Chapter 4
Water Harvesting Practices in Mountain Areas[1]

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Introduction

The availability of clean water, like clean air, has been taken for granted by most communities. However, because of increasing demand, limited supplies, pollution of fresh water bodies, and the soaring costs of providing clean water, the perception of water as a free commodity is beginning to change (Agrawal and Narain 1997). From a bountiful natural resource with unrestricted access, at least for drinking purposes, water is quickly becoming a commodity with a price tag that is bought and sold in the market. Many signals of alarm are being raised about the growing scarcity of fresh water and the urgent need for efficient and equitable water-harvesting systems (Agrawal and Narain 1997; SHERPA 1996).

Broadly defined, local water-harvesting systems include all measures adopted by households and communities to collect water for different purposes. They include tapping various sources, transporting, conveyance and storage, and all the other different socioeconomic and cultural practices that are organized to supply water. Wherever it is in short supply, concerted efforts have been made to ensure its reliable and equitable distribution, at least during critical planting periods. Two different systems have been in operation. One system found in the rural areas of most developing countries is locally operated, small-scale, people-centered, farmer-based or managed, and easy to maintain and rebuild. This system still plays an important role but is now feared to be 'breaking down' and has been referred to as the 'dying wisdom' (Agrawal and Narain 1997). The other systems are those that are driven by modern technologies of large-scale, engineering-dominated, non-participatory, and government controlled or jointly controlled by large firms and governments; and these are playing an increasing role in the supply of fresh water in most urban and some rural communities. In some places one can find a limited degree of interface but this dichotomy has continued to prevail for the most part (Ramaswamy 1998) .

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1 Opinions expressed are solely those of the author

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In most mountain areas, the story of water harvesting is always one of struggle. Indeed, the progress of many mountain communities over the centuries can be perceived from the changing flow of water and the success of their water-harvesting systems. While most mountain areas are relatively well endowed in terms of different water resources, getting it to where and for when it is needed is a serious challenge. The verticality of mountain areas has confined water bodies, generally, either to the extreme heights (in the form of snow or glaciers) or to deep valley bottoms (in the form of rivers and streams), while most settlements are in between and substantial effort is required to transport water from the source to the point of supply. In the HKH mountain areas there is also a marked seasonality in water supplies, particularly in terms of rainfall. There is a short period of high-intensity rainfall followed by a protracted dry season. Unstable geology, slope, and massive discharges make it very difficult and costly to store summer runoff. Thus, when it is available, much of it goes away. It is therefore not surprising that, in most mountain communities, fetching drinking water daily occupies a significant amount of time for various household members – mainly the time of women and children. During the rainy season, getting sufficient water to the fields in time for the limited growing seasons and disposing of extra water are important tasks. In view of all these factors, the struggle for water and the struggle against water have been critical features in survival for mountain communities. Success or failure in these struggles may very well determine whether a community continues to settle in a certain area or abandon it and begin the arduous cycle all over again in another area.

The main purpose of this paper is to provide an overview of the six case studies prepared describing important features of prevailing water-harvesting systems of different mountain communities in parts of India, Nepal, and Pakistan. The paper is organized into several sections – each section discussing common points underlying the different water-harvesting systems (WHS). While there are many similarities to these different WHS, there are also important differences reflecting unique responses to specific environments. The last section looks at community WHS and discusses the critical issues in WHS.

BACKGROUND TO THE CASE STUDY AREAS

There are two case studies each from India, Nepal, and Pakistan. From a water-harvesting perspective, three are from relatively dry areas: Balochistan (in Pakistan) has desert-type conditions and Ladakh (in north India) and Mustang in central north Nepal are both in the rain shadow (Trans-Himalayan) and could be classified as cold deserts (Mushtaq 1999; Khan 1998; Lohani and Banskota 1999). The three other case studies are from relatively wetter areas than the first three– where rainfall is above 1,000 mm per annum. From Pakistan the case study is about a small watershed in Mansehera district in NWFP (Khan 1998). From India it is about a watershed in the Tehri Garhwal district in the State of Uttar Pradesh (CSWCRTI 1998) and from Nepal the case study is from Kabhrepalanchok (Kabhre) district lying directly east of Kathmandu (Lohani and Banskota 1999). In terms of elevation, all three are at lower altitudes (i.e., below 1,500 m). Rainfall decreases from east to west throughout the HKH region and based on this one can conclude that Balochistan (Pakistan) in the west is much drier than Kabhre (Nepal) in the east (Map 1).

In general, all the case studies note that there are fewer difficulties encountered in harvesting drinking water than in harvesting water for other purposes. Drinking water for people and livestock has posed no major problems so far. However, it is a common feature that women spend a lot of time fetching drinking water for the household in all study areas.

There are serious problems in all areas regarding supplies of water for irrigation. The problems differ in nature as well as in severity from case to case. Most water-harvesting systems have focussed on providing sufficient supplies for irrigation, and this is where one can find many complex institutional arrangements for ensuring water supplies in critical planting seasons.

From India, the **Ladakh** case study highlighted the existence of a fairly complex traditional institutional system for irrigation. There are many different systems extant that vary widely from watershed to watershed. Given the limited growing season and the desert-like conditions, the water available is used to maximise the area under irrigation. Because planting periods are short, water has to be distributed quickly to the fields. There is little room for individual decisions, except on one's own land. Water allocation, distribution, and supervision and monitoring are major community concerns. For a few weeks, the entire community is mobilised to manage water distribution. The future of such systems is being questioned, however, not so much because of the failure of the water-harvesting technology, but more on account of the increasing difficulty of mobilising the community members to actively participate in the traditional water-harvesting systems (Lohani and Banskota 1999).

The **Tehri Garhwal** case study identifies many interesting practices of local water harvesting. These include the use of plants for purifying water and the separation of water sources for different social groups. While there has been a significant expansion in the use of modern systems such as lift pumps to supply water, traditional systems are still very important for most people in the watershed in spite of the number of breakdowns and lack of maintenance (CSWCRTI 1998).

Two case study areas in Nepal are similar to those in India. One from the Trans-Himalayan region and the other from the middle hills. In the Trans-Himalayan area in **Mustang**, Nepal (Parajuli and Sharma1999), the institutional mechanisms for water harvesting are complex and well organized and, although similar to those found in Ladakh, there are also many variations. Interestingly, one of the points raised is that the prevailing system has not been modified or redesigned to cater to the increased need for irrigation arising out of the recent introduction of horticulture and tree farming. The priority in the prevailing irrigation system is still for the production of cereals. The second case study area in Nepal is from the middle hills in an area east of Kathmandu in **Kabhre district.** There appears to have been many interventions in the past to improve local water-harvesting systems, both for drinking and irrigation. The most recent example of community mobilisation for water harvesting has been the establishment of a micro-hydro electricity plant for which a fairly elaborate community organization was put into place. Outside resources have played an important role in various interventions. The main issue appears to be the need for greater local resource mobilisation to support present and future water-harvesting activities (Lohani and Banskota 1999).

An important highlight from the **Balochistan** case study area is that increased access to supplies of groundwater has resulted in greater sedentarisation of the community with substantial increases in income for those owning land and having access to groundwater. It is said to have reduced seasonal migration to other areas; changed women's work burden in comparison to the previous nomadic lifestyle; and resulted in an improved quality of life for the community. The main worry at present appears to be the mining of groundwater, its rapidly declining levels, and future supplies. There are important questions about maintaining future water supplies at the current levels (Mushtaq 1999)

The unique feature of the **Mansehra** case study area is the lack of a community organized water distribution system, either informal or formal. Although there is group involvement in various water-harvesting activities, decisions regarding how much water to use, when to use it, and how to use it are made by the person controlling the source. Those living upstream consider it their right to irrigate their fields first. If water is remaining then downstream households can irrigate their fields. Upstream farmers can divert any amount of water to their fields at any time they wish. This practice has evolved into an inequitable and uneven water distribution system. This has forced people downstream to adopt cropping systems that do not require too much water. Some have been even forced to leave their lands fallow (Khan 1998).

OVERVIEW OF WATER-HARVESTING SYSTEMS

Based upon what has been described in the various case studies, it is possible to identify some features common to most water-harvesting systems (Map 1) discussed.

Demand Factors. The demand for water is rapidly increasing. The most common uses are for drinking and irrigation. With many socioeconomic changes, demand is increasing and diversifying. It is a big challenge for local systems that have not altered significantly over decades to to meet this rapidly growing demand for water.

Supply of Water. Various water sources are used by the community for fresh water supplies. The sources discussed in the case studies include rainfall, streams, ponds, springs, marshes, groundwater, snowmelt, oozings, and, in one case, even moisture.

Technology. Technologies for water harvesting vary a great deal from the use of rocks and earth in community-based stream diversion systems to complex lift pumps. However, such technologies appear to be most prominent in three areas of access.

Diversion is the first activity for which some type of technology is used to tap a certain water source and redirect the water to the required location. This is usually to a storage system where some type of storage technology plays an important role. The third area in which technology is used is the distribution and conveyance system through which water is again channelled, stored, and finally used by the household or for irrigation.

In all the technologies used for diversion, storage, and distribution, both traditional and modern inputs, ranging from stone structures to the use of cement, GI pipes, electric pumps, and various types of regulating instrument, are used.

Institutions. Institutions here refer to the organizations and various social practices, rules, and regulations used to harvest water. Water harvesting varies from being a predominantly individual activity to one in which there is a a lot of community involvement. The main areas in which the community plays a role are water allocation between households and fields, the maintenance of water bodies, and conflict resolution between different households over water sharing. Penalties are established and enforced. While most of these are informal, the recent trend is to formalise local institutions involved in water harvesting. With increasing government involvement, the formalisation aspects are becoming stronger. This formalisation is resented to a certain extent by local water-harvesting groups.

Apart from these common features of local water-harvesting systems, more recently government **policies and development projects for** water resources have also been introduced. Policies and development projects influence all the above four aspects. Map 1 shows the policies and development projects circling all the four components of water-harvesting systems. It should also be noted that policies and development interventions do not always support local systems. They may exist in parallel. This is an aspect that requires further study.

There are also other factors such as *environment, productivity, equity*, and *gender* that could have an influence on local water-harvesting systems over time, but these are perceived as indirect impacts on the evolution of the water-harvesting system. For instance, if water distribution is extremely unequal, a time may come when the system either breaks down completely or changes. Inequality may be reflected in increasing poverty/deprivation of some groups and other social conditions that may eventually alter the water-harvesting system. Indirectly, the impact of these factors may be seen over a period of time.

The role of environmental factors is also indirect. Deforestation is reported to have resulted in drying up of springs, forcing households to make changes in their water supply system. Better understanding and proper management of these non-water-related factors and their impacts on water-harvesting systems are very important in terms of long- term sustainability of water harvesting practices.

The Demand for Water

Water is needed for domestic and livestock consumption, for irrigation and milling purposes, and, in some cases, for small-scale power generation. Domestic uses and livestock and irrigation demands are the most important needs in rural areas. Drinking water (both for people and livestock) supplies seem to be adequate in most areas, although there are frequent instances of seasonal scarcity. In most of the areas of the HKH, the current levels of need for human and livestock consumption are less than the level of supply, while for irrigation the demand exceeds supply; and this occurs mainly during the planting season (CSWCRTI 1998; Ladakh Hill Council 1999; Parajuli and Sharma 1998).

There is an indication that the demand for water has increased significantly over the years. In all the studies both human and livestock populations are reported to have increased a great deal, although the rate is somewhat lower in the Trans-Himalayan areas of Ladakh and Mustang (Ladakh Hill Council1999; Parajuli and Sharma 1999). In Garhkot Watershed, it was pointed out that water requirements @ 150 lpd per household was 32,900 litres/day in 1981, and by 1998 this had increased to 53,000 litres/day (CSWCRTI 1998). Increases in demand are also caused by the introduction of new activities such as new water supplies for water mills (Mustang), Micro-hydro Electricity Plants (Kabhrepalanchok), improvements in water supply through piped systems (in all cases), groundwater pumping (Balochistan), and new water lift systems (Garhkot). There are also interesting variations in demand according to altitude and ethnicity. In Garhkot (India) it was mentioned that water needs for livestock are twice those of humans in high altitude zones, nearly one half in middle altitude zones, and almost equal in valley areas (CSWCRTI1998). In Kabhrepalanchok, water demands of Bhramin and Chettri groups are more pronounced than those of the Tamang people, and this is mainly because of the agricultural and livestock practices in the different elevation zones occupied by these groups (Lohani and Banskota 1999).

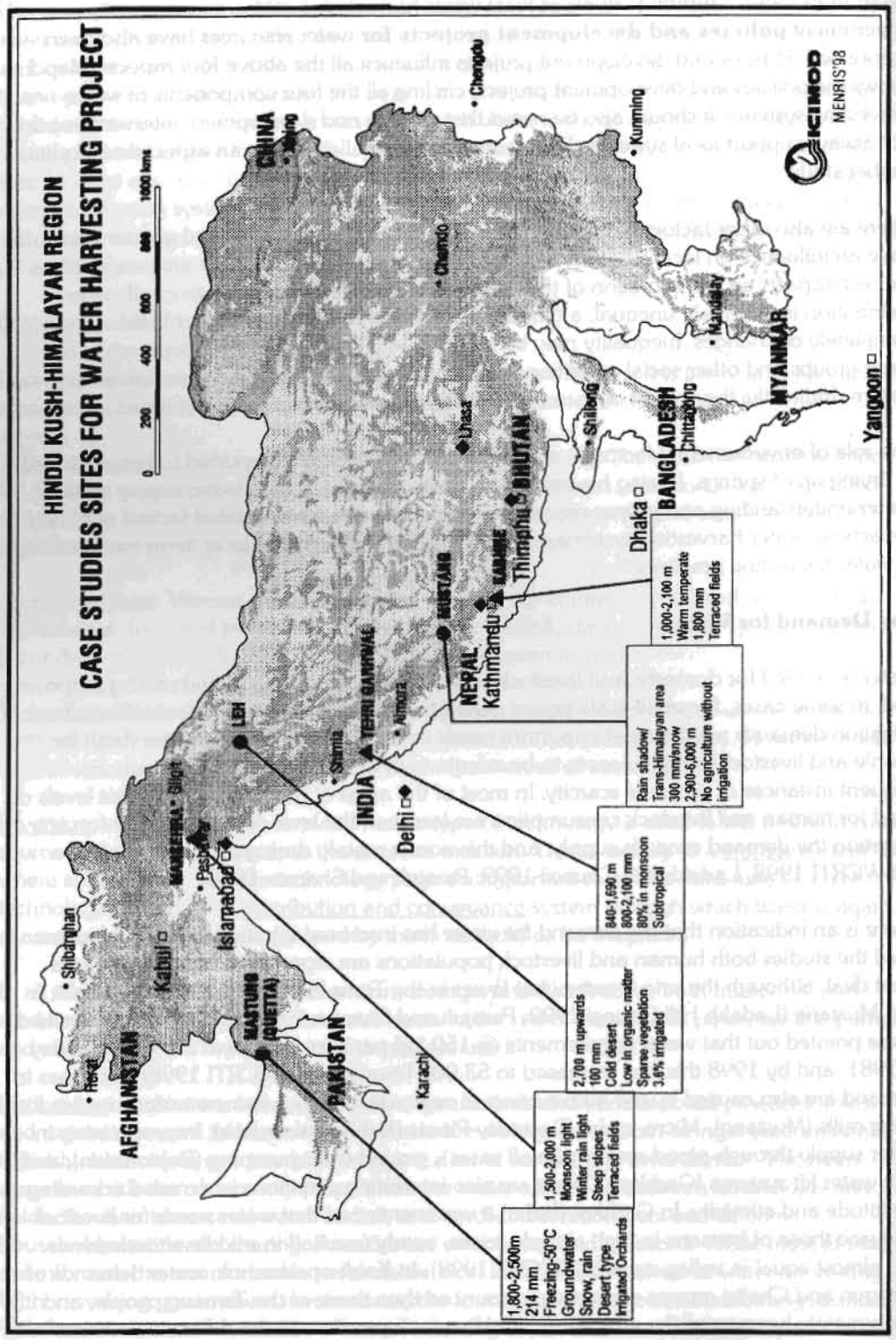

Figure 1: Case Study Sites for Water Harvesting Projects

Some of the main issues regarding water needs are outlined in the following passages.

- There has been a rapid increase in the demand for water for both drinking and irrigation, and it is expected to grow even more in future in all areas. Increases in human and livestock population, intensification of agriculture, and the introduction of new development activities are contributing to this surge in demand for fresh water in mountain areas.
- While there has been no absolute shortage of drinking water reported so far, apart from seasonal scarcity, households are already tapping multiple sources of water to meet the growing demand.
- The demand for water has varied by both elevation and ethnicity. This is a sensitive issue, as it is a potential source of conflict which will need attention in future.
- The case studies do not discuss the changing nature of household water needs by different purposes, and this is an area that needs looking into because efficient demand management will be an important component of future water-harvesting systems.
- All the case studies focus on rural areas. The urban areas present another scenario. Much of the future investment for water harvesting could be influenced by the needs of urban areas, although most water resources originate in rural areas. Equitable sharing of costs for harvesting water resources may be an important issue between rural and urban areas in future.

The Supply Side

Most water-harvesting systems are tapping different sources of local supply. In the areas covered by the case studies there are several sources of water.

Different Sources

Snowmelt is an important source of supply in Ladakh and Mustang and plays a role in Balochistan also. This source is only available during warm periods. It is interesting to note that there is a great deal of variability in water flow, both seasonally and on a daily basis. In Ladakh, the snowmelt of the day is collected and released only in the evening (Parajuli and Sharma1999). Other measures to harvest snow include snow fencing and moisture conservation. Snow fencing is achieved by building walls at right angles to the prevailing winds and this results in deposition of snow on the wall: a form of water conservation.

Rainfall is the next source of supply and is more important in the non-arid lower elevations; for example, the three watersheds of Tehri Garhwal in India, Kabhre in Nepal and Mansehra (NWFP) in Pakistan. The main issue in harvesting rainfall is runoff storage and safe disposal. Most of the time there is either **too little** rainfall or **too much** rainfall, indicating a high degree of variability. In Garhkot watershed, the average rainfall varies from 826 to 2,115 mm, 80 per cent is confined to the three months of the rainy season. The rolling topography and steep slopes result in rapid runoff (CSWCRTI 1998).

Springs were identified as sources of supply in all watersheds. Generally, spring water is stored in tanks and used as and where necessary. These appear to be very important in the watersheds located at lower altitudes. Local words used to describe springs are *dhara* (in Tehri Garhwal) and *mul* (in Kabhre and Garhwal).

Wells were also used in some watersheds. The word *kuwa* appears to be commonly used in Tehri Garhwal, Kabhre, and Mansehra for a well.

Streams and Rivers have been identified as a distinct category in all the case studies. One important point is that the streams and rivers used for local water-harvesting purposes are relatively small ones and not the bigger perennial rivers. The smaller rivers and streams are characterised by large fluctuations in water flow, being almost completely dry in the summer months before the rains. There is, therefore, acute seasonal water scarcity, while inaccessible rivers flow in deep valley bottoms. In the Tehri Garhwal case study it was indicated that the government is providing water from a lift-system by tapping one of these perennially flowing valley bottom rivers. As smaller water sources dry up or flows decrease, more costly and difficult options may become necessary and tapping bigger rivers might become inevitable if stronger conservation and protection of existing water bodies are not implemented along with more efficient harvesting systems.

Underground Water was a very important source for the case study area in Balochistan where lift-pumps are used to pump groundwater from fairly deep wells. There has been a history of using deeper and deeper wells for fresh water as the demand grew and sources closer by decreased. In other areas, wells are also a mechanism for collecting groundwater, but most of the wells were reported to be drying up; and this was the case in particular in Garhkot (India) and Kabhrepalanchok (Nepal).

Other sources of supply also include **'lakes, marshes, and oozings'**— reported only in Ladakh

Supply Side Issues

Use of Multiple Sources of Water— In the case study areas, all the communities were using most of the available sources of water for different requirements. In some, in spite of all these efforts, there were continuing problems because water supplies were insufficient. Given the likely scenario that demand for water will grow rapidly, supply constraints are going to be a major problem in the future. This raises important questions about new investments, increasing water charges to reflect the additional cost of water storage and supply, better demand management, and greater use-efficiency and reduction of waste.

Supply Bottlenecks — Supply problems have been identified in all cases. In Gharkhot (Tehri Garhwal, India) it was indicated that many water sources in the area had dried up during the past 20-30 years – forcing some villagers to abandon their old settlements and move to new locations (CSWCRTI 1998). In the same area, lack of fresh water from traditional sources has resulted in the government investing in a water-lift scheme for drinking water. In Balochistan, the amount of water available from tubewells is not sufficient and there is a continuing decrease in water tables, ranging from 10-12 ft annually in different areas (Mushtaq 1999). As accessible sources dry up or become inadequate, there will be great pressure for new investments in local water-supply systems.

Control of Water Sources and Access Rights — With increasing demand for water, there is evidence of growing conflict between different groups. First there are already differences in perception between government and local communities about water rights. In the Kabhre Case Study, it was pointed out that The Water Resources' Act 2049 (1992) had established that water is State Property and that, whereas individuals and communities would have

usufructory rights for various uses, the State could revoke these users' rights (Lohani and Banskota, 1999). Another source of conflict indicated by the authors is that certain external interventions had destroyed small local schemes operated by the people to carry out large-scale development work, resulting in dislocation of traditional systems (Lohani and Banskota 1999). At district level, the establishment of a separate Water Resources' Committee to adjudicate over water disputes is a new institutional development in the district (Lohani and Banskota 1999).

Similar developments have been indicated by the Indian Case Study from Tehri Garhwal. The State government enacted the Kumaon and Garhwal Water Act of 1975 which terminated the current and customary rights of individuals and village communities. The Act took away the jurisdiction of the local community over all water sources (CSWCRTI 1998). Fortunately, the Act has not made any difference to existing practices so far. If local systems need to be altered for different reasons, it could lead to difficulties in the future.

The other type of conflict is between communities. While most communities are willing to share their water resources with others (mainly those living downstream), there is a limit to this. In Mustang, water disputes have taken place over water for irrigating orchards and plantation trees, both of which have been established through relatively new activities in the area (Parajuli and Sharma 1998). Another dispute reported in the Mustang Case Study was in relation to external support for improving the water conveyance system to one village which resulted in diverting more water than was the custom traditionally. The dispute was registered with the district administration and resulted in suspension of all external support to this project (Parajuli and Sharma 1998).

Watershed Conditions and Depletion of Water Sources — Deterioration in watershed conditions caused by increased deforestation and cultivation and the resulting soil erosion has dried up many springs and wells. With reduced vegetation there is increased runoff and limited groundwater recharge. Open grazing has also been a problem as it has resulted in reduction of vegetation from sloping areas. While some of the case study areas have responded by banning the cutting of trees and introducing improved watershed management activities, in many areas the problems continue. As older systems fail on account of these environmental problems, communities look to governments to provide new water supply systems.

Poor Maintenance — In the past villagers jointly undertook the cleaning and repair of local water-harvesting systems. Those unable to work provided hired labour while people like widows and the handicapped were exempt from contributions. The government played no role in the operation and maintenance of these systems. Many of the systems even had paid watchmen to look after them. Recently traditional systems have begun to break down. As new systems are provided by the government, there is little interest in upkeep of the older ones. In other instances, the effort needed to make the system functional is simply too great for the community.

Water Harvesting Technologies

The technologies for water harvesting are as varied as the communities throughout these mountains. Most communities have provided their own unique touch to technologies that perform functions of water diversion, conveyance, and storage.

Technologies for Diverting and Tapping Water

Technologies for diverting and tapping water range from simple rock and boulder structures to check dams. In most cases, all or a part of the river or stream is blocked and water is diverted to different canals. The flow is regulated by the use of locally fabricated valves for closing and opening. In the case of groundwater, tubewells or lift pumps bring the underground water to the surface. In Balochistan an intricate system of '*karez*' has been developed as underground channels for transporting water for irrigation in a very arid region (Hafez1998).

Storage Technology

Storage technologies include natural and man-made tanks and tank-like structures designed for storing water for some period of time. The release of water from these tanks is generally regulated by the use of simple opening and closing devices. In Ladakh tanks are called *zing*, whereas in Mustang they are known as *ching*. In Tehri Garhwal, water storage tanks are referred to as *naula* and *hauzi* (a tank for animals). As mentioned earlier, *kuwa* refers to shallow wells found in all the warmer watersheds. Use of shallow wells has also been reported in Mansehra district.

It should also be noted that water in the fields is also stored by means of simple structures, especially when fields need to be flooded. There are also storage systems using various types of tanks and pots for collecting and storing water in the house.

Distribution Technologies

In most cases, distribution technologies are based on a series of canals that carry water to the different fields and homes. This is where one finds complex institutional mechanisms that regulate the flow of water along these canals during critical planting periods. The physical aspects are relatively simple, although the use of cement and pipes to make these systems more permanent has increased. However, the amount of water that goes to the field during planting season is a socially-determined process. This process becomes more elaborate with increasing scarcity of water as seen in the arid zones of the Trans-Himalayan areas. In some of the areas (reported in Mansehra) wooden channels are also used to distribute water.

In Situ Water Storage and Harvesting

In all cases one finds many references to technologies used for *in situ* water storage, water distribution, and control of runoff (Khan 1998; Hafez1998;Ladakh Hill Council 1999; Lohani and Banskota 1999; Parajuli and Sharma 1998; SHERPA 1996). These are as follow.

- Level terracing helps to retain rainfall and control runoff. The length of terraces depends upon slope and soil structure.
- Field bunds built of earth or stone to hold water in the fields for a period of time.
- Earthen ponds are used as drinking water sources for livestock.
- Afforestation is important for improving the overall water supply in the watershed.
- Roof-top rainwater harvesting during the rainy season is becoming popular.
- Modern Piped Water Supply Systems

In all the case study areas, some of the population is benefitting from modern piped water supply systems, although their numbers appear to be relatively small. This is seen as the future alternative to local water-harvesting systems.

Some of the main points regarding changes in technology are as follow.

- Traditional technologies are based on local resources and cost little to maintain and manage. However, they are labour intensive, and it is becoming more and more difficult to mobilise adequate labour at the time when and in the place where it is needed. There are many reasons for this labour problem: outmigration of men for jobs outside the area, breakdown in traditional patterns of control over land resources, different individual priorities, and access to alternative water sources are among them.
- Introduction of and expansion in modern technologies are constrained primarily by the lack of resources. Although, as the Nepal case study points out (Lohani and Banskota 1999), the need to mobilise local resources and become financially viable is recognised, this is not seen in practice. There is, at present, great dependency on outside support and subsidies for the use and expansion of modern systems of water harvesting.

Institutional Dimensions

The organizations, both formal and informal, responsible for the management of water-harvesting systems vary significantly, some have over a hundred years of history while others have only recently been introduced. There are examples of individual, community, private, and government systems (Uphoff 1992).

Types of Organizational System

Individual Ownership/Private System —The highlight of this system is that the individual has complete freedom to use the water in any way she/he desires. Obviously, she/ he has to make all the investments needed to operate the water-supply system. This type of system was reported in both the case studies from Pakistan. In the case of Balochistan,installation of deep tubewells for irrigation of one's land is an entirely private decision (Mushtaq 1999). It is less apparent in Mansehra, although even there the person who has the access to water appears to be under no obligation whatsoever to share it with others (Khan 1998). There is some community participation for maintenance, but this appears to be more a case of mobilisation by water-controlling households. There are no apparent water benefits that induce the community to participate.

Informal Working Arrangements at Community Level — Under this arrangement, households do not have a regularly working community organization but have instead agreed to an informal working arrangement which is visible and activated whenever there is a task to be fulfilled. Working rules are well known and accepted by the community. Everyone is willing to abide by them even without a formal organization to oversee them. If and when there is a problem, the community organization is quickly activated and acquires the legitimacy of a formal organization. This type of organizational set-up was reported on in Tehri Garhwal and Kabhre district in Nepal for traditional irrigation systems (CSWCRTI 1998; Lohani and Banskota 1999).

In Tehri Garhwal there is a roster that identifies the water requirements of different households and areas. This has been worked out on the basis of land holdings in the 1940s.

This system is still followed today (CSWCRTI 1998). Within each group, the redistribution of water is another separate issue. In Kabhre also one finds informal committees deciding about water sharing in older irrigation systems, but there are no written rules (Lohani and Banskota 1999).

Control Community and Management — In the case of community control and management there is a formal, local organization with different positions and responsibilities for the management of water resources for irrigation. This is seen in both Ladakh and Mustang where fairly elaborate sets of rules (written in the case of Mustang) have been laid down on almost all aspects of irrigation. Rules deal with with the date of commencement of water harvesting, the selection of different office bearers and their duties and responsibilities, entitlement to shares of water, and the role of different households (Ladakh Hill Council 1999; Parajuli and Sharma 1998). A *gempa* (a small group of people) heads village organizations and provides the overall leadership for all social, agricultural, and development activities such as water management in the village. The *gempa* is also subject to many rules to ensure accountability and proper management (Parajuli and Sharma 1998). In Ladakh, the *Pabchu* system has been described in detail as the process by which a village without access to a water source receives water for a certain period in the critical growing season according to clearly set out rules and norms (Ladakh Hill Council 1999). There are some areas that have no right to any water from streams because they have access to water from alternative sources such as springs and marshes. In order to provide legitimacy to the system, it was well integrated with both religious activities and political power. The overall organization appears to be similar in Mustang. The extensive role of the community organization is to ensure adequate irrigation of all lands in the village during critical planting periods. Election of office bearers and their role in ensuring proper water distribution according to water shares are complex arrangements. In both cases, the systems in place appear to be fairly rigid because of the need to distribute water quickly over a very short planting period. It should be noted that these community organizations are not considered official or legally recognised by the government, as they are not registered with the government as per the set rules and regulations. In Mustang it was reported that, in order to receive local governments funds, some of these local organizations have registered themselves as water user groups (Parajuli and Sharma 1998).

Formal Local Organizations — This is clearly a new trend. Local project activities are using beneficiary organizations and user groups as mechanisms. This kind of organization has been reported in all the case studies, but references are found most in the Kabhre case study. Water projects are undertaken as an offspin by separate organizations established for irrigation and micro-hydro projects (Lohani and Banskota1999). In Tehri also there is a movement to promote water-user societies (CSWCRTI 1998). The Balochistan case study also reported that some development projects had started to work with beneficiary organizations for water harvesting (Mushtaq 1999).

Local Government — Local governments have also been active in improving local water-harvesting systems. However, this appears to be fairly limited. In the Tehri Garhwal case the head of the local government becomes a *de facto* contractor for most government projects at the local level for the area under his jurisdiction (CSWCRTI 1998).

Provincial or State Government — Provincial governments (state/county level) are also involved in bigger water-supply systems over areas under their jurisdiction: examples being groundwater supplies in Balochistan and lift–water supplies in Tehri Garhwal.

Water Allocation System

One of the main responsibilities of the organizations managing local water-harvesting activities is the implementation of an agreed system of water allocation. In the case studies, different systems of water allocation have been described. Allocation takes place primarily when the main crop is being planted.

Water Shares Based on Land Holdings — In many cases, water shares were based on land holdings. The total land holdings were divided into a certain number of water shares. The time needed to irrigate all the land was determined by dividing the number of water shares by the number of days the water was to be allocated on a daily basis. Daily water shares were estimated and water was allocated accordingly. Within each share it was again redistributed according to the convenience for irrigation. Water shares were determined according to land holdings called *thok* in Teri Garhwal (CSWCRTI 1998). Each water share corresponding to a certain amount of land holding, was referred to as *chyure* in Mustang (Parajuli and Sharma 1998) .

Water Allocation According to Tanks — In Ladakh, water was allocated under the *pabchu* system of tanks or *zings* (Khan 1998; Ladakh Hill Council 1999). It was sealed in the evenings and the water was allowed to collect. The next day it was released for irrigation on a turn by turn basis. All the water bodies were closely watched by different households during the critical sowing period so that no rules were breached.

Prior Appropriation — Prior appropriation was also commonly reported, although certain agreements had been in place for a long time and these were observed by the community.

Private Ownership —The most clear-cut case of private ownership was for groundwater harvesting in which lift pumps were used to supply water to the orchards. The water pumped out by the households from their land was considered their property.

User Groups and User Fees — User groups and user fees were new developments reported in Nepal. A new irrigation project had established a user group and had also stipulated the fees to be paid for using the water for irrigation. In a way, the fee reflected the amount of water one was authorised to use and is a growing practice in local irrigation systems (Pushpandagan and Murugan 1998).

Conflicts

Several conflicts are pointed out by the case studies, and these were in relation to (i) water appropriation among riparian parties and (ii) the sharing of costs for development and maintenance. The case studies have pointed out that the conflicts were eventually resolved. In one instance, the conflict was resolved after the government project paid the full cost of the project. In another, the dispute remained unresolved and the project had more or less closed down.

Maintenance

Traditionally, maintenance has remained an important responsibility of the organization responsible for water harvesting. It should be noted that all the case studies indicated major breakdowns in many traditional irrigation channels, tanks, wells, ponds, and diversion

structures. This is a new development indicating that local water-harvesting systems and their structures, in spite of their critical importance for daily survival as well as for agriculture, are facing problems. Some of the reasons for this breakdown are environmental, others are socioeconomic and institutional. While there is some progress in terms of introducing new water-harvesting systems through different government programmes, the role of local water-harvesting systems is still very important (Uphoff 1992). Increasing breakdown in local water-harvesting systems has serious and far-reaching implications for local food supplies and agriculture in mountain areas.

Water Policies and Development Interventions

Despite all the positive intentions of most water-related policies, all the case studies stressed that there is no recognition of the customary rights of the community in the use of water. In both the Tehri Garhwal case and the two cases from Nepal, it was mentioned that new water policies had explicitly identified that water was the property of the state. This gives the state the right to revoke user rights whenever necessary (CSWCRTI 1998; Ladakh Hill Council 1998; Lohani and Banskota 1999; Parajuli and Sharma 1998).

Fortunately this has not been implemented to the letter. There are other provisions in the Acts that permit the devolution of water management authority to local water user groups. However, even here the Acts fail to recognise those traditional bodies not formally registered with the authorities, thus creating problems for many traditional groups in the context of access to critically needed resources (CSWCRTI 1998; Ladakh Hill Council 1999).

In the Pakistan case study, water policies relevant to local water harvesting were not identified, apart from groundwater pumping for which there is a law that prohibits the installation of pumps within specific limits. It is pointed out that this law is not followed simply because it is difficult to administer (Mushtaq 1999

There are a number of other problems identified by the Nepal case studies in relation to local contributions and subsidies. The policies stipulate that a certain percentage should be contributed by the local people. This is, however, observed only by government departments. INGOs implementing water projects have provided full subsidies with no local contributions for water projects (Ladakh Hill Council 1999; Lohani and Banskota 1999).

Productivity

As water is a basic human need, supplies of clean drinking water are important for the overall health of the people. Water-borne diseases are the most serious problem in most rural mountain areas in the HKH. Such diseases are responsible not only for poor health but also for the high rates of infant mortality. Adequate measures need to be taken to guarantee safe drinking water.

In the case studies there were several references to the use of polluted water. There was also one case in which a high level of nitrates was found in the water (CSWCRTI 1998).

With regard to the impact of irrigation on agriculture, discussion is limited. Details for on-farm impacts of irrigation are available but not specifically for mountain areas (Chaudhry 1994). First, in three of the case study sites, there can be no agriculture without irrigation because of the arid, desert-like conditions. In Ladakh the irrigation system supports

traditional crops with fairly low productivity and needs to be supported by more research. The case study from Kabhre points out that cropping intensity with irrigation can reach 300 per cent, whereas without irrigation it is only 125 per cent (Lohani and Banskota 1999). In the Mansehra case study, one finds that the farms that have water grow rice and wheat whereas those without grow maize (Khan 1998). Although the precise impact on productivity is not discussed, the case studies indicate that reliable and adequate irrigation systems are crucial for agricultural development and reduction of poverty in mountain areas (MOWR/DOI 1996).

Equity Aspects

Information about equity aspects is quite circumstantial. First, as discussed under productivity, there is a substantial difference in cropping intensity between farms with and without water. Second, although upstream farmers have prior appropriation rights, sometimes this is carried too far and downstream farmers are forced to leave their fields fallow (Khan 1998). In Ladakh and Mustang, where water scarcity is greater than in other areas, greater attention appears to be given to equity aspects than in the other systems. In Ladakh, a water official or *churpun* is appointed to ensure that no fields are left unirrigated (Ladakh Hill Council 1999). Similarly, in Mustang the water shares are distributed in such a manner that all have access to some water for irrigation (Parajuli and Sharma1999). In the case study from Tehri Garhwal, equity problems were raised with respect to certain social groups and tail-enders. Because water distribution follows land-ownership pattern, there is an inbuilt inequality in the distribution of water. Development projects may also contribute to the growing inequality by concentrating development activities in lowland areas. This has been reported in the case from Kabhre (Lohani and Banskota1999).

Gender Dimensions

According to the case studies, women are responsible for fetching drinking water for both the household and the livestock (Khan 1998; Ladakh Hill Council 1999; Lohani and Banskota 1999; Parajuli and Sharma 1998). This has been referred to as 'soft' work in one of the case studies (CSWCRTI 1998). Another interesting point raised by the Mustang case study is that women work with the head of the animal (inside the house) while men work with the tail (outside the house) (Parajuli and Sharma 1998). It has been recognised that fetching water is difficult work, and even more so in mountain areas. Further details on gender aspects are missing, although most of the case studies have pointed out that currently there is no decision-making role for women in the management of local water-harvesting systems.

Environmental Aspects

The case studies point to the increasing deterioration of the environment and relate it to the depletion of water resources. In the case from Balochistan, there is a reference to denudation of forests and ranges leading to desertification and abandonment of farmlands (Mushtaq 1999). The Mansehra case study refers to deforestation and a decrease in the supply of spring water (Khan 1998).

Ladakh presents a somewhat different picture of community activities with a strong harmony with nature reinforced by social, cultural, and religious practices. Water sources are not only protected but also revered. Notwithstanding, there are many rapid socioeconomic

changes that are undermining some of these strong pro-environmental value systems (Khan 1998).

In Tehri Garhwal, the tradition of protecting springs and treating them with different medicinal herbs is falling out of practice. High levels of nitrate in the water caused by the uncontrolled use of chemical fertilizers are reported (CSWCRTI 1998).

There are strong indications that loss of forests has led to a decrease in water supplies. The communities also seem to understand this quite well, although their responses appear to be limited.

CONCLUSIONS

Common issues emerge from discussion of local water-harvesting systems in the different case study areas. All of these issues may not be equally relevant in all cases, but they nevertheless are valid to some extent. Improvement in local water-harvesting systems can be brought about by either upgrading existing systems or introducing new systems; and this is already the case in many instances. However the pace of expansion of modern, government-supported technologies (such as groundwater lift pumps) for water-harvesting systems is quite slow and represents a relatively small proportion of the total systems in operation: this is the situation in spite of the growing commitments to improve water-harvesting systems in the countries concerned. The implication on resources of replacing traditional community or individual water-harvesting systems with modern ones is important and replacement also seems somewhat unrealistic. The best option is to place equal emphasis on improving existing practices and provide new ones wherever feasible. At a time when water scarcity is compelling societies to change their past notions of water as a free good, failure to take advantage of the vast local resources mobilised by the community to develop water-harvesting systems would be an unfortunate wastage of resources. It is in this context that priorities have been identified.

Strengthen Local Water-harvesting Organizations

Barring a few cases, most local water-harvesting systems are based upon community organizations. These are organizations of the water users themselves, and it is this ownership factor that has sustained these systems in the past (Uphoff 1992). In view of the changes in the socioeconomic conditions, both local and non-local, some older systems are beginning to fall apart. Because of this, there is an increasing tendency to depend less and less on community management and look after one's needs and requirements through new investments in different technologies and other arrangements. As long as water is plentiful, there may be room for individual adjustments but, over time, this will become more difficult as water scarcity increases. With increasing socioeconomic change the need for water will grow very rapidly along with the growth in population. Clearly, unless the local community steps in, there will be no workable solutions. At the same time, the present needs cannot be managed by very loose types of local organization. Organizations have to be capable of handling funds, hiring staff, allocating water efficiently and fairly, enforcing rules and regulations, and becoming involved in many other tasks that take a great deal of effort. In the example from Kabhrepalanchok in Nepal, the efforts made to strengthen local organization for the management of the hydroelectric project is a good example of the type of effort needed. In this project local people are enabled to make decisions about every aspect of project planning, implementation and operation, and fund raising by themselves.

Motivators have been attached to the community and its various groups to work on different aspects. The guiding principles of the project are based on organizing the local beneficiaries, encouraging savings, developing skills, encouraging women's participation, and protecting the environment (Lohani and Banskota 1999). It may not be possible to have the same intensity of focus as the above project when it comes to dealing with many local water-harvesting systems. It is important to emphasise that traditional community-based resources have many positive components, and these need to be adapted and improved to meet the new realities on the ground. If left to themselves, organizations may be unable to cope with the new challenges thrust upon them by outside forces.

The Changing Role of Government

In the past there has been a tendency for the government to operate in parallel to local systems, giving priority to modern, externally supported technology and inadequate attention to the management and financing aspects. While this may be changing to some extent with the increased emphasis on participatory approaches and the need for local co-financing, governments often choose to undertake new activities rather than improving old ones. Clearly, given the rising demand for water, many new projects on water harvesting will be needed, but these should not be undertaken at the cost of existing systems. As a matter of fact, by building on existing systems, one could provide more extensive coverage with strong community support. In order to move in this direction many changes are needed in existing rules, operational practices, and other areas to enable the government and the community to work together. Unless this becomes a deliberate policy, the present dichotomy will continue with the local communities unwilling to participate in activities that have been imposed upon them from outside. In the long run, this will result in a waste of scarce resources, benefitting no one. The specific areas in which changes are needed so that the government and the community can work together to improve local water-harvesting systems will vary from area to area and need to be studied more carefully.

Improving Environmental Management and Preventing Loss and Damage to Renewable Natural Resources

Environmental change has been singled out in many of the case studies as an important reason for the breakdown of local water-harvesting systems. Deforestation is probably the most common reason given for the drying up of streams, springs, and wells. Increasing soil erosion and landslides have also disrupted local water-harvesting systems, and the community has found it very difficult to reinstate them. Natural factors, such as powerful earthquakes that result in landslides and debris flows, disturb water sources. While it will not be possible to cope with some of the bigger natural events, there are many things communities can do and have done in the past to protect and manage water sources and water-harvesting systems. Vegetation cover, land-use management, slope stabilisation measures, and river and stream embankment protection are some of the past practices and need to be emphasised and supported. A critical problem is that most of these activities are labour intensive and local labour is not as easily available or as interested in doing unpaid or community work as in the past. In many areas like the cold deserts, mobilising labour has been quite difficult. Conservation of natural resources and environmental management have to also be taken into consideration as economically rewarding activities so that people start making investments in these areas. This raises important questions about resources for these activities and we need to look at beneficiary issues and pricing mechanisms carefully.

Appropriate Technology

Questions of appropriateness have been raised with respect to both existing and modern technologies for local water harvesting. In traditional systems, the low level of efficiency has been the main problem. Frequent breakdowns, leakages, and inadequacy of control mechanisms were certainly not such big disadvantages in earlier times when the demand for water was low and labour was plentiful. Now, at a time when every drop of water is needed, improvements are essential. With simple interventions, such as plastic pipes to replace open channels, it has been possible to increase water supplies and prevent leakages. At all points in the water-harvesting continuum, it is possible to think of improvements, and these need to be looked at closely. Insofar as modern systems are concerned, the principal problems are costs and management. If local people had to pay for systems that are over-designed and capital intensive; that require sophisticated skills to handle and operate; and, most importantly, lack adequate maintenance back-up, they would be unaffordable. Appropriate technology is a location-specific issue, and it is difficult to generalise in terms of the main areas in which improvements are needed. An hour with the local people can result in identifying many of these problems and gaps. Consultation with the people should not be restricted to identifying the problem. They should also be involved in working out the solutions. Sometimes new developments in different areas may be unknown to local people and here outsiders could have a role in soliciting their assessment about the appropriateness of these technologies. This continues to be an important area in spite of all the work that has been done and which is still in process.

Demand Management

This is probably the most difficult area for the future and will also be one of the most critical issues in the management of water resources. It is not true that rural people do not understand the scarcity value of water. Already, in many areas, people spend long hours every day fetching limited amounts of water. The *pabchu* and *chuyre* systems seen in the Trans-Himalayan areas are beautiful examples of community regulated systems of water distribution.The amount of water one gets for irrigation is based on water shares that have been worked out and which are well accepted. In other areas also there are fairly clear notions of water distribution based upon assessment of needs. All of this applies primarily to the irrigation of the main food crop. With increasing diversion of irrigation for new activities, such as horticulture, tree planting on private lands, and others whose benefits are not community wide, there is reluctance to participate. There is also the problem of industrial and downstream demands for water and, in most instances, these actors have not made any investment in the water harvesting system. As users and demands diversify, the complexity and the conflicts are likely to multiply and a system for demand management by all parties concerned will be needed so that water is not misused.

There are many aspects to demand management. The experience so far in urban areas with measuring and pricing the use of water has not proved to be very successful, as the concept of paying for basic uses of water is still not accepted. At the same time, private supply of water to those that can afford it has been increasing, and the question here is whether or not the price of water reflects its scarcity value. Differentiation of demand by type of need and use of water is not going to be easy and yet, without concerted efforts to do so, the scenario for fresh water supplies and the sustainability of local water-harvesting systems look quite bleak.

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