Chapter 8
Battal (Mansehra) Water Harvesting Technologies and Management Systems

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1. Introduction

In the Northern part of South Asia, the long mountain chain covers an area of 45,000 sq. km. and consists of the Himalayas, the Karakoram range, and the Hindu Kush. The Sanskrit term *Himalaya* means the abode of snow and the peaks of these mountains are covered with perpetual snow. Inhabitants of the mountainous regions are faced with the dilemma of water shortage or excess. During monsoon they receive excess rainfall and too little for the rest of the year. For centuries, these people have been struggling to live in the harsh environment.

Local communities in these mountains have developed indigenous techniques and skills for harnessing available water resources. With an increase in population, the demand for water has increased several fold; the competition for water for domestic and agricultural use has also increased. Given the scarcity of water, its proper management has become more critical to provide relief to the suffering of the inhabitants in mountains regions.

The NWFP

The main land uses in the North West Frontier Province (NWFP) are agriculture, forestry, and rangelands. The total cultivated area of the NWFP is 1.92 million hectares (19% of the total area): forest land—1.72 million hectares (17%), rangeland–1.78 million hectares (18%), agriculturally unproductive—2.97 million hectares (29%), and unclassified—1.74 million hectares (17%) (Mian and Mirza 1993). Given the vast area under forests, grazing, and rangeland, it is imperative to develop an effective management programme for these resources. Forests play a vital role in protecting the country's fragile watersheds, which yield power and water for the large agricultural economy of the rest of Pakistan.

The NWFP has a rich heritage of wildlife and plant resources which is diminishing as a result of population pressure and other human interventions. The number of people residing in the forested mountain regions is increasing rapidly. Increase in human population has increased the pressure on forest resources to meet the local needs for timber and fuel. It has resulted in the extension of cultivation on to steep slopes, and this has augmented losses of soil and water. Sustainable development of the watershed is, therefore, essential for conservation of natural resources.

This report is partially based on a case study of a micro-watershed in Battal, Mansehra district (NWFP), Pakistan, undertaken for the Water Harvesting Project of the International Centre for Integrated Mountain Development (ICIMOD). The duration of this study was 12 weeks, the field work started on August 1, 1998. Data were collected until the end of September 1998.The background information about the project area, i.e., information about climate, soil, vegetation, and so on and the socioeconomic conditions of the households in terms of landholding, tenancy status, and per capita income are discussed in the Annex to this paper.[1] Local drinking and irrigation water supplies are also dealt with in the Annex. Specific attention has been given to gender issues and management of the water supply system. Indigenous methods of water harvesting are presented in Section 2. Water harvesting practices in other parts of Pakistan are discussed in Section 3. Section 4 describes the role of different government agencies and NGOs in the development and management of local water-harvesting systems. Section 5 deals with institutional capacities and local experiences in water harvesting. National policies on water harvesting, water resource management, and implications on water harvesting and the problems are discussed in Section 6.Critical issues and recommendation are presented in Section 7.

2. LOCAL WATER HARVESTING TECHNOLOGY, PRACTICES AND KNOWLEDGE

The villages in the area were representative of the region of Pakistan in terms of the different types of water- harvesting techniques practised. Details of the different water-harvesting practices are given below.

Local Water Harvesting Practices

Check Dams

Check dams are made of earth and stones, built across the natural streams to pond water upstream. The water collected in the reservoir is used for irrigation, drinking, or other household uses. Usually, these dams are small in size and are erected in the foothills. The dams are temporary structures, mostly built in the dry season. Small dams are constructed by individual families, while bigger structures are erected jointly by community groups.

Level Terracing on Gentle Slopes

Level terraces are common in the Battal watershed (Figure 8.1). These terraces are wider than others and have little or no slope and are effective in retaining rainfall water on different levels of terrace. This practice serves the dual purpose of controlling runoff and preventing soil erosion. The terraces are mainly constructed for raising field crops and fruit trees.

Terracing on Steep Slopes

Because there is limited land for cultivation of crops, some farmers construct narrow terraces on steep slopes (Figure 8.2). These terraces are 1.2 to 1.5 metres wide and one or two rows of plants are cultivated on them. Since they are not properly designed, they have further accelerated land degradation in the watershed. This practice is mostly adopted by poor farmers in the area.

[1] Editorial Note : Details of the study have been kept almost in their entirety in the Annex.

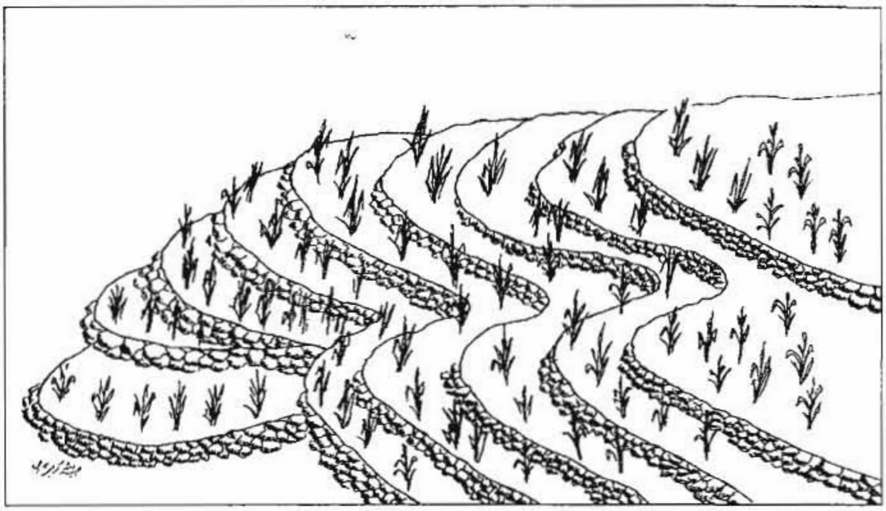


Figure 8.1: **Terraces on gentle slopes**

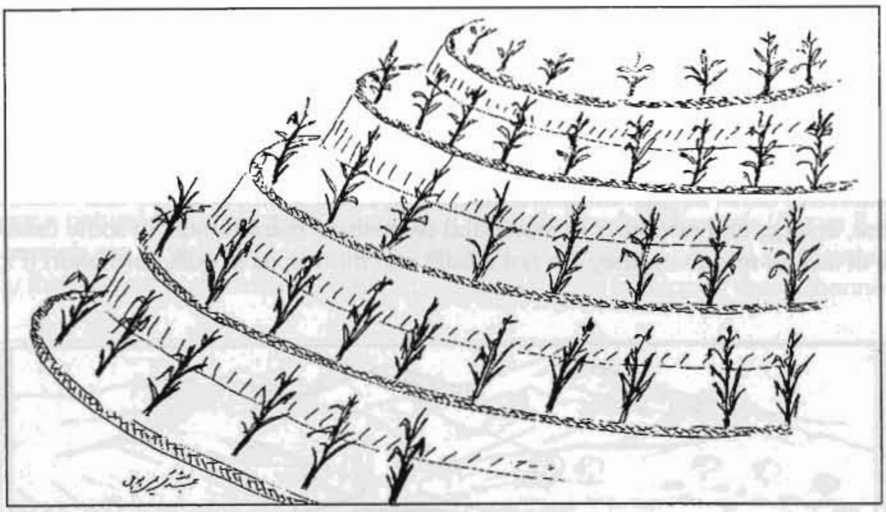


Figure 8.2: **Terraces on steep slopes**

Earthen Ponds

Small ponds are constructed to store water for irrigation of cultivated fields (Figure 8.3). The dimensions of the pond depend upon the amount of water needed for irrigation. Earthen bunds or large stones are placed around the bank of the pond to stabilise it. These ponds are usually located uphill and are used for irrigation of fields downhill. Runoff and rainfall water are collected in these ponds. In some cases, water from these ponds is used for both irrigation and domestic needs. This practice is common in all the villages in the watershed.

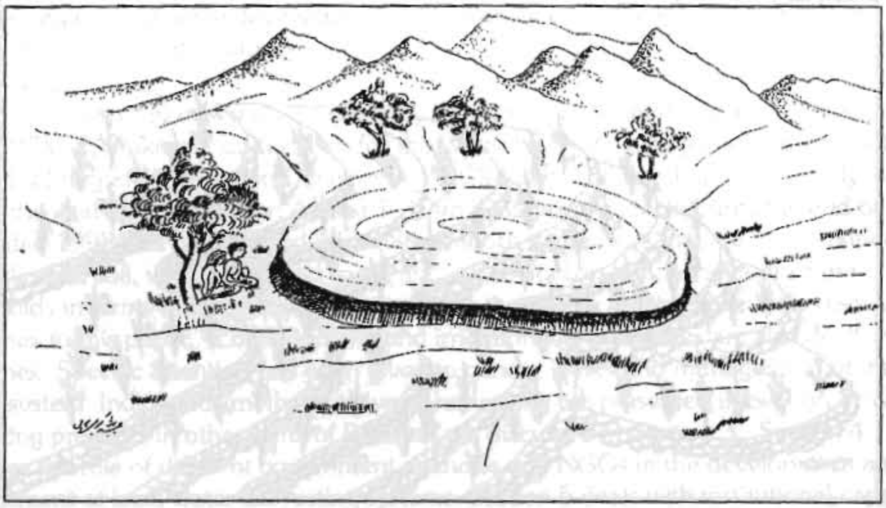


Figure 8.3: **An Earthen pond for irrigation and domestic needs**

Field Bunding

Earthern or stone bunds are constructed around the field boundary to retain runoff water and to prevent overflow into the fields. This method has been found to be very effective in controlling runoff and erosion. It is practised widely by farmers in the watershed. Sometimes, when there is heavy rainfall, these bunds are eroded and farmers have to reconstruct them. The height of these bunds ranges from 0.30 to 0.60 m and the width from 0.60 to 0.90 m. In some places, where there is a danger of bank erosion, stone walls are constructed instead. Although field bunding is a popular practice for retaining water in the field, sometimes the bunds overflow and are undermined or completely washed away during excessive rains. In such situations farmers face serious losses of soil and water, and it takes time, energy, and resources to repair and reconstruct these bunds. In some cases, because of lack of resources, they are not rebuilt and this results in gully formation (Figure 8.4).

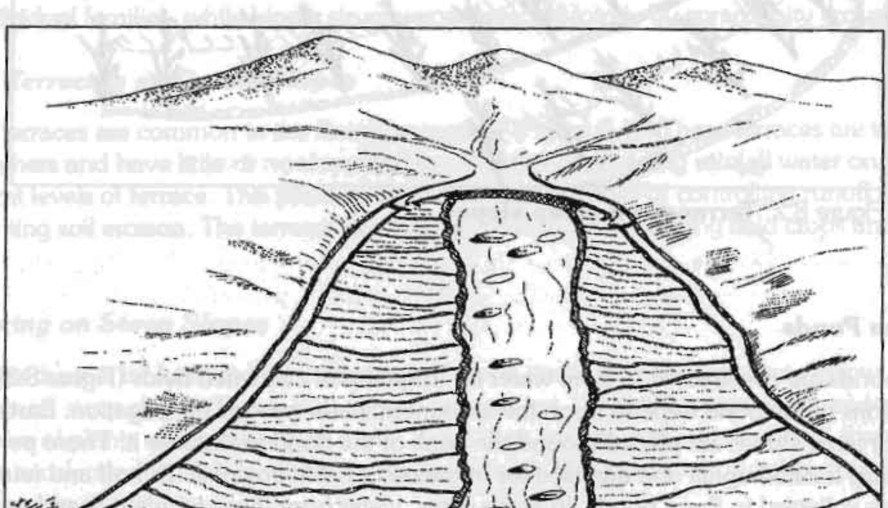


Figure 8.4: **Typical spring irrigation system with field bunding**

Water Wells (Kua)

A hole is dug in sedimentary rock where groundwater oozes naturally to the surface. The quality of this water is good for drinking as it is free of sediment, debris, and other impurities. This practice is also common in all the other villages in the watershed. A potential site for digging a well is identified by the elders of the community. Usually, these wells are dug near the foothills and close to the houses. Some people have constructed *kua* in their homes to meet domestic water needs. The depth of these wells is about one metre and widths range from 1 to 1.5 m.

Diversion Structures

Diverting floods coming from natural streams and gullies is an efficient method of harvesting runoff. Walls made of earth and stones are constructed to divert runoff to the terraced fields. These structures are temporary and farmers construct them on the spot to divert water to their fields. The diversion walls are four to six metres high and one to two metres wide. The efficiency of such structures depends upon the location of the area (upstream versus downstream), timely construction of the structures with respect to seasonal flooding, and on their strength to embank the flood water.

Spring Galleries

There are many springs in the watershed, although their number and capacity have decreased due to deforestation. In order to meet drinking water requirements, the government-constructed community water supply schemes. Under these schemes, water from small springs is channelled through G. I. pipes and collected into bigger storage tanks from where it is supplied to the local community by gravity flow. Pipes commonly burst in winter when temperatures are frequently below freezing.

Wooden Channels

Water over a natural stream or gully is conveyed through wooden channels (Figure 8.5). These channels are rectangular in shape and about 0.30 m deep. They are constructed locally by the farmers from cuttings of tree trunks. Pillars used to support these channels are

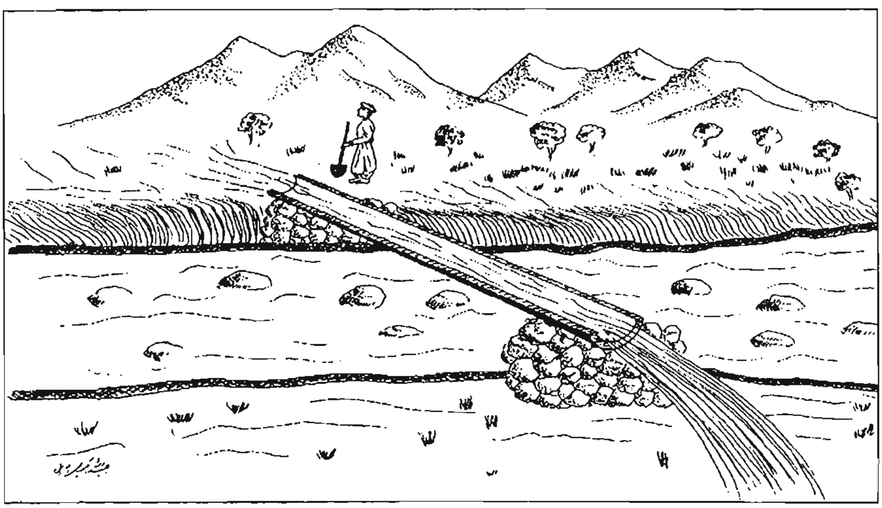


Figure 8.5: **A wooden channel**

also made of wood. This is a very simple, cheap, and effective method of carrying water over streams to cultivated land.

Gender Role in Water Harvesting

Water harvesting is generally carried out by men (Table 8.1). One of the reasons why men do this job is the risk involved in the control and diversion of fast flowing water to the fields. Women help to harvest runoff water, but their contribution is relatively small (4%). About one-third of interviewees did not respond to the question, because they did not own much land in the selected micro-watershed.

Table 8.1: **Gender role in water harvesting**

Name of Village	Women	Men	Individual House hold	Local Bodies	Govern-ment	No Response
	% Respondents					
Malokra	0	73	5	0	0	22
Palai	3	60	6	0	0	31
Kandi	5	52	5	0	0	38
Overall Avg	3	62	5	0	0	30

Management of Water Harvesting

Management of water harvesting for irrigation is normally carried out either by individual households (34 to 41%) or by communities (23 to 32%) as shown in Table 8.2. One-third of the households have no landed property and did not respond to this question. During snowmelt in April they construct earthen bunds to divert water to the fields. The role of the Government or NGOs in the development of water-harvesting practices in the selected watershed is negligible. However, the Government and NGOs have introduced various projects on water harvesting in other parts of the country.

Table 8.2: **Runoff water management system**

Name of Village	Community Management	Government	Individual	Other	No Response
	% Respondents				
Malokra	32	0	41	5	22
Palai	23	0	34	3	40
Kandi	24	0	38	0	38
Overall Avg	26	0	38	3	33

Organization of Farmers for Water Harvesting

In the watershed selected there is no formal organization for water harvesting. However, whenever they have a common irrigation channel or a water supply system, they do get together for its maintenance and repair in an informal manner (Table 8.3). About two-thirds of the people were not sure about any organization for water harvesting. It seems to be that farmers are organized for water harvesting, either by influential individuals or by landlords, for a specific task. Table 8.3 suggests a degree of leadership qualities ranging from 9 to 29% in individuals who organize farmers for water harvesting with no inputs from the Government.

Table 8.3: **Organization of farmers for water harvesting**

Name of Village	Individual	Community	By Land Lords	Govern-ment	No Response
	% Respondents				
Malokra	27	0	5	0	68
Palai	9	9	6	0	77
Kandi	29	10	5	0	57
Overall Avg	22	6	5	0	67

Distribution of Runoff Water

There is no proper method of runoff water distribution in the watershed area, but the natural general rule of upstream to downstream distribution is practised in the selected micro-watershed. Those land owners/farmers who are in the upper reaches of the watershed consider it their right to use the runoff water first, as no formal water users' association for distribution of water existed in the area. In the absence of a formal water users' association, it is but natural to follow the principle of the first opportunity by virtue of location along the stream.

Changes in Runoff Water Harvesting Practices

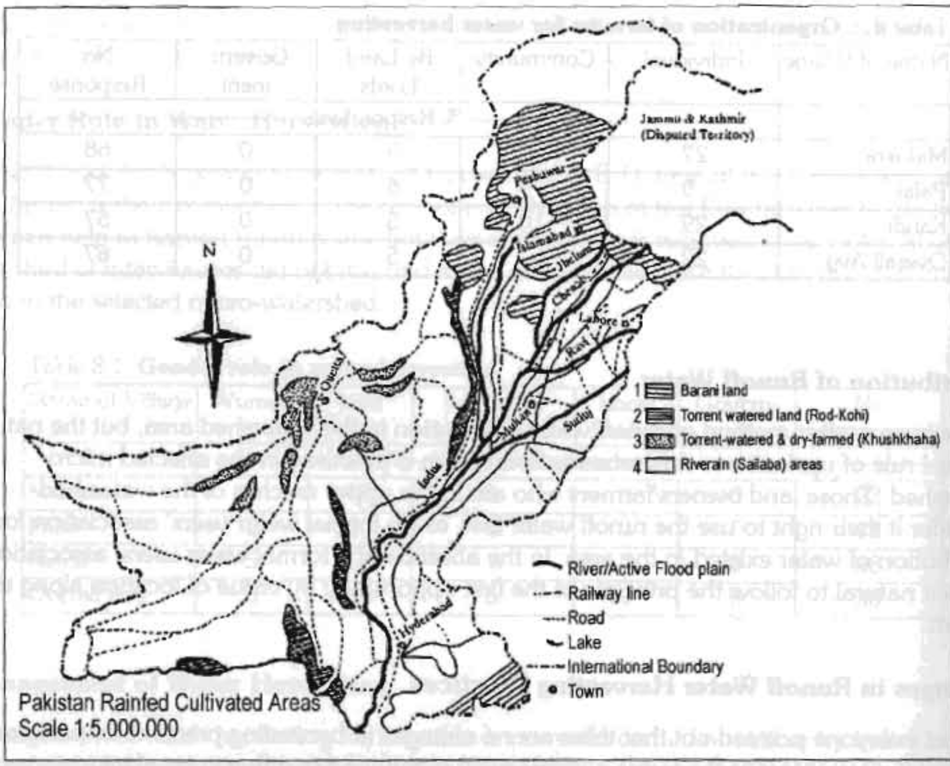
Almost everyone pointed out that there are no changes in harvesting practices or patterns for runoff water. Most of the farmers interviewed mentioned that there was always a scarcity of water during cropping season and that they would like to have more water for irrigation from the adjacent micro-watershed. This would mean major changes in the existing runoff harvesting system to satisfy crop requirements.

Critical Issues Related to Harvesting Runoff

About 10% of the farmers who harvest runoff use structures of mud and stone for diversion of runoff water to their fields for irrigation, and most of the time these bunds are washed away by floods. Harvesting runoff takes place only during cropping season. Runoff collects in some of the terraced fields from the upstream macro-catchment and in the case of heavy rainfall there is no adequate or safe drainage disposal system through which excess runoff can be removed. Because of inadequate storage capacity and a poor surface drainage disposal system, severe soil loss and, in some cases, even complete loss of cultivated land occur.

3. Water Harvesting Practices in Other Parts of Pakistan

Water harvesting is mainly practised in rainfed areas of Pakistan. The term rainfed means agriculture with controlled irrigation. It includes Rod Kohi, Sailaba and *Khuskhaba* cultivation (Map 1). Rod Kohi cultivation is carried out by diverting and spreading the intermittent flow of hill torrents. *Khuskhaba* cultivation is practised in the western cool, semi-arid region where crops are sown with a minimum of pre-cultivation either immediately after the first rains in winter or in expectation of precipitation in mid-December to early March. Sailaba cultivation refers to areas where production of crops depends on residual moisture from summer floods and rains.



Map 1: **Map showing rainfed cultivated area in Pakistan (Adopted from PARK, 1990)**

Khuskhaba

Khuskhaba cultivation is mainly found in Balochistan province (Figure 8.6). *Khuskhaba* cultivation is merely chance cropping with successful crops being raised on an average once in five years. Locally, the availability of moisture for crops is enhanced by water-harvesting

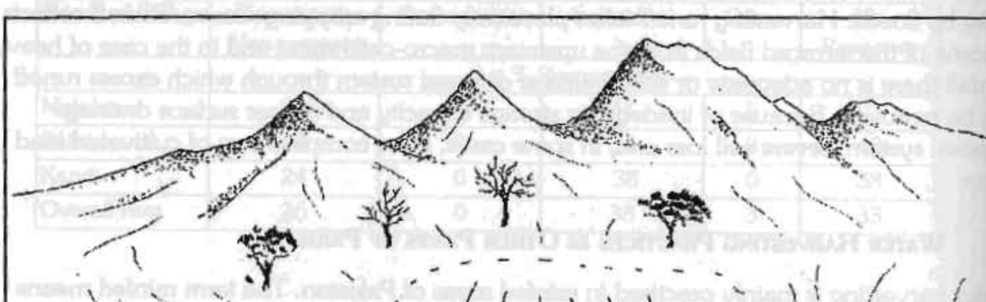


Figure 8.6: **Khuskhaba in Balochistan**

techniques in which runoff from large uncultivated blocks of land is diverted and carried to cultivated fields by means of ridges. *Khuskhaba* is mainly practised in the Quetta-Sarawan and Zhob-Loralai areas.

Rod Kohi

The Rod Kohi system of irrigation is known as the *Wandhera* system and uses flood water from mountainous streams (Figure 8.7). The flowing seasonal streams or *Rod* are blocked by earthen bunds, rain is fed into the bed and flood water is diverted to cultivated lands that have strong embankments built according to the rights framed through settlement. Manual and bullock labour are provided free of charge by farming communities to construct bunds to divert the flood water and this practice is called *Kamara*. The Rod Kohi system is largely practised in D. I. Khan (NWFP), but is also found on a small scale in other parts of Pakistan (Kohistan, Karak, Lasbela, Kachhi plains, the Salt range). In D. I. Khan district, it is under the overall control of the government /district administration (Revenue Department)

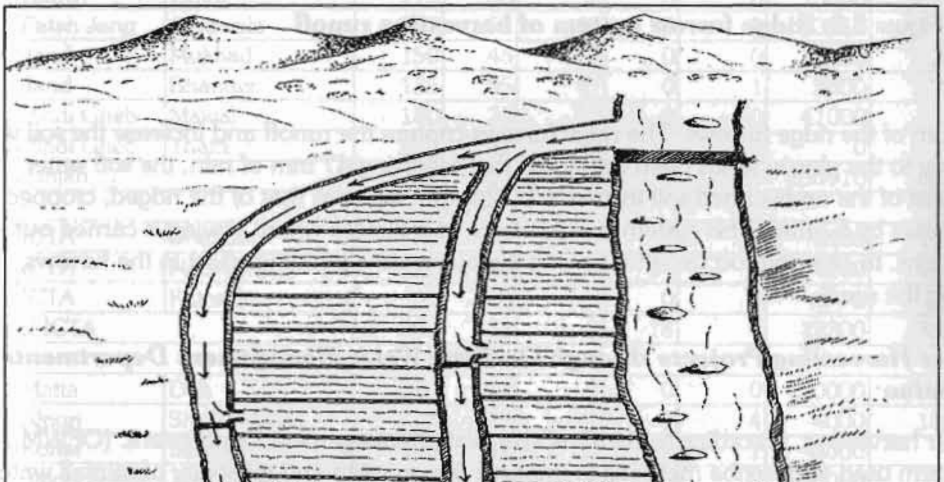


Figure 8.7: **Rod Kohi irrigation system in D. I. Khan, NWFP**

Sailaba

Sailaba lands in Pakistan occupy sub-humid to semi-arid and arid sub-tropical continental lowlands. They mainly occur along river courses. The rainfall varies from 900 mm in the north to 150 mm in the south. The general lay of land is generally undulating, having young floodplain features of sandy levees, silty flats, and clayey depressions. The silty flats covering 70 to 80% of the area are used for unirrigated cultivation of wheat crops using residual moisture from summer floods. Because of flood hazards, little cropping is carried out in summer. It is practised mainly in the Indus floodplains. Crops are grown after monsoon season is over. It is usually winter cropping.

Ridging

In ridging an indigenous plough is used by the farmers (Figure 8.8). The instrument is made in such a way that when ploughing it pushes and loosens the soil to either side making ridges from 8 to 15 cm high. Farmers place the seeds four to six centimetres below the

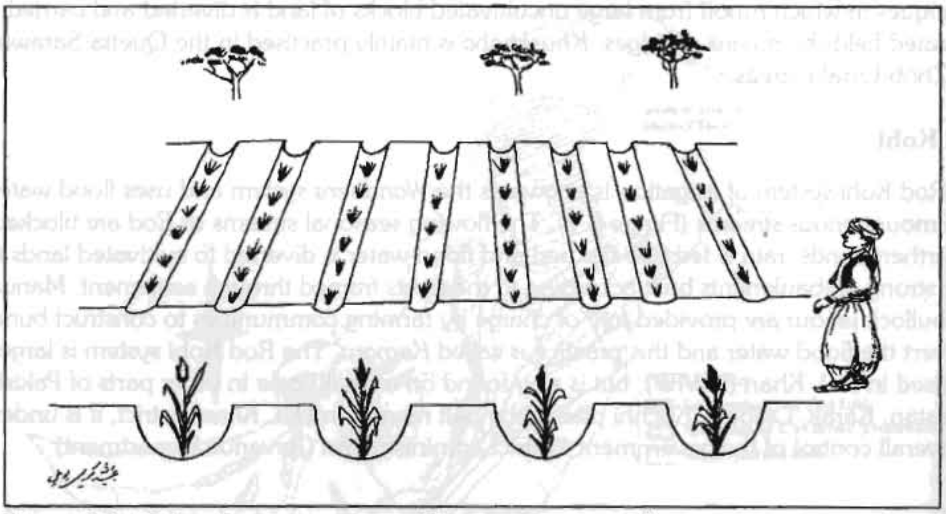


Figure 8.8: **Ridge furrow system of harvesting runoff**

bottom of the ridge furrows. The ridge furrows capture the runoff and increase the soil water supply to the plants. It has been estimated that following 47 mm of rain, the soil water content of the undisturbed soil increases by 24 mm, whereas that of the ridged, cropped soil increases by 57 mm. This system is only viable in a climate where sowing is carried out after the rains. In case rain occurs after sowing it may create a ponding effect in the furrows, killing the seeds.

Water Harvesting Projects through On-Farm Water Management Departments in Pakistan

Water harvesting, according to the On-Farm Water Management Department. (OFWM), is the term used to describe methods to improve the quantity and reliability of rainfall water harvested and delivered to the crop root zone. It may include field improvements to increase the infiltration and uniformity of infiltration of direct rainfall on fields to the root zone, the use of rainfall from adjacent micro-catchments to supplement direct rainfall on to the fields, and the diversion of small streams (perennial or ephemeral) into the fields.

The OFWM Department with financial assistance from the Overseas' Economic Cooperation Fund (OECF) of the Japanese Government began various water-harvesting schemes all over Pakistan in 1993. Under this programme, fifteen schemes in Barani Punjab, three in Islamabad Capital Territory Area (ICTA), eight in the NWFP, and two in Balochistan were completed. The goal of these water-harvesting projects was to manage water directly from rainfall for the production of field and tree crops and range grasses for livestock and human consumption in order to maximise farm income through improved sustainable productivity. The current status of these water-harvesting projects is summarised in Table 8.4. The principal activities undertaken in these schemes are forest and fruit tree plantation on steeply sloping lands, contour terracing, field spillways and waterways to control flow, and field bunding on gently sloping lands, storage ponds, and reservoirs and check dam construction in topographic depressions.

Table 8.4: **Status of water-harvesting projects implemented by the OFWM in Pakistan (1993-98)**

S. No.	Location	Name of Water Harvesting Site	Command Area (ha)	No. of Terraces	No. of Spillways	Water-ways (km)	Ponds/ Dams	Forest Trees Planted	Fruit Trees Planted
			PUNJAB						
1	Rawalpindi	Kot Kolian	350	170	46	0	2	10000	1400
2	Kahuta	Sehale Ferozai	175	50	2	1	2	1000	0
3	Gugar Khan	NegialPur	100	37	3	0	1	7000	0
4.	Gugar Khan	Chehri Bangial	150	30	1	0	1	5000	0
5.	Jhelum	D. M. Waris	354	60	35	0	2	27400	2000
6.	Chakwal	Sirral	175	85	249	0	2	40000	500
7.	Chakwal	Koka Dakhli	170	44	0	0	0	7500	700
8.	Talagang	Mial	120	80	48	0	0	7100	0
9.	Talagang	Dher Moond	161	110	20	0	1	30000	0
10.	Attock	Golra	175	38	2	0	0	15000	500
11.	Fateh Jang	Ajoowala	257	52	62	0	0	13910	1000
12.	Jand	Mukhad	150	45	12	0	0	30000	300
13.	Jand	Bhander	135	65	47	0	1	2000	200
14.	Pindi Gheb	Makial	180	70	94	0	0	41000	0
15.	Pindi Gheb	Thatti	285	21	0	0	0	0	0
Total Punjab			2937	957	621	1	12	236910	6600
			ICTA						
16.	ICTA	Dhahala	100	39	0	4	0	8100	1900
17.	ICTA	Nazirabad	200	14	0	14	0	4200	1450
18.	ICTA	Katreel	60	0	0	0	0	0	0
Total of ICTA			360	53	0	18	0	12300	3350
			NWFP						
19.	Matta	Dub	200	24	0	0	0	30000	18000
20.	Alpuri	Shwar Maira	73	36	0	0	4	4000	1800
21.	Kohat	Bamma	100	31	2	0	1	3000	0
22.	Saido Sharif	Toot Shah	168	72	0	0	0	40000	3330
23.	Bannu	Danda Azimabad	95	11	0	1	0	6480	36
24	Kulachi	Gara Bakhtiar	200	25	4	2	1	2000	0
25	Karak	Karapa	138	0	0	0	0	0	0
26	Lakki Marwat	Ahmed Khel	228	12	0	0	1	1500	0
Total of NWFP			1202	211	6	3	7	86980	23166
			BALOCHISTAN						
27	Kalat	Pulseir Malki	650	50	0	0	1	5700	0
28.	Musa Khel	Khosa Rara Sham	490	18	0	0	1	0	0
Total of Balochistan			1140	68	0	0	2	5700	0

4. Programmes and Projects on Water Harvesting

The Department of Forests, Fisheries and Wildlife, Department of Irrigation, Department of On-farm Water Management, Soil Conservation, Agricultural Engineering Department, Public Health Engineering, and Department of Rural Development are the major government agencies involved in the development of water-harvesting projects. The main activities of these departments related to water harvesting are described in this section.

Department of Forests, Fisheries and Wildlife

The mandate of the Department is sustainable and integrated development of natural resources. Some examples of the forestry sector projects on integrated watershed management are as follow.

Title	*Basic Concept*
Watershed Management Project	Watershed Protection through Afforestation
Social Forestry Project	Reforestation through Community Involvement
Siran Valley Forestry Project	Natural Resource Conservation through Community Participation
Flood Rehabilitation in the Himalayan Jungle Project	Community Participation
Environmental Rehabilitation in Malakand Division	Participatory Watershed Management
Protection, Conservation and Management of Migratory Bird Species in the NWFP	Sustainable Use of Wildlife

Department of Irrigation

The Department of Irrigation is generally dealing with major irrigation infrastructure and its operation and maintenance in Pakistan. However, under the Irrigation Department the Directorate of Small Dams is responsible for water-harvesting projects on a relatively large scale. The Directorate of Small Dams is constructing small dams for harnessing runoff water. Several small dams are being constructed throughout Pakistan. The Irrigation Department extends help to farming communities in the development of large spring irrigation projects in hilly areas. Besides that they also help in some places in the use of flood runoff water.

Department of On-Farm Water Management

The main task of the Department of On-farm Water Management is to line water courses and level land in the main irrigation system command area of Pakistan. However, recently they have also been working on water-harvesting projects. The main water-harvesting projects involve water tanks for collection of spring water in the hilly areas of Pakistan and small ponds for harvesting rainfall runoff. Recently the Department has been working on integrated watershed development projects in eight locations in the NWFP. Similar projects are being executed in other provinces of Pakistan with financial assistance from the Overseas' Economic Cooperation Fund (OECF) of Japan.

Department of Soil Conservation

The Department of Soil Conservation is mainly responsible for protection of cultivated land from erosion. The Department constructs flood protection structures to safeguard cultivated lands in the flood zones or from concentrated flow. The Department also constructed check dams, spurs, gabion structures, and ponds for water harvesting.

Agricultural Engineering Department

The Agricultural Engineering Department is mainly responsible for levelling uncultivated and cultivated land also for constructing tubewells for irrigation. In addition, the Department is also helping farming communities to construct diversion structures for runoff water harvesting.

Public Health Engineering Department

The Public Health Engineering Department is responsible for development, operation, and maintenance of drinking water supply schemes in both rural and urban areas. Mostly they construct tubewells for water supplies. In addition water supply schemes consist of construction of underground galleries, small dams on perennial springs and to check flood water, and storage reservoirs. In hill areas they collect spring water directly from the source and supply it to rural communities through galvanized iron pipes. Some drinking water supply schemes were completed about 10-20 years ago by the Public Health Engineering Department.

Local Government and Rural Development

This Department is responsible for providing different infrastructure and maintenance of the same and development projects (roads, schools, health, and drinking water supply) in the rural areas. In hill areas they collect spring water for drinking water supplies and also construct tanks/ponds for domestic use.

Other government agencies that are working in the rural areas on different development projects are given below.

- Communication and Works Department
- Water and Power Development Authority
- Health Department
- Livestock and Dairy Department
- Agricultural Extension Department
- Forestry Department
- Mansehra District Council
- Industries, Labour and Manpower Department
- Agricultural Research Universities

NGOs

Several NGOs are working in Mansehra on rural developments projects. However, in the selected micro-watershed, NGOs did not contribute much to development. A few of the important NGOs helping in the development of rural communities in Mansehra district are listed below.

- National Rural Support Programme
- Sarhad Rural Support Corporation
- SUNGI Development Foundation
- International Union for the Conservation of Natural Resources (IUCN)
- Mansehra Village Support Programme

Community Organizations (COs) in Mansehra

The rural communities are organizing themselves to change their destiny and get out of the chain of poverty and misery. At present there are more than a thousand community organizations that have emerged during the past decade in the NWFP. The names of the two village-based community organizations (VOs) are the

- Social Welfare Society and
- Harori Youth Club, Battal.

5. HUMAN AND INSTITUTIONAL CAPACITIES

Institutions play a vital role in the development of nations/communities. For stable regulation of important processes in societies, certain structures and patterns are established that are commonly called institutions. Institutions can be defined as those stable regulatory organizational principles and rules that govern interactive processes between the people themselves and the environment in which they are living. In societies social changes are induced by a multitude of exogenous and endogenous influencing factors. Most of the population in Pakistan lives in rural areas where economies are based primarily on agriculture. Important factors that induce institutional changes and lead to socioeconomic changes in the remote mountainous regions are as follow.

- Rapid population growth
- Increased expectations among the population
- Changes in demand
- Commercialisation tendencies
- Technological changes and advancement
- Government policy

The above-mentioned factors can produce endogenous social and economic tensions in the communities if the rate of development is not maintained by human and institutional capacities. No system, policy, or development activity can be successfully maintained and operated without the support of the local population. The support of local populations can be obtained in an effective manner provided the human and institutional capacities are sufficiently flexible and capable of accommodating changes in the cultural and socioeconomic norms and patterns. To introduce such changes in an area, literacy, learning aptitude, and economic needs are interdependent. Some of these aspects are briefly discussed in the succeeding section.

Technical Skills for Operation and Maintenance of a Water-harvesting System

There is no formal water users' association for operation and maintenance of water channels and drinking water supply schemes in the area studied (see Annex). However, informally they do construct and clean the irrigation channels as well drinking water supply schemes The farmers do have rich experiences in an informal tradition of collaborative work in such activities as the construction of mosques, irrigation channels, and the maintenance of both, besides farming activities such as weeding. This system of informal organization has been prevalent for a long time.

People definitely have the aptitude and tendency to cooperate and work jointly. There is great scope for development of human and as well as institutional capacities with respect to technical skills for operation and maintenance of WHS.

Role of Group Action in Use of Water Resources

The NWFP population is growing rapidly, widening the gap between consumption and availability of the resource. Therefore, pressure on the limited available natural resources and competition for the use of land and water resources increase. The role of group action is confounded by several factors such as small landholdings. However, construction of check dams, afforestation, and management of grazing land will increase the supply of spring water for irrigation and drinking water supplies. Since people were interested and showed a keen interest in development of such projects, it suggested that there is a need to organize them to be able to handle some of these projects through working and acting in groups.

Local Experiences and Implication for Policies on Water Harvesting

In general the farming communities living in the mountains have rich experiences in water harvesting. By participation of these local communities with the Government/NGOs their living standards can be improved. At present, because of poverty and small landholdings the spirit of cooperation is missing. Natural resources are shrinking and, as a result of overexploitation of these resources beyond their limits, severe problems have been created for local communities. A lack of committed local leadership because of the diversity of ethnic groups living in the selected watershed and low literacy rates are the main constraints to development activities. Poor coordination of efforts on the part of the Government and the rural communities is another cause behind degradation of natural resources.

6. POLICIES ON WATER HARVESTING/WATER RESOURCES

The world faces severe and growing challenges to maintaining water quality and meeting the rapid growing demand for water resources. New sources of water are increasingly expensive to exploit, limiting the potential for expansion of new water supplies. Water used for irrigation, the most important use of water in developing countries, will likely have to be diverted to meet the needs of urban areas and industries, but must remain the principal engine of agricultural growth.

New strategies for water development and management are urgently needed to avert severe national, regional, and local water scarcities that will depress agricultural production, parch the household and industrial sectors, damage the environment, and escalate water-related health problems. This chapter describes existing government policies on water harvesting, water management, flood protection, and their implications and strategies and institutional reforms to meet the mounting challenges now and in the future.

Harnessing of Hill Torrents

Food shortages have necessitated development of additional resources of land and water in Pakistan, as the gap between food production and the growing demand has been widening. In the circumstances, improvement of irrigation supplies to *barani* (rainfed) areas and cultivation of wastelands by proper management of hill torrent flows are considered inevitable. Proper management of these hill torrents can also help to protect people and infrastructure from devastating flood damage.

Depending upon the varying physiological and demographic conditions, five different types of strategy can be adopted for harnessing hill torrents: (1) dispersion structures, (2) diversion structures, (3) detention dams, (4) storage dams, and (5) channelisation. In addition to these structural measures, non structural measures in the form of vegetation and watershed management practices can also be adopted. The Government of Pakistan is keen to harness the flood flows of these hill torrents since they are located in the most backward areas of Pakistan and the tangible losses are tremendous. Moreover, management of these hill torrents is bound to stimulate other development activities in the area. The economic internal rate of return from the development of hill torrents is estimated to be over 25%.

Flood Protection Programme in Pakistan

Destructive floods, both large and small, have been taking a heavy toll on life and property in Pakistan. Monetary losses during major floods since 1950 amount to billions of rupees, including loss of land due to erosion along the banks of main and tributary rivers. In order to safeguard lands from inundation 5,550 km of embankment have been constructed along major rivers and their tributaries in Pakistan.

By proper planning, effective means can not only help to minimise flood losses but can also conserve surplus flows to increase water supplies for productive use and to promote the welfare of the community. This can be accomplished through construction of flood storage mechanisms.

Institutional Reforms

The present national policy is to establish a programme of participatory water management. The policy of participatory water management will bring about positive changes in water supply and management systems by achieving the following.

- Increasing irrigation efficiency, equity in water distribution, agricultural productivity, and service equality
- Increasing participation of farmers and mobilising the community, giving them a sense of ownership
- Reducing conflicts and political inference
- Using O&M funds effectively and promoting better cost recovery
- Better linkages since the farmers have been represented on Provincial Irrigation and Drainage authorities and Area Water boards.

The criteria for selecting locations for pilot projects includes easy accessibility of the system, positive attitude of farmers, a broad-based concept so that all aspects of water management can be addressed, canal/channels with representative ownership, and guarantees that withdrawal of government financial assistance can be effected without undermining the sustainability of the project/system.

Current Status of National Policies on Water Harvesting/Water Resources' Management

The ordinance for creation of Provincial Irrigation Development Authorities (PIDAs) has already been enacted by the provincial assemblies. The existing secretaries of Irrigation Departments are to act as managing directors for meaningful management of the authorities. However, it is essential that farmers should be given training in basic literacy, O&M of channels, water harvesting/management, assessment of water rates, accounting/ book-keeping, election procedures and byelaws, and maintenance of equipment; whereas the Provincial Irrigation Department (PID) and on-farm water management development (OFWM) staff should be trained in the concept of PIM, improved role of institutions, research and development, and monitoring and evaluation.

7. Critical Issues and Recommendations

Natural resources are limited and there has to be a balance between their use and replenishment. The increasing population further aggravates the fragile ecosystem of the mountains through increasing demands for food, shelter, and jobs. Some of the critical issues to be addressed in future planning are listed here.

- Scarcity of agricultural land, water, forests, and other natural resources
- High rate of deforestation, desertification, and loss of biodiversity
- Food security-the immediate need is for food security at both household and community level. This can be achieved by increased agricultural productivity through efficient and wise use of the available land and water resources.
- A serious timber deficiency for fuel, construction, and so on
- The mountain economy is crippled and needs immediate attention.
- Slow pace of human resource development for management of natural resources
- Lack of educational opportunities
- Lack of employment opportunities
- Lack of adequate allocation of funding

The following recommendations are proposed to alleviate poverty and to conserve natural resources.

- Existing local water-harvesting technologies and management systems should be critically evaluated before any external technology is introduced.
- All watershed resource users should be involved in identifying problems.
- Training programmes that develop leadership attitudes, knowledge, and skills in local users should be organized.
- Women should be approached to identify their problems. For work with women, women motivators should be hired locally.
- The national policy should be to implement those water management and soil conservation activities that generate quick income and create an environment for sustainable development.
- An awareness campaign and assistance are needed to promote the awareness of rural communities about the efficient use of natural resources.
- The institutional capacity for natural resource management at the local level must be strengthened.
- New crops such as tea and fruit trees should be introduced to improve household income.
- Regeneration of watershed resources for strengthening infrastructures such as roads, health facilities, drinking water, and irrigation supplies with the participation of rural communities
- There is a need for greater efforts to strengthen farmer organizations/village communities in order to improve the operation and maintenance of the irrigation and water supply system.
- In general, there ought to be benefits from an improved extension programme addressing water requirements for different crops and assurance that farmers are fully aware of the problems of both over-irrigation and under-irrigation in obtaining good yields.

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Annex 1

Objectives of the Study in Battal, Mansehra District

The specific objectives of the case study were as follow.

- To assess and analyse the socioeconomic conditions of the communities in the micro-watershed command area
- To develop a better understanding of technical, organizational, and managerial aspects of Local Water-harvesting Systems (LWHS)
- To examine the gender and environmental considerations in LWHS
- To assess the policies for LWHS
- To investigate the existence of water users' associations and community- based organizations
- To formulate recommendations for the efficient use of natural resources in the watershed and measures to strengthen human and institutional capacities.

Selected Micro-Watershed

Site Selection Criteria

Certain criteria were kept in mind while selecting the watershed: the main points were as follow.

- The watershed and its inhabitants should be typical of the social and economic environment of the surrounding areas of the HKH.
- The watershed should have agricultural, forest, and rangeland.
- It should be easily accessible for the research team.
- The size of the watershed should be preferably between five to 50 sq. km.
- Rainfall and runoff data for the watershed should be available or easily estimible.
- The local people should be willing to cooperate with the research team.

The micro-watershed selected is representative of the surrounding northern mountains of Pakistan in term of socioeconomic conditions, cropping pattern, local water-harvesting practices, water supplies, and management system. It should be noted, however, that people residing in the southern mountainous areas of the NWFP have developed their own indigenous technologies and practices.

Information provided by the local people about the watershed during the rapid appraisal survey enabled us to estimate the area to be over five square kilometres. However, when the size of the watershed was determined from the Survey of Pakistan it was found to be about three square kilometres.

The Battal micro-watershed is located in the District of Mansehra in the North West Frontier Province of Pakistan. The total area of the district is about 439,423 ha, with an arable area of about 80,747 ha (18% of the total area). The average altitude is about 1,082 metres. Mansehra District has three tehsil(s) or sub-districts (Mansehra, Battagram, and Balakot) and a village council in (Union Council) Battal. Most of the area is hilly and agricultural land is in the form of terraced fields on the slopes of the hills (NWFP Development Statistics 1997).

The sampled population of the watershed totals about 900 inhabitants, giving a population density of about 300/km². It is located 25 km towards the north-east of the Silk Route (Karakoram highway) which leads to China and passes through Mansehra. It is located between latitudes 34.67° to 34.70° and longitudes 73.16° to 73.17°. The altitude of the watershed ranges from 1,500 to 2,000 metres.

Climate

The long-term average annual rainfall in the selected micro-watershed is well over 1,000 mm. Most of this rainfall (> 600 mm) occurs during monsoon (July-August) and during the month of March. The monthly average rainfall values are shown in Figure A1. It is obvious that September, October, November, and December are the driest months of the year. The selected watershed receives up to one metre of snow from December to March. Winter is quite cold, the temperature is below zero during the months of January and February, while the summer is pleasant with an average maximum temperature of about 25°C. The mean annual relative humidity at the selected site is about 59%.

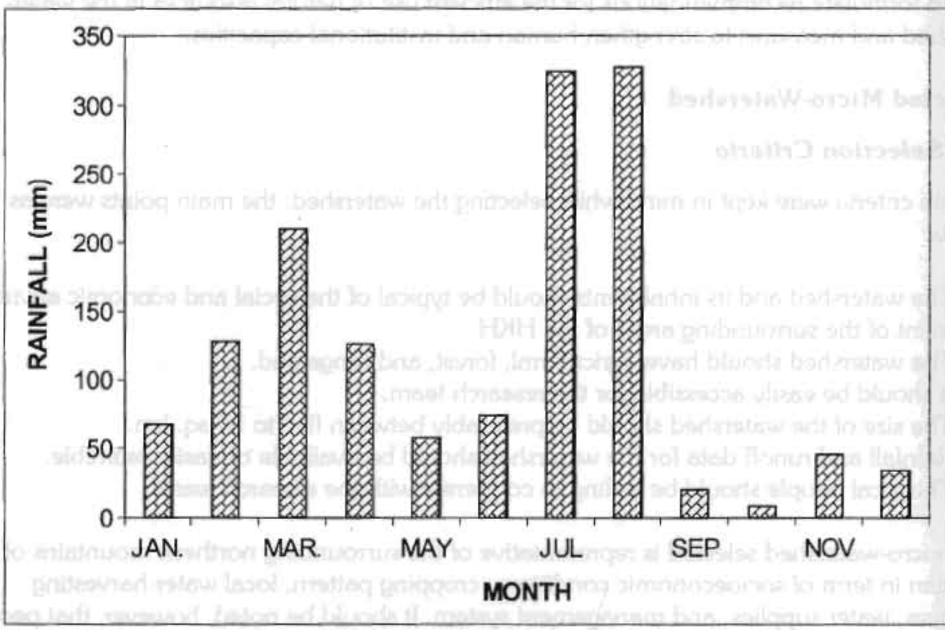

Figure A1: **Average monthly rainfall in the selected watershed**

Soils

The selected micro-watershed has rugged terrain and high relief with an average elevation of about 1,750 metres above mean sea level (masl). The soil and the vegetation vary along with their position on the top sequence. Soils on the steep slopes are lateritic and gravelly, whereas silt loam or loam are found in the valleys. The steep slopes in the upper parts of the watershed make agriculture virtually impossible and hazardous. Because each household has very limited land resources, the farmers grow maize crops on the very steep slopes. Population pressure has led to a serious degree of overgrazing, soil erosion, and deforestation.

Vegetation

Vegetation and crop production are influenced by the climate of the area. In the selected micro-watershed, maize and rice are the main summer (kharif or wet season) crops whereas wheat, mustard, and barley are the main winter crops (rabi). During winter, most of the watershed is covered with snow for four months, however, wheat, mustard, and barley are grown in the irrigated valley on a small proportion of the land. In addition, on a very small area, apples and some vegetables are also grown. Predominant forest species found in the area are *Pinus wallichiana*, *Pinus roxburghii*, and *Robinia pseudococacia*. Intense rainfall has resulted in a good vegetation cover. The common rangelands, however, are under tremendous pressure from overgrazing, and this has resulted in severe erosion problems on the steep slopes.

The objective of the study was to discover the constraints related to water resource development/management and explore possible solutions to improve the economic environment and provide the inhabitants with an opportunity to achieve an acceptable standard of living and income.

Methodology

This study can best be characterised as an exploratory one. The selected micro-watershed was visited by a field team. A structured proforma was used to collect information on the socioeconomic conditions, land use, water-harvesting technologies, water supplies, irrigation, and critical issues related to local water harvesting. Ninety-seven farmers were interviewed in three different villages (41 in Malokra, 35 in Palai, and 21 in Kandi). Open group discussions were held with the farmers to solicit their opinions about local water-harvesting practices. Besides interviews with the farmers, visual observations were also made. Information about the selected area was also collected from other sources such as government departments and NGOs working in the area. A sample survey was carried out in August-September 1998.

Socioeconomic Profile of the Households

The socioeconomic condition of the households was assessed in terms of age, literacy status, ethnic groups, housing and ownership, income per household, landholdings, and tenancy status. The results are presented in the following sections.

Distribution of Household Members by Age Group

The sample population was 900. About 20% of the population is below five years of age and a little more than 23% are from six to 16 years, which means that about 43% of the population is below the age of 16 (Table A1). These statistics indicate a heavy dependence

Table A1: **Distribution of household members**

Name of Village	Sample Size	Total Sample Population	<5 Year Male	<5 Year Female	6 -16 Year Male	6 -16 Year Female	16 - 60 Year Male	16 - 60 Year Female	Total Male	Total Female
			(%)							
Malokra	41	353	11	9	13	10	30	27	54	46
Palai	35	358	10	12	18	13	23	24	51	49
Kandi	21	189	7	3	15	13	35	27	57	43
Overall Avg	97	900	9	8	15	12	30	26	54	46

ratio, and this is typical of the less developed area of the country. The female population is 46% of the total. On average each household has about nine members.

Literacy Status of Heads of Household

Household size in the sampled villages is given in Table A2. The literacy rate of the household heads was lowest (38%) in Kandi; however, overall it was found to be relatively high (50%). The NWFP has the second lowest literacy rate (17%) among the provinces of Pakistan and the literacy rate among females is exceptionally low (6%). In 1991-92, the male and female school enrollment rates were 73 and 25% respectively (Government of NWFP 1996).

Table A2: **Literacy status of heads of household**

Name of village	Literate household heads	
	No	Per cent
Malokra	25	61
Palai	15	43
Kandi	8	38
Total (Watershed)	48	50

This rate is for literate heads of households in villages.

Occupation — On average two persons in each household work on farms, one each working in Pakistan and overseas. Young men seek employment in Pakistan or overseas to earn a considerable amount of money in a short period. Employment and daily labour are an important source of income for the households. The cereal produced on the farms is hardly enough for six months per household. For the rest of the year they have to buy cereals from the market.

Ethnic Groups

The selected micro-watershed is inhabited by total diverse ethnic group (Table A3). The main tribes include the Gujar, and they account for 25%, followed by the Awan (21%), Akhund Khel (19%), and Swati (11%). The rest of the ethnic groups (the Tanoli, Kashmiri, Qureshi, Khunzada, Mughal, Turk, and Khoja) account 24%. All of the inhabitants in the selected micro-watershed are Muslims.

Table A3: **Ethnic groups in the selected watershed**

Cast	Total (%)
Tanoli	5
Awan	21
Swati	11
Akhund Khel	19
Kashmiri	3
Qureshi	6
Gujar	25
Khunzada	1
Mughal	5
Turk	2
Khoja	2

Housing and Ownership

Housing facilities in the selected micro-watershed are generally poor. Most of the structures (78%) are *katcha* (non-masonry), made of mud, wood, and stones and using very little or no cement (Table A4). Ventilation and proper heating are almost non-existent, room space per capita is very small, and the hygienic conditions are very poor—about four per cent of the houses are *pacca*. The houses are generally built on terraces and look like layers of dwelling structures. The courtyard of a house is the roof of the next one below and so on.

Table A4: **Housing structures**

Name of Village	*Katcha* Houses	Semi-*Pacca* Houses	*Pacca* Houses
		%	
Malokra	78	17	5
Palai	74	20	6
Kandi	81	19	0
Overall Avg	77	19	4

Katcha = mud house
Pacca = brick and cement (masonry) house

The majority of households (80%) own their houses. Rented houses account for 20%, while employers or other categories of houses do not exist (Table A5). In Palai village the number of house owners is relatively less (63%) than in the other villages. Most of the houses lack basic facilities such as flush toilets and piped drinking water supplies.

Table A5: **House ownership**

Name of Village	Owned Houses	Rented Houses	Houses provided by Employers
	%		
Malokra	85	15	0
Palai	63	37	0
Kandi	90	10	0
Overall Avg	80	20	0

Income Per Household

The per capita income of the sample households is below the national average (Table A6). The heavy dependency on salaries and wages (more than 80%) is rather striking. Income dispersion in the sample villages is relatively small. During 1993-94, per capita national income was about Rs 10,589.By assuming a growth rate of five per cent the projected per capita income for the year 1997-98 is expected to be Rs 12,871. The average per capita income of the households in the selected watershed is 35% of the national per capita income. This means that the majority of the population in the area is living below the poverty line level as it comes to approximately US$100 per year.

Table A6: **Income Per Household**

Source of Income	Income Per Household (Rupees)			
	Name of Village			Average
	Malokra	Palai	Kandi	
Cereal Crops	4585	1886	381	2284
Horticulture	0	0	0	0
Forest	0	0	0	0
Livestock	1171	171	0	447
Private Employment	15244	22800	15524	17856
Govt. Employment	18220	6286	27762	17422
Overseas Employment	5366	2057	0	2474
Total Income	44586	33200	43667	40483
Members per Household	9	10	9	9
Income Per Household	4954	3320	4852	4498

There were 45.00 Pakistani rupees to 1 US dollar in 1998.

Size of Land Holdings and Tenancy Status

In the selected micro-watershed, the land owned by the people includes rainfed land (36.8%), irrigated land (23.4%), forest land (20.4%), and rangeland (19.4%). This diversity is associated with the scarcity of water for irrigation. The average size of the farm per household in irrigated and rainfed areas of the watershed is 0.42 ha and 1.06 ha respectively (Table A7). Nieuwkoop (1989) reported that the average farm size in Buner is about 1.98 ha (irrigated and rainfed). The average farm size in the selected micro-watershed is 25% less than in districts adjacent to Buner with the same topography.

Table A7: **Landholdings**

Name of Village	Total Area (ha)	Irrigated	Rainfed	Range Land	Forest
Malokra	103.84	25.00	27.78	24.84	20.37
Palai	51.36	17.74	33.69	28.88	19.94
Kandi	14.57	16.90	33.91	20.35	0.71
Total	169.77	57.98	95.38	74.07	41.02

The majority of farmers (54%) are owners, followed by tenants (26%), and owner/tenants (20%) (Figure A2). The landholdings are very small (< 2 ha), except for a few landlords

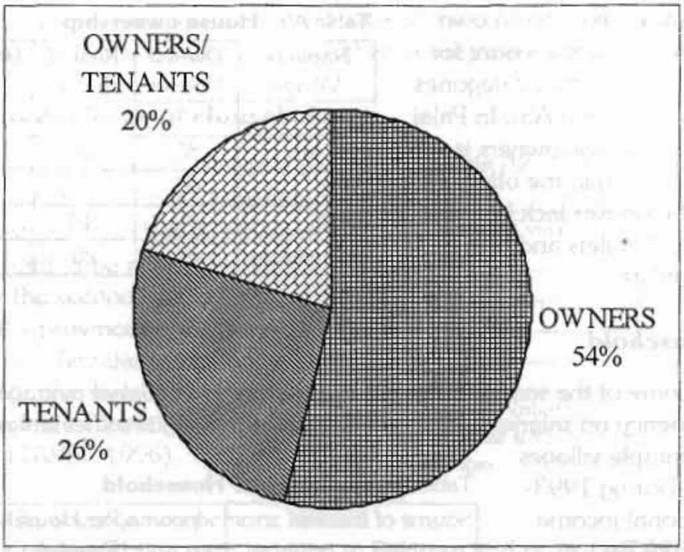

Figure A2: **Tenancy Status of the Sample Households**

who own more than 10 ha of land. Khan and Akram (1985) carried out a socioeconomic survey in Mansehra and reported that owners constituted 52.55 and tenants 12.3% and that the average landholding was 0.62 ha.

Forest Species and for Firewood Collection

The dominant forest species found in the area is *Pinus wallichiana* which covers more than 70% of the forested land (Table A8). Malokra has the highest percentage (70.3%) of forest area. On average forest land per household is relatively small: less than one hectare.

Table A8: **Major forest species in the area**

Name of Village (hh)	Forest Species	Forest Area (ha)	Per cent	Forest Area per Household (ha)
Malokra (41)	*Pinus wallichiana*	24.9	70.3	0.6
Palai (35)	*Pinus wallichiana/ Pinus roxburghii*	9.5	26.7	0.3
Kandi (21)	*Robinia pseudocacia*	1.0	2.8	0.0

The number and type of forest trees cut for firewood and building are given in Table A9.The number of forest trees cut for building purposes is less than one per year per household. Village-wise the number of trees cut per household per year ranges from 0.5 to 2 trees. However, in the absence of natural gas for cooking, trees are mainly cut for firewood. *Pinus wallichiana, Robinia pseudocacia* and *Ilenthus altissima* are the common forest species that are used for firewood in the area.

Wildlife

Biological diversity is under threat in Pakistan because of destruction of habitats and over hunting of discrete populations. This is in spite of the fact that Pakistan has ratified the International Convention on Biological Diversity and agreed to implement the

Table A9: **Forest species used for building and firewood**

Name of Village	Trees Cut per Household Per Year					
	For Building			For Fuel		
	Type of Tree	No	Per house hold	Type of Tree	No	Per house-hold
Malokra	*Pinus wallichiana*	14	0.3	*Pinus wallichiana*		
				Robinia pseudocacia *Ilenthus altissima*	71	2
Palai	*Pinus wallichiana*	16	0.5	*Pinus wallichiana* *Robinia pseudocacia* *Ilenthus altissima*	17	0.5
Kandi				*Robinia pseudocacia* *Ilenthus altissima*	27	1.3

recommendations of the United Nations Conference on Environment and Development related to Biological Diversity, which was held in Rio, Brazil, in 1992. The NWFP is home to different mammals and bird species. The endangered mammals are Barking Deer, Brown Bear, Chinkara Gazelle, Flat-horned Markhor, Hog Deer, and Kashmiri Grey Langur. Endangered bird species include the Cheer Pheasant and Western Tragopan. In the selected micro-watershed, a few common animals such as jackals and birds were reported by the respondents. However, it was pointed out by the interviewees that there had been more wild animals in the past.

Cropping Pattern

During the winter season, most of the watershed is covered with snow, making cultivation virtually impossible. However, in irrigated valleys, wheat, mustard, and barley are grown on a small area in winter: maize and rice are the main summer crops. Besides this, on a very small area, apples and some vegetables are also grown. A cropping calendar and a rotation schedule of the major crops grown in the selected villages are given in Table A10. Wheat-maize is the dominant cropping rotation on rainfed land as well as in remote irrigated areas. The other cropping rotations on irrigated farms are rice-berseem and rice-wheat. Khan *et al.* (1992) conducted a diagnostic study of five villages in Mansehra district. They found that major cropping rotations in the area were wheat-fallow-wheat, maize-fallow-maize.

Table A11: **Cropping calendar**

Crop	Sowing	Harvest	Cropping Rotation
Maize	April/May	Sept/Oct	Rice - Fodder-Mustard
Rice	April/May	Sept/Oct	Rice - Fallow-Wheat
Wheat	November	Jan/Feb	Maize - Fodder
Mustard	November	Jan/Feb	Maize - Fallow-Mustard

<u>Cropping Calendar</u>

In the selected sample villages, the cropping intensity is about 100% on rainfed and irrigated land. The farmers seldom keep their land fallow in summer. However, in winter, due to snow cover, they do not grow winter crops. Wheat is grown on a small area and is

Table A10: **Cropping Pattern in the selected watershed**

Name of Village	Rainfed Crops (ha)		Kharif Crops (Summer) Irrigated Crops (ha)				Rabi Crops (Winter)			
	Maize		Rice		Maize		Rice		Wheat	
	Total	Per HH	Total	Per HH	Total	Per HH	Total	Per HH	Total	Per HH
Malokra	26.0	0.6	0	0.0	1.0	0.0	33.7	1.3	2.7	0.1
Palai	8.6	0.2	1	0.0	2.5	0.0	14.8	1.7	1.3	0.1
Kandi	4.8	0.2	0	0.0	0.0	0.0	0.0	0.0	3.0	0.6
Total Watershed	39.4	0.4	1	1.0	3.5	0.1	48.5	1.2	7.0	0.2

used as a fodder for cattle (Table A11). Maize is normally grown in April/May and harvested in September/October, while rice is also planted in April/May and harvested in September.

Yield of Major Crops

Major crops grown in the selected micro-watershed in summer season are maize and rice. An average yield of maize in the sample villages ranged from 1,102 to 1,634 kg/ha and rice yields from 1,352 to 1,806 kg/ha (Table A12). The yield of both these cereal crops is far below the potential yield (about 3,000 kg/ha). The environmental conditions in the area could favorably be exploited for growing many field, fruit, and vegetable crops. New crop species and varieties, e. g. , sunflower, safflower, sorghum, soybean, lentils, canola; vegetable crops such as peas, onion, garlic; and fruit crops such as figs, apricots, and strawberries could be introduced. Introduction of these crops can increase the income of farmers.

Table A12: **Yield of major cereal crops**

Name of Village	Maize Cropped Area (in ha)	Maize Yield (kg/ha)	Rice Cropped Area (in ha)	Rice Yield (kg/ha)
Malokra	33.7	1634	26.0	1526
Palai	14.8	1220	8.6	1806
Kandi	9.6	1102	4.8	1352
Total Watrshed	58.1	1319	39.4	1561

Because of the poor road infrastructure, scarce water resources, and availability of poor agricultural extension services in the micro-watershed the farmers do not grow high value cash crops (fruits and vegetable). With improved infrastructure, such as roads and water supplies, the farmers would be able to grow more high-value cash crops. They would also benefit from technical knowhow about high-value cash crop production and protection technology.

<u>Livestock and Poultry</u>

The main types of livestock kept by farmers are buffaloes, cows, bullocks, goats, and sheep (Table 813). Buffaloes, cows, and goats are kept mainly for their milk. Bullocks are used as a source of draught power because the steeply sloping terraced fields and small holdings do not allow the use of tractors. Buffaloes are kept per household on average at a rate of seven cows, 17 bullocks, 13 goats, and five sheep per village. Because of the rough terrain, very few sheep are kept compared to goats.

The number of chickens per household ranged from four to seven with an average of about six. Comparing the average number of chickens with the average household size, it can be concluded that the production per family is not even one chicken per person. The major reason for low poultry production is disease. Two poultry farms are also raising chickens (Table A13).

Table A13: **Livestock composition**

Livestock	Livestock per Household			Average
	Malokra	Palai	Kandi	
Buffaloes	21	28	8	19
Cows	0	11	10	7
Goats	25	11	2	13
Sheep	0	14	0	5
Bullocks	12	21	18	17
Donkeys	8	11	0	6
Mules	0	0	0	0
Poultry	234	242	78	185
Horses	0	4	0	1

Annex 2

Local Water Supply and Management Systems

The main sources, quality, and distribution of water, maintenance of water supply systems, gender issues related to water supplies, and assessment of irrigation requirements for major cereal crops and maintenance of water supply systems are dealt with here.

Water Supplies for Irrigation

Main Source of Water Supply for Irrigation

Springs are the main source of irrigation in the selected micro-watershed, followed by ponds and runoff water. About 60% of the farmers irrigate their fields, although they only have small landholdings. About 39% of them use spring water for irrigation, nine per cent use runoff water, and 10% use pond water to irrigate small terraced strips of land to grow maize and rice in summer. In the winter, because of the snow, no crops are grown (Table A14). During a visit to the area in September, the amount of spring water observed was sparse (< 10 l/s), but people claimed that more water is normally available during the monsoon period (July and August) and severe shortages of water for irrigation occur during the months of May and June.

Table A14: **Main sources of water for irrigation**

Name of Village	Spring	River	Water Channel	Ponds	Runoff WH	No Response
	% Respondents					
Malokra	59	0	0	12	7	22
Palai	20	3	0	6	9	63
Kandi	33	0	0	14	14	38
Overall Avg	37	1	0	11	10	41

Quality and Quantity of Water for Irrigation

In general, the quality of water used for irrigation was found to be good. However, the quantity of water was less than the crops needed during the growing season. About half of the households with irrigated land complained about the shortage of water for irrigation (Table 8.15). Only 17% of the respondents were satisfied with the supply. In Kandi, which is located upstream in the micro-watershed, the availability of water is relatively better (38%) than in the other two villages. Malokra suffers from a severe shortage of water for irrigation, as 73% of respondents complained about the shortage (Table A15).

Table A15: **Sufficiency of water supply for irrigation**

Name of Village	Surplus	Adequate	Short	No Response
	% Respondents			
Malokra	0	5	73	22
Palai	0	6	31	63
Kandi	0	38	29	33
Overall Avg	0	17	44	39

Distribution of Water for Irrigation

Traditionally those living upstream in the watershed considered it their right to irrigate their fields first. As a general rule, during the division of land among the different households, spring water is also divided. If the flow rate of the spring is too small, then water turns are allocated to individual households. About two-thirds of the households interviewed mentioned that there is no water distribution. However, from 2 to 14% with an overall average of five per cent of the respondents stated that there is proper water distribution based on the numbers of families living in the area. Water is not distributed per landholding at all (Table A16).

Table A16: **Distribution of water for irrigation**

Name of Village	On Land Basis	Household Basis	Upstream to Down stream Rule	Crop Need Basis	No Distribution	No Response
	---------- % Respondents ----------					
Malokra	0	2	44	0	32	22
Palai	0	3	9	0	26	63
Kandi	0	14	19	0	33	33
Overall Avg.	0	5	26	1	30	38

According to the respondents, water is not sold. First upstream farmers irrigate their fields and if there is still excess water then downstream households can irrigate their fields. Upstream farmers can divert water to their fields any time and as much as they wish to do so. Sometimes the spring water available is divided into small streams and several farmers irrigate their fields at a time.

This issue of water rights has resulted in an inequitable and uneven water distribution system which has produced differences in the cropping pattern. The farmers along the headwaters of the spring grow more rice and use more water than those at the tail end. At the tail end, farmers do not get enough water, so they grow more maize and one can also see some fallow land. The farmers interviewed were not satisfied with the distribution system. In general, equity of water distribution is extremely poor in the schemes where there is no proper rotation.

Right and Access to Irrigation

In the mountain region, the general rules for water rights are (a) if the source of a spring is located on someone's land then he/she has the full right to divert the spring water to his/her fields for irrigation, but (b) if he/she does not need water or if the spring flow rate is more than his/her requirements then downstream farmers can irrigate their fields. The Government has declared land in the vicinity of a spring to be irrigated land, and pond owners and farmers downstream have the right to use the spring water for irrigation.

Maintenance of Irrigation Channels

On average about 45% of the respondents who had landholdings stated that maintenance of irrigation channels is usually carried out by individual households and 15% stated that it is carried out by the community (Table A17). In general, it can be concluded that maintenance of the field channels is carried out by individual households and headworks by the community with no support from government agencies/institutions.

Table A17: **Maintenance of irrigation channels**

Name of Village	Community Management	Government	Individual	Other	No Response
	% Respondents				
Malokra	12	0	66	0	22
Palai	17	0	20	0	63
Kandi	14	0	47	0	38
Overall Avg	15	0	45	0	40

Gender Issues Related to Irrigation

Irrigation is generally the task of men according to two-thirds of the respondents (Table A18). Women do participate in the irrigation of fields, but their participation is limited (4%).

Table A18: **Irrigation of cropped fields**

Name of Village	Women	Men	Both	No Response
	% Respondents			
Malokra	0	78	4	18
Palai	3	69	0	31
Kandi	5	62	0	38
Overall Avg	4	69	2	29

Irrigation Requirements for Cereal Crops

The major cereal crops grown during summer season are maize and rice. Maize is grown in both irrigated and rainfed areas. In rainfed areas maize is grown on about two-thirds of the cultivated land, whereas the area under rice is negligible. However, rice is the predominant crop on irrigated lands in the watershed and is grown on more than two-thirds of the area.

Requirements for Irrigating Maize

The requirement for irrigating maize crop was computed by CROPWAT by using weather data from a nearby weather station (Gilgat) at about the same altitude as local data were not available. Irrigation requirements per decade are shown in Figure A3. The peak irrigation requirements for maize occur during the month of June. The same was confirmed through interviews with farmers who stated that there was a shortage of water in the month of June. In general, irrigation requirements for maize ranged from 3 to 48 mm/decade during the growing period. In the month of July and August, as a result of the dense rainfall, the irrigation requirements were zero.

Requirements for Irrigating Rice

Rice needs much more water than other cereal crops. A lot of water is lost through pecolation, therefore, a continuous water supply is needed throughout the growing season. Irrigation requirements for rice per decade are shown in Figure A4. The peak irrigation requirements occur during the months of May and June. Irrigation requirements for rice ranged from 95 to 156 mm/decade during the months of May and June. During group

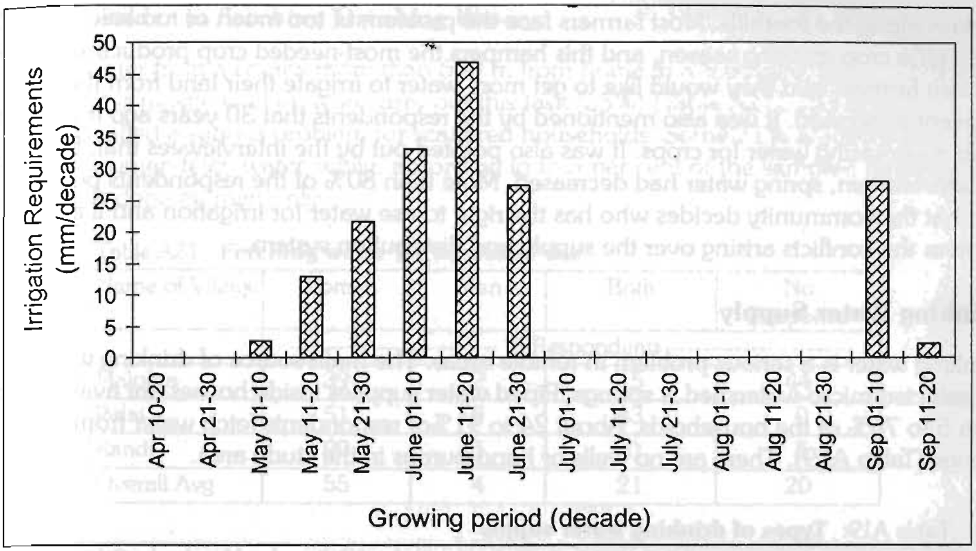

Figure A3: **Irrigation requirements for maize crops in Battal (Mansehra)**

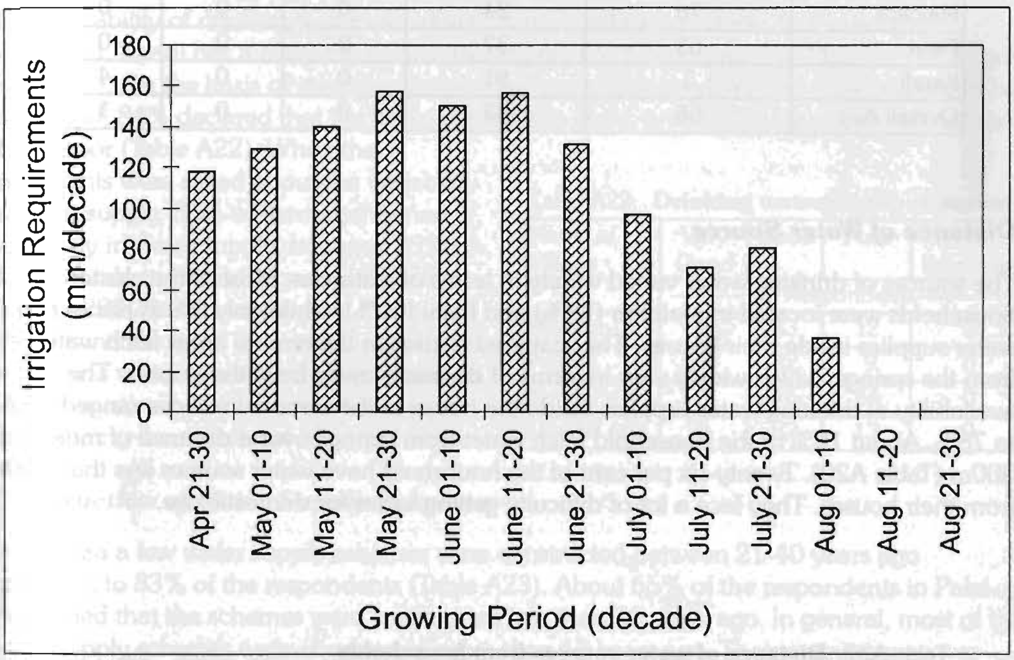

Figure A4: **Irrigation requirements for rice crops in Battal (Mansehra)**

interviews, respondents claimed there was a shortage of water. They proposed that water from the adjacent watershed be diverted to meet their irrigation needs because of the heavy irrigation requirements for rice.

Major Problems and Constraints in Supply of Water for Irrigation

The irrigated fields are small, located in rugged terrain, and difficult to reach. Only a small proportion of the land is used for agricultural production. Much of this land is in isolated pockets along the foothills. Most farmers face the problem of too much or too little water during the crop growing season, and this hampers the most-needed crop production. During the visit farmers said they would like to get more water to irrigate their land from the adjacent watershed. It was also mentioned by the respondents that 30 years ago there had been more spring water for crops. It was also pointed out by the interviewees that, because of deforestation, spring water had decreased. More than 80% of the respondents pointed out that the community decides who has the right to use water for irrigation and it also resolves the conflicts arising over the supply and distribution system.

Drinking Water Supply

Drinking water is a serious problem in remote areas. The main source of drinking water in the selected micro-watershed is springs. Piped water supplies inside houses are available for from 5 to 76% of the households. About 24 to 91%of respondents fetch water from the springs (Table A19). There are no wells or hand pumps in the study area.

Table A19: **Types of drinking water supply**

Name of Village	Pipe Supply inside house	From Spring in pitches	Wells	Hand Pump	Others
	% Respondents				
Malokra	76	24	0	0	0
Palai	63	37	0	0	0
Kandi	5	91	0	0	4
Overall Avg	56	43	0	0	1

Distance of Water Source

The sources of drinking water varied widely in terms of distances. Most of the cluster households were located in Malokra (78%) and Palai (60%), while only 5% in Kandi had water supplies inside their houses. The scattered houses in the remote areas fetch water from the springs, which widely vary in terms of distances away from the houses. The availability of drinking water supplies inside the house in the sampled villages ranged from 5 to 78%. About 18% of the household fetch water from springs over a distance of more than 500m (Table A20). Twenty-six per cent of the household have water sources less than 500m from their houses. They face a lot of difficulty getting water for domestic use.

Table A20: **Distance of water sources from households**

Name of Village	Inside houses	Less than 100 m	100-500 m	> 500 m	Others
	% Respondents				
Malokra	78	7	0	15	0
Palai	60	6	20	14	0
Kandi	5	33	33	29	0
Overall Avg	56	12	14	18	0

Role of Gender in Fetching Drinking Water

Fetching water from a source more than 500 m from home in a mountainous region is quite fatiguing. It is mostly women who carry out this task (55%) (Table A21). Drinking water can be rightly called a serious problem for scattered households. Some 21% reported that both men and women fetch water, while, according to four per cent of the sampled households, this work is done by men only.

Table A21: **Fetching water for domestic use**

Name of Village	Women	Men	Both	No Response
	------------------------- % Respondents			-----------------------
Malokra	39	2	15	44
Palai	51	8	43	0
Kandi	90	5	0	5
Overall Avg	55	4	21	20

Drinking Water Supply Situation

The availability of drinking water varied widely from village to village. In the selected watershed, Kandi has a relatively poor water supply (24%) compared to Malokra (12%) and Palai (9%). On the basis of overall averages, five per cent considered the water supply to be very good, 84% declared that the water supply was good, and 13% of them mentioned that it was poor (Table A22). When the inhabitants were asked about the variability in water supply, 80% of them mentioned a variability in water supply, however 20% of the respondents did not agree with them (Table A22). About two-thirds of the respondents declared that, in general, there was excess water available during monsoon (July-August), while there was shortage of water during the months of May and June.

Table A22: **Drinking water supply situation**

Name of Village	Very Good	Good	Poor	No Response
	---------- % Respondents			------------
Malokra	5	83	12	0
Palai	9	82	9	0
Kandi	0	76	24	0
Overall Avg	5	82	13	0

Construction of Water Supply Schemes

In Malokra a few water supply schemes were constructed between 21-40 years ago according to 83% of the respondents (Table A23). About 65% of the respondents in Palai mentioned that the schemes were constructed less than 20 years ago. In general, most of the water supply schemes were constructed more than 10 years ago. Their maintenance was very poor. Due to landslides and snow, the water supply is interrupted for several days during winter and monsoon seasons. Maintenance of the drinking water supply is the responsibility of the communities/users.

Table A23: **Time-frame for construction of the completed schemes**

Name of Village	< 10 Years old	11-20 years	21-40 Years	> 40 Years	Others
	---------------- % Respondents				-----------------
Malokra	2	0	83	0	2
Palai	6	65	9	20	0
Kandi	19	14	29	24	14
Overall Avg	7	29	44	18	4

Quality of Drinking Water

Table A24: **Quality of drinking water supply**

Name of Village	Very Good	Good	Bad	No Response
	% Respondents			
Malokra	0	22	78	0
Palai	3	49	49	0
Kandi	0	81	14	5
Overall Avg	1	44	54	1

Only a few (3% in Palai) respondents considered the quality of the water to be very good; 44% thought it was good, whereas half of the respondents (54%) were not satisfied with the quality of drinking water (Table A24). The main reason is that open spring water is collected and supplied through the pipes. The main collection points are exposed to several contaminants, e. g. , animal waste, dead leaves, debris, and sediment. Animals also drink from the springs and some households wash their clothes in them. With such unhygienic water, chances of water-borne diseases increase.

Maintenance of Drinking Water Supply Schemes

Drinking water supply schemes are maintained by individual households (43 to 60%) or by the community (40 to 56%) (Table A25). Although, some of the water supply schemes were constructed by government agencies, they do not maintain them. Fifty per cent of the respondents stated that water supply schemes are maintained by individual households or by the community. During the visit it was observed that most of the water supply schemes were in poor condition. Several scattered households have dug shallow holes of about 50 litres in capacity near the bed of the concentrated flow in the watershed for collection of groundwater. They fetch water from these shallow holes for domestic use, while some fetch water directly from small springs.

Table A25: **Drinking water supply maintenance**

Name of Village	Community Management	Government	Individual	Other	No Response
	% Respondents				
Malokra	56	0	44	0	0
Palai	40	0	60	0	0
Kandi	52	0	43	0	5
Overall Avg	50	0	50	0	1

Major Problems Related to Drinking Water Supply

The quantity and quality of drinking water supplied to cluster households are very poor. Water supply schemes are in very poor condition and need to be improved. Water supply schemes collect water directly from springs and most of the inflow points are prone to contamination by debris, dead leaves, and animal waste. Due to lack of water supplies for domestic use some households wash their clothes and also bathe in the upstream reaches of the watershed. Another problem is that most of the pipes are exposed to severe weather conditions and landslides. Water supplies are interrupted by burst pipes in low temperatures or landslides.

On the other hand, most scattered households do not have piped water supplies because they are poor. Normally the women have to fetch water from springs for domestic use.

In the past there used to be more spring water but, because of deforestation and overgrazing, the discharge from the water source has decreased significantly as a result of greater runoff and limited percolation.