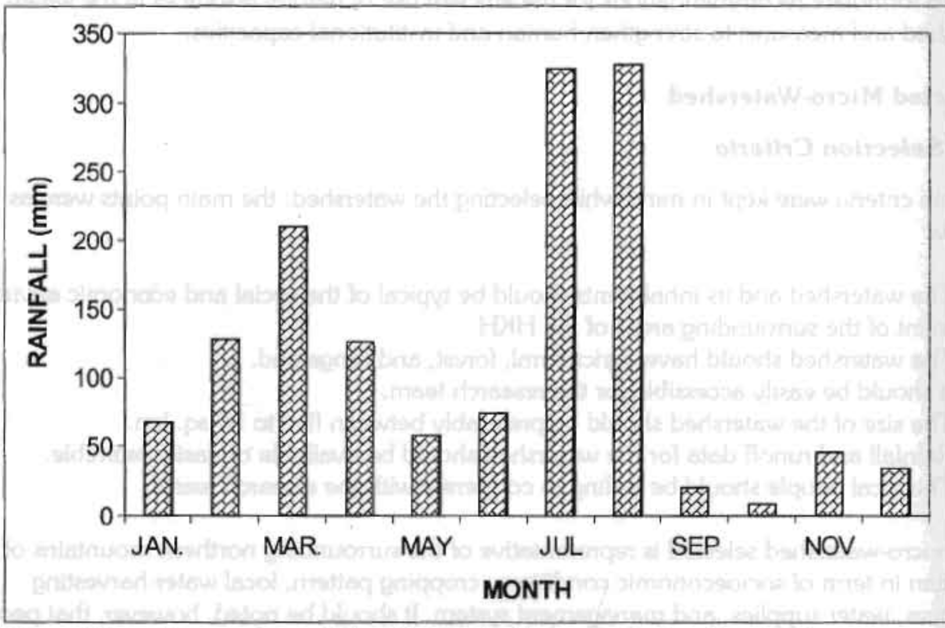


Figure A1: **Average monthly rainfall in the selected watershed**

Soils

The selected micro-watershed has rugged terrain and high relief with an average elevation of about 1,750 metres above mean sea level (masl). The soil and the vegetation vary along with their position on the top sequence. Soils on the steep slopes are lateritic and gravelly, whereas silt loam or loam are found in the valleys. The steep slopes in the upper parts of the watershed make agriculture virtually impossible and hazardous. Because each household has very limited land resources, the farmers grow maize crops on the very steep slopes. Population pressure has led to a serious degree of overgrazing, soil erosion, and deforestation.

Vegetation

Vegetation and crop production are influenced by the climate of the area. In the selected micro-watershed, maize and rice are the main summer (kharif or wet season) crops whereas wheat, mustard, and barley are the main winter crops (rabi). During winter, most of the watershed is covered with snow for four months, however, wheat, mustard, and barley are grown in the irrigated valley on a small proportion of the land. In addition, on a very small area, apples and some vegetables are also grown. Predominant forest species found in the area are *Pinus wallichiana*, *Pinus roxburghii*, and *Robinia pseudocacia*. Intense rainfall has resulted in a good vegetation cover. The common rangelands, however, are under tremendous pressure from overgrazing, and this has resulted in severe erosion problems on the steep slopes.

The objective of the study was to discover the constraints related to water resource development/management and explore possible solutions to improve the economic environment and provide the inhabitants with an opportunity to achieve an acceptable standard of living and income.

Methodology

This study can best be characterised as an exploratory one. The selected micro-watershed was visited by a field team. A structured proforma was used to collect information on the socioeconomic conditions, land use, water-harvesting technologies, water supplies, irrigation, and critical issues related to local water harvesting. Ninety-seven farmers were interviewed in three different villages (41 in Malokra, 35 in Palai, and 21 in Kandi). Open group discussions were held with the farmers to solicit their opinions about local water-harvesting practices. Besides interviews with the farmers, visual observations were also made. Information about the selected area was also collected from other sources such as government departments and NGOs working in the area. A sample survey was carried out in August-September 1998.

Socioeconomic Profile of the Households

The socioeconomic condition of the households was assessed in terms of age, literacy status, ethnic groups, housing and ownership, income per household, landholdings, and tenancy status. The results are presented in the following sections.

Distribution of Household Members by Age Group

The sample population was 900. About 20% of the population is below five years of age and a little more than 23% are from six to 16 years, which means that about 43% of the population is below the age of 16 (Table A1). These statistics indicate a heavy dependence

Table A1: **Distribution of household members**

Name of	Sample Size	Total Sample	<5 Year		6 -16 Year		16 - 60 Year		Total	
Village		Population	Male	Female	Male	Female	Male	Female	Male	Female
					(%)					
Malokra	41	353	11	9	13	10	30	27	54	46
Palai	35	358	10	12	18	13	23	24	51	49
Kandi	21	189	7	3	15	13	35	27	57	43
Overall Avg	97	900	9	8	15	12	30	26	54	46

ratio, and this is typical of the less developed area of the country. The female population is 46% of the total. On average each household has about nine members.

Literacy Status of Heads of Household

Household size in the sampled villages is given in Table A2. The literacy rate of the household heads was lowest (38%) in Kandi; however, overall it was found to be relatively high (50%). The NWFP has the second lowest literacy rate (17%) among the provinces of Pakistan and the literacy rate among females is exceptionally low (6%). In 1991-92, the male and female school enrollment rates were 73 and 25% respectively (Government of NWFP 1996).

Table A2: **Literacy status of heads of household**

Name of village	Literate household heads	
	No	Per cent
Malokra	25	61
Palai	15	43
Kandi	8	38
Total (Watershed)	48	50

This rate is for literate heads of households in villages.

Occupation — On average two persons in each household work on farms, one each working in Pakistan and overseas. Young men seek employment in Pakistan or overseas to earn a considerable amount of money in a short period. Employment and daily labour are an important source of income for the households. The cereal produced on the farms is hardly enough for six months per household. For the rest of the year they have to buy cereals from the market.

Ethnic Groups

The selected micro-watershed is inhabited by total diverse ethnic group (Table A3). The main tribes include the Gujar, and they account for 25%, followed by the Awan (21%), Akhund Khel (19%), and Swati (11%). The rest of the ethnic groups (the Tanoli, Kashmiri, Qureshi, Khunzada, Mughal, Turk, and Khoja) account 24%. All of the inhabitants in the selected micro-watershed are Muslims.

Table A3: **Ethnic groups in the selected watershed**

Cast	Total (%)
Tanoli	5
Awan	21
Swati	11
Akhund Khel	19
Kashmiri	3
Qureshi	6
Gujar	25
Khunzada	1
Mughal	5
Turk	2
Khoja	2

Housing and Ownership

Housing facilities in the selected micro-watershed are generally poor. Most of the structures (78%) are *katcha* (non-masonry), made of mud, wood, and stones and using very little or no cement (Table A4). Ventilation and proper heating are almost non-existent, room space per capita is very small, and the hygienic conditions are very poor—about four per cent of the houses are *pacca*. The houses are generally built on terraces and look like layers of dwelling structures. The courtyard of a house is the roof of the next one below and so on.

Table A4: **Housing structures**

Name of Village	*Katcha* Houses	Semi-*Pacca* Houses	*Pacca* Houses
		%	
Malokra	78	17	5
Palai	74	20	6
Kandi	81	19	0
Overall Avg	77	19	4

Katcha = mud house
Pacca = brick and cement (masonry) house

The majority of households (80%) own their houses. Rented houses account for 20%, while employers or other categories of houses do not exist (Table A5). In Palai village the number of house owners is relatively less (63%) than in the other villages. Most of the houses lack basic facilities such as flush toilets and piped drinking water supplies.

Table A5: **House ownership**

Name of Village	Owned Houses	Rented Houses	Houses provided by Employers
	%		
Malokra	85	15	0
Palai	63	37	0
Kandi	90	10	0
Overall Avg	80	20	0

Income Per Household

The per capita income of the sample households is below the national average (Table A6). The heavy dependency on salaries and wages (more than 80%) is rather striking. Income dispersion in the sample villages is relatively small. During 1993-94, per capita national income was about Rs 10,589.By assuming a growth rate of five per cent the projected per capita income for the year 1997-98 is expected to be Rs 12,871. The average per capita income of the households in the selected watershed is 35% of the national per capita income. This means that the majority of the population in the area is living below the poverty line level as it comes to approximately US$100 per year.

Table A6: **Income Per Household**

Source of Income	Income Per Household (Rupees)			
	Name of Village			Average
	Malokra	Palai	Kandi	
Cereal Crops	4585	1886	381	2284
Horticulture	0	0	0	0
Forest	0	0	0	0
Livestock	1171	171	0	447
Private Employment	15244	22800	15524	17856
Govt. Employment	18220	6286	27762	17422
Overseas Employment	5366	2057	0	2474
Total Income	44586	33200	43667	40483
Members per Household	9	10	9	9
Income Per Household	4954	3320	4852	4498

There were 45.00 Pakistani rupees to 1 US dollar in 1998.

Size of Land Holdings and Tenancy Status

In the selected micro-watershed, the land owned by the people includes rainfed land (36.8%), irrigated land (23.4%), forest land (20.4%), and rangeland (19.4%). This diversity is associated with the scarcity of water for irrigation. The average size of the farm per household in irrigated and rainfed areas of the watershed is 0.42 ha and 1.06 ha respectively (Table A7). Nieuwkoop (1989) reported that the average farm size in Buner is about 1.98 ha (irrigated and rainfed). The average farm size in the selected micro-watershed is 25% less than in districts adjacent to Buner with the same topography.

Table A7: **Landholdings**

Name of Village	Total Area (ha)	Irrigated	Rainfed	Range Land	Forest
Malokra	103.84	25.00	27.78	24.84	20.37
Palai	51.36	17.74	33.69	28.88	19.94
Kandi	14.57	16.90	33.91	20.35	0.71
Total	169.77	57.98	95.38	74.07	41.02

The majority of farmers (54%) are owners, followed by tenants (26%), and owner/tenants (20%) (Figure A2). The landholdings are very small (< 2 ha), except for a few landlords

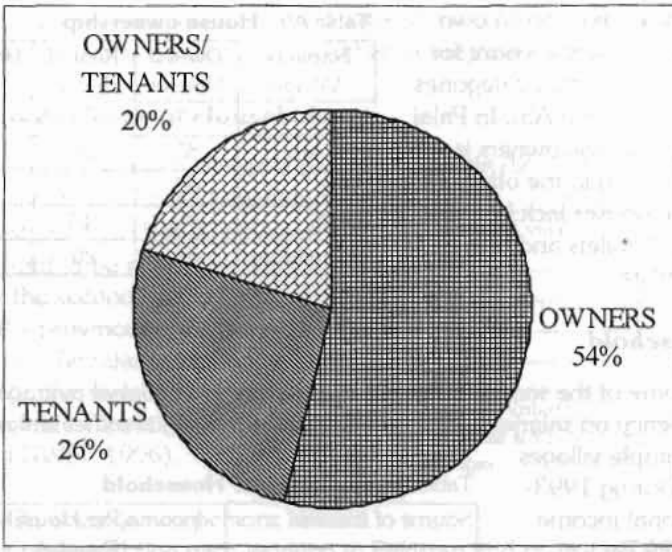


Figure A2: **Tenancy Status of the Sample Households**

who own more than 10 ha of land. Khan and Akram (1985) carried out a socioeconomic survey in Mansehra and reported that owners constituted 52.55 and tenants 12.3% and that the average landholding was 0.62 ha.

Forest Species and for Firewood Collection

The dominant forest species found in the area is *Pinus wallichiana* which covers more than 70% of the forested land (Table A8). Malokra has the highest percentage (70.3%) of forest area. On average forest land per household is relatively small: less than one hectare.

Table A8: **Major forest species in the area**

Name of Village (hh)	Forest Species	Forest Area (ha)	Per cent	Forest Area per Household (ha)
Malokra (41)	*Pinus wallichiana*	24.9	70.3	0.6
Palai (35)	*Pinus wallichiana/ Pinus roxburghii*	9.5	26.7	0.3
Kandi (21)	*Robinia pseudocacia*	1.0	2.8	0.0

The number and type of forest trees cut for firewood and building are given in Table A9.The number of forest trees cut for building purposes is less than one per year per household. Village-wise the number of trees cut per household per year ranges from 0.5 to 2 trees. However, in the absence of natural gas for cooking, trees are mainly cut for firewood. *Pinus wallichiana, Robinia pseudocacia* and *Ilenthus altissima* are the common forest species that are used for firewood in the area.

Wildlife

Biological diversity is under threat in Pakistan because of destruction of habitats and over hunting of discrete populations. This is in spite of the fact that Pakistan has ratified the International Convention on Biological Diversity and agreed to implement the

Table A9: **Forest species used for building and firewood**

Name of Village	Trees Cut per Household Per Year					
	For Building			For Fuel		
	Type of Tree	No	Per house hold	Type of Tree	No	Per house-hold
Malokra	*Pinus wallichiana*	14	0.3	*Pinus wallichiana*		
				Robinia pseudocacia *Ilenthus altissima*	71	2
Palai	*Pinus wallichiana*	16	0.5	*Pinus wallichiana* *Robinia pseudocacia* *Ilenthus altissima*	17	0.5
Kandi				*Robinia pseudocacia* *Ilenthus altissima*	27	1.3

recommendations of the United Nations Conference on Environment and Development related to Biological Diversity, which was held in Rio, Brazil, in 1992. The NWFP is home to different mammals and bird species. The endangered mammals are Barking Deer, Brown Bear, Chinkara Gazelle, Flat-horned Markhor, Hog Deer, and Kashmiri Grey Langur. Endangered bird species include the Cheer Pheasant and Western Tragopan. In the selected micro-watershed, a few common animals such as jackals and birds were reported by the respondents. However, it was pointed out by the interviewees that there had been more wild animals in the past.

Cropping Pattern

During the winter season, most of the watershed is covered with snow, making cultivation virtually impossible. However, in irrigated valleys, wheat, mustard, and barley are grown on a small area in winter: maize and rice are the main summer crops. Besides this, on a very small area, apples and some vegetables are also grown. A cropping calendar and a rotation schedule of the major crops grown in the selected villages are given in Table A10. Wheat-maize is the dominant cropping rotation on rainfed land as well as in remote irrigated areas. The other cropping rotations on irrigated farms are rice-berseem and rice-wheat. Khan *et al.* (1992) conducted a diagnostic study of five villages in Mansehra district. They found that major cropping rotations in the area were wheat-fallow-wheat, maize-fallow-maize.

Table A11: **Cropping calendar**

Crop	Sowing	Harvest	Cropping Rotation
Maize	April/May	Sept/Oct	Rice - Fodder-Mustard
Rice	April/May	Sept/Oct	Rice - Fallow-Wheat
Wheat	November	Jan/Feb	Maize - Fodder
Mustard	November	Jan/Feb	Maize - Fallow-Mustard

<u>Cropping Calendar</u>

In the selected sample villages, the cropping intensity is about 100% on rainfed and irrigated land. The farmers seldom keep their land fallow in summer. However, in winter, due to snow cover, they do not grow winter crops. Wheat is grown on a small area and is

Table A10: **Cropping Pattern in the selected watershed**

Name of Village	Rainfed Crops (ha)		Kharif Crops (Summer) Irrigated Crops (ha)				Rabi Crops (Winter)			
	Maize		Rice		Maize		Rice		Wheat	
	Total	Per HH	Total	Per HH	Total	Per HH	Total	Per HH	Total	Per HH
Malokra	26.0	0.6	0	0.0	1.0	0.0	33.7	1.3	2.7	0.1
Palai	8.6	0.2	1	0.0	2.5	0.0	14.8	1.7	1.3	0.1
Kandi	4.8	0.2	0	0.0	0.0	0.0	0.0	0.0	3.0	0.6
Total Watershed	39.4	0.4	1	1.0	3.5	0.1	48.5	1.2	7.0	0.2

used as a fodder for cattle (Table A11). Maize is normally grown in April/May and harvested in September/October, while rice is also planted in April/May and harvested in September.

Yield of Major Crops

Major crops grown in the selected micro-watershed in summer season are maize and rice. An average yield of maize in the sample villages ranged from 1,102 to 1,634 kg/ha and rice yields from 1,352 to 1,806 kg/ha (Table A12). The yield of both these cereal crops is far below the potential yield (about 3,000 kg/ha). The environmental conditions in the area could favorably be exploited for growing many field, fruit, and vegetable crops. New crop species and varieties, e. g. , sunflower, safflower, sorghum, soybean, lentils, canola; vegetable crops such as peas, onion, garlic; and fruit crops such as figs, apricots, and strawberries could be introduced. Introduction of these crops can increase the income of farmers.

Table A12: **Yield of major cereal crops**

Name of Village	Maize Cropped Area (in ha)	Maize Yield (kg/ha)	Rice Cropped Area (in ha)	Rice Yield (kg/ha)
Malokra	33.7	1634	26.0	1526
Palai	14.8	1220	8.6	1806
Kandi	9.6	1102	4.8	1352
Total Watrshed	58.1	1319	39.4	1561

Because of the poor road infrastructure, scarce water resources, and availability of poor agricultural extension services in the micro-watershed the farmers do not grow high value cash crops (fruits and vegetable). With improved infrastructure, such as roads and water supplies, the farmers would be able to grow more high-value cash crops. They would also benefit from technical knowhow about high-value cash crop production and protection technology.

<u>Livestock and Poultry</u>

The main types of livestock kept by farmers are buffaloes, cows, bullocks, goats, and sheep (Table 813). Buffaloes, cows, and goats are kept mainly for their milk. Bullocks are used as a source of draught power because the steeply sloping terraced fields and small holdings do not allow the use of tractors. Buffaloes are kept per household on average at a rate of seven cows, 17 bullocks, 13 goats, and five sheep per village. Because of the rough terrain, very few sheep are kept compared to goats.

The number of chickens per household ranged from four to seven with an average of about six. Comparing the average number of chickens with the average household size, it can be concluded that the production per family is not even one chicken per person. The major reason for low poultry production is disease. Two poultry farms are also raising chickens (Table A13).

Table A13: **Livestock composition**

Livestock	Livestock per Household			Average
	Malokra	Palai	Kandi	
Buffaloes	21	28	8	19
Cows	0	11	10	7
Goats	25	11	2	13
Sheep	0	14	0	5
Bullocks	12	21	18	17
Donkeys	8	11	0	6
Mules	0	0	0	0
Poultry	234	242	78	185
Horses	0	4	0	1

Annex 2

Local Water Supply and Management Systems

The main sources, quality, and distribution of water, maintenance of water supply systems, gender issues related to water supplies, and assessment of irrigation requirements for major cereal crops and maintenance of water supply systems are dealt with here.

Water Supplies for Irrigation

Main Source of Water Supply for Irrigation

Springs are the main source of irrigation in the selected micro-watershed, followed by ponds and runoff water. About 60% of the farmers irrigate their fields, although they only have small landholdings. About 39% of them use spring water for irrigation, nine per cent use runoff water, and 10% use pond water to irrigate small terraced strips of land to grow maize and rice in summer. In the winter, because of the snow, no crops are grown (Table A14). During a visit to the area in September, the amount of spring water observed was sparse (< 10 l/s), but people claimed that more water is normally available during the monsoon period (July and August) and severe shortages of water for irrigation occur during the months of May and June.

Table A14: **Main sources of water for irrigation**

Name of Village	Spring	River	Water Channel	Ponds	Runoff WH	No Response
	% Respondents					
Malokra	59	0	0	12	7	22
Palai	20	3	0	6	9	63
Kandi	33	0	0	14	14	38
Overall Avg	37	1	0	11	10	41

Quality and Quantity of Water for Irrigation

In general, the quality of water used for irrigation was found to be good. However, the quantity of water was less than the crops needed during the growing season. About half of the households with irrigated land complained about the shortage of water for irrigation (Table 8.15). Only 17% of the respondents were satisfied with the supply. In Kandi, which is located upstream in the micro-watershed, the availability of water is relatively better (38%) than in the other two villages. Malokra suffers from a severe shortage of water for irrigation, as 73% of respondents complained about the shortage (Table A15).

Table A15: **Sufficiency of water supply for irrigation**

Name of Village	Surplus	Adequate	Short	No Response
	% Respondents			
Malokra	0	5	73	22
Palai	0	6	31	63
Kandi	0	38	29	33
Overall Avg	0	17	44	39

Distribution of Water for Irrigation

Traditionally those living upstream in the watershed considered it their right to irrigate their fields first. As a general rule, during the division of land among the different households, spring water is also divided. If the flow rate of the spring is too small, then water turns are allocated to individual households. About two-thirds of the households interviewed mentioned that there is no water distribution. However, from 2 to 14% with an overall average of five per cent of the respondents stated that there is proper water distribution based on the numbers of families living in the area. Water is not distributed per landholding at all (Table A16).

Table A16: **Distribution of water for irrigation**

Name of Village	On Land Basis	Household Basis	Upstream to Down stream Rule	Crop Need Basis	No Distribution	No Response
	---------- % Respondents ----------					
Malokra	0	2	44	0	32	22
Palai	0	3	9	0	26	63
Kandi	0	14	19	0	33	33
Overall Avg.	0	5	26	1	30	38

According to the respondents, water is not sold. First upstream farmers irrigate their fields and if there is still excess water then downstream households can irrigate their fields. Upstream farmers can divert water to their fields any time and as much as they wish to do so. Sometimes the spring water available is divided into small streams and several farmers irrigate their fields at a time.

This issue of water rights has resulted in an inequitable and uneven water distribution system which has produced differences in the cropping pattern. The farmers along the headwaters of the spring grow more rice and use more water than those at the tail end. At the tail end, farmers do not get enough water, so they grow more maize and one can also see some fallow land. The farmers interviewed were not satisfied with the distribution system. In general, equity of water distribution is extremely poor in the schemes where there is no proper rotation.

Right and Access to Irrigation

In the mountain region, the general rules for water rights are (a) if the source of a spring is located on someone's land then he/she has the full right to divert the spring water to his/her fields for irrigation, but (b) if he/she does not need water or if the spring flow rate is more than his/her requirements then downstream farmers can irrigate their fields. The Government has declared land in the vicinity of a spring to be irrigated land, and pond owners and farmers downstream have the right to use the spring water for irrigation.

Maintenance of Irrigation Channels

On average about 45% of the respondents who had landholdings stated that maintenance of irrigation channels is usually carried out by individual households and 15% stated that it is carried out by the community (Table A17). In general, it can be concluded that maintenance of the field channels is carried out by individual households and headworks by the community with no support from government agencies/institutions.

Table A17: **Maintenance of irrigation channels**

Name of Village	Community Management	Government	Individual	Other	No Response
	% Respondents				
Malokra	12	0	66	0	22
Palai	17	0	20	0	63
Kandi	14	0	47	0	38
Overall Avg	15	0	45	0	40

Gender Issues Related to Irrigation

Irrigation is generally the task of men according to two-thirds of the respondents (Table A18). Women do participate in the irrigation of fields, but their participation is limited (4%).

Table A18: **Irrigation of cropped fields**

Name of Village	Women	Men	Both	No Response
	% Respondents			
Malokra	0	78	4	18
Palai	3	69	0	31
Kandi	5	62	0	38
Overall Avg	4	69	2	29

Irrigation Requirements for Cereal Crops

The major cereal crops grown during summer season are maize and rice. Maize is grown in both irrigated and rainfed areas. In rainfed areas maize is grown on about two-thirds of the cultivated land, whereas the area under rice is negligible. However, rice is the predominant crop on irrigated lands in the watershed and is grown on more than two-thirds of the area.

Requirements for Irrigating Maize

The requirement for irrigating maize crop was computed by CROPWAT by using weather data from a nearby weather station (Gilgat) at about the same altitude as local data were not available. Irrigation requirements per decade are shown in Figure A3. The peak irrigation requirements for maize occur during the month of June. The same was confirmed through interviews with farmers who stated that there was a shortage of water in the month of June. In general, irrigation requirements for maize ranged from 3 to 48 mm/decade during the growing period. In the month of July and August, as a result of the dense rainfall, the irrigation requirements were zero.

Requirements for Irrigating Rice

Rice needs much more water than other cereal crops. A lot of water is lost through pecolation, therefore, a continuous water supply is needed throughout the growing season. Irrigation requirements for rice per decade are shown in Figure A4. The peak irrigation requirements occur during the months of May and June. Irrigation requirements for rice ranged from 95 to 156 mm/decade during the months of May and June. During group

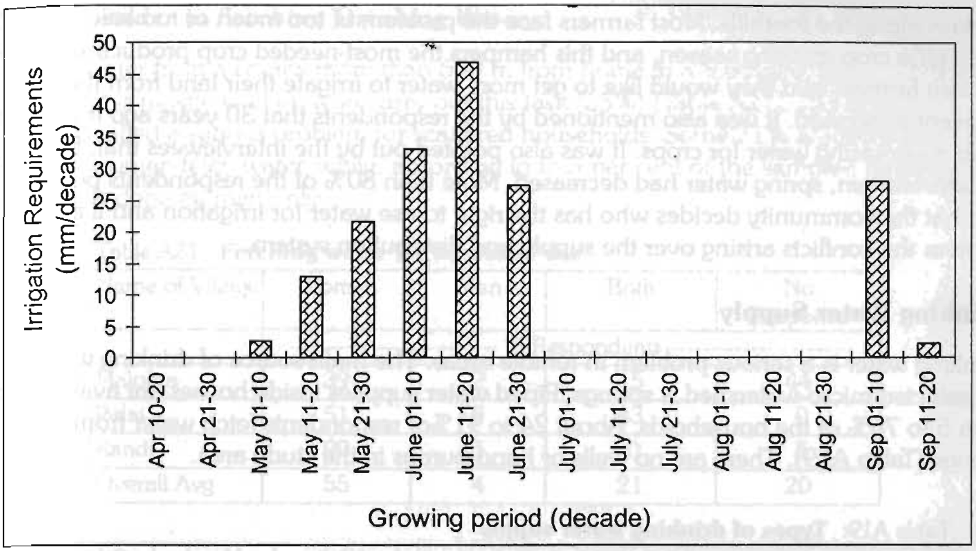


Figure A3: **Irrigation requirements for maize crops in Battal (Mansehra)**

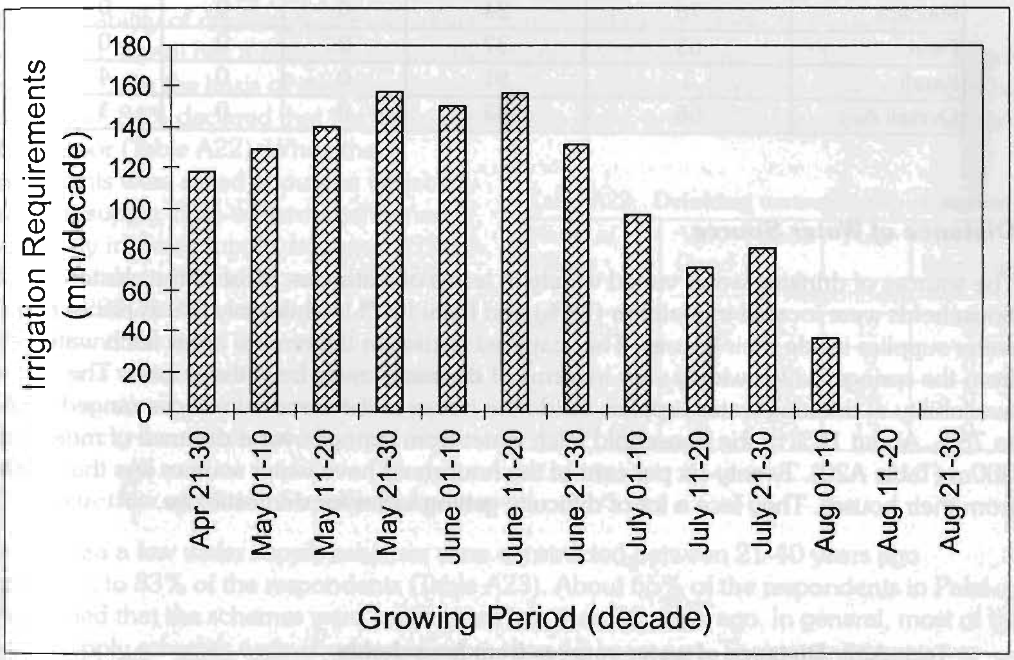


Figure A4: **Irrigation requirements for rice crops in Battal (Mansehra)**

interviews, respondents claimed there was a shortage of water. They proposed that water from the adjacent watershed be diverted to meet their irrigation needs because of the heavy irrigation requirements for rice.

Major Problems and Constraints in Supply of Water for Irrigation

The irrigated fields are small, located in rugged terrain, and difficult to reach. Only a small proportion of the land is used for agricultural production. Much of this land is in isolated pockets along the foothills. Most farmers face the problem of too much or too little water during the crop growing season, and this hampers the most-needed crop production. During the visit farmers said they would like to get more water to irrigate their land from the adjacent watershed. It was also mentioned by the respondents that 30 years ago there had been more spring water for crops. It was also pointed out by the interviewees that, because of deforestation, spring water had decreased. More than 80% of the respondents pointed out that the community decides who has the right to use water for irrigation and it also resolves the conflicts arising over the supply and distribution system.

Drinking Water Supply

Drinking water is a serious problem in remote areas. The main source of drinking water in the selected micro-watershed is springs. Piped water supplies inside houses are available for from 5 to 76% of the households. About 24 to 91%of respondents fetch water from the springs (Table A19). There are no wells or hand pumps in the study area.

Table A19: **Types of drinking water supply**

Name of Village	Pipe Supply inside house	From Spring in pitches	Wells	Hand Pump	Others
	% Respondents				
Malokra	76	24	0	0	0
Palai	63	37	0	0	0
Kandi	5	91	0	0	4
Overall Avg	56	43	0	0	1

Distance of Water Source

The sources of drinking water varied widely in terms of distances. Most of the cluster households were located in Malokra (78%) and Palai (60%), while only 5% in Kandi had water supplies inside their houses. The scattered houses in the remote areas fetch water from the springs, which widely vary in terms of distances away from the houses. The availability of drinking water supplies inside the house in the sampled villages ranged from 5 to 78%. About 18% of the household fetch water from springs over a distance of more than 500m (Table A20). Twenty-six per cent of the household have water sources less than 500m from their houses. They face a lot of difficulty getting water for domestic use.

Table A20: **Distance of water sources from households**

Name of Village	Inside houses	Less than 100 m	100-500 m	> 500 m	Others
	% Respondents				
Malokra	78	7	0	15	0
Palai	60	6	20	14	0
Kandi	5	33	33	29	0
Overall Avg	56	12	14	18	0

Role of Gender in Fetching Drinking Water

Fetching water from a source more than 500 m from home in a mountainous region is quite fatiguing. It is mostly women who carry out this task (55%) (Table A21). Drinking water can be rightly called a serious problem for scattered households. Some 21% reported that both men and women fetch water, while, according to four per cent of the sampled households, this work is done by men only.

Table A21: **Fetching water for domestic use**

Name of Village	Women	Men	Both	No Response
	------------ % Respondents ------------			
Malokra	39	2	15	44
Palai	51	8	43	0
Kandi	90	5	0	5
Overall Avg	55	4	21	20

Drinking Water Supply Situation

The availability of drinking water varied widely from village to village. In the selected watershed, Kandi has a relatively poor water supply (24%) compared to Malokra (12%) and Palai (9%). On the basis of overall averages, five per cent considered the water supply to be very good, 84% declared that the water supply was good, and 13% of them mentioned that it was poor (Table A22). When the inhabitants were asked about the variability in water supply, 80% of them mentioned a variability in water supply, however 20% of the respondents did not agree with them (Table A22). About two-thirds of the respondents declared that, in general, there was excess water available during monsoon (July-August), while there was shortage of water during the months of May and June.

Table A22: **Drinking water supply situation**

Name of Village	Very Good	Good	Poor	No Response
	------ % Respondents ------			
Malokra	5	83	12	0
Palai	9	82	9	0
Kandi	0	76	24	0
Overall Avg	5	82	13	0

Construction of Water Supply Schemes

In Malokra a few water supply schemes were constructed between 21-40 years ago according to 83% of the respondents (Table A23). About 65% of the respondents in Palai mentioned that the schemes were constructed less than 20 years ago. In general, most of the water supply schemes were constructed more than 10 years ago. Their maintenance was very poor. Due to landslides and snow, the water supply is interrupted for several days during winter and monsoon seasons. Maintenance of the drinking water supply is the responsibility of the communities/users.

Table A23: **Time-frame for construction of the completed schemes**

Name of Village	< 10 Years old	11-20 years	21-40 Years	> 40 Years	Others
	------ % Respondents ------				
Malokra	2	0	83	0	2
Palai	6	65	9	20	0
Kandi	19	14	29	24	14
Overall Avg	7	29	44	18	4

Quality of Drinking Water

Table A24: **Quality of drinking water supply**

Name of Village	Very Good	Good	Bad	No Response
	% Respondents			
Malokra	0	22	78	0
Palai	3	49	49	0
Kandi	0	81	14	5
Overall Avg	1	44	54	1

Only a few (3% in Palai) respondents considered the quality of the water to be very good; 44% thought it was good, whereas half of the respondents (54%) were not satisfied with the quality of drinking water (Table A24). The main reason is that open spring water is collected and supplied through the pipes. The main collection points are exposed to several contaminants, e. g. , animal waste, dead leaves, debris, and sediment. Animals also drink from the springs and some households wash their clothes in them. With such unhygienic water, chances of water-borne diseases increase.

Maintenance of Drinking Water Supply Schemes

Drinking water supply schemes are maintained by individual households (43 to 60%) or by the community (40 to 56%) (Table A25). Although, some of the water supply schemes were constructed by government agencies, they do not maintain them. Fifty per cent of the respondents stated that water supply schemes are maintained by individual households or by the community. During the visit it was observed that most of the water supply schemes were in poor condition. Several scattered households have dug shallow holes of about 50 litres in capacity near the bed of the concentrated flow in the watershed for collection of groundwater. They fetch water from these shallow holes for domestic use, while some fetch water directly from small springs.

Table A25: **Drinking water supply maintenance**

Name of Village	Community Management	Government	Individual	Other	No Response
	% Respondents				
Malokra	56	0	44	0	0
Palai	40	0	60	0	0
Kandi	52	0	43	0	5
Overall Avg	50	0	50	0	1

Major Problems Related to Drinking Water Supply

The quantity and quality of drinking water supplied to cluster households are very poor. Water supply schemes are in very poor condition and need to be improved. Water supply schemes collect water directly from springs and most of the inflow points are prone to contamination by debris, dead leaves, and animal waste. Due to lack of water supplies for domestic use some households wash their clothes and also bathe in the upstream reaches of the watershed. Another problem is that most of the pipes are exposed to severe weather conditions and landslides. Water supplies are interrupted by burst pipes in low temperatures or landslides.

On the other hand, most scattered households do not have piped water supplies because they are poor. Normally the women have to fetch water from springs for domestic use.

In the past there used to be more spring water but, because of deforestation and overgrazing, the discharge from the water source has decreased significantly as a result of greater runoff and limited percolation.

Chapter 9
Water Harvesting Technologies and Management System in a Micro-watershed in Ladakh, India

S. Dawa[1], D. Dana[2], P. Namgyal[3]

1. General

Ladakh constitutes the northern-most part of India. It is a high altitude region, the lowest point being 2,700 masl and some of the mountain peaks are over 7,000 metres high. Leh, the capital of Ladakh, is at an altitude of 3,500 m and there are villages as high as 4,500 masl.

Ladakh physically lies to the north of the Great Himalayan Range and south of the Karakoram Range. It is straddled by two other parallel ranges, the Zanskar and the Ladakh, in addition to the Great Himalayan and Karakoram ranges, all of them traversing roughly from south-east to northwest.

Ladakh is connected with other parts of India and the outside world by the 434km-long Srinagar-Leh road and 472km-long Manali - Leh road. The two roads remain open for traffic from June to October only. For the remaining seven months, no traffic is possible because of heavy snowfall over Zojila on the Srinagar-Leh road and over Rotang on the Manali – Leh road. During this period, the only available means of transportation between Ladakh and the outside world is by air.

Agriculture in Ladakh is completely dependent on irrigation and is spread over about 230 watersheds, big and small. The sources of water are rain, snowbanks, glaciers, springs, and marshes, depending on the location and size of the village. The larger villages (with fifty or more households) are generally situated on *tokpo* (streams) fed by snowbanks and/or glaciers located in the higher reaches of the catchment area. Smaller villages or hamlets (some as small as just one or two families) may depend on a spring only in addition to runoff from snowmelt or rain in the limited catchments above the villages. The size of the area irrigated in a watershed depends on two important factors (1) agricultural season and (2) availability of water.

The dates for sowing and harvesting are fixed by climatogical factors. These cannot be advanced or delayed without jeopardising the quality and quantity of crop yields. Advancing the sowing date may inhibit germination of seeds and any delay in sowing may lead to a situation in which the crop may not mature at all because of low temperatures or even snowfall during late autumn.

Rather than the total quantity available, seasonality of water supplies restricts the irrigable area in a watershed. This is especially true of sizeable watersheds dependent on large snowbanks and/or glaciers. Generally the amount of water available in the *tokpo* when the first irrigation after sowing becomes imminent is critical. This is the time when the ambient temperature is not high enough to induce the melting of snow (not to speak of glaciers) in the higher reaches above the watershed but irrigation is indispensable for the welfare of the crop if it is to mature in time for a plentiful harvest. It can thus be concluded that the amount of water available in a *tokpo* during the first irrigation period generally limits the area that can be irrigated. All watersheds in Ladakh, except those fed by the Indus and its tributaries, have been developed by village communities to optimum capacity depending upon the minimum quantity of water available during the sowing season. Water that is seen going waste during the rest of the summer cannot be used given the limited resources of village communities. How to use the surplus water through an economically viable system is a challenge that modern planners and developers will have to meet in order to increase the area irrigated in any watershed.

2. SELECTION OF A WATERSHED FOR THE CASE STUDY

The selection of a watershed for the study proposed was finalised after going through a list of all the 200 and odd watersheds in the district. Given the limited period available for the study and vastness of the region, a short list of four was prepared. Details of the four watersheds are given in Table 9.1.

Table 9.1: **Description of watersheds studied**

S. No	Name	Area Irrigated(in *kanal[s]*)	Population 1981 Census	Source of Water for Irrigation	Orientation	Whether Village Share Wwater with Other Villages
1	2	3	4	5	6	7
1.	Alchi	77.0	557	Spring and snowmentl.	Northern aspect	No
2.	Phey	44.0	176	Local springs and *tokpo*	Southern aspect	Yes – village Phayang upstream has the prior right over the water of glacier/snow fed *tokpo*
3.	Stok	188.0	1,077	Glacier, snowbanks and springs	Northern aspect	No
4.	Sakti – Chemrey	468.7	2,809	Snowbanks, glacier and springs	Southern aspect	*Tokpo* shared by Sakti and Chemrey

Each of the above watersheds is easy to reach and connected by motorable road with Leh. All of them are within a radius of about 60 km of Leh, the capital of Ladakh. They are all in the main Indus Valley; Alchi and Stok on the left and Phey and Chemrey – Sakti on the right of the river. Alchi and Stok are single villages located on glacial/alluvial fans. On the other hand, Phey and Chemrey-Sakti, particularly the latter, are fairly long valleys on the southern side of the Ladakhi range. In fact, a large number of villages and watersheds in the district share similarities with these villages: location with a southern aspect, scarcity of water in early spring, little or no glaciers in the catchment area, fairly large irrigable area, and so on. Stok of course is a large watershed, but it is gifted with very large glacial masses; its only problem being its location to the north of the Zanskar range, which delays melting of glaciers/snow in early spring. Alchi suffers from a chronic shortage of water as there are no glaciers above. The limited snowbanks are not adequate enough to last the entire agricultural season. Consequently, shortage of water during the latter part of the season is the constraint as far as this village is concerned. Also, it is not a very typical watershed in that only one or two other watersheds (for example, Stakmachik) face similar problems. Phey was a bit too close to Leh; although being a small watershed a more intensive and in-depth study might have resulted. On the other hand, Chemrey-Sakti is a more representative watershed, and the report and recommendations based on it might have possibilities for replication in a majority of watersheds in the region. The present study thus includes the Sakti-Chemrey-Karu watershed with an emphasis on *pab-chu* which is perhaps unique to this watershed, though similar practices are prevalent in other large watersheds in the region.

3. The Watershed

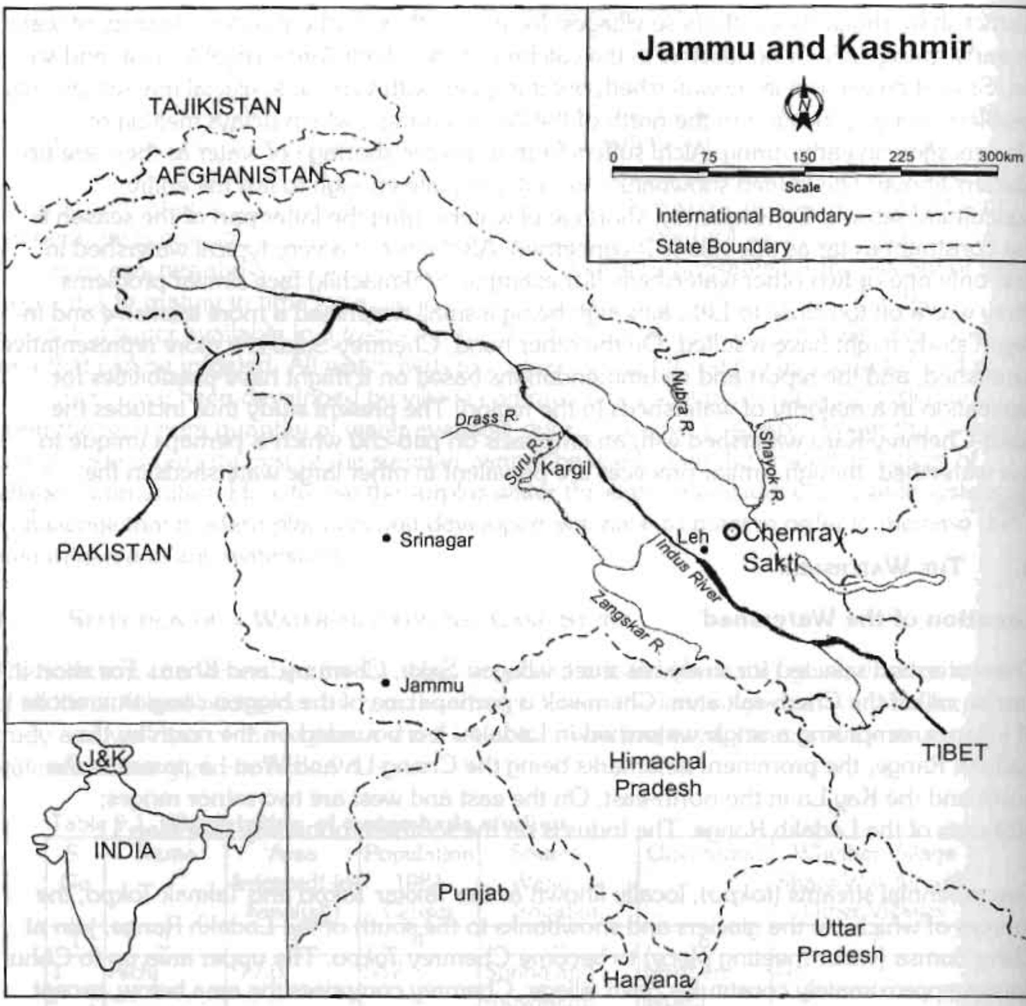
Location of the Watershed

The watershed selected for study has three villages: Sakti, Chemray, and Kharu. For short it can be called the Chem-sak area. Chem-sak is perhaps one of the biggest conglomerations of villages comprising a single watershed in Ladakh. It is bounded on the north by the Ladakh Range, the prominent landmarks being the Chang-La and Wari-La passes in the north and the Kay La in the north-east. On the east and west are two minor ranges; offshoots of the Ladakh Range. The Indus is on the southern boundary (see Map 1).

Two perennial streams (*tokpo*), locally known as the Takkar *Tokpo* and Taknak *Tokpo*, the sources of which are the glaciers and snowbanks to the south of the Ladakh Range, join at Chhu Zomsa (water meeting place) to become Chemrey *Tokpo*. The upper area up to Chhu Zomsa approximately constitutes Sakti village. Chemrey comprises the area below, except for the small village of Kharu which is situated on the right of the Tokpa in its lower reaches. Chemrey *Tokpo* joins the Indus at Kharu-do, which is located on the Leh-Manali/Leh-Nyoma road and is only 35 kilometres south east of Leh. Another important road going to Durbuk and Pangong takes off at Kharu-do and traverses the entire length of Kharu and Chemrey villages up to Dablung spring. The road then climbs in a rising gradient along the mountain on the left side of Takkar *Tokpo* in a series of hairpin bends until it crosses the Ladakh Range at Chang-La at an altitude of 5,358 m before descending to Durbuk and Pangong Lake area. One more road is under construction. This begins at Dablung spring and follows the left side of Taknak *Tokpo*. It will rise up to Wari-La (5,311m); its ultimate destination being Deskit in Nubra Valley. The watershed area is thus served well as far as roads are concerned.

Physical Attributes of the Watershed

The total area of the watershed 184 sq. km. Most of the area, however, is covered by dry and rugged mountain ranges, particularly to the east and the west, and contributes little to the watershed except for scattered bushes and other vegetable matter for fuel and grazing of animals. The mountainous area around Wari-La, Chang-La, and Key-La, on the other hand, is the source of water for the watershed, besides providing good summer grazing for animals.



Map 1: **Index Map**

The Y-shaped watershed has an eleven and a half kilometre trunk from Kharu-do to Chhu Zomsa and its upstream branches are each five and a half kilometres long up to the highest points where cultivation and permanent human settlements are feasible. Chang-La and Wari-La are again five to six kilometres away from these places as the crow flies.

Trade Centres of the Past

Earlier, Sakti and Chemrey were very important trading centres. During summer, Changpa, Tibetan nomadic traders, would come to Dablung with sheep, goats, and wool to barter for grain, and in the autumn they would come to Gamath in Chemrey to sell salt. At these times sheep and goats in thousands could be seen around the camp sites. The barter system involved considerable transactions in wool and salt as well as sheep and goats in exchange for *tsampa*, (ground barley) grain, apricots, and other products of Ladakh. The people of Sakti and Chemrey in general benefited from the trade. Some of the better-off families took an active part in the trade and made a profit. Unfortunately, after the 1962 India-China war, the trade stopped—to the economic detriment of the people of the villages.

Population

Of the three villages, Sakti is the largest in terms of population and Chemray the longest, the distance from Kharu-do to Dablung being eleven and a half kilometres. Kharu, situated on the right bank of the *Tokpo* in the lower portion of Chemrey, is the smallest. The populations of the three villages, according to the 1981 census were as follow: Sakti 1,620, Chemrey 1,060, and Kharu 129.Since no enumeration took place in 1991, the population in 1998 has been estimated at Sakti 2,600, Chemrey 1,700, and Kharu 200 (See Table 9.2).

Table 9.2: **Population of Chem-Sak Watershed**

Villages	1981	1991*	1998*
Sakti	1620	2120	2600
Chemrey	1060	1390	1700
Kharu	129	169	200
Total	2809	3679	4500

* Estimated

Religion

The villagers are almost all Buddhist by religion; there being only a couple of Muslim families in the entire watershed. Apart from the famous *Gonpa* (monastery) of Chemrey, the valley has the only Nyingmapa *Gonpa* (of Takthok) in Ladakh at Sakti, besides a small Gelugpa *gonpa* at Takar and the Kharu *gonpa* headed by the *Rimpoche* (reincarnate lama) of Stakna.

The three villages have a surprisingly large number of Lathos and La-Chang (Plate 1).

Geology

The valley of Chem–Sak is a longitudinal glaciated valley carved out of granite along the southern slope of the Ladakh granite complex. Three phases of granitic activity are reported: hornblende granite, hornblende biotite granite, and leuco granite with its appletic and pegmatitic veins showing an intrusive relationship with each other. The lenco granite is the most dominant and the youngest of all intrudes into the other varieties of granite present in the area. The hornblende granite is the oldest in this part of the Ladakh granite series. A few dolerite dykes also cross cut the granitic body in this area.

The granite, to the south, is uncomfortably overlain by a thick sequence of rhythmically bedded purple and green sandstone, shale, and conglomerates of the Indus Group. This contact is very well preserved South of Upshi on the left bank of the River Indus. The valley floor at higher level is covered by moraine composed of granite boulder at one to five metres with fine to coarse materials and gravel, cobbles, and stones. The glacial deposits descend steeply with the valley floor to merge with the alluvial terrace of Indus River. The alluvial terrace is standing five to ten metres above the present bank of the River Indus.

Soil

The watershed, as stated earlier, is a glaciated valley with the two sides comprising bare and rugged granite mountains between which are the glacial and culluvial deposits on which for over the ages have settled the villages of Sakti, Chemrey, and Kharu. The bed of the valley on either side slopes towards the *tokpo* which drains the valley. The soil comprising glacial and culluvial deposits is very similar to those obtaining in villages on the right of the Indus Valley in Ladakh. Generally, the soil in the watershed is considered to be very fertile and the villagers get a bumper harvest whenever there is no shortage of water in the *tokpo*.

Climate

Sakti is considered to be generally colder than Leh and it is at a higher altitude too. The altitude near Chhu Zomsa is 3,760 masl compared to 3,500 m at Leh. That Sakti is colder is indirectly corroborated by the fact that whereas wheat and fruit such as apples thrive in Leh, this does not apply to Sakti. Temperature data recorded by the Border Roads' Organisation (BRO) at Sakti and the Ladakh Ecological Development Group in Leh for one year seem to substantiate this, although in July 1998 Sakti was warmer by 1.36 degrees celsius during the day (Table 9.3). Table 9.3 also gives the temperature data for Changla where the minimum temperature is below freezing point throughout the year; the maximuim being above the freezing point only from June to October. This gives an indication of the time when snow or ice might possibly melt.

Table 9.3: **Irrigated and Irrigable Land**

Village	Area		
	Irrigated	Irrigable	Total Irrigable
Sakti	254.40	124.80	379.20
Chemrey	182.00	58.20	240.20
Kharu	32.30	13.50	45.80
Total	468.70	196.50	665.20

4. THE SOURCES OF WATER

The following passages discuss the main sources of water in the watershed.

Snowbanks

Although, like other villages in the district, not much snow occurs over the village, the depth of snow is greater in the higher reaches of the watershed. Unfortunately, no reliable data on snowfall in the higher reaches are available. Data for a year obtained from the Border Roads' Organisation (BRO) which maintains the road across Changla somehow appear to be far from reliable. The fact remains that the higher reaches receive considerable amounts of snow during the winter months which block the road sometimes for a week or two until cleared by deploying bulldozers as well as manual labour.

Rainfall

The average rainfall at Sakti may not be different from that of Leh, although the data made available by the BRO seem to show a much higher value. In the higher reaches more rainfall is received, particularly in the months of August and September—and this definitely should be contributing to the total water resources of the watershed at a time when the snowbanks have already melted away and water is required for the ripening of crops.

Glaciers

As the watershed is located to the south of the Ladakh Range, giving it a sunny aspect, only a few small glaciers are found in sub-valleys with northern aspects. Melting such glaciers should take place some time in late summer when there is solar insolation to melt the ice mass. In fact, there have been instances in which, during acute scarcity of water for irrigation, villagers have discussed the possibility of having a technology to induce glacial melt. The amount of water for irrigation contributed by rain, snow, and glaciers is unfortunately a question mark in the absence of reliable data.

Springs

There are quite a few springs, marshes, and oozing which visibly contribute their share, however small, towards the water resources in the watershed. Some of the larger springs and marshes are listed below.

1. Dablung (*spang chenmo*) spring and marshes (Plate 2)
2. Shagang Gnema *spang* marshes
3. Tsaskang Tubji spring and marshes

In the traditional Ladakhi water management system, springs and marshes have apparently received more than their due share of importance. In quite a few cases, certain families and hamlets situated immediately below springs or marshes have been deprived of any claim on the water from the *tokpo*. Four families: Kalaksa, Jonggar, Tongstot (1), and Tongstot (2) have an independent *Yura* (irrigation channel) by the name of Rumrum, which begins immediately below Dablung, to irrigate their fields. They have no right to the *tokpo*. Similarly, Shagangnema, with its springs and marshes, constitutes the source for irrigating the fields in Sabchak as well as the whole of Kharu village and the small hamlets up to Kharu-dho without any right, legal or traditional, to the water from the *tokpo*. Other examples elsewhere in the District are the hamlets of Skara below Leh and Ayu below Saboo which are exclusively dependent on springs and marshes without any right over the *tokpo* coming down from the upper parts of the village.

Agriculture

The areas irrigated, irrigable, and total irrigable land in the three villages as per the *riwaji-abpashi* (traditional irrigation system) of the Revenue Records are given in the box below. The irrigated area, it will be seen, represents only 2.5% and the total irrigable area only 3.6% of the watershed area. This is explained by the fact that most of the watershed area is covered by barren mountains. Even the 196.5 hectares of irrigable land which can be easily irrigated by the existing system, cannot be cultivated during certain periods of the limited agricultural season because of shortage of water. If water was not so scarce, there is enough land lying barren in Chemrey and Sakti which could be put to agricultural uses.

Only one crop can be grown in the watershed. Barley is the principal one; although some fields have peas or mustard. Only a very limited area in lower Chemrey is used to grow wheat. Similarly, fruit crops such as apricots and apples are rare and confined to Kharu and Kharudo.

5. WATER-HARVESTING TECHNOLOGIES

Yura and Zing

The *tokpo* that drain the watershed have their sources in the higher reaches of Changla and Warila in the Ladakh Range. The Takkar *tokpo* has two branches above Langday, one of them originating from a small glacier very close to Changla and the other from a glacier near Ke-la. Similarly, Taknak *tokpo* has three branches above Taknak. One of them begins at Wari-la and the other two, locally known as Zala Kongma and Yogma, have their sources in the small glaciers at the head of the *nallah* (valley) by the same name. The two *tokpo*, after joining near Chhuzomsa, continue downstream as Chemrey *tokpo* to join the Indus at Kharu-do.

The villagers of Sakti, Chemrey, and Kharu have, over the years, built numerous *yura* (channels or leats) draining out from the *tokpo* besides more than a dozen *zing* (tanks or ponds) for irrigation purposes. The *yura* are gravity channels dug in the soil and strengthened wherever required by drystone walls and rendered semi-impervious by using fine soil or sods. Each *yura*, at the place in which it begins, has a *raks* (crude bund or weir of dry boulders) thrown across the *tokpo* and a *rka* (sluice, generally a gap) with a *rka-do* (a boulder to close or open) to regulate the supply of water at its mouth. The *yura* itself, some as long as a kilometre or even longer with velvety turfs and carpets of flowers on their banks, makes a pretty picture in the rural landscape of the village (Plates 3 and 4). Their utility and efficiency are living tributes to the ingenuity of the Ladakhi farmers. The *zing* (ponds) are dug into the native soil with earthen bunds towards the downstream side buttressed with rough drystone masonry (Plates 5 and 6). These also have crude but quite effective outlets for delivering the accumulated water for irrigation as and when the pond is full.

Sakti and Chemray are two fairly large revenue villages in the district of Ladakh. Sakti is traditionally supposed to have a 100 families and Chemray 80 families. The number of families has, of course, increased over the years, there being 314 houses in Sakti and 241 houses in Chemray according to the 1981 census. Both of them are divided into four *ngalakh* or *chutso mohallah* (neighbourhoods). The four *mohalla* of Sakti are called Takar, Taknak, Hamil, and Tukchu, and those of Chemray Gnala, Peu, Gamat, and Yoknes. For the purpose of revenue administration, each village is headed by a *Nambardar* with a *kotwal* (assistant to the village) in each *chutso* under him.

There are 18 *yura* (5 on the right and 13 on the left side) of Takar *Tokpo* and 17 (9 on the right side and 8 on the left side) of Taknak *Tokpo* making a total of 35 *yura* in Sakti. Each *yura* has a name and a list of the *yura* is given below.

Sakti Village

Takar*Tokpo*(*Yura* on the Right Side)

1. Tagar Dung *Yura*
2. Rekha *Yura*
3. Lungkay *Yura*
4 Ladong *Yura*
5. Khabrak *Yura*

***Yura* on the Left Side**

1. Langday *Yura*
2. Tagar Dung *Yura*
3. Piyang *Yura*
4. Rangi-shell *Yura*
5. Sumkha *Yura*
6. Toktseling Gongma *Yura*
7. Toktseling Yogma *Yura*
8. Khabrak *Yura*
9. Tongspon Khangyok *Yura*
10. Phaney Yurtung *Yura*
11. Tongspon Yurtung *Yura*
12. Kyangkar Gongma *Yura*
13. Kyangkar Yogma *Yura*

Taknak *Tokpo*(*Yura* on the Right Side)

1. Taknak Gongma *Yura*
2. Pharkey *Yura*
3. Khekhar *Yura*
4. Zarok *Yura*
5. Tunchu Gongyur
6. Tukchu Yogur
7. Pigmo Rig *Yura*
8. Korkor *Yura*
9. Tukchu Payur

***Yura* on the Left Side**

1. Yulgo *Yura*
2. Balti *Yura*
3. Lharjay *Yura*
4. Deygong *Yura*
5. Thabi *Yura*
6. Taktak *Yura*
7. Lalay *Yura*
8. Olthang Tingting *Yura*

Similarly, there are eight *yura* on the right and eight on the left side of Chemrey *Tokpo* up to Shagang Gnema. They are listed below.

Chemrey Village

Chemrey *Tokpo* (*Yura* on the Right Side)

1.	Nalla Kongma *Yura*	5.	Ziyuma Gongma *Yura*
2.	Nalla Kongma *Yura*	6.	Ziyuma Yogma *Yura*
3.	Peu Gongma *Yura*	7.	Khalatse *Yura* Gongma
4.	Peu Yogma *Yura*	8.	Khalatse *Yura* Yogma

***Yura* on the Left Side**

1.	Yurlog *Yura*	5.	Payur *Yura*
2.	Larak *Yura*	6.	Yogyur
3.	Ketong *Yura*	7.	Yognes *Yura* Gongma
4.	Koyur *Yura*	8.	Yognes *Yura* Yogma

Downstream of Shagong Gnema, there are nearly a dozen *yura* in Sabchak, Tangye, Kharu, Tharmat, and Kharudoo. These have not been listed as they are entirely dependent on the springs and marshes of Shagang Gnema and have no right over the water of the *tokpo.*

In addition to the *yura* there are as many as 14 *zing* (tanks) in Sakti and Chemrey above Shagang Gnema. There are nine in Sakti and five in Chemrey:they are listed below.

Sakti

1.	Sumkha (Sherney Takar)	6.	Kharchug (Hamil, Taknak)
2.	Nagluk,(Sherney Takar)	7.	Tukchu Gongma (Tukchu, Taknak)
3.	Kyangkar (Takar)	8.	Pingmoring (Pharka, Taknak)
4.	Kyangkar Yogma (Takar)	8.	Tukchu Yogma (Tunchu, Taknak)
5.	Kalaksa (Hamil, Taknak)		

Chemrey

1.	Gnala Gongma (Gnala)	4.	Zeoma (Gamat)
2.	Gnala Yokma (Gnala)	5.	Zing Chhenmo (Yoknnes)
3.	Peu (Ppeu)		

Other Technologies

The *yura* and *zing* described above are the main water-harvesting technologies prevalent in the watershed. In fact these are the structures mostly in use in all the watersheds of the district. In addition there are some technologies peculiar to the watershed, or which are not very common. These are described in the ensuing passages.

Yursal or Yursar

There are two *yura*, one on Kay *Tokpo* above Tagar and another on Wari *tokpo* above Taknak, which divert the water from the parent *tokpo* for a kilometre or more but do not directly irrigate any fields. Both of them are at around 4,500 masl. They are given the name *yursar* (new *yura)* or *yursal* (cleaning the *yura*). The nomenclatures do not explain the purpose of the *yura*. According to the villagers, a considerable portion of the discharge of the parent *tokpo* somehow disappears if the water is allowed to continue flowing in it. Perhaps the water infiltrates into loose glacial deposits and subterranean channels and ultimately into underground aquifers, most probably to reappear as springs and marshes, but is lost to the farmers for immediate irrigation of their fields. The *yursar* which are built as gravity channels along the mountain slope avoid the portion of the *tokpo* where water visibly disappears. The water thus saved rejoins the *tokpo* at a lower point and becomes available for immediate use. During the old days, these used to be repaired and maintained by the villagers of Tagar and Taknak. For this, the villagers downstream, it is said, would contribute some grain for *yursal*, i.e., cleaning the *yura*. This apparently gave the name *yursal* to these *yura*.

Snow Fencing

In the old days the villagers constructed stone walls at right angles to the generally prevalent wind direction in Chang-la and Wari-la with a view to encouraging the deposition of snow on the leeward side of the wall. Remains of such walls can be seen even now. About two decades ago, the Public Works Department (PWD) built such walls a little below Wari-la. According to the villagers, these were very effective. Unfortunately there has been no proper monitoring and follow-up action. Snow fencing encourages deposition of snow thereby leading to moisture conservation and is mentioned in the Agricultural Yearbook of the U. S. Department of Agriculture (1995).

Ice Formation for Moisture Conservation

Two years ago boulders were placed as bunds across the *nallah* above Tagar. The idea behind this venture was that the water, when obstructed by the bund, would freeze and accumulate behind it and, on melting in early spring, would augment water resources. Unfortunately, the water did not freeze, although similar experiments in the *tokpo* at Shara are said to have been a success.

6. MANAGEMENT AND DISTRIBUTION OF WATER FOR IRRIGATION

Given the extent of the watershed area spread over a length of 16 to 17 kilometres, and the rather large irrigated area in the watershed of 665 hectares, management of irrigation in the watershed is bound to be problematic. This is accentuated by the fact that the watershed is comprised of three independent villages: Sakti, Chemrey, and Kharu. Sakti, located in the upper reaches of the watershed, obviously enjoyed a natural advantage, besides being the bigger in terms of population as well as cultivated and cultivable areas. Chemrey, though located downstream from Sakti with a smaller population and lesser-cultivated area, had its own sphere of influence historically insofar as it was the seat of one of the large monasteries of the Khagyudpa sect. Kharu is the smallest village and apparently had no claims whatsoever on the water of the *tokpo*. It depends on the springs and oozings of Shagang Nyema (marsh/meadow), which it shares with the Sapchak settlement of Chemrey, and Tsaskang Tupji spring, besides whatever surplus water is available in the *tokpo* after meeting the requirements of the irrigated areas in Sakti and Chemrey above Shagang Nyegma.

The villagers of Chemrey and Sakti, it appears, were always in an adversarial situation as they were dependent on the same *tokpo* for irrigation. For equitable distribution of the limited water, villagers had evolved a system by which water for certain days and nights was diverted to Chemrey by closing the mouth of all the *yura* (irrigation channels or leats) in Sakti. This was known as *pabchu* (water brought down by closing the *yura* upstream).

History of *Pabchu*

The earliest historical reference to the *Pabchu* system is found in an order issued by King Jamyang Namgyal in 1571 A. D. which stipulates that the water flowing in the two streams from the upper valley would be used for eight days and nights by Sakti village and four days and nights by Chemrey village.

Inevitably, as happens in such cases, there were disputes between the two villages and the matter reached the court of King Deldan Namgyal who issued an edict on the 16th day of the third month of the year of the snake, corresponding to the year 1629 A. D. , from the palace at Sakti. The order, while making mention of the repeated disputes over water for irrigation between the two villages and their inability to give a clear picture due to their respective village interests, had increased the number of days/nights by two in favour of Chemrey to 14 days/nights. Strangely enough, the order is silent as to when Sakti will irrigate its fields. It also requires the people of Chemrey to offer the meat of one sheep or goat and 12 pots of *chhang* (a local brew made from barley) to the people of Sakti. The custom of offering meat and *chhang* by the villagers of Chemrey continues to this day and is known as *Sha-Chhang* (meat-*chhang*). Tsespal Namgyal, who was the last king of Ladakh, before, the region was incorporated into the Jammu kingdom in the 1830s, as a result of the conquest by General Zorawar Singh of Maharaja Gulab Singh of Jammu, also issued an edict. The original copy of this order is available in Chemrey *Gonpa*. While mentioning the earlier orders of Jamyang Namgyal, Deldan Namgyal, and Tsewang Namgyal and their violation by the people of Sakti, the order again stipulates that Sakti people would use the water for eight days/nights and Chemrey for four days/nights. It further requires the Chemrey people to deliver *Sha-Chhang* to the Sakti people on the first of the third Ladakhi month and from that day until harvest the people of Chemrey are entitled to four days/ nights and the people of Sakti to eight days/nights.

The *riwaji-abpashi* for Chemrey, which was prepared during the first decade of the 20th century, is silent about the *pabchu*. However, and rather fortunately, the *riwaji-abpashi* for Sakti village makes specific mention of the entitlement to water for irrigation in favour of Chemrey village. An English translation of the relevant extract from the *riwaji-abshi is* reproduced below.

"In case there is an acute shortage of water, over a five-day period, water from the two streams for a day and night is taken by the people of Chemrey and water for four days and nights **used** by Sakti. Ngerpa of Chemrey *Gonpa* accompanied by the villagers of Chemrey divert **the** water from Taggar and Tagnak by fixing seals for one day and night. "

As prevalent today, the villagers of Chemrey draw the water of the *tokpo* for two nights and the intervening day, Sakti villagers using the water for seven days and six nights. The entitlement to water of the two villages as per the various royal orders, *riwaji-abpashi*, and the situation on the ground as of today, which has the obvious acceptance of both villages, is given in Table 9.5.

The Pabchu

The royal orders and a *Riwaj-i-abpashi* specify the periods for which the water of the *tokpo* will be shared between the villagers of Sakti and Chemrey. It is now proposed to describe in detail how this operates on the ground at present. The entire operation is known as *pabchu*. In the *pabchu* system the villagers of Chemrey upstream of Shagongnema use the water for

Table 9.5: **Entitlement to water for irrigation in Sakti and Chemrey according to royal edicts and other documents**

S. No.	Reference to Royal Order/ Other documents	Entitlement	
		Sakti	Chemrey
1.	King Jamyang Namgyal 1571 AD	8 days/nights (66.6%)	4 days/nights (33.3%)
2.	King Deldan Namgyal 1629 AD	Order silent	14 days/nights
3.	King Tsespal Namgyal	8 days/nights (66.6%)	4 days/nights (33.3%)
4.	*Riwaji-Abpashi*	8 days/nights (80%)	2 days/nights (20%)
5.	Present Situation	6 nights + 7 days (81%)	2 nights + 1 day (19%)

two nights and the intervening day and the villagers of Sakti for seven days and six nights thereafter. The lower portion of Chemrey comprising of 15 families of Yognes and 26 families of Gamat are responsible for the management of *pabchu*. Chemrey *gonpa* with most of its fields (nearly 18% of all fields) in these two *mohalla* has an important role. The villagers of Ngalla and Peu, although part of Chemrey, do not have any role in the management of the *pabchu*.

The first event in the *pabchu* system in the irrigation season is the delivery of Sha-Chhang (meat and *chhang*) comprising of a sheep or a goat and 16 pots of *chhang* (barley beer) by the representatives of Chemrey village to the villagers of Sakti. Of Late, IRs 500/- is paid in lieu of the meat. This takes place on the 3rd day of the 3rd month of the Ladakhi calendar. The meat and *chhang* are contributed by the *gonpa*. The actual *pabchu* can start on the 8th day of the 5th month of the Ladakhi calendar. Every time Chemrey requires a *pabchu,* a pot of *chhang* is delivered one day earlier to the headman of Sakti village. Sometimes Chemrey village may require an extra *pabchu* or two. This generally happens when the Ladakhi year has an extra month. In such cases people from Chemrey make a *shabe* (special request) for an extra *pabchu* for which again a pot of *chhang* called *shadam* (literally a water bottle) is delivered to the headman of Sakti. On the day fixed for a *pabchu,* one member each of all the 41 families of Gamat and Yognes proceed to the various *yura* to divert the water. The team is led by two *Churpon*(s) (village water overseers), one each from Gamat and Yognes, two *Chukorpa*(s) (water supervisors) supervise the operations and two *Thetse-pa*(s) whose duty is to affix an impression of a *the-tse* (wooden seal) (Plate 16) on a bund across the mouth of all the *yura* above Zeomazing. Each family is allotted a *yura* or two for watch and ward, and the turn is fixed for three years by drawing lots. The *Churpon*(s) were earlier elected by the villagers when persons with qualities of leadership and influence were preferred. Generally this took place after the conclusion of *saka* (ceremony to work at the date for the first ploughing of the season). Of late the status of the *churpon* seems to have dimished and the position is being assumed on a turn by turn basis. The same thing has happened with the *Chukorpa(s)*. Earlier the position was held by two prominent families, the Nyerpapa and Tongspon, in the the village.

In the past, the *Gonpa* also took a very active part and contributed a team of six persons: the *Ngotsab* (representative of the Chhagzot), *Nyeryog,* two senior lamas, and two junior lamas. No one from the *Gonpa* participates now. If found absolutely necessary the *Chhagzot* (manager) sometimes puts in an appearance. The representatives of the 41 families of Gamat and Yognes, including the two *Churpon*, two *Chukorpa*, and the two *thetse-pa* leave for Sakti late in the afternoon when the lamas of Chemrey Gonpa are called to *Tsok* (assembly) by ringing the *Gyalna* (royal gong) from the roof of the *Gonpa*. This is at about 3 p.m. The two *thetse-pa(s)*, after diverting the water, fix the wooden seal on each of the *yura* up to the *chuzomsa* and then one of them proceeds to Tagar and the other to Taknak, repeating the operation on each *yura*. Meanwhile, the representatives responsible for the watch and ward of the *yura* station themselves at the headworks of the *yura*. The five *yura* between Zeoma *zing* and *Zing* chhenmo are closed simultaneously and representatives from Yognes are responsible for their watch and ward, although no seals are impressed on these. The water now flowing down the *tokpo* for the whole night is stored in Zeoma *zing* and *Zing* chhenmo by roughly dividing it into two equal parts. This goes on for the following day and the next night also, except that three *yura*, namely, Tagar Dong, Rangi Shell, and Khabrak in Sakti are entitled to *Do-tam* from mid-morning (about 10 a.m.) until shadows appear on Urgain Tak (a rocky feature opposite Taktak *Gonpa*) in the evening (about 5 p.m.). *Do-Tam* means a mark on a stone, a sort of gauge to determine the depth of water to be let into the *yura* which is apparently a concession from villagers of Chemrey to the fields belonging to the *Gonpa* and the Kalon family. Lalay *yura* on Taknak *tokpo* also gets *Do-Tam*. According to the Chemrey villagers this was extracted by the head of an influential family on the plea that fish will perish if the *yura* is completely dry. In fact, sometime the *Do-Tam* for Lalay *yura* is called *nyachu* (water for fish). The six *yura* in Ngala and Peu *mohalla* in Chemrey, namely, Ngala Gongyur, Ngala Yogyur, Peu Koyar, Peu Yokyur, Yarlok, and Larak are also entitled to *Do-Tam*. Earlier representatives from Ngala and Peu went to Khabrak on the Tagar *tokpo,* where the *Ngotsab* of the *Gonpa* would be camping, to request the *Do-Tam*. Now that the *Ngotsab* does not participate, the *Do-Tam* for the six *yura* are allowed automatically, the timing being the same as for the *yura* in Tagar *tokpo.* Kiting and Zeema Kongma *yura* are allowed water from early morning besides the *Do-tam* as families under the two *yura* take part in *pabchu* operations also.

At about 5 p.m. in the evening when shadows appears on the Urgain Tak, *Do-tam* is discontinued and the *yura* are again sealed by the *thetse-pa*. Water from all the *yura* continues to flow down to Zeoma and Zing chhenmo during the night. During the late hours of the second night, when the sparrows begin to chirp (about 4 a.m.), the villagers of Gamat and Yognes, who have been guarding the *yura* for the previous two nights and the intervening day leave for their homes, thus signalling the end of a *pabchu*. The farmers of Sakti and Ngala and Peu in Chemrey then divert the water of the *tokpo* into their *yura* as per arrangements applicable during the non-*pabchu* period.

Distribution of Water from the *Pabchu* in Gamat and Yoknes

The water that flows down on the first night is called *pabchu* and that of the second night *chatchu* (water to be cut off). The flow is naturally greater during *chatchu.* During an extremely dry season, *pabchu* water which reaches Zeoma *zing* at about midnight and *Zing* chhenmo a little later can hardly fill the two *zing* by morning. When full, the *zing* can irrigate about half its command area. Once Zeoma *zing* is filled, Gamat can use its share of the water by diverting it into its *yura.* Since the two *zing* and *yura* under them happen to be the main beneficiaries of *pabchu,* details about the two *zing* and *yura* under them are given in Table 9.5. It will be seen that the capacity of Zeoma *zing* is 2,550 cubic metres and that of *Zing* chhenmo 2,830 cubic metres. The two *zing* together irrigate about 118 hectares of which 8.73 hectares are *Majing* (best land) 85.08 hectares *Barjing* (average land) 8.95 hectares *Thajing* (poor land), 5.05 hectares *Olthang* (pastures with alfafa or lucerne crops), and 10.09 hectares others (miscellaneous).

The water collected in Zeoma *zing* or *Zing* chenmo is distributed through the *yura* by dividing it into four equal parts to four groups of families in each *zing*. Each group is headed by a *margo* (group leader) and the water is rationed in order to irrigate the maximum area in each group.

Distribution of Water during the non-*Pabchu* Period in Different Villages

Chemrey-Chemrey village comprising four *mohalla* has its own management system for distribution of water from the *tokpo* during the non-*pabchu* period. While water during the day is used by the villagers of Ngala and Peu, all the *yura* of Ngala and Peu are closed and water diverted to Gamat for two nights and to Yognes for one night. This arrangement is called *ziray*. The *yura* below Zeoma *Zing* in Gamat are also closed on the night when Yognes gets the *ziray*. During a *ziray*, half the villagers of Gamat are involved in diverting the water of the *yura* in Ngala and Peu which is stored in Zeoma *zing* and subsequently used for irrigation of the fields. During the next night, the other half of the village does the same. The same arrangements are made for the night when Yognes gets the *ziray* except that they have to arrange for watch and ward of the *yura* between Zeoma and *Zing* chhenmo also. The water of course is stored in *Zing* chhenmo and used during the day for irrigation.

The villagers in Yognes are entitled to the water of the *yura* below Zeoma *zing* during the night when Gamat receives *ziray*. This is called *zaga*. For *zaga* the families in Yognes are divided into four groups and a group manages the diversion of water from the *yura* below Zeoma and it is used for irrigation after storing it in *Zing* chhenmo. It will thus be clear that during the six non-*pabchu* nights Gamat gets four *ziray* and Yognes gets two *ziray* and four *zaga*. For *ziray* and *zaga*, a day is reckoned from chirping of sparrows in the morning to the ringing of GyalGna from the roof of Chemrey *Gonpa* (about 3 p. m.).

Sakti-Being located upstream, Sakti has little problem in the distribution of water during the non-*pabchu* period. Generally, the upper portion of the village irrigates during the day and the lower portion during the night by storing in *zing*. Takar proper uses the water of the *tokpo* from the rising of *minduk* (the Pleiades constellation which appears at about four a. m.) in the morning sky to mid-morning (about 10.00 a. m.) followed by Kyankar up to mid-day. From mid-day to evening, it is again the turn of Takkar proper. Sharney collects the water from evening to the rising of *minduk* by storing it in the two *zing* of Sumkha and Nakluk and the fields are irrigated the next morning.

Table 9.6: **Salient features of the irrigation system in Gamat and Yognes *Mohalla*(s)**

Zing		Yura			
Name of *zing*.	Capacity in cm	Name of Yura	Approx. capacity (cumecs)	Approx. length metres	Area irrigated (ha)
Zeuma *Zing* (Gamat)	2550	(a) Zeoma Yogma	0.05	520	3.95
		(b) Koyur	0.15	1560	17.51
		Payur	0.17	1000	11.64
		Yogyur	0.14	600	31.82
Zing Chhenmo (Yognes)	2830	Yura Kongma	0.16	750	27.60
		(c) *Yura* Yogma	0.17	1500	20.11
		Khalatse *Yura*	0.05	250	5.25
				Total	117.88

On the Taknak side, night water is used by Hamil and Tookchu by storing in Kalaksa, Kharchung, and Tukchu Kongma *zing*. The higher portion of the village —Taknak proper— uses the water during the day. Some of the lower *yura* are free to use whatever water is flowing in the *tokpo* both day and night.

Distribution of Water in Sabchak and Kharu

As stated earlier, areas below Shagang Gnema, comprised of the Sabchak and Kharu-Do hamlets of Chemrey and Kharu villages, have no claims on the *tokpo* water. They are completely dependent on the spring and oozings of Shagang gnema and other springs. Whereas Sabchak gets the water during the day, the water for the night is shared by Sabchak and Kharu Kongyur on alternative nights. The other *yura* depend on the springs downstream of Shagang gnema and whatever water may be flowing in the *tokpo*. It appears that Sabchak and Kharu generally do not face a shortage of water for irrigation.

7. Other Relevant Issues

Other Uses of Water

With farming as the main economic activity, irrigation is naturally the most important use of water in the watershed. For human consumption, people generally depend on the *tokpo*, although Sakti has a rudimentary piped water supply based on springs as the source which works during the summer months but has to be stopped in winter because of freezing conditions. The rising population and Army and Border Roads' Organisation (BRO) camps in the watershed are possible sources of contamination. A gravity scheme for Chemrey that began about 20 years ago has failed to function. Recently, a tubewell was drilled and hopefully the village will have a piped water supply in the near future.

As for the domestic animals, the *tokpo* will continue as the source for drinking water in the future also. There are no other demands for water from other sources except for irrigation to meet the demand for extension and intensification of agriculture from an increasing population.

Gender

Gender was a non-issue in traditional Ladakhi society in which women enjoyed a status in no way inferior to that of men. Women as mothers enjoyed special privileges in the family. Their role in agricultural activities was to prepare food and carry it to the work site, perhaps assisted by a grown-up daughter, while the men, including neighbours with whom the family has *bes* arrangements, were engaged in various laborious activities required from time to time. In fact most of the tiresome activities are carried out by men; lighter work such as sowing, levelling fields are carried out by the young, women, and the elderly. The special status of women in the traditional society is perhaps reflected by the fact that the best field of the family is given the name *majing* (mother's field) and to married daughters the parental home is the *makhang* (mother's house). Recent developments resulting in the men seeking paid employment, however, have put women under greater pressure and they have to spend more time engaged in agricultural activities which were traditionally done by the men.

The Traditional Water-harvesting Technologies

The traditional water-harvesting technologies have made a significant contribution to the development of the agricultural system and society in the region. These, particularly the ones based on *tokpo* and springs, make optimum use of water resources within the constraints of the seasonal water supplies and the short summer season when crops can be grown. Earlier, there was also the over-riding importance farmers gave to the production of cereals to meet their food requirements. The possibility of using the surplus water during the summer months for growing short duration crops like mustard, fodder, and vegetables on new areas to meet the growing demands of an increasing population needs to be examined. There is also scope for improving the efficiency of existing irrigation systems by reducing the transmission and seepage losses in the *yura* and *zing*. This will require identification of locally-available materials that are less susceptible to damage from frost for lining the *yura*.

The experiments already carried out for moisture conservation as ice and snow should be pursued and results thereof, if found viable economically, used to evolve suitable guidelines for identification of sites and specifications such as type, size, and spacing of structures required.

New technologies such as drip and sprinkler irrigation systems may be tried to establish their suitability for the local environment and crops.

Management System

The traditional management systems that have evolved over time in a traditional society obviously cannot meet the present day requirements when there are competing and conflicting demands for labour and other resources. This is clearly brought out in the case of *pabchu* in which forty or more people from Gamat and Yognes in Chemrey have to spend 36 hours guarding 50 or more *yura* during each round of *pabchu*. At an average daily wage of Rs 125 for labour, the total expenses for one *pabchu* in terms of wages alone will be around IRs 10,000. If an agricultural season requires five *pabchu*, this would mean IRs 50,000 per year. On the other hand, it should not be difficult to work out an equally, if not more, efficient system requiring at most 10 people to ensure the operation of the *pabchu*. This will need many meetings and discussions among the villagers of Chemrey leading to the constitution of a committee under a *Churpon* with initiative and qualities of leadership for management of the *pabchu*. It will also require negotiation and consultation with the villagers of Sakti and Ngala and Peu of Chemrey. The committee at a later date, when the Panchayati system is introduced, may function as a sub-committee of the *Panchayat*.

At present *yura* and *zing* are being repaired with funds provided by the Block Development Officer (BDO). Traditionally, these were carried out by the villagers voluntarily and regularly. They have now become dependant on government funding and when the funds are not forthcoming the *yura* and *zing* remain unrepaired. The proposed committee should be made responsible for the annual maintenance of the water-harvesting structures for which the necessary funds can be made available by the BDO through the *Panchayat* on a yearly basis.

Role of Non-government Organisations(NGOs)

Non-government Organisations have not done any work on water harvesting or management in the study area so far. The Government of India has introduced the concept of watershed development under the Desert Development Agency (DDA) and Sakti, Chemrey, and Karu will be taking up the programme soon. The programme, which is based on a participatory approach at the grass roots' level, will be funded by the DDA, each watershed getting an IRs 2,500,000 spread over a period of four years. Chemrey, Sakti, and

Kharu, considering the area and population, have been designated as four watersheds. Each watershed will have a general body representing all the families in the watershed with a Watershed Association to plan and implement the programmes. The necessary technical expertise will be provided by the Watershed Development Team (WTD) of the Project Implementation Agency (PIA), which ideally should be a Non-government Organisation, but can be a government department also in which no NGO is involved. In the case of Chemrey, Sakti, and Karu, the Leh Nutrition Project (LNP), a well-known local NGO, is the PIA which will coordinate the programmes in 10 to 12 watersheds through its WTD of four experts, one each in the fields of Social Sciences, Engineering, Agriculture, and Animal Husbandry.

Role of Government Agencies

Little has been done in the sphere of water harvesting and management by government agencies as far as the area under study is concerned. The Rural Engineering Wing (REW) of the BDO has been spending some money every year, mainly on repairing existing *yura* and de-silting of *zing*. The only interesting work carried out so far by the department is the construction of some bunds across the *tokpo* above Taknak with the idea of encouraging formation of ice behind the walls which, on melting, would perhaps increase the water resources in the watershed. Unfortunately, freezing water somehow failed to materialise in Taknak, although similar experiments are reported to have proved successful elsewhere.

The REW has used some interesting and innovative technologies based on traditional knowledge at other places in the district. A couple of *yura* have been successfully built through very loose strata, rendering the section of the *yura* semi-impervious and thereby capable of holding water, by encouraging the growth of mustard or millet—the seeds of which are floated into the downflow of water. This is an interesting phenomenon much talked about by the locals in the past and REW has demonstrated its efficacy by actually employing it in a couple of *yura* it has built.

The PWD had been investigating the possibility of diverting some water flowing towards the north of Warila to Sakti. So far nothing concrete has emerged regarding the feasibility of such a venture.

Difficulties Encountered in Carrying Out the Case Study

Lack of basic and up-to-date data about the region as well as the study area was perhaps the most critical issue. The study took place late in the agricultural season and as a result it was not possible to ascertain the availability of and requirements for water for irrigation from time to time. In future, such studies should ideally cover at least one complete agricultural season, thereby enabling collection of more data covering all facets of the activities involved.

8. Recommendations

1. The traditional system of water management needs to be revived and, in cases like that of the *pabchu* system, streamlined, resulting in the involvement of less labour and expenditure. Steps are needed to ensure proper capacity building at the village/*mohalla* level through a participatory approach ultimately leading to the formation of small committees for management of the systems.

2. The existing water-harvesting technologies, such as *yura* and *zing*, require improvements with a view to minimising transmission and seepage losses. To start with, the idle length of the *yura* should be improved by providing a lining. Suitable local materials less susceptible to damage from frost and involving minimum use of materials like cement will have to be identified.
3. Use of polyethylene film could also be tried for lining *zing*.
4. Studies and experiments on moisture conservation in the form of ice and snow should be continued and systematically monitored. The results of these experiments used to prepare guidelines for adoption at suitable sites.
5. New technologies such as drip and sprinkler irrigation systems should be tried out in some small watersheds to establish their suitability for the environment of Ladakh and for the types of crop grown.
6. More case studies on water-harvesting technologies and management systems should be tried out over a full irrigation season and they should include discharge observations at various sources, studies in consumptive use of water for different crops, and estimates of evaporation losses so that more comprehensive recommendations covering the various technologies and irrigation practices can be formulated.

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Plates

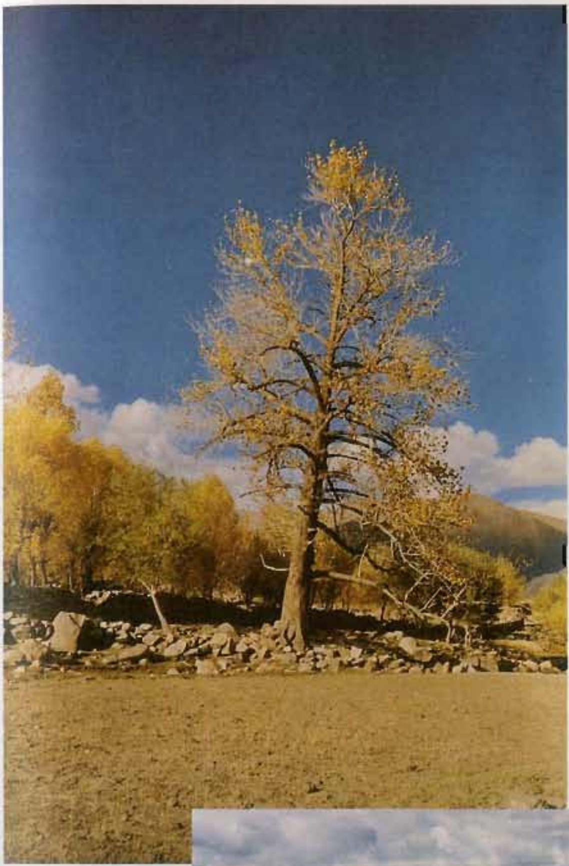

Plate 1: **View of a La-chang**

Plate 2: **Chemrey as seen from a vantage point at Sakti. Dablung springs in the foreground and Zangskar range in the background**

Plate 3: **View of Kitong *yura***

Plate 4: **View of a *yura***

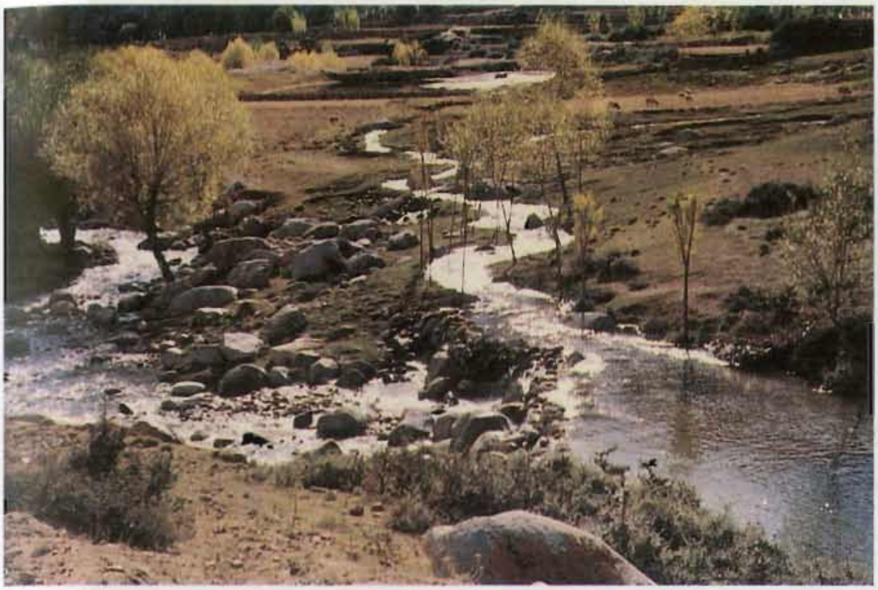

Plate 5: **Zioma zing with *yura* feeding it**

Plate 6: **Zioma *zing* from downstream site**

Plate 7: **Zing chenmo**

Plate 8: **Zing chenmo viewed from downstream**

Plate 9: **The-tse, the wooden seal**

Chapter 10

Study of Local Water-harvesting Systems in a Micro-watershed in the Upper Mustang Region of Nepal

U.N. Parajuli and C. Sharma[1]

1. Introduction

Problem Statement and Objectives of the Study[2]

Nepal is predominantly a mountainous country with over 75% of its area located in the Hindu Kush-Himalayas. There are wide altitudinal variations within a short horizontal distance, as a result of which the country has extreme variations in physiography and agro-ecology. Over 80% of the population living in the Nepalese mountains derive their living from three main natural resources: water, land, and forests. Because of the extreme variations in physiography, the availability of these natural resources also varies greatly within short horizontal distances.

Depending upon the natural resources available, need for water (for household consumption, livestock use, irrigation and other purposes), and social organisation of an area, mountain communities in Nepal have developed indigenous water-harvesting systems and management practices. Use of indigenous knowledge and strong community participation are the basis for the development of these systems.

Although the country is rich in water resources, for the people living in the mountains, use of this water remained a significant problem. Inaccessibility, as a result of geographical constraints and topographical complexities, and wide seasonal variations in the availability of water are in part causes for this. The situation is aggravated by an ever-increasing human population. It is estimated that the average annual growth rate is about 2.5% (APROSC 1995; MOA 1997)[3]. The present population density in the mountains of Nepal, that is 700/ km^2 of cultivated land, is one of the highest in the world (Farrington and Mathema 1991).

1 Umesh Nath Parajuli is a Senior Divisional Engineer with the Department of Irrigation, His Majesty's Government of Nepal, and holds a Ph. D Degree from the Wageningen Agricultural University, The Netherlands. Chiranjivi Sharma is an environmental specialist and is currently working as a consultant with the Second Irrigation Sector Project.

2 The objectives of the study are reproduced and elaborated upon here from ICIMOD (1997).

3 Considerable uncertainty exists regarding the population growth rate of the country. MPE (1998) estimates the population growth rate during 1991-1996 to be 2.37%, while CBS (1994) estimates it to be 2.66%.

With the increasing options of development and intensification of human activities in water resources, the demand for water has also increased very rapidly. Although these indigenous systems were fairly sustainable in the past, at present many of them are incapable of meeting the ever-increasing needs of the people. With the increasing shortage of water resources, declining soil fertility, and degradation of natural forest (Mishra 1998; Abington and Clinch 1992; Shrestha 1992), living in the mountains is becoming even more difficult than previously. As a result, migration has been taking place from the mountains to the Terai (the plains in the southern parts of Nepal) over the past 30 years at an increasing pace.

In this context, as noted by Chalise (1997), protecting local water resources and improving indigenous water-harvesting systems and their management practices have become imperative if the water resources available are to meet the present and future needs of mountain communities. Thus, identifying, developing, and implementing appropriate policies and programmes for the management of local water resources in close partnership with the local communities are essential.

This study therefore intends to identify ways to improve and sustain local water-harvesting systems in the Upper Mustang area of Nepal.

The specific objectives of this study are to:

- develop a better understanding of the technical, organisational, and managerial aspects of local water-harvesting systems (LWHSs) in a micro-watershed in the Upper Mustang area of Nepal;
- evaluate the extent to which LWHSs have an impact on, and are influenced by, gender and environmental considerations;
- assess the prevailing policies on water harvesting and management practices and identify the areas of change needed to improve and sustain LWHSs; and
- explore the feasibility of establishing water users' associations as an institutional mechanism for sustainable use of local water resources based on the experience of local water-harvesting bodies.

Methodology

The study used rapid appraisal methodology. For this study, both quantitative and qualitative data were collected using various tools and techniques such as measurement, non-structured small-group interviews, and observation. Regarding the usefulness of this method, Pradhan *et al.* (1987) note that this method is most appropriate if the purpose of the study is to seek a comprehensive understanding of a local water-harvesting system (LWHS) within a short period of time.

Site Selection

In Nepal, the information available regarding local water-harvesting systems is inadequate. For this reason, the researchers first carried out a reconnaissance study of a few watersheds in the Chusang Village Development Committee (VDC) area for the first few days. Table 10.1 shows the salient features of the watersheds studied under the reconnaissance study. Figure 10.1 shows their locations.

Based on the reconnaissance study, the Ghyakhar *Khola* watershed was found to be the most representative watershed in the area. Also, unlike the other watersheds studied, this watershed serves two villages. Thus, the Ghyakhar *Khola* watershed was selected for detailed rapid appraisal.

Table 10.1: **Salient features of the watersheds studied**

Name of village	Watershed		Canal length (km)	Irrigated area (ha)	Number of households	Size of households	Size of holding
	Name	Catchment area (sq km)					
Ghyakhar	Ghyakhar *Khola*	16.0	3.8	20	17	5.41	1.18
Chaile	Ghyakhar *Khola*	16.0	1.12	17	13	8.23	1.31
Tetang	Ha *Khola*	9.75	4.51	25	51	-	0.49
Tangbe	Tangbe *Khola*	96.50	2.0	30	38	-	0.79
Chusang	Narshing *Khola*	112.84	1.3	40	40	-	1.00

Source: Field Survey (1998) and BDA (1995)

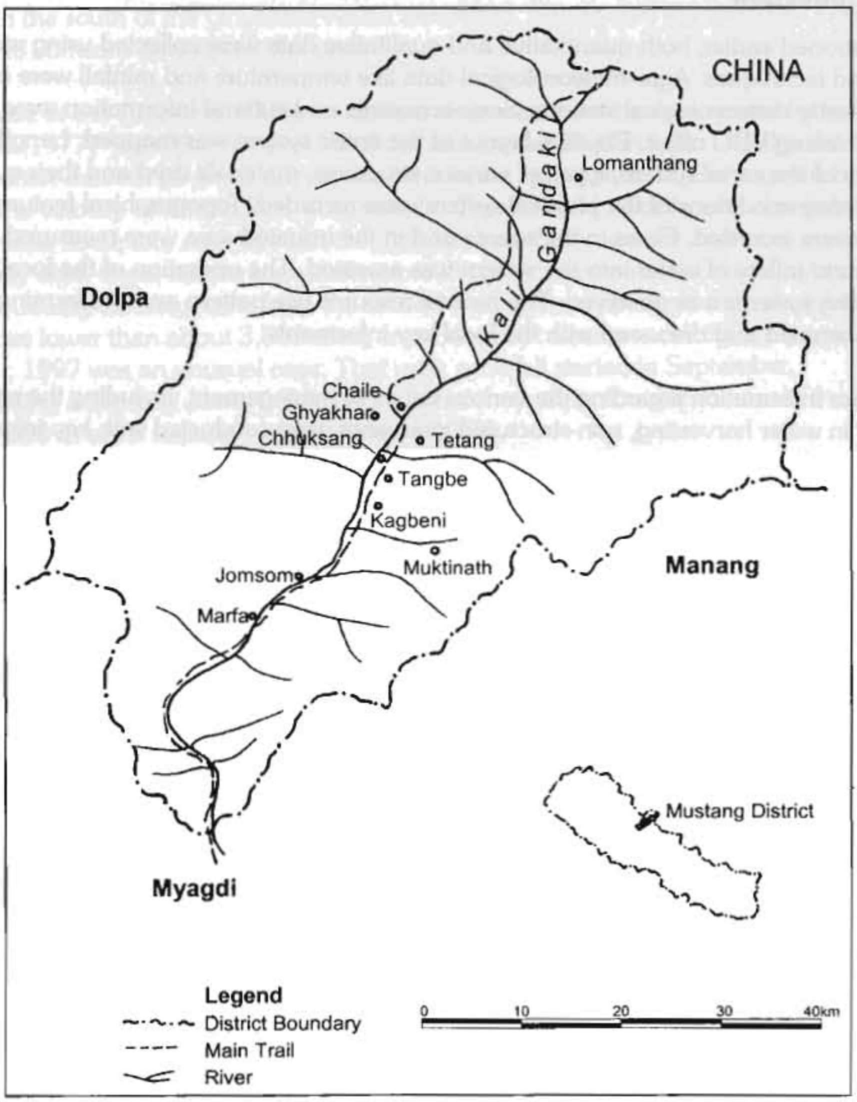

Figure 10.1: **Locations of watersheds studied**

Management of the Study

Study of a local water-harvesting system consists of mainly technical, social, environmental, and economic components which are interwoven. Ideally, a team of researchers from the above-mentioned disciplines should provide a more complete analysis of LWHSs. However, given the constraints of time and capital resources, it was not possible to design such a comprehensive study team. Therefore, the study team consisted only of an irrigation engineer and an environmental specialist. The field study was assisted by a locally-hired research assistant who had some knowledge about the local community.

The field study commenced on 24th June 1998 and was completed on 10th July 1998.The researchers spent the first few days in Pokhara and Jomsom in discussion with various personnel in GOs, NGOs, and INGOs working in the area. Annex I is a list of the various personnel met during the field study period and Annex II is the field study schedule.

Data Collection

As mentioned earlier, both quantitative and qualitative data were collected using various tools and techniques. Agro-meteorological data like temperature and rainfall were collected from nearby meteorological stations. Socioeconomic and cultural information were recorded from Chusang VDC office. Physical layout of the entire system was mapped. Length and capacity of the canal system, types of various structures, materials used and their quality, and existing conditions of the physical system were recorded. Topographical features of the LWHS were recorded. Flows in the source and in the irrigated area were measured. The year-round inflow of water into the system was assessed. The operation of the local water-harvesting systems was observed. The natural resource use pattern and the farming system were examined and discussed with the local key informants.

To gather information regarding the various issues of management, including the role of gender in water harvesting, non-structured interviews were conducted with key informants such as users of water-harvesting systems, including women, water user committee members, various actors involved in the development of the systems, development workers (GOs and NGOs), and local political leaders.

Problems and Limitations

One must recognise that rapid appraisal has its own limitations. One of the main methodological limitations is the short duration of the study. Some of the complex issues may remain unanswered in the short period of study. It was observed that, as also noted by Banskota and Partap (1996), communities in Upper Mustang are still very hesitant to interact with outsiders. They do not like to share information with outsiders.

Many LWHSs in the Mustang district are located at very high altitudes and are very difficult to access. This imposed serious problems in selecting systems for the study and in managing other logistical support.

Unavailability of long-term time-series' data was the other limitation. In Nepal, time-series' data related to hydrology, agro-meteorology, agriculture, and socioeconomics are not available at the system level. The researchers had to heavily depend on the data collected by themselves.

2. Biophysical Resources and Their Management in the Ghyakhar *Khola* Watershed

An Overview of the Ghyakhar *Khola* Watershed

The Ghyakhar Khola watershed, which is a micro-watershed on the Kali Gandaki River, is located in the Chusang VDC area in the northern part of the Mustang district, referred to here as Upper Mustang[4] (Figure 10.1). The area lies completely in the rain shadow of the great Himalayan peaks, Nilgiri (7,223 m), Dhaulagiri (8,172 m), and Annapurna (8,072 m). The Kali Gandaki River, which runs from north to south, bisects the district into two parts and has carved the deepest gorge in the world.

The area is characterised by inaccessibility. It is linked to Beni Bazar, a town in Myagdi district, which is the nearest road-head, by a mule track. It takes a five days' walk to reach the Ghyakhar Khola watershed from Beni Bazar. Mules, mountain goats, and porters are the only means of transport to the watershed area. Jomsom is the district headquarters and is located in the south of the Ghyakhar Khola watershed. Air services are available from Pokhara to Jomsom throughout the year.

The climate of the Ghyakhar *Khola* watershed is semi-arid; so the area resembles a desert. Robinson (1977)[5] classified the climate of the area as the Tibetan type. Usually, the wind velocity often exceeds 25 knots during day time in the spring season (Gurung and Shrestha 1997). The velocity of wind differs with altitude. Greater wind velocity was observed in the Kali Gandaki floodplain area than on the high terraces. Summers are cool and winters are excessively cold. Great temperature differences occur between sun and shade, and night and day. Usually freezing starts from the second half of November and then snowfall starts. At altitudes lower than about 3,500 masl, snow does not remain more than a month. However, 1997 was an unusual case. That year, snowfall started in September, accumulating a depth of about 1.5 m and it lasted more than a month. Snow in the areas above 5,500 m starts melting in April (Takaya 1977).

The mean monthly rainfall varies from five millimetres (mm) in December to 92 mm in August. The average annual rainfall is about 300 mm, about 71% of which occurs in summer (June-September). Precipitation in winter is mostly in the form of snow. The average mean monthly temperature varies between 4.34 and 17.47 celsius[6]. Figure 10.1 shows the mean water balance of the Jomsom area which gives an indicative value for the Ghyakhar *Khola* watershed.

Figure 10.2 shows that the area exhibits a water deficit throughout the year, indicating the importance of water for crops and for other uses.

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4 In general, the Mustang district is divided into Upper Mustang and Lower Mustang. The area that extends from the north of Jomsom village to the border of Tibet is referred to here as Upper Mustang. As the area adjoins Tibet, this area shares the spectacular high desert landscape of the Tibetan Plateau. The people of Upper Mustang mostly belong to Bhotia-Gurung and Bista ethnic groups and speak a Tibetan dialect. Lower Mustang spans the length south of Jomsom and north of Tatopani village. This region is composed largely of dry valley slopes and terraces that enclose the great, rubbly floodplains of the Kali Gandaki River. Traditionally, this region is known as Thak Satsae. The dominant ethnic group in this region is Thakali.

5 Cited by Nelson *et al.* (1980).

6 Time series' data on temperature and precipitation are not available for the Ghyakhar *Khola* watershed. Data on precipitation presented here belong to Muktinath village (3,609 masl; 830 35' East; 280 49' North) which is the nearest and most representative metereological station. The data on temperature were obtained from the Jomsom metereological station (2,744 masl 830 43' East; 280 47' North).

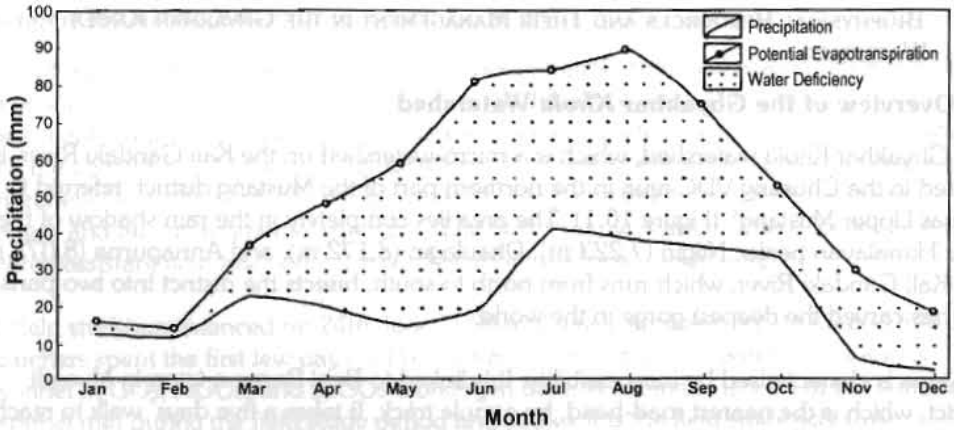

Figure 10.2: **Water balance of the area (Jomsom)**
Source: ICIMOD (1996)

The higher per cent of rainfall during summer implies that the rainfall distribution in the area is still dictated by the summer monsoon. Fort (1987) notes that this climatic regime is typical of the Central Himalayas and differs a great deal from that of the Ladakh and Karakoram regions, the western Himalayas, where maximum precipitation occurs in winter.

Further, in relation to micro-rainfall distribution, Sakya (1978) notes that the effect of wind blowing from south to north along the Kali Gandaki Valley sweeps away most of the clouds and the moisture from the middle of the valley, which reduces the rainfall but the sides of the valley are buffeted with clouds and mist. As a result, the rainfall on the sides of the valley is much heavier than that in the middle of the valley. Comparison of rainfall distribution patterns between the villages of Muktinath (located on the side of the valley) and Jomsom (located in the middle of the valley), as presented by Fort (1987), also testifies to this.

Physical Resources

Topography

The topography of the watershed is extremely undulating with large altitudinal variations ranging between 2,900 and 6,000 masl within a horizontal distance of seven kilometres. The watershed slopes from west to east. In the western part of the watershed, the land slope varies between 60 and above 100%. This part of the watershed virtually does not have any gently sloped land. However, in the eastern part of the watershed, in the foothills of the mountains, moranial terraces are formed with landslopes varying between 10 and 20%. Two villages, namely, Ghyakhar and Chaile, are located at 3,261 and 2,921 masl respectively on these moranial terraces.

Kali Gandaki River in the east, the Himalayas in the west, Samar village in the north, and Kherku Lhapcha Mountain in the south form the watershed's boundaries.

Land Use

The land-use pattern is determined by the topography, soil, and availability of water for irrigation. In the Ghyakhar *Khola* watershed, based on topography, broadly four land types are recognised, and they in turn determine the land-use pattern. These land types are: (a) moraine terraces; (b) canyon slopes; (c) ridge land and bare ground; and (d) grassland and forested slopes.

Much of the area under the moraine terraces where water for irrigation is available are cultivated. This is permitted by the comparatively moderate land slope, the smoothness of the surface, suitable soil, and access to streams for irrigation water. Some areas on moraine terraces located at higher elevation than the canal remained as grassland and bare ground because of the unavailability of water for irrigation, although they are suitable for cultivation. With the development of irrigation facilities these types/areas of land can be brought under cultivation. Similarly, on canyon slopes, rugged and difficult attributes of the terrain restricted cultivation and development of other infrastructure. Table 10.2 presents the estimated land-use pattern of the Ghyakhar *Khola* watershed.

Table 10.2: **Land use pattern in the Ghyakhar *Khola* watershed**

Land-use Type	Area in Per Cent		
	Ghyakhar Village	Chaile Village	Total
Agriculture	1.2 (20 ha)	1.0 (17 ha)	2.2
Tree plantation	0.7 (13 ha)	0.5 (7 ha)	1.2
Natural forest cover	1.0	0.0	1.0
Bushes	16	4	20.0
Rock outcrops	10	5	15.0
Bare slopes	40	16.6	56.6
Snow covered	3	0	3.0
Others	0.8	0.2	1.0
Total	72.7	27.3	100

Source: Field Observations 1998

Distribution of the present cultivated land among the households is not equitable. The average landholding of cultivated land per household is 1.2 ha. In this watershed, land is not a scarce resource. At present, considerable areas of land cultivated in the past by the native people are lying fallow. If managed properly, these land areas could be irrigated with the existing irrigation system. It is amazing that people are not interested in cultivating crops and fruit on these types of land. Shortage of labour and other inputs and lack of markets are the reasons for this. Recently, villagers have started cultivating trees on these abundant terraces.

a. Geomorphology and Soil

As mentioned earlier, the geomorphology of the area where villages are located has developed through moraine deposition (LRMP 1986; Gurung 1980). Such moraine terraces are characterised by pebbles, gravel, cobbles, and boulders of quartzite, schist, and limestone (Fort *et al.* 1979). The dominant rock types of the Ghyakhar *Khola* watershed are limestone, shale, claystone, gravel boulders, and conglomerates. The geological materials on the moraine terraces are thick, partially cemented and cobble deposits. These materials are classified under the *Tethys* group. This group largely consists of marine argillaceous and carbonate sediments, representing an age from the Middle Paleozoic to the end of the Mesozoic (NCST 1980). The majority of rock types are fragile and erosive.

The soil on the moraine terraces is of gravelly loam to loam and is dark brown in colour. The depth of soil varies between 0.5 and above 1.0 m. The soil on the cultivated land was observed to contain high organic matter and have medium range water-holding capacity. The soil in the area is dominated by *aridisols* (Carson 1992). This type of soil is suitable for roots, tubers, legumes, fruit orchards, and cereals provided irrigation facilities are available.

Soil erosion is one of the main problems in the Ghyakhar *Khola* watershed. The main factors responsible for the high rate of erosion include high wind velocity, composition of fragile geological materials with wide ranges in terms of gradient and relief, sparse vegetation, freezing of the ground for long periods, and substantial flows of snowmelt. The extent and magnitude of soil erosion differs from one land type to another[7].

Erosion has adversely effected conservation and sustainable development of natural resources. As a result, for the last one and a half decades, efforts are being made to arrest soil erosion in the area. Tree plantation especially has received priority for arresting erosion, because trees work as a windbreak, reduce the loss of topsoil, and help maintain overall soil fertility.

Biological Resources

Natural Vegetation and Wildlife

Natural vegetation in the Ghyakhar *Khola* watershed is sparse due to the dry and wind-swept ecology of the area. As a result, wildlife density in the area is also very low. Although both natural vegetation and wildlife are sparse, some rare species are available. However, they may disappear any time if proper measures are not taken to protect them. It was observed that, along the canals and along natural drainage and depressions, plant density was high, implying that scarcity of moisture in other areas is the main reason for sparse vegetation. Table 10.3 shows the species of natural vegetation and wildlife existing in the Ghyakhar *Khola* watershed.

Table 10.3: **Species of natural vegetation and wildlife available in the Ghyakhar *Khola* watershed**

Natural Vegetation		Wildlife		
Local Name	Scientific Name	Local Name	Scientific Name	Estimated Number
-	*Artemesia* spp	Chyangku (Snow leopard)	*Panthera uncia*	4-5
-	*Caragana gerardiana*	Syeli (Jackal)	*Canis aureus*	100-150
-	*Caragana brevispina*	Enka (Jungle cat)	*Felis chaus*	4-5
-	*Lonicera spinosa*	Bagh (Bengal Tiger)	*Panthera tigris tigris*	1-2
Dhupi	*Juniperus squamata*	Knauwar (Blue sheep)	*Pseudois nayaur*	100
Bhojpatra	*Betula alnoides*	Kharayo (Hare)	*Lepus oiostolus*	8-10
Ban Chutro	*Berberis aristata*	La (Himalayan musk deer)	*Hemutragus jemlahicus*	1-2
		Chituwa (leopard)	*Panthera pardus*	4-5

Source: Field Survey, 1998; Dobremez (1983); and Basnyat (1989)

7 As mentioned earlier, the moraine terraces have gentle slopes. As a result, these land units are less prone to erosion and landslides. The canyon slopes, formed by the Kali Gandaki River and Ghyakhar *Khola*, are severely eroded because of their steep slopes. Ridgelands and bare ground, in the upper part of Chaile village, have turned into badlands due to severe wind erosion. Though slight rill erosion and few gullies were observed, the upper ridges of Ghyakhar Village are less prone to erosion. Grasslands and forested slopes in the watershed are relatively less susceptible to wind erosion due to the presence of ground cover. Only a few stabilised gullies were encountered during the field visit. This type of land has been used for free livestock grazing. Soil erosion on grasslands is estimated to be 25 tonnes per hectare per year (CARE 1994).

The benefit of these plant species for soil and water conservation is immense. Basnyat (1989) notes that the community of *Caragana* spp, in fact, is the only natural source that arrests progressive desertification in the area. Loss of *Caragana* spp, which is the only dominant plant type in the area, leads to exposure of the soil surface and further increases wind erosion. This process reduces soil organic matter and plant nutrients, leads to deterioration in soil structure, reduces the moisture-holding capacity, and eventually leads to loss in land productivity, which is an indicator of the degree of desertification (Wagley 1997).

Interviews with the villagers suggested that natural vegetation and wildlife density decreased in the watershed due to encroachment by Tibetan refugees, Khampas. Similar observations were also noted by Nelson *et al.* (1980). Khampas, from Kham in Tibet, are the followers of the Dalai Lama and were exiled from Tibet during the Cultural Revolution in the early 1960s.

The area is also an important corridor for migratory birds, including geese and many water fowl. At least two species of crane, including the endangered black-necked crane, use this flyway (AHF 1998).

Farming System

The farming system in the watershed involves the production of cereal crops, raising livestock, and cultivation of fruit and farm-grown trees, all of which have strong interrelations with the agro-ecosystem as a whole. Nelson *et al.* (1980) and Takays (1977) classified this agricultural system as the oasis type.

Villagers predominantly practise traditional subsistence agriculture[8]. The principal cereal crops grown are buckwheat (*Fagopyrum esculentus*) in the summer and naked barley (*Hordeum* sp) in the winter. Other than these principal crops, wheat, maize, mustard, and vegetables are grown on nominal areas of land, mainly for domestic and livestock consumption.

Water for irrigation, farmyard manure, and labour are the main inputs for the cultivation of cereal crops. Of these inputs, water for irrigation is the main one. The reason for this was explained earlier. The most critical water shortage period for winter crops is the second half of February to April. During this period, relatively high temperatures with dry wind increase the rate of evapotranspiration. Consequently, crops need more water. Naked barley usually requires irrigating three to five times depending upon the nature of the monsoon. Similarly, buckwheat also requires irrigating three to four times, including during the pre-sowing period. Other crops grown on a small scale, such as vegetables, need frequent irrigation. Fruit orchards and farm trees also require irrigation from time to time.

Farmyard manure is the main source of plant nutrients. Local people are very conscious about the use of manure on their farmland. There is also a practice of using human excreta mixed with animal dung. Pits for collecting animal dung and human excreta were encountered within the farmland.[9] Although various organisations have introduced improved seeds, chemical fertilizers, and pesticides for the cultivation of cereal crops, their use is practically nil. Seeds for all the principal crops are either produced by the farmers themselves or are exchanged by the farmers among themselves.

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8 Information received from the villagers suggested that production from cultivated land is hardly sufficient for five to six months.

9 The farmers of Tetang village reported the practice of collecting silt from the canal for use as manure mixed with farmyard manure.

All the agricultural activities are carried out by human labour and animal draught power. The area has a shortage of labour, especially during periods of sowing and harvesting. Exchange of labour is the basis of labour management.

Livestock are the dominant component of the farming system. They provide draught power and manure for cultivation, milk for domestic consumption, and meat for cash income. Mules are used to transport goods for cash income. Table 10.4 shows the livestock population by species and their main uses.

Table 10.4: **Livestock population by species and their main uses**

Livestock species	Number of livestock in the villages			Number of households raising livestock (out of 30 households)	Average livestock per household	Main uses
	Ghyakhar	Chaile	Total			
dzopa[10] (*jhopa*)	32	22	54	21	1.8	Draught power and transportation
Cow	54	30	84	26	2.8	Milk and manure
Goat (*chyangra*)	258	302	560	17	18.6	Meat
Horse	12	10	22	16	0.73	Riding
Mule	22	22	44	9	1.46	Transportation

Source: Field Survey(1998)

Livestock are left free to graze. During summer, they are kept at higher altitude on the *lekh* known as *kharka*[11]. However, during winter they are kept in the village and graze in the nearby areas.

Fruit orchards and farm-grown trees are very popular in the area and occupy considerable areas of land. The horticultural centre at Marpha sells plants and offers methods of cultivation for fruit orchards. Although fruit orchards can generate considerable amounts of cash income, they are grown mainly for domestic consumption because of unavailability of markets. The commonly-grown fruits include apricots and apples. It is interesting that people in Ghyakhar village have also developed a community orchard. The concept of community orchards is new to this area. Besides fruit orchards, farm-grown trees are also raised along irrigation canals, natural drainage, and other fringe areas. During the past decade, plantation of farm-grown trees has increased considerably. The main plant species grown are *Populas ciliata* and *Salix* spp with irrigation.

Human Resources

Off-farm Activities

The people in the Ghyakhar *Khola* watershed carry out various off-farm activities to earn a living. Of the various off-farm activities, trading in wool and wool products in India[12], trading in medicinal herbs and musk of the Himalayan deer, and transporting goods from one place to another on mules are the main ones. Apart from these activities, some people also work in the hotels in Pokhara. Most families carry out off-farm activities during winter when freezing occurs at home.

10 *Dzopa* is a crossbreed between the yak and a local cow known as *lulu*.

11 *Kharka* is an area with natural grass or small bushes where livestock usually graze. Each village has its own *kharka*. For example, households in Chaile village take their livestock to Vena Kharka.

12 Information received from villagers suggested that, during winter, people in this area purchase wool and woollen products in one part of India and sell the same in other areas with a Tibetan brand name.

Although tourism is one of the important sources of income in the Mustang district, people in this watershed area do not benefit from it much. The reason is that, until recently, this area (from the north of Kagbeni village up to the Tibetan border) was prohibited for foreign tourists and was opened only in 1992. As a result, this area still lacks the basic infrastructure for tourism. Although the number of tourists in this area is constantly increasing[13], the tourists mainly travel in groups with trekking companies, and almost all the services and essential items for food and trekking, including drinking water, are imported. Hence, in this area, the local people and hotel owners have received the minimum direct benefit from tourism although they have received some indirect benefits[14]

Unlike other parts of the country, population (human resource) is sparsely distributed[15]. Although the population density with respect to the total land area of the district is quite low (about $4/km^2$), the population density on arable land is quite high ($251/km^2$) (CARE 1994). Based on the 1991 census, the population growth in the district is only one per cent compared to the the national average of 2.5%. Goldstein (1981) suspects that the reasons for controlled population growth in the area are harsh living conditions and the practice of fraternal polyandry. Note that, in Upper Mustang, fraternal polyandry used to be a common practice until not too long ago. However, during our field visit, interviews with the villagers suggested that this system was breaking down. LRMP (1986) also made similar observations. The other reason for controlled population growth, as noted by Sharma and Partap (1993), is the tradition of making the second eldest daughter a jhuma (Buddhist nun). Table 10.5 shows the number of households and human population in Chaile and Ghyakhar villages in the Ghyakhar Khola watershed.

Table 10.5: **Number of households and population in the watershed by village**

Village	Household	Population			Male/female	Family size
	Number	Female	Male	Total	Ratio	
Chaile village	13	43	64	107	1:0.48	8.2
Ghyakhar village	17	39	53	92	1:0.35	5.4
Total	30	82	117	199		

Source: Chusang VDC, Mustang, 1998

The ethnic composition in the Ghyakhar Khola watershed is Mustange-Gurung (93%) and Bishwokarma (7%). The Mustange-Gurungs are Tibetanised Gurung communmities in which Buddhist influence is strong. Iijima (1977) notes that the main characteristics of the Mustange-Gurung are Tibetan-origin, Tibetan-Buddhism, pastoralism, trade and agriculture, and consumption of meat, including beef (yak meat) and liquor. Iijima (1977) further notes that in this community women enjoy greater freedom than women in other communities of the midhills.

13 According to the ACAP office in Jomsom, in 1997, 813 tourists visited the Mustang district. Of these tourists, only about 10 to 20% visited Upper Mustang. The rest travelled only as far as Kagbeni and Muktinath villages, the lower parts of Upper Mustang.

14 Each tourist travelling to Upper Mustang has to pay US$700 for ten days as an entry fee to the government. About 27% of this entry fee goes to ACAP (Sharma 1998), which spends it on the area.

15 Villages in the Mustang district are sparsely distributed. Usually, it takes more than an hour to travel from one village to another. They are located in locations where basic resources such as land and water are available. Also, the location of a village and houses in it are designed applying a defensive mechanism for the emergency period. The houses are perfectly Tibetan in style with a flat mud roof that is used for storing fuelwood for emergency.

Each village in Upper Mustang has its own village organisation with written rules, and this is unique in the country. The village organisation, its institutional arrangements, and the role of women in the village organisation are discussed individually in forthcoming sections.

The major festivals of the native inhabitants are Lo-shar[16], Buddha Jayanti, and Chartung. Chartung is celebrated at Muktinath temple.

Each village in the watershed has one primary school. Interviews with the personnel in the District Education Office, Mustang, suggested that about 20% of the women and 40% of the men in the Ghyakhar Khola watershed are literate.

Women's participation in all types of development activities is acceptable to the community members. During the field visit, no discrimination in treatment between men and women in any aspect was observed. The division of labour between men and women is quite clear. Men are responsible for outdoor work such as ploughing, staying in the *kharka* (pastures), attending funeral processions, and other social activities, whereas the responsibilities of women include household chores such as cooking, cleaning, tending children, and participation in social activities. Activities that are performed together are farming, trade, and business.

Management of Natural Resources

The important natural resources in the Ghyakhar Khola watershed are snowmelt[17] (water), cultivated land, pasture, and forest. Local communities manage these resources applying indigenous techniques.

Water Resource Management

The main source of water for human activities in the Ghyakhar Khola watershed is melting snow. Other sources include winter precipitation and summer showers on a small scale, which, however, do not fulfill the villagers' water needs. As a result, in each village, water from a snow-fed stream is diverted through the open canal and is collected in a tank before being distributed to different users for various uses. The physical components of these water-harvesting systems are discussed separately in the forthcoming section.

On the basis of priority, the main uses of water are for household consumption, livestock uses[18], irrigation, and operation of water mills. In irrigation, cereal crops receive the first priority, followed by fruit orchards and farm-grown trees. The present needs for both domestic consumption and livestock uses are less than the amount of water available. However, for irrigation, the present demands exceed the supply, mainly during the spring season. Even during summer, water as an essential input for cultivation would not become surplus if not managed properly. Thus, villagers have developed elaborate water management practices for irrigation, and these are discussed separately.

For irrigation, spring (February-April) is the difficult period in terms of short supplies, while for domestic consumption and livestock uses, winter is the most difficult period. The reason

16 *Lo-shar* means new year. *Lo* means year and *shar* means new.
17 The water resulting from the melting of snow; it may evaporate, seep into the ground, or become a part of runoff.
18 Drinking and dipping are the main uses of water for livestock.

is, during winter, water freezes in most places. For irrigation, the recent demands for increased water supplies are from February to April.

Land/Soil Management

The land and/or soil in the study area are managed by various indigenous techniques. The important techniques applied include construction of levelled terraces, plantation of farm-grown trees, use of organic manure for fertilization, and provision of irrigation. There is an amazing system of levelled terraces that has been constructed for cultivation of upland crops, and such systems are rarely found in middle mountain areas. Terraces are bordered by constructing stone walls of between one and three metres in height on the outward slope. The use of terraces for upland crops is primarily a response to the perceived agricultural advantages of increased soil depth, reduced soil losses, and assistance in water control. Plantation of farm trees for sustainable management of soil is not a new technique in the area. This has been deduced by the presence of old popular and willow trees which have multifarious advantages. The important ecological and economic benefits of farm-grown trees include protection of soil from surface erosion, reduction of the effects of wind, stabilisation of sloping land, provision of feed and litter for livestock, and source of fuelwood as energy. The use of organic manure has ensured replenishment of soil fertility.

With increasing intensification of human activity on land [19], the intensity of the above management practices-planting more farm-grown trees, applying more organic manure, and provision of irrigation-has also increased.

Pasture Management

Each village has its own pasture area on the *kharka*. Traditional management practices restrict the use of pasture by other villages. Though the area under pasture is plentiful, grass for grazing is scarce. Basnyat (1989) indicates that the areas under grazing land are grossly overstocked. Lack of moisture is the main reason for this. Note that livestock are one of the main sources of employment for the people living in this area. The grazing land is therefore an important natural resource. However, to date not much effort has been made to develop grazing land. This has restricted the development of livestock in the area. A simple technology to harvest snow to conserve moisture could be useful in this respect. For example, constructing a small furrow along the contour may preserve additional moisture when the snow melts. However, this needs further study.

Forest Management

Forest areas are the most scarce and over-exploited resources in the area. It was observed that most forest species were uprooted for fuelwood. Basnyat (1989) notes that human impact upon this semi-arid ecosystem has been disastrous because of destruction of Juniper forest, defoliation of a vast area of forage plants, and uprooting of the remaining cushion and fallen plants for fuelwood. Currently, the local community has realised the need to manage the forests. ACAP and CARE-Nepal have assisted them. At present, afforestation has increased significantly.

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19 In this area, fragmentation and sub-division of land are prevented by the local inheritance law as explained later.

3. PHYSICAL COMPONENTS OF WATER-HARVESTING SYSTEMS

In the watershed studied, two types of water-harvesting system were found. They are referred to here as gravity canal and modern, piped canal systems. The gravity canal is an indigenous system and meets most of the people's needs. Until recently, the gravity canal system used to supply water also for domestic use. However, with the recent[20] introduction of the modern, piped canal system, which are designed on conventional engineering principles, by external agencies, much of the water for domestic uses is supplied through this system. The villagers still use water from the gravity canal system for washing and cleaning.

Both Ghyakhar and Chaile have independent water-harvesting systems of the type described in the previous paragraph. Figure 10.3 gives the positive gravity canal systems in the watershed. In Ghyakhar, the gravity canal system supplies water for livestock, irrigation, and for operation of water mills. However, in Chaile, there is an independent open canal system for the water mill, and the gravity canal mainly supplies water for livestock use and irrigation.

These indigenous gravity canal systems, which were developed by the villagers on their own initiative and with their own investment, are found all over the mountain region. Local ingenuity and skills have been applied over the ages together with community participation; an important and common feature of management. Many of these systems date back quite a long way and are based on indigenous technologies that suit the ecological and social settings.

In the absence of well-researched historical data, it is difficult to determine when these systems were originally constructed. However, since the area is located completely in the rainshadow of the Nilgiri Himalayas, and considering the fact that settlement there is impossible without water, it can be surmised that these systems must have been there from the very inception of settlement in the area. Thakali *et al.* (1992) note that the history of this area starts in the seventh century, so some of these indigenous gravity canal systems probably date back to the seventh century too.

Gravity Canal Systems

The gravity canal systems discussed here are run-of-the-river types with intermediate reservoirs, referred to here as irrigation tanks. The source river, feeder canal[21], irrigation and livestock tanks, and the distribution canals are the physical components of a gravity canal system. Apart from the winter period (mid-November to mid-January), a gravity canal system operates continuously throughout the year. During winter, the entire system freezes because of freezing cold temperatures.

Source River and Intake

The Ghyakhar *Khola*, a perennial stream, is the main source of water for both Ghyakhar and Chaile villages in the watershed. The stream is a tributary of the Kali Gandaki River and flows from north to south. It originates from an altitude of about 6,000 m and merges with the Kali Gandaki River at an altitude of about 2,900 m. The catchment area of this river is about 16 sq. km. The total length of the stream in the watershed is about 7.75 km. The fact

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[20] The modern piped water supply system was introduced to the watershed about a decade ago.

[21] The canal, which conveys water from the source, is referred to here as a feeder canal.

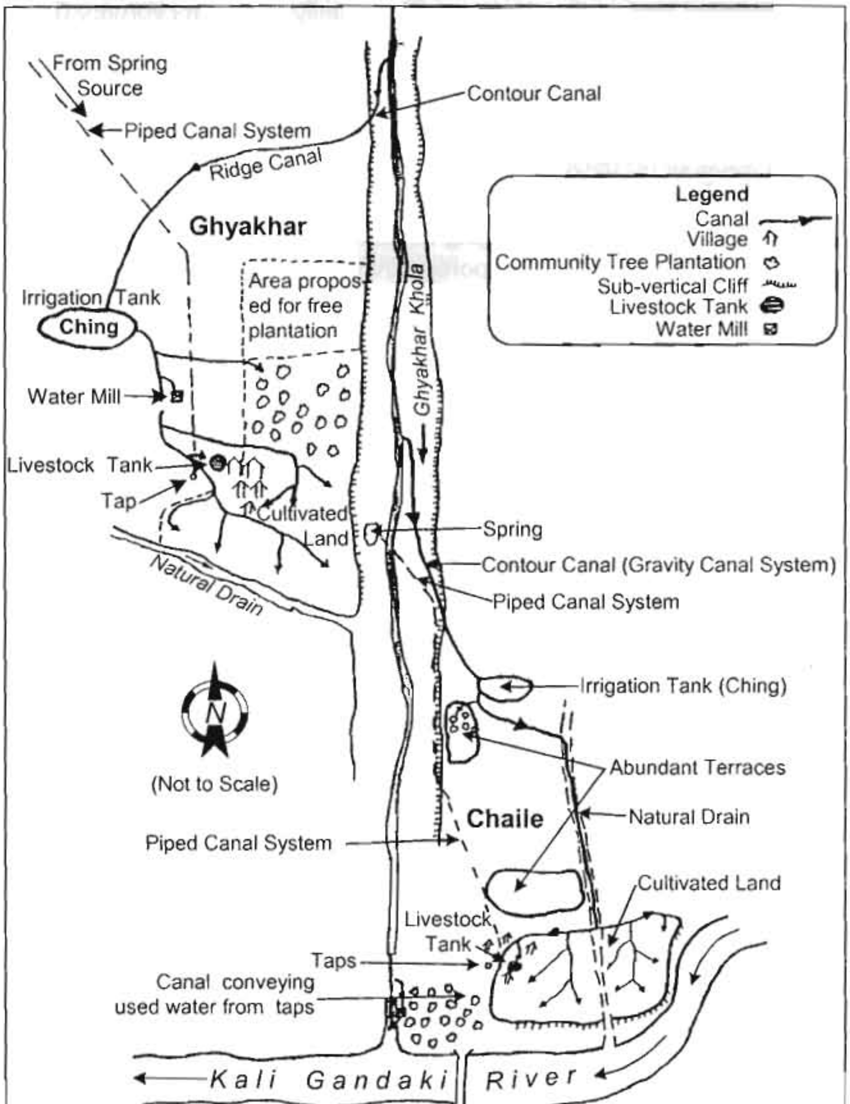

Figure 10.3: **Layout map of the gravity canal systems in the watershed**

that the area above 5,500 m in Nepal is perpetually covered by snow (Jha 1992; LRMP 1986; Metz 1989) indicates that the stream is augmented by snowmelt throughout the year. The average slope of the stream is 40%.

Since the Ghyakhar *Khola* is snowfed, its flow characteristics are entirely different from those of spring-fed (rainfed) streams. In snowfed streams, snow and glaciers melt slowly throughout the day. As a result, stream flow increases considerably in the late evening in comparison to the morning. During the field study period, the stream discharged about 100 litres per second (lps) in the morning, while in the evening the flow reached about 400 lps. Information from the villagers suggested that such a wide variation in river flow throughout the day occurs only during summer. This is because more snow melts in the summer than in any other season.

In the case of a snowfed stream, the minimum flow usually occurs in February (DOI 1990) and the stream discharges a fairly uniform flow throughout the day. Estimation of the mean monthly flow in such an ungauged stream is extremely difficult as snowmelt depends heavily upon aspects and relief. However, based on discussions with the villagers, it is estimated that the stream discharges a minimum flow of about 30-40 lps during February.

The intake of the gravity canal belonging to Ghyakhar is located about three km upstream from the intake of the gravity canal belonging to Chaile. Both intakes are of a temporary nature. An intake simply consists of a temporary diversion weir constructed across the stream and an unregulated opening connected to the feeder canal. The weir is laid slightly skewed from the main direction of the flow[22]. The idea is to increase the crest length of the weir across the direction of the flow. Although this increases the crest length, the discharge intensity decreases, thereby increasing its stability[23]. In both intakes, the diversion weirs simply divert the flow into their respective feeder canals without being required to raise the water level in the stream. Sengupta (1993) classifies this type of diversion weir as the flood channel type. Materials available locally such as boulders and mud are used to construct an intake. Recently, semi-permanent structures made of gabion have also been constructed in the stream to protect the intake and to allow easy diversion of flow. Although the diversion weirs need frequent maintenance, especially in the monsoon season, it is not considered a big task. Usually, a few villagers can carry out the maintenance in a few hours.

Feeder Canal

In both villages, the feeder canals start from the intake and end at the respective irrigation tanks. Table 10.6 shows the physical features of these canals.

Table 10.6: **Physical features of the feeder canals**

	Canal length (km)	Irrigated area (ha)	Average capacity (lps)	Measured flow[24] (lps)
Ghyakhar canal	3.8	20	30	18
Chaile canal	1.2	17	25	14

The feeder canal belonging to Chaile is aligned along the contour across a steep hill slope with a certain gradient. Until recently, the feeder canal was earthen. In 1991, CARE-Nepal intervened and introduced a 200 mm diameter polythene pipe in its major portions instead of the open canal. This was done mainly to increase efficiency of conveyance. At the inlet of the polythene pipe located close to the source stream, an escape structure with an inlet chamber made of cement is constructed. Some stretches of the main canal are still earthen.

Similarly, in Ghyakhar, the first few metres (about 300 m) of the main canal are aligned along the contour across the hill slope. In the past, this portion of the main canal was earthen. Part of this portion of the main canal, especially in the head reach, is lined with cement stone masonry by CARE-Nepal and the rest was replaced by polythene pipe[25]

22 Pandey (1995) notes that, in the Indian Himalayas, temporary diversion weirs are usually laid at an angle between 30 and 60 degrees to the stream axis. He further notes that weirs constructed right angle to the direction of flow have to be replaced frequently.

23 Discharge intensity is the flow per unit width of weir. With a larger discharge intensity, the action on the stream floor will be more intensive and will also involve greater risk of outflanking (Singh 1972).

24 The flows were measured in the first week of July 1998, upstream from the respective irrigation tanks.

25 During the early 1980s, the government assisted the villagers by providing polythene pipes through the Hill Agricultural Development Programme (HADP). In 1991, CARE-Nepal again laid a 150 mm diameter polythene pipe parallel to the pipe laid by HADP to augment the flow.

From chainage about 300 m down to the irrigation tank, the feeder canal is aligned along the hill slope with a gradient varying between 10 and 100%. Because the canal is steep, flow velocity is excessively high and turbulent. Such a canal will erode if not protected. To prevent erosion, this portion of the feeder canal, which is more than two km long, is completely lined. In the canal bed, flat stones are laid in a cascade by overlapping them, and stone walls are constructed on its sides. Figure 10.4 shows a section and view of the lined canal. This portion of the feeder canal exhibits a beautiful example of local skill in constructing such a long lined canal using local materials in order to prevent erosion.

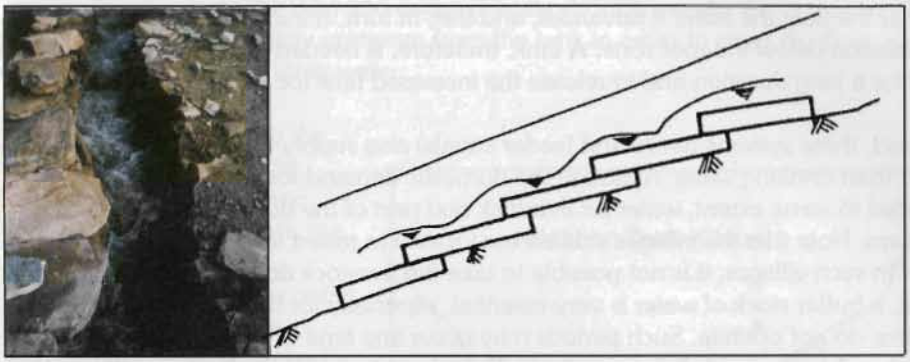

Figure 10.4: **A section and view of the lined gravity canal in the Ghyakhar Village**

At this stage, the question comes to mind, why did the villagers avoid a contour canal like the one in Chaile and construct such a steep canal? The reason is that to construct a contour canal from the uppermost point of the irrigated area up to the source, the canal alignment had to cross a vertical cliff for a considerable length. Constructing and maintaining a canal on such a vertical cliff could be extremely difficult. In order to avoid this vertical cliff, the villagers located the intake further upstream at the source in order to gain height and aligned the feeder canal through elevations higher than the vertical cliff. After passing the cliff zone, the canal is aligned down the hill slope in order to convey water to the desired area. Although this increased both the canal length and the construction costs, maintaining the canal became relatively easy. This implies that the villagers are knowledgeable and capable actors who can develop technically sound and manageable water conveying systems in a given ecological and social setting.

Irrigation Tank

The feeder canal leads to an artificial reservoir, referred to here as an irrigation tank, where water is stored through the night and released the following morning. Locally, such tanks are known as *ching*. *Ching* help to regulate and distribute water among different users. Use of such small tanks in the irrigation systems in Upper Mustang is very popular. Not only in Nepal but also in the Indian Himalayas, the use of this type of tank by villagers has been widely documented (D'Souza 1997; Singh 1997; Sengupta 1993). D'Souza (1997) further notes that, in Ladakh, such tanks are locally known as *zing*. Surprisingly, the local names given to the tank in both Mustang and Ladakh sound strikingly similar, despite their separation by a distance of over 800 km. Plates 10.1a and 10.1b shows a *ching*.

One may raise the question, unlike in the many middle mountain areas where villagers do not have such tanks in run-of-the-river systems, why is an interim reservoir (a tank) needed in these systems? There are two reasons for this.

First, during the winter season (January-February) the flow available in the canal is very small. Note that, in a snowfed stream, the minimum flow usually occurs in February. Discussions with farmers suggest that, during winter, the feeder canal discharges about six-to eight lps upstream from the tank. This flow further decreases at the farm inlet if applied directly. Such a small flow is not enough for surface irrigation by the border method[26]. The reason is that most of this small flow seeps into the terraces and may not advance through them. Therefore, irrigation by the border method requires a considerably large flow. The greater the flow the faster it advances, and this, in turn, minimises losses by deep percolation below the root zone. A tank, therefore, is needed to collect the small amounts of flow for a long duration and to release the increased flow for a short duration.

Second, these systems (tanks and feeder canals) also supply water for all domestic needs other than drinking water. Although the domestic demand for water on these systems has reduced to some extent, water for livestock and part of the domestic needs are still supplied by them. Note that the villages studied are located in raised terraces much above the source river. In such villages, it is not possible to take the livestock down to the river to drink. As a result, a buffer stock of water is very essential, especially for those periods in which the systems do not operate. Such periods may occur any time of the year due to either canal breach or heavy snowfall during winter. Thus, irrigation tanks help to maintain a buffer stock of water for both livestock and for domestic uses in case the conveying systems do not operate for a few days.

It has been observed that, in Chusang, which is located slightly above the floodplains of the Narshing *Khola*, the run-of-the-river type of gravity canal system does not have any such tank. The reason is that Narshing *Khola* discharges relatively high flow. Consequently, water supplies in the canal are also relatively high, requiring no further augmentation in stream size. Also, the livestock can go to the source river to drink within a short time.

In sum, the above discussions lead us to conclude that a village located at much higher elevation than the source river discharging substantially low flow uses an intermediate reservoir (irrigation tank) in its run-of-the-river system mainly for two reasons. They are: to increase the stream size required for efficient irrigation by the border method and to maintain a buffer stock of water for both livestock and domestic uses.

Location of an irrigation tank in a village is determined by the location of the irrigated area and a suitable site for its construction. Usually they are located uphill so that all the land below can be irrigated. In Chaile, it takes about one hour to reach the tank from the village, while in Ghyakhar it takes about half an hour.

These tanks are small in size and designed to store the flow available through the night. They are constructed simply by excavating the earth. The topography of the area where a tank is constructed determines its shape. Table 10.7 shows the physical features of these tanks in both Chaile and Ghyakhar.

[26] To irrigate cereal crops, a terrace is sub-divided into several long strips of land and surface irrigation by border method is practised.

Table 10.7: **Physical features of the irrigation tanks**

Village	Average length (m)	Average width (m)	Average depth (m)	Live storage (cu.m.)
Chaile	20	15	2.5	750
Ghyakhar	40	20	2.5	2000

An irrigation tank consists of an outlet constructed close to the tank bed and an overflow side spillway. Both the outlet and overflow side spillway are located close to the inlet so that the settling distance for the suspended silt is minimum. This helps to minimise siltation in the tank, especially when both the inlet and outlet operate simultaneously. An open-closed type of structure is constructed slightly upstream from the tank in order to close the flow into the tank when it is not needed to store water.

Constructing an outlet close to the bed of about a 2.5 m deep tank, mainly to avoid the seepage and leakage losses through its joints, is a difficult task. A conventional engineering design for such an outlet needs elaborate arrangements. However, farmers have developed a simple and functional structure made of local materials, and it works perfectly. Figure 10.5 shows a plan and section of a tank outlet.

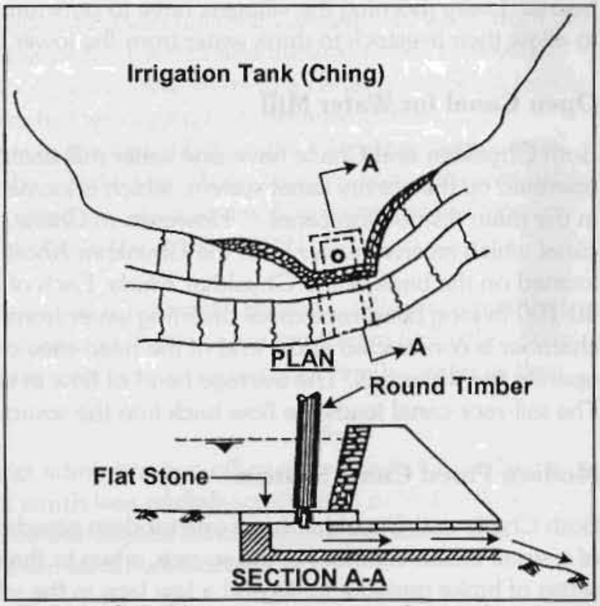

Figure 10.5: **Plan and section of a tank outlet**

A tank outlet simply consists of a rectangular chamber constructed of mud and stone. The chamber is covered by a single thick flat stone. The cover stone is about 15cm thick and a circular hole of about 10cm diameter is drilled through its centre to let water into the chamber. To let the water flow through the tank, the hole is opened and to stop the flow the hole is closed. The chamber is connected to a covered canal, also made of stone and mud, which leads the flow to an open canal outside the tank. All the joints in this structure are carefully sealed with indigenous aquatic plants like moss which are brought from higher altitudes. Further, the periphery of this structure is carefully compacted with earth to prevent seepage and leakage.

Long round timber is used to open or close the circular hole in the flat stone. This activity is performed from the tank bank. The end point of this long round timber is slightly tapered and fits well into the circular hole like a socket. As a result, water does not leak.

Distribution Canals

In both Chaile and Ghyakhar, an outlet from an irrigation tank leads the flow into their respective main distribution canals, which are further split into several branch and field channels. Many of these branch and field channels are aligned along the natural drainage and irrigate land on both sides. In many places along these canals, boulders are placed to check the flow velocity and avoid erosion of the canal bed. All landholdings are connected to the several hierarchies of distribution canals.

Of the many distribution canals, one is aligned through the village. This canal supplies water for domestic uses and is linked with a livestock tank.

Livestock Tank

Both Ghyakhar and Chaile have one livestock tank each, located in the middle of the village. Plate 2 shows a livestock tank. Livestock drink water from this tank. A livestock tank is much smaller in size than an irrigation tank. Occasionally, the distribution canal aligned through the village supplies water to this tank.

Interviews with the villagers revealed that during winter the water in the livestock tank freezes. Every morning the villagers have to puncture the frozen upper layer with a steel rod to allow their livestock to drink water from the lower layer.

Open Canal for Water Mill

Both Ghyakhar and Chaile have one water mill each. In Ghyakhar, the water mill is operated by the gravity canal system, which is located downstream from the irrigation tank in the main distribution canal.[27] However, in Chaile, it is operated by an independent open canal which receives water from the Ghyakhar *Khola*. The water mill belonging to Chaile is located on the bank of the Ghyakhar *Khola*. Each of these water mills simply consists of a 40-100 m long head-race canal diverting water from the source (canal or river). A small chamber is constructed at the end of the head-race canal from where water is dropped to operate the water mill. The average head of flow in these water mills is about 2.0 metres. The tail-race canal leads the flow back into the source.

Modern Piped Canal System

Both Chaile and Ghyakhar have one modern piped canal system each. This system consists of a small intake chamber at the source, a two to three km long polythene pipeline with a series of brake pressure tanks and a few taps in the village. In both villages, spring water is tapped for this purpose. Spring water has several advantages over stream water. It does not freeze in winter. Thus, a supply of water is maintained even in winter. Further, the quality of water is comparatively good. In Ghyakhar, this system has one tap located in the middle of the village, while in Chaile the system has two taps, both located close to one another. In Chaile, the drainage from both the taps (used water) are merged into a single channel and conveyed to irrigate the farm-grown trees which are located close to the village. However, in Ghyakhar, used water from the tap is merged with the water in the gravity canal system.

Inter-system Water Dispute

In the watershed studied, there was a serious inter-system water dispute between Ghyakhar and Chaile over the right to use the source water for the use of gravity canal systems in the respective villages. This dispute is the result of external intervention in both systems.

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27 Until recently, the water mill belonging to Ghyakhar village was located on the banks of the Ghyakhar River and it used to be operated with river water. In an external intervention in 1991, CARE-Nepal assisted the villagers in shifting this water mill from the river to its present location.

As mentioned earlier, the first few hundred metres (about 300 m[28]) of the feeder canal belonging to Ghyakhar are aligned along the contour across the hill slope. In the past, this portion of the feeder canal was earthen. In the early 1980s, the feeder canal from chainage of about 100-300 m was replaced by a polythene pipe with grant assistance under the HADP. Note that the first 100 m of the feeder canal was still earthen and seepage from this portion of the feeder canal used to join the stream, thereby augmenting the stream flow used by Chaile downstream. In 1991, this portion of the earthen canal was also lined with cement stone masonry by CARE-Nepal, and an additional polythene pipe of 150 mm in diameter was laid from chainage 100-300 m parallel to the pipe laid earlier. With this intervention, especially by lining the first 100 m of the feeder canal with cement work, the backflow into the stream due to seepage from the canal was reduced. As a result, an inter-system water dispute arose between Ghyakhar and Chaile over the right to use the source water.

Villagers from Chaile argue that, in the past, there was an understanding between the two villages regarding the water conveyance system of Ghyakhar. According to them, this understanding allowed the Ghyakhar villagers to divert unlimited amounts of water from the source into their feeder canal. However, the water diverted was allowed to be conveyed only through the local canal. The term, local canal, here refers to a canal constructed locally without using any external materials. They further argued that, because of this understanding, no polythene pipe was laid in the first 100 m of the Ghyakhar feeder canal when the intervention was first made in the 1980s. The Chaile villagers blame the Ghyakhar villagers for breaking the traditionally accepted social understanding regarding the types of water conveyance canals by lining this portion of the canal in 1991.

The story from the Ghyakhar villagers, however, is different. Ghyakhar villagers argue that no such understanding exists. They further argued that because the stream lies within their political boundary, it is their source, and they are free to use and convey the water as they like.

This dispute was registered with the district administration office. As a result, CARE-Nepal suspended all physical intervention work which was partially completed in both villages. Although various personnel tried to resolve this dispute administratively, socially, and politically, until quite recently this dispute remained unresolved.

The agreement between CARE-Nepal and the government, which allows CARE to intervene in development work in the Mustang district, ended in December 1998.Both villages, Ghyakhar and Chaile, knew very well about the closing date of CARE-Nepal's grant. Therefore, both of them wanted to complete the improvement of the (now suspended) physical work before this date. Because of this, CARE-Nepal managed to bring both the villages into consensus and a tri-party agreement was made between the two villages and CARE-Nepal. This tri-party agreement allows for completion of the suspended work in the irrigated areas. However, both villages are curiously watching each other. The intervention work has not yet started after this agreement. It is yet to be seen how the tri-party agreement is executed.

[28] The lengths of the canal mentioned here are estimated based on information from the villagers. They were not physically measured by the researchers.

4. MANAGEMENT OF WATER-HARVESTING SYSTEMS

Management of water-harvesting systems includes organisational and institutional arrangements, water allocation/distribution for all uses, operation of modern, piped canal systems and water mills, system maintenance, and water-related disputes within a village. This section describes and discusses these management activities individually

Organisational and Institutional Arrangements

Each village in Upper Mustang has a single-tiered village level organisation,[29] and this is perhaps unique in the country. These village organisations have their own written rules,[30] which may differ from village to village. Each of these organisations is headed by a group of people (on the basis of joint leadership) designated as a *gempa*. The seniormost members of each household in the village are general members of this organisation. These members have strong internal cohesion against other villagers or outsiders, and this is often enforced by the local legal system.

The number of *gempa* in a village depends on the number of households. The more households there are the more *gempa*. In the watershed studied, Chaile has two *gempa* whereas Ghyakhar has three.[31] Note that Chaile and Ghyakhar have 13 and 17 households respectively. Of the several *gempa* in a village, usually the oldest one acts as the chief and others act as deputies.

Gempa are selected for one year among the general members through a lottery system.[32] For example, Ghyakhar Village has a total of 17 households. Accordingly, this village organisation has 17 members. In the lottery method, the three winners have to become *gempa* for that particular year. For the following year again, the lottery method is used among the remaining members to select the *gempa*.

As remuneration, each *gempa* receives about 15 *pathi* of naked barley per year, which is collected from all the households on an equal basis. Usually the *gempa* are not allowed to leave the village without permission, even during winter. If any of them leaves the village, a fine of one *pathi*[33] of naked barley per night is levied as a penalty; this fine goes to the village fund.

The *gempa* provide overall leadership for all social, agricultural, and development activities in the village. Though *gempa* have the power to make decvisions, they do not have the right to change social norms that have been practised for centuries. The main responsibilities of the *gempa* are to enforce social rules and regulations, protect public property and resources, manage public funds, summon village meetings, and impose fines (usually in kind) on those who do not follow social norms. For example, in the village meeting, there is a rule that each household should send one member between 18 and 59 years of age. If a household fails to do so, it has to pay four *pathi* of naked barley as a fine. Such a fine goes to the

29 These village organisations do not have any defined institutional linkages with the VDC. However, since the VDC (comprising several villages) is the only officially recognised organisation, it forwards all the development, administrative, and legal issues of a village to the higher authorities in the government for implementation.

30 The researchers were not allowed to study these written rules.

31 In some bigger villages, *gempa* are further assisted by their subordinates, known as *chowa*. The main responsibility of a *chowa* is to communicate messages from the *gempa* to the villagers. For example, the Tetang village organisation, having 51 households, has three *gempa* and four *chowa*.

32 The lottery method is discussed later in this section.

33 *Pathi* is a measure of volume. One *pathi* of naked barley is approximately 3. 5 kg.

gempa and is shared equally among its members. In contrast, if a *gempa* does not attend the village assembly, then a fine double that paid by the general members is levied. Such a fine goes to the village fund. *Gempa* are accountable to the villagers. At the end of their term of office, the village account is thoroughly investigated by the villagers and also by their successors. Ramble *et al.* (1998) noted that, in some villages, where *gempa* had sold village property for private benefit, they had been punished by the villagers.

All village problems or disputes are discussed in the regular village meeting chaired by the *gempa*. Although it has been noted that women usually do not take part in the village meeting (Ramble *et al.* 1998), in Ghyakhar it was observed that considerable numbers of women were present in a village meeting held to decide the resource mobilisation issue. This indicates that any responsible member of the household (within the age group from 18 to 59), irrespective of gender, can take part in the village meeting.

Clearly, the current traditional village organisation, in which the chairpersons (*gempa*) are accountable to the general members, indicates a high level of community organisation for managing village resources and enforcing social rules. However, officially, these organisations are not recognised by prevailing government policies.

Women and Village Organisation

In each village, women gather frequently, mainly to perform religious activities. In such gatherings, they also discuss all kinds of social and development-related issues. Ramble *et al.* (1998) note that this women's forum plays an advisory role to the main village meeting, and the decisions reached at village meetings are merely a formalisation of extensive prior discussions held in the women's forum. In this sense, women's role in the village meeting is influential, though indirect. It has been noted also that usually women are not eligible for the post of *gempa* (Ramble *et al.* 1998). However, based on interviews with the villagers in Ghyakhar, this study suggests that a woman, especially in a female-headed household, can become a *gempa*. Unlike the male *gempa*, a female *gempa* would not perform the job of a messenger which requires moving around the village and informing the villagers about decisions. Such a job is performed by other male *gempa*. Selecting a female as a *gempa* and making no gender restrictions in the context of taking part in the general assembly indicates a lot of involvement of women in the decision-making process. The decision-making process is very democratic. It is discussed below.

In many villages, women's organisations, called *aama samuha,* have also been formed, mainly by ACAP and the District Women's Development Office, to bring women into the mainstream of development. In some villages they are active, whereas in others they are defunct. The issues regarding the sustainability of *aama samuha* and their involvement in development activities are mixed. Many of these women's groups sustain themselves by raising funds (unauthorised) from outsiders such as development workers and tourists. Also, to bring women into the mainstream of development, all the development programmes launched by various GOs, NGOs, and INGOs have a criterion that at least 20% of the total members in a users' group must be women.

Process of Decision-making

Depending on the issue, three methods, namely, lottery, voting, and consensus, are used in the process of decision-making. The following paragraphs describe and discuss each of these methods individually.

Lottery Method

The lottery method is the most commonly used method of decision-making, especially when some persons are to be identified to carry out a job. For example, when irrigation starts, the question arises who will irrigate first? In such a situation, this method is used to identify the irrigation turn in a rotational water distribution system.

In this method, two dice, locally known as *para*, each having a number ranging from one to six, are used. The game is played by slowly rolling the *para* on to level ground. The numbers rolled on the topfacing surface of the *para* are noted. In this game, the maximum number one can get is 12 and the minimum number is two. Each member plays the *para* one time and the number each of them receives is recorded by a *gempa*. The person receiving the maximum number wins the lottery.

During our field work in Ghyakhar, villagers were maintaining the conventional piped canal system. For this, it was required to transport some sand to two sites. Of the two sites one was close to the village and the other was far away. To select persons to transport sand to these two sites, a *gempa* moved around the village announcing an immediate meeting. Within a few minutes, one representative from each household gathered at a pre-announced venue. The *gempa* announced the use of *para* to divide the villagers into two groups to transport sand to these two places. Each member started playing *para*. It was observed that about half of the members who played *para* were female. Plate 10.3 shows a picture of the villagers playing *para* on that day. Those persons who had received the higher numbers carried sand to the closest site, while those persons who had received lower numbers had to carry sand to the site farthest away.

Devkota (1997) notes that Tetang Village in Upper Mustang uses small wooden pieces of a similar shape and size for the lottery. He also notes that, in this method, the total number of wooden pieces is equal to the total number of households. A few wooden pieces, equal to the number of villagers to be selected for a job, are marked and all the wooden pieces are kept in a closed container. Each member is then required to pick one wooden piece from the closed container. The villagers who pick the marked wooden pieces are selected. In this method, however, it is very cumbersome to make wooden pieces of a similar shape and size and to mark some of them. Also, while picking the wooden pieces, some villagers may be able to pick the desired pieces by touching and sensing with their fingers. For this reason the lottery method using *para* is most popular in Upper Mustang.

Consensus

Consensus is needed when a capable person is to be selected to represent the village. For example, nominating a secretary for development work in the village undertaken by various GOs, NGOs, and INGOs. This is because the secretary plays a key role in the development activity and such a person should at least be literate. Also, the secretary should be able to devote some time and should be capable of discussing matters with the external development workers. If a lottery method is used to select such a person, the person selected may not possess the right qualities. In Ghyakhar, a local school teacher is usually selected as the secretary for all development activities using the method of consensus.

Interviews with the villagers in Ghyakhar suggested that this method of decision-making is becoming popular, especially for development activities. This is because disputes in development work may not promote full participation. They further reported that, in the fiscal year 1997/98, a consensus was reached among the villagers to maintain the modern, piped canal system using the available fund of Rs 41,000 under the self-help programme (*gramin swabalamban karyakram*[34]). In such issues, if consensus cannot be reached, decision-making by open voting is adopted, as discussed below.

Open Voting

The open voting method of decision-making is used to decide major issues in the village. Allocating development funds and fixing the priority of resource mobilisation for various development and agricultural activities are examples of such issues.

In this method, one member of each household, irrespective of sex, has the right to cast one vote. Small pieces of stone are used as the ballot. Before the start of voting, *gempa* members define the issue and the members have to vote yes or no. Usually the voting starts with the seniormost person putting small pieces of stone in predetermined places. After completion of voting, the result is declared by the *gempa*. The majority is the basis of decision-making.

Water Allocation and Distribution

The principle of water allocation[35] varies with the uses of water. Except for irrigation, for all other uses water is allocated according to the needs and demands of users, covering both quantity and time. For these uses, the supply exceeds the demand. As a result, the villagers use water as and when required from their respective systems as long as the systems remain in operation. However, for irrigation, water is allocated to all the villagers based on the water shares they own, as mentioned below. This is because irrigation requires more water than other uses and, during peak periods of irrigation, the demand exceeds the supply. In such a situation, without an allocation principle agreed upon by the villagers, competition to use scarce water increases and ultimately leads to water-related disputes.

Water allocation for irrigation differs according to the crops grown. Cereal crops followed by orchards and farm-grown trees get the first priority for irrigation. To irrigate cereal crops, water is allocated according to villagers' shares, locally known as *chyure*. However, for irrigating orchards and trees there are no defined bases for allocating water. Villagers irrigate them whenever water is not needed for cereal crops. The reason is that these crops (orchards and trees) have been cultivated during recent decades only and no water allocation principles exist for their irrigation.

Information from the farmers indicates that the principal of allocation of water shares for irrigation of cereal crops was fixed long ago by their ancestors, and they believe that the basis of allocation is with respect to land. In Chaile, water for irrigation is available, it is thought, to the extent of 12 *chyure*, while in Ghyakhar it is considered to be to the extent of 22 *chyure*. The number of *chyure* for villagers in Chaile varies between 0.25 and 1.5, while in Ghyakhar it varies between one and four.

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34 A *gramin swabalamban karayakram* is a development programme which is planned and implemented by the villagers according to their needs. Under this programme, each year the government allocates Rs 500,000 to each Village Development Committee comprised of several villages.

35 The term water allocation here refers to assignment of water from a water-harvesting system to individual users and specifies who will get how much water and when. As a principle agreed upon by the users, it also reflects the rights of a user to water. Water distribution, however, is the actual process of making water available to the users with the help of some physical devices supported by institutional arrangements to meet the principle of water allocation.

In both villages, water rights for irrigation are attached to the land. Transfer of land rights automatically transfers the water rights attached to it.[36]

Distribution of Water for Irrigation

Of the various activities in managing water for irrigation, distribution is the most contentious and reflects the final distribution of benefits from an irrigation system.

The feeder canal conveys water from the source to the irrigation tank from which the flow of water is regulated. Every day in the evening, when the tank becomes practically empty, the outlet of the tank is closed and water from the feeder canal is stored through the night. The stored water is released for irrigation through the outlet the following morning until the tank becomes practically empty. This cycle is repeated daily.

In Ghyakhar, water is distributed to villagers on a turn by turn basis in a one-week cycle. Distributing water in a one-week cycle makes it easy for the villagers to remember their turn. For example, if a villager first receives water on Monday, he always continues to receive water on the same day throughout the irrigation period. Thus, simplicity is one of the characteristics of water management in Ghyakhar.

As mentioned earlier, the water available for irrigation in the gravity canal system in Ghyakhar is considered to consist of 22 shares. To prepare a rotational cycle of one week, the first 21 shares are first divided into seven groups, each group consisting of three shares. The remaining share (22nd share) is then merged with one of the above seven groups by lottery. In the second cycle of irrigation, this last share is merged with some other group for equitable distribution of water. Thus, in each cycle of irrigation, six groups consist of three shares, while the seventh group consists of four shares. The groups are prepared in such a way that the landholdings corresponding to water shares in each group are near each other. By doing so, the transient loss while distributing water is minimised. Also, there is a rule that one villager cannot have more than one share in a group, irrespective of the number of shares he owns. For example, if a person has four shares he will be located in four groups, with a maximum of one share in each group. Thus, each group consists of at least three or more villagers. After forming the groups, the lottery method is used to decide the ordering of irrigation for each of them.

Each group receives water for one day. Usually the irrigation time starts at about five a. m. in the morning and ends in the evening when the tank becomes practically empty. Depending on the cropping season, the *gempa* decide the time duration for the groups. It is the responsibility of the *gempa* to close and open the tank at the specified times.

To distribute water among the villagers in a group, an open-closed type of distribution is used. In this open-closed type of distribution, the flow is fixed and there is no need to split the flow into two or more parts. When closed, the flow is zero, and when open all water flows through.

Although time-share rotation is a popular method of distributing water equitably, in Ghyakhar this method is not practised. The reason for this is that time-share rotation is

36 In this area, fragmentation of land and water rights is prevented by the local inheritance law. Usually the eldest son inherits the land. Consequently, the water rights attached to the land are automatically transferred to the eldest son.

suitable only for uniform flow.[37] In Ghyakhar, since water is released from an irrigation tank, outflow is not uniform. Flow is greater in the morning and decreases gradually over time as the level of water in the tank lowers. This has required villagers to adopt irrigation by turn. Water from one villager's terrace is diverted to another villager's terrace after the former completes irrigation. However, the number of terraces each farmer is authorised to irrigate in turn depends on the water shares owned in that group. This is elaborated upon below.

In this village, among the groups, equity is judged on the basis of time-sharing. For example, each group receives water for one day. However, within a group, equity is judged neither with respect to the flow nor with respect to the time water is received, but rather on the basis of the number of terraces each villager irrigates in turn, which depends on the water shares owned.[38] For example, if a villager with 0.5 of a unit of water shares is allowed to irrigate one terrace in turn, another villager with one unit is allowed to irrigate two terraces, one after another. This measure of equity has advantages over the time-share measure of equity, because it accommodates soil types, terrace conditions, and conveyance losses.

The water distribution practices of Chaile are similar to those of Ghyakhar.

Operation of the Modern, Piped Canal System and Water Mill

A piped canal system operates continuously throughout the year, except during periods of excessive snowfall in winter. During such periods, the river is the only source of drinking water. Since the flow in the system is regulated automatically with the help of an intake chamber constructed close to the source, it works continuously without an operator. The *gempa* are responsible for its operation. In case there is a problem the *gempa* depute somebody for inspection.

Unlike the drinking water supply system, the water mill operates as and when needed. This system does not have a separate person deputed for its operation. A villager who needs to grind cereals has to divert the water from the source and operate the water mill. The source may be a canal or the river. As mentioned earlier, in Ghyakhar, the water mill is operated by a gravity canal system. Thus, the operation of the water mill has to be synchronised with the operation of the gravity canal system. However, in Chaile, since the water mill is operated by an independent canal, it can be operated as and when needed. Though this increases flexibility of operation, the maintenance requirement is high because of the independent canal system.

System Maintenance and Resource Mobilisation

System maintenance involves repairing the intake, cleaning the canals, and desilting the irrigation tank. Where closed polythene pipes are used, either in the gravity canal or in piped canal systems, pipes choke occasionally, requiring maintenance. By experience (by hammering the pipe on its top surface) the villagers can trace the points in a pipeline where they are choked. The maintenance activity in this case involves cutting and rejoining the pipes after removing the debris collected inside.

[37] Uniform flow here refers to that flow which does not fluctuate considerably with respect to time.

[38] In this area, for irrigation, a terrace is divided into several strips of land parallel to one another and irrigation is according to the border method of surface irrigation in which each of these strips in turn receives water. In the border method, water is fed to the head of each strip and flows to the lower end. When the advancing water in each of these strips reaches the lower end, it is presumed that irrigation in that strip is complete, irrespective of the total depth of water applied and the time required.

The basis of resource mobilisation, especially labour, for the operation and maintenance of various water-harvesting systems varies for each. To maintain a gravity canal system, resources mobilised are based on each villager's water shares. However, to maintain the modern, piped canal system and water mill, the basis of resource mobilisation is with respect to households (equal contribution), although their actual use (benefit from the systems) may not be equal to all households. For example, a household having a lot of family members may use more drinking water than a household with a few. Administration costs appear to be a factor in quantifying the benefits to households from these systems for proportional mobilisation of resources for their maintenance.

Of the various water-harvesting systems, the gravity canal system needs more frequent maintenance. In both Ghyakhar and Chaile, regular maintenance of the feeder canal and the intake of the respective gravity canal systems is carried out three times a year as follows.

- Before the pre-sowing irrigation of naked barley (this falls before the winter season)
- Before the first irrigation after the germination of naked barley (this falls immediately after the winter season)
- Before the pre-sowing irrigation of buckwheat (this falls during the monsoon season)

However, the irrigation tanks are desilted once a year, usually after the monsoon season.[39] During winter, the system remains covered by snow and when the snow melts more damage is caused. As a result, maintenance immediately after winter requires more resources than at other times, especially labour. Information from the villagers suggested that, with the recent introduction of polythene pipes in the canal, the maintenance requirements have decreased. In each maintenance period, the *gempa* decide the day of maintenance and labour is mobilised according to need. For easy computation of proportionality, the number of labourers mobilised always remains divisible by the total number of water shares in a gravity canal system. For example, in Ghyakhar, depending upon the volume of work 44, 22 or 11 labourers are mobilised. When a total of 44 labourers is to be mobilised, a villager with a one-unit water share provides two labourers. Note that the total number of water shares in Ghyakhar is considered to be 22 *chyure*.

Unlike the gravity canal systems, there is no fixed timing for the maintenance of piped canal systems and water mills. They are maintained as and when needed and their maintenance requirements are relatively low.

Water-related Disputes

In Ghyakhar, no water-related disputes were reported. However, in Chaile, it was learned that sometimes minor disputes occur over the distribution of water for irrigation of orchards and farm-grown trees. The reason is, as mentioned earlier, that these crops were established only a few decades ago and there are no defined water distribution rules for irrigating these crops. Information from villagers in Chaile suggested that, with crop diversification, demand for water has increased and the villagers are thinking of enforcing rules for irrigation as in the case of cereal crops. The *gempa* resolve such minor water-related disputes.

[39] During snowmelt in the catchment, especially in the monsoon season, quite a few times big masses of earth slide into the river and obstruct the entire flow. Such incidents create accumulation of water upstream from the obstruction, which breaks apart after a few hours. As a result, the flow in this period carries a large amount of suspended sediment. The villagers reported that this water is not collected in the irrigation tank. However, sometimes they are ignorant of such incidents and a large amount of sediment enters the irrigation tank.

5. PROGRAMMES AND PROJECTS ON WATER HARVESTING AND MANAGEMENT

Various programmes and projects on water harvesting and management are implemented by different organisations in Upper Mustang. The objectives of these programmes and projects differ from one another. The ultimate goal of each is to raise the standards of living of the local community by improving the management of natural resources.

To improve the economic status of the local inhabitants and the ecology of the area, it is imperative to conserve and preserve the environmental and cultural diversities that exist in the area. In this context, His Majesty's Government of Nepal has been soliciting the interest of various NGOs, INGOs, and other donor agencies to work in this area. As a result, various programmes and projects are being implemented by a number of organisations in this area. Some of the organisations and agencies that are involved are as follow.

Natural Resource Management Project (NRMP)
Upper Mustang Conservation and Development Project (UMCDP)
Mustang Development Service Association (MDSA)
Government line agencies—
District Irrigation Office (DIO)
District Water Supply Office (DWSO)
District Livestock Service Office (DLSO)
District Agricultural Development Office (DADO)
District Soil Conservation Office (DSCO)
Horticultural Centre, Marpha
District Development Committee

Natural Resource Management Project (NRMP)

NRMP has been implemented by CARE-Nepal in collaboration with the Social Welfare Council (SWC) in Upper Mustang since 1989.The main objective of this project is to promote self-reliance among the participant communities to fulfill their basic needs. The intermediate objectives include the following.

- To increase the capability of participant communities to identify, plan, and manage development activities through appropriate community institution and capacity-building measures (including non-formal education for women and girls) in order to increase their confidence and active participation in the local development process
- To increase the application of environmentally-sound farming practices by 40% of the farmers in participant communities, thereby protecting the environment and increasing farming productivity and household incomes
- To improve the capacity of the communities to manage, rehabilitate, and conserve natural resources through integrated physical and community infrastructure and increased application of sustainable natural resource management and energy consumption practices
- Tto ensure that at least 25% of married women have functional knowledge of health and sanitation, thereby creating a better environment for the family and for community welfare

To achieve the above-stated objectives, the project has various components. They are rural infrastructure, agroforestry/livestock, community organisation, domestic energy, primary health care, and non-formal education.

Rural infrastructure is one of the important components of the project and includes irrigation, water supply and sanitation, river training, and miscellaneous work such as dipping tank construction and water mill renovation.

Agroforestry/livestock consists of sapling production on private land, tree plantation on community and private land, forage crop production, dipping ponds for external parasite treatment, and organising training in different subjects such as crops and kitchen gardening.

Community organisation includes a variety of activities to increase the capabilities of participant communities to identify, initiate, and manage development projects with a view to meeting their basic needs.

Domestic energy relates to energy conservation such as improved cooking stoves with chimneys, solar heaters, solar bathrooms, and improved water mills.

Primary health care was started in mid-1993 and emphasis has been put on community-based training and extension services. Similarly, non-formal education covers literacy programmes for both adults and children.

The approach followed by the NRMP focuses on self-reliance and sustainability. Projects are selected based on identification and prioritisation of community needs. A community development committee (CDC) is formed in each village and their capacity is developed to enable them to generate and use funds and handle the project independently. The CDCs are formed by coordinating the traditional village-level organisations and the Village Development Committee concerned. Moreover, special attention has been paid to ensure women's election to the CDC and their active participation in community development work.

The Annapurna Conservation Area Project (ACAP) and the Upper Mustang Conservation and Development Project (UMCDP)

The King Mahendra Trust for Nature Conservation (KMTNC) implements the ACAP and UMCDP projects. ACAP and UMCDP recently opened offices in Jomsom and Lomanthang respectively. Of these projects, the UMCDP is active in Upper Mustang. The main objectives of the UMCDP are to conserve the natural and cultural resources of the area by integrating them with tourism management and sustainable community development. UMCDP mainly focuses on creating awareness rather than infrastructural development.

Natural resource conservation comprises mainly tree plantation and conservation of natural forest and wildlife. Tourism development includes establishment of visitor information centres and checkposts, lodge management, and development of women's entrepreneurship in tourism and waste management. Similarly, heritage conservation mainly includes restoration of traditional monasteries and encouragement of local cultures and customs.

Promotion of fuel-efficient stoves, solar energy, kerosene depots, and development of hydropower are the activities under alternative energy. Similarly, community development programmes include development of rural infrastructure (irrigation, drinking water supply, and trails/bridges) and other support programmes such as schools, general health, and women's development by organising adult literacy classes. Although water-related infrastructural development is also an important objective, such activities are very few and far between. Assistance in this sector mainly includes institutional support and supply of external construction materials and skilled manpower.

Local communities are involved in all aspects of resource conservation and development by forming users' groups in each village development committee—comprising several villages.

Mustang Development Service Association (MDSA)

Mustang Development Service Association (MDSA) is an INGO funded by Japanese nationals. This INGO has been active in the Mustang district since 1992. The major objectives are to:

- increase agricultural production through crop diversification and improvement of the cropping system;
- develop high-value crops and livestock farming;
- improve the physical infrastructure of schools and the literacy rate; and
- reduce the infant mortality rate by increasing awareness among the local people about hygiene and sanitation.

MDSA implements various programmes to fulfill its objectives in the district. Most of them are confined to the lower Mustang area. Programmes implemented in Upper Mustang include rice cultivation, school development, social service, and other technical and financial support. The approach of MDSA does not emphasise people's participation and, therefore, it works independently.

Programmes of Government Line Agencies

The district-level offices of different Ministries of His Majesty's Government of Nepal (HMGN) have their own programmes. The District Irrigation Office (DIO) in Mustang is the main agency for development of irrigation. Since 1997, the Nepal Irrigation Sector Project (NISP), funded by the World Bank, has been implemented. The main objective of the NISP is to improve productivity and sustainability of irrigation systems in the district. The NISP assists in renovation and construction of small- and medium-scale, farmer-managed irrigation systems (FMIS). It covers technical, institutional, environmental, and economic aspects of the projects. The working modality of NISP is based on demand-driven and participatory approaches. Prior to the NISP, the Dhaulagiri Irrigation Development Project (DIDP) and Resource Conservation and Utilisation Project (RCUP) had intervened in the traditional water-harvesting systems, focusing mainly on irrigation and natural resource conservation.

The District Water Supply Office (DWSO) in Mustang is mainly responsible for supplying potable water. Other line agencies implement the Government's regular programmes. The Horticultural Centre in Marpha is playing an important role in introducing new technology and varieties of fruit and vegetables in the area. The programmes implemented by the District Development Committee (DDC) are the following: Remote Area Development Committee (RADC), Bridge Building at Local Level (BBLL), Local Development Construction Project (LDCP), Rural Self-help Programme (*Gramin Swablaman Karyakram*), and the Parliamentary Fund Programme.

Coordination among the Agencies/Organisations Involved in the Development of Upper Mustang

The coordination mechanism among the NGOs, INGOs, line agencies, and DDC is very weak. At the district level, the DDC is responsible for establishing this relationship among the various organisations. For this purpose, the DDC calls all the organisations involved in district development to present their programmes and projects to the District Assembly.

Other than informal discussions among the various GOs/NGOs/INGOs, no other co-ordination mechanisms have been developed by the DDC. As a result, there is duplication of programmes and projects implemented by different organisations. For instance, CARE-Nepal, UMCDP, and a number of line agencies are implementing similar types of programmes and projects in the same geographical location. A well-coordinated programme, on the other hand, may help to distribute resources more equitably in the area and also may help to exploit water resources more efficiently.

CARE-Nepal and UMCDP have developed an understanding for establishing a working relationship in the area. In this regard, they have signed a memorandum of understanding, especially for incentive/subsidy policies, to implement their development programmes.

Comparison of the Programmes and Projects

Except for MDSA, programmes, and projects implemented by all the other agencies follow the users' participatory approach. However, MDSA does not give emphasis to participation of users and develops and implements its programmes independently. Although most of the agencies follow a participatory approach, the modality of participation differs for each. For example, in the programmes implemented by the government line agencies, the cost-sharing mechanism follows the basis of percentage. However, in the programmes implemented by CARE-Nepal and UMCDP, the cost-sharing mechanism does not follow the percentage basis. In these programmes, irrespective of the total cost, all the local costs are borne by the users and the external costs are granted by the respective agencies.

Further, the modality of formation of a users' organisation for their participation also differs for each. For example, in the programmes implemented by CARE-Nepal, users' organisations are first formed at the village level which look after all the developmental activities in the village. Although villagers are free to form their users' organisation, special attention has been given to linking the users' organisation with the traditional village organisation and the VDC. In some villages, gempa also lead the users' organisations, while in some, the gempa are simply members of the users' organisation. Usually, members of the VDC are also members of the users' organisation. Unlike this modality adopted by CARE-Nepal, in the programmes implemented by UMCDP, users' organisations are formed at the VDC level comprising several villages. No special attention has been given to linking users' organisations with traditional village organisations.

In the programmes implemented by government line agencies, specific users' organisations for particular activities, such as irrigation, drinking water supply, forestry, and so on, are formed as per their respective policies, and they are registered with the district administration office. These organisations simply act as construction committees.

Impact of Programmes and Projects on the Ecology, Local Economy and Women

Of the various programmes, the programmes on irrigation development and agro-forestry have shown a direct impact on ecology. With the rehabilitation of irrigation systems, mainly by CARE-Nepal, water intake in the systems has improved. This has helped in the development of agro-forestry. Although CARE-Nepal claimed there was an improvement in crop yield with the rehabilitation of irrigation systems, information from the villagers suggested that not much improvement in crop yields has been noted. As a result, irrigation development does not seem to have brought about any remarkable improvement in the local economy. However, villagers agreed that, following the rehabilitation of irrigation systems, maintenance requirements have reduced considerably. although water intake in the system has improved, lack of support services is the main reason for not achieving targeted improvement in the local economy.

The tourism development programme shows a direct impact on the local economy, mainly in the Lower Mustang area. Since the Upper Mustang area was only recently opened for international tourism, at present the impact of tourism development on the local economy is nominal. However, in future, the heritage conservation and tourism development programmes being implemented by the UMCDP may help to promote tourism in the Upper Mustang area, which in turn may help to improve the local economy of Upper Mustang as has been the case in the Lower Mustang area.

The job opportunities created by these programmes have had a direct impact on the local economy. Transporting materials and providing development services, such as construction of civil works, are among the examples of such job opportunities. Considerable capital resources are being invested in the Mustang district by the government and other agencies. Of these, more than half goes to transportation, mainly undertaken by the local community with their mules. Note that, in the Ghyakhar Khola watershed, about 30% of households own mules. This means that at least 30% of the households are directly benefited by these programmes.

Similarly, the programmes that have had a direct impact on women are agro-forestry, drinking water supply, domestic energy, alternative energy, and non-formal education. These programmes have lessened the burden of women and are also contributing to some extent to developing women's status by providing literacy and entrepreneurship training.

6. Implications and Impact of Policies on Water Harvesting

National Water Resource Policies Related to the Himalayan Remote Areas

In the Himalayan region of Nepal, water as a usable resource is scarce, although the country is rich in water resources. The government has given high priority to the sustainable development of water resources. Accordingly, various policies and programmes have been formulated. The country's eighth plan (1992-1997) and the recently formulated ninth plan (1997-2000) stress the involvement of the semi-government, non-government, and private sectors in the implementation of water resource projects with people's participation (NPC 1992; 1998). Both plans emphasise dissemination of simple, low-cost and appropriate technologies that can be maintained by local communities. Also, importance is given to the development of sprinkler, drip, and water conservation technologies for the remote mountain areas. The ninth plan also gives priority to legal arrangements for water rights.

In accordance with government policy, various INGOs are intervening in water resource development in the Upper Mustang area. There are very few development activities that are being implemented by the government alone. As a result, local people were unaware about the government policies on water resource development. The important issues that were raised during group discussions by the local people include the following.

- Water rights
- Prioritisation of the uses of water resources
- Participation
- Organisational arrangements for managing water

The following paragraphs describe and discuss these issues individually.

Water Rights

As mentioned earlier, the inter-system dispute over water rights between Chaile and Ghyakhar, which was under appeal in the Mustang District Court, has been the result of external intervention in these systems. Such disputes over water rights arising as a result of external intervention have also been documented in other areas (Pradhan 1997; Benda-Beckmann 1997; Pradhan 1994). Non-recognition of the customary water rights that preceded external intervention is in part the reason for this. Note that the Water Resources' Act 1992 clearly spells out that the ownership rights of all the water resources in the country are vested in the state (MOWR 1993). This provision rejects the existence of customary ownership rights to water that the community has been managing for centuries. Although some provisions in the Act have made room for recognition of the customary use rights for water, such provisions do not make it mandatory for law implementors to respect customary ownership rights (Khadka 1997). As a result, customary ownership rights may be threatened. Legal recognition of the customary water rights prior to external intervention may help to reduce such inter-system disputes.

Also, with the non-recognition of customary water rights, local communities may feel that they are losing their water rights and may even tend to depend more on the government for the management of water resources. It has been accepted that, without full participation of the local community, water resources cannot be managed well. Thus, to involve the community in water management, it is essential to accept indigenous management practices and legally recognise the customary ownership of water.

However, by recognising the customary rights of the community who are using water at present, the future water needs of the growing population may also be threatened. Thus, while recognising customary water rights, future needs for water in the watershed should also be kept in mind. This means that planning for water resources should be carried out on a watershed basis rather than on an individual system basis. Although it is a difficult task to recognise the existing customary water rights of the community and at the same time preserve the water needs of a growing population, further research on this issue may be able to come up with solutions to this problem.

Prioritisation of the Use of Water Resources

The Water Resources' Act 1992 prioritised the use of water resources as per the following order.

- Drinking water and domestic uses
- Irrigation
- Agricultural uses for animal husbandry and fisheries
- Hydropower
- Cottage industry, industrial enterprises, and mining
- Navigation
- Recreational uses
- Other uses

However, in actual practice, such an order of priority cannot always be followed. For example, if a community desires to develop a drinking water supply system from a source that is being used by some other community over time for some other use, a dispute is bound to arise. Even though the Water Resources' Act 1992 gave the first priority to drinking water, usually it is difficult to ignore the existing customary water rights. Information from the villagers and also our own experience suggest that, in such a situation, the existing water users do not allow the development of any other system that might hamper their water rights, unless it is imposed by the Court, and that would be extremely difficult to implement in the field.

At this stage, it would be useful to know how the customary water rights are defined locally. In actual practice, customary water rights have, for a long time, been determined by their use and by the location of water resources with respect to the political boundary of a village. For example, if a village wants to use water resources from a source located in the political boundary of another village, the former village will have to take the permission of the latter village. Note that the source of the drinking water supply system in Chaile is located within the political boundary of Ghyakhar and the Chaile villagers had to obtain permission from the Ghyakhar villagers to use the source. Also, as mentioned earlier, location of the Ghyakhar Khola within the political boundary of Ghyakhar is the main argument given by the Ghyakhar villagers in the inter-system dispute between Ghyakhar and Chaile villages.

Further, as mentioned earlier, in Ghyakhar, water for livestock receives higher priority than irrigation although the Water Resources' Act prioritised irrigation before livestock. Between irrigation and livestock uses, the priority given to livestock seems to be more logical. The reason is that the value of livestock is more than that of crops. Crops can survive for a few days without water while livestock cannot.

The above discussions imply that, in actual practice, prioritisation of water uses does not follow the prioritisation stipulated by the Water Resources' Act 1992; rather such prioritisation is determined by customary water rights and existing practices.

Participation

Nepal's eighth and ninth five-year development plans clearly emphasised participatory and demand-driven approaches to the development of water resources. The basic premise of the participatory approach is that greater people's participation in all stages of water resource development leads to a greater sense of ownership and control over the system on the part of users; in turn leading to better use of scarce water resources and increased benefits from them.

One of the indicators of people's participationin and demand-driven approaches to the development of water resources is the development of a cost-sharing mechanism by the users. For example, for the rehabilitation and improvement of an irrigation system in the Himalayan region, the Irrigation Policy 1997 clearly demands a contribution of at least seven per cent of the estimated cost of rehabilitation from the users (MOWR 1997). The Irrigation Policy 1997 (Section 4.4.4) also clearly spells out that all the irrigation development activities in the country, whether by mobilising the country's internal resources or by using external resources, will be implemented only in line with this policy. However, in actual practice this policy is not being implemented. In the water-related programme undertaken by CARE-Nepal in Upper Mustang, the cost-sharing mechanism is somewhat different. Whatever the total cost of the programme, all the local costs are borne by the users and the external costs are borne by CARE-Nepal. On an average, the users' contributions vary between 30 and 40% of the total cost (Ramble *et al.* 1998). Even if the users demand the cost-sharing mechanism stipulated in the Irrigation Policy 1997, they cannot enforce it. However, in the same region, the cost-sharing mechanism followed by the Department of Irrigation in the rehabilitation of irrigation systems through the World Bank-funded Nepal Irrigation Sector Project strictly follows the provisions stipulated in the Irrigation Policy 1997.

The above discussion raises two issues. First, although the Irrigation Policy does not specify the upper limit of users' contributions, different cost-sharing mechanisms by different agencies in the same region at the same time may not be socially justifiable. Second, the fact that the people in the same region are contributing 30 to 40% of the total cost for the same type of work implies that the subsidy being provided by the Government is very high. Such a high subsidy may simply attract the people to grab government resources even if there is no serious demand. Consequently, the basic goal of 'demand-driven' may not be met.

Thus, the issue of subsidy by the external agency in the development of water resources needs to be reviewed in relation to both the people's and the government's capacity in order to fulfill the basic goals of participation and a demand-driven approach.

Traditional Organisation to Manage Water

As mentioned earlier, each village in the Upper Mustang region has a traditional village organisation which is very efficient in managing the water resources, irrespective of their uses. These village organisations not only manage water resources but also deal with all social, agricultural, and development issues. Different organisations like these have existed throughout the country for centuries (Pradhan 1989). The pattern of organisation varies with the social structure, physical system, and agro-ecological conditions of an area. Some of these organisations have written rules, whereas some of them simply operate on the basis of the social norms and values that have been accepted by the community as an unwritten constitution. Also, some of these organisations have been established to manage specific water uses, whereas some of them manage various aspects of society. Usually, these organisations are headed by experienced and socially-recognised persons who can convince the users to follow the social norms for using water. In some areas, chairpersons are elected, whereas in others the post of chairperson is hereditary.

Notwithstanding the different traditional organisations throughout the country for managing water resources, the prevailing Water Resources' Policy does not officially recognise them. In contrast, the Water Resources' Policy requires formation of specific water users' associations with elaborate constitutional arrangements, and such systems are not often needed to manage small water resource systems in the mountain community. Such organisations need to be registered with the government as a prerequisite for receiving external assistance. This is mandatory for all water uses such as irrigation, drinking water, and small hydropower. The Water Resources' Policy also presumes that the registered water users' associations continue to manage water in a better way.

However, the story is somewhat different in actual practice. Many of these organisations are formed and registered with the Government simply as a prerequisite for receiving government assistance, not for improving the management of water. The following example testifies to this.

A number of water users' organisations registered with the Chief District Administration Office in the Mustang district were reviewed. Sixteen organisations were registered under the

Water Resources' Regulations 1993. Of these sixteen organisations, only seven were renewed (up to two years ago), implying that the majority of them are defunct. This implies that the majority of these water users' associations simply acted as a construction committee and provided witnesses for government expenditure. This is against the philosophy of the government policy. In actual practice, traditional organisations continue to manage water resources as before the external intervention. This indicates that institutional support needs to focus more on traditional organisations by officially recognising and strengthening them.

7. Summary, Critical Issues and Recommendations

This case study has shown how villagers in Ghyakhar watershed took into account various ecological and sociocultural considerations in the design and management of the physical infrastructure of traditional water-harvesting systems. It has also illustrated that villagers are knowledgeable and capable actors who can develop and manage socially and technically sound water-harvesting systems with practical experience. Of the various ecological considerations, availability of water and topography are the main. Sociocultural considerations mainly include the organisational and institutional arrangements in the design and management of physical infrastructure.

Construction of an interim reservoir (*ching*) in a run-of-the-river system to manage scarce water supplies is an example of ecological influence in the design of physical infrastructure. Another ecological influence is the adaptation of levelled terraces for the cultivation of upland crops. This adaptation is primarily a response to the perceived agricultural advantages of increased soil depth, reduced soil losses, and assistance in water control. Location of a *ching* in a water-harvesting system, the alignments of canals through land with varying slopes, and the necessity to line these canals in order to increase conveying efficiency and to minimise erosion hazards are some examples of topographical influence on the design and management of physical infrastructure.

Similarly, aligning the canal through the village for domestic use, which helps mainly women and involves women in the process of decision-making, demonstrates the gender influence on design and management of physical infrastructure of traditional water-harvesting systems.

This case study shows that, at present, on the basis of priority, the main uses of water are for household consumption, livestock, irrigation, and operation of the water mill. The present level of supply for both domestic consumption and livestock uses is more than the level of demand. However, for irrigation, the present demand exceeds the supply, mainly during the spring season. As a result, villagers have developed elaborate water-management practices for irrigation use supported by strong organisational/institutional arrangements.

For irrigation use, the spring season (February-April) is when supplies are the lowest, while for domestic consumption and livestock uses winter is the period of scarcity because of freezing temperatures. The present demands for an increase in water supplies are for the months of February to April.

At present, although these traditional water-harvesting systems may be sustainable and well managed, with the increased options of development, demand for water also increases very rapidly. In this context, the study has also identified critical issues related to the future development of water systems to meet the demands of a growing population.

Critical Issues

The critical issues discussed here encompass both the strengths and weaknesses of the traditional water-harvesting system for future development of water resources. Different weaknesses related to accessibility, harsh climatic conditions, and inefficiency of traditional water-harvesting systems have been constraining the sustainable development of water resources. On the other hand, there are many opportunities that can be explored for sustainable development of water resources, and these in turn may help to raise the living standards of the community. As the region falls in a rainshadow area, the importance of water resources is immense, determining the sustainability of livelihoods and overall development of the region.

Inaccessibility is the biggest constraint to overall development of the area. The region lacks basic infrastructure for overall development and it lacks markets. As a result, people are unable to sell their local products. This is one of the main reasons why people are not too interested in producing high-value crops like fruit and off-season vegetables despite improved cultivation technologies, improved varieties of high-value crops, land, and a suitable climate. Similarly, the harsh climatic conditions, which are extremely cold during winter and very dry in the spring, hinder sustainable development of the area. Sometimes heavy snowfall paralyses most activities, compelling the inhabitants to migrate to the lower hills during winter. Many researchers (AHF 1998; Gurung 1980) suspect that the region is suffering from increasing desertification due to cold and dry climatic conditions.

Most of the traditional water-harvesting systems consist of open earthen canals. The soil along the canals is very porous. As a result, a large quantity of water goes to waste through excessive seepage and leakage through these open canals. The long length of feeder and distribution canals through fragile alignments further aggravates the situation in terms of both high conveyance losses and maintenance requirements. Although the introduction of polythene pipes has improved the water intake of the systems, there is still much to be done to conserve scarce water.

Among the many uses, irrigation consumes most water. Although the local people have developed levelled terraces and the border method of surface irrigation, which is relatively efficient for cereal crops, such surface irrigation is not efficient for irrigating orchards and farm-grown trees. In view of the increasing area under tree plantation, suitable technological packages, such as drip irrigation, or low-cost technology, such as furrows along a contour for irrigation, are essential to conserve scarce water. Local knowledge regarding the design and management of tanks to store water and the experience of laying and maintaining polythene pipes, which the community has gained over a period of time, provide opportunities to use the drip irrigation system. Further, the prevailing topography provides enough hydraulic head to operate drip irrigation without requiring a power plant, and otherwise this would not be possible in the plains. Thus, a small technological input can help develop drip irrigation which is very suitable in terms of water conservation for the development of tree crops.

This case study shows that, in the village, water for livestock use is not a constraint on the further development of livestock. What actually restricts the development of livestock is the lack of pasture as a result of moisture stress.

Because of the unequal distribution of rainfall, which is more pronounced at high altitudes (*lekh*) than in the river valley, much of the traditional pasture land is located at high altitudes. This is the reason why most of the time (except during winters) livestock are kept there. The other areas contain sparse and low quality grass, a result of moisture stress. Even these high altitude pastures suffer from moisture stress and are overgrazed by mountain goats. However, to date not much effort has been made to develop pasture.

The area receives a considerable amount of snowfall during winter, and this could be a valuable resource if used properly. A simple technology for harvesting snow for conserving moisture could be fruitful for pasture development. For example, constructing a small furrow along the contour or a check-dam in the depression may preserve additional moisture when the snow melts. However, this needs further study.

This study shows that past and present government policies and programmes have given very little consideration to mountain specificities. By and large, most of the policies and programmes for remote mountain areas are also similar to those for other parts of the country. Lack of mountain-specific policies and programmes has been a constraint to the development of this area. The important issues related to water policy are water rights, prioritisation of the uses of water, people's participation, and organisational arrangements to manage water. This study shows that despite the various provisions made in the Water Resources' Act and policies, traditional practices in respect of prioritisation of the uses of water and customary water rights prevail in the region. This study further shows that, since the region has well-organised traditional village organisations to manage water, formation of specific water users' organisations, as stipulated by the prevailing Water Resources' Policy, may not be viable. Rather, traditional organisations should be strengthened and promoted by recognising them officially. The study further shows that the subsidy policy of the government should also be reviewed to fulfill the basic goals of people's participation and the demand-driven approach.

Recommendations

Considering the ecological setting of an area and cultural practices of the local community, development of livestock, cultivation of high-value crops, and agro-forestry (farm-grown trees) are the most prominent development options for the area in relation to water. Such developments further support the development of tourism which has been identified as one of the important development options for this area. It is to be noted that water resources' development includes various challenges like the livelihood challenge, hydraulic challenge, organisation challenge, and support challenge, of which the support challenge is the most critical (Vincent 1995). Thus development initiatives need to be multi-dimensional to address all the above challenges. Important suggestions in this respect, as important outcomes of the present study, are given below.

- Promote water resource planning on a watershed basis rather than on an individual system basis

Promotion of water resource planning on a watershed basis can provide many opportunities for equitable distribution of water, prioritisation of the uses of water, planning for future needs, and protection of watershed conditions. It can also help to minimise inter-system disputes.

- Promote snow-harvesting techniques for pasture development

Livestock are among the main sources of livelihood for the people living in this area.

Therefore, pasture land is one of the most important resources. Although there are plenty of areas under pasture, grass is scarce as a result of moisture stress, and this has restricted the development of livestock. The promotion of snow-harvesting techniques for pasture development is therefore essential.

- Introduce improved irrigation technologies

Although indigenous technologies are suitable for surface irrigation for cereal crops, they are not efficient (in terms of water use) for tree crops. Given the importance of tree crops and scarce water resources, it is imperative to develop improved irrigation technology suitable for tree crops.

- Give priority to mountain-specific policies and programmes

In Nepal, most of the policies and programmes for remote mountain areas are also identical to those for other parts of the country. Lack of mountain-specific policies and programmes has been constraining the development of this area. Provision of specific mountain policies and programmes may help to ensure the sustainable use and development of these resources.

- Promote the capabilities of traditional village organisations and recognise them officially

It has been accepted that, without full participation of the local community, sustainable development of water resources cannot be achieved. To involve the community in water resource development, it is essential to promote their organisations and recognize them officially.

- Promote market opportunities for high-value crops

Development of water resources not only includes hydraulic and organisational challenges but also includes support challenges. Promotion of market opportunities is one such support challenge. Although the potentials of high-value crops are rich in the area, lack of markets restricts their development. It is, therefore, imperative to develop market opportunities for the development of water resources.

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Plates

Plates 1a and b: ***A ching***

Plate 2: **Livestock tank**

Plate 3: **Villagers playing para**

Chapter 11

Water Harvesting Practices in Balochistan

Mushtaq Ahmed

1. Introduction

Background

There is great concern about future supplies of water for irrigation and domestic purposes in the uplands of Balochistan. The principal source of income of populations in the uplands is agriculture. Rainfall is scanty, erratic, and irregular. The only source of irrigation and drinking water is groundwater tapped through tubewells and wells. As a result of extension of electricity, tapping groundwater by tubewells /open surface wells has become cheaper. Irrigated crop areas have expanded making more demands on water supplies. Consequently, the number of tubewells / wells has increased substantially over the past decades. Pressure has increased on the aquifers because discharge has by far overtaken recharge. Water tables in the tubewells and wells have fallen. Extracting water from a depth has increased costs, both investment and operational. Now shortage of water for irrigation of crops and drinking is imminent if appropriate control measures are not adopted. Desertification of arable areas can occur.

Another threat to soil conservation occurs where land is denuded by unscrupulous cutting of bushes / trees for fuel. Land erosion caused by flash floods and wind has been causing considerable damage to agriculture, irrigation sources, and forest lands.

Watersheds are the only continuous and reliable supply of water, providing a lifeline to agricultural activities, the source of employment for the vast majority of the population. The removal of almost all vegetation has negatively affected the water infiltration rate.

During the last 40 years, new villages have been established in the watershed area. Rangelands have been exploited by transhumant flocks and the remaining vegetation has been uprooted for firewood consumption. The removal of almost all vegetation has negatively affected the water infiltration rate and increased soil erosion, with the consequence that little of the original topsoil is left. Faced with a steady decline in the availability of fodder for their herds, transhumant people have set up villages changing their productive system from transhumant grazing to permanent agriculture. The pressure on land, vegetation, and water has increased to the point that many people can no longer sustain themselves through agricultural production (FAO 1993).

Water harvesting is carried out mainly for two purposes: one for irrigatiing crops and the other for drinking water. In the study area, two kinds of agriculture are practised. Firstly, crops, orchards, vegetables, and fodder are cultivated and irrigated with water from 'kareze' (which have dried up) and shallow and deep wells operated by electricity. Secondly, wheat, barley, sorghum, and cumin depend on flood- and rain water harvested through dykes, both large and small. Drinking water supplies either come from the tubewells meant for agriculture or the tubewells installed by the government specifically for drinking water supply. Most villagers obtain water for drinking and other purposes from water channels flowing through the village carrying water to fields. Women and children are generally responsible for fetching water.

Most sources of drinking water are of questionable quality and often difficult to access. Since women are mostly responsible for the collection of household water supplies, the distances they need to travel to the source and the primitive means of transportation place a considerable burden in terms of time and effort on their daily work loads. In addition, the poor quality of water collected and the primitive methods of transport and storage perpetuate health problems caused by contaminated water.

The low status of women in the largely traditional societies in Balochistan hinders their access to safe drinking water as well as other social services and limits their decision-making authority within the household and community.

The limited and depleting groundwater sources stand as a basic limiting factor to provision of a sustained water supply. In addition, institutional weakness, lack of adequate planning, and lack of involvement of communities, particularly women, in operation and maintenance of public water schemes have been identified as major constraints in the past.

Women in the rural areas are the prime carriers and users of drinking water, which is used for the family. All the drinking water programmes should therefore ensure that women's crucial role in water management is not undermined.

Objectives

This case study was carried out in Kanak Valley, Noza micro-(sub) watershed area, in five villages covering 30 households. The objectives of this study are to investigate the following aspects.

- Socioeconomic and cultural conditions
- The water supply for irrigation and drinking
- Role of women as users of water and as decision-makers

Methodology

As a first step, a questionnaire containing socioeconomic aspects and in line with the outline agreed upon for the case study was developed. Discussions were held with the Forest Department about selection of a suitable area served by the micro-watershed and about the interview schedule. A female researcher was contracted to carry out the study. The Forest Department had a number of interviewers, both female and male, who helped carry out the interviews in the villages selected.

The micro-watershed selected for the case study is Noza watershed in Kanak Valley, Mastung District. The following five villages and 30 households were selected (Table 11.1).

Table 11.1: **Number of Villages and Households**

Village	Number of Households
Babri	10
Raza Mohammad	5
Nihal Khan	5
Bentary	5
Mohammad Hassan	5
Total	30

2. LOCATION AND COMMUNICATION

Location

Kanak Valley, where the micro-watershed lies, is located in the newly created Mastung District, about 45 km south - west of Quetta. Maps show the location of the study area and micro-watershed. The area commanded by Noza micro-watershed is 8,100 ha.

Communication

The RCD (Regional Cooperation for Development) highway connects the area with Quetta, Mastung - Nushki. The area has metalled roads connecting villages. The villages in the suburb lie only at a distance ranging from two to 10 km from the main road. The railway line (Quetta - Taftan) also passes through the area and there is a railway station at Dringer. There are local bus services daily for Quetta and Mastung (District Headquarters). The large villages have a telephone exchange and post office.

Topography

The topography of the area ranges between 1,800 to 2,500 masl from south to north.

Climate

Kanak Valley, where Noza micro-watershed is located, is situated in the desert belt of Balochistan and its climate is classified as arid, sub - tropical continental highland, with low rainfall, low humidity, frequent winds, severe winters, and mild summers. The cold season starts in early November and ends in March. There are two rainy seasons. The winter season is from December to April with frequent rainfall on the higher mountains and occasional ones in the valley. Between December to February, the area receives snowfall. Summer rains occur in July - August in the form of storms. The mean annual precipitation in the study area is 214 mm. Long dry spells are common. Therefore, dry farming is often risky unless there are years of favourable rainfall.

There is considerable variation in temperatures with the mean winter temperature being about about 24°C. The minimum temperatures are frequently below freezing from mid - November to the end of January. Maximum temperatures in June and July vary between 30° and 50°C (FAO 1993).

The meteorological data for Mastung district are given in Table 11.2.

3. SOIL AND WATER RESOURCES

Soils

Soil formation in the study area consists of parent materials of limestone and shale. Alluvial sorting out and deposition of these materials have been generated from different landforms:

Table 11.2: **Meteorological data for Mastung District**

Months	Rainfall (mm) Average 1931 / 1960	Rainfall (mm) Average 1991 / 1992	Temperature (Mean)	Humidity %
January	57.1	40.3	3.2	60
February	44.1	63.1	3.6	62
March	39.3	52.5	10.2	54
April	16.0	77.3	13.7	46
May	9.5	20.3	18.4	40
June	2.3	0.3	23.5	43
July	10.9	0.0	25.5	51
August	8.0	0.0	23.8	50
September	0.3	0.8	19.6	41
October	0.8	1.3	13.7	38
November	3.3	9.4	7.8	34
December	22.1	15.7	5.1	64
Total	214.0	281.0		

alluvial forms, piedmont plains, piedmont basins and playas, and stream floodplains. The the alluvial soils are of a gravelly loam texture, strongly calcareous, and moderately alkaline. Water infiltration is good with low holding capacity. The piedmont plain soils are loamy to silty, strongly calcareous, moderately alkaline, and have few or no weak fragments in their profile. The average pH is 7.9.In the piedmont basins and playas, the soils are clayey, deeply developed, strongly calcareous, and moderately alkaline. The stream floodplains are moderately to deeply developed, silty, brown / dark brown to yellowish brown, strongly calcareous, and moderately alkaline.

Land Use

There are three main kinds of land use in the study area.

Irrigated farming is practised on the piedmont plains and stream floodplains. Open surface wells / tubewells are on the permanent sources of water and over time replaced the kareze. Because of continuous lowering of the groundwater table, all the kareze are dry now.

Rainfed farming is of two types in the study area : 'sailaba' and 'khushkaba'. In the sailaba system the lands are irrigated with flood water coming from seasonal small streams and checked by embankments constructed across the stream bed and diverted to the fields. Stream flows are more intense during monsoon and the soil particles carried by the runoff increase soil productivity. The khushkaba lands receive moisture from rainfall of very localised runoff. The bounds are banks of earth with no spillways. Wheat, barley, and beans are sown in winter season.

Water Resources

The three available sources of water for irrigation are tubewells, open surface wells, and precipitation in the form of rain and snow. Since the average annual rainfall in Mastung district is not more that 214 mm, the farmers in the area have to depend on the first two sources. With existing agricultural practices, the available water sources cannot meet the requirements of the land. Because of the pressure on groundwater resources from agriculture, almost all the kareze have become dry. According to a study undertaken in the

Kanak Valley (FAO 1994), a continuous decline in the groundwater level in the area has been observed. The central parts of the valley have suffered a considerable drop, resulting in drying up of the majority of shallow wells. Tubewells are bored in the bottom of open surface wells. Boring of deep wells not only increases the cost of water but also puts pressure on aquifers from continuous pumping. Presently there is no proper legislation for controlling over-exploitation of groundwater resources in the area.

Evaluation of different water supply sources in terms of acceptable service standards, of quality, quantity, access, and reliability is difficult, but it is presumed that both the public water schemes and the irrigation system meet the minimal criteria for safe and adequate drinking water. The quality of unprotected water sources is generally less satisfactory than that of water from the public system.

4. SOCIOECONOMIC PROFILE

Population and Community Structure

The Kanak Valley including the study area has 40 villages that range from having 25 to 500 households. There are approximately 20,000 persons in the valley. The average family size is 7.1 (FAO 1993).

According to the survey undertaken and information gathered from 30 households in five villages in the Noza micro-watershed command area, the following picture emerges (Table 11.3).

Table 11.3: **Number of Family Members–Distribution by age and gender (N=30)**

	Age	Male	Female	Total
Children				
	0 – 5	22	21	43
	6 – 10	40	33	73
	11 – 15	21	17	38
Adults				
	16 - 25	28	34	62
	26 - 35	23	17	40
	36 - 45	12	7	19
	46 - 55	6	9	15
	56 & Above	16	7	23
	Total	168	145	313

The population in the study area consisting of 30 households in five villages totals 313 persons with men dominating. The male female ratio is 1.16:1. Among children 47.4% belong to the age group six – ten years followed by 0 - 5 and 11 - 15 year age groups. The adult population lies mostly in the age groups from 16 - 25 and from 26 - 35 years. The average family size is 10.4 persons with a range of from 5 - 20 persons per family.

There are two types of family in the study area: nuclear and joint families. The joint family is composed of different brothers with their wives, children, and their grandparents. In this system, the elder brother is the chief who manages all the money contributed by all earning members of the family. In the nuclear family system, the elder plays the role of coordinating the economic activities and social affairs. Individual adults do not have complete autonomy, they are obliged to follow the orders of the chief. The families are exclusively managed by male members. Women have little to say in family affairs.

Ethnic Distribution

The population in the study area belongs to the Brahvi linguistic group, and, historically, they are the sons of the soil. The main tribes are the Bengalzai, Babri, Sumalani, and Mengals (Table 11.4).

Bangalzai, the main tribe, has a Badozai sub-tribe with further division into Guand, Shahanzai, and Gulerzai. The majority of households (70 %) in the study area are Bangalzai, followed by Babri, Sumalani, and Mengal.

Table 11.4: **Ethnic distribution of households by tribe and sub-tribe**

Tribe	Sub - Tribe	Number of Households
Bengalzai	Badozai / Guand	8
	Badozai / Shahanzai	5
	Badozai / Gulerzai	2
	Badozai	6
	sub-total	21
Babri	Anarzai / Kotorzai	4
Sumalani		3
Mengal	Mehmoodzai	2
	Total	30

Education

The literacy rate and the standards of education are poor. The following Table (Table 11.5) shows the education status and literacy rates in the study area.

Table 11.5: **Education by class and gender**

Level	Male	Female	Total	Percentage
Primary	40	6	46	50.5
Middle	27	3	30	33
High	11	-	11	12.01
College	4	-	4	4.4

There are 91 persons out of 240 reported to have had some level of education. More than 80% never got beyond primary and middle levels, with 50.5% dropping out at primary level. Nevertheless, the literacy rate in the study area is 29.1% and is as low as 6.2% among women (Table 11.6).

Table 11.6: **No of schools by class level**

Level	Male	Female	Total
Primary	3	1	4
Middle	1	-	1
Total	4	1	5

There are five schools in the villages covered, four primary and one middle. There is only one primary school for girls.

This situation is partially related to the conservative attitude of the Brahvi people. Parents prefer to keep their children at home, especially girls, as they think schools are far from their houses. Above all, the feudal chiefs do not have a positive attitude towards educating their people because they, perhaps, presume that literacy will result in them losing their hold over the people. Lack of schools, particularly for girls, in the study area emphasises the problem.

Living Conditions

Living conditions in a family household and village are reflected by the construction, space, ventilation, and availability of lighting and heating facilities. Table 11.7 gives the number of households, type of construction, and their facilities.

All houses are *katcha* or constructed with mud and stones. The number of rooms in a house varies from two to seven and is related to the size of family. Only one house has ventilation while 29 households have closed rooms with no window for aeration. Electricity has been supplied to 26 houses and heating during winter is with coal, wood, and bushes. Almost all houses have animal sheds. Sketch maps of two typical houses (Figures 11.1 and 11.2) have been given to show the facilities in the villages in the study area.

Migration

A few decades ago, most of the population in Mastung and other areas used to migrate to the plains of Sibi, Dhadar, and other locations to survive the harsh cold weather and

Table 11.7: **Number of Households by Mode of Construction, Rooms and Facilities**

Facility	Number
Construction	
Katcha	30
Pacca	-
Number of Rooms	
2	4
3	4
4	6
5	5
6	8
7	3
Aeration	
Ventilation	1
Closed	29
Electricity	26
Heating	
Coal / Wood	30
Animal Shed	29

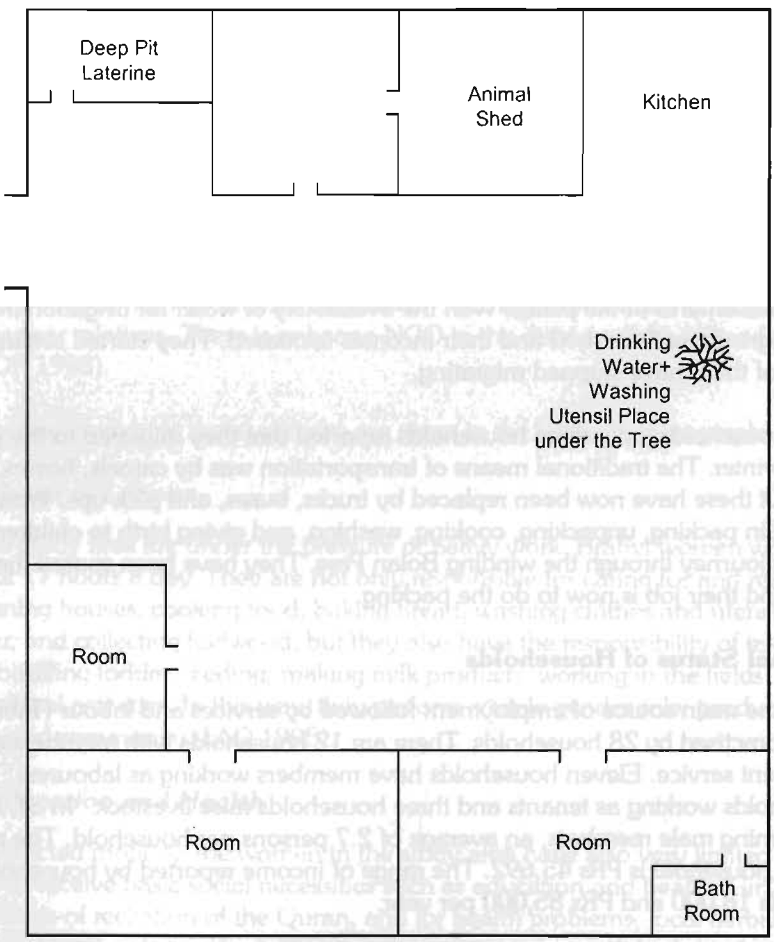

Figure11.1: **Sketch Map of a House Village: Nihal Khan**

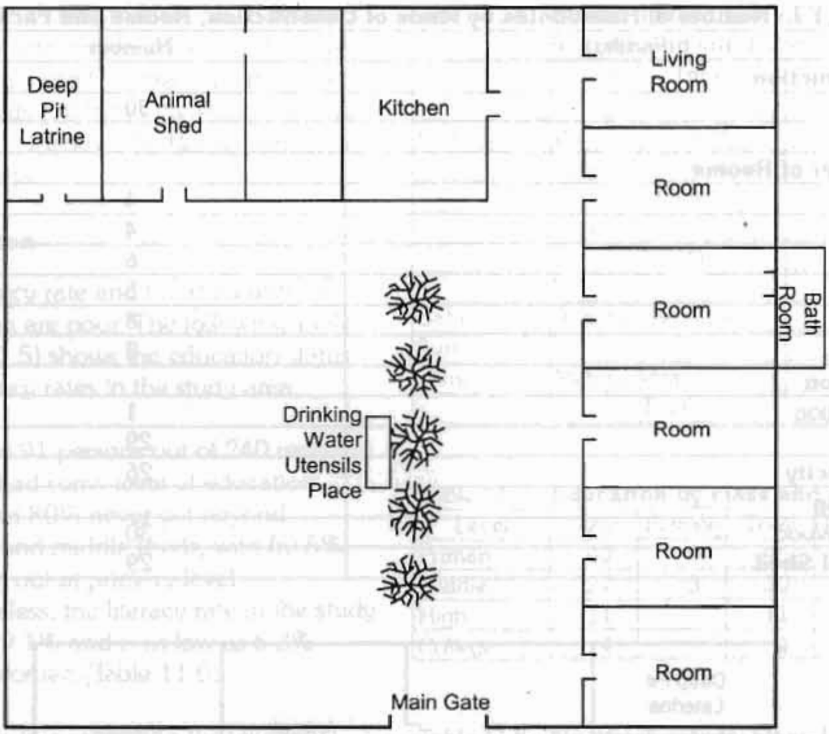

Figure 11.2: **Sketch Map of a House**
Village: Mahammad Hassan

inactive season and to look for job opportunities either by offering their services as seasonal labour in the crop production sector or by feeding their goats and sheep. They had temporary settlements in the plains. With the availability of water for irrigation from wells / tubewells, agriculture flourished and their incomes increased. They started settling down. Now, most of them have stopped migrating.

Out of 30 households, only three households reported that they migrated to the plains during the winter. The traditional means of transportation was by camels, horses, or donkeys, but these have now been replaced by trucks, buses, and pick-ups. Women used to be involved in packing, unpacking, cooking, washing, and giving birth to children during a month-long journey through the winding Bolan Pass. They have been spared these hardships and their job is now to do the packing.

Professional Status of Households

Farming is the main source of employment followed by services and labour (Table 11.8). Farming is practised by 28 households. There are 12 households with members employed in government service. Eleven households have members working as labourers. There are four households working as tenants and three households raise livestock. In all, households have 81 earning male members, an average of 2.7 persons per household. The average income per household is PRs 45,692. The range of income reported by households is between PRs 18,000 and PRs 85,000 per year.

Table 11.8: **Distribution of households by profession, number of earning members and average income/household**

Profession	Number	% age
Land Owner	28	93
Tenant	4	13
Service	12	40
Livestock	3	10
Labour	11	37
Earning Members	81	2.7 average
Total Income / Household		
	Range (PRs '000)	18 - 85
	Average (PRs)	45,692

Gender Issues

Gender issues arise as a result of the low status and position of female members in the household as well as in society. Women do enjoy freedom of movement but only within the village. While going outside the village, a male member of the family has to accompany them. There is no *purdah* inside the village. Women are not involved in any decision-making. Women exclusively perform household chores; however, economic activities in agriculture are shared by both genders. Money is only handled by men. Women generally fetch water and fuel from far - flung areas. Their husbands are responsible for tending animals and crops. Women do the cooking, cleaning, washing, and looking after the children. Women do keep poultry and rabbits besides livestock which are fed orchard waste. Jewellery is the only asset owned by the women. The parents have expectations of financial assistance from their sons in old age as well as that both genedrs will look after their physical comfort.

Both genders have obligations to live together in all situations. In very rare cases, on the assumption of betrayal, men do divorce their wives. Marriages are mostly arranged with a preference for near relatives. There is only one NGO in the district, which is headed by a woman (UNDP 1998).

Iissues confronting women in the study area are given in the following paragraphs.

Gender Division of Labour

Women in the study area are under the pressure of heavy work. Brahvi women work on average about 17 hours a day. They are not only responsible for caring for and rearing children, cleaning houses, cooking food, baking bread, washing clothes and utensils, and fetching water, and collecting fuelwood, but they also have the responsibility of taking care of animals, collecting fodder, feeding, making milk products, working in the fields, assisting men in agricultural activities. In this way, they perform a triple gender role: productive, reproductive, and community (FAO 1995).

Access to Education and Health

Because of restricted mobility, the women in the study area have also very limited opportunities to receive basic social necessities such as education and health. Girl's education consists of recitation of the Quran, and for health problems, local herbal medicine practitioners (*hakeem*) or *taveez* from the *mullah* or a visit to some holy shrine have to provide a solution. Only when life is at stake do women members get taken to Mastung and Quetta.

Participation in Decision-making

Inside the compound women manage everything for the family, but outside the compound walls, the role of women in decision-making is negligible. Even in the house, women have no voice in domestic matters. In the study area, 50% of the women reported that their opinion in household affairs is accepted by the men members.

Access to Capital and Credit

The rural women have no access to capital and credit in general. The marketing of agricultural commodities is exclusively carried out by men members as well as handling all cash.

Access to Agricultural Extension and Information

The access to agricultural extension services and information by women is very poor. Although women participate intensively in agricultural activities, the dissemination of information and techniques is entirely imparted to men. In some cases, training in food and nutrition, health, child care, and home management is provided to women while men are trained in extension services to improve farming practices. Men in the family rarely discuss information with the women (FAO 1995).

Organisational Role of Women

Table 11.9 shows how many households are members in village organizations, organizational functions, and women's participation.

FAO has recently introduced different income-generating schemes and nine households have membership in these organisations. In addition, women by themselves run 20 schemes in savings, credit, tree planting, and other income- generating activities. Eighteen households are participating in credit schemes in poultry and sheep raising with 306 members, each scheme is comprised of 11 to 17 women members. No woman has access to credit other than from the FAO-operated programme (FAO 1997) The women do not own any property; therefore they cannot approach banks for loans or credit as they have no collatoral or guarantee.

Table 11.9: **Households with membership in an organisation, function of the organisation and women's participation**

		Number of Households	
a.	Membership in Organization	9	
b.	Separate Women's Organizations in Sewing, Credit, Tree Plantation, and Income generation	20	
c.	Poultry, Sheep Raising, Credit Schemes by Women	Number	Members
		18	306*

* Includes women from other households in the village not covered by the study.

Women in Agriculture

Women work in the fields on a seasonal basis. In the spring and summer they plant seedlings and thereafter at intervals they weed the crops. Women clean and store winter wheat. In the fall women go to the fields daily to harvest onions (FAO 1993).

In the study area, women help men with almost all crop management operations. Table 11.10 gives women's participation in agricultural activities.

Table 11.10: **Women's participation in agricultural activities**

Activities	Household	
	Number	(%)
Cleaning Seeds	18	60
Sowing	17	57
Weeding	28	93
Harvesting	28	93
Threshing	2	7
Storing	22	73

Women mostly participate in cleaning seeds, sowing crops, weeding, harvesting, threshing, and storing. In weeding and harvesting, 93 % of the women take part, while in storing produce, cleaning seeds, and sowing operations also women do participate.

Role of Women in Caring for Livestock

Livestock are the secondary source of income in rural areas and are especially important as far as raising domestic animals is concerned. Sometimes, a family is hired to graze all the sheep and goats in the village. Women from the household milk the animals and feed them in their compounds. Children collect fodder for the animals to eat at night and at other times women bring weeds and onion stalks from the fields for fodder. They generally look after sick animals and assist in delivery of sheep and goats. In raising domestic animals women have a pronounced role. In the study area, there were 119 goats, 111 sheep, and two cows managed by 30 households. Women are generally responsible for raising and managing these animals. Animals are mostly watered at home (23 households). Only five households take their animals to water storage tanks. Animals are watered by women, generally once a day. Activities include health care, milk processing, and preparation of milk products such as butter, local cheese, ghee, and buttermilk. Besides collection of fodder for animals and collection of farmyard manure, hay and silage making are the responsibility of women. In some cases, women also handle the buying and selling of animals (goats and sheep) and their by-products— including hides for water bags and wool for carpets, grain bags, and ropes.

Every household keeps an average of 10 poultry. Through poultry raising women supplement both their incomes and nutrition. In the absence of improved and proper knowhow, such as vaccination and balanced feed, poultry farming is very risky. Sometimes mortality is as high as from 50 to 70%. Poultry is generally raised on kitchen and food-grain wastes. Rabbit farming has also been introduced into the study area.

Health

Health services are very minimal in the study area. Only one Basic Health Unit exists in Babri Village. Child and maternal mortality are high. Serious health cases are treated either at Mastung (District Headquarters at a distance of 16 km away) or taken to Quetta where specialised health facilities are available (Table 11.11).

Table 11.11: **Incidence of disease in the study area**

Disease	Households
Malaria	29
Diarrhoea	8
Typhoid	2

The three major diseases reported were malaria (97 %), diarrhea (27 %), and typhoid (7 %). Most villagers are aware of the relationship between clean water and good health (UNICEF 1984). Bad or unclean water is thought to cause the following complaints.

- Fever
- Stomach pain
- Indigestion, heartburn
- Distension, gas
- Dysentry
- Constipation
- Vomiting
- Lack of appetite
- Cholera
- Pneumonia
- Kidney stones

In addition, a connection was made between bathing in dirty water and a variety of skin ailments, such as rashes and boils, which afflict children especially.

Critical Issues

The main critical issue confronting the study area is the rapid rate of depletion in the water table in the tubewells. The households owning tubewells reported a decline in the water table ranging from 10 - 20 ft annually. This poses a grave threat and can result in drying up of water and consequent desertification and abandonment of land. The other issue is the shortage of social amenities leading to low literacy, poor health, and other related problems. Neglect of women's participation in community affairs has meant that the impetus necessary to uplift the general welfare of families is lacking. Denudation of range and forest areas has constrained the recharge of aquifers and regrowth of fodder for animals.

5. PUBLIC SECTOR / NGO ROLE IN SOCIAL INFRASTRUCTURE

Institutional responsibilities for planning and establishing public water supply schemes rest with two government agencies and their affiliated bodies. The Public Health Engineering Department (PHED), created in 1987, has the mandate to design and construct safe water supply systems in both rural and urban areas. Once established, operation and maintenance of these schemes are supposed to devolve to local communities. For the most part, the focus of the department has been on large drinking water supply schemes. The local Government and Rural Development Department (LGRDD) deals with people at the community, union council, and district levels. Its mandate is to help organise communities and provide basic services in public works—including improvement and development of all rural drinking water supply schemes as well as supervision of water and sanitation projects. The Social Action Programme (SAP), namely SAP - I (1993 - 96) contributed substantially towards improving the existing indicators in education, health, rural water supply and sanitation, and welfare of the population in Balochistan. Building upon the foundation of SAP - I, SAP - II began in 1997 – 98, emphasising community involvement from design to operation and maintenance and working in partnership with NGOs.

According to the survey, there are more than 160 NGOs working in Balochistan in various activities. There are about 10 NGOs working in watershed management, agriculture, rural development, and drinking water supply activities. Most NGOs operate from Quetta and, if required, extend their activities to other parts of Balochistan. There is only one NGO working in Mastung district.

6. LOCAL WATER SUPPLY AND MANAGEMENT SYSTEMS

Water supplies for both drinking and irrigation of crops are predominantly derived from groundwater. The local systems include kareze (which have dried up), springs, open surface wells, and those converted into deep wells / tubewells.

Sources of Drinking Water

The drinking water in the study area is collected from government and privately-managed tubewells, water channels, and water storage tanks (Table 11.12).

Table 11.12: **Source of drinking water in the study area**

Source	House-holds	Remarks
Government tubewells—piped water	10	Water charges Rs 40/annum
Private tubewells	17	Free, at a distance of from 300 to 1,000 ft
Water channel	3	
Water storage tank	15	Water tank cleaned once a year and 9 households reported it to be full of water plants and fungi

For drinking purposes, there is sufficient water available. As far as quality is concerned, mostly clean and sweet water is available. The households collecting drinking water from the open water channels have chances of drinking contaminated water. The water channels are generally *katcha* and open, and puddles form where water is diverted for irrigation. Water storage tanks are *katcha* (without linings) and some are full of plants. About 15 households collect drinking water from the tanks. The tubewells, both government and private, lie at a distance ranging between 300 and 1,000 ft. The Government supplies drinking water to households in Babri Village (10 households reported collecting water from pipes in the study area) and each household has to pay Rs 40 per annum as water charges. The private tubewell owners do not charge any money and users can collect water free of charge, but individual ownership of the tubewell is resulting in the loss of rights by communities. Individual owners of tubewells in fact prefer to irrigate orchards instead of supplying drinking water to neighbours.

Means of Water Conveyance

Means used for obtaining drinking water are different for different areas. In order to fetch suitable water, most households are willing to take more time and effort than for other tasks such as washing dishes and laundry. If the source is far away, the men are responsible for collecting water and use animals to carry the water.

However, among the villages covered by the study, Babri village receives water through a pipeline, and this is further distributed by pipes to the households. The households in the other villages use different means to convey or fetch water (Table 11.13).

Most of the households in the study villages use utensils and rubber tubes to fetch water while others use buckets and pitchers. Most of the households fetch water once and twice a day. Five households reported three to four trips for water. Only one household collects water every second day. Women are reported to be responsible for fetching water. The women go to fetch water in groups and on the way, or at the source, they exchange views / news.

Table 11.13: **Means used for water conveyance, frequency of water collection**

Means Used	Households
Rubber Tubes	10
Buckets	7
Pitcher	6
Utensils	14
Frequency / No of Trips	
Once a day	9
Twice a day	15
3 - 4 times a day	5
Every second day	1

The water is stored generally in water storage tanks which are built alongside or near tubewells. These are mostly owned by tubewell owners. The study households had *katcha* storage tanks. *Katcha* water storage tanks are ideal breeding grounds for water-borne diseases.

Domestic Water Storage Arrangements

Domestically, water is stored in different ways in the study area (Table 11.14).

The main means of storing drinking water are rubber tubes and pitchers. Households store water for drinking, washing dishes, and bathing in the *hammam* (drums for water fitted with taps) which can store more than 45 gallons of water. The cleanliness of domestic water storage equipment is reflected by the number of times the storage utensils are cleaned. Most households reported cleaning domestic water storage vessels once a week; some households cleaned their vessels daily.

Table 11.14: **Household water storage arrangements**

Means of Storage	No. of Households
Rubber tubes	27
Pitchers	22
Hammams (drums)	12
Utensils including buckets	5
Frequency of Cleaning	
Daily	10
Every second day	1
Once a week	13
Once in two weeks	

Water for Irrigation

There are two crop production systems in the study area: irrigated and non-irrigated. Irrigated crop production depends mostly on tubewells where the water table is deep. Tubewells are the predominant source of irrigation for crop production. Non-irrigated crop production is carried out in two conditions. One is the sailaba, in which flood water is harvested by constructing large bunds (dykes) with spillways. The other depends directly on the rains. In the rainfed system, flash-flood water is checked by small embankments. The only source of irrigation available in the study area is by tubewell. Crops are irrigated from tubewells that are owned or water is purchased from a tubewell owner (Table 11.15).

There are 11 tubewells owned by households and three tubewells are contracted for supplying water for crops. The quantity of water available from these tubewells is insufficient, and there is a decreasing trend in water tables in the tubewells in the study area, registering a depletion of from 10 to 20 ft annually. Tubewells are owned individually by households. The government maintains tubewells for drinking water supplies. The quality of water from these tubewells is good and water is fit for irrigation. If the present water table depletion trend continues, salinity will be encountered at some stage. Decrease in the supply of water for irrigation will have an adverse impact on crops irrigated by tubewells, and this will ultimately affect household incomes adversely.

Table 11.15: **Sources of irrigation by village**

Village	Number of Tubewells	
	Owned	Contracted
Babri	4	-
Raza Mohammad	2	2
Nihal Khan	-	1
Bentary	3	-
Mohammad Hassan	2	-
Total	11	3

Cost of water from tubewells depends on the discharge of water, depth of the water table, motor, and other factors such as maintenance and electricity charges. The investment needed to install a tubewell with a water table at a depth of from 300 - 500 ft varies between Rs 1.00 - 1.50 million. However, the per hour cost of irrigation from a tubewell with a water table of 300 - 400 ft ranges between Rs 30 and Rs 45. The per acre cost of irrigation for orchards and vegetables is higher than for grain crops as they require far more watering (15 – 22 times) than grain crops (3 – 5 times).

Water is usually stored in *katcha* water tanks dug into the ground. The size and depth of water tank are related to the discharge from the tubewell and area irrigated. Nevertheless, frequent interruption in electricity has necessitated the construction of water storage tanks. The Department of Agriculture, through the On-Farm Water Management Project, has provided subsidies for the construction of *pucca* (built from masonry works) water storage tanks to prevent water from seeping away. All the households owning tubewells have *katcha* storage tanks.

Water for irrigation is carried and distributed to the fields through *katcha* channels. The water loss estimated from *katcha* channels is about 30%.

Uses of Water

Groundwater is the essential reversible resource. The most important income-generating activities, irrigated and pastoralism, depend mainly on groundwater. Traditionally kareze were used to extract groundwater for irrigation agriculture and domestic requirements. Then dugwells were used for irrigation. Dugwells irrigate about 1.5 ha. Diesel wells took over in the 1960s. In the 1970s diesel pumps were replaced by cheaper electric pumps. A standard tubewell provides irrigation for approximately 15 ha. Rain water is checked by constructed dykes and embankments to irrigate a limited area.

The cultivated area owned by households is 198 ha of which 14 ha are rented. The irrigation status of this area is as follows.

-	Irrigated Land	84 acres
-	Unirrigated Land	48 acres
	Total :	132 acres

Only 67% of the total cultivated land owned and rented is used. Table 11.16 gives the crops grown by household and area under crops.

Crops grown on irrigated lands include fruit trees, vegetables, onions, wheat, and fodder. Crops grown on unirrigated land are wheat and barley. Cumin seed is grown both in irrigated and unirrigated conditions. The average cultivated landholding is 4.4ha.

Table 11.16: **Crops grown by household and area under crops**

Crop	No. of Households	Area in ha
Orchard	8	28
Vegetable	2	2
Onion	15	21
Wheat	29	61
Barley	14	19
Cumin	5	5
Fodder	3	2

Note: the average cultivated landholding is 4.4 ha.

7. INSTITUTIONAL ASPECTS

A threat is posed by continuous depletion in water tables. This problem stems from over-exploitation of groundwater and a mushrooming in installation of tubewells over aquifers with limited water supplies. Although there is a law that prohibits installation of tubewells to within specific limits, this law is not followed in true spirit. Interruption in electricity supply and increasing electricity charges have led to adoption of illegal means in the use of electricity. Tubewell installation is undertaken by the Irrigation Department for irrigation and the Public Health Department for drinking water supplies. The Forest Department carries out watershed management programmes. The impact of watershed programmes has not as as yet been felt. Unscrupulous uprooting of trees and bushes in the watershed area goes unnoticed. There are very few instances of improvement in the watershed command area. The present effort in rangeland rehabilitation is still in the demonstration stages (FAO 1997).

8. CONFLICTS AND THEIR RESOLUTION

Table 11.17: **Nature of conflicts reported by households**

Nature	Households
Tribal	8
Water-related	2
Land-related	22

There are generally three kinds of conflict in the study area: a) tribal b) water-, and c) land-related. Most of the households reported a prevalence of land-related conflicts (Table 11.17) arising from distribution of land within families, tribal disputes over ownership of land, and illegal confiscation of land. Tribal conflicts result from murder, rape, and elopement. Tribal feuds are the most dangerous and linger on for generations and many innocent people become victims. Very few households reported water-related conflicts; those reported were usually involving the route of the water channel.

9. POLICIES (NATIONAL / PROVINCIAL) AND PROGRAMMES

As an adequate and regular supply of water is needed for cultivation of crops, drinking, and other uses. Agriculture is a principal user of water. Most water resources are derived from precipitation in the uplands—including the study area. The main source of water for irrigation is underground aquifers. An increase in the number of tubewells has exerted damaging pressure on these aquifers resulting in less and less water. Discharge is far greater then recharge. Issues relating to water are centred around the following.

- Scarcity of water
- Depletion of groundwater resources
- Wastage of flood water
- Inefficient use of irrigation water
- Absence of control over groundwater abstraction
- Availability and quality of water for drinking purposes
- Involvement of communities, particularly the actual users of drinking water, the women, in the drinking water supply scheme
- Inadequacy of institutions

National as well as provincial policies relating to water harvesting, for both irrigation and drinking purposes, have been oriented towards improving water supplies, especially in water-scarce areas, to increase the efficiency of usage, introduce and implement programmes to improve water recharge, use flood water for non - irrigated agriculture, and improve access to drinking water by involving communities in the drinking water supply programme. The institutions involved in improving water supplies are Irrigation, Agriculture, Forestry, Public Health Engineering, Local Government and Rural Development, and NGOs. The Irrigation Department implements programmes to investigate and tap groundwater resources and install tubewells to increase water supplies for irrigation, construct checkdams, harvest flood water, improve recharge, and legislate undue installation of tubewells and over-exploitation of groundwater.

Watershed degradation has resulted in an increase in the incidences of flash floods, soil erosion, siltation of irrigation dams, decrease in the natural recharge rate of groundwater, and other problems. The importance of watershed management in increasing groundwater recharge has been realised in the province. The irrigation department has constructed delay action dams to increase recharge. There is a lack of collaboration between the irrigation department and other related departments. The Department of Agriculture has been undertaking On-Farm Water Management Programmes in the Province to increase supplies of water for irrigation and improve efficiency in its usage. The programme includes construction and improvement of water courses, construction of water storage tanks, and precision land levelling. Flood irrigation and harvesting are most commonly practised in Balochistan through development by the private sector with support from the government. The private sector has been instrumental in this respect as the farmers divert the flood flows by constructing low to medium height earthen bunds on perennial and ephemeral streams to serve as diversion structures. Construction of simple and small dykes across slopes in alluvial farms and valley areas is also carried out to store and conserve water whenever there is rain.

The Public Health Engineering and Local Government and Rural Development Department are involved in improving water and sanitation in rural Balochistan. Drinking water supplies are delivered by installing tubewells and providing water taps for the houses. The major project through which drinking water supply is being arranged is the SAP-II, and water and sanitation are among the components.

Because of the failure of government institutions to implement effective programmes in irrigation and drinking water supplies, the participation of communities in designing, implementing, operating, and maintaining irrigation and drinking water supply schemes / programmes has been made mandatory in order to explore new approaches to involving communities by introducing innovative ways to deliver social services to people's doorsteps. SAP was launched in 1992 – 93 with this in mind and has been extended for another five years. This programme was designed to provide five basic social services, of which one is rural water supply. The overall objective is to improve access to safe drinking water through participation of communities. The programme focuses on women and girls, facilitating behavioural change in order to realise the full benefits from such services, improved government / NGO capacities, and policy refinement. Following the policies and strategies of SAP-I (1992 - 1996)and SAP-II (1997 - 2002), a uniform policy is adopted in each province / area. The uniform policy establishes beneficiary community involvement at each stage of scheme construction or rehabilitation from planning to preparation and operation.

The Balochistan Rural Water Supply and Sanitation Project has also been working in Balochistan to provide safe drinking water to the rural population (GOP 1997).

10. Conclusions

The Noza micro- (sub) watershed has over time been run over by Afghan refugees for grazing their livestock. Overgrazing and use of bushes for fuel led to its denudation, leading to a reduction in infiltration of water for the replenishment of aquifers. Sources of water for irrigation and drinking have registered a continuous lowering in the water table. Extraction of water from depths ranging from 300 to 500 ft has not only increased operation costs but has also has led to the drying up of aquifers.

Everyone depends on agriculture in one way or the other. The present socioeconomic welfare of the area is directly related to sustainability and replenishment of water resources. There has been a rise in standards of living as a result of increases in income generated by high-value orchards and crops. Traditional winter migration is decreasing and people have adopted a sedentary way of life, but housing and living conditions are still as they were a hundred years ago.

Consciousness about education and health has increased. The female population has not received much in terms of education or literacy programmes. Access to education in terms of educational institutions is provided. Attitudes towards education are feudal and religious norms do not allow the spread of education, especially among women. Health facilities are minimal in the area. For treatment, people travel to city centres. Children and women are the main sufferers as they require immediate attention and treatment.

Women contribute to agriculture and livestock by assisting men in the fields and in raising livestock (goats and sheep). Nevertheless remuneration and recognition are negligible. Women have become involved in income-generating schemes and women's organisations have been formed at village level. Even then their participation is limited. Women are not yet able to accept changes in their present way of life. Still a breakthrough has been achieved. With education, women can become empowered and assert their opinions on family and other matters.

Water is of tremendous importance in the life of village women. Being the sole water collectors and carriers in the family, a major portion of their time is spent on this. They have to travel long distances repeatedly to fetch water. The quality of water in the open and *katcha* (not-concrete) water tanks and water channels used for irrigating orchards and crops is poor for drinking purposes, as they are polluted with fungi and micro-organisms, and these are seldom cleaned. The government, through the Social Action Programme (SAP) has provided tap water connections to some villages. Most villages, however, still do not have them. A range of vessels is used to fetch drinking water and storage facilities are generally not clean. Pollution of water tanks and channels often results in water-borne diseases, a major cause of morbidity and mortality among children in the study area.

The harsh environmental conditions and meagre resources, oppressive economic conditions, and inept infrastructure are the main constraints to development in the study area. The traditional feudal system and illiteracy have further aggravated this situation.

The low social status of women and traditional norms have kept women from the mainstream of society. The role of services offered by women is not recognised. However, there have been some changes and a transition in women's economic role has begun. Stress is being placed on equality of treatment and the role of women in social upliftment. Government policies and programmes are being oriented to include community along with women in the formulation, implementation, and operation of area and community-specific schemes / projects.

11. Recommendations

The issues raised and problems of an imminent nature, whether they are related to sustainability of resources or provision of gender-related socioeconomic facilities or institutional inadequancies, need to be addressed seriously. Moreover, the condition of the most deprived and oppressed members of society, the women, needs to be improved and their share in the socioeconomic field needs to be provided. Social improvement should be realistically pursued. The specific recommendations arising from the study are as follow.

1. In order to save the depleting water tables, a serious threat to the sources of water for irrigation and drinking, further digging of tubewells should be prohibited.
2. Introduction / extension of on- and off-farm water-saving techniques should take place.
3. Watershed management programmes should be strengthened and the necessary measures adopted to improve watershed areas.
4. Improvement of economic conditions should be facilitated by activating and involving women in income-generating programmes and activities.
5. Hygienic house construction by providing for properly ventilated rooms, water storage, sanitation, and animal shed placement should be introduced.
6. Domestic animal raising by providing appropriate training in livestock management and disease treatment skills should be improved.
7. Better access to potable and hygienically safe water in close proximity to the houses, economic water usage techniques, hygiene and sanitation, and education should be provided.
8. Local training of women on a modern and commercial basis to improve their capabilities in culturally permissible enterprises should be introduced.
9. Introduction and training on development and use of time-saving and viable practices and uses such as food processing and preservation, improved farming methods, rearing exotic livestock breeds, nutrition and disease control, and linking women to agricultural extension services should be facilitated.
10. Legislation on minimum wages for handicrafts and agriculture (hired labour)should be enacted.
11. Awareness of the potential rights as enunciated by Islam to remove social evils should be raised.
12. Access of villagers to education and health care should be increased and NGOs encouraged to extend their outreach to villages.

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Annex I

Detailed Workshop Programme Schedule

Day One: Sunday, 14 March 1999

09:00	Arrival and Registration
09:30	**INAUGURAL SESSION**
	• Background on Workshop: Suresh R. Chalise • Opening Remarks: Director General, ICIMOD • Remarks: Ujjwal Pradhan, Ford Foundation • Vote of Thanks, Saleem A. Sial
10:00	Tea Break and Group Photo
10:45	**SESSION - I**
	Case Studies on Water Harvesting Technologies and Management Systems
	• Overview of Case Studies: Mahesh Banskota • Highlights of Case Studies • UP Hills, India: Ram Babu • Ladakh, India: Deldan B. Dana - Midhills, Nepal: Jyoti Prashad Lohani - Mustang, Nepal: Chiranjivi Sharma - NWFP, Pakistan: Muhammad Jamal • Balochistan, Pakistan: Mushtaq Ahmad • Discussions on Case Studies
13:00	Lunch Break
14:00	**SESSION - II**
	Country Reviews on Policies, Programmes and Institutions
	• Overview of Policies: Prachanda Pradhan • Highlights of Countries Reviews on Policies • Bhutan: Kaylzang Tshering • China: Liu Changming • India: V.S. Saravanan • Nepal: Shanker K. Malla • Pakistan: Shahid M. Zia
15:30	Tea Break
16:00	Discussions on Policy Reviews
17:00	End of Day 1
19:00	Reception Dinner Hosted by the Director General of ICIMOD

Day Two: Monday, 15 March 1999	
	SESSION- III
09:00	Rural Water Supply and Sanitation Project, Lumbini Zone, Auli Keinanen
09:20	Rainwater Harvesting and Utilization in the Hills of Lumbini Zone, Ramesh Bohra
09:45	Comments by the Community Representatives from Rural Water Supply Project Lumbini Zone, Mr. Lok Bahadur Gyawali and Mrs. Kamla Gyawali
10:15	Water and Watershed Management in the Indian Himalayas, Chandi Prashad Bhat
11:00	Traditional Irrigation Management in Jumla, Western Nepal, D.D. Devkota
11:30	Tea Break
	Field Visit
12:00-1600	Departure for field to observe traditional water- harvesting systems at Bhaktapur

Day Three: Tuesday, 16 March 1999	
	SESSION - IV
9:00	**Group Discussions**
	Group A, Institutional Aspects • Policies on Water Harvesting for Irrigation • Policies on Water Harvesting for Household Uses • Equity among Upstream/Downstream Water Users • Participation by Water Users (Both Men and Women) • Local Governance • National Project Working Groups • Management Systems • Networking
	Group B, Financing Programmes • Subsidies/Incentives by Governments, Banks, Private Enterprises • Funding from NGOs and INGOs • National Programmes on Water Harvesting
	Group C, Technologies and Research for Sustainable Development of Local Water-harvesting Systems • Traditional Technologies and Their Limitations (*Zings, Spouts, Karez, Tanks*). • Innovations (Ferro-cement Cisterns, 1-2-1 project China, Underground Cemented Tanks, High Efficiency Conveyance and End Use Systems) • Integrated Programmes Including, Water Storage Facilities, Orchards/ Vegetables Gardening and Raising Dairy Animals, Tourism.
10:30	Tea Break
11:00	Group Discussions Continued
12:30	Presentation of Groups Recommendations
13:00	Lunch Break
14:30-16:00	**SESSION - V (PLENARY)**
	Finalisation of Recommendations

Annex II
List of Participants

SN	Country	Name	Address
1.	**Bangladesh**	Md. Shahjahan, Executive Engineer	Chittagong Hill Tract Development Board Fax: 88-02-860781 Tel: 88-02-860613
2.	**Bhutan**	Mr. Kaylzang Tshering Chief Irrigation Officer	Research, Extension and Irrigation Division Ministry of Agriculture Thimphu, Bhutan Fax: 975-2-23562 Tel: 975-2-22228
3.	**China**	Prof. Liu Changming Academician	Chinese Academy of Sciences Institute of Geography, Bldg 917, Datun Road or Anwai, Beijing 100101 Fax: 86-10-64889309 Tel: 86-10-64889306 e-mail: cmliu@pku.edu.cn liucm@dls.iog.ac.cn
4.	**India**	Dr. Ram Babu Head Economics and Project Planning Division	Central Soil and Water Conservation Research and Training Institute (CSWCRTI) 218 Kaulagarh Road Dehradun 248 195, U.P. Fax: 91-135-754213 Tel: 91-135-757212 e-mail: cswcrti!@x400.nicgw.nic.in
5.		Dr. V.S. Saravanan	Centre for Science and Environment 41 Tughlakabad Institutional Area New Delhi 110062 Fax: 91-11-6985879 Tel:91-11-6983394/6986399 e-mail: saravanan@cseindia.org
6.		Mr. B. Deldan Dana C/o Karakuram Hotel	Near Ecological Centre P.O. Box 120 Leh, Ladakh (J and K) Fax: 0 198253154 Tel: 0 198253174
7.		Mr. Sonam Dawa Advisor	Ladakh Ecological Development Group Leh- 194101, Ladakh, India Fax:52284 Tel: 0 1982-53221; 52482 (R) e-mail: leh@x400.nicgw.nic.in
8.		Dr. Ujjwat Pradhan Programme Officer	Ford Foundation 55 Lodi Estate New Delhi - 3, India Fax 91-11-4627147 Tel: 91-11-46 19441 e-mail: u.pradhan@fordfound.org
9.		Ms. Radhika Johari Programme Assistant	Ford Foundation 55 Lodi Estate New Delhi - 3, India Fax 91-11-4627147 Tel: 91-11-46 19441 ail: r.johari@fordfound.org

1.	**Nepal**	**Mr.** Jyoti Prashad Lohani	CPRA Sano Gauchar Kathmlandu Tel: 977-1-430353 e-mail: aashis@mos.com.np
2.		Mr. Devi D. Devkota	Jumla, Nepal
3.		Dr. Shanti Nath Shrestha Senior Div. Engineer	Department of Irrigation Jawalakhel, Kathmandu Tel: 977-1-537311
4.		Mr. Murari Upadhyay Consultant	Fax: 977-1-411642 Tel: 977-1-421463
5.		Mr. Duman Thapa President	Mountain Resources Group P.O. Box 4610 Kathmandu, Nepal Fax: 977-1-572555 e-mail: duman@wlink.com.np
6.		Mr. Chiranjibi Sharma	Agricultural Projects Services Centre (APROSC) P.O. Box 7716, Kathmandu Tel: 371731 (R) e-mail: chiran@htp.com.np
7.		Dr. Prachanda Pradhan	FMIS Promotion Trust P.O. Box 32, Lalitpur Pulchowk, Kathmandu Fax: 977-1-524104 Tel: 977-1-524916 e-mail: pradhan@prachand.mos.com.np
8.		Mr. Shankar K. Malla	IIDS, P.O. Box 2254, Purano Baneshwor, Kathmandu Fax: 977-1-520413 Tel: 977-1-478930
9.		Dr. Mohan M. Sainju Executive Chairman	IIDS, P.O. Box 2254, Purano Baneshwor, Kathmandu Fax: 977-1-520413 Tel: 977-1-478930
10.		Mrs. Auli Keinanen, Deputy Team Leader	HMG/FINNIDA Rural Water Supply and Sanitation Project P.O. Box 12, Butwal Rupandehi Fax # 071-40842 Tel: 977-71-40782,40513 e-mail: rwsspbtw@wlink.com.np akeinanen@wlink.com.np
11.		Mr. Ramesh Bohara, DDP Advisor	HMG/FINNIDA Rural Water Supply and Sanitation Project P.O. Box 12, Butwal Rupandehi Fax 977-71-40842 Tel: 40513 e-mail: rwsspbtw@wlink.com.np
12.		Mr. Dhibba P. Subedi Technical Advisor	HMG/FINNIDA Rural Water Supply and Sanitation Project P.O. Bok 12, Butwal Rupandehi Fax 977-71-40842 Tel: 40513

13.		Radha Gyawali VDC Ward Member	FINNIDA
14.		Mrs. Kamla Gyawali WVC Member	FINNIDA
15.		Mr. Lok Bahadur Gywaii, VDC Chairman	HMG/FINNIDA P.O. Box 12, Butwal Rupandehi
16.		Mr. Bhimarjun Pandey	HMG/FINNIDA District Development Committee Office Gulmi Fax: 079-20229, 20240 Tel: 079-20229
17.		Mr. Krishna Lai Piya	HMG/Nepal Ministry of Local Development District Development Committee Argakhanchi, Lumbini Zone Rural Water Supply and Sanitation Project, Agarkhanchi Nepal-Finland Cooperation Tel and Fax: 077-20144
18.		Mr. Mohan Raj Chapagain	HMG/FINNIDA Rural Water Supply and Sanitation Project P.O. Box 12, Butwal Rupandehi Fax: 079-20229, 20240 Tel: 079-20274
19.		Mr. Govinda Ram K.C. Senior Divisional	DoLIDAR Butwal
20.		Mr. Anil Mishra Assistant Professor	Civil Engineering Dept. Water Resources Section Institute of Engineering P.O. Box 8557, Kathmandu Tel 977-1-521260 (0); 310065 (R) Fax:312490 e-mail; anil@mishra.mos.com.np
21.		Mr. Bishnu Raj Upreti Ph.D. Student	Wageningen Agricultural University Hollandswegl, 670KN Wageingen The Netherlands
22.		Basu Dev Joshi Associate Professor	Central Department of Geography Tribhuvan University Kirtipur, Kathmandu
23.	**Pakistan**	Dr. Muhammad Jamal Khan Khattak	Chairman, Department of Water Management NWFP Agricultural University, Peshawar, Fax 92-0921-845020 Tel: 92-0921-845020 e-mail: jamal@water.psh.brain.net.pk
24.		Mr. Mushtaq Ahmed Agr. Economist	Directorate-of Agricultural Planning Agriculture Department Govt. of Balochistan FAX # 92-81-9211509 Tel: 9211508 Email: khushhal@gak3.ptc.pk.
25.		Dr. Shahid Zia Research Fellow	Sustainable Developmdnt Policy Institute (SDPI) No. 3 UN Boulevard, Diplomatic Enclave - 1, G-5/1, P.O. Box 2342, Islamabad Fax 92-51-278135 Tel:51-270674/278134 shahid@sdpi.org

26.	**ICIMOD**	Dr. Mahesh Banskota	International Centre for Integrated Mountain Development (ICIMOD) P.O. Box 3226, Kathmandu, Nepal Fax: 977-1-524509, 536747 Tel: 977-1-525313, 536739 2-mail: banskota@icimod.org.np
27.		Prof. S.R. Chalise	International Centre for Integrated Mountain Development (ICIMOD) P.O. Box 3226, Kathmandu, Nepal Fax: 977-1-524509, 536747 Tel: 977-1-525313, 525312 e-mail: chalise@icimod.org.np
28.		Pro. Li Tianchi	International Centre for Integrated Mountain Development (ICIMOD) P.O. Box 3226, Kathmandu, Nepal Fax: 977-1-524509, 536747 Tel: 977-1-525313, 525312 e-mail: tianchi@icimod.org.np
29.		Mr. Saleern A. Sial	International Centre for Integrated Mountain Development (ICIMOD) P.O. Box 3226, Kathmandu, Nepal Fax: 977-1-524509, 536747 Tel: 977-1-525313, 525312 e-mail: sial@icimod.org.np
30.		Mr. Anupam Bhatia	International Centre for Integrated Mountain Development (ICIMOD) P.O. Box 3226, Kathmandu, Nepal Fax: 977-1-524509, 536747 Tel: 977-1-525313 e-mail: anupam@icimod.org.np
31.		Mr. Gopal Nakarmi	International Centre for Integrated Mountain Development (ICIMOD) P.O. Box 3226, Kathmandu, Nepal Fax: 977-1-524509, 536747 Tel: 977-1-525313 e-mail: gopal@icimod.org.np

About the Editors

Mahesh Banskota is currently Deputy Director General of the International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal. He has been with ICIMOD since 1984 in different capacities and has written extensively on various aspects of mountain environment and development. Prior to joining ICIMOD he was with Nepal Administrative Staff College and Tribhuvan University. He has also worked for national organisations in Nepal such as the National Planning Commission, Nepal Rastra (Central) Bank, an International Organisations such as Asian Development Bank, ESCAP, ILO, and UNEP. He received his Ph. D from Cornell University (USA) majoring in City and Regional Planning and his M. A. in Economics from Delhi School of Economics.

Suresh Raj Chalise is presently the Coordinator of the Water Programme at the International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal. He joined ICIMOD in 1984 and his work and publications have been mainly in the areas of climate, hydrology and water resources, hazard management and environmental conservation in the Hindu Kush-Himalayas (HKH). He is also presently the Executive Secretary of HKH-FRIEND, a regional network for hydrological research under the global FRIEND (Flow Regimes from International Experimental and Network Data) project of UNESCO's International Hydrological Programme (IHP). Before joining ICIMOD he was associated with Tribhuvan University, Kathmandu, where he taught Physics and later founded the Department of Meteorology in 1973. Professor Chalise is also a former Dean of the Institute of Science and Technology of Tribhuvan University. Professor Chalise has an MSc. in Physics from Calcutta University and pursued post graduate studies and research at Reading University (U. K.) and the University of Poona (India). He is a Fellow of the Royal Meteorological Society (U. K.) and is also associated with the International Association of Hydrological Sciences (IAHS) and the International Water Resources Association (IWRA) as well as other scientific societies in Nepal and India. He was also associated in an honorary capacity with the bi-national (Nepal and UK) Board of Budhanilkantha School, Kathmandu, and was awarded an MBE for his contributions to the school by the United Kingdom. He received a Gorkha Dakshin Bahu (Class IV) for distinguished service by His Majesty's Government of Nepal.

Participating Countries of the Hindu Kush-Himalayan Region

 Afghanistan

 Bangladesh

 Bhutan

 China

 India

 Myanmar

 Nepal

 Pakistan

International Centre for Integrated Mountain Development

4/80 Jawalakhel, GPO Box 3226 Kathmandu, Nepal

Telephone
+977 1 525313

Fax
+977 1 524509

e-mail
distri@icimod.org.np

Web site
http://www.icimod.org.np

Cable
ICIMOD NEPAL