Chapter 10

# Study of Local Water-harvesting Systems in a Micro-watershed in the Upper Mustang Region of Nepal

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## 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).

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[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)

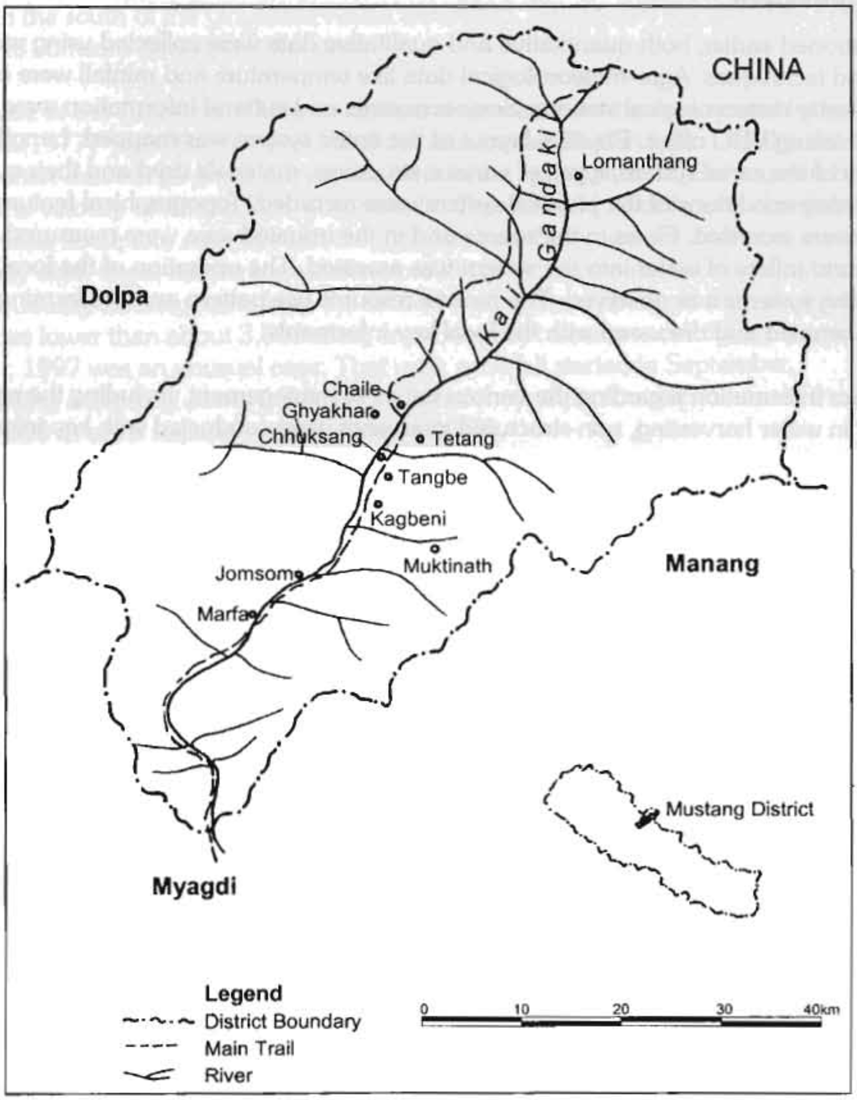


Figure 10.1: **Locations of watersheds studied**

## 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).

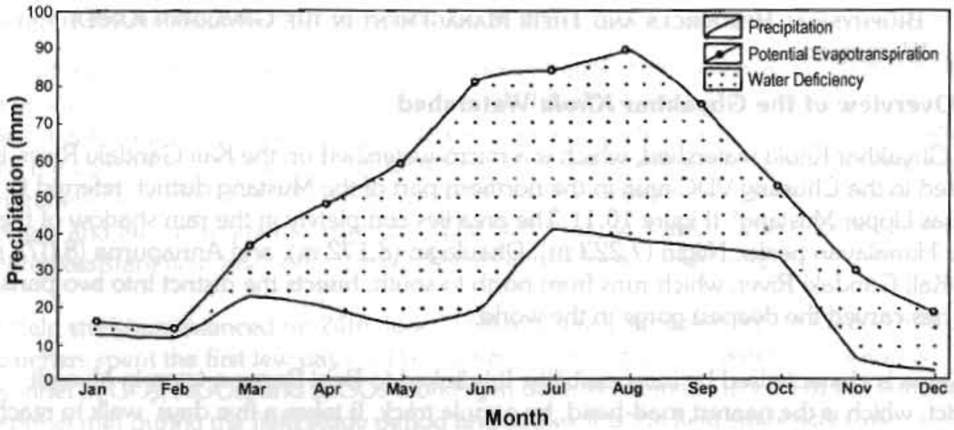


Figure 10.2: **Water balance of the area (Jomsom)**
Source: ICIMOD (1996)

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.

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/km²), the population density on arable land is quite high (251/km²) (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.

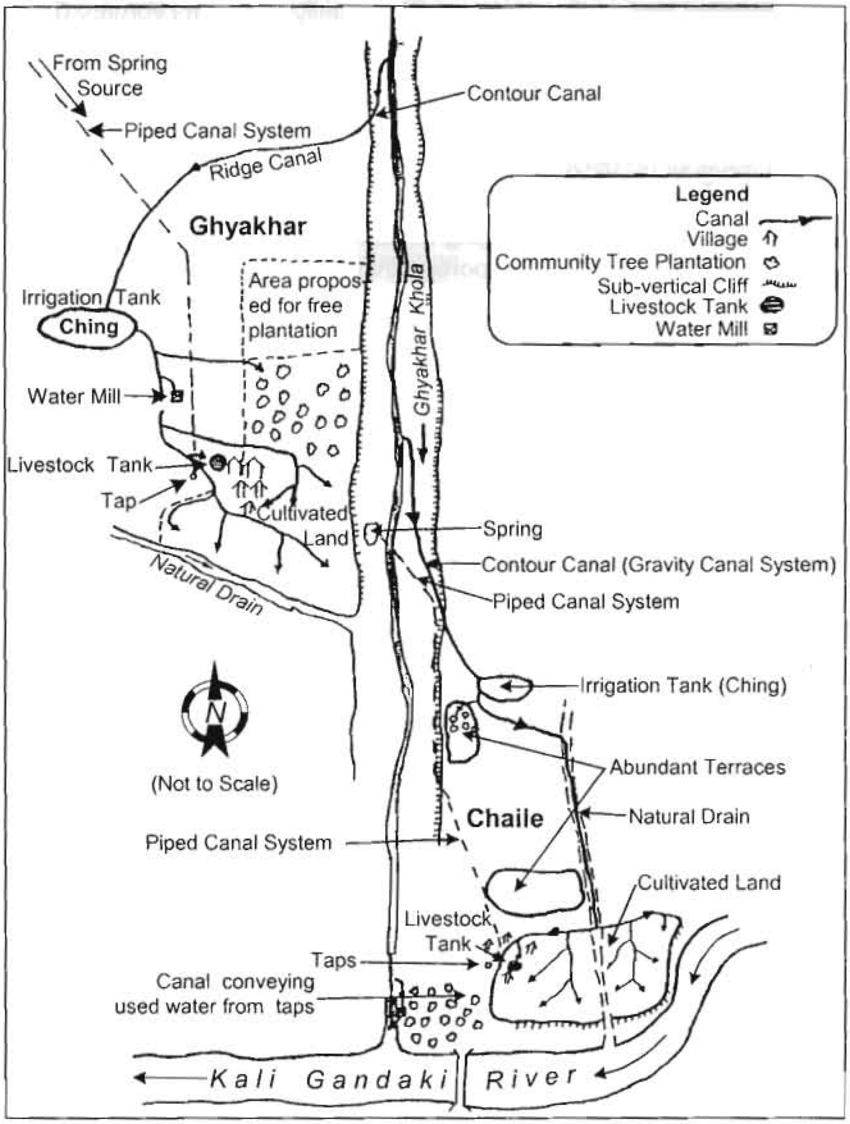


Figure 10.3: **Layout map of the gravity canal systems in the watershed**

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.

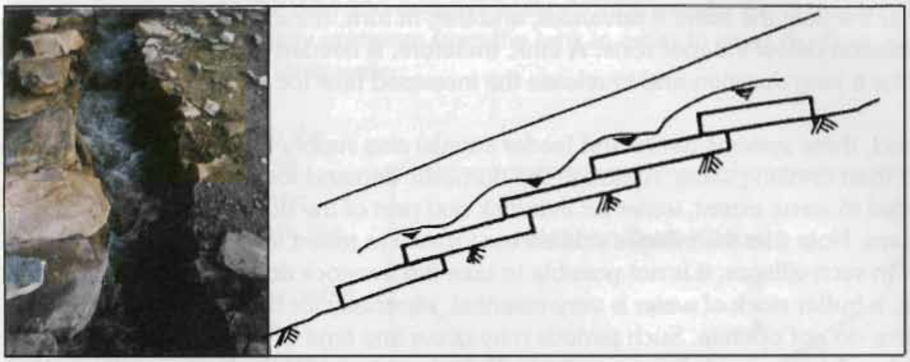

Figure 10.4: **A section and view of the lined gravity canal in the Ghyakhar Village**

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.

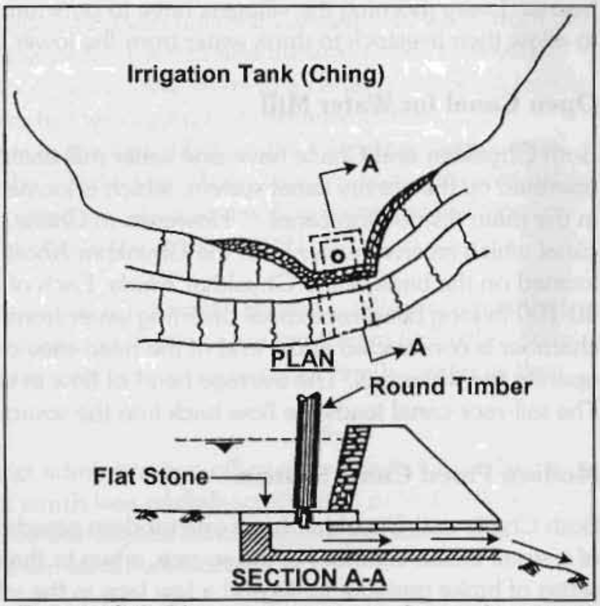


Figure 10.5: **Plan and section of a tank outlet**

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.

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.

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**