Chapter 5
Water Harvesting Policies in Mountain Areas of Pakistan

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

1. Introduction

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

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

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

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

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

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

Physical characteristics

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

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

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

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

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

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

Socioeconomic conditions

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

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

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

Source: IIED 1998

2. WATER HARVESTING PROGRAMMES IN PAKISTAN

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

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

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

The rod kohi water-harvesting system of Southern NWFP

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

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

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

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

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

Advantages and disadvantages of the Rod Kohi System

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

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

Water harvesting in Northern Balochistan

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

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

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

Water sources and need for rain water harvesting

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

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

Water-harvesting system for rainfed farming in Pishin

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

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

3. POLICIES THAT INFLUENCE WATER HARVESTING AT LOCAL LEVEL

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

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

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

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

Deforestation and water supplies

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

New farming systems and demand for water

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

Subsidies and water resources

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

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

Research policy and water harvesting

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

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

Watershed management

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

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

1. Steeply Sloping Land
- 1.1 Erosion Protection
- 1.2 Forestry Plantations on eyebrow and reverse terraces
- 1.3 Range Development

2. Gently Sloping Land
- 2.1 Contour Terracing
- 2.2 Waterways grassed to control flow
- 2.3 Pasture Development

3. Terraced Land
- 3.1 Field levelling (level or graded)
- 3.2 Improvements to field bunds
- 3.3 Field spillways and waterways
- 3.4 Ridge and furrows or contour furrows
- 3.5 Improved tillage practices
- 3.6 Development of micro-catchments (where annual rainfall is less than 750 mm)
- 3.7 Improved farming systems--including development of rotations, improved varieties and others.

4. Rainfall Regimes

Annual rainfall:

< 250 mm	} Developed micro-catchments:
250-500 mm	} in field-field-hill runoff-alternate
500-750 mm	}
> 750 mm	No additional catchment required.

5. Eroded Land-Gullied
- 5.1 Check structures and other erosion protection structures

6. Small Streams
- 6.1 Diversion weirs and channels
- 6.2 Check dams for storage

7. Depressions
- 7.1 Storage ponds
- 7.2 Reservoirs
- 7.3 Check dams

Source: Information from the Government of Pakistan

4. INSTITUTIONS INVOLVED IN WATER HARVESTING

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

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

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

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

5. Recommendations for Future Action

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

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

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

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

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

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

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

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

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

(million hectares)

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

Source: Economic Survey 1997-98,pp 62

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

(millimetres)

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

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

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

(million acre feet)

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

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

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

Government Agencies

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

International Agencies

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

Private Sector

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

Non-Government Organisations (NGOs)

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

International NGOs

1. Action Aid-Pakistan

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

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

Source: Pakistan National Conservation Strategy (Table 2.9)