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Drought Mitigation in Pakistan: Current Status and Options for Future Strategies

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International Water Management Institute

FUTURE HARVEST
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Executive Summary

Droughts are typical in Pakistan as in most of southwest Asia and continue causing multiple adverse impacts. This study is a part of the Regional Project on "Drought Assessment and Potential for Mitigation in Southwest Asia," which is being implemented by IWMI in collaboration with regional partners and which is aimed to review the current status of drought-related issues and measures in Pakistan. This paper reviews factors affecting, or associated with, droughts, focusing on the target areas (Baluchistan and Sindh provinces), identifying gaps in the institutional and policy arenas with recommendations for remedial measures, providing analyses of coping strategies adopted by stakeholders in mitigating droughts, and documenting lessons gained during previous drought cycles.

Pakistan frequently experiences several droughts. The Punjab province experienced the worst droughts in 1899, 1920 and 1935. The North-West Frontier Province (NWFP) experienced the worst droughts in 1902 and 1951, while Sindh had its worst droughts in 1871, 1881, 1899, 1931, 1947 and 1999. The most severe droughts at the national scale were perhaps the most recent, which occurred in 1999–2000 prolonging up to 2002. The rainfall is erratic and river flows have dropped. Water in the Tarbela dam reaches the dead level in late February or early March almost every year. The current live reservoir capacity in the Indus basin has been reduced due to siltation. The recent drought has also exposed the vulnerability of the Indus basin irrigation system and environmental issues in deltaic areas.

Agricultural growth suffered a severe setback during 2000–2001 as a result of drought. While major crops registered a negative growth of almost 10%, the overall agriculture recorded a negative growth of 2.6%. The drought persisted throughout 2001–2002, resulting in water shortage of up to 51% of normal supplies as against 40% of the previous year. The total flows of water in major rivers also declined to 109 billion m^3 against an average of 162 billion m^3. Rainfall has also been below normal. The canal head withdrawals have also witnessed significant decline. Notwithstanding severe water shortages, the farmers in Pakistan undertook various measures to minimize their adverse effects. These include judicious use of water, exploitation of groundwater, purchase of water from tube wells, improvements in cultural practices, and better overall management. As a result, overall agriculture registered a positive growth of 1.4% in 2001–2002 as against a decline of 2.6% during 2000–2001. Droughts have also affected the performance of nonagriculture sectors. Pakistan's nonagricultural GDP growth remained stable at around 4.3% in 2001–2002. Therefore, when adjusted for drought impact, the real GDP is provisionally estimated to grow by 4.7% against 5.2% in 2000–2001. The slower growth in real GDP over these 2 years was caused by drought. If there had been no drought, Pakistan's economic growth would have been 5%.

Water harvesting, management and use are common practices for drinking or farming either directly harvesting the runoff or by storing it in small surface and subsurface reservoirs. The stored water is used for supplemental irrigation and other consumptive uses. In nonirrigated areas, the majority of farmers are still practicing traditional water-harvesting systems, *sailaba* or spate irrigation and *khushkhaba* or runoff farming. These harvesting systems were adversely affected by the introduction of new technological interventions (like deep tube wells) and by recurring droughts.

The descriptive information on traditional and new technological interventions is available, but there is a complete *gap of quantitative knowledge* on how the new technologies have affected the traditional and sustainable interventions like *karezes*. There is hardly any information available regarding the impact of new technologies on lowering of the water table and mining of groundwater in Baluchistan. Similar impacts were observed in the arid zones of the Sindh province, where indiscriminate use of groundwater using deep tube wells led to drying up of the shallow dug-wells

and intrusion of saline water. There is a unique opportunity in Baluchistan to document the impacts of deep tube-well technology on the drying of karezes, resulting in shifting the benefits of electricity tariff subsidy to the resource-rich farmers. Baluchistan provides a unique opportunity to the *Region* in the assessment of the impacts of new technologies on the karez system. A comprehensive research study is needed to address this issue in a scientific manner.

The institutional arrangements are reasonably well defined for the drought-relief activities, but there is hardly any institutional mechanism for drought preparedness and mitigation to address the long-term issues. The *strategy* for technological development in Baluchistan and arid areas of Sindh should be based on the *assessment of the potential resources available for development through integrating activities of spate irrigation with the objective of spreading of floodwater to increase the command area and recharging the regional groundwater resources.*

The study conclusions and recommendations are:

- The *existing system* of *monitoring drought* and its *impacts* on various sectors is weak. There is a need to develop a *policy for access to information* related to drought and water management. Such information databases themselves are limited at present. A similar situation exists at the *regional level.* Sharing and exchange of information regarding drought monitoring and impact assessment are also limited among the countries of the region. India is ahead in this regard and Pakistan can learn from the Indian experiences. Similarly, exchange of information and building joint programs between Pakistan and Iran would help the two countries.

- Farmers are not aware of actual crop water requirements, and irrigation-scheduling practices are still largely based on the amount of water available with the farmer and the situation of the farm. Farmers tend to *overirrigate* to cover the unleveled fields. Efforts are needed to help farmers in efficient conveyance and application of pumped groundwater. The *water-management technologies* developed in the Indus basin regarding conveyance and application of water at the farm are very promising, as Pakistan was ahead of the countries in the region. Even then such technologies were hardly tested and adapted in the drought-prone areas.

- Pakistan can provide a unique opportunity to share the experiences of the watercourse improvement program, laser leveling, furrow-bed irrigation, skimming wells and salinity management. Reciprocally, Pakistan can learn from India and Iran in the area of drip and sprinkler irrigation systems as both these countries are ahead in this regard. A *regional research and development program* for drought and water management seems justified for exchange of experiences and knowledge and to build future activities.

- Farmers should be encouraged and motivated to use indigenous water-harvesting technologies for *sailaba* (spate irrigation) and *khushkhaba* (localized runoff farming) areas. These systems of *water spreading* if *integrated with recharging the groundwater* can provide cost-effective interventions for mitigating the drought impacts.

- Due to the excessive *exploitation of groundwater* coupled with the successive *drought,* water tables in different parts of Sindh and especially in Baluchistan have considerably declined. Communities should be directly involved in the campaign of recharging the aquifers and in the *conjunctive use and management* of surface water and groundwater resources. Pakistan's Indus basin experiences of conjunctive use of water have to be used and adapted in the drought-prone areas of Baluchistan and Sindh provinces. Such experiences if translated to the nonirrigated areas can provide an excellent opportunity for the countries of the region.

- *Efficient irrigation methods, farm layout, balanced use of fertilizer and pesticides,* and integrated nutrient management remain limited and are the key factors underlying low productivity in Sindh and Baluchistan. The productivity of agriculture and livelihoods of communities are dependent on the availability of the right type of tools, which can extract water from larger depths.

- Farmers should be encouraged, motivated and trained in the adoption of *efficient water-use technologies,* such as sprinkler and drip irrigation, laser leveling, raised-bed planting, rainwater harvesting, watercourse lining and water-storage tanks, which have proven successful in different arid environments of Pakistan. The experiences of India and Iran are available for other countries of the region.

- Presently, there is no comprehensive *drought-mitigation infrastructure and strategy* at the federal and provincial levels. Institutional arrangements and their capacities are inadequate at the federal and provincial levels to effectively launch the early warning systems, preparedness and contingency plans, and rehabilitation measures, while such arrangements are nonexistent at the district level. In fact, this is the weakest area in the region as a whole. This justifies *a regional initiative* to evaluate the existing institutional setups and mechanisms for drought mitigation and build an effective structure and mechanisms, which can be adopted by the countries of the region. A collaborative effort is needed in the region with the active involvement of IWMI.

- For formulation and *implementation of the National Drought Policy,* there is a need to *establish an apex organization* for the planning, coordination and monitoring of the policy interventions at the federal level. This organization may be entrusted with the responsibility for providing an enabling framework to the provincial governments, where they are motivated to establish a similar organizational setup at the provincial levels to provide linkages and coordination among the line departments and the district governments.

Introduction

Droughts are some of the most complex natural disasters, and are difficult to predict and mitigate due to a number of factors involved, lack of precise information on many drought-related issues, difficulties in defining a drought (its start, end and magnitude), etc. The spatial and temporal characterization and assessment of a drought are only meaningful if they are integrated with the socioeconomic indicators. The lack of integrating socioeconomics with the hydrometeorology of droughts is one major limitation of the work already done in this area. The other important aspect is that a drought must be seen from the end of impacts and mitigation measures while developing drought-characterization-assessment approaches. These impacts will also vary in space and time due to regional variability.

Droughts are typical in Pakistan as in most of southwest Asia and continue to cause multiple adverse impacts. To design successful anti-drought measures, the current state of the art in drought assessment and management in countries of the region must be first critically analyzed and gaps identified. This study is a part of the Regional Project on "Drought Assessment and Potential for Mitigation in Southwest Asia," being implemented by IWMI in collaboration with partners in the region. The project is funded by the US Department of State, and has a focus on Afghanistan, India and Pakistan. The entire project is designed to examine the multiplicity of drought-related issues in the region and is intended as a "survey," to prepare the ground for a large-scale drought research and action program in the countries of the region. This particular study is aimed to review the current status of drought-related issues and measures in Pakistan. It is also supplemented by the socioeconomic survey, conducted jointly by IWMI and Pakistan Agricultural Research Council (PARC) in the provinces of Sindh and Baluchistan (the results of the survey are presented in a different report).

The Baluchistan and Sindh provinces are selected as target areas in Pakistan, as a start, but the study also addresses issues of national importance. This paper reviews factors affecting or associated with droughts, focusing on the target areas, identifying gaps in the institutional and policy arenas with recommendations for remedial measures, providing analyses of coping strategies adopted by various stakeholders in mitigating droughts, and documenting lessons gained during previous drought cycles.

More specifically, the study focuses on two groups of issues: technological interventions to combat droughts and institutional arrangements and policies for managing droughts in Pakistan. The first group includes issues like traditional water-conservation methods in target areas and their effectiveness during droughts, new technological measures proposed and the extent of their implementation, prospects for such interventions in target areas for the future in the short and long-term, etc.

The second group deals with issues like the state of the art of drought-monitoring in Pakistan, processes of drought declaration and links with relief plans, institutional responsibilities for all of the above, gaps in institutional and policy aspects in drought management at present, etc.

It is envisaged that the results of the Pakistan study would be of interest to the federal and provincial governments to further focus their drought-mitigation activities in the country. The results would also be helpful for the planners and policymakers for identifying the future program of action related to drought-mitigation and -relief programs.

Target Areas

Baluchistan

The geographical area of Baluchistan is around 347,190 km^2 and it is the largest province of Pakistan constituting about 44% of the country's geographical area. According to the 1998 Census, the population of the province is around 6.51 million (GOP 2002). The population is sparsely distributed, with its density around 19 persons per km^2. Around 78% of the population lives in the rural areas. The climate largely ranges from semiarid to hyperarid and temperature regimes vary widely from cool, temperate to tropical. Cold winters and mild summers characterize the northern highlands. Most of the precipitation is received in winter ranging from 250 to 350 mm. In the southwestern desert, the annual rainfall ranges from 50 to 125 mm and summers are hottest, with temperature occasionally rising above 50 °C. Annual evaporation rates are very high, exceeding 3,000 mm.

Agriculture and livestock production are the two dominant sectors contributing to the Baluchistan economy, accounting for over 50% of the provincial GDP and employing roughly 67% of the labor force (GOP 2003). The limited precipitation and availability of surface water drastically restricted the cultivated land to around 2.1 million hectares (Mha) during 2000–2001, which is around 6% of the province's geographical area. About 47% of the cultivated area is irrigated, while the remaining 53% is under *sailaba* (floodwater) and *khushkhaba* (rainfall and localized runoff) farming systems (GOP 2002). Although irrigated crop production plays a dominant role in the agricultural economy of Baluchistan, sailaba and khushkaba farming systems contribute to the livelihood of a sizeable majority of the population, regarded as the poorest of the poor. These two farming systems are dependent on precipitation and runoff and their performance also fluctuates drastically with the variations in precipitation and runoff. Without runoff, economical harvests are not possible due to low precipitation.

The wide agro-ecological diversity of Baluchistan permits cultivation of a wide range of field crops and horticulture. Although the province is a net importer of wheat, traditionally cereal production (wheat, rice, barley, sorghum and millet) has remained important to its economy, covering 70% of the cropped area and contributing 50% to the gross value of crops (GOP 2002). Besides, it serves as an important source of fodder for the livestock. The high altitude arid environments provide an ideal condition for the production of deciduous fruits. Baluchistan's share of deciduous fruits (apples, plums, pears, apricots, peaches and pomegranates) and nondeciduous fruits (dates) ranges from 35 to 85% of Pakistan's production. In the case of grapes, almonds and cumin, the province has an exclusive monopoly in the country.

Irrigated agriculture is dependent both on surface water and groundwater resources. The Khirthar and Pat Feeder canals of the Indus basin system and Lasbella canal feed the major area under irrigated agriculture from the Hub dam. Another important source of surface water is the floodwater that flows through the streams. Around 30% of the floodwater is harnessed for agriculture through sailaba diversions, storage dams and minor perennial irrigation schemes. The groundwater resource is available for irrigated agriculture through karezes, springs and wells. With the availability of electricity from the national grid, there has been a tremendous increase in the number of tube wells. Indiscriminate installation of tube wells and pumping of water in excess of recharge have caused lowering of the water table resulting in the drying of dug-wells and a number of karezes and springs.

The mining of groundwater and lowering of the water table are causing serious concern regarding sustainability of groundwater-irrigated agriculture.

Baluchistan's important economic activity is livestock production, which is one of the major sources of livelihood for around 70% of the rural population. Around 92% of the geographical area of the province has been categorized as rangelands, which provide grazing to around 20 million of the small ruminants (sheep and goats). Three livestock production systems are prevalent in the province: a) a small percentage of the agro-pastoralists is sedentary, they grow crops and maintain livestock and often have access to fodder and crop residues; b) a large proportion of livestock owners are transhumant, who commute between winter and summer quarters to adjust to the seasonal feed requirements; they also grow rain-fed crops; c) about 50% of the livestock owners are nomadic and constantly move between highlands and plains and sometimes cross international borders; they are entirely dependent on livestock for their livelihood, which is earned through trading of livestock and livestock products. Livestock marketing is often through middlemen and is highly exploitative. Livestock health services are provided by the Livestock Department through veterinary hospitals, dispensaries and mobile units but in several districts these are grossly inadequate.

Sindh

The geographical area of the Sindh province is around 140, 914 km^2 and the population is over 30 million. Around 13% of the geographical area is under irrigated agriculture by perennial and nonperennial canals from the Indus basin. Salinity and waterlogging affect about half the irrigated area. The inefficient irrigation system and slow movement of water in the Indus river, due to the low gradient towards the sea, encourage percolation and cause waterlogging. In over two-thirds of the area of canal-irrigated agriculture, the groundwater is brackish.

The Thar region of the Sindh province is a large desert with sub-Saharan conditions and comprises 20,000 km^2. Runoff agriculture and livestock production are the primary means of subsistence in this area. Annual rainfall in a wet year ranges between 200 and 250 mm and occurs mostly during the monsoonal season. The incident of rainfall and runoff in a wet year permits growing of millet as the main food crop. Guar is the main cash crop. It also supports growth of a range of grasses providing feed resource to the livestock throughout the year. It also recharges the thin fresh groundwater layer and provides opportunities for collection of surface runoff in earthen ponds. Lack or absence of rainfall during the monsoonal season results in acute shortage of food and fodder. People search for alternative sources for their livelihood, usually migrating to the periphery of the canal commands for seeking labor and taking loans from informal institutions for subsistence. Normally, these loans are available on high interest rates.

The Kohistan area of the province is extending along the west and northwestern border of the province, which is mountainous and is also dependent on runoff for farming of crops (millet, sorghum, mungbean and guar) and production of livestock (both large and small ruminants). Rainfall in these areas is scanty ranging from 100 to 120 mm and is highly erratic. The Kachho area lying between irrigated plains and the Kohistan belt is also dependent on rainfall in the ctachment areas, and failure of runoff affects the livelihood of people. However, the farmers have developed ways to find the shallow groundwater and increase yield even in areas having very little recharge through the installation of horizontal galleries.

The vast arid lands in both provinces with no source of canal irrigation and low precipitation offer little scope for perennial-irrigated agriculture. However, these areas are highly suitable for traditional farming systems (sailaba and khushkhaba) and livestock production, particularly small ruminants, cattle and camel. These animals are well adapted to the harsh environments and utilize available range resources efficiently.

Droughts and Their Impacts in Pakistan

A Country-Wide Perspective

Pakistan frequently experiences several droughts. The Punjab province underwent the worst droughts in 1899, 1920 and 1935. The North-West Frontier Province (NWFP) experienced such droughts in 1902 and 1951, while Sindh had its worst droughts in 1871, 1881, 1899, 1931, 1947 and 1999. The most severe droughts at the national scale were perhaps the most recent which occurred in 1999–2000 prolonging up to 2002 in certain areas. The rainfall is erratic and river flows have dropped. The water in the Tarbela dam reaches dead level in late February or early March almost every year. The current live reservoir capacity in the Indus basin has been reduced due to siltation. The recent drought has also exposed the vulnerability of the Indus basin irrigation system and environmental issues in deltaic areas.

Agricultural growth suffered a severe setback during 2000–2001 as a result of the drought. While major crops (wheat, cotton and rice) registered a negative growth of almost 10%, the overall agriculture recorded a negative growth of 2.6% during 2000–2001. The performance of minor crops (cereals, vegetables, fruits, condiments, oil seeds, fodder and others) was also affected by the prevalent long dry spell. The drought persisted throughout 2001–2002, resulting in water shortage of up to 51% of normal supplies as against 40% of the previous year. The total flows of water in major rivers also declined to 109 billion m^3 against an average of 162 billion m^3. Rainfall has also been below normal. The canal-head withdrawals in *kharif* 2001 and *rabi* 2001–2002 seasons have also witnessed a significant decline. Notwithstanding severe water shortages, the farmers in Pakistan have undertaken various measures to minimize their adverse effects. These include the judicious use of water, exploitation of groundwater, purchase of water from tube wells, improvements in cultural practices and better overall management. As a result, overall agriculture registered a positive growth of 1.4% in 2001–2002 as against a decline of 2.6% during 2000–2001 (Ahmad et al. 2003).

Drought also affected the performance of nonagricultural sectors. Pakistan's nonagricultural GDP growth remained stable at around 4.3% in 2001–2002 (table 1). Therefore, when adjusted for drought impact, the real GDP is provisionally estimated to grow by 4.7% against 5.2% in 2000–2001. The slower growth in real GDP over these 2 years was caused by drought. Had there been no drought, Pakistan's economic growth would have been around 5% (Ahmad et al. 2003).

Table 1. Real GDP growth with and without drought (%).

Sector	1999–2000	2000–2001	2001–2002
Real GDP	3.9	2.5	3.6
Nonagricultural GDP	3.1	4.2	4.3
Real GDP growth adjusted for drought impact	4.0	5.2	4.7

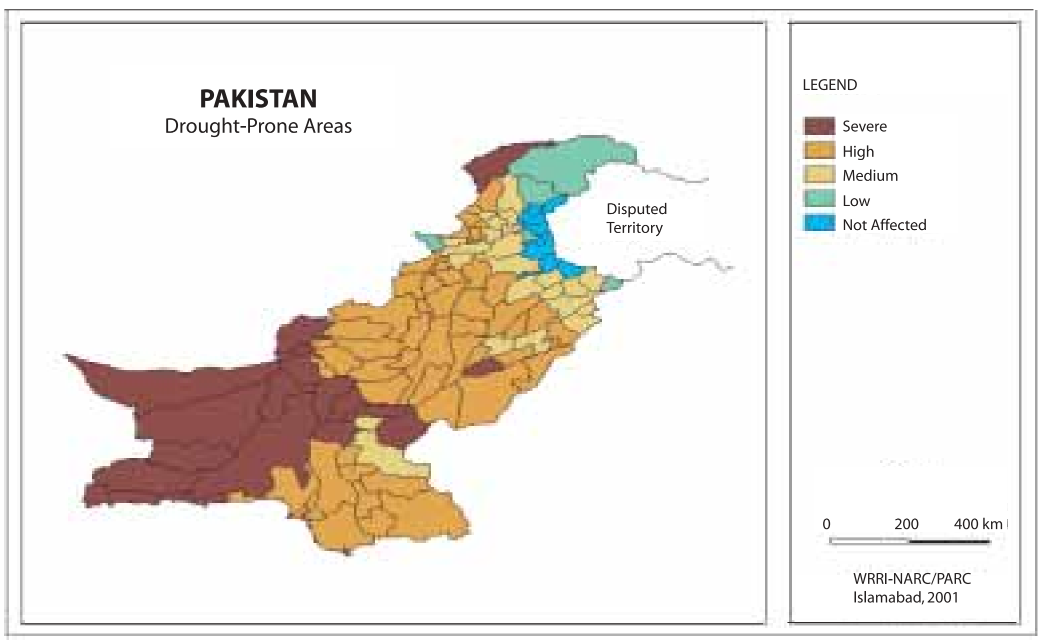
Note: The real GDP growth is calculated by excluding value added in agriculture and electricity and gas distribution.

The Government of Pakistan has implemented a relief program for the drought-affected areas with the objective of mitigating the effects of drought on the livelihood of rural communities. The major difficulty faced in the launching of a need-based project is the development or assessment of criteria, which is in line with the requirement of the affected areas. In 2001 the Planning and

Development Division assigned the task to develop drought characterization and classification criteria to a number of institutions, and for this purpose the same task was assigned to the WRRI-NARC (WRRI 2001). Two characterization criteria were used by WRRI (2001).

Aridity index is a ratio of 50% probability of rainfall and the crop evapotranspiration. Based on the aridity index, aridity classes were categorized considering humid, subhumid, semiarid, arid and hyperarid agro-climates. The GIS software Arc Info was used for database development and spatial analysis. Based on the aridity, four classes of drought-prone areas—severe, high, moderate and low—were identified. The drought-prone districts were classified based on the aridity index of each district (figure 1). Another criterion, *percent households having access to piped water supply,* was used to further characterize the drought-prone districts. In terms of both criteria, the Baluchistan and parts of Sindh provinces were ranked as "severely affected."

Figure 1. Drought-prone areas of Pakistan characterized, based on aridity index.



Impacts of the Recent Drought in Baluchistan and Sindh Provinces

Droughts in the Sindh and Baluchistan provinces have always been part of life, but they have increased in recent years. Both provinces suffered from the recent severe drought of 1998–2002, which affected the human/livestock population, crops and water resources. The drought resulted from the continuous lack of rainfall. In most severely affected areas, not a single drop of water was received during 1998–2002. In the Baluchistan province as a whole, the winter rains were reduced by 60 to 73% in some years. The situation is particularly serious in areas where groundwater is either deep or brackish and no surface-water resource is available. Other factors that increase the adverse impact of droughts include overexploitation of groundwater in violation of groundwater regulations, deforestation, depletion of grazing pastures due to lack of management, poor farm water management and lack of controlled cropping patterns (Ahmad et al. 2003).

In the Thar region of Sindh province, rains were down to only 30% (60 mm) and 12% (24 mm) of normal, during the years 1999 and 2000, respectively. Further, it was received in one storm and did not contribute to crop production and germination of range grasses. Other drought-affected, areas of Sindh—Mirpur Khas, Sanghar, Dadu and Thatta—received no rains during the last 5 to 6 years, totally eliminating rain-fed crop production, and livestock sustaining on rangeland vegetation, the two primary means of subsistence in these areas.

The latest drought in Sindh and Baluchistan is estimated to have affected over 3.3 million people, including thousands who became refugees and hundreds who died of thirst and starvation. It was also reported that about 30 million livestock were affected, including over 2 million that died. An emergency relief plan, involving an amount of about US$28 million, was carried out as part of the disaster-mitigation effort. Measures were adopted to strengthen logistics support, provide drinking water and material supplies to the drought-hit areas, medical cover to the affected population and treatment to endangered cattle. Food and fodder were also distributed (GOP 2001; Ahmad et al. 2003). The government has also taken up short- and long-term measures for continued supply of water to the drought-prone areas. The short-term measures include projects for groundwater recharge of Quetta, Pishin, Mastung and Mangochar valleys. Various long-term measures such as construction of small-scale storage reservoirs are also planned (Ahmad et al. 2003). Some drought impacts in the two provinces are briefly reviewed below.

Water Resources

In Baluchistan province, overexploitation of the groundwater resource, through tube wells, has caused an alarming rate of depletion of the water table in the Lora-Pashin, Nari river and Zoab basins. The extended drought preventing any recharge to the aquifer has further aggravated the situation in these overdrawn basins. Lowering of the water table has resulted in drying up of dug-wells, particularly in the uplands and 70% percent of the karezes (traditional water-harvesting and delivery systems) and natural springs. Karezes and springs, which are still alive, are running at only 1/2 to 1/3 of their capacities, with a drastic reduction in their command area. Lowering of the water table has also caused drying up of tube wells in several areas or reducing their discharge by up to 50%. Tube wells with diesel engines had to be abandoned because of their inability to pump water beyond a certain depth. Stream flows available for traditional sailaba cultivation (see next section for details) has either totally dried up or drastically reduced because there was no rainfall (FAO/WFP 2000a, b).

In the Sindh province, failure of rainfall and reduced flow of water in rivers and canals have affected groundwater recharge resulting in lowering of the water table, which had a positive impact on the productivity of irrigated agriculture due to waterlogging in the pre-drought situation. The surface wells in nonirrigated areas have dried and at some places the tube wells have also gone out of commission. The earthquake that hit areas in Badin and Tharparker districts in 2000 has also resulted in lowering of the water table from about 50 m to 150 m. Reduced stream flows have particularly affected the adjacent dug-wells, creating serious problems of availability of drinking water for human beings, as well as for livestock. Reduced recharge has also increased the salinity of groundwater. There was an overall shortage of 30 to 40% in the water flows of the Indus basin canals further multiplying the negative effects of drought. Reduced supply of canal water has resulted in a substantial reduction in cropped area of major crops and productivity (FAO/WFP 2000b; 2002a).

Crops

In the most severely drought-affected areas of Baluchistan, khushkhaba and sailaba farming (see next section for details) has totally disappeared. In areas severely or moderately affected by drought, crop areas have been reduced by 60 to 80% with productivity loss by almost 50%. Millet, sorghum, mungbean, guar and castor bean have been the traditional kharif crops while barley; rape and mustard have been the rabi crops. In addition to producing grains for human consumption or sale, these crops have been the primary source of stalks/crop residues for livestock feeding. A reduction to the extent of 87% has occurred in cropped area between 1995–1996 and 2000–2001. The area under wheat, barley and sorghum has registered drastic reductions of 84%, 96% and 95%, respectively (table 2).

Table 2. Areas of selected crops under sailaba and khushkhaba farming in Baluchistan.

Year	Total cropped area (ha)	Area under major crops (ha)			
		Wheat	Barley	Rape and mustard	Sorghum
1995–1996	257,110	133,090	21,105	10,723	44,675
1996–1997	99,593	42,180	14,498	4,820	7,549
1998–1999	90,759	46,835	8,197	3,908	4,350
1999–2000	35,934	17,908	1,318	588	4,300
2000–2001	33,529	23,000	824	1,080	3,623
2001–2002	32,743	21,306	775	4,489	2,280

Due to the drying up of a large number of karezes and natural springs and reduced discharge from the tube wells, the cropped area served by wells has also been reduced by 15 to 20% and the yields have been reduced to the tune of 25 to 30% (FAO/WFP 2000a; 2002a, b).

According to a recent survey by the Department of Agriculture, about 40% apple, peach and apricot orchards in upland Baluchistan, have dried, cut and sold as fuel during 2000–2002. Orchards that have survived are producing 30 to 40% less fruit of low quality because of reduced availability of water for irrigation. Rain-fed and irrigated fodder production has decreased considerably. This, coupled with a drastic reduction in the productivity of range grasses, has created problems for the sustenance of livestock even in reduced numbers.

Trends of substitution of low-water deltaic crops like cotton and cumin in place of high-water deltaic crops like onion in Kharan, Chaghi, Lasbella and Panjgur were observed. The need for training of both the farmers and the extension staff of the Agriculture Department, in production management of a new crop like cotton, was evident (FAO/WFP 2000a; 2002b).

Drought also increased the soil salinity in several areas because of reduced leaching of salts and more evapotranspiration. The increased salinity has had adverse effects on crop yields. Because of the continuous dry weather there was increased wind erosion of surface soil. Farm operations jobs have reduced by almost 60% adding to unemployment. There was an increased incidence of pests and diseases. Drought, coupled with pest infestation, has threatened the date palm economy.

In the province of Sindh, the sailaba farming in drought-affected areas of Dadu, Thatta and Mirpur Khas districts has been completely eroded due to failure of rains during 5 years. In the Tharparkar district, moderate monsoonal rains in 2001 enabled planting of rain-fed crops, though yields were much below normal. The year 2002 went almost dry in Tharparkar with no crop production. Carryover stalks of sorghum and millet from the summer of 2001 helped in sustaining the livestock during the first half of 2002 but, later, the flock owners had to migrate to the canal commands (FAO /WFP 2000b; 2002a).

Reduced water supply in the Indus basin canal system has caused major reductions in area and production of major crops. The combination of drought and reduced irrigation water supply had a negative effect on crop production. Reductions in area during 2000–2001 and 2001–2002, in comparison with 1998–1999, have ranged from 11.1 to 54.3% and those in production from 12.8 to 55.0%. Reductions are particularly high in rice, millet and kharif fodder (table 3). This drop in crop production in the irrigated areas has reduced their capacity to support the migrant stockowners from the Thar desert by providing employment and crop residues to feed their livestock.

Reduced aquifer recharge and consequent lowering of the water table have increased salinity of the groundwater making it hazardous for human and livestock consumption. At places, the salt

Table 3. Area and production** of major crops in Sindh.*

Crop	1998–99		2000–2001				2001–2002			
	Area	Prod	Area	Prod	% change over 1998–1999		Area	Prod	% change over 1998–1999	
					Area	Prod			Area	Prod
Wheat	1124	2675	811	2226	-28	-17	875	2101	-22	-22
Rice	704	1930	540	1682	-23	-13	461	1159	-35	-40
Sugarcane	271	17051	239	12050	-12	-29	241	11416	-11	-33
Cotton	630	2134	524	2141	-17	0	547	2443	-13	15
Sorghum	110	64	87	52	-21	-19	89	57	-19	-11
Millet	175	73	80	41	-54	-44	100	54	-43	-26
Fodder-R	196	3069	109	1382	-45	-55	145	1956	-22	-35
Fodder-K	205	6741	178	5878	-14	-13	153	5372	-25	-20

* Area is ’000 ha

** Production of cotton in ’000 bales, all others in ’000 mt.

contents of groundwater were reported to have increased from less than 1,000 ppm to over 2,000 ppm (FAO/WFP 2002a). The data collected by WRRI indicated that, in certain areas, the salinity of groundwater was as high as 6,000 ppm due to seawater intrusion.

Rangelands of Baluchistan (91% of the total geographical area) have traditionally supported over 20 million of livestock. Over the years, these rangelands have degraded due to overgrazing and fuelwood extraction. The influx of a large number of Afghan refugees, along with their livestock had put added pressure on grazing lands. The persistent 5-year drought has further aggravated the situation resulting in severe damage to net productivity of rangelands, dropping from 60 kg/ha to 18 kg/ha. Vast areas have been denuded and the carrying capacity of these rangelands has reduced considerably. The flock owners were forced to sell their stock at prices up to 5 times lower compared to the pre-drought prices. Mortality due to hunger and disease infestation of malnourished animals has increased severalfold. Distress sale and mortality together have resulted in an overall reduction of 35% in stock size, with the individual owners in most severely affected areas losing 80–100% of their animals (FAO/WFP 2002a).

The prevailing livestock production systems offered resilience and choices to shift between summer and winter quarters. This coping mechanism has shrunk to a large extent due to reduction in range feed resources because of drought. Kachhi plains and canal-irrigated areas of the Naseerabad Division were traditionally home to large nomadic/transhumant herds during winter. However, these areas have very little to offer during drought years.

Dropped leaves, fruits and weeds extracted out of orchards constituted an important source of supplementing the feed available for grazing. With 40% orchards in upland Baluchistan dried, cut and sold as fuel, this source of supplementary feed has virtually disappeared in several areas. The livestock feed resources have further reduced due to stoppage of fodder intercropping in orchards because of water scarcity. This has happened particularly in Panjgour and Turbat where date and pomegranate orchards have been traditionally intercropped with berseem and lucerne during winter (FAO/WFP 2000a; 2002b).

In a fairly large population of small ruminants, two breeding seasons (2001 and 2002) were completely lost because of reduced conception due to poor feed and health of the mothers. In many cases, pregnant animals aborted and a 10–15% lamb/kid mortality occurred due to shortage of milk with mothers. The stock buildup capacity has, thus, been drastically reduced and flock replacements are not becoming available to many graziers (FAO/WFP 2002a; 2002b).

Traditionally, livestock provides ready cash whenever needed to meet the household needs, but most farmers' ready cash has depleted. The situation has become particularly serious for those having livestock as the sole means of subsistence. Most of the small ruminant herds have been grazed by hired graziers, which was a source of employment. Reduced stocks have resulted in fewer jobs adding to unemployment.

The availability of meat, milk and milk products, as part of the family diet, has either totally disappeared or drastically reduced adding to malnutrition and poor health, particularly in children and nursing mothers. Due to malnutrition and poor health of animals, both quantitative and qualitative reduction has occurred in the production of wool and hair. Poor-quality products were sold at 50% of the normal price. The cottage industry has been adversely affected (FAO/WFP 2000a, b; 2002b).

Recently, due to reduced availability of stock, the small ruminants were sold at a higher price in Baluchistan and the mutton prices went up by almost 60%. In Sindh, drought-affected areas in the five districts have a total livestock population of 5.6 million heads. In normal years, about

20% flock owners from these districts shift to canal-irrigated areas taking along 15–20% small ruminants and 80% cattle. On-farm jobs, particularly related to rice and sugarcane harvest, are available in the irrigated areas to these migrant flock owners. Sugarcane tops and rice straw constitute a major source of feed for their livestock. If required, fodder is also purchased or traded against wage labor. Drop in acreage of major crops due to reduced availability of irrigation water in the canals has reduced the quantity of these feed supplements available for the migrating livestock and has also shrunk the job market. As the availability of crop residues and range biomass in the drought-affected areas has continued to deteriorate further, there has been a larger migration of livestock, increasing pressure on the feed resources available in the irrigated areas (FAO/WFP 2000a; 2002b).

Over 50% of the livestock population in drought-affected areas of Sindh has suffered from malnutrition with a concomitant increase in disease infestation due to reduced immunity. The mortality rate of small ruminants has increased by 10–15%. Drastic reduction has occurred in their breeding efficiency with only 45–55% ewes/goats breeding during the 2001 and 2002 seasons. Almost 20 to 25% of the lamb/kid crop succumbed due to low milk availability during the drought of the last 2 years.

Households

Changes in diet. The normal diet of the people of Baluchistan in the pre-drought period comprised wheat bread, tea, meat, milk, yogurt, vegetables and fruit. Seasonal vegetables and fruits were a part of the normal diet of the people living in the rural areas of Sindh and Baluchistan, while meat and milk products were more prominent in the diet of people dependent on livestock for their livelihood, especially in Baluchistan. Drought has restricted the access of affected people to food items. Their present diet comprises wheat flour and tea in Baluchistan and wheat flour, onion and chili in Sindh.

Earlier, the people had at least two regular meals a day. Most drought-affected people were forced to subsist on one meal. Wheat flour is the principal item of expenditure of the family income, followed by cooking oil. As cash resources depleted, it became hard to purchase oil and most meals were uncooked, as they comprised bread eaten with tea, chili or onion. There was evidence of food substitution in some areas of Sindh where people have taken rice in place of bread for their evening meal. Because of the lack of animals people have stopped making *laandi,* a form of dried meat, the staple winter diet of the Pashtun tribes of Baluchistan, and also *lassi,* the buttermilk, a favorite drink in both provinces. No house had food supplies beyond a day or two. In areas where fodder was scarce, people were forced to share their bread with their animals.

The government's free food distributions have, from the point of view of those affected, promised much but delivered little. Many of those affected, particularly in Sindh, who would otherwise have migrated to the canal commands, stayed at their villages in anticipation of receiving government wheat. Those who did receive this aid mostly got it only once, as a short-term relief. Without regular follow-up of distributions, this wheat appears to have made no significant improvement in the overall picture of food security.

Changes in living patterns. Water is a primary need of those affected by droughts; the search for its regular supply has caused widespread migration. This has converted a large population of settled villagers into migrants or refugees. A large number of traditional migrants or nomads have been forced to settle in and around places having regular supply of water. This double load of settlers has caused undue pressure on host villages, by depleting their water sources. The competition for local work added to the pressure on the job market, and the relations between the existing population and refugees often resulted in conflicts.

Since other sources of income have dried up, members of the affected families were forced to involve in the search for supplementing family income through occasional work. Women who traditionally stitched and embroidered clothes for family use are now trying to do so for commercial purposes. However, women are not receiving adequate compensation for this work because of the absence of markets for their products and reduced demand. Child labor has increased; older boys are now being sent to towns and larger villages in search of employment. Farmers are undertaking town jobs of the kind they have no training or aptitude for, and are being paid less than normal wages.

Since most of the family income is spent on the purchase of food, there is usually no cash surplus for buying other essentials (clothing, bedding, soap). This, together with the lack of water for cleaning purposes, has led to very unsanitary and unhygienic conditions prevailing in the houses and shelters of drought-affected families (FAO/WFP 2002a).

Health impacts. Use of brackish water in arid zones is an underlying cause for the poor state of human health. The method of water transportation and storage (ponds, tanks and plastic containers) exposes it to various forms of contamination. This is why the most common health complaints relate to diarrhea, vomiting and fever among children. This, together with a poor diet, has caused the widespread malnutrition reported among women and children by FAO/WFP (2002a, b). Diarrhea and enteric disorders were found in 30% of the children. Women were seen as affected by malnutrition as children. The impact of malnutrition was particularly severe on pregnant and nursing women, who have a greater demand for food energy. Because of illness and frailness, many of them complained of having no breast milk for feeding their babies. Since there was no adequate alternative to mothers' milk in the villages, or any proper weaning foods, the life of the infants appeared to be at considerable risk (FAO/WFP 2002a, b). Malnutrition also increased the vulnerability of those who were affected to such catastrophic diseases as tuberculosis and hepatitis.

Vulnerable groups. Women and children have been affected more by drought. While men have the option to go to work in towns where they have a wider choice in food and access to clean drinking water—which is reflected in their visibly better state of health—the women remain tied to the house. Their burden increases when the men are away because they have to take care of the entire household needs, even those that are normally taken care of by men, such as collecting firewood and fodder and the sale of animals in emergencies. Women are at the tail end of the family meal. They eat whatever is left after the men and children have eaten. Women also bear the burden of anguish when their children do not get enough to eat or when children's essential needs remain unmet.

Children's food needs are also more varied because of their growing age. Devoid as it is of most essential nutrients, their diet invariably leads to malnutrition and other diseases. Night blindness, scurvy and anemia are common among children and are caused by the lack of vitamins A, C and B12 in the body. Further, children do not discriminate between good and bad food when they are hungry. They often eat stale or contaminated food, which causes the high incidence of gastric and intestinal disorders (FAO/WFP 2002a, b).

Water Harvesting and Conservation

Traditional Methods and Their Extent

Water harvesting is a common practice in arid areas of both Sindh and Baluchistan provinces. Water harvesting captures rainfall and/or runoff and utilizes it for drinking or farming either directly or by storing it in small surface and subsurface reservoirs. The stored water can be used for supplemental irrigation and other consumptive uses. In nonirrigated areas, the majority of farmers are still practicing traditional water-harvesting systems, which date back even to 3000 BC. Traditional water-harvesting and -conservation practices common in the provinces of Baluchistan and Sindh are briefly described below.

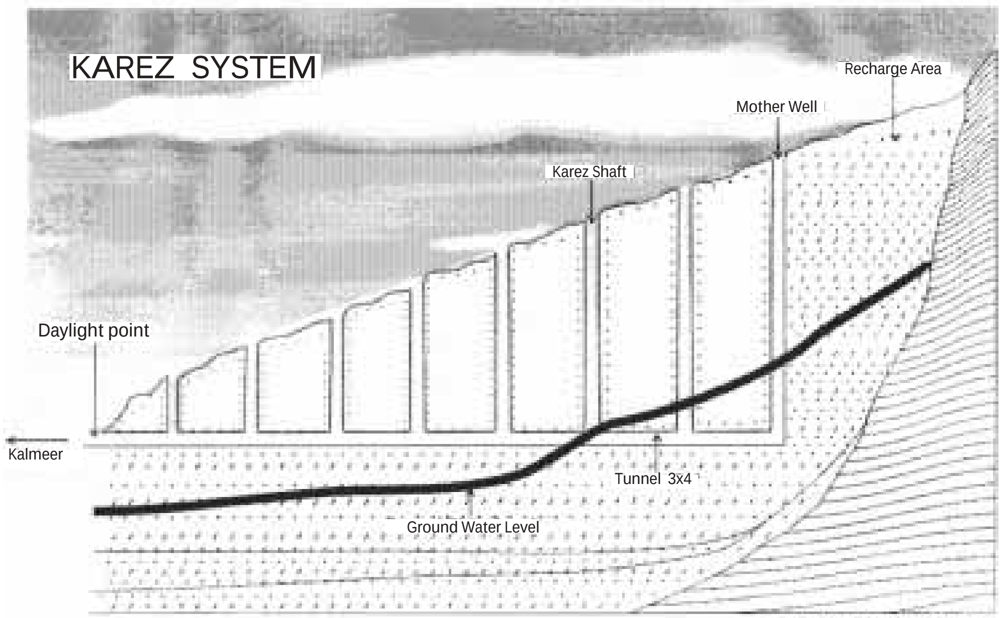
Karezes

The *karez* or *qanat* is one of the oldest traditional irrigation systems of Baluchistan (as well as in neighboring Afghanistan), which was devised as a means of tapping groundwater supplies using gravity flow. It is a gently sloping tunnel that conveys water from below the water table to the ground surface. It consists of a series of dug-wells and tunnels that collect groundwater and discharge it to the command area. Each karez delivers water to the fields of shareholders, who have contributed money and labor for its construction. The 'modern' karezes are typically 1 to 5 km long, but have been as long as 50 km in the past. In areas having very low rainfall, and having little capacity for storage of surface water, the karez is the primary mechanism for water harvesting and delivery in Baluchistan. The residents of an area mark the site where the precipitation drained into an underground formation followed by the appearance of water a few kilometers downstream of the command area. The man who organizes villagers to begin and complete the arduous task of building a karez and maintaining it over time holds the office of Sarishtra, the manager of a karez. The Sarishtra holds the land immediately adjacent to the "daylight point" from which the water is discharged.

The residents first dug a well down to the groundwater table. This well is called the mother well (figure 2). In the expected direction of groundwater flow, more wells at a distance of 50–100 meters apart are dug to check the flowing water. Once a karez is established, it can be used for years. A census in 1998 revealed that there were 493 karezes in Baluchistan (IUCN 2000). An average karez can irrigate 10–20 hectares. Karezes, which yield up to 200 liters/sec normally, serve a maximum of 200 shareholders.

A karez is a perennial source of water both for domestic and irrigation purposes. In places without a freshwater supply, karez water is used for drinking, washing of clothes, cleaning of utensils, etc. A few decades ago, the agricultural economy was totally dependent upon the supply of karez water. The area irrigated by karezes in Baluchistan decreased from 14.2% in 1980 to 7.5% in 2000 (GOP 2000).

Figure 2. A schematic cross-section of a karez system.



Sailaba or Rod-Kohi System

The sailaba or rod-kohi system is widely practiced in the Sindh and Baluchistan provinces. The sailaba cultivation is done by diversion and spreading of intermittent flows of hill torrents. As the water comes down the hill, it is checked by a series of earthen diversion bunds. To meet their local irrigation needs small communities have constructed diversion bunds on a number of smaller streams for irrigation. The water thus checked is allowed to seep slowly down into the soil. Water rights have been historically determined. Water can only go through the main, predetermined channel. The water is allowed to flow out of the side water channels only when there is excess water. Relatively large fields, each over 3 hectares, may be irrigated in this system and deep-rooted crops are usually recommended. The hill-torrent areas in Baluchistan are the Kachhi, Zhob-Loralai, Makran coastal area and the Kharan closed basin, and in Sindh they are the Karachi area, Khirther range and Sehwan and Pataro areas (Ahmad 2001; 2003a).

The potential for sailaba in Baluchistan is estimated as 1.1 million hectares. The historical data, however, indicate that sailaba cultivation has decreased from 0.33 million hectares in 1980 to 0.17 million hectares in 2000 (GOP 2000). The floodwater in the sailaba system is collected in two different ways: troughing the *bandat* systems and diversion of ephemeral streams.

Bandat systems. In the valley bottom, large bunds are made by farmers to serve as field demarcation boundaries and to trap runoff water. In this system, 0.5- to 3-m high bunds (earth embankments), depending on the topography of the land, are constructed on the main seasonal riverbeds to divert floodwater and lead it to the bunded fields (Khan 1994). The floodwater originating from the upper Loralai district flows through parts of Loralai, Kohlu and Sibi before entering the Sindh province. The bunds have been traditionally built by animal labor (camel and bullocks) but now it is common to see increasing use of bulldozers and tractors. The bunds are simply banks of earth. Farmers raise their crops on areas where runoff is collected.

Diversion of ephemeral streams. Another common practice in upland Baluchistan is to terrace stony land alongside ephemeral streams at the top of the valleys, near the mountains, and divert the stream flow into the fields by dams extending into the streambeds. Stream flow generally occurs following the intense storms of the monsoonal period, bringing sediments from the surrounding hills, which provide nutrients for crop production (Rees et al. 1987).

Khushkhaba System

The Khushkhaba system comprises in-situ conservation of incidental rainwater and catching runoff from large uncultivated blocks and diverting it to cultivated fields. Fields receive water directly from precipitation or from localized runoff. The khushkhaba is merely a chance cropping with a successful crop being raised on average once in 5 years. The main difference between the khushkaba lands and the sailaba lands is that the catchment area of the former is small and is often not bigger than the field enclosed by the embankment or bund. Embankments are made facing the hills, so that the natural gradient within the bunded area helps collect the runoff above the embankments (Khan 1994). The area inside the bund is deliberately left uneven with the areas closer to the bund being the lowest. This is done so that, in the case of high rainfall, the runoff from adjacent areas upslope collects near the embankments and provides enough water at least to grow crops in the lower half of the fields (0.5–1% slope), and to encourage rainfall to run off into the tilled bunded field below to increase both its soil-moisture content and, consequently, the yield of the dryland crop. It is mainly practiced in Quetta-Sarawan and Zhob-Loralai areas of the Baluchistan province. The area under khushkaba cultivation in Baluchistan was estimated as 0.32 million hectares in 1980 and 0.34 million hectares in 2000 (GOP 1980, 1990, 2000).

Tarai

The most common type of water conservation in the arid regions of Sindh is a dugout commonly called “tarai.” Tarais collect rainwater for water supply and are filled from the water drained from a level watershed and collecting area. They could be dug cheaply in low-lying areas with clay soil where there is some runoff. The depth of water in a tarai is normally 3–4 m. The water from tarais, which is less than 3-m deep, is fast lost through evaporation. The evaporation rate is relative to the amount of runoff received and its frequency during a year. The evaporation rate in drought-prone areas is significant, as there are prolonged dry spells with no rainfall or runoff received during the dry year. Therefore, the tarai depth is normally twice the annual evaporation in the area. They are dug so deep as to hold water for long periods. A tarai has sloping sides so that livestock can have access to water. Desilting is needed after 3–4 years.

Small Dams

Small dams on channels and streams, however, collect and store more water than tarais. Several such dams have been constructed in hilly and mountainous areas at some places on the streams to store rainwater. These are typical in the Kohistan area of the Sindh province. The reservoir of water in small dams can serve both animals and human beings. In the Kohistan region, particularly where many rainwater streams (nain) flow heavily during and after rainfall for a considerable period, such reservoirs retain water for some time after the end of the rainy season. The soil retains moisture for longer period to support dryland agriculture.

Wells

In most of the rangelands, the dependable and common source of water is wells, where groundwater is of usable quality. Water from the well is raised manually or by animal power. The wells are usually dug along the riverbeds and channels to harvest the shallow seepage water.

A comparison of the area irrigated by different sources during the selected decades in the Baluchistan and Sindh provinces is presented in table 4.

Table 4. Area irrigated by different sources (GOP 1980, 1990, 2000).

Area (ha)	Baluchistan			Sindh		
	1980	1990	2000	1980	1990	2000
Total cultivated area	995,710	1,163,387	1,271,872	3,167,054	2,874,033	3,255,334
By canal only	177,594	206,690	281,859	2,285,259	2,132,546	2,658,510
By canal and tube well	—	—	15,689	164,112	134,226	154,912
By canal and others	—	—	—	8,207	—	—
By tube well only	40,779	105,629	202,281	51,813	44,080	40,181
By well only	8,488	—	—	3,312	—	—
By karez only	49,218	54,096	52,750	—	—	—
Tank/bandat/rod-kohi/spring	39,955	—	—	8,927	—	—
Tank/bandat	—	38,415	12,399	—	7,772	7,457
Spring/rod-kohi	—	127,430	89,437	—	30,223	44,983
Unspecified	30,213	58,244	47,624	6,753	2,074	529
Not irrigated	—	—	55,274	97,779	48,807	64,015
Sailaba	330,370	192,255	172,482	35,200	12,398	3,042
Barani	319,106	380,644	342,074	505,701	461,905	281,706

Effectiveness of Traditional Water Conservation during Drought

Karezes

The efficiency of the traditional karez systems has been negatively affected during the last 20 years for two reasons. First, due to recurring droughts, and second due to the installation of a large number of tube wells and dug-wells (more than 25,000 functional tube wells exist throughout Baluchistan at present). The rate of depletion of groundwater in Baluchistan has been accelerated from approximately 0.2 meters per year (m/yr.) prior to 1989 to the present rate of 1 to 1.5 m/yr. (Khan 2002). The installation of a large number of tube wells has contributed significantly to lowering the groundwater table, which has dropped from 15 to 80 m in the last 30 years. The latest drought has devastated entire ecosystems as water supplies for domestic use, agriculture, water and vegetation recede or vanish altogether. A key advantage of the karez is that it delivers water year-round, even in years when rainfall is below average. According to Appell et al. (2003), during the recent drought in Baluchistan, the karez continued to deliver enough water to meet people's needs for about 2 years. However, due to the continuous drought condition, natural flows in karezes and springs are also drying up. Community-owned and -maintained karezes were replaced by private wells owned by a few individuals.

During the last decade, the government departments, National Rural Support Programme (NRSP) and NGOs working in the area have restored nearly 200 karezes. Till July 2002, NRSP and its community organizations had rehabilitated 112 karezes in Turbat, benefiting over 13,000 households (Appell et al. 2003). In some areas, including those close to the Dasht river, the karez is a vital link to water-storage facilities. The government has recently built a number of water-storage bunds, which are also linked to the karez system.

Sailaba and Khushkhaba Systems

Crops grown under these irrigation systems give poor yield and return and thus the investments are very risky. However, these farming systems in conjunction with livestock do provide an off-farm income, which is the major source for many of the poor farming communities. These types of water-harvesting systems are dependent on the monsoon, which is unreliable in upland Baluchistan. Due to below-normal rainfall during the past 4 years, many parts could not receive enough rains to recharge the water sources. The abrupt decline in rainfall (less than 50% of normal) in most of the uplands has caused complete drying of water sources for domestic needs. The long period of moisture stress during the drought coupled with shallow rooting results in very low yields. Both sailaba and khushkhaba are managed in traditional ways. These systems serve only to meet the barest needs of the farmers. In the most severely drought-affected areas of Baluchistan, cropping of khushkhaba and sailaba types has totally disappeared. In areas severely or moderately affected by drought, crop areas have reduced by 60 to 80% with productivity going down by almost 50% due to moisture stress. Stream flows available for sailaba cultivation have either totally dried up or drastically reduced because of failure of rainfall (Chaudhri et al. 2002). The area under wheat, barley and sorghum has registered drastic reductions of 84%, 96% and 95%, respectively.

During the drought and dry spells of the last few years, the floodwater was received in reduced quantity and, consequently, the command area was severely affected. The farmers either harvested the wilted crop or could not cultivate due to water scarcity.

Tarais, Small Dams and Wells

In Sindh, very limited efforts have been made to accumulate the rainwater that may be utilized for cultivation of land. Several projects like mole dam, Kacho reservoir, development of lakes, depressions and reservoirs are lying unattended and ignored for many years. These water bodies can substantially harvest the rainwater for using it for valued crops. During the recent drought, the districts of Tharparkar, Kohistan and Dadu were severely affected and Tarais either dry up completely or become heavily polluted. The other water sources like ponds have dried up due to extreme drought and water in the wells has also fallen. With the drying up of sources of water, the herders had to move 10–12 km to water their animals and, during extreme scarcity, they out-migrated to irrigated areas (Isani 2000). Due to lack of moisture, crops such as millet, guar and grasses have dried up completely and overgrazing has caused poor vegetative cover, resulting in desertification.

New Water-Harvesting and Conservation Methods

Runoff-Runon Systems for Khushkaba Areas

The dryland-farming system of upland Baluchistan faces many constraints mainly due to low and erratic rainfall, which varies from 150 to 300 mm annually. The dryland farmers classify 3 to 5 years out of 10 as a poor crop year with low grain and fodder yields. The farmers have, therefore, developed several water-harvesting practices that minimize production risk. Based on the observations of the valley-bottom soils, Rees et al. (1987) suggested more modest and practical interventions. Since crop growth in the upper portions of most fields is usually patchy and poor, the possibility of treating this unproductive land lies in reducing infiltration of rainwater and increased runon in the cropping area near the bund. The upper portion was treated either by plowing to remove vegetation and loosening the soil or by heavy planking to pulverize and level the soil or by wetting to induce crust formation. This wetting can be artificial, using an outside source of water or the first rain of the season will cause crust formation after the pulverization treatment of the soil. Other treatments such as concreting or mixing salt with soil to engender a strongly impermeable crust are possible but these are much more expensive than the treatments explained above. This technique has produced a satisfactory crust on both a sandy loam soil and a sandy clay loam soil. According to Rees et al. (1987), these interventions have resulted in additional soil-moisture storage in the cropping area near the bunds.

Water Ponds and Storage Tanks

The available water sources in mountains and deserts of Baluchistan have often a small discharge and the direct application of this low flow results in higher conveyance and application losses. A standard size water pond is an integral component of a farm's infrastructure throughout Baluchistan. Before the rains, people normally construct small ponds, which are either mud-plastered or cemented, to store/conserve rainwater for domestic use and, in some cases, for animals. The size of these ponds varies from place to place. The stored water is available for a period of 4 to 6 months, depending on the size of ponds, prevailing weather conditions and its use (FAO/WFP 2002a). Water ponds constructed in these areas conserve water by increasing the volumetric flow through its intermittent and timely releases. The Pakistan Council of Research in Water Resources (PCRWR) has developed 6 ponds in the Cholistan desert to collect rainwater runoff from 90 hectares of land. These ponds have been designed to catch maximum rainwater in the shortest possible time to avoid water losses. The depth of ponds varies from 4 to 6 m with a storage capacity from 2,000 to 5,000 m^3 (Bhutta et al. 2002). Farmers plant timber and forage trees all around the pond to meet their domestic needs. The advantage of ponds is that farmers keep their ponds filled round the clock, using them as and when the need arises, and selling this water to neighbors. An additional advantage is that earthen ponds also recharge the groundwater.

PARC has developed earthen ponds and storage reservoirs in both the target areas, where the variable depth concept is used so that during the dry spell the water in a reservoir can be restricted to a smaller area with a larger depth to ensure water availability for longer durations. The sand filters coupled with hand pumps around these ponds provided a low-cost technology for rural communities' water supply. In addition, in the areas of Barkhan and Musa Khel districts, facilities for washing clothes and water were provided to maintain the quality of the stored water. Rural communities were motivated to restrict the entry of livestock to the ponded area to avoid associated water pollution (Ahmad 2001).

In Sindh, a number of storage tanks and new tarais (plus a number of rehabilitated ones) were built or are under construction. The capacity of tanks depends on the intensity of rainfall but, in general, the rainwater-harvesting practices are feasible in areas receiving more than 150 mm rainfall annually.

Artificial Recharge to Groundwater

Due to the continuous overdraft, Baluchistan's groundwater aquifers are dropping at 3.5 m annually. In Sindh, less rainfall and reduced flow of water in rivers and canals have also affected the groundwater recharge, resulting in the progressive lowering of the water table. Reduced stream flow has particularly affected the dug-wells along their course, creating a serious drinking water problem. The most critical issue, therefore, in both provinces is how to stabilize and maintain the groundwater table. One possible solution is artificial recharge of groundwater. The artificial recharge techniques include a) plantation of appropriate plant species, b) "inverted" well, c) recharge dam, d) loose-stone check dam, e) deep dug-wells, f) ponds and recharge basins, g) depression, h) benching, and i) spreading of water.

Plantation. The plantation reduces the rate of runoff by trapping and delaying the water with associated reduction in the level of silt carried in the floodwater. This technique results in significant impact on water conservation and improvement in Baluchistan, having sufficient soil cover. Studies reported that an 80 mm storm of rainfall on vegetative catchments could produce a lower peak flow than that from a 20 mm storm in catchments without plantation. It is also reported that the vegetative measures can add around 33% more to the groundwater recharge (Majeed 2000).

Recharge dams (delay action dams). This technique consists of constructing dams across streams to store floodwater for recharging of groundwater. The dams delay the passage of floodwater by retaining it behind impoundment structures. Recharge then takes place by infiltration behind the structures through the reservoir bed. A number of such dams have been built in Baluchistan and Sindh over the last two decades. These are popularly known as *delay-action dams*. Unfortunately, many of these do not have any means of releasing water downstream of the dam. Typically, they have high initial recharge rates due to high porosity of the bed but these rates then fall exponentially with each rainstorm due to high silt load brought in by the floodwater. A limited case study on the effectiveness of such dams was conducted on the Pechi delay-action dam near Ziarat using water balance, isotopic and chemical techniques. The purpose of the dam was to collect rainwater in the flood season and to supplement the nearby karezes by recharging groundwater. The study failed to establish any hydraulic interconnection between the dam reservoir and downstream karezes. The main reason was sedimentation of finer materials in the reservoir bed.

Recently, the PCRWR constructed a leaky dam near Quetta with an aim to overcome the problems faced in delay-action dams. The main feature of this dam is that, contrary to the existing practice in Baluchistan, the main body of the dam is leaking. The structure of the dam is gabion with stones held together with wire mesh. The dam is built so that it allows the slow release of water through its body for recharging groundwater. The dam body also has the provision for release of water through a number of gate valves, which could be used once the dam structure gets clogged with sediments. A monitoring system has also been placed to check the effectiveness of the dam for recharging groundwater.

The results of some studies regarding the effectiveness of delay-action dams indicated that these structures enjoy considerable popular support in Baluchistan. The Executive Committee of the National Economic Council (ECNEC) has recently approved the construction of 54 delay-action dams, estimated at almost US$8 million. These will be built in Quetta, Pishin, Mastung, Qila Abdulla and Mangochar. The Japan International Cooperation Agency (JICA) has also offered a grant of around US$14 million for the construction of five delay-action dams. The Asian Development Bank (ADB) and the World Bank (WB) have also agreed to finance desiltation of delay-action dams and construction of new dams under the National Drainage Program of Pakistan. All this is expected to contribute positively to groundwater recharge. The efficacy of delay-action dams can be enhanced by providing exit pipes for draining the silt-free water downstream for infiltration into the streambed.

In the Sindh province, the Society for the Conservation and Protection of Environment (SCOPE), a Pakistani NGO working on the implementation of United Nation Convention to Combat Desertification (UNCCD) constructed a small retention dam to save land and water resources of the Gadap area, an agricultural greenbelt in the Malir district of Karachi in the Sindh province (SCOPE 2002). Malir, which was once known for its abundance of arable land and water resources, became desertified due to excessive sand and gravel excavation from the beds of hill torrents, groundwater exploitation and prolonged recurring droughts. The groundwater level dropped from some 20 m in 1960 to 90–200 m in 1999. Owing to the scarcity of water, out of 29,210 hectares, only 2,600 hectares of land are cultivated. With the construction of a 3.5-m high check dam in the Khar valley of the Malir district, the rainwater can be stored for domestic purposes and to recharge the groundwater aquifer. The Raingun Sprinkling Irrigation System was installed to economize the use of irrigation water at two different farms in the Gadap Union Council. Since the construction of the weir, runoff has been successfully stored in the lake. This lake is able to store water for most of the year and the groundwater level in the adjacent area has risen sharply. Many dried wells and water holes become functional. After every monsoon, rainwater percolation increases and aquifers are being replenished. The Sindh Arid Zone Development Authority (SAZDA) carried out studies for the construction of small dams in Kohistan and Thar regions (Rahamoo 2004).

In the Zhob district of Baluchistan, Human Development Foundation (HDF), in partnership with the local communities, constructed a delay-action dam for recharging groundwater. The dam has a capacity to store about 110,000 m^3 of water and the catchment area is about 12 km^2. Before the dam was built, there was little vegetation around. In 2002–2003, a few rains filled the dam to a depth of over 8 m. This has raised the water level in the karezes and wells in the vicinity of the dam, on average, to about 3 m. HDF also helped the community to install hand pumps in the villages to provide water for domestic use. Traveling long distances to collect water from earthen ponds, which is not safe for domestic use, has stopped.

Recharge wells. This technique basically consists of drilling a borehole to provide a direct path for water to infiltrate and to recharge the groundwater. The water may flow under gravity or may be injected through reverse pumping. It is reported that good recharge rates can be achieved through injection wells to an average ranging from 1,235 to 5,725 m^3/day with a minimum of 200 m^3/day. Dug-wells can also be used as a recharging device.

Unfortunately, very often a precipitation of less than 25 mm occurs, which seldom results in any runoff. Rainfall of more than 25 mm often occurs after a long dry spell and is not effective.

Occasional precipitation causing a runoff carries a large amount of sediment, which is harmful to the success of artificial recharge practices in Baluchistan.

Hand Pumps

In areas where the groundwater table is not very deep, the hand pump is the best solution for domestic water supplies. In Aranji sub-tehsil of the Khuzdar district, Baluchistan, the water table in several places during the recent drought was about 12 m. About 30–35 hand pumps were installed under the UN World Food Programme. One hand pump is sufficient for some 50 persons. Furthermore, the Public Health Engineering and Irrigation & Power Department of Baluchistan has installed around 28 tube wells and 50 hand pumps to meet the water shortage for irrigation and drinking purposes in various districts (Khan 2002a, b). The local communities welcomed this technological intervention.

In the Sindh province, there are 37,391 tube wells installed in the public and private sector. In view of the overall situation of drought in the province, over the past 3–4 years, the number of tube wells has increased by around 60% from 1997–1998 to 2000–2001. A new scenario has emerged whereby the water zone is being exhausted through excessive pumping of groundwater through tube wells. The Rotary Club of Karachi Sunset Millennium, together with Pakistan Insaf Welfare Trust (PIWT) has installed 180 hand pumps in the drought-affected areas of urban Sindh. PIWT has evolved a system through which the community having 300 or more persons is entitled to have a water pump. The pumps were installed at a public place or at a community center like a mosque, so that everyone has access to the water.

Improved Tillage and Furrow-Ridge Planting

Although this is not strictly a drought-proofing measure, improved tillage may lead to increased yields, which is important for creating food reserves. The effect of tillage on crop growth and yield is not only to increase infiltration of rainwater but also to break the hardpan, which allows better root growth or increased nitrogen minerlization of the inverted soil.

Farmers in Baluchistan are using a dual-purpose plowing and planting implement, the 'desi-plow.' This produces ridges 8 to 15 cm high, depending on the soil type and pushes the loose soil to either side to form a ridge-furrow system. This enables farmers to place seed in moist soil by planting 4 to 6 cm below the bottom of the furrow. Rees et al. (1987) observed that following 47 mm of rainfall, the soil water content of the basin increased by 24 mm, whereas that of the furrow-ridged system increased by 57 mm. Both in Sindh and Baluchistan, most of the crops including wheat can be sown on ridges, which can save about 30% of water.

High-Efficiency Irrigation Technology

In most of Baluchistan, irrigation methods commonly followed by farmers include the controlled flood-irrigation technique on either wide-border strips or basins. In some areas, where soil is sandy, gravity irrigation results in significant wastage of water due to seepage. Almost all fruits, vegetables and winter fodder crops are overirrigated. As much as double the amount of water required is applied. The application efficiency in fields is 25–40% (IUCN 2000).

During the early 1990s, PARC, with the collaboration of the local industry, started producing high-pressure pumps for agricultural purposes, local manufacturing of sprinkler and drip irrigation systems (polyethylene-based). The local production of sprinkler and drip-irrigation systems helped the local people to start installing these systems. However, large-scale adoption of these systems in Baluchistan is limited due to low value of water and heavily subsidized electricity tariff. The subsidy on electricity consumed by the farmer is around 90%, where the farmer is supposed to pay only 10%, as a fixed rate of Rs4,000 (around US$70) per month. The other root cause for the adoption of these systems is the nonexistence of local irrigation companies in the provinces.

PARC collaborates with the local companies to initiate local production of PVC-based drip irrigation systems and to establish local dealership and irrigation companies for the installation of these systems. The installation of demonstrations throughout Baluchistan and in other parts of Pakistan is now ongoing. The Government of Baluchistan with the assistance of the Khushhali Bank is considering the formulation of a Water Conservation Fund, where assistance will be provided to the farmers through the Khushhali Bank, and systems will be installed by the private sector on a turnkey basis. The installed cost (capital plus installation cost) for the drip irrigation system by Engro-Asai supported Company of Civic Abyari is less than Rs50,000 (US$880) per hectare. PARC in collaboration with the local pump industry has also indigenized Raingun sprinkler irrigation systems (Hussain and Yasin 2003).

Watercourse Improvement

Considerable wastage of water occurs in watercourses. The main causes of operational losses are seepage, overflow, vegetation and rodent holes. Currently, the supply of canal water to the Pat Feeder and Khirther canals in Baluchistan is supplemented by more than 25,000 public and private tube wells in Baluchistan. Nearly 40% is lost in the delivery system due to improperly designed and maintained watercourses. Only 60% of water reaches the fields where field unevenness further accentuates the losses by 20–25% (Gill et al. 2002).

In the Sindh province, watercourse losses were in the range of 44%. After lining with PVC geo-membranes, water losses were reduced to less than 3% (Kazmi 2001). The Government of Sindh is also negotiating a watercourse-lining project with the WB. The project will be implemented in 28 villages of 4 districts of the Sindh province covering a total length of 50 km with 1.8 km per village (Memon 2002). Overall, in Pakistan about 33% of total watercourses have been improved.

Furrow-Bed Irrigation

The basin irrigation method is commonly used in the Sindh and Baluchistan provinces, with the highest water consumption and the lowest water use efficiency. Furrow-bed irrigation is considered the most efficient method of water application. Raising row-crops like cotton on beds with row-to-row spacing of 75 cm is gaining popularity amongst the farmers, mainly because it saves water; the cost of crop production is also substantially reduced. IWMI has conducted furrow-bed irrigation trials in cotton-wheat regions of Punjab and Sindh and results have been very encouraging. Planting of cotton on beds and furrow irrigation have resulted in a 30–35% increase in yield with around a 40–45% saving in water (IWMI 1999a). The technique is also being evaluated for rice production and has the potential to grow rice with less water (Gill et al. 2002).

Zero-Till Technology

Zero-till drill and production technology was developed by PARC during the late 1980s. PARC worked with the local manufacturing industry to initiate the local manufacturing of zero-till drills. Zero-till technology refers to planting crops without seedbed preparation. This technology has been introduced in the Sindh province. It has been beneficially used for planting wheat without any seedbed preparation after the harvest of rice. It allows utilization and conservation of the antecedent soil moisture, saves time due to early planting and increases wheat yield (IWMI 1999b; OFWM 1998). Around 30–40% of water can be saved with zero tillage along with precision land leveling. The area under zero tillage in Pakistan has increased exponentially over the last 4 years with 20 hectares in 1996–97 to 78,500 hectares in 2001–2002 (Gill et al. 2002).

Laser-Leveling Technology

Precision land leveling (PLL) improves irrigation application efficiency and increases the uniformity of application with less chances of overirrigation or under-irrigation. It is becoming increasingly popular among the farmers because of its benefits in terms of higher water use efficiency and crop yield. At present, the Directorate of Water Management is providing laser levelers to the farming community on a monthly rent (Memon 2002). The data collected in Punjab revealed that 80% of farmers benefiting from this technology have smallholdings (Gill et al. 2002). The main advantages of PLL are reduction in application losses of up to 25%, reduction in labor requirement by 35% and increase in crop yield by 20% (Sattar et al. 2001).

Adjusting Cropping Pattern with Water Availability

High-delta crops like sugarcane and rice not only consume a larger portion of available water but also contribute to waterlogging. Wheat, cotton, rice and sugarcane are the major crops of Sindh, which constitute 68% of the total cropped area, while the horticultural crops that Sindh produces are banana (73%) mango (34) and chili (88%). The combined effect of the recent drought and reduced irrigation water supply reduced the cropped area and crop production of major crops in Sindh in 2001–2002. In Baluchistan, due to the drying up of a large number of karezes and natural springs and reduced discharge from tube wells, the cropped area was reduced and productions were negatively affected in the same period. The reduction in the production of major crops in Sindh (compared to 1998–1999) was in the range of - 4 to -40% and in Baluchistan of -8 to -20% (GOP 2003).

The Government of Sindh decided that low-deltaic crops such as sugar beet, cotton and oilseeds should replace the high-deltaic crops like sugarcane and rice in accordance with the soil and climatic conditions. Following this policy, the Ministry of Food, Agriculture and Livestock initiated a campaign in the Sindh province to replace sugarcane area by sugarbeet, which resulted in increased areas under sugar beet in the lower Sindh province during the year 2001–2002. Sugarbeet grew well and growers welcomed it as a promising rabi crop.

Rice is the other high-deltaic crop to be replaced with cotton. Cotton not only gives better income to the farmers but also the gross revenue per unit of irrigation water is much higher for cotton than for rice (Memon 2002).

Existing and Required Institutional Mechanisms for Implementation

Departments of Agriculture (provincial and district) and water user associations (WUAs) are responsible for implementation of *Watercourse Improvement and Construction of Water Storage Tanks*. Under the Local Government Ordinance of 2001, the Department of Agriculture was decentralized, and among others, water management functions of the OFWM Directorate were also devolved to the District Governments.

The Department of Agriculture is the lead implementing agency and the provincial Directorate of OFWM has the overall responsibility for social mobilization to establish WUAs to implement watercourse improvement and construction of water-storage tanks. The Director of OFWM acts as the Project Director for the national and provincial programs and is responsible for implementation of projects through the District and Field Teams.

Laser leveling has been introduced in both the provinces under the OFWM projects. For large-scale introduction of this intervention, the federal and provincial governments are in the process of shifting this responsibility to the private sector and the farmers' institutions including the WUAs. The OFWM training institutions would be responsible for the training of the tractor operators and the engineering staff. The import duty and taxes on laser-leveling equipment have been removed under the recent package announced by the President of Pakistan for the farmers. As the laser-leveling units are now being produced locally, it is expected that repair and maintenance facilities would be available to the users shortly. Similarly, zero-till and the OFWM and Agricultural Extension staff in both the provinces are introducing furrow-bed systems.

In the Baluchistan province, the Irrigation and Power Department (IPD) is the main public-sector agency responsible for the planning and operation of irrigation schemes. The Public Health Engineering department, in collaboration with the local bodies and the Rural Development Department is responsible for providing drinking water to the rural communities. The Baluchistan Water and Sanitation Authority is responsible for the provision of water supply to the Quetta city. The IPD is responsible for developing major groundwater-development projects and installation of tube wells for the public-sector agencies and for private individuals. The PCRWR is involved in research related to the leaky delay-action dams in Baluchistan. The hand pumps are primarily installed by the local NGOs with the help of the Public Health Engineering and IPD.

In general, in the Sindh province, there is currently no established mechanism to promote and introduce the new technologies and to document their efficiency in mitigating drought impacts. Thus there is a need to have effective institutional mechanisms for the transfer of technology to the water users. Appropriate institutional arrangements are also needed for effective coordination between the line departments and the research and development (R&D) institutions in the province. Such arrangements are crucial to providing technical backstop and developing support to the rural and urban communities of the drought-prone districts. This could be accomplished by the establishment of an apex organization addressing the issues of drought and water management in the arid zones of the Sindh province.

A drought management plan is essential for the drought-prone districts of the Sindh province covering the Kohistan, Khirther range and the arid zones. The plan should include a clear coping mechanism to mitigate the impacts of droughts. Both Baluchistan and Sindh have limited water resources. But both still do not make efficient use of the available water resources. The existing irrigation-scheduling practices are still largely based on the conventional approaches of flood irrigation and have a tendency to overirrigate. To address this issue, an effective extension service is needed for the transfer of management practices and water-use-production technology to the farmers.

Farmers should be motivated and trained in the use of emerging efficient water-use methods such as sprinkler and drip irrigation, laser leveling, raised-bed planting, watercourse lining and water storage tanks, which have proven successful in different arid environments of Pakistan.

Due to the excessive exploitation of groundwater coupled with the successive and recurring droughts, groundwater tables in different parts of Sindh and Baluchistan have considerably declined. Traditional water-harvesting and irrigation systems often fail. This overexploitation of the resource has caused devastating impacts on drinking-water supplies for the urban and rural populations. To arrest this trend, the government needs to develop appropriate policies to effectively manage and monitor groundwater development and use. Steps should be taken for the revision and enforcement of water laws. Communities should be directly involved in the campaign of recharging the groundwater aquifers and in the conjunctive use and management of surface water and groundwater resources.

Prospects for New Technologies

Some of the interventions described have proved to be very effective and widely accepted by the farmers, planners and policymakers at the national level. The government is well aware of the huge water losses in canals and the need for On-Farm Water Management (OFWM) programs and is already developing a program for improvement and lining of 86,000 watercourses of the country to save water in the long-term (GOP 2004). Farmers have to share 55% of the cost of improving watercourses.

Under the OFWM-project funded by the WB, about 200 water-storage tanks, each with a capacity of storing 180 m^3 and serving from 5 to 10 farms, would be constructed during the next 4 years on a cost-sharing basis. Using the Government Federal Grant, the Government of Sindh has undertaken development schemes (duration of 12 to 36 months), which include installation of tube wells, construction of delay-action dams, small dams, recharge dams, drinking-water supply through pipelines, introduction of drip irrigation systems in Thar and Kohistan regions and community-based cactus plantations in arid zone of Sindh (GOS 2000).

The Government of Baluchistan decided to allocate a similar-sized Federal Government grant of around US$16 million to projects identified as medium- to long-term drought-mitigation strategies. These include the construction of 11 dams, 250 windmills, development of 28 tube wells, 50 low-cost water supply schemes and uplift of 100 karezes (FAO/WFP 2000a, b). In Baluchistan, rehabilitating the karez is a significant means of restoring water supply to communities. National NGOs, such as NRSP with funding from UNDP and the Federal Government have rehabilitated 112 karezes in Turbat. The introduction of high-efficiency irrigation systems has potential to improve water distribution and efficiency within the karez system.

In Pakistan overall, currently about 0.7 million hectares of land are being irrigated the through the rod-kohli system, where water is diverted from the hill torrents. There is a potential to irrigate 2 million hectares of agricultural land and this would need an investment of about US$85 million (GOP 2004).

Under the 10-year Perspective Development Plan (2001–2011), pilot projects for the sprinkler/drip systems over 4,000 hectares will be undertaken in the country (GOP 2001). In Baluchistan, where indiscriminate expansion of authorized and unauthorized tube wells and the overirrigation of orchards and vegetables have led to mining of groundwater aquifers, such systems are most appropriate and have a great potential. The drip-irrigation research concluded that it saves groundwater and significantly increases the yields of orchards.

Under the 10-year Perspective Development Plan (2001–2011) of the water sector, precision land leveling of about 150,000 hectares will be undertaken in the country (GOP 2001; GOP 2004). Due to lack of suitable arrangements for providing equitable access to farmers, so far only a limited number of demonstrations were possible, and these have been generally targeted for relatively large farms. The Government of Sindh is planning to consider a PLL program in each district by making the equipment available to the farming community on a cost-sharing basis. The prospects for the adoption of this technology are very high in future.

The land, water and climate play an important role in the adaptation of a cropping pattern but traditions affect the decision making. Many crops are still grown in places where other crops are more appropriate. Change of cropping pattern can have a significant effect on water savings. In the Sindh province, the production of sugar is much higher than the requirements of the province. Ahmad (2003b) proposed (in combination with improvement of watercourses and lining of canals) a 10-year strategy to reduce the rice and sugarcane cultivation by 20% and increase yield by 20% to meet the shortfall due to reduction in area. It is essential for Pakistan to introduce new crop zoning and cropping patterns to efficiently utilize the scarce water.

Current Institutions and Policies for Drought Mitigation

Drought Monitoring

Monitoring of drought-related hydrometeorological and other variables in Pakistan is carried out by several agencies, including the Pakistan Meteorological Department, Water and Power Development Authority, Provincial Irrigation and Drainage Authorities and District Governments.

Pakistan Meteorological Department (PMD)

PMD is a federal agency under the Ministry of Defense, with a mandate to monitor and analyze meteorological parameters including drought events. It maintains a network of about 200 meteorological stations across the country. A Drought and Environmental Monitoring Centre (DEMC) has been established within the organizational setup of the PMD. This center has planned to install 350 additional meteorological stations, particularly to strengthen the existing drought-monitoring system in the country. The DEMC has also established the Regional Meteorological Centres in each of the four provinces to provide support for monitoring of drought at the provincial level. The Regional Meteorological Centers collect the real-time data of meteorological parameters and communicate these to the PMD headquarters for analysis (PMD 1999, 2000, 2003). Regional Meteorological Centres are located in Quetta (Baluchistan), Karachi (Sindh), Lahore (Punjab) and Peshawar (NWFP).

At PMD headquarters, data and information received from the Regional Meteorological Centres and shared with WMO are processed and synthesized using established methodologies and criteria related to drought indices to generate information related to drought hazards. If the numerical values computed using the drought indices indicate that a certain area has been engulfed in drought conditions, then PMD asks the respective meteorological station(s) to supplement the climatic findings with the physical surveys and ground-truth analysis in the drought-affected areas. If the ground-truth surveys also support the empirical findings, then PMD communicates the drought-alert signals the Home Secretary of the respective provinces and the Emergency Relief Cell within the Cabinet Division of the Government of Pakistan to take necessary measures in the affected areas.

PMD explores drought characteristics like intensity, magnitude and extent (spatial and temporal). For the assessment and characterization of drought events and drought-affected areas, PMD has been using *Percent Normal Method*, *Aridity Index* and *Standardized Precipitation Index* as drought indicators (PMD 1999, 2000, 2003).

Percent Normal is the simplest drought indicator and can be calculated by dividing the actual precipitation of any station with normal precipitation (typically based on 30-years' mean). If the rainfall is less than 40% of seasonal normal rainfall at any station for two consecutive seasons (winter and summer under Pakistani conditions), the drought conditions are set on for that particular station. PMD has identified drought-prone areas of the country by analyzing the historical precipitation data (1931–1988) of important locations. Time-series charts of the seasonal rainfall amounts thus developed have revealed that the higher the seasonal normal values, the lesser the chances of drought incidence and vice versa. As a result, Northern Areas, NWFP and parts of the northern Punjab have seldom experienced droughts, where seasonal normal is higher due to the presence of western disturbances. Contrary to these, the areas lying in the south and southwestern side of the country (Sindh and Baluchistan and Southern Punjab) have lower seasonal normal and, consequently, have more drought-prone features.

Aridity Index (AI) was used by the PMD as a criterion to evaluates drought-severity conditions (light, moderate or severe). The Aridity Index is defined as a ratio of 50% probability of rainfall to the actual crop evapotranspiration. The computation of Aridity Index requires data on precipitation and reference crop evapotranspiration. Meteorological data of temperature, humidity, and wind speed and sunshine hours are needed to compute the reference evapotranspiration.

Standardized Precipitation Index (SPI) quantifies the precipitation deficit for multiple time scales. These time scales reflect the impact of drought on the availability of different water resources. The SPI calculation for any location is based on the long-term precipitation records for a desired period. This long-term precipitation record is fitted to a probability distribution, which is transformed into the normal distribution so that the mean SPI for the location and desired period is zero. Positive SPI values indicate greater-than median precipitation, while negative values indicate lesser-than median precipitation. Because the SPI is normalized, wetter and drier climates can be represented in the same way, and wet periods can also be monitored using SPI.

A drought event occurs any time when SPI is continuously negative and reaches intensity where the SPI is −1.0 or less. The event ends when SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and intensity for each month that event continues. The accumulated magnitude of drought is a positive sum of SPI for all the months within a drought event. PMD (2003) has analyzed the last drought episode in the country by using SPI as a criterion at 48 locations of the country with different time scales.

Water and Power Development Authority (WAPDA)

WAPDA is a federal agency responsible for collection of river flows, hydrometeorological data in the Indus basin and its catchments and for analyses of the impacts of any climatic changes in the river flows, storage-reservoir levels and groundwater levels in the country. WAPDA maintains the largest number of hydrometeorological and stream-gauging stations in the country. The processed information is made available to the concerned federal and provincial agencies through fax and on the website in case the country is facing a drought. They also provide such information to the Indus Rivers System Authority (IRSA), to the Federal Committee on Agriculture and, in addition, to the PMD and the drought-relief and mitigation-related agencies. In the recent drought, such information was made available to all the concerned parties on a daily basis through fax by the IRSA.

Provincial Irrigation and Drainage Authorities

These authorities are responsible not only for managing the canal deliveries but also for monitoring the canal diversions and distributing water within the canal network in the Indus basin. They are also responsible for sharing this information with all the concerned institutions in the country and work on an emergency basis during the drought periods. They also exercise the practices and schedules for managing the shortages in the canal supplies. During the drought period of 1998–2002, provincial Irrigation and Power Departments (IPDs) implemented comprehensive interventions including a) conservation of water releases from storage reservoirs during slack demand period and their reallocation during critical stages, b) canal water allocations on a priority basis to canal commands having brackish groundwater, and c) operating canals on revised rotations.

The District Governments

District Governments now include Departments of Agriculture, Livestock, Public Health, Revenue, etc. The field staff report to their respective district headquarters and the provincial departments any unusual changes due to a prolonged dry spell, i.e., reduced water availability for agriculture, livestock and for rural population. They also report such happenings to the District Governments, as these departments have been devolved and now their district staff are directly under the control of the district administration. The District Coordination Officer and the Nazim (District Public Representative) coordinate the information provided by various line departments and keep the provincial administration informed accordingly. The devolution system certainly has an edge to coordinate the monitoring information at the local level.

The major limitation in the monitoring of the drought is the integration of the hydrological, meteorological and socioeconomic information, as no single institution is responsible for the monitoring of drought in the country.

National Calamity Act

The Federal Government is responsible for developing a framework and undertake necessary mitigation measures and relief support for the social and economic revival of calamity-stricken areas (due to floods, droughts, earthquakes) and communities. The West Pakistan National Calamities (Prevention and Relief) Act, 1958, provides the required legislative basis and framework to counter the effects of various hazards. According to this Act, whenever a province or any part thereof is affected or threatened by calamities (droughts, floods, earthquakes, fire epidemic or any other disaster), the Government, by notification declares the whole or any part of the province as a calamity-affected area (GOP 1958).

This Act entrusts the provincial Board of Revenue to appoint a Relief Commissioner (which most of the time, is the senior-most member of the Revenue Board) for calamity-declared areas including the drought-affected areas. The primary role of the Relief Commissioner as outlined in the 1958 Act is reproduced as follows:

Collect field reports about losses of life, livestock and property and apprise the provincial and federal governments of these losses. Suggest compensatory fiscal amount for the calamity-affected areas, to the provincial and federal governments including postponement of land and other government taxes, tariffs, revenues, etc. Provide approved compensation to the affected population through District Relief Officers. The focus of the Act is therefore on relief measures.

Drought-Relief Measures

Whenever, under the National Calamity Act of 1958, any part of the country is declared as a drought-affected area, the federal, provincial and district governments have to respond to the situation by initiating a variety of relief and mitigation measures. The emergent relief measures for the severely affected communities include distribution of food, fodder, water, tents, blankets, medical supplies, and mobile medical and vaccination teams. Relief expenditures are supported through emergency budgetary allocations by both the federal and the provincial governments.

Depending on the drought severity, as suggested by the drought-monitoring and assessment, and resulting vulnerabilities, the Government of Pakistan may designate an area as either *drought-*

affected or *severely drought-affected*. The relief plans initiated for the rehabilitation of these two categories vary. The government allocates more funds and undertakes extensive relief measures on a priority basis in the severely affected areas compared to the less-affected areas. Furthermore, in *severely affected* areas, the government may either waive off the land and other revenue taxes, postpone or even write-off the loan recoveries, may extend the special cash grants from the higher authorities (President, Prime Minister or Governor) along with the emergency relief supports of subsidized or free ration and water supplies, public and veterinary health facilities and fodder for livestock.

Problems observed in relief operations during the latest droughts in Baluchistan and Sindh included a) lack of a database on assessment and impacts of drought; b) lack of an appropriate analysis of the records and data collected; c) the attitudinal and behavioral problems; d) lack of commitment and devotion in relief operations and distribution of materials; e) lack of service orientation, especially in the health services; f) lack of awareness and culture of the relief camps; g) clear-cut role of the public and private-sector institutions and interdependencies; h) lack of public participation and media support; i) moral values of the society; and j) lack of coordination among the line departments.

Assessment of Required Relief

To estimate the worth of these relief-support programs as well as to prioritize the specific requirements of drought-affected areas, under the present legislative framework, the Provincial Relief Commissioners have the responsibility for drought assessment and to apprise the Federal and Provincial Governments of the required relief support. Most of the time, Relief Commissioners accomplish this task through the Provincial Board of Revenues and Revenue Departments.

To evaluate the impacts of drought on the livelihood of the rural and urban population and on the availability of water resources for domestic, water and irrigation purposes, extensive field visits and surveys are carried out by the Provincial Revenue Departments in drought-affected areas (GOB 2003). Similarly, the impacts of drought on health, sanitation and nutrition conditions in the drought-affected areas are also assessed through extensive field surveys and visits. In addition to the official field surveys and visits, NGOs and international donor agencies (UNDP, WFP, FAO, WHO) also conduct studies and surveys for the assessment of food and nonfood requirements in the drought-affected areas with an objective to provide information on the assessment of the severity of drought impacts. The Relief Support Programmes of donor agencies are structured on the basis of the requirements given by the government. Such surveys were conducted by FAO and UNDP during 1999–2002, which provided a realistic assessment of the damages of droughts and assessment of requirements for the Relief Support Programme (UN 2001; WB 2001; UNDP 2003).

The Board of Revenue of the Sindh Government carried out an assessment of the recent drought during 1999–2002 in the Sindh province while NGOs (Pattan, Action Churches together) and donor agencies (FAO, WFP, WHO) carried out independent surveys to evaluate the food, health and sanitation conditions in the drought-affected areas (PDO 2001; UN 2001; WB 2001, UNDP 2003).

The Bureau of Statistics, under the overall supervision of Planning and Development Department, Government of Baluchistan, carried out an assessment of the impacts of drought during 1998–2002 while the UNDP, FAO, OXFAM, and Islamic Relief carried out independent surveys in drought-affected areas of the province to evaluate food- and nonfood-supply assessments in the province.

Based upon these survey results, the Relief Commissioners of the concerned provinces rationally quantify and prioritize the relief-support measures, so that optimal compensation (both in cash and kind) for the affected communities can be ensured. To coordinate various relief measures for social and economic revival and rehabilitation of the drought-affected areas in the country as well as to maintain the liaison with the international donors, the Federal Government has established the institution including the following:

- Federal Drought Emergency Relief and Assistance (DERA) Unit
- Emergency Relief Cell (ERC) in the Cabinet Division of the federal government
- National Steering Committee

Drought Emergency Relief and Assistance (DERA) Program

For rehabilitation of the drought-affected areas of the country during the latest drought, the Government of Pakistan commissioned the DERA Program. For the execution of the activities of the DERA Program, funding was sought from the international donor agencies. The ADB and WB responded to the request of GOP and a total loan of US$140 million was approved (ADB contributed US$100 million and the WB contributed US$40 million). In addition to the loan, the government allocated US$20 million (mainly in the form of services) for the DERA Program. Out of a total DERA finding of US$160 million, the share of Sindh and Baluchistan provinces was 30% each, while allocations for Punjab and NWFP were 25% and 15%, respectively.

The focus of the program is on the provision of sustainable drinking-water supplies, water management and conservation for sustainable livelihood (agriculture and livestock), support for construction of roads and restoration of drought-affected orchards. The program also provides essential social services. Based on the source of funding, the DERA Program has been subdivided into the *Drought Impact Mitigation and Recovery Component (DIMRC)* and the DERA component.

The sectors identified for investment under WB funding (*DERA component*) in drought-affected areas of the country are irrigation, road construction, agriculture and rural water-supply schemes. However, the major thrust was on the provision of water supply, road construction and irrigation facilities, where 36, 35 and 23% of the total allocation under the DERA component were invested. In the Sindh province, the priority sectors were road construction and water-supply schemes for which 76 and 23% of the provincial allocations were utilized while, the situation was altogether different in the Baluchistan province, where irrigation was the top priority sector and where 54% of the provincial share was spent in the water sector.

The funding of the ADB (DIMRC) is mainly focused on water, agriculture, health, road construction and community welfare schemes in the drought-affected areas of different provinces. However, different provinces have different priority sectors. For example, the emphasis of the Government of Sindh is more on road construction in drought-affected areas, where 75% of the provincial DIMRC allocations were invested. In the Baluchistan province, the main thrust was on schemes related to water development. Installation of tube wells, rural water-supply schemes, construction of delay-action dams and improvement and renovation of karezes were accomplished in drought-affected areas of the province.

Federal Institutional Arrangements

The Emergency Relief Cell is a part of the Cabinet Division, Government of Pakistan. The history of this Cell dates back to 1970, when a catastrophic cyclone caused widespread devastation in the former East Pakistan. This Cell prepared a "National Disaster Plan" in 1974. The purpose of the Disaster Plan was to establish procedures, prescribe an organizational setup, fix primary responsibilities and support functions of the implementing agencies involved and standardize procedures for monitoring of the disaster operations. The plan embraces all disaster situations and envisages utilization of available resources (governmental, semigovernmental and nongovernmental). Being action-oriented, functional and flexible, the plan is capable of meeting disaster situations of various intensity as well as multiple contingencies. Despite being small, the Emergency Relief Cell is playing a substantial role in mitigation of disaster including drought:

- Provide assistance in cash and in relief materials to supplement the resources of provincial governments during droughts.

- Maintain liaison with international aid-giving agencies, volunteer organizations and donor countries for drought-relief measures.

- Administer the Prime Minister's Food Relief Fund at the federal level.

- Provide mobility including helicopters for rescue of the affected people and for relief operations.

To accomplish these responsibilities/operations in drought-affected areas the following infrastructure is available with ERC.

The *Emergency Control Room* of the Emergency Relief Cell goes into operation during the flood or drought season or other natural disasters. It maintains constant liaison with the Engineers Directorate of Pakistan Army, Federal Flood Commission, Pakistan Meteorological Department, Provincial Governments Relief Commissioners and Relief Officers. Daily situation reports are received from the drought-stricken areas through the Provincial Governments and the concerned Federal Agencies, and a comprehensive report is compiled depicting the latest position of the drought-affected area. Such reports help in decision making and in channelizing the relief operations.

Warehouse of the Emergency Relief Cell is located at Islamabad for stockpiling of essential relief items to be used during emergency situations. The Warehouse has basic nonperishable medicines and nonperishable goods (blankets, clothing and tents, etc.) that can be rushed to the affected areas at short notice.

A Deputy Director, located at Karachi, heads the relief *Goods Dispatch Organization* of the Emergency Relief Cell. This organization is responsible for making arrangements for receipt and dispatch of all relief goods from foreign and local agencies in the event of a disaster. The organization is also responsible for clearance and making flight arrangements at airports, seaports, refueling of planes, reception of crews, custom clearance and all other related formalities.

The *Aviation Squadron* of the Emergency Relief Cell maintains a fleet of six helicopters out of which three are nonoperational due to the nonavailability of spare parts. These helicopters are detailed for rescue operations during disaster and visits of relief officials to the drought-affected areas.

For the effective coordination and monitoring of the DERA program at the federal level, the Government of Pakistan has appointed Secretary, Planning and Development Division as the Federal Drought Coordinator. To assist the Federal Drought Coordinator, the National Steering Committee was established during November 2001. The steering committee is chaired by the Deputy Secretary, Planning and Development Division and has representation from various federal, provincial and international donor agencies. The Steering Committee has constituted the DERA Unit as its Secretariat, which is headed by the National Project Director. The primary function of the Steering Committee is to analyze and approve the relief schemes as submitted by the provincial DERA Units.

Provincial Institutional Arrangements

To coordinate, monitor and implement the drought-response strategy at the provincial level, the Relief Commissions were established under the instruction of the Federal Government. In addition to these, the provinces also have their own mechanisms to strengthen the relief-support activities within provincial jurisdictions. Similarly, to execute and monitor the DERA activities, provincial Steering Committees and Secretariats in the form of DERA Units have been constituted in all the four provincial headquarters. The specific institutional arrangements of the Baluchistan province (established during the latest drought) include the following:

- Relief Commission, Quetta
- Drought Crisis Control Centre (DCCC)
- Provincial Drought Management Committee (PDMC)
- Provincial DERA Unit, Quetta

The specific institutional arrangements of the Sindh province (established during the latest drought) include the following:

- Relief Commission, Karachi
- Provincial Steering Committee
- Provincial DERA Unit Karachi

The structure and role of the district-level institutional arrangements in the form of District Drought Control Committees have also been included in the DERA manifesto, but these are practically either nonexistent or inactive.

Political Aspects of Drought Declaration and Mitigation

Drought is not a sudden event but rather a process, which accumulates slowly over time in any region or area. As a result, it provides ample time for the state managers to undertake preemptive measures to minimize the vulnerabilities of the regions that are at risk. However, since governments have to initiate extensive programs at huge investment costs, they tend to ignore the issue at its emerging stage. Similar politics/tactics are being practiced in Pakistan, where economic stability is always questionable. The Government of Sindh, with an objective to avoid the rigorous pressure exerted by the extensive relief measures on limited fiscal resources, tries to ignore the dilemma being developed in the drought-affected areas. However, when the national and international media and NGOs highlight the sufferings in the drought-affected areas, and also the government perceives the green signals of donations from the international community, the initiatives are taken by the authorities.

The other interference of the politicians is to get their own districts declared as drought-affected to seek relief support. Therefore, politics also plays a critical role in the declaration of the drought-affected areas. The media and local NGOs also play a vital role in documenting the impacts of droughts and the assessment of the needs of the relief measures.

Political considerations also affect the measures, which are planned to reduce the distress and havoc of the drought-affected regions through several ways. First, if a drought-affected area belongs to a public representative who is from a ruling party, it may get relief support on a priority basis, even if the situation is not “that bad.” On the other hand, if the drought-affected area is under control of a public representative of the opposition group, the relief may come late and be insufficient; and consequently, the disaster becomes inevitable. Similarly, some pressure groups within the government oppose relevant plans, which may alleviate droughts in the longer run. Strong opposition to the construction of new surface storage dams on the Indus is just one example.

Gaps in Drought Mitigation

Gaps in Knowledge and Information

Impacts of Tube Wells on the Karez System

The *traditional water-harvesting and management* interventions used by the rural communities were sustainable compared to the introduction of the new technologies during the last three decades. For example, the karez was a traditional water-harnessing and irrigation system, which was sustainable for the development and utilization of scarce resources of groundwater in the fragile ecosystems of Baluchistan. The karez water-harnessing and irrigation system was designed using the local knowledge and skills to address the needs of the rural communities irrespective of their investment capacities. Therefore, the resource-rich and resource-poor farmers were equally involved in the development of karez and the system was aimed to have social equity, where water was available to all the households based on their contribution in the development of the karez system. With the development of deep tube-well technology and the provision of the National Electric Grid system in Baluchistan, the indiscriminate exploitation of groundwater through deep tube wells resulted in drying of karezes, and the resource-rich farmers started drilling deeper to ensure pumping of sufficient quantities of water under the conditions of continuous lowering of the water table.

The descriptive information on traditional and new technological interventions is available, but there is a complete gap of quantitative knowledge on how the new technologies affected the traditional and sustainable interventions like karezes. There is hardly any information available regarding the impact of new technologies in lowering of the water table and mining of groundwater in Baluchistan. Similar impacts were observed in the arid zones of the Sindh province, where indiscriminate use of groundwater by deep tube wells has led to the drying up of the shallow dug-wells and intrusion of saline water. There is a unique opportunity in Baluchistan to document the impacts of deep tube-well technology on the drying of karezes, which resulted in shifting the benefits of electric tariff subsidy to the resource-rich farmers. Baluchistan provides a unique opportunity to the *Region* in the assessment of the impacts of new technologies on the karez system. A comprehensive research study is needed to address this issue in a scientific manner.

Spate Irrigation and Groundwater Recharge

In Baluchistan, the *sailaba (spate irrigation)* system was historically given higher priority prior to the introduction of deep tube-well technology and the availability of electricity. The government is now providing a subsidy of Rs7 billion per annum on electric tariff for 14,363 deep tube wells, which provided opportunity to farmers to overexploit the groundwater for growing high-value crops. This resulted in the neglect of the sailaba system, which was very effective in spreading of floodwater and recharging the groundwater. Instead of the development of the sailaba system, delay-action dams were constructed by deploying huge financial resources to recharge the groundwater aquifer. There is a general consensus that the delay-action dams provide recharge to the shallow groundwater under very localized conditions. The contribution of delay-action dams for recharging the deep groundwater and at regional or basin level is still to be documented.

In general, little is known about the efficiencies of artificial recharge methods, which are a major issue in the Baluchistan province and the arid zones of the Sindh. Little is also known about the performance of water-harvesting and conservation methods under drought conditions of different extremity and about their impacts on the water-resources availability and sustainability.

There have been studies to address the issue of *sedimentation* in the delay-action dams due to the heavy inflow of sediments in the floodwater. The concept of *Leaky Delay-Action Dams* was developed by the PCRWR, which reduces the speed of floodwater but allows slow release of floodwater downstream of the dam through outlets. This intervention is promising and might provide an effective intervention for the recharge of groundwater. However, there is a need to conduct a comprehensive study to document the techno-economics of delay-action dams in recharging the shallow groundwater in the localized and the regional contexts. Pakistan can share the experiences in recharging the groundwater in arid fragile environments with other countries in the region.

Research and Adaptations

There is hardly any institution having a mandate for R&D in the area of drought mitigation. The Arid Zone Research Center (AZRC), Quetta (an institution PARC) is involved in research related to the drought-prone areas, but their activities are limited to the agronomic, economic and management research for the khushkhaba areas and rangelands. The technologies developed by AZRC perform only if there is sufficient incidental rainfall; otherwise, crop harvests are not possible under drought conditions. The other limitation is that AZRC does not work at the scale of hydrological units, like river basins, and their research focuses primarily at the farm level.

In Pakistan's Indus basin, a number of water-management interventions has been developed over the last two decades. This includes water management at the farm level, especially the improved water conveyance and application technologies. But these technologies were not tested in the drought-prone areas. Thus there is an opportunity to test and evaluate these interventions in drought-prone areas of Baluchistan and Sindh provinces of Pakistan. In addition, Pakistan can also benefit from Iran's experiences in the area of drip irrigation, as it is much ahead of Pakistan. Reciprocally, Iran can benefit from Pakistan's experiences of watercourse improvement, laser leveling and furrow-bed irrigation systems.

Drought Preparedness and Mitigation

The knowledge and information for designing drought preparedness and mitigation measures are limited. The gap in knowledge is basically due to the disjointed efforts conducted by various institutions. Pakistan can learn from the countries of the region (e.g., India) that have been developing programs for drought mitigation.

Institutions

The institutional arrangements are reasonably well defined for the drought-relief activities, but there is hardly any institutional mechanism for drought preparedness and mitigation to address the long-term issues.

There is a lack of appropriate institutional arrangements and mechanisms to develop effective linkages between the public-sector institutions, nongovernmental organizations, the private sector and the civil society. Although these institutions worked in a more collaborative fashion during the latest drought period, such collaboration was limited to the so-called relief measures and never became part of their routine activities.

Presently, there is no comprehensive drought-mitigation infrastructure and strategy at the federal and provincial levels. Contrary to the well-established flood mitigation with adequate institutional arrangements, the drought-mitigation activities, by and large, are managed on an ad hoc basis. Institutional arrangements and their capacities are inadequate at the federal and provincial levels to effectively launch the early warning systems, preparedness and contingency plans, and rehabilitation measures, while such arrangements are nonexistent at the district level.

The major limitation in the monitoring of the drought is the integration of the hydrological, meteorological and socioeconomic information, as no single institution is responsible for the monitoring of drought in Pakistan.

Pakistan can learn from the regional experiences from Iran and India by sharing knowledge and information in the area of drought preparedness in relation to the institutional aspects. A regional study on institutional aspects is very much needed to share existing experiences and to learn how an effective institutional framework can be developed through a regional effort.

Policies

There is hardly any policy of the Governments of Baluchistan and Sindh for drought preparedness, mitigation and coping mechanisms. Only ad hoc measures were adopted after the recent drought, which persisted during the last 6 years (1998–2004).

Recently, the ADB initiated a Programme Loan for Baluchistan entitled "Baluchistan Resource Management Programme," which has four components: a) fiscal and financial management, b) public-service delivery, c) water-resources management policy, and d) private-sector development strategy. The formulation of the Water Resources Management Policy was well received by the Government of Baluchistan and other stakeholders because of the severe impacts of the prolonged drought (1998–2004) on the mining of groundwater and lowering of the water table.

The formulation of the Water Resources Management Policy would depend on the availability of reliable information regarding the availability and use of water resources, which is very limited at present. In Pakistan, information on the Indus basin is reasonable, but areas outside the Indus basin, including Baluchistan, have been neglected. Thus there is a gap in reliable information on surface water and groundwater. The impacts of drought were so severe that there is urgency for the reassessment of the resource availability.

Although there is an understanding for the need to formulate a policy there is hardly any commitment at the political level to enforce such a policy. Therefore, there is a need to initiate R&D activities to support the development of an implementable policy and a reforms agenda.

Everyone is convinced that lack of implementation is a major issue but hardly any systematic effort exists for the identification of mechanisms for the implementation of any policy or reforms. Therefore, there is a need to study alternative options for implementation of drought-mitigation and water-resources-management policy and reforms. Another issue is the impact of socioeconomics and political regimes on the drought preparedness and mitigation policies in the region, as the political system always affects technological and institutional efforts.

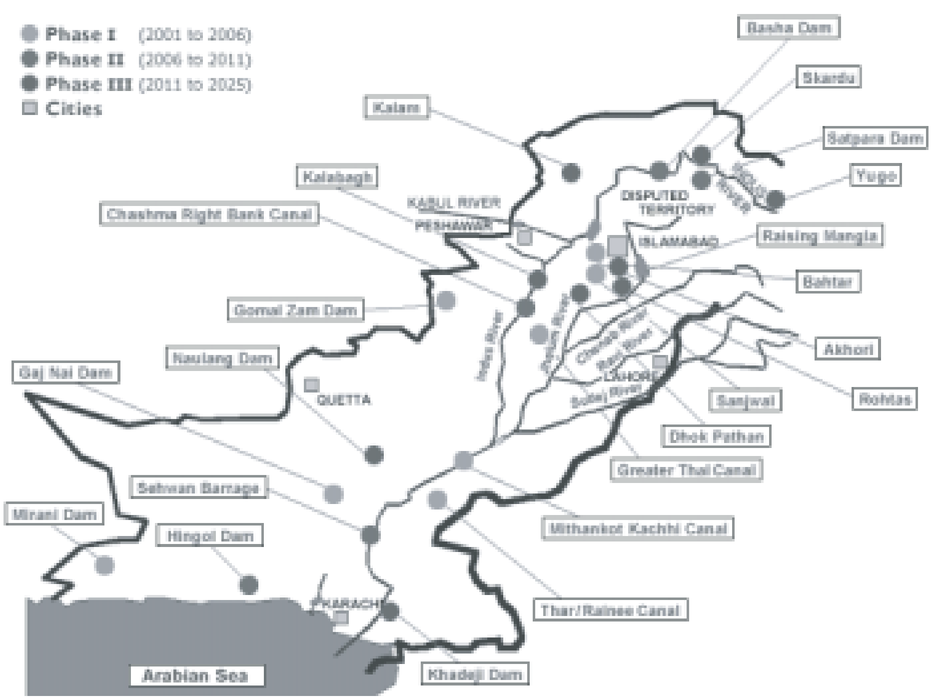
Options for Future Strategy

Technological

The APN study on the "Impacts of Climate Change on Availability of Water Resources in South Asia," including Pakistan indicated that extreme events like *droughts* and floods are going to become *severer* in the future. Considering the probability of having more frequent droughts in the future, there is a need to integrate the aspects of drought and water management by developing a strategy for research on *"Drought and Water Management"* in an integrated fashion. In fact, there should be one word giving the meaning of both drought and water management in arid environments, particularly those outside the Indus river basin.

Overall, in Pakistan, drought management should be part of the larger national water-development strategies and plans. WAPDA's comprehensive program of Water Resources and Hydropower Development has been designed to avert the impacts of droughts and desertification in the country on a longer-term basis by augmenting the existing canal-water supplies. The projects included in the Vision along with the site locations are presented in figure 3. The projects of *Vision 2025* have been included in the *Perspective Development Plan* for the period 2001–2011. Work on several projects (Mangla Dam Raising, Rainee, Katchi and Greater Thal Canals) has already started. All the three mentioned canals will provide water to drought-prone areas (WAPDA 1987, 2001).

Figure 3. Location map of the water development projects envisaged under Vision 2025.



The *future strategy* for technological development should depend on the realistic assessment of the surface-water resources in the fragile drought-prone environments, as the groundwater resources in these environments are limited. A good example is the Baluchistan province where the groundwater resources constitute 4% of the annual available water resources. The other 96% is available from the surface-water resources. Therefore, emphasis should be placed on surface water, out of which, around 30% is available from the Indus basin and 66% from the floodwater. Out of the floodwater, around 30% is utilized and the balance 70% is lost unutilized. Thus the potential source of development is the *floodwater*, which could be, and is, presently being used for the sailaba area, dependent on spate irrigation. The situation is similar in arid zones of the Sindh province. The other aspect worth considering is the risk involved in the availability of floodwater due to low rainfall. There is a need to conduct research for the development of a strategy for technological development with active participation of water users and link spate irrigation with interventions related to recharge of the groundwater. The unutilized floodwater available for potential development in Baluchistan is around 12 billion m^3, which is equivalent to the designed live storage capacity of the Tarbela dam.

Presently, the Irrigation and Power Department is actively involved in the construction of delay-action dams for recharging the groundwater. The effectiveness of these dams is questionable from two standpoints: First, whether the delay-action dam contributes significantly to recharging the shallow groundwater or deep groundwater. Second, what is its contribution at the local and regional levels? The Government of Baluchistan is stuck with making a decision on the effective ways of recharging the groundwater.

In summary, the *strategy* for technological development in Baluchistan and arid areas of Sindh should be based on the *assessment of the potential resources available for development through integrating activities of spate irrigation with the objective of spreading of floodwater to increase the command area and recharging the regional groundwater resources.*

Institutional

The institutional aspects of *spate irrigation and regional groundwater recharge* are very complex and include water user institutions, line departments, district governments, research institutions, policy institutions and public representative institutions.

The major problem is that the Irrigation and Power Department is engaged in, and will continue to handle, spate irrigation and groundwater recharge activities in traditional surface irrigation approaches. In fact, there is a need to document the traditional systems of spate irrigation and then *evolve improvements with active participation of the water users' institutions* prevailing in the area. The major issue is how to make the traditional water user institutions sustainable in terms of both capacity and financial autonomy.

The *institutional development strategy* should revolve around the existing institutions and the policies related to the participation of users in the planning, appraisal, design and implementation of the schemes. There is also a need to review the existing structure and mandate of the public-sector institutions, especially after the devolution at the district level; the role of the provincial institutions was never reviewed. This is also a handicap in the development of the district governments and the implementation of the devolution agenda.

The introduction of the devolution was an effort in the right direction, but due to the lack of reorientation of the provincial institutions and identification of the revised role, the whole experiment of devolution is at stake.

Most of the line departments have been devolved under the district government, except the Irrigation and Power Department. The *basin-wide* approach is always preferred to the sustainable management of water resources. But all the other line departments are organized under the boundaries of the district administration. Therefore, the conflict between the *administrative and hydrological boundaries* has to be resolved to achieve the overall objective of sustainable resources management under drought conditions.

In summary, institutional development is needed to have active participation of water user institutions in the management of water resources. This would be achieved through assigning specific roles to the water user institutions and reorientation of the provincial line departments. There is also a need to bridge the gap between administrative and hydrological boundaries.

Policy

In the policy arena, there is a need to have IWRM and Drought Mitigation Policy for Baluchistan and Sindh provinces of Pakistan. The ADB, under the Baluchistan Resource Management Programme, has started formulating the Policy Paper on IWRM in which drought-mitigation measures will also be considered. But there is complete lack of support information and knowledge to develop an efficient policy and reform agenda. The following aspects should be considered as part of the proposed strategy:

- Review the existing policies related to drought and water management and identify the policy research areas.

- Identify the potential national collaborators for initiating the policy research covering areas like reassessment of the resources, basin-wide management plans, implementation of the drought-mitigation and water-management interventions, institutional arrangements, participation of water user institutions including gender participation, etc.

- Presently, the emphasis of the policy is on providing subsidy on electricity tariff, infrastructural development like the construction of surface irrigation schemes and delay-action dams, whereas very little emphasis is placed on the management of the resource. This resulted in mining of groundwater and lowering of the water table.

- There is a need to formulate policies which link the development of the resource within the framework of the IWRM and drought mitigation.

- The basin approach is essential for the management of the resource; therefore, policy research is needed on how to bridge the conflict between the hydrological boundaries and the administrative boundaries.

- A poverty reduction focus is essential along with the management of the resource. Therefore, research is needed on how the poor are located within the existing ecosystems covering the canal irrigated area, minor perennial irrigation schemes, tube-well irrigation, sailaba and khushkhaba. An interesting aspect is that electricity subsidy is given to the 50% of tube well owners who are operating their tube wells on electricity, whereas the balance 50% tube wells are being operated on diesel fuel. Thus diesel operated tube well owners are deprived of any subsidy. Another aspect is that the poorest of the poor live in the sailaba and khushkhaba areas, which are completely neglected. Drought-related policies should help in poverty alleviation in these areas.

- One critical issue is the high O&M of the water schemes for both water supply and irrigation. The concept of hading over of the schemes to the community fails because they cannot manage these schemes due to the high O&M costs. In fact, the community was never asked what type of schemes they wanted and what level of O&M they could manage. There is a need to review the existing policy of infrastructure development in drought-prone areas.

Conclusions and Recommendations

The *existing system* of *monitoring drought* and *its impacts* on various sectors is weak. The dissemination and sharing of the available information to the civil society and between and across government departments and with organizations outside government system are limited. There is a need to develop a *policy for the access to information* related to drought and water management. Such information databases themselves are limited at present. A similar situation exists at the *regional level.* Sharing and exchange of information regarding drought monitoring and impact assessment are also limited among the countries of the region. India is ahead in this regard and Pakistan can learn from their experiences. Similarly, exchange of information and building joint programs between Pakistan and Iran would help the two countries as the climate and environment are similar in both countries (at least in Baluchistan and adjacent areas of Iran).

Both target areas (provinces) considered in this document have limited water resources in areas outsides the Indus basin. Still they do not make efficient use of the available resources. Farmers are not aware of actual crop water requirements and irrigation-scheduling practices are still largely based on the amount of water available with the farmer and the situation of the farm. Farmers tend to *overirrigate* to cover the unleveled fields. Efforts are needed to help farmers in efficient conveyance and application of pumped groundwater. The *water-management technologies* developed in the Indus basin regarding conveyance and application of water at the farm are very promising as Pakistan was ahead of the countries in the region. Even then such technologies were hardly tested and adapted in the drought-prone areas. Pakistan can provide a unique opportunity to share the experiences of the watercourse-improvement program, laser leveling, furrow-bed irrigation, skimming wells and salinity management. Similarly, Pakistan can learn from India and Iran in the area of drip and sprinkler irrigation systems as both these countries are ahead in this regard. A *regional research and development program* for drought and water management seems justified for exchanging experiences and knowledge and building future activities.

Farmers should be encouraged and motivated to use indigenous water-harvesting technologies for sailaba and khushkhaba areas. There is a need to understand the traditional systems of sailaba and khushkhaba and suggest improvements within the existing framework instead of introducing conventional surface-irrigation schemes. The use of local knowledge and wisdom is essential along with active participation of local water user institutions. Pakistan is ahead of the region in developing the sailaba irrigation as such systems have been in place since 3000 BC. These systems of *water spreading* if *integrated with recharging the groundwater* can provide cost-effective intervention for mitigating the drought impacts. The spate-irrigation development provides a workable option for the normal years and such systems do not provide water during droughts. Thus the population has to migrate from these areas during the drought. Therefore, provision of *water-storage dams* can provide a source of small-scale irrigation for the drought periods so that rural communities can stay in these areas. Furthermore, such dams can also provide a source for supplemental irrigation. Provision of water for high-value agriculture in sailaba systems would be the ultimate goal of mitigating the impacts of drought. The experiences of Iran under the Program of Jihad-a-Sadindgi are highly valuable for other countries of the region to learn how the rural communities and the experts were motivated to construct small storage dams.

Due to the excessive *exploitation of groundwater,* coupled with successive *droughts,* the water tables in different parts of Sindh, especially in Baluchistan, have declined considerably . In Baluchistan, even karezes (traditional groundwater irrigation systems have dried up. This overexploitation of the resource has caused devastating impacts on drinking water supplies for urban and rural populations. For conservation of the resource, the government needs to develop appropriate policies to effectively manage and monitor groundwater development and use. Steps should be taken for the revision and enforcement of water laws. Communities should be directly involved in the campaign of recharging the aquifers and in the *conjunctive use and management* of surface water and groundwater resources. Pakistan's Indus basin experiences of conjunctive use of water have to be used and adapted in the drought-prone areas of Baluchistan and Sindh provinces. Such experiences if translated for the nonirrigated areas can provide excellent examples for the countries of the region.

The use of *efficient irrigation methods, farm layout, balanced use of fertilizer and pesticides,* and integrated nutrient management remain limited and is one of the key factors underlying low productivity in Sindh and Baluchistan. There is a need to arrange *demonstrations by the WUAs* to disseminate a full range of improved water-management and water-use-crop-production practices to the WUA members. Training of WUA members would be an essential element of the whole program. A program of breeding and selection of crop varieties, which can extract water from a deeper level should be established. Such varieties coupled with water management can revolutionize sailaba areas. The character of the sailaba system is that 1–2 irrigations of 1–1.5 m depths are applied to mature the wheat crop. The soils are rich in nutrients and farmers are not using any chemical fertilizers, as every flood brings fresh silt of 5–7 cm in depth. These ecologies are therefore potential locations for organic farming in the region.

Farmers should be encouraged, motivated and trained in the adoption of *efficient water-use technologies* such as sprinkler and drip irrigation, laser leveling, raised-bed planting, rainwater harvesting, watercourse lining and water-storage tanks, which have proven successful in different arid environments of Pakistan. Involvement of the private sector in the provision of services to farmers is the only workable option, as the public-sector institutions are not tuned to provide services in this regard.

A *drought-mitigation plan* is essential for the drought-prone districts of the Sindh and Baluchistan provinces. This should also include climatic change impacts on the availability of water resources and to develop coping mechanisms to address the drought impacts. In fact, such a plan has to be integrated in the overall perspective development plan so that all the sectoral development plans should look into drought-mitigation aspects in their routine development activities.

Presently, there is no comprehensive *drought-mitigation infrastructure and strategy* at the federal and provincial levels. Contrary to the well-established flood mitigation with adequate institutional arrangements, the drought-mitigation activities are, by and large, managed on an ad hoc basis. Institutional arrangements and their capacities are inadequate at the federal and provincial levels to effectively launch the early warning systems, preparedness and contingency plans, and rehabilitation measures, while such arrangements are nonexistent at the district level. In fact, this is the weak area in the region as a whole. This justifies *a regional initiative* to evaluate the existing institutional setup and mechanisms for drought mitigation and build an effective structure and mechanisms, which can be adopted by the countries of the region.

To mitigate the drought impacts, it is essential to formulate and adopt a *National Drought Policy* on a priority basis. The suggested *guiding principles* for the formulation of the National Drought Policy include the following:

- Favor preparedness over insurance, insurance over relief and incentives over regulations.
- Set research priorities to address the needs of rural communities and urban households considering the effectiveness and limitations of the existing coping mechanisms.
- Coordinate the activities of the drought-mitigation services at the federal, provincial and district levels.
- Participation of public representatives and the civil society is an essential element of any policy.
- A consultation and communication strategy should be formulated while developing the National Drought Policy. The purpose is to build understanding and ownership of the Policy by all the stakeholders.
- Sharing and exchange of experiences from the countries of the region having similarities.

Preparedness, which includes drought planning, plan implementation, proactive mitigation, risk management, resource stewardships, consideration of environmental concerns and public education should be the elements of the new policy. This policy would require a shift from the current emphasis on ad hoc relief measures to the proactive risk management.

For *implementation of the National Drought Policy,* there is a need to *establish an apex organization* for the planning, coordination and monitoring of the policy interventions at the federal level. This organization may be entrusted with the responsibility for providing an enabling framework to the provincial governments, where they are motivated to establish a similar organizational setup at the provincial levels to provide linkages and coordination among the line departments and the district governments. A consultant input will be required to prepare the outline for the proposed organization at the federal and provincial levels. At the district level, a District Drought Mitigation Committee would be required to implement and monitor the programs as envisaged by the federal and provincial governments.

There is a need to develop regional *R&D Program for Drought Mitigation and Water Management* through active involvement of international organizations and NARS. It should be aimed at a) sharing and exchange of existing knowledge and information between participating countries, b) studying the policy and institutional aspects under each participating-country National Program and encouraging testing and adoption of successful interventions in the participating countries, and c) evaluating the impacts of socioeconomic and political changes on the policies of drought and water management in the region.

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