Report No. R-49

BALOCHISTAN COMMUNITY IRRIGATION AND AGRICULTURE PROJECT

COMMUNITY IRRIGATION SYSTEMS IN THE PROVINCE OF BALOCHISTAN

by

OLAF VERHEIJEN

HALCROW – EUROCONSULT-NESPAK - TECHNO CONSULT
Technical Assistance Team
PO Box 255, Quetta, Balochistan

April 1998
PAKISTAN NATIONAL PROGRAM
INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE
LAHORE

BALOCHISTAN COMMUNITY IRRIGATION AND AGRICULTURE PROJECT

COMMUNITY IRRIGATION SYSTEMS IN THE PROVINCE OF BALOCHISTAN

TABLE OF CONTENTS

TABLE OF CONTENTS i

LIST OF FIGURES ii

LIST OF TABLES iii

LIST OF BOXES iv

NOTATION AND GLOSSARY v

FORWORD vi

SUMMARY vii

1 INTRODUCTION 1

2 PROVINCE OF BALOCHISTAN 3

2.1 AREA AND LOCATION 3
2.2 TOPOGRAPHY AND SOILS 3
2.3 CLIMATE 6
2.4 POPULATION 8

3 WATER RESOURCES AND IRRIGATION SYSTEMS 10

3.1 FLOOD IRRIGATION 10
3.2 WATER HARVESTING 20
3.3 PERENNIAL IRRIGATION 20
3.3.1 Large Scale River and Canal Systems 21
3.3.2 Minor Irrigation Systems 21

4 AGRICULTURE 22

4.1 LAND UTILISATION 22
4.2 MODE OF IRRIGATION 23
4.3 LAND TENURE AND FARM SIZE 28
4.3.1 Land Tenure 30
4.3.2 Farm Size 30
4.4 AGRICULTURAL LABOUR AND MECHANISATION 32
4.5 TENANCY 34
4.5.1 Sharecropping 34
4.5.2 Hereditary Tenancy 35
4.6 CROPPING PATTERN 36
4.6.1 Cereals 37
4.6.2 Vegetables 40
4.6.3 Fruit Crops 40

5 MAIN WATER SOURCES **42**
5.1 KAREZE SYSTEMS 42
5.2 SPRINGS 48
5.3 INFILTRATION GALLERIES 48
5.4 RIVER INTAKES 50
6 WATER AND LAND RIGHTS **53**
6.1 WATER RIGHTS 53
6.1.1 Special Water Rights *53*
6.1.2 Number of Water Shareholders *55*
6.1.3 Distribution of Water Rights *57*
6.2 LAND RIGHTS 58
6.2.1 Distribution of Land Rights *60*
6.2.2 Farm Size *60*
6.2.3 Communal Land *61*
6.3 LEASE AND SALE OF LAND AND WATER RIGHTS 63
6.3.1 Sale of Land and Water Rights *63*
6.3.2 Lease of Water Shares *64*
6.3.3 Tenancy *65*
7 OPERATION AND MAINTENANCE ARRANGEMENTS **69**
7.1 WATER DISTRIBUTION 69
7.1.1 Irrigation Cycle *69*
7.1.2 Role of Water Bailiff in Water Distribution *72*
7.1.3 Water Distribution System *73*
7.2 MAINTENANCE OF WATER SOURCES AND CONVEYANCE SYSTEM 74
7.2.1 Maintenance of Water Sources *75*
7.2.2 Maintenance of Conveyance System *76*
7.2.3 Contribution of Labour and Money for Scheme Maintenance *78*
7.2.4 Role of Water Bailiff in Scheme Maintenance *79*
8 AGRICULTURAL SYSTEMS **81**
8.1 AGRICULTURAL SYSTEM IN HIGHER ALTITUDE AREAS 81
8.2 AGRICULTURAL SYSTEM IN LOWER ALTITUDE AREAS 85
8.3 AVERAGE YIELDS FOR MAIN CROPS 88
Bibliography **91**

LIST OF FIGURES

Figure 1.1. Location map of Balochistan Province 2
Figure 2.1. Divisions and Districts of the Province of Balochistan. 4
Figure 2.2. Physical relief of the Province of Balochistan 5
Figure 2.3. Average annual rainfall over the Province of Balochistan. 7
Figure 3.1. Major river basins in the Province of Balochistan 11
Figure 8.1. Crop calender for 4 BCIAP Community Irrigation Schemes above 4,000ft altitude in Balochistan. 85
Figure 8.2. Crop calender for 4 BCIAP Community Irrigation Schemes below 4,000ft altitude in Balochistan. 86

LIST OF TABLES

Table 4.1. Land utilisation in Balochistan in 1972 and 1980. 15
Table 4.2. Cultivated area classified by mode of irrigation in Balochistan in 1972 .and 1980. 16
Table 4.3. Area irrigated by different perennial sources of irrigation in Balochistan. 17
Table 4.4. Development of wells and tubewells installed in Balochistan. 18
Table 4.5. Land tenure of private farms and farm area in Balochistan in 1972 and 1980 23
Table 4.6. Number and area of private farms by size of farm in Balochistan in 1972 and 1980. 24
Table 4.7. Number of tractors and threshers in Balochistan 25
Table 4.8. Tenancy Arrangements in Balochistan in 1972 and 1980. 26
Table 4.9. Agro-climatic zones in Balochistan 28
Table 4.10. Cropped area for cereals in Balochistan. 30
Table 4.11. Cropped area for major vegetables in Balochistan. 30
Table 4.12. Cropped area and average yield for major fruit crops in Balochistan. 31
Table 5.1. Distribution of 340 community irrigation schemes by district and by water source. 34
Table 6.1. Quartile distribution of water rights and number of water shareholders for BCIAP Community Irrigation Schemes in Balochistan. 49
Table 6.2. Average perennially irrigated cropped area for 17 BCIAP Community I rrigation Schemes in Balochistan. 52
Table 6.3. Sale prices for water shares for a number of community irrigation systems in Balochistan. 55
Table 6.4. Tenancy arrangements in 19 BCIAP Community Irrigation Schemes in Balochistan. 58
Table 6.5. Additional tenancy conditions in 10 BCIAP Community Irrigation Schemes in Balochistan. 59
Table 7.1. Irrigation cycles for 19 BCIAP Community Irrigation Schemes in Balochistan 61
Table 8.1. Climatic conditions for 11 BCIAP Community Irrigation Schemes above 4,000ft altitude in Balochistan 73
Table 8.2. Cropping patterns for 11 BCIAP Community Irrigation Schemes above
4,000ft altitude in Balochistan. 75
Table 8.3. Climatic conditions for 8 BCIAP Community Irrigation Schemes below 4,000ft altitude in Balochistan 77
Table 8.4. Cropping patterns for 7 BCIAP Community Irrigation Schemes below 4,000ft altitude in Balochistan 79
Table 8.5. Average Yield, Financial Gross Revenue and Financial Gross Margin per acre for main crops in 16 BCIAP Community Irrigation Schemes in Balochistan. 80

LIST OF BOXES

Box 1. Kareze Development in Ahmad Wal. 38
Box 2. Traditional Infiltration Galleries in Killi Oras. 40
Box 3. Free Intake Structure in Mirjanzai. 42
Box 4. Special Water Rights in Munara Kalan Kareze. 46
Box 5. Distribution of Land Rights in Kunara. 50
Box 6. Complex water distribution system in pandran. 63
Box 7. Maintenance of main channel in Kunara. 68

NOTATION AND GLOSSARY

ACTUAL CURRENCY EQUIVALENTS

US$	1	=	Rs	40.07 (March 1997)
Rs	1	=	US$	0.0249

PREVIOUS CURRENCY EQUIVALENTS

US$	1	=	Rs	26.00 (June 1993)
US$	1	=	Rs	34.34 (November 1995)
US$	1	=	Rs	35.90 (August 1996)

WEIGHTS AND MEASURES

Imperial/US Units		**Metric Units**
1 inch (in)	=	25.4 millimetres (mm)
1 foot (ft)	=	0.305 metres (m)
1 mile	=	1.609 kilometres (km)
1 ton	=	1.016 metric tonne (t)
1 acre	=	0.405 hectares (ha)
1 cusec (ft^3/sec)	=	0.0283 cumec (m^3/sec)

Pakistan Units		**Imperial Units**		**Metric Units**
1 maund	=	82.3 lbs	=	37.32 kg

GLOSSARY

Awara	-	block rotation
Barani	-	rain fed agriculture
BCIAP	-	Balochistan Community Irrigation and Agriculture Project
Chashma	-	spring
Ghanda	-	flood diversion bund
Jagir	-	revenue holding
Kareze	-	underground water collection conduit
Kharif	-	summer irrigation season, from June to September
Khushkaba	-	agriculture irrigated by runoff
Mir-i-aab	-	water bailiff
Nullah	-	river channel with intermittent flow
Rabi	-	winter irrigation season, from October to May
Rais	-	water bailiff
Sailaba	-	flood irrigation
Sardar	-	tribal leader
Shamilat	-	communally owned

FOREWORD

The author, Mr. Olaf Verheijen, has been closely associated with the "Balochistan Community Irrigation and Agriculture Project" (BCIAP) and a similar project that preceded BCIAP. As a sociologist, he was responsible for establishing socio-economic criteria for selecting community irrigation systems to be included in the project. The Foreign Ministry of The Netherlands has provided some of the funding for both projects.

The Headquarters of IIMI, located in Colombo, Sri Lanka, has provided core funding during 1997 and 1998 to establish a research program in the Province of Balochistan. This program, under the direction of Dr. M. S. Shafique and assisted by Ms. Ineke Kalwij, was initiated at the Agriculture Research Institute on 1 June 1997.

IIMI hopes to significantly expand the research program in Balochistan during 1999. This study has already proven to be quite valuable in selecting potential research sites. We would like to thank the consulting firms of Halcrow (United Kingdom) and Euroconsult (The Netherlands) for permitting us to publish this report. Finally, we have much appreciation for the good work of Mr. Olaf Verheijen and wish him continued success in Kenya.

Gaylord V. Skogerboe
Director
Pakistan National Program
International Irrigation Management Institute, Lahore

1 INTRODUCTION

In Balochistan, approximately 265,000 hectares (655,000 acres) are irrigated by small scale perennial irrigation systems, which have been mainly developed and are operated and maintained by the farmers themselves. The main water sources for these minor irrigation systems are karezes, springs, wells, infiltration galleries and diversion structures and they range in size from a few hectares to several thousand hectares of irrigated land. Most small irrigation systems with a well as the main water source are individually owned and operated, whereas minor schemes with other water sources normally belong to a community of shareholders. The number of shareholders sharing a small irrigation system ranges between a few families resident in one small village to several hundred belonging to several villages. The aim of this paper is to describe the main characteristics of community irrigation systems in Balochistan.

Most information is derived from reconnaissance visit reports to 185 community irrigation schemes throughout the Province and screening reports for 20 schemes, which have been selected for development under the Balochistan Community Irrigation and Agriculture Project (BCIAP)[1].

Before the main aspects of community irrigation systems in Balochistan are described in Chapter 5 to Chapter 8, the main characteristics of the Province of Balochistan and its agricultural sector will be presented in order to give the context in which community irrigation systems have been developed and are operated within the Province. Statistical data from two Agricultural Censuses and the Agricultural Statistics of the Balochistan Agricultural Department have been used to describe the land use, farm size and the cropped areas for different crops. Although the quality of these statistical data could be questioned, they have been used to give a general picture of the agricultural sector in Balochistan and the different trends during the 1980's and the first half of the 1990's.

---

[1] The Project is implemented by the Government of Balochistan through the Provincial Irrigation Department with the technical assistance of two foreign consultancy firms, Sir William Halcrow & Partners Ltd and Euroconsult, and two consultancy firms from Pakistan, NESPAK and Techno-Consult, aimed at the development of 30 perennial irrigation schemes and 4 flood irrigation schemes with a high level of community participation.

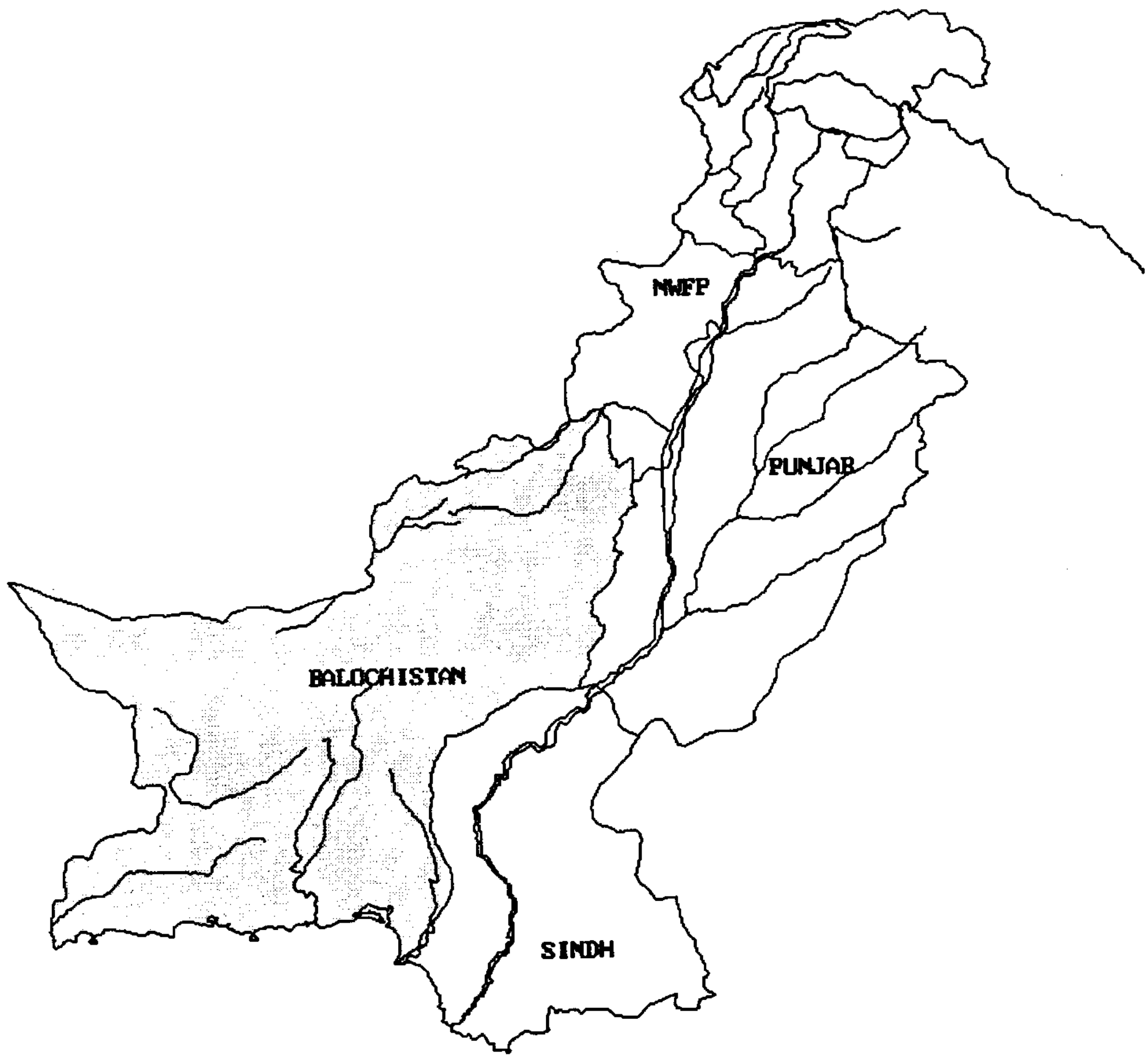


Figure 1.1. Location map of Balochistan Province.

2 PROVINCE OF BALOCHISTAN

2.1 AREA AND LOCATION

The Province of Balochistan is the largest of Pakistan's four provinces with a total area of 347,220 km^2 and constitutes about 43% of the country's total land area. It lies between latitudes 25 and 32 north and longitudes 62 and 70 east. Balochistan forms the southwest part of Pakistan and is bounded by the Arabian Sea in the south, Iran and Afghanistan to the west and north, and the North West Frontier Province and the provinces of Punjab and Sindh to the east. Balochistan is divided into six administrative divisions and 27 districts.[2] A map of Balochistan with the divisions and districts together with the district headquarters is given in Figure 2.1.

2.2 TOPOGRAPHY AND SOILS

Balochistan was formed by the uplifting, folding and faulting of mainly sedimentary rock formations of the Indo-Pakistan subcontinent colliding with the Asian continent. Along the western front of this movement, there are several active faults associated with frequent seismic activity, the most famous being the Quetta earthquake of 1935. A number of extinct volcanoes are situated in the Koh-i-Sultan Range in the west of the Province.

Topographically, Balochistan is the eastern extension of the Iranian plateau, subdivided by moderately high to high mountain ranges running roughly north-south and extend into the Himalayan system. The highest mountains, including the Sulaiman, Toba-Kakar-Khurasan and Central Brahui ranges, are located in the northern and central parts of the Province with most peaks and passes over 2,300 metres (7,000 feet). The highest mountain, the Loe Sar, reaches 3,500 metres.[3] The physical relief of the Province is given in Figure 2.2.

Approximately 51.7% of Balochistan's land area can be classified as high and low mountains, whereas 21.5% as gravelly fans and terraces, 11.6% as piedmont plains, 7.5% as sand plains, 2.8% as river plains and 2% as saline basins or playas.[4]

---

[2] Pakistan/Netherlands Project, Strengthening of Planning and Development Department (June 1994): Concept Eighth Five Year Plan 1993-1998 Government of Balochistan, p.1-3; Balochistan Minor Irrigation and Agricultural Development Project - Phase II (June 1993): Project Preparation Report Volume 1, p.8; Balochistan Community Irrigation and Agriculture Project (May 1995): Technical Proposal Volume 1 Main Report, p.1.

[3] BMIADP (June 1993): Project Preparation Report Volume 2 Annex 1, p.1; BCIAP (May 1995): p.3; World Bank (August 1995): Staff Appraisal Report Balochistan Community Irrigation and Agriculture Project, p.1.

[4] Van Gils and Baig (January 1992): Environmental Profile of Balochistan, p.9.

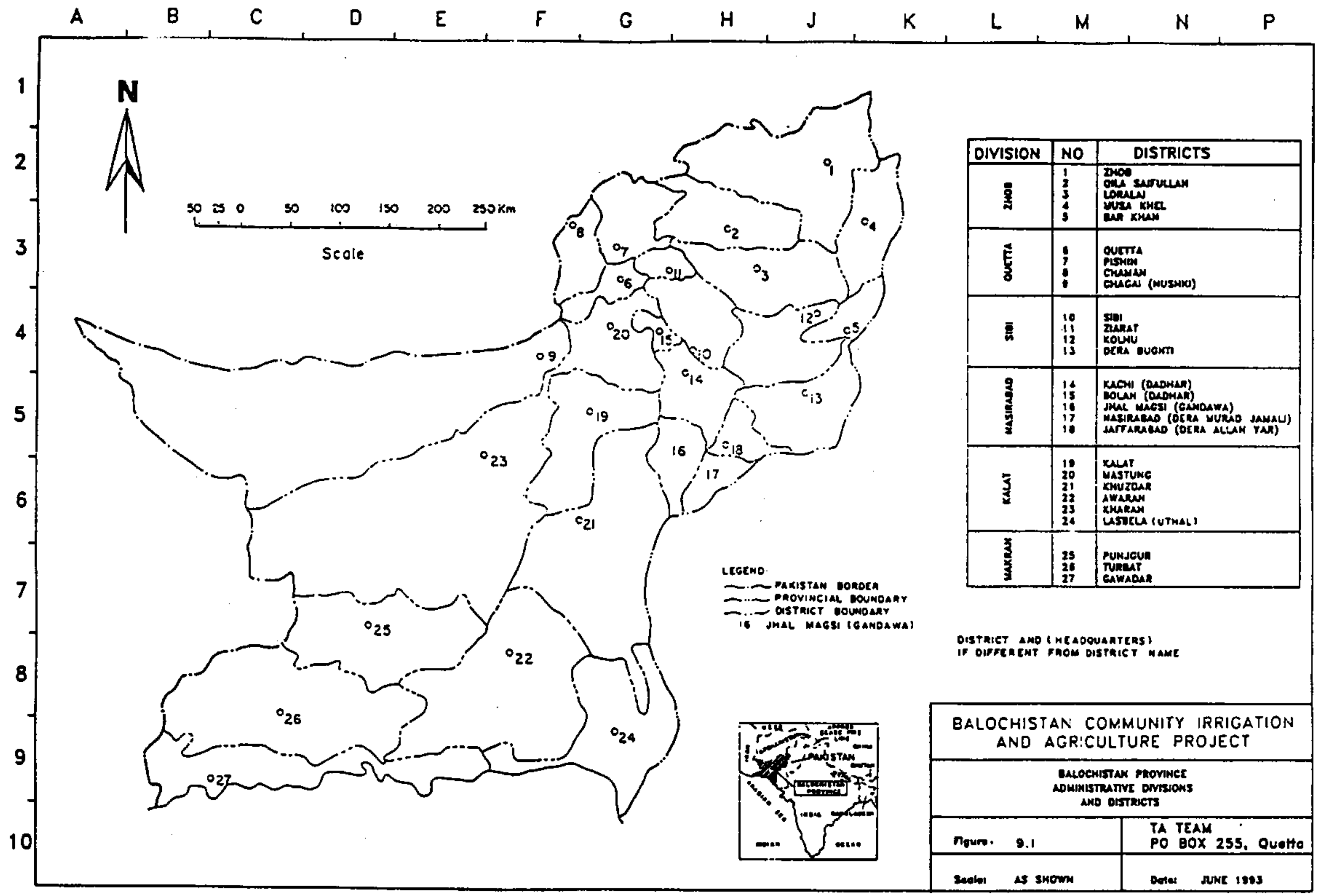


Figure 2.1. Divisions and Districts of the Province of Balochistan.

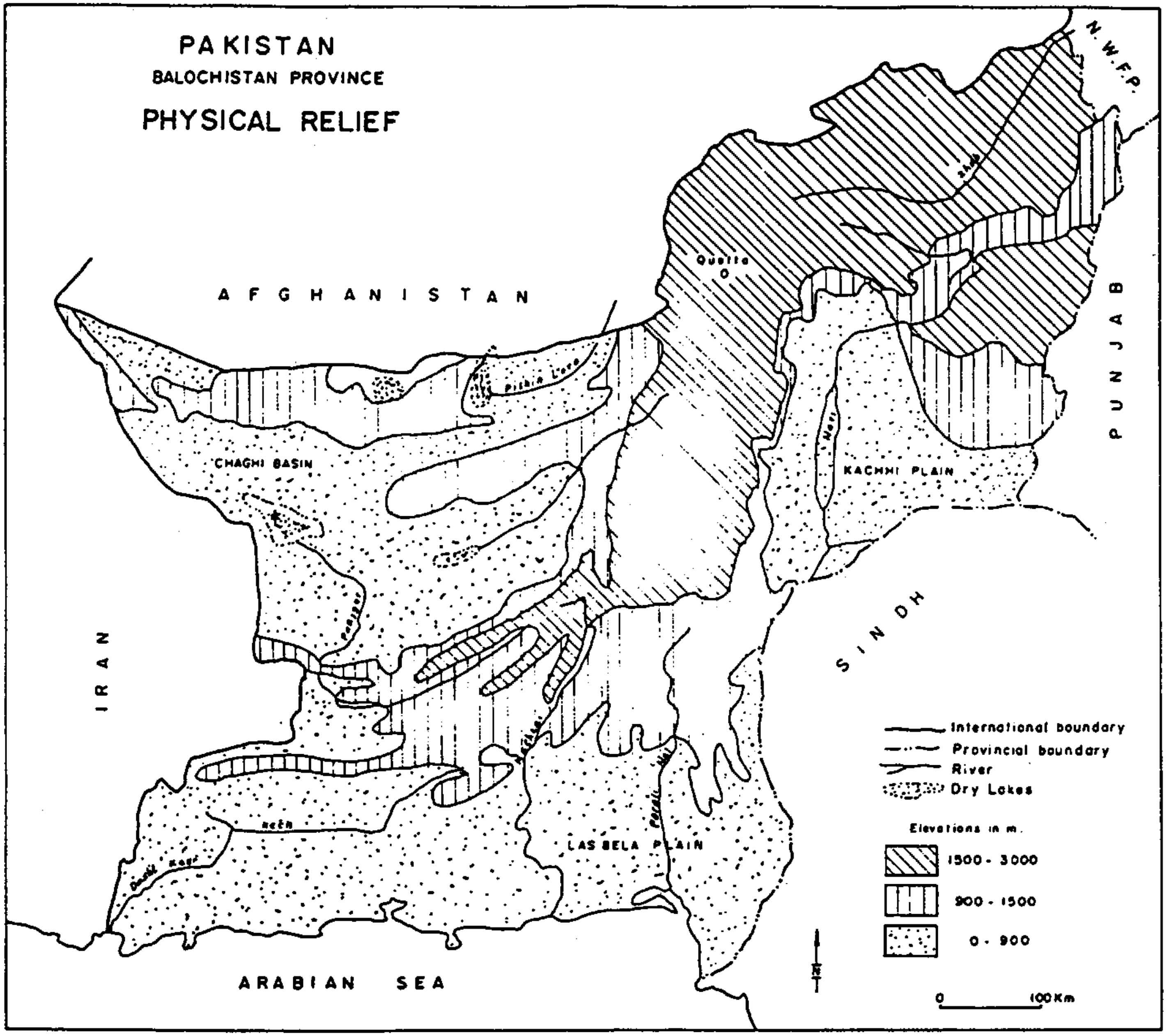


Figure 2.2. Physical relief of the Province of Balochistan.

The soils in Balochistan are derived from limestone, sandstone and shale. On the mountain peaks and upper slopes, over 75% of the surface is generally bare rock. At the foot of the mountains, gravelly fans and terraces are located with older soils having gravelly textures, which are 40cm to 80cm deep, strongly calcareous and mildly to moderately alkaline. The soils of the piedmont plains are generally deep, free draining loams and silty loams with occasional patches of clays and sandy loams. These soils are usually strongly calcareous and become very hard when dry, whereas they are strongly alkaline and the organic and nutrient content is low. Most of the potentially arable soils in Balochistan are confined to the piedmont and river plains, where the soils are generally fine textured and deep.[5]

2.3 CLIMATE

Balochistan has a continental semi-arid climate and is strongly influenced by topography. The climate is characterised by extremes of temperatures ranging from very hot summers on the plains in the east of the Province to freezing winter conditions in the mountainous north.

Temperatures in the south of Balochistan are moderated to some extent by the Arabian Sea, but inland there is marked continental effect resulting in high annual and daily ranges. Typical mean daily summer temperatures range from 27.5 °C in Muslimbagh at an altitude of 1,800 metres (5,900ft) to 38.1 °C in Sibi, which is only 133 metres (440ft) above sea level. The corresponding mean daily temperatures in January for Muslimbagh and Sibi are 3.7 °C and 13.8 °C, respectively. Above 1,500 metres (5,000ft), winter frost is common and in higher areas it can be severe with minimum temperatures of minus 20°C or below.

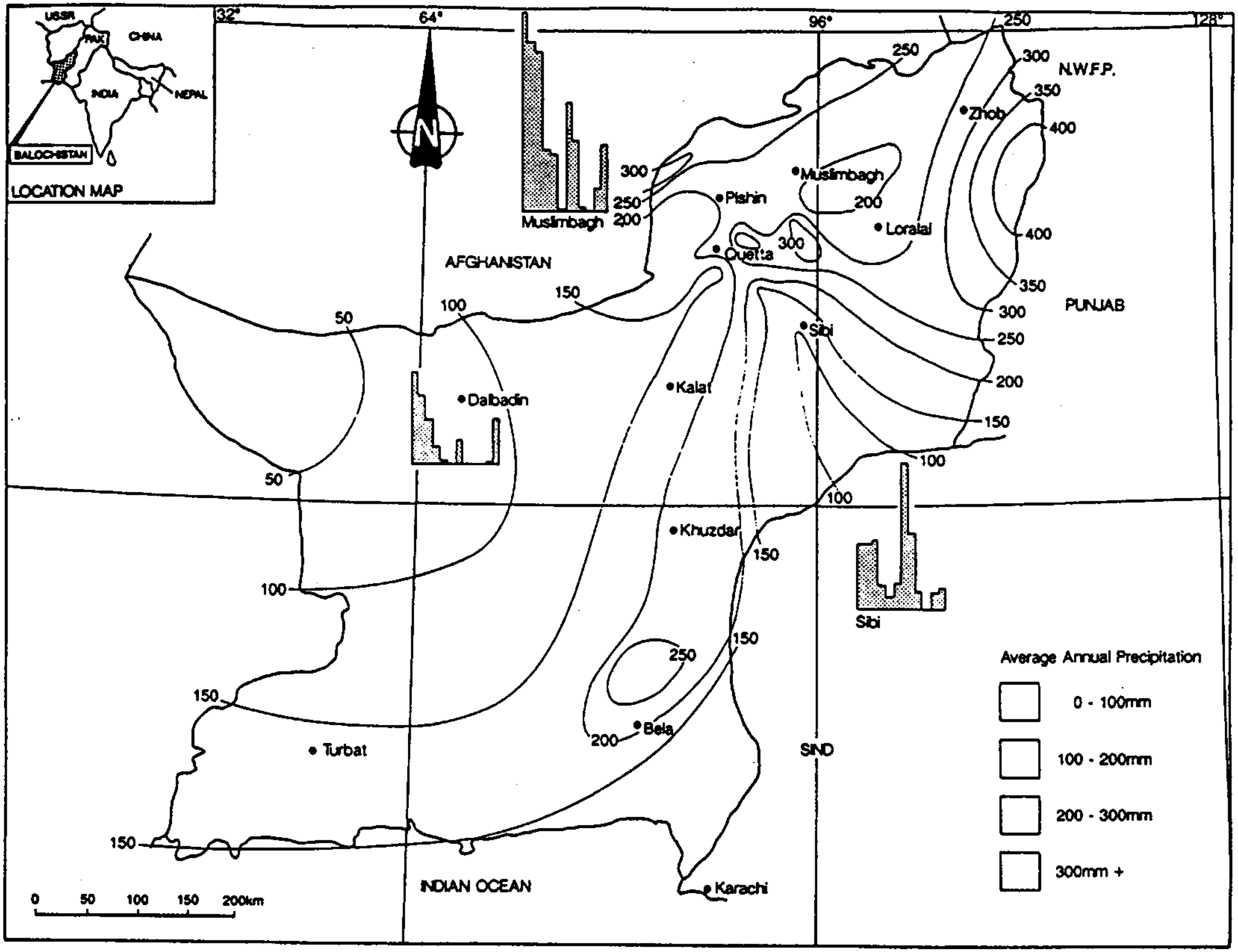
The Province falls under the influence of three rainfall patterns. Between November and April, western depressions originating in the Mediterranean area or over the Persian Gulf are drawn in by the extensive anticyclonic system which lies over southern and central Asia. When the moist air is forced to rise over the northern and central mountain ranges, it condenses and falls either as rainfall with a gentle intensity or snow. From June to August, eastern depressions bring the monsoon and the rainfall is characterised by intense storms of short duration. During the transitional periods of May-June and September-October, Arabian Sea cyclones occasionally move westward or northwestward to the coast of Balochistan causing disturbances in the normally more settled weather conditions during these months.

Due to these three weather systems and the topography of the Province, the west of Balochistan receives most of its rainfall during the winter months, whereas in the east, it occurs in summer and in the centre on a line through Las Bela, Khuzdar, Loralai and Zhob the summer and winter rains are roughly equal. The mountain ranges in the north and centre of the Province effectively block the continued westward movement of the monsoonal systems. The median annual rainfall ranges from just over 400mm in the northeast to less than 50mm in the west of the Province. In the low altitude region in the east of Balochistan an average of 7 to 10 rainy days are recorded annually, whereas the lower mountainous regions have 10 to 19 rainy days and the higher mountainous regions 20 to 28 days. Rainfall is very unreliable in timing and amount from year to year and place to place.

Generally, humidity is low ranging between 40% and 50%, but it increases in the higher areas during the winter months under the influence of western depressions and over most of Balochistan in July and August when the monsoon penetrates the Province. Annual evapotranspiration often exceeds 2,000mm. An isohyetal map of the average annual precipitation over the Province is given in Figure 2.3.

---

[5] BCIAP (May 1995): p.4.



BALOCHISTAN PROVINCE: AVERAGE ANNUAL PRECIPITATION

Figure 2.3. Average annual rainfall over the Province of Balochistan.

2.4 POPULATION

During the first four decades of the twentieth century, the total population of Balochistan ranged between 800,000 and 860,000. The severe autumn of 1918 and famine in 1920 and 1921 seriously reduced the population. In 1951, the population rose to 1,086,591. In the second half of the twentieth century, Balochistan has experienced a large increase in its population. In 1961, the population was estimated at 1,251,837 and in 1971 at 2,428,678. According to the most recent Population Census of 1981, the population rose to 4,305,000 or 5.1% of the total population for Pakistan. According to A.H. Siddiqi[6], many factors may have caused the increase, but better coverage and more accurate enumeration are important ones.

Assuming that the population growth rate has remained at the national level of 3.0%, the estimated population in 1995 would be approximately 7.16 million. During the 1980's, Balochistan experienced an influx of about 1.5 million refugees from Afghanistan and their subsequent repatriation in recent years has had a significant effect of the demographic development of the Province.

According to the Census of 1981, 84.5% of the total population of Balochistan was living in rural areas. The population is clustered in a few favourable areas, whereas many parts of the Province have hardly any population. Important clusters of people can be found in the Quetta Valley with a density of 143 persons per km^2, the central portion of the Pishin Plain with 87 persons per km^2 and Nasirabad District with 69 persons per km^2. Secondary clusters occur in the productive river valleys of the Zhob River, the Loralai and Anambar Basins and the Kalat-Khuzdar area.[7]

More than 40% of Balochistan's population still leads a nomadic or semi-nomadic way of life by travelling between the mountainous areas for summer pastures to the lowlands for winter pastures. However, the nomadic way of life is undergoing significant changes due to reduced access to pastures and restricted freedom of movement. Consequently, most tribal groups have become less dependent on livestock and derive incomes from transport, handicraft, agriculture and migrant labour.

The population of Balochistan is ethnically heterogenous with three main ethnic groups. The Pathans are largely found in the north of the Province, such as Quetta, Pishin, Zhob and Loralai areas. The Balouchis are mainly living in the Kharan, Makran, Sibi and Chagai areas, whereas the Brahuis are predominantly found in the highland areas lying between Quetta and Las Bela and in the northwestern and south-central sections of southern Balochistan. Smaller tribal groups residing in the Province are the Jat living in the Kachhi area and the Lasis, who are mainly found in Las Bela and eastern part of the Makran.

---

[6] Akhtar Husain Siddiqi (1991): Baluchistan (Pakistan), Its Society, Resources and Development, p.165.

[7] Akhtar Husain Siddiqi (1991): p.156 - 163; BCIAP (May 1995): p.14.

Furthermore, small groups of Sindhi, Punjabis, Hazaras and Mohajirs are also resident in different parts of Balochistan.

The Pathans, Balouchis and Brahuis are all organised into different tribes, whereas each tribe is subdivided into numerous clans and subclans. Pathan identity is characterised by its dependency on membership in a council of equals, representing the brotherhood model and each male member is of equal social status. The Balouch society is dominated by a hierarchy of social strata with the tribal leader or *Sardar* as the intermediary between the tribe and the government, who must guard and guide his followers without disrupting the social order. The Brahui tribes are traditionally organised in well-knitted communities. Each tribe is led by a *Sardar* and maintains a high degree of internal autonomy and an essential element within each household is the sharing of common rights, animal holdings and expandable goods. Brahuis prefer grazing to agriculture and many of them still are nomadic or semi-nomadic, moving their animals and their possessions between the highlands and the lowlands according to the seasons.[8]

[8] Akhtar Husain Siddiqi (1991): p.151 - 156.

3 WATER RESOURCES AND IRRIGATION SYSTEMS

Water resources in Balochistan are extremely scarce and virtually every perennial source is already being utilised. Irrigation water is derived from surface water sources, such as flood flows and the perennial base flow in rivers, sub-surface flow through the river gravels, springs and ground water sources through the development of traditional karezes, shallow dug wells and deep tubewells.

In addition to the Indus Basin, approximately thirteen river basins can be identified throughout Balochistan. Most rivers are hill torrents and small streams (*nullahs*), which only have surface flows after intense rain storms. The Province only has a few perennial rivers with a base flow of more than 1,000 litres per second. According to their drainage pattern, the perennial rivers can be divided into four groups: the Kachhi Plain drainage with the Nari, Sukleji, Mula, Chakkar, Lehri, Bolan and Karkh as the main rivers; the Indus drainage with the Zhob river; the Arabian Sea drainage mainly though the Dasht, Hingol, Porali, Hub and Winder; and the Kharan Desert drainage with the Mashkel, Baddo and Morjen. The major river basins are given in Figure 3.1.

The total estimated irrigable area in Balochistan is some 1,520,000 hectares, of which 330,000 hectares (22%) is irrigated by flood diversion systems, 640,000 hectares (42%) by water harvesting and 550,000 hectares (36%) by perennial irrigation.[9]

3.1 FLOOD IRRIGATION

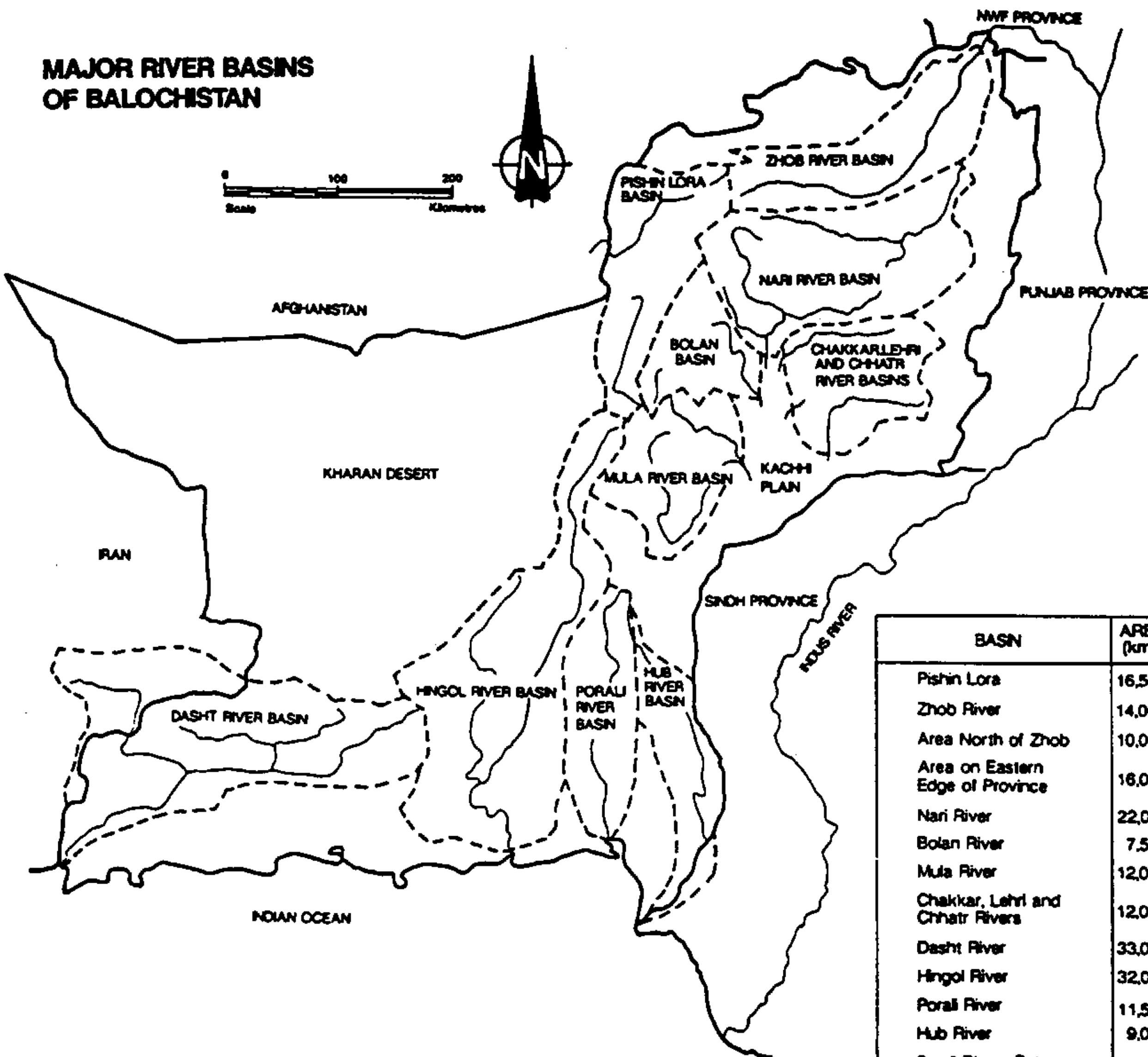
Flood irrigation, locally known as *sailaba* or *manda sailaba*, is widely practised in the Province and different techniques have evolved over the centuries to utilise flood water for irrigation. Flood events normally have a short duration with a rapid rise and swift recession to zero flow. The flow magnitude is extremely variable between events and there is little uniformity in the number of events that may occur in any given year. Consequently, the inter-annual variability of flow volumes is great and flood irrigation is associated with a high degree of uncertainty.

The basic principal involves the diversion of flood water from the river to the command area, where it is conveyed into large bunded basins to a depth of 60 to 90 centimetres (2 to 3 feet) and allowed to infiltrate into the soil. Suitable soils for flood irrigation are deep and fine textured and they have a high moisture retention capacity in order to store sufficient water within the soil profile to mature a drought tolerant crop, such as wheat and sorghum. Because of the short flashy nature of the floods, the volumes of water that have to be diverted are considerable in order to irrigate a sizeable area.

Two methods of diversion have been developed in the Province. The first method consists of the construction of a bund or *ghanda* across the river to increase the upstream water level and divert the flow into the flood channel. Usually, there is no provision for a spillway and as the flood rises the bund is either deliberately breached or fails due to overtopping. The second method uses a spur constructed partially across the river to divert a portion of the flood flow into the conveyance system. Large flood flows

---

[9] BCIAP (May 1995): p.7-8; World Bank (August 1995): p.11-12.



BASIN	AREA (km^2)	RUN OFF (mm)	BASIN OUTFLOW Average (cusecs)
Pishin Lora	16,500	6	113
Zhob River	14,000	18	279
Area North of Zhob	10,000	12	134
Area on Eastern Edge of Province	16,000	28	505
Nari River	22,000	28	696
Bolan River	7,500	15	124
Mula River	12,000	11	145
Chakkar, Lehri and Chhatr Rivers	12,000	40	540
Dasht River	33,000	12	448
Hingol River	32,000	13	459
Porali River	11,500	70	900
Hub River	9,000	33	335
Small Rivers Between Last 4 Above	25,000	12	335

Figure 3.1. Major river basins in the Province of Balochistan.

normally breach the *ghanda* or wash away the diversion spurs before sufficient water has reached the command area and it is often not possible to re-build the diversion structure during the same flood season. Consequently, only a limited portion of the total command area can be brought under cultivation.

Both of these methods require considerable labour input by the farmers to maintain and/or to reconstruct the bunds after every major flood. The frequent reconstruction of the diversion structure and the operation and maintenance of the large distribution system, which often extends over an area of many thousands of acres, requires a strong and effective organisation among the farmers. Costs are normally shared on the basis of benefits received, which depends on the elevation of individual land holdings and their proximity to the water supply.

In the major flood irrigation areas, complex relationships have evolved between villages sharing the same flood source. Often agreements are made to ensure that the upstream abstractors, who take the spate waters first, are obliged to deliberately break their bund after a certain period of time, releasing the remainder of the spate flow for diversion, in turn, by the communities further downstream. Within individual flood irrigation schemes, regulations have evolved to govern the distribution of available flood water in order to ensure an equitable distribution. In the past, these rules were strictly enforced by traditional rulers. However, the declining power of tribal leaders has led in some areas to a breakdown in the traditional operation rules, which is depriving downstream users of their share of the available flood water and they are often forced to seek redress in the courts or appeal directly to the local administration. The problem is further aggravated by the increasing use of tractors and bulldozers, allowing farmers to build higher and stronger bunds than was previously possible with simple oxen drawn dam scoops.[10]

3.2 WATER HARVESTING

Water harvesting, locally called *khushkaba*, has been practised for hundreds of years and it is basically a small scale version of flood irrigation where localised surface runoff is diverted into basins. Because the catchment areas tend to be very small, the risks involved are considerable, although it is nonetheless more reliable than just rainfed (*barani*) agriculture.[11]

3.3 PERENNIAL IRRIGATION

Perennial irrigation in the Province can be sub-divided into large scale river and canal systems and small scale or minor irrigation systems.

---

[10] BMIADP (June 1993): Project Preparation Report, Volume 3, Annex IX, p.1 - 2; BCIAP (May 1995): p.8.

[11] BCIAP (May 1995): p.8.

3.3.1 Large Scale River and Canal Systems

This form of irrigation is restricted primarily to the canal irrigated districts of Nasirabad and Jaffarabad, which are fed by the Pat Feeder, Desert and Khirthar Canal systems, emanating from the Gudu and Sukkur Barrages on the Indus River, respectively. Both systems are operated and maintained by the Provincial Irrigation Department down to the minor off-takes and the farmers within the watercourse command area are responsible for the water distribution and the maintenance of the command area channels. Water distribution is based on the *warabandi,* or fixed rotation system, with proportional division down to the minor off-takes and time division within the watercourse command area.

These large scale river and canal irrigated areas account for 285,000 hectares or 19% of the estimated potential irrigable area in the Province. A number of development projects, such as the Pat Feeder Canal Rehabilitation Project, are currently being executed.[12]

3.3.2 Minor Irrigation Systems

Small scale or minor irrigation systems in the Province derive water from both surface and ground water sources. Perennial water sources are relatively small with base flows rarely exceeding 1 cumec (35 cusecs) and most are less than 0.1 cumec (3.5 cusecs). The larger systems are associated with the diversion of water from perennial rivers, such as the Nari, Hub and Zhob. Some of these systems have been developed by the colonial powers during the early part of this century. Most larger systems are operated and maintained by the Provincial Irrigation Department in the same way as the large scale canal systems.

About 265,000 hectares, or 17% of the total estimated potential irrigable area in Balochistan, is under command of minor irrigation systems.[13] The different aspects of minor or community irrigation systems in Balochistan will be described in Chapters 5 to 8 of this paper.

---

[12] BCIAP (May 1995): p.8.

[13] BMIADP (June 1993): Project Preparation Report, Volume 3, Annex VIII, p.1-2; BCIAP (May 1995): p.8-9.

4 AGRICULTURE

Due to the prevailing climatic conditions of the Province in which temperature is highly correlated with altitude, it is possible to grow temperate crops and semi-tropical crops within a comparatively short distance from each other. In the higher areas in the north and centre of Balochistan, deciduous fruit crops and temperate summer vegetables are grown due to the cold winters and warm summers. The mild and frost-free winters of the west, south and east of the Province are more suited for semi-tropical crops and winter vegetable production.

Agriculture is still the main economic activity in Balochistan, accounting for some 54% to 60% of the provincial gross domestic product. According to a Labour Force Survey in 1987/88, the agricultural sector employed 66.5% of the total labour force in the Province against a national average of 51.2%. It is estimated that Balochistan's agricultural sector grew strongly during the 1980's. Output in vegetables and fruit has reportedly increased at a rate of 6 to 7% annually and gross farm incomes in real terms grew at a little more than 9% annually.[14] Balochistan is a net exporter of fruits and vegetables to other provinces of Pakistan and its share of many deciduous fruits, such as apples, apricots, pomegranates, plums and pears, in Pakistan's total production ranges between 35% and 80%. Although cereal production covers approximately 70% of the total cropped area, Balochistan is a net importer of basic food staples, such as wheat and rice.[15]

4.1 LAND UTILISATION

According to the Agriculture Census of 1980, the Province of Balochistan had 3,891,566 acres of farm land, of which 2,454,851 acres (63.1%) were classified as cultivated. Of the total cultivated farm area, 1,783,180 acres or 72.6% of the total cultivated area were sown and 671,671 acres or 27.4% were lying fallow. Compared with the figures of the Agricultural Census of 1972, the total farm area decreased by 427,482 acres or about 10%, whereas the farm area increased by 7% between 1960 and 1972. According to Syed M. Arif, the decline in farm area during the 1970's occurred due a number of factors, such as urbanisation, industrialisation, drying up of karezes, trend towards orchards, rainfall and population pressure.[16]

---

[14] Planning and Development Department (June 1994): Chapter 1, p.3; World Bank (August 1995): p.2-3.

[15] Planning and Development Department (June 1994): Chapter 8, p.1.

[16] Syed M. Arif (1991): Agricultural Economy of Balochistan, p.43.

Between 1972 and 1980, the total net sown area rose by 344,249 acres or 24%, whereas the total fallow area only decreased slightly by 11%.[17] The main figures concerning land utilisation in Balochistan are summarised in Table 4.1.

Table 4.1. Land utilisation in Balochistan in 1972 and 1980.

Area	Census 1972		Census 1980	
	acres	% of Total Farm Area	acres	% of Total Farm Area
Total Farm Area	4,319,048	-	3,891,566	-
Total Cultivated Area of which:	2,196,899	50.9	2,454,851	63.1
Total Net Sown Area	1,438,931	33.3	1,783,180	45.8
Total Fallow Area	757,968	17.5	671,671	17.3
Total Uncultivated Area	2,122,149	49.1	1,436,715	36.9

Source: Census of Agriculture 1972 and 1980.

The overall cropping intensity[18] increased from 71% in 1972 to 78% in 1980. However, the cropping intensity varies significantly per district with Kharan and Sibi Districts only having a cropping intensity of 41% and 49%, respectively, whereas in Nasirabad, Panjgur and Turbat Districts, it is as high as 93%, 95% and 104% in 1980, respectively.

4.2 MODE OF IRRIGATION

According to the Agricultural Census of 1980, 852,108 acres or 34.7% of the total cultivated area in Balochistan was perennially irrigated. The main sources for perennial irrigation are the major canal systems in the east of the Province irrigating 435,987 acres or 51.2% of the total perennially irrigated cultivated area, whereas water from karezes and tubewells was irrigating 121,356 acres (14.2%) and 100,571 acres (11.8%), respectively. Between 1972 and 1980, the cultivated area irrigated by tubewells increased spectacularly by 67,440 acres (203.6%), whereas the total cultivated area commanded by karezes also rose significantly by 39,192 acres (47.7%). However, it is rather surprising that the total perennially irrigated area decreased by 25,931 acres (3.0%) during the same period. The main reason could be a more precise classification by mode of irrigation during the census

[17] Agricultural Census Organisation (November 1975): Pakistan Census of Agriculture 1972, Province Report Baluchistan, p. 52 and 56; Agricultural Census Organisation, Statistics Division (May 1983): Pakistan Census of Agriculture 1980, Province Report Baluchistan, p.58 and 69.

[18] Intensity of cropping represents the total cropped area (aggregate area of crops raised in a farm during one calendar year including the area under fruit trees) in terms of total cultivated area multiplied by 100 and indicates the extent to which the cultivated area was used for cropping.

of 1980 as the total cultivated area irrigated by 'unspecified sources' decreased by 263,688 acres (77.9%), whereas the cultivated areas classified as *sailaba* and *barani* increased from 373,596 acres to 1,638,739 acres or around 340%. If the category 'unspecified sources' is excluded, the total perennially irrigated cultivated area rose from 539,730 acres in 1972 to 777,487 acres in 1980; an increase of 237,757 acres or 44.1%.[19] The main figures regarding mode of irrigation from both agricultural censuses are summarised in Table 4.2.

Table 4.2. Cultivated area classified by mode of irrigation in Balochistan in 1972 .and 1980.

	Census 1972		Census 1980	
	acres	% of total cultivated area	acres	% of total cultivated area
Total Cultivated Area	2,196,899	-	2,454,851	-
Total Perennially Irrigated Area of which:	878,039	40.0	852,108	34.7
Canal	409,351	18.6	435,987	17.8
Tubewell	33,131	1.5	100,571	4.1
Well	15,084	0.7	20,951	0.9
Kareze	82,164	3.7	121,356	4.9
Other and Unspecified Sources	338,309	15.4	173,277	7.1
Flood Irrigation or *Sailaba*	373,596	17.0	815,994	33.2
Rainfed or *Barani*			786,745	32.0
Not Irrigated	945,264	43.0	-	-

Source: Census of Agriculture 1972 and 1980.

The Agricultural Statistics of Balochistan give another picture of the total area irrigated by perennial water sources and are outlined in Table 4.3. According to the Agricultural Statistics of 1985-86, a total area of 510,900 hectares (1,262,690 acres) was perennially irrigated and by 1994-95 it had increased by 60% to 817,525 hectares (2,020,104 acres).

The total area under perennial irrigation in the Agricultural Census of 1980 and the Agricultural Statistics of Balochistan differ significantly and it is very difficult to explain the discrepancy. Especially, the cultivated area under canal and tubewell irrigation varies

[19] Agricultural Census Organisation (November 1975): p.90; Agricultural Census Organisation (May 1983): p.81.

dramatically and the differences cannot only be explained by the rapid installation of tubewells or improvements to the canal system.

Table 4.3. Area irrigated by different perennial sources of irrigation in Balochistan.

	Agr. Stats. 1985-86		Agr. Stats. 1989-90		Agr. Stats. 1994-95	
	ha.	% of total area under perennial irrigation	ha.	% of total area under perennial irrigation	ha.	% of total area under perennial irrigation
Area under Perennial Irrigation	510,900	-	646,960	-	817,525	-
Canall[1]	340,610	66.7	450,480	69.6	493,692	60.4
Tubewell	95,660	18.7	130,830	20.2	214,891	26.3
Well	15,830	3.1	10,520	1.6	14,192	1.7
Kareze, springs and other	58,800	11.5	55,130	8.5	94,750	11.6

Source: Agricultural Statistics of Balochistan 1985-86, 1989-90 and 1994-95.

[1] Including the large scale canal systems in Nasirabad Division and small channels diverting water from weirs.

The most salient development is the enormous expansion of area irrigated by tubewells from 95,660 hectares in 1985-86 to 214,891 hectares in 1994-95, which is an increase of 125%. The area under canal irrigation also saw a significant expansion of 45% during the same period. The area irrigated by karezes declined slightly (6%) between 1985-86 and 1989-90, but it increased significantly (72%) during the first half of the 1990's.[20]

According to the Agricultural Statistics of Balochistan 1994-95, about 60% of all perennially irrigated area in the Province was under command of large canal systems, such as the Pat Feeder and Kirthar Canals in the Nasirabad Division. About one-quarter of the cultivated area with perennial irrigation received water from tubewells and about 12% was irrigated by karezes, springs and other minor sources.

[20] Statistics Wing of Directorate General of Agriculture Department Balochistan: Agricultural Statistics of Balochistan 1985-86 (p.112), 1989-90 (p.143) and 1994-95 (p.132).

Until the first half of the 1960's, ground water in Balochistan was only exploited by shallow wells and kareze systems[21]. Shallow dug wells have provided a valuable source of water for irrigation for centuries and Persian wheels powered by camels and donkeys are still extensively used to lift water to the surface through an endless chain of buckets, which are usually made of steel nowadays. The yield of a shallow well with a Persian wheel is generally sufficient to irrigate 2 to 3 acres. The maximum practical depth from which water can be raised is about 7½ metres (25 feet), which effectively limits the use of Persian wheels to areas with a shallow water table. The introduction of motorised pumps has enabled farmers to extract water from deeper wells, but there is still a limit to the depth a well can be dug by hand.

From the second half of the 1960's, the installation of dug wells and later of tubewells has developed rapidly. At the end of the 1960's, 2,442 tubewells were reported in Balochistan, whereas in 1974-75 it increased to 4,335 tubewells.[22] Table 4.4 shows the spectacular growth in the number of shallow wells and tubewells in the Province during the 1980s and the first half of the 1990's. Between 1985-86 and 1994-95, the total number of tubewells increased by around 75%, whereas the number of shallow wells decreased by approximately 26% during the same period.

Table 4.4. Development of wells and tubewells installed in Balochistan.

	Agr. Stats. 1985-86	Agr. Stats. 1989-90		Agr. Stats. 1994-95	
	Number	Number	Increase in % since 1985-86	Number	Increase in % since 1989-90
Shallow wells	3,190	1,967	- 38.3	2,355	+19.7
Tubewells	8,167	14, 125	+73.0	17,568	+24.4
- diesel tubewells	3,417	6,621	+93.8	8,988	+35.7
- electrified tubewells	4,750	7,504	+58.0	8,580	+14.3
Total	11,357	16,092	+41.7	19,923	+23.8

Source: Agricultural Statistics of Balochistan 1985-86, 1989-90 and 1994-95

Between 1985-86 and 1994-95, the number of diesel-driven and electrified tubewells increased by 163% and 81%, respectively. In 1993, there were officially 9,639 electrified agricultural wells in the Province. In addition, there were also a substantial number of

[21] The kareze system will be described in detail in 5.1.

[22] Akhtar Husain Siddiqi (1991): p.199 and Syed M. Arif (1991): p.54.

illegally connected tubewells, as well as diesel-driven wells in large areas of Balochistan, which were not yet connected to the electricity grid.[23]

The development of shallow wells and tubewells was actively supported by government policies in order to utilise available ground water, which was seen as the key to Balochistan's agricultural prosperity. For instance, wells were installed free of cost, pumping equipment was subsidized and interest free loans for the purchase of pumping equipment were provided by the Agricultural Development Bank of Pakistan (ADBP). Furthermore, electricity rates are also subsidized and a system of flat rates is applied for most electrified tubewells. The majority of dugwells and tubewells have a discharge of 2½ to 12½ litres per second.[24]

The rapid progress with village electrification throughout the Province will ensure that the existing trend will continue. However, the uncontrolled development of new tubewells and the applied system of flat rates for electricity consumption encouraging over-pumping have resulted in the over-exploitation of many aquifers. Ground water aquifers in Balochistan are by no means unlimited and there has been recent concern about the alarming rate at which the water table has been falling due to over-exploitation of ground water. For the period 1976-89, the average annual decline of the water table levels was 0.24 metre in the Quetta Valley, 0.32 metre in the Pishin sub-basin, 0.66 metre in the Mastung sub-basin and 1.14 metre in the Manguchar sub-basin (source: WAPDA 1992). According to more recent data from the Water Resources Bureau of the Power & Irrigation Department for the period 1989-95, the water levels in the Quetta Valley have dropped by 40 feet in only 7 years.

Little quantitative information is available on natural ground water recharge. In general, it is believed that substantial recharge occurs in the mountains, some in the nullahs and little on the alluvial fan and valley floor. Infiltration into the ground water directly from precipitation is of little or no significance. Consequently, existing karezes and shallow dug wells, which utilise the same ground water source as most tubewells, have dried up in a number of the more developed valleys in the Province, such as the Pishin, Quetta and Mastung valleys.[25]

In response to the increasing ground water crisis, the traditional *harim* rule was reactivated, which has its origin in Islamic water law and it specifies a prohibited zone in the vicinity of karezes and wells in which no other well or kareze can be developed. In Balochistan, a minimum distance of 250 metres in silty soils and 500 metres in gravelly conditions is applied. The *harim*, however, has been formulated in the era of karezes and Persian wheels, but it is not an effective instrument in regulating mechanised ground water exploitation.

---

[23] F. van Steenbergen (undated): The Frontier Problem in Incipient Groundwater Management Regimes in Balochistan (Pakistan), p.6.

[24] F. van Steenbergen (undated): p.6.

[25] F. van Steenbergen (undated): p.4; Van Gils and Shabbir Baig (1992): p.32-33.

Next >>

In 1978, the Provincial Government introduced the Groundwater Rights Administration Ordinance, which has the objective 'to regulate the use of ground water and to administer the rights of the various persons therein'. The Ordinance has established the procedures and framework within the district civil administration to issue permits for the development of new karezes, dug wells and tubewells. The relevant authorities are the District Water Committees, composed of the Deputy Commissioner, the district heads of the Irrigation and Agriculture Departments, as well as two appointed local 'notables'.

Before giving out a permit, the Committees would firstly hear objections from surrounding landowners. An appeal to the decision of the District Water Committees could be made to the Divisional Commissioner and the Provincial Water Board, consisting of the Additional Chief Secretary (Development), the provincial heads of the Irrigation and Agriculture Departments and appointed notables. The Provincial Water Board also has the responsibility to formulate policies on ground water withdrawal.

The Groundwater Rights Administration Ordinance of 1978 is providing a legal and institutional framework for local resource management by involving the local administration, as well as tribal elders, and allowing flexibility in determining the rules for the use of ground water as a common property. However, the main shortcoming of the existing Ordinance is the lack of involvement of local communities in the formulation and implementation of ground water management rules. Furthermore, the implementation of the Ordinance has failed totally as it has not managed to put in place an effective system to regulate the use of ground water in Balochistan. Due to the absence of proper guidelines, the District Water Committees applied the *harim* distances instead. But after farmers had disputed the refusal of a water permit on the argument that in their area the local minimum distance was 200 feet instead of 750 feet, the Chief Minister decided in October 1990 by decree that the *harim* should be applied all over the Province of Balochistan.[26]

4.3 LAND TENURE AND FARM SIZE

Historical occupation of an area is the most common origin of claim to land property, which dates back to the seventeenth and eighteenth centuries, when invasions by warlords from Persia and Afghanistan during the last days of the Moghul empire redefined tribal territories and spheres of influence. The direct and indirect rule of Balochistan by the British colonial government improved the law and order situation and resulted in the sedentarisation of previously nomadic people, whereas political gifts and commercial transactions were other sources of land claims.

Systematic registration of land titles, occupancy rights and water rights started at the beginning of this century, but only in those areas that were administered directly by the British colonial administration. In the territories controlled by the native State of Kalat before 1948, registration of land and water rights did not take place, although land deeds

[26] F. van Steenbergen (undated): p.8 - 11.

were occasionally given by the ruling elite. Only after the merger of the Kalat State with Pakistan were land and water rights formally registered for the first time.

With the adoption of the Land Reform Act in 1967, a formal legal basis was formed for the registration of land titles in the Record of Rights, which is the cadastral record. For each settled area, a Record of Rights is prepared, which specifies for each combination of landlord and tenant, if any, the plot of land cultivated, its size, title to it and the source of water. The plot numbers correspond with a cadastral map and the administrative unit for these land and water records is a *mouza*, consisting of a village or a cluster of villages. Copies of the records are kept at the Tehsil office and the office of the Deputy Commissioner or Political Agent. The formal registration of land and water titles gives a measure of increased security and the Tehsildar is responsible for the maintenance of the Record of Rights at the local level. However, it is not unusual that the Record of Rights are not regularly updated, which reduces the effectiveness of the cadastral records and consequently the security of tenure. For instance, land transfers and divisions at inheritance are not usually entered in the cadastral records, but they are informally administered and recognized at the village level.

The formal registration of land and water rights has also resulted in a number of different disputes and abuse. One dispute concerns the controversy between revenue rights and ownership rights. In many Balouch areas that previously belonged to the Kalat State, local tribal leaders received the exclusive rights to collect revenue (*jagir*) from designated areas in return for their support to the central authority of the native state. Normally, the *jagir* gave the right to claim one-fifth to one-sixth of the agricultural production from each individual farmer. These revenue rights were officially abolished in 1958. However, the *jagir* system resembles a tenure system where landowners have given barren land to tenants, who developed it and acquired occupancy rights in return. The occupancy tenants pay one-fourth to one-sixth of the harvested crop to the original landowner. During the registration process of land and water rights in the 1960's and 1970's, previous revenue holders tried to register land as their property, claiming that they were the original landowners, whereas the farmers were occupancy tenants. In other areas of southern Balochistan, occupancy tenants claimed that they were the landlords by suggesting that the original landowners were revenue holders.

Another dispute is related to the registration of communally owned land as government property, whereas tribal customary rights recognise these lands as belonging to specific communities.

To keep their properties intact by avoiding the ceilings on landownership, which have been defined in the Land Reform Acts of 1958, 1972 and 1974, large landowners have formally registered portions of their lands in the name of the tenants cultivating these lands during the registration of land and water rights. In reality, however, they have retained full control over all of the land.

4.3.1 Land Tenure

According to the Agricultural Census of 1980, about 80% of all farm area belonging to private farms in Balochistan was operated by the owners themselves and 20% by tenants. If the figures concerning land tenure of 1980 are compared with those of the Agricultural Census of 1972, the total number of owner-operated farms has increased by 25%, whereas the number of tenants decreased by about 9%. During the same period, the total farm area operated by the landowners decreased by about 190,000 acres (5.7%), whereas the total farm area operated by tenants declined by about 240,000 acres (23.8%).

4.3.2 Farm Size

The agricultural sector of Balochistan is dominated by small farmers. According to the Agricultural Census of 1980, 28.6% of all farms had less than 5 acres of farm area comprising only 3.4% of all farm area in the Province and 82.2% were smaller than 25 acres comprising 36.4% of all farm area. About 18% of all private farms had an average size of 25 acres or more and they owned approximately 64% of all farm area. Compared with the figures of the Agricultural Census of 1972, the number of farmers smaller than 5 acres increased by approximately 5% and their share of total farm area rose by nearly 1.5%. In 1972, 76.4% of all farms were smaller than 25 acres comprising 27.1% of all farm area, whereas 23.6% of the farms with an average size of 25 acres and above were the owners of approximately 73% of all farm area in the Province. Between 1972 and 1980, the overall farm size decreased from 25.0 acres to 19.2 acres (23.2%) and this trend will have continued during the 1980's and the first half of the 1990's.

Large landholdings in the Province are mainly concentrated in the large canal irrigated areas of Nasirabad Division as well as in Chagai, Kachhi, Quetta and Gwadar Districts, with average farm sizes ranging from 30.3 to 46.8 acres of farm area, whereas in Zhob, Turbat and Panjgur Districts the average farm sizes are smaller than 10 acres of farm area. Landholdings in flood irrigated areas are normally larger than in perennially irrigated areas. However, the actual size of land that is cultivated changes significantly from year to year depending on the occurrence of controllable floods.

Another important trend between 1972 and 1980 was the significant increase of farm area that was brought under cultivation. In 1972, it was reported that 51% of all farm area could be classified as cultivated area, whereas eight years later 63% of all farm area was considered as cultivated area. In 1980, farms smaller than 1 acre had 87.5% of their farm area under cultivation, whilst farms with an average size of 1 acre to under 50 acres cultivated 68% to 76% of their total farm area. The extension of cultivated area was made possible due to a number of developments in the agricultural sector, such as the installation of large numbers of tubewells throughout the Province and further mechanisation, which allowed farmers to develop more land. The overall average size of cultivated area per farm only decreased by 0.6 acres (4.7%) between 1972 and 1980.

Table 4.5. Land tenure of private farms and farm area in Balochistan in 1972 and 1980.

	Census 1972		Census 1980	
	Number	% of Total Number of Private Farms	Number	% of Total Number of Private Farms
Number of Private Farms of which:	172,766	-	202,440	-
Owner-operated	126,285	73.1	158,557	78.3
Owner-cum-tenant	13,395	7.8	13,681	6.8
Tenant	33,086	19.1	30,201	14.9
	Acres	% of Total Farm Area	Acres	% of Total Farm Area
Total Farm Area of which:	4,319,048	-	3,891,566	-
Owner-operated	2,924,736	67.7	2,912,199	74.8
Owner-cum-tenant of which:	636,958	14.7	430,721	11.1
Owner self-operated	394,475	9.1	217,964	5.6
Tenant operated	242,483	5.6	212,757	5.5
Tenant	757,354	17.5	548,653	14.1

Source: Census of Agriculture 1972 and 1980

In 1980, owner operated farms had an average farm size of 18.4 acres, of which 11.2 acres (60.9%) was classified as cultivated area, while owner-cum-tenant-operated farms had an average farm size of 31.5 acres with 18.6 acres (59.1%) of cultivated area and an average tenant-operated farm was 18.2 acres in size with 14.3 acres (78.6%) considered as cultivated area.

Tenant-operated farms smaller than 1 acre had the highest cropping intensity (167%) in 1980, whereas owner-cum-tenant-operated farms with 150 acres and more had the lowest cropping intensity (59%) during the same year.

Table 4.6. Number and area of private farms by size of farm in Balochistan in 1972 and 1980.

Farm Size	Farms		Farm Area		Cultivated Area		Cultivated Area as % of Farm Area
	Total	%	Average Size	%	Avera ge Size	%	
Agricultural Census 1972							
Total	172,766	-	25.0	-	12.7		50.9
						-	
under 1.0 acre	3,710	2.1	0.5	0.1	0.4		81.9
1.0 to under 2.5 acres	19,878	11.5	1.6	0.7	1.1	0.1	69.1
2.5 to under 5.0 acres	17,828	10.3	3.5	1.2	2.3	1.0	64.7
						1.9	
5.0 to under 7.5 acres	21,188	12.3	5.8	2.8	3.7		63.6
7.5 to under 12.5 acres	33,764	19.5	9.9	7.7	6.6	3.5	66.7
12.5 to under 25.0 acres	35,725	20.7	17.7	14.6	12.6	10.1	71.4
						20.6	
25.0 to under 50.0 acres	22,738	13.2	33.0	17.4	21.7		65.8
50.0 to under 150 acres	13,909	8.1	73.0	23.5	35.3	22.5	48.3
150 acres and above	4,026	2.3	340.0	31.5	98.6	22.3	29.2
						18.1	
Agricultural Census 1980							
Total	202,440	-	19.2	-	12.1	-	63.1
under 1.0 acre	5,921	2.9	0.4	0.1	0.3	0.1	87.5
1.0 to under 2.5 acres	29,018	14.3	1.6	1.2	1.2	1.4	75.6
2.5 to under 5.0 acres	23,147	11.4	3.5	2.1	2.6	2.4	73.1
5.0 to under 7.5 acres	24,473	12.1	5.7	3.6	4.0	4.0	70.1
7.5 to under 12.5 acres	45,757	22.6	10.0	11.8	7.6	14.1	75.7
12.5 to under 25.0 acres	38,189	18.9	18.0	17.6	13.6	21.2	75.8
25.0 to under 50.0 acres	19,929	9.8	33.0	16.9	22.5	18.2	68.1
50.0 to under 150 acres	13,139	6.5	72.2	24.4	40.6	21.7	56.3
150 acres and above	2,867	1.4	304.8	22.5	144.3	16.9	47.4

Source: Census of Agriculture 1972 and 1980

4.4 AGRICULTURAL LABOUR AND MECHANISATION

Most small farmers use family labour to cultivate their fields, but additional labour is hired temporarily during periods of peak demand, such as land preparation and harvesting. Family composition and socio-cultural values determine mainly the availability of family labour. For instance, among the Pathan population, it is very uncommon that women undertake farm work in the fields, but they are actively involved in post-harvest activities and livestock husbandry. In Balouch areas, women are more involved in agricultural activities including transplanting of rice and vegetables, weeding, harvesting and post-harvest activities, as well as livestock husbandry. Ploughing and irrigation at night are normally not undertaken by women.

According to the Agricultural Census of 1972, an average farm household had 7.5 members, of which approximately 37% was younger than 10 years, and about 17% of the farms reported the use of casual labour. In 1980, the average number of household members was 8 with nearly 43% under 10 years, whereas only 2% of the farms employed permanent hired workers. Compared with figures from 1972, the number of farms having permanent hired workers declined from nearly 9,000 to less than 4,000 and the number of permanent hired workers decreased from 17,764 to 8,598 (51.6%).

Data on the development of agricultural labour for the 1980's and the first half of the 1990's are lacking. It is difficult to assess how the demand for temporary and permanent labourers has developed during these years due to a number of factors. In the first place, the average farm size is gradually,declining due to inheritance and, consequently, more small farmers can cultivate all of the ir land with the available family labour. Secondly, further intensification of the cropping pattern by extending the area under vegetables and orchard crops could have increased the demand for hired labour. Thirdly, further mechanisation and the adoption of new technologies in the agricultural sector, especially the increase in number of tractors and the utilisation of fertiliser and improved seeds, could have negative as well as positive effects regarding the demand for hired labour. On the one hand, mechanisation could have replaced hired labour. For instance, farmers can develop new land or plough their existing fields themselves with the help of a tractor instead of hiring labour. On the other hand, the demand for hired labour may have increased due to mechanisation and the adoption of new technologies. For instance, farmers need additional labour to cultivate the newly developed land, which has been developed and prepared with tractors. The introduction of new varieties and the utilisation of fertilisers has resulted in larger yields and farmers have to hire temporary labour, because the available family labour is not sufficient during harvesting time.

The increase in number of tractors and threshers between 1985-86 and 1994-95 is shown in Table 4.7.

Table 4.7. Number of tractors and threshers in Balochistan.

	Agr. Stats. 1985-86	Agr. Stats. 1989-90		Agr. Stats. 1994-95	
	Number	Number	Increase in % since 1985-86	Number	Increase in % since 1989-90
Tractors	3,141	4,671	+48.7	6,225	+33.3
Threshers	156	422	+170.5	1,097	+160.0

Source: Agricultural Statistics of Balochistan 1985-86, 1989-90 and 1994-95

Between 1985-86 and 1994-95, the number of tractors and threshers increased by approximately 100% and 600%, respectively. During the same period, the use of chemical fertilisers rose by about 220% and, in relation to cropped area, increased from 17.58 kg per hectare in 1985-86 to 34.11 kg per hectare in 1994-95.

4.5 TENANCY

With approximately 20% of all farm area in the Province operated by tenants, tenancy is an important aspect of the agricultural sector in Balochistan, although its extent is decreasing with the total farm area operated declining by approximately 24% between 1972 and 1980. The most dominant tenancy arrangement is sharecropping with 86.5% of all tenant-operated farm area in 1980. However, the importance of sharecropping declined since 1972 when 93.8% of all tenant-operated farm area had sharecropping arrangements.

Table 4.8. Tenancy Arrangements in Balochistan in 1972 and 1980.

	Census 1972		Census 1980	
	Acres	% of Total Tenant Operated Farm Area	Acres	% of Total Tenant Operated Farm Area
Total tenant-operated farm area, of which:	999,837	-	761,411	-
Sharecropped	938,048	93.8	643	86.5
Leased	59,271	5.9	42,305	5.6
Other	2,518	0.3	60,463	7.9

Source: Census of Agriculture 1972 and 1980

4.5.1 Sharecropping

The exact terms of sharecropping tenancy arrangements differ between the different areas throughout Balochistan. According to the Agricultural Census of 1972, the owner's share in production was 50% for about 72% of all reported sharecropping contracts, whereas for approximately 17% of all reported sharecropping arrangements the landowners received two-thirds or more of the production. In only 7% of all reported sharecropping contracts, the tenant's share was 75% of the production. However, the respective crop shares for the landowner and the tenant depend on a number of factors, such as the prevailing cropping pattern and the value of crops, the inputs provided by either the landowner and/or the tenant, perceived risks, the availability of family labour, the extent of mechanisation and labour opportunities on local labour markets.

Tenancy arrangements for the cultivation of vegetables are normally better than for other perennially irrigated crops, because of the specialist nature of vegetable production and the higher labour inputs. If the tenant provides all of the labour and arranges the preparation of the land and the landowner contributes the seeds and half of the fertiliser, both parties are entitled to half of the crop. The tenant's share is only one-third, if he does not provide the draft animals or tractor for the preparation of the land. For cereal crops, such as wheat and sorghum, similar tenancy arrangements exists, although it is usually expected that the tenant also shares in the cost of seeds.

There is, however, a considerable regional variation in tenancy arrangements, which can be partly explained by the conditions on the local labour markets. In areas with a shortage of labour opportunities and an oversupply of labour, such as the Kachhi plains, where the tenant's share in wheat cultivation is only one-fourth, whereas in areas with better labour opportunities the tenants receive half of the crop even when the landlord still provides the tractors or draft animals. Due to the influx of a large number of refugees from Afghanistan during the 1980's, the labour markets in the border areas have been under high pressure and, consequently, daily wages and tenant's share were lower.

Although the conditions on local labour markets determine partly regional variations in tenancy arrangements, fluctuations in the labour market do not lead immediately to readjustments in the prevailing tenancy arrangement, because tenants are usually recruited from the same village or the surrounding villages and the same tenant is cultivating the landlord's land for a longer period.

In addition to a share of the crop, a number of informal obligations and privileges complement the tenancy arrangement, such as free access to fodder, housing and interest-free credits for the tenants. If tenants come from other areas, the landowners usually have to provide these additional conditions. The credits provided by the landowners normally concern small seasonal loans to bridge the tenant family's cash needs during the cropping season and they are usually recovered without interest at the time of harvest.

4.5.2 Hereditary Tenancy

Especially in the flood irrigated areas in southern Balochistan, hereditary tenancy is a peculiar form of land tenure. In the past, landowners invited tenants (*lathband*) to develop their land by levelling and constructing bunds and occupancy rights were given in return. These rights are permanent and they have a measure of security as they are entered in the Record of Rights and provisions in the Balochistan Tenancy Act of 1979, which prescribes mechanisms for ejection. Hereditary tenancy rights can be transferred to heirs or even sold to others. The only condition is that the tenant keeps the field bunds intact and cultivates the land, for which he can even employ tenants-at-will.

The occupancy or hereditary tenants are in fact the full operators of the land arranging all farm inputs themselves. For the use of the land, the hereditary tenant gives a share of the harvested crop to the original landowners, which is normally one-twentieth to one-fourth. When the original landowner wants to dissolve the occupancy rights, he either has to buy out the hereditary tenant by offering him a part of the land or he has to give him land elsewhere. The specific hereditary tenancy arrangements determines if the tenant can claim two-fifths to two-thirds of the land when the landlord decides to dissolve the arrangement or to sell the land.

As in perennially irrigated areas, tenancy-at-will in flood irrigated areas is normally a response to a shortage of family labour, especially during the time of harvest. However, landowning families in flood irrigated areas may also decide to lease their land to tenants, because they lack the necessary resources, such as a pair of bullocks and seeds, to cultivate their fields themselves.

4.6 CROPPING PATTERN

Although other factors, such as marketing opportunities, availability of inputs and credits, labour supply, farmers skills and preferences and land tenure, also influence the cropping patterns, it is the variation in climatical conditions and particularly in seasonal temperatures that has the greatest influence on the different cropping patterns throughout Balochistan. Water availability and soil types are two other major controlling factors, but they can be adjusted to a certain extent. The major agro-climatic zones within the Province are outlined in Table 4.9.

Table 4.9. Agro-climatic zones in Balochistan.

Zone	Area	Climate	Main Crops
I	Mountain Areas > 6,500ft (2,000m)	Severe winters and cool summers with temperatures rarely over 30C and 200 to 300mm rainfall	Apples, plums, cherries, pears, summer vegetables, wheat, barley, potatoes and alfalfa
II	Upper Valleys 4,000 - 6,000ft (1,200 – 2,000m)	Cold winters and mild summers with temperatures rarely over 35C and 200 to 300mm rainfall	Apples, apricots, almonds, grapes, pomegranates, summer vegetables, wheat, barley, potatoes and alfalfa
III	Middle Valleys 2,000 - 4,000ft (600 - 1,200m)	Frost during winter and warm summers with low and variable rainfall	Pome fruits in upper range and sub-tropical fruits in lower range, winter and summer vegetables, paleze, wheat, barley, pulses and fodder
IV	Lower Valleys 1,000 - 2,000ft (300 – 600m)	Mild winters and hot summers with variable summer rains of less than 200mm	Tropical and sub-tropical fruits, winter vegetables, wheat, sorghum, rice, oilseeds and fodder
V	Plains and Lowlands < 1,000ft (300m)	Mild to warm winters and very hot summers with low and variable summer rainfall	Tropical and sub-tropical fruits, mangoes, sapodilla, dates, castor, winter vegetables, fodder, sorghum and rice

Source: BMIADP (June 1993): Project Preparation Report

Narrow valleys with terraced fields that are often created by importing soil and small though generally reliable perennial water sources are typical for Zone I. The communities are highly dependent on the cultivation of deciduous fruit, especially high quality apples, but other crops are also grown, such as summer vegetables, wheat and potatoes. Cropping patterns in Zone II are similar but slightly more diverse than those in Zone I and dominated by deciduous fruits, such as apples, almonds, apricots and pomegranates, which are intercropped in the early years with wheat, alfalfa and vegetables.

Below 4,000ft (1,200m) apple production is not possible due to poor quality and yield and other perennial orchard crops, such as pomegranate, peach and some citrus, as well as a large variety of summer vegetables, are mainly found in Zone III. Cropping patterns in Zone IV are dominated by the cultivation of sub-tropical fruits, cereals, winter vegetables and oilseeds, such as rape, sesame, castor and sunflower. The very hot summers restrict the cropping options in Zone V. Dates, mangoes and some citrus are grown with winter wheat, vegetables and fodder in areas with perennial irrigation sources. Drought resistant cereals, such as sorghum, are the main crop within flood irrigated areas of Zones IV and V.[27]

Balochistan has two distinct cropping seasons. The winter or *rabi* season starts during the autumn months (September to November) when the land is prepared and the crops, such as wheat, are planted and it ends during spring (March to May) with the harvesting of the crops. The summer or *kharif* season begins during spring with the first irrigation of the orchards and the planting of vegetables and it ends with the harvesting of apples during the months of October and November.

According to the Agricultural Statistics of Balochistan, Balochistan had a total cropped area of 909,691 hectares (2,247,846 acres) in 1994-95, of which 487,901 hectares (53.6%) was cropped during the *rabi* season and 421,790 hectares (46,4%) during the *kharif* season. Wheat is the most important crop during the winter season with 340,500 hectares or 69.8% of total cropped area during *rabi* season, followed by barley, oilseeds and fodder. Rice and fruit crops are the dominant crops during the summer season with 124,325 hectares (29,5% of total *kharif* crops) and 118,514 hectares (28.1%), respectively, whereas sorghum, fodder, onions, melons and vegetables are other important *kharif* crops.

4.6.1 Cereals

Wheat is the main staple throughout the Province. Although the actual area under wheat varies from year to year due to fluctuations in the flood irrigated area, the general trend is that the total area under wheat has increased by 37.5% between 1985-86 and 1994-95. During the same period, the average yield also improved from 1,667 kg per hectare to 2,320 kg per hectare. The average yield on flood irrigated and *khushkaba* fields is significantly lower with only 1,134 kg per hectare during the 1994-95 season.

Rice is mainly grown in the large canal irrigated areas of the Nasirabad Division in the eastern part of the Province. The total area increased by 32.1% between 1985-86 and 1994-95, but the average yield declined from 2,712 kg per hectare to 1,911 kg per hectare during the same period.

Sorghum and barley are mainly grown as a green fodder and their cropped area extended by 42.7% and 200%, respectively, between 1985-86 and 1994-95. The average yield for sorghum grain improved from 672 kg per hectare to 856 kg per hectare, whereas for barley the average yield increased significantly from 812 kg per hectare in 1985-86 to 1,398 kg per hectare in 1994-95.

---

[27] Sir William Halcrow & Partners Ltd. (May 1995): Technical Proposal Volume 1, p.12 - 14.

Table 4.10. Cropped area for cereals in Balochistan.

Crop	Agr. Stats. 1985-86	Agr. Stats. 1989-90		Agr. Stats. 1994-95	
	Hectares	Hectares	Increase in % since 1985-86	Hectares	Increase in % since 1989-90
Wheat	247,610	296,670	+19.8	340,500	+14.8
Rice	94,090	108,208	+15.0	124,325	+14.9
Sorghum	43,181	54,398	+26.0	61,636	+13.3
Barley	13,280	20,356	+53.3	39,845	+95.7
Maize	4,887	4,604	-5.8	4,210	-8.6

Source: Agricultural Statistics of Balochistan 1985-86, 1989-90 and 1994-95

4.6.2 Vegetables

A large variety of vegetables are grown in different parts of Balochistan, such as tomatoes, onions, chillies, potatoes, melons, okra, cucumbers, egg plants, pumpkins, cauliflower, peas, radish, spinach, turnip, beet root, cabbages and carrots. The cultivation of vegetables is considered to be very profitable as the yields are generally high and the produce is of good quality. It is mainly concentrated in areas with good transport opportunities, suitable soils, availability of manure and reliable irrigation sources.[28]

The changes in cropped area for the most important vegetable crops between 1985-86 and 1994-95 are outlined in Table 4.11.

Table 4.11. Cropped area for major vegetables in Balochistan.

Crop	Agr. Stats. 1985-86	Agr. Stats. 1989-90		Agr. Stats. 1994-95	
	Hectares	Hectares	Increase in % since 1985-86	Hectares	Increase in % since 1989-90
Onion	6,210	12,063	+94.3	18,152	+50.5
Melons	12,594	15,139	+20.2	15,995	+5.7
Potatoes	5,419	6,784	+25.2	6,054	-10.8
Tomatoes	3,820	4,304	+12.7	5,353	+24.4
Chillies	3,324	3,511	+5.6	4,036	+15.0
Other Vegetables	9,279	10,276	+10.7	13,665	+33.0

Source: Agricultural Statistics of Balochistan 1985-86, 1989-90 and 1994-95

[28] Akhtar Husain Siddiqi (1991): p.224.

Between 1985-86 and 1994-95, the total cropped area under vegetables extended from 40,646 hectares to 63,255 hectares, which is an increase of 55.6%. The cropped area under onions expanded dramatically by 192%, whereas the cultivation of tomatoes and other vegetables were also augmented significantly by 40% and 47%, respectively.

4.6.3 Fruit Crops

Especially in perennially irrigated areas above 3,500ft, orchard crops are an important source of income for farmers. According to the Agricultural Statistics, the total area under orchard crops increased by 71% between 1985-86 and 1992-93[29]. Orchard crops are predominantly grown on small farm holdings of 1 to 2 hectares and the main areas of fruit production within Balochistan are Loralai, Pishin, Turbat, Qila Saifullah, Kalat, Quetta and Zhob Districts with 75% of the total area under fruits in 1989-90. It is estimated that the total production of fruits increased from 328,847 tonnes in 1985-86 to 669,856 tonnes in 1992-93. The increase in production of approximately 100% is solely the result of the expansion of area under orchard crops, because the average yields per hectare have not improved during the same period. Data on area and average yields for major fruit crops are summarised in Table 4.12.

Table 4.12. Cropped area and average yield for major fruit crops in Balochistan.

	Agr. Stats. 1985-86		Agr. Stats. 1992-93	
Crop	Hectares	Average Yield per Hectare (kg)	Hectares	Average Yield per Hectare (kg)
Apple	9,748	15,665	23,257	15,503
Almond	6,706	4,789	8,751	4,786
Apricot	3,593	18,442	7,442	18,511
Grapes	2,840	10,912	3,690	11,291
Peach	1,076	13,635	2,127	14,052
Plum	1,132	17,426	2,203	17,385
Pomegranate	1,405	23,075	2,823	23,047
Dates	9,312	9,488	10,736	9,565
Other Fruits	2,712	-	4,940	-
Total	38,524	-	65,969	-

Source: Agricultural Statistics of Balochistan 1985-86 and 1992-93

Apples are mainly grown in areas with an altitude of 4,000ft and higher, whereas the prime quality apples are coming from mountainous areas above 6,500ft due to a greater number of chilling hours. Recently developed apple orchards are dominated by "red and yellow

[29] Agricultural Statistics for the year 1992-93 have been used, because the 1994-95 Agricultural Statistics contain unrealistic figures for the area and production of dates.

delicious" varieties, whereas older varieties such as Kashmiri and Amri have become less popular. These local rootstocks begin bearing after 7 to 8 years and the peak yields are obtained when the trees are 15 to 18 years old. Tree density is approximately 70 to 100 per acre and, as long as the trees are not bearing, intercropping with vegetables and alfalfa is common. Generally, farmers do not appreciate pruning of orchard trees as it seems to remove branches that could bear fruit. Consequently, the trees become far too tall with many weak branches, reducing the life of the tree. The typical average yield for mature apple orchards under traditional systems of husbandry are 15 tonnes per hectare, whereas average yields up to 40 tonnes are possible under improved husbandry practices, including pruning, proper fertilisation and spraying. Picking takes place from July to October, whereas in higher areas it may be extended into November as well. Grading is often carried out in the orchard and packed into 18 to 20 kg crates using newspapers and rice straw as protection material. The marketing of apples is undertaken either by the farmers themselves or by contractors, who purchase the future harvest during spring when the trees are blossoming. Normally, the contractor pays the owner of the orchard one-third to half of the agreed price in advance. The introduction of semi-dwarf rootstocks has had a mixed reception, despite different advantages, such as smaller trees making spraying, pruning and picking easier, earlier bearing by 3 to 4 years, tree density of 240 per acre and supposedly higher yields.

Apricots are mainly grown in the lower upland areas and the trees start bearing fruits after 3 to 4 years and are in full production at the age of 10 to 12 years. Picking takes place from May to July and average yields range between 15 and 19 tonnes per hectare. As almonds are the first fruit trees that blossom and the limiting factor in the production is early spring frost, almond orchards are predominantly concentrated in the lower upland areas. The first crop is obtained after 3 to 4 years and trees come into full bearing from 10 years onwards. Harvesting of almonds is carried out from July to August and the yield averages 4 to 5 tonnes per hectare. In many fruit growing areas throughout the Province, almonds are on the decline as many farmers replace older trees by other more profitable orchard crops, in particular apples.

Grapes are mainly grown at an elevation of 5,000 to 6,000ft in Quetta, Pishin, Chaman, Zhob, Mastung and Kalat Districts. In Zhob District, farmers use pergola trellis in order to have sufficient ventilation, whereas in the other areas the vines are grown in parallel trenches to protect the fruits from wind scorch. Pomegranates have become more popular due to an increasing demand from the Punjab and Karachi and they are grown principally in lower areas of Loralai, Pishin, Zhob and Khuzdar Districts, because the crop is fairly heat-tolerant and cannot withstand low temperatures. The picking season starts in the beginning of August and lasts until the end of October and average yields vary from 18 to 25 tonnes per hectare.

Dates are the most important orchard crop in the western and southwestern parts of Balochistan, in particular in Turbat District with nearly 50% of the total area under dates in 1989-90. Date trees produce fruits after three to eight years and the harvest lasts from July to September.[30] A wide range of other deciduous fruits are also grown on a smaller scale by farmers in the areas above 1,000ft, including peaches, plums, cherries, figs, mulberries, pistachios, nectarines and walnuts. In the southern plains and coastal areas, a large variety of sub-tropical fruits are being cultivated, such as papaya, guava, coconut, banana, mango, orange, mandarin, chikoo and lemon.

---

[30] Akhtar Husain Siddiqi (1991): p.248.

5 MAIN WATER SOURCES

BALOCHISTAN

Community irrigation systems in Balochistan can be best categorised according to the water source or method of extraction. Based on information about 340 community irrigation schemes that have been visited during the preparation and the first year of the BCIA Project, the distribution of schemes according to the main source for irrigation water is as follows:

- kareze: 111 (32.6%)
- spring: 66 (19.4%)
- infiltration gallery: 26 (7.6%)
- river diversion: 137 (40.3%)

Karezes are mainly situated in the northern and central districts of Balochistan, such as Pishin, Loralai, Kalat, Ziarat, Chaman, Qila Saifullah and Khuzdar Districts, whereas springs are primarily found in the central mountain range of Kalat and Khuzdar Districts and in the Harnai Valley of Sibi District. Traditional infiltration galleries are foremostly located in Pishin, Loralai and Zhob Districts. Diversion of surface flow in (semi-) perennial rivers are found in almost all districts of the Province, except in Chagai and Mastung Districts. Zhob, Khuzdar, Sibi and Chaman Districts have the largest concentration of community irrigation systems with free intake structures. The distribution of the four main water sources per district is summarised in Table 5.1.

The four main sources of community irrigation systems in Balochistan will be described more in detail in the following sections of this chapter.

5.1 KAREZE SYSTEMS

Kareze systems are thought to have been in use in Balochistan since the time of the Moghuls during the 16th and 17th centuries, although some ancient karezes are even older. The kareze is a gently sloping tunnel which conveys water from below the watertable to the ground surface. The traditional method of kareze construction is by a well, termed the mother well, being sunk to prove the presence and depth of the watertable. The depth of the mother well varies from less than 25 ft to 150ft or more. The choice of location of the mother well is determined by variations in vegetation, general topographical conditions, the slope of the land and the site of the land to be irrigated. When the mother well has struck a constant flow of water in a permeable stratum, the alignment and slope of the kareze tunnel from the mother well to the point where the tunnel is to come to the surface has to be calculated. If the gradient is too steep, the water will flow too fast inside the tunnel and erode its walls, causing the tunnel to collapse. The construction of the tunnel normally begins from this point by digging back towards the mother well, although occasionally work is begun simultaneously at both ends. The length of the kareze tunnel depends on the depth of the mother well and the slope of the ground surface and it varies from less than 100 metres to several kilometres, whereas its height is approximately 4ft and its width is 2½ to 3ft.

Chashma Kareze in Loralai District with only three wells is a good example of a very short kareze, whereas Maluk Kareze (Pishin District) is about 4,000ft long and over 60ft deep at the top end, while Muradabad Kareze in Chagai District has a length of 10,000ft.

Table 5.1. Distribution of 340 community irrigation schemes by district and by water source[31].

District	Kareze	Spring	Infiltration Gallery	River Intake
Zhob Division				
Barkhan	-	1	-	6
Loralai	16	4	7	9
Musa Khel	-	4	-	7
Qila Saifullah	8	1	1	6
Zhob	5	7	5	23
Quetta Division				
Chagai	6	-	-	-
Chaman	8	1	3	12
Pishin	32	-	8	2
Quetta	-	-	-	2
Sibi Division				
Kohlu	5	4	-	2
Sibi	-	11	1	14
Ziarat	9	6	-	5
Nasirabad Division				
Bolan	-	1	-	3
Jhal Magsi	-	-	-	3
Kachhi	-	-	-	3
Kalat Division				
Kalat	10	15	-	6
Kharan	-	1	-	4
Khuzdar/Awaran	7	10	1	21
Las Bela	-	-	-	2
Mastung	5	-	-	-
Makran Division				
Gwadar	-	-	-	1
Panjgur	-	-	-	4
Turbat	-	-	-	2

[31] The Districts of Nasirabad and Jaffarabad in Nasirabad Division and Dera Bughti in Sibi Division are not included.

One of the most difficult problems during the construction of the kareze tunnel is to avoid the rush of water when the tunnel enters the water-bearing section and a break-through is made. The kareze tunnel is usually unlined, but if it passes through softer soil, flat stones are used to strengthen its walls and ceiling. Vertical shafts are either sunk from the surface to the tunnel or sunk first and then connected by a tunnel at an interval of 15 to 50 metres. The main purpose of the shafts is to give ventilation during the construction and cleaning of the kareze tunnel and to enable the soil excavated to be hauled to the surface in a bucket by a wind-lass. Each shaft is normally surrounded by spoil heaps and from the air a kareze has the appearance of a line of small craters. These spoil heaps protect the shafts against flood damage by run-off water from adjacent hill sides.[32]

The length of the water-bearing section, which is the part of the tunnel below the watertable, determines largely the kareze's discharge, because it is in this section that ground water seeps into the tunnel and generates the water flow. Seasonal variations in the discharge occur in response to fluctuations in the watertable. For instance, Balozai Kareze in Pishin District only had a measured discharge of 0.64 cusec just before the start of the winter rains in December 1995, but in March 1996 its discharge had increased to 4.31 cusecs due to very good winter rains. In years with significant recharge of the watertable, the kareze's discharge increases, whereas under drought conditions, the discharge declines due to a falling watertable. If the watertable falls below the level of the kareze tunnel, water flow from the kareze will cease completely. However, most alluvial fan aquifers have an enormous storage capacity and karezes only begin to dry up after a number of years of drought. [33] Many karezes in Balochistan have an average discharge of 0.5 cusec of water, but larger karezes can have a water supply of several cusecs. For instance, Munara Kalan Kareze in Loralai District has an average measured discharge of 4.85 cusecs in 1995 and 1996, whereas Maluk Kareze in Pishin District had a discharge of 8.32 cusecs in March 1996.

At the beginning of the 20th century, karezes were important water sources for irrigation in many areas of Balochistan. The Gazetteer of Baluchistan reported that there were 278 karezes in the Quetta-Pishin District in 1904 irrigating 66% of the total area under perennial irrigation. According to the same source, there were 381 karezes in the Sarawan District (present Kalat and Mastung Districts), of which only 250 were functioning, whereas 123 and 116 were reported in Zhob and Loralai Districts, respectively. With 127 karezes in 1904, the kareze was also an important source for irrigation in the Makran region and the following Balouch saying expressed the importance attached to irrigation from karezes: *"A mosque should be demolished if it obstructs the course of a kareze"*. In 1905, Chagai District only had 23 karezes, but the Gazetteer reported that there are ruins of many old karezes in all parts of the District and some of these old karezes were of a considerable size, indicating

---

[32] P. Beaumont, M. Bonine and K. McLachlan (1989):Qanat, Kariz & Khattara; Traditional Water Systems in the Middle East and North Africa, p.6, 7,17 and 23.

[33] P. Beaumont, M. Bonine and K. McLachlan (1989): p.19 and 23; Akhtar Husain Siddiqi (1991): p.107; BCIAP: flow measurement programme.

that the water supply from karezes was greater in former days. Ruins of old karezes are also reported from Zhob, Loralai, Makran and Quetta-Pishin Districts.[34]

The development of a kareze represents an enormous capital investment and it takes many years to complete the construction works. Therefore, karezes are generally constructed by joint capital. According to the Gazetteer of Baluchistan, the British colonial government encouraged the construction of new karezes at the end of the 19th century and the beginning of the 20th century by granting subsidised loans and by exempting newly developed karezes from payment of revenues for a term of years. Due to this policy, 17 new karezes were developed between 1890 and 1905 in Quetta and Pishin Districts alone and the construction of 7 karezes started in Chagai District between 1901 and 1905.[35]

There were reportedly 791 functional karezes in the Province in 1990.[36] Although the ruins of many karezes indicates that the decline of karezes has started a long time ago, a large number of karezes have been abandoned during the last two to three decades due to a number of factors. The rapid development of tubewells in Balochistan has disrupted the operation and management of karezes. The installation of tubewells in the vicinity of karezes, in particular near the mother well, has affected the discharges of karezes by lowering the watertable and in a number of instances karezes have dried up completely. For instance, the Karezghai scheme near Muslimbagh in Qila Saifullah District previously had three karezes providing irrigation water for an extensive command area. But due to the development of a number of tubewells adjacent to the karezes, one kareze has dried up completely some 10 years ago, whereas the discharge of the second kareze has been reduced significantly. Another example is Zulfiqar Kareze in Loralai District, where the shareholders themselves have installed a tubewell in the vicinity of the kareze mother well. As a result, the farmers had to deepen the kareze tunnel several times in order to restore the water flow due to the falling water table. Consequently, the upper command area cannot be irrigated any more because it is lying too high.

The introduction of tubewells has also allowed wealthier farmers, who can afford the installation of an individual tubewell, to abandon the karezes, leaving the poorer shareholders with insufficient resources to maintain these traditional water sources and it has weakened the traditional social system responsible for the organisation and implementation of kareze maintenance. The inability to maintain the karezes has caused some karezes to dry up totally, while poor maintenance has lead to a significant reduction in the water flow of many other karezes. The installation of tubewells by the wealthier farmers has enabled them to improve their economic and social status through increased agricultural productivity, whereas the failure of karezes has lead to a decline in the economic and social well-being of those who

---

[34] The Gazetteer of Baluchistan (1986): Chagai, Quetta-Pishin, Zhob, Loralai and Sarawan Districts (first published in 1906).

[35] The Gazetteer of Baluchistan (Quetta-Pishin) (1986): p.147; The Gazetteer of Baluchistan (Chagai) (1986): p.109.

[36] Pakistan/Netherlands Project Strengthening of Planning and Development Project (June 1994): p.7-11.

continue to depend on kareze water to irrigate their fields. The major consequence of the introduction of tubewells is that it has caused higher levels of social and economic inequality in many rural communities.[37]

The Dado Kareze in the village of Ibrahimzai, Pishin District, dried up five years ago, because the wealthier shareholders are not interested any more in the kareze as they have developed their own tubewells, while the other shareholders are unable to collect enough money for the cleaning of the kareze. In the same district, the Jamal Kareze dried up completely after it collapsed totally in 1987, whereas the tunnel of Sharan Kareze caved in over a length of 30 wells in 1981, reducing the discharge significantly. The Akhtarzai Kareze in Qila Saifullah District has also not been reconstructed after it collapsed partially in 1992, because the main water shareholders have installed their own tubewells. Although there are several hundred water shareholders in the Kazha Kareze in Chaman District, it has not been cleaned for many years, because many families have water rights in other karezes, or they have developed dug wells. Consequently, the Kazha Kareze has become very unreliable as it dries up regularly.

The rehabilitation of collapsed and/or dried-up karezes is very rare in these days. But occasionally it is undertaken by the original shareholders with or without financial assistance from outside agencies. One example is the rehabilitation of Churmi Kareze in Pishin District. Reportedly, the kareze collapsed some 70 years ago and the shareholders were not capable of restoring the water flow. To find new sources of income, the shareholders were forced to leave their village. In 1964, however, the original shareholders decided to start with the rehabilitation of the collapsed kareze and the work was completed in 1981. According to two shareholders, a total sum of Rs 4,000,000 has been spent to hire skilled labourers to undertake the rehabilitation work. Presently, the kareze has an estimated discharge of 2 to 3 cusecs, irrigating two separate command areas. Another example is Mullah Ahmed Kareze in Loralai District, which was rehabilitated in 1968 after it was blocked for nearly two decades. The rehabilitation works were undertaken by the tribal head (*sardar*) of the Sagara Clan of the Kakar Tribe by spending Rs 362,000 himself and Rs 20,000 from the Union Council. In return for his investment, the *sardar* received a special water share of 3 *shabanaroz* (72 hours) and 60 acres of land from the community. Following the partial collapse of Saleh Din Kareze in Pishin District, the water shareholders hired a team of *karezgar* to construct a new tunnel around the collapsed section. The *karezgar* asked Rs 1,650 per yard for excavation in rock and Rs 450 per yard in loose soils. In the Shina Khwara scheme, the rehabilitation of a kareze, which was completely collapsed in 1982, was undertaken by a contractor under an UNHCR-financed income generating project for Afghan refugees in 1995 without any contributions by the water shareholders themselves.

The development of new karezes is very uncommon in Balochistan, but it has not been abandoned completely. Box 1 outlines the main aspects of Gorandi and Muradabad Karezes, which have been developed in recent times. Another example is the development of a kareze at the foot of the Khosobai Mountain in Khuzdar District by members of the Kori

[37] Syed M. Arif (1991): p.33 - 38.

Tribe about twenty years ago. However, after they had completed three wells, they stopped the works because they were not able to divert the small water flow to their fields, which were located several kilometres from the water source. The shareholders, belonging to the Zehri Pandrani Tribe, have developed the kareze by extending the length of the kareze tunnel after they received the water rights during a court case. Presently, water from the kareze is conveyed through a 8 kilometre long earthen channel to the command area, where the farmers grow summer vegetables and winter wheat.

Box 1. Kareze Development in Ahmad Wal.

The Ahmad Wal Perennial Irrigation Scheme is situated along the main road from Quetta to the Iranian border, about 17 miles of Nushki town in Chagai District. The scheme consists of Gorandi and Muradabad Karezes. The Gorandi Kareze was constructed in the 1950's, whereas the work on Muradabad Kareze started in 1968 and it was partially completed in 1991 at a total cost of Rs 2,700,000.

For the development of both karezes, the kareze developers, locally called *khat kash*, and the original landowners agreed that upon the successful completion of the karezes the *khat kash* would receive land rights in return for part of the water rights. The original consortium of kareze developers for Muradabad consisted of 16 persons, but during the 23 years of development, a large number of consortium members were forced to withdraw as they were no longer able to provide the required investment. Consequently, they lost their investment, because they could not sell their share in the future kareze to outsiders. This provision was imposed to discourage consortium members from abandoning the work and to protect the kareze right from being purchased by local powerful persons.

At the completion of the kareze development work in 1991, only three of the original consortium members remained and the land rights in the designated command area were distributed in accordance with the water rights as agreed in 1973. The *khat kash* and the original landowners also agreed to draw up a new contract for the further development of Muradabad Kareze. For a period of seven years, the original landowners have agreed that the income from their crop share is used for further excavation of the kareze.

Both karezes are partly managed as collective enterprises by three irrigation managers *(rais)*, who arrange the maintenance of the scheme and engage tenants to work on the land. Presently, 30 families have water shares in the two karezes. The combined discharge is 1.25 cusecs irrigating a total command area of 118 acres, on which the farmers grow wheat, onions, cumin and vegetables.

The further development of existing karezes by extending the kareze tunnel, or by constructing an additional (branch) tunnel, is not uncommon. Water shareholders in Killi Churmian (Pishin District) have spent Rs 150,000 in 1994 for the extension of the length of the kareze tunnel in order to increase the discharge. In the same area, Gwal Kareze was extended in 1992 with the financial assistance of a Canadian NGO, while the shareholders of Mullah Ahmed Kareze have constructed an additional kareze tunnel in 1994 and 1995 in order to enhance the water supply. In 1992, UNHCR provided Rs 400,000 under a special income-generating programme for Afghan refugees for the extension of Munara Kalan Kareze by constructing 12 new wells.

5.2 SPRINGS

Natural springs are another perennial source for irrigation water in different parts of the Province. Detailed information about the actual number of springs is not available, but according to the Gazetteer of Baluchistan (1906), there were 1,811 springs in Baluchistan at the beginning of this century. Almost all springs are found in the mountainous areas of northern and central parts of the Province, such as Quetta-Pishin and Zhob with 908 and 437 springs, respectively.

The Gazetteer of Baluchistan does not mention if the springs are used for irrigation purposes or only for domestic use. But in Loralai District 11,185 acres were irrigated by springs, whereas in the Harnai valley (Sibi District) and the Muslimbagh and Qila Saifullah regions of Zhob District 4,963 acres and 3,703 acres were under command of springs at the beginning of the 20th century.[38]

The discharge of springs ranges from less than 1 cusec of water to several cusecs. One of the largest springs is Sarkan Chashma in the Harnai Valley (Sibi District) with a measured discharge of 35.44 cusecs. Other important springs are Pui and Aghbarg in Loralai District with discharges ranging from 5 to 10 cusecs and the Chashma Chut in Pandran (Kalat District) with a measured discharge between 3.3 and 4.0 cusecs.

5.3 INFILTRATION GALLERIES

Infiltration galleries intercept mainly the sub-surface flow in river beds, which frequently continues throughout the year even though the surface flow may be seasonal. Traditionally, farmers have excavated trenches either across or parallel with the flow, which are sometimes left open, but more often a dry stone conduit covered with stone slabs and bed material is provided. As with karezes, these traditional galleries can be 1.5 kilometres long and over 4.5 metres deep at the uppermost end.

The discharge of many traditional infiltration galleries is relatively small. Reconnaissance visits to 23 irrigation systems with a traditional infiltration gallery as a main source of irrigation water have revealed that the average discharge is approximately 0.8 cusec. With 1.65 cusecs, the traditional infiltration gallery in Pasra Kachhi (Loralai District) had the largest measured discharge, whereas one of the galleries near the village of Mullazai (Pishin District) reportedly has a discharge between 2 and 3 cusecs.

[38] The Gazetteer of Baluchistan (1986): Loralai, p.179; Sibi, p.114 and Zhob, p.143.

The main problem of many traditional infiltration galleries is near the exit point where the gallery comes close to the surface and it is liable to collapse during floods. The danger of flood damage to infiltration galleries is described in Box 2.

Normally, infiltration galleries are situated at relatively large distances from each other in order to ensure that the downstream galleries do not dry up due the diversion of all of the available sub-surface flow by upstream galleries during the dry season. In certain areas, such as Khuzdar, there are regulations between upstream and downstream communities regarding the type and length of diversion structures. For instance, upstream communities along the Mula River near the village of Raiko are only allowed to construct a diversion structure, including an infiltration gallery, to the middle of the river.

Box 2. Traditional Infiltration Galleries in Killi Oras.

The village of Killi Oras is situated 17 miles southwest of Loralai town in Loralai District just north of the Ziarat - Loralai road. Some 40 years ago, farmers built two infiltration galleries in the Sanjawi Manda, which is a left bank tributary of the Kanni Manda. One gallery follows the right bank of the river and it estimated to be 2,500ft long and its depth is between 6 and 8ft, except near the exit point. The second gallery is aligned diagonally across the river and it is approximately 350ft long and between 2 and 5ft deep. When the second gallery was first developed, the left bank farmers successfully objected to the gallery being extended to the eastern half of the river, because the Killi Oras farmers are only entitled to extract surface and sub-surface water up to half-way across the river bed and the Zarha Sanjawo scheme on the opposite bank is entitled to the other half.

The lower end of the larger infiltration gallery is subject to flood damage and collapses frequently. The exit point has moved progressively upstream and in 1988 a flood caused major damage to the lower 350ft long section of the gallery. Consequently, water from the gallery is discharged back into the river and flows down an unlined channel excavated in the river gravels and is picked up 700ft downstream at a free intake which diverts the water into the main channel.

The water supply from both galleries has proved to be reliable and the existing infiltration galleries have worked well despite the relative shallow depth. The minimum water flow in the river normally occurs before the onset of the summer monsoons, when it approximately half the normal winter level. The water losses from the shallow sections of both galleries immediately before their exit points and the unlined channel between the exit point of the right bank gallery and the free intake structure are difficult to assess. When the sub-surface flow in the river is just below the surface, the losses are likely to be less as the river bed material is already saturated. However, when the sub-surface water level is well below the bed of the river, significant losses are anticipated.

Presently, the minimum measured discharge of both infiltration galleries together is 1.1 cusec. About 36 water shareholders using the water for irrigating of 87 acres of orchards and 19 acres of vegetables during the summer months and 17 acres of winter wheat.

However, there are also areas where a number of infiltration galleries have been constructed in the same river within a short distance of each other. One example is the Rud Mullazai in the southeastern part of Pishin District, where four dry stone galleries have been constructed within a total distance of a few kilometres. There appears to be some interference between the upper two galleries, but the discharge of the others seems to be relatively independent. All four galleries are constructed close to the surface of the river bed and are frequently damaged or completely scoured out during the flood season. During the winter season, when there is no demand for irrigation water, the farmers close the galleries in order to "store water in the river bed". In the same area, farmers resident in the village of Garshin have built five galleries in the river bed of the Sur Ghund Nullah.

5.4 RIVER INTAKES

Free intake structures are normally built by farmers to divert all or a portion of the perennial or seasonal surface flow in the river bed to their fields. The most common free intake structure is a spur or bund that is constructed from river bed material. The size of the spur is mainly determined by the width of the river bed and the location of the base flow channel, which can change from year to year after large floods. The construction of a diversion spur requires a significant amount of labour input, although oxen have been gradually replaced by tractors, allowing farmers to build stronger and higher spurs in a shorter period. It is not uncommon that farmers are also using reeds and branches of trees to strengthen their spurs. If a spur is built from gravel material, farmers occasionally use silt to reduce the seepage losses.

However, free intake structures are less reliable sources for perennial irrigation because of the wide meandering nature of many rivers and the occurrence of floods, which are washing out intake structures frequently and interrupting the diversion of irrigation water for a number of days. On major rivers with major floods, such as the Zhob and the Mula, it is impossible for the farmers to rebuild their intake structure during the flood season once it has been washed out by the first flood. A good example of an irrigation system where farmers are unable to divert surface water during the monsoon season is Mirjanzai, which is described in Box 3. Farmers from the village of Raiko (Khuzdar District) are also unable to maintain their diversion spur during the monsoon season, because the floods in the Mula river are too frequent and too severe. The farmers reconstruct their spur during the month of September or October requiring the input of 25 men for 10 days and about Rs 10,000 to rent a tractor. Consequently, they can only grow wheat during the *rabi* season, but even during the winter months the spur is washed out four to five times.

A degrading river bed is another major problem that many irrigation systems with free intake structures are experiencing. If a river bed degrades, the farmers have two options that will allow them to continue to divert surface flow to their fields: to construct the spur further upstream or building a higher diversion structure at the same site. The first option is only possible if there is a suitable site to build the diversion spur and convey the irrigation water to the command area and if the farmers are allowed to construct a diversion structure by upstream communities. In many areas of Balochistan, the river bed is distributed between different communities situated along the river and the exact boundaries of each "constituency" are normally known and recognized by members of these communities. Under normal circumstances, each community is only allowed to build a diversion structure in its own section of the river bed. However, there are irrigation systems where the farmers cannot build another diversion structure further upstream, because they were already constructing their spur near the upper boundary of their section. If the relations with the upstream community are not strained due to a dispute and the first upstream diversion structure is not too close to the new site, the downstream farmers could ask for the permission of the neighbouring upstream community to build their spur within their section of the river bed. For instance, the farmers from Jug Zidi (Khuzdar District) were allowed to build their new spur within the river bed section of the Kolachi River that belongs to the upstream village of Gazezai after the original spur site was seriously eroded by the heavy flood of July 1995.

Box 3. Free Intake Structure in Mirjanzai.

The village of Alif Mirjanzai is situated on the right bank of the Narechi Rud, 72 kilometres east of Duki town in Loralai District. In 1995, 156 families were resident in the village, of which 79 households have water rights in the irrigation scheme.

The present irrigation system consists of two diversion bunds constructed near the right bank of the river diverting approximately 10.5 cusecs to an extensive command area through an unlined channel over a distance of approximately 4 kilometres. The farmers manage to maintain the irrigation water supplies during the winter season as the floods in the river are smaller and less frequent than during the summer months. Normally, the farmers rebuild both diversion spurs during the month of October and they are able to divert surface flow from the river until the start of the monsoon rains in June or July. However, even during the winter, the bunds can be washed out two or three times, requiring reasonably rapid construction to avoid loss of the rabi season crops, such as wheat and barley.

The frequency and magnitude of the floods during the summer season precludes the diversion of irrigation water from June/July to October. During this period, the diversion bunds would have to be reconstructed many times, involving significant expenditures. The loss of water during the time of the actual flood, along with the time required to rebuild the spurs, would result in considerable crop losses.

The second solution to the problem of a degrading river bed is the construction of a higher spur at the same site. Due to the presence of more tractors in many rural communities, farmers are able to build higher diversion structures than previously was possible. However, it will be more difficult for the farmers to rebuild higher spurs if they are washed away by floods. For example, the farmers in Kuhan village (Khuzdar District) have only been able to construct a large and very high spur with the help of a bulldozer hired from the Government after the July 1995 flood had degraded the river bed of the Mula River by several feet. If this spur would be washed out by one of the first floods, it will be impossible for the community to reconstruct it again and the standing crops would fail completely. Further upstream of Kuhan, farmers from the village of Pani Wand can only irrigate the lower fields with water diverted from the Mula River by a spur after the river bed was degraded by the same major flood in 1995.

Due to a degrading river bed, there are many irrigation systems with free intake structures that have been abandoned by the farmers, because they are not able anymore to divert the surface flow to their fields. Water shareholders in the Khatol Kot scheme have not irrigated their fields for the last 20 years, because the river bed of the Zhob River has degraded to such an extent that they are unable to build an earthen spur to divert water to their extensive command area on the right bank of the river.

Another disadvantage of free intake structures is that there is no control on the high flows entering the conveyance system, causing erosion in the command area and depositing sediment.

The discharge of free intake structures depends mainly on the size, the strength, and the number of the constructed spurs, as well as on the available surface flow in the river bed that could be diverted. Normally, farmers construct one single diversion spur to divert the total available surface flow or a portion of it. The total discharge of a single spur can vary from less than 0.5 cusec in Gastoi (Zhob District) to 16.8 and 17.4 cusecs for the Nazi & Sheikhan Viala and Harnai Viala in Sibi District, respectively.

However, there is a possibility that farmers can erect two or more spurs within a relatively short distance in order to divert water to one or several command areas situated on one or both banks of the river. Farmers in Mirjanzai (Loralai District) constructed two spurs to divert surface water to one large command area on the right bank of the river, whereas in the village of Sabakzai (Zhob District) two spurs are maintained in order to irrigate two separate command areas on both banks of the Sawar Rud. A total of ten independent free intake structures have been constructed in the Jogizai Rud by farmers from Sharan Jogizai in Qila Saifullah District in order to irrigate small command areas on both banks of the river. The surface flow in the Dorai Lahar (Zhob District) is diverted at seven different sites to small command areas on both river banks by an earthen spur and a small concrete weir. One of the larger community irrigation schemes in Balochistan is the Karkh system in Khuzdar District where ten free intake structures divert surface flow to several extensive command areas on both banks of the Karkh or Karu River. According to the cadastral records, approximately 3,200 acres of land are irrigated to grow mainly wheat and rice and about 1,025 families are entitled to water from these diversion structures.

6 WATER AND LAND RIGHTS

6.1 WATER RIGHTS

Water rights in perennial irrigation systems in Balochistan are usually well defined at the family level and they are expressed in fixed time shares of the original irrigation cycle. To distribute water rights, different mechanisms have been utilised to determine the size of individual water shares. In many community irrigation systems, individual water rights are derived from the initial contributions to the development of the water resource, such as a kareze. In irrigation schemes that depend on the base surface flow in perennial rivers, the water rights were distributed according to existing land rights in the irrigable area.

But there are also less common mechanisms to determine water rights. In some areas, where groups of persons without land rights have developed karezes, water shares in the kareze have been exchanged for land rights with the original landowners. A very peculiar form of distribution of water rights was applied in Mirjanzai irrigation scheme in Loralai District. About 150 years ago, one Alif Nika, belonging to the Mirjanzai clan of the Luni tribe, settled with his family on the right bank of the Narechi River after he had bought land and water rights from the locally resident Zarkoon tribe. Subsequently, he distributed land and water rights among his sons and other recently settled families under the condition that they provide guests with food and assist in the protection of the village against attacks by other tribes. If one family failed to fulfil these obligations, it lost its land and water rights automatically. At present, these same rules are still applied.

There are also community irrigation systems in Balochistan, where the water rights have not been distributed permanently among the individual shareholders and their families. For instance, the distribution of water rights in Lakharo irrigation system (Khuzdar District) follows the clan-wise distribution of cultivable land that can be commanded from the infiltration gallery and are presently only defined at the clan level.

Water rights are still communal property in the village of Kunara (Jhal Magsi District). Each male child is given an equal water share upon his birth, which entitles him to utilise the full perennial flow for 25 minutes in the winter season and 15 minutes during the summer months. The water share becomes effective in the first winter season after the boys birth and it is withdrawn upon a man's death. If the deceased leaves a family behind, a dispensation is given of two years, during which his family can continue to utilise his water share.

6.1.1 Special Water Rights

In many community irrigation systems throughout the Province, special water shares have been established for different purposes. A common special water share is given to the local water bailiff, locally called *mir-i-aab* or *rais*, as a compensation for his services, which normally include the organisation and supervision of maintenance work, supervision of water distribution, arbitration and/or collection of cash contributions. The size of the special water for the water bailiff is mainly determined by the number of tasks and responsibilities assigned to him.

However, the sizes of special water shares for water bailiffs varies considerably. For instance, two *rais* in Maighatti (Khuzdar District), who are responsible for the mobilisation of labour for scheme maintenance, supervision of water distribution and solving internal disputes, receive ½ hour of water, whereas the water bailiff in Yousuf Kach scheme is compensated for the same services by a special water of 6 hours in both main channels. The *rais* of Bizni Kareze is not only responsible for the organisation and supervision of the maintenance of the scheme, including the mobilisation of labour and collection of money, but he has also to check the kareze and the main channel after rainfall and floods. For his services, the *rais* receives a special water share of 24 hours during each 24 day irrigation cycl,e as well as another water share of 48 hours that he can only use once a year. Normally, these special water shares for water bailiffs are awarded for a whole year, but it is also possible that a special water share is only issued for a limited period of time. In Sargarh and Zakhpel Karezes (Loralai District), a water bailiff is only appointed for six months to supervise the water distribution and only during this period he receives a special water share of 4 hours. A *mir-i-aab* is only appointed in Mando Viala scheme (Pishin District) if there is an internal dispute between water shareholders and for his arbitration the water bailiff receives 4 hours of water during each irrigation cycle.

Special water shares could also be given to the village *mullah* (leader of prayers in the mosque) and/or religious institutions, such as the village mosque and *madrassa* (religious school). In Munara Kalan Kareze, the village *mullah* receives a special share of 12 hours, whereas in Kunara all five mosques are entitled to special water shares of 20 shares of 15 to 25 minutes each. A special water share of 6 hours belongs to a local spiritual man in Mirjanzai.

Farmers could also decide to include a special share in the normal irrigation cycle to compensate water losses during the wetting of the earthen channels. A special water share of 2½ days is applied on three branch channels of the Sawar scheme in Zhob District in each water cycle of 30 days to cover the water losses during the irrigation cycle. In Mirjanzai, a special water share of 24 hours, locally called *raswani*, is used to wet both main channels over their full length at the beginning of the cropping season.

Permanent or temporary special water shares could also be established, which are leased seasonally or annually to raise money for collective purposes, such as repair of damaged irrigation structures or for the construction of a village mosque. For example, farmers in Mando Viala scheme leased a special water of 24 hours for three years to finance the rehabilitation of a major syphon and in Kan Mehtarzai (Qila Saifullah District) two communally owned water shares of 24 hours each are auctioned annually to raise money for scheme maintenance and development. In Khari (Jhal Magsi District), a communal water share of 24 hours was leased for one season to finance the construction of a small aqueduct.

Special water shares could also be given to local craftsmen, such as the blacksmith, to compensate them for the services provided. In Kunara, very special water shares were given to the descendants of villagers, who died as voluntary recruits in the British army during the Second World War.

Box 4. Special Water Rights in Munara Kalan Kareze.

The Munara Kalan Kareze scheme is situated approximately 15 miles northwest of Loralai town in Loralai District. The scheme consists of a very old kareze with a measured discharge of 4.1 to 5.6 cusecs. The kareze water is conveyed to a number of command areas mainly situated around the village through an unlined, 20,000ft long channel, including five tunnels.

Originally, the water rights in the kareze were distributed equally between the four sub-clans of the Utmankhel clan of the Kakar tribe, that were resident in the village. Presently, 51 extended families have a permanent water shares in the kareze, which entitles them to irrigate their fields during both cropping seasons. The smallest individual water share is one hour and seven minutes, while the largest water share is 27 hours.

In addition to the ordinary water shares, there are also a number of special water shares. One special water share of 12 hours is for the village *mullah,* whereas another special water share of 12 hours belonged to the local blacksmith. But since the village does not have a blacksmith any more, the special water share is distributed equally among the four sub-clans.

The third special water share of 36 hours is called *Kalagan* and its origin lies in the historical residential pattern during the pre-colonial time, when the water shareholders and their families were living in three different forts. After the Kalagan Fort was abandoned, a special share of 36 hours was included in the existing irrigation cycle to allow the farmers to develop new fields near the site of the abandoned fort. Nowadays, the Kalagan command area is not cultivated any more, but the special Kalagan water share has not been abandoned and all four sub-clans receive an equal portion. Some decades ago, three hours of the Kalagan share were sold as a separate share to one man and his family, who had settled in the village. Although this 3 hour water share officially gives right to use water from the kareze during the *kharif* season only, the five heirs are allowed to use the kareze water during the winter season as well.

6.1.2 Number of Water Shareholders

The number of water shareholders in community irrigation systems in Balochistan varies from one to more than a thousand. For instance, Sain Ghulam Shah Chhap scheme in Khuzdar District belongs to one family and its water is used to irrigate land of the shareholder himself, whereas a few farmers lease water to grow wheat and onions on their land and the *sardar* of the Sasoli tribe can use water from the spring for free. There are also schemes where only a few families possess all of the water rights, such as Pir Umar and Surgaz schemes in Khuzdar District with only three and four shareholding families, who hire tenants to cultivate their fields. In Bolan District, the Bolan weir diverts approximately 31 cusecs of water into the Inami Canal and all water rights belong to eleven families, who employ tenants to cultivate about 2,000 acres of irrigated land.

However, the majority of perennial irrigation schemes in Balochistan are owned by a larger number of farmers and their families. The average number of water shareholders in twenty community irrigation systems, which have been studied under the Balochistan Community Irrigation and Agriculture Project, is 129, ranging from 24 individual shareholders in Maluk Kareze to 434 in Sanzala Kareze.

In Balochistan, not all resident families have permanent water rights in the community irrigation system due to a number of different reasons. A first category of families without permanent water rights consists of families that have settled in the villages after the water shares were distributed. For instance, the *Chashma Chut* is the main source for irrigation water in Pandran and it belonged originally to the Pandrani tribe, who developed the spring a few centuries ago. Since then, families belonging to other tribes and clans have settled in the village and a number of them have bought water shares from the original owners. Presently, there are 95 families with water shares in the spring, of which 66 families are permanently resident in the village, and there are 86 resident families without water rights. However, 62 families without water rights in the spring have their own land and they are leasing water from the shareholders, whereas the other 26 families practice flood irrigation or are working as tenants.

A second category concerns families whose original water shares have been sold. Poverty and indebtedness are the main reasons to sell water titles to wealthier shareholders in the same community.

A third category are the village artisans, such as messengers, blacksmiths and carpenters, who are considered as a different social class. Traditionally, they are given a share in the crop in return for all of the work that they have undertaken on request of the land and water shareholders. Where the subsistence economy has lost its significance, these traditional arrangements are often replaced by direct payments in cash. However, in comparatively isolated and poor communities, particularly in the southern parts of Balochistan, the traditional arrangements between local craftsmen, known as *lori*, and farmers still persist. In Zerin Hasoi (Khuzdar District), a blacksmith and his family receives 5 kg of every 6 *maund* (224 kg) of harvested wheat and rice annually as a compensation for the repair of agricultural equipment, such as ploughs, from all of the resident farming families. Same arrangements are also reported in Lakharo, Kunara and Ahmad Wal.

The proportion of resident families without water rights in the community irrigation system varies significantly. There are communities where all resident families have a water share in the irrigation scheme, such as Lel Gat & Spezandai scheme in Ziarat District. But there are also communities where more than half of the resident population do not have water rights in the main irrigation source, such as Ahmed Wal and Maluk Kareze. If these families have their own land, they could have access to other perennial water sources to irrigate their fields, such as dugwells and tubewells, or they practice water harvesting or flood irrigation. In Mina Bazar, for instance, most of the 86 resident families without water rights in one of the three community irrigation systems have developed their own dug wells, whereas in Khari most of the 120 resident families without water shares in the irrigation system are practising *khushkaba*. Families without land and water rights at all derive an income as tenants, day labourers, livestock or other off-farm sources of income, such as low-paid government jobs, transport, business or the sale of wood.

6.1.3 Distribution of Water Rights

The distribution of individual water rights within a community irrigation system can vary from equal to very skewed. An example of a very equal distribution of water rights is Zerin Hasoi in Khuzdar District, where each water shareholders receives an equal water share on the condition that he has contributed labour during the reconstruction of the diversion spur and the cleaning of the main channel at the beginning of each cropping season.

The distribution of water rights is very unequal in Nok Joe Kareze (Khuzdar District), where the *sardar* of the Zehri tribe is entitled to use 50% of the total water flow. In the Takatu Zawar Kanr scheme in Pishin District, the distribution of water rights among the 30 water shareholders is also very skewed with 3 water users (10%) owning 62.5% of all of the water.

The distribution of water shares in 18 BCIAP community irrigation schemes is relatively egalitarian[39]. On average, the group of 25% largest water shareholders (upper quartile) possesses about 55% of the water rights in the schemes, whereas the group of 25% smallest water shareholders is entitled to approximately 7%. The quartile distribution of water rights in the 18 BCIAP schemes are given in Table 6.1.

[39] During the preparation of the BCIA Project, a computer simulation was undertaken to calculate the normal variation in resource rights that only occurs due to inheritance. Starting from a completely egalitarian distribution in the first generation, the property owned by the group of 25% largest shareholders in the sixth generation (about 150 years later) is 68% on average.

Table 6.1. Quartile distribution of water rights and number of water shareholders for BCIAP Community Irrigation Schemes in Balochistan[40].

Schemes	Lower Quartile	Second Quartile	Third Quartile	Upper Quartile	Number of Water Shareholders
Killi Oras	11.3	12.5	24.7	51.0	36
Lel Gat & Spezandai	11.1	18.5	26.8	43.6	115
Kunara	7.0	14.0	20.0	59.0	205
Mina Bazar	8.1	15.3	24.3	52.9	166
Ahmad Wal	11.9	14.8	23.8	49.5	30
Maluk Kareze	4.8	11.7	24.5	59.0	24
Yousuf Kach	6.0	13.0	25.0	56.0	109
Pandran	8.6	15.2	25.1	51.1	94
Kalan Kareze	6.0	11.5	22.6	59.9	57
Khari	3.8	11.6	23.1	61.5	183
Domandi	6.7	12.5	21.3	59.5	222
Mirjanzai	8.3	14.6	23.3	53.8	79
Bizni	5.5	14.0	23.9	56.6	83
Mara Tangi	11.0	19.7	28.2	41.1	51
Takri-Khojakzai1	3.2	10.6	23.3	62.9	157
Narezai1	2.3	12.9	26.8	58.0	200
Badinzai	5.9	13.8	25.1	55.3	311
Sanzala Kareze	5.5	12.1	21.0	61.5	434
Averages	7.1	13.8	24.2	55.1	142

[1] Water is distributed according to land rights.

6.2 LAND RIGHTS

In the large majority of community irrigation systems in Balochistan, the land rights are determined by historical occupation of the area, which gives a claim to land property. However, the sale of land titles and political gifts have been sources of land claims as well. The distribution of land rights in Maluk Kareze is based on a complex settlement history. Although there is some doubt about the original ownership of the land, members of the Akhezai clan of the Achakzai tribe claim that the land rights were given by Ahmed Shah

[40] Lakharo scheme has not been included because water rights are only distributed at the clan level, whereas the registered water distribution system in Zerin Hasoi is not applied and the land and water rights are not exactly known in Koshk.

Abdali, the warrior king of Afghanistan, in the late eighteenth century as a reward for their contribution to his military campaigns. Subsequently, parts of the land were sold to people from other tribes, such as the Ashezai, Tareen, Kakar and Syed. A large tract of land at the extreme tail of the left bank channel originally belonged to the King of Afghanistan, who allowed a number of Syed families to cultivate it as hereditary tenants. In return for this right, the Syeds were supposed to pay an annual contribution to the King. But since the area came under control of the British Indian Government, these payments have stopped. The distribution of land rights in Kunara, which are based partly on historical occupation and partly on previous revenue rights is described in Box 5.

Box 5. Distribution of Land Rights in Kunara.

The village of Kunara is located on the right bank of the Kashok River in Jhal Magsi District, about 7 miles northwest of Gandava town at an altitude of 300ft. The climate is harsh with very hot summers and mild winters. The total annual rainfall is about 100mm. The irrigation water supply to Kunara comprises a free intake structure in the Kashok River. The river has eroded a deep gorge with vertical cliff faces along both sides for approximately 10,000ft downstream of the existing off-take. Water is diverted through a 28,000ft long unlined channel to two distinct command areas. In 1992, the village of Kunara had a total population of 2,172 persons, consisting of 191 households.

Presently, there are two groups that have land and water rights in the Kunara irrigation scheme. The first group consists of the original settlers of the area, who belong to the Tumpani lineage of the (Balouch) Lashari tribe. The other group with land and water titles are the descendants from the former revenue holders, who are Brahui tribesmen belonging to the Zehri tribe. During the time of the Kalat State, the land of Kunara was given as a revenue holding (*jagir*) to the Mullazai clan of the Zehri tribe as a reward for their support to the ruler of Kalat State. The revenue holding allowed the Mullazai clan to appropriate one-fifth of the perennially irrigated crop and one-sixth of the flood irrigated crop, after the cesses to Kalat State had been paid. At a later stage, the *jagir* right was transferred to the more powerful Zarakzai clan of the Zehri tribe, because the Mullazai tribe was often unable to claim their share of the crops (*batai*).

In 1965, the revenue holdings were officially cancelled under the Jagir Abolishment Act, but many revenue holders in the Kachhi Plains did not accept this loss of privilege. In Kunara, the Zarakzai clan contested the abolishment of their revenue estate in a series of court cases and they also tried to manipulate the land settlement that was undertaken in 1975. As a result, the Lashari farmers have been entered as hereditary tenants in the Record of Rights, paying land rent to the Zarakzai clan. After the courts decided in favour of the Lashari farmers, the Zarakzai refused to accept the court's decisions and created a law and order problem in the area. The dispute was finally resolved in 1987, when both parties agreed upon a new distribution of land rights: the Lashari farmers gave a tract of land as well as one-fifth of the water rights of the perennial water supply from the Kashok River to the Zarakzai clan.

Individual land and water rights do not always coincide, because differences can occur due to a number of reasons. The initial distribution of water shares in a community irrigation system was related to investment of individual shareholders in the development of the water source, such as a kareze, or the construction of irrigation infrastructure. It is also possible that individual water shareholders have sold their water shares, or a portion of them, independently of their land titles, or land was sold without water rights. In Pandran, for example, the water rights are separated from the land rights due to land and water transactions in the past between the original owners of the water source and other families, who settled in the village. Consequently, a number of water shareholders have insufficient land to utilise all of their water and they have leased a portion of their water share to other water shareholders in the spring with surplus land, or to farmers without water rights.

6.2.1 Distribution of Land Rights

According to the cadastral records, the group of 25% largest landowners in 17 BCIAP schemes owns about 63% of all of the registered cultivated land, whereas the group of 25% smallest landholders is entitled to about 5%. According to the Agricultural Census of 1980, 28.6% of all private farms in Balochistan were smaller than 5 acres and they only comprised 3.4% of all farm land, while 17.8% of all private farms were 25 acres or larger comprising 63.8% of all farm area in the Province.

The formal registration of individual land rights in many areas of Balochistan took place during the 1960's and many Record of Rights have not been updated since then. Therefore, the actual distribution of land rights in most BCIAP community irrigation schemes will have changed due to inheritance.

6.2.2 Farm Size

According to the Agricultural Census of 1980, an average farm had 19.2 acres of farm land, of which 12.1 acres was cultivated. About 17% of all private farms in the Province had less than 2.5 acres of farm land and approximately 41% were smaller than 7.5 acres. However, these statistics include perennially as well as *khushkaba* and flood irrigated farm land. The average farm size in flood irrigated areas of Balochistan is normally larger than for farms with perennial irrigation sources.

Using data of the Agricultural Census of 1980, the average perennially irrigated cropped area per farm was 4.9 acres, ranging from less than 1 acre in Gwadar, Panjgur, Las Bela and Dera Bughti Districts to 19.3 acres in Nasirabad District. About 41% of all private farms in Balochistan have less than 2 acres of perennially irrigated cropped area in 1980 and 17.3% had even less than 1 acre.

The average perennially irrigated cropped area per farm and the quartile distribution for 17 BCIAP community irrigation schemes are outlined in Table 6.2. The average perennially irrigated cropped area per farm is 2.37 acres, varying from only 0.30 acres in Domandi to 5.03 acres in Mirjanzai. The group of 50% smallest farmers only have access to less than 1.5 acres on average, whereas the lower quartile even has less than 1 acre on average.

Table 6.2. Average perennially irrigated cropped area for 17 BCIAP Community Irrigation Schemes in Balochistan.

Schemes	AVERAGE IRRIGATED CROPPED AREA				
	Lower Quartile	Second Quartile	Third Quartile	Upper Quartile	Total average farm size
Killi Oras	1.54	1.71	3.38	6.97	3.42
Lel Gat & Spezandai	0.35	0.59	0.85	1.38	0.79
Lakharo	0.10	0.29	0.63	3.10	1.03
Mina Bazar	0.85	1.61	2.56	5.57	2.63
Ahmad Wal	1.87	2.33	3.74	7.79	3.93
Maluk Kareze	0.91	2.22	4.66	11.21	4.75
Yousuf Kach	0.22	0.48	0.92	2.06	0.92
Pandran	0.72	1.27	2.10	4.28	2.10
Munara Kalan Kareze	1.03	1.97	3.87	10.26	4.28
Khari	0.25	0.76	1.50	4.01	1.63
Domandi	0.08	0.15	0.25	0.71	0.30
Mirjanzai	1.67	2.93	4.68	10.81	5.03
Bizni	0.27	0.69	1.17	2.78	1.23
Zerin Hasoi	0.43	0.66	1.30	4.54	1.73
Mara Tangi	1.75	3.14	4.49	6.54	3.98
Narezai	0.05	0.23	0.48	1.04	0.45
Sanzala Kareze	0.46	1.00	1.74	5.09	2.07
Averages	0.74	1.30	2.25	5.18	2.37

6.2.3 Communal Land

Generally, all cultivated land is permanently distributed among individual families and the land titles have been registered formally with the government in the Record of Rights. However, it is common that uncultivated and uncultivable land, including grazing lands and forest, is communally owned. Normally, all families in the community are allowed to use these lands under communal tenure to graze their livestock or to collect fuel wood. It is not uncommon that usufruct rights are leased to persons from outside the community. The pastures belonging to the village of Alif Mirjanzai are still communal property and the grazing rights are leased annually for Rs 60,000 to Rs 90,000 to nomadic livestock owners, who graze with their animals in the area during the winter months. The community in Kunara decided to lease the cutting rights for their communally owned forest to a business man in order to raise money for collective purposes.

Especially in Pathan communities in the northern areas of the Province, it is common that cultivable land, that cannot be irrigated, is communally owned, but that individual shares have already been allocated. As soon as the communal land, locally called *shamilat*, can be brought under cultivation, it will be sub-divided according to the previously allocated shares. It also occurs that individually owned land, that cannot be cultivated anymore, becomes *shamilat* land again until cultivation is possible in the future.

A very common form of land tenure is the *awara* or block rotation system, which is practised in perennially irrigated areas with sufficient land resources in order to preserve soil fertility. Under this land tenure system, each family has been given a land title in communally owned land, but plots of land are not permanently allocated. Normally, one specific *awara* or block of land is earmarked for cultivation at the beginning of the main cropping season and a lottery system determines which farmers will utilise which specific plot of land. The main reason to utilise the lottery system is to spread the risk to cultivate a less fertile plot of land or to have a plot of land at the tail of the command area. An *awara* system with four rotation blocks is still in use in the village of Sanni (Kachhi District) and land is distributed among the farmers during an annual lottery, because every farmer prefers to have a plot of land in the head reach of the command area. The Singiali-Kakoor scheme in Barkhan District has two separate command areas, of which only one is cultivated each year. Both command areas have two rotation blocks. Land in the Singiali command area is permanently distributed among the water shareholders, whereas the Kakoor command area is still communally owned and during an annual lottery the plots of land are distributed according to the size of the individual water shares.

Although the *awara* system with an annual lottery enhances equity among the farmers, it prevents them from making significant investments in land improvement or the cultivation of perennial crops, such as orchards. However, it has become common that farmers decide to designate one or more *awara* blocks for permanent cultivation in order to allow the development of orchards or to grow vegetables. In Munara Kalan Kareze, for instance, an *awara* system with four rotation blocks was originally in place, but two blocks are currently under permanent cultivation, whereas the other two blocks are still rotated to grow winter wheat. Although an *awara* system with three rotation blocks is still in place in Wahar (Loralai District), farmers are allowed to develop orchards in the upper *awara*, which they can irrigate annually.

Normally, each farmer has the same land and water rights in each *awara*, but it is also possible that rights differ in each rotation block. The Sawar scheme in Zhob District is an example, where the land and water rights to the different blocks differ due to previous transactions of land and water titles. The implication is that the majority of farmers only have land and/or water rights in one or two *awara*. Consequently, farmers have adopted a number of strategies, which would allow them to develop orchards, including the exchange or lease of water shares and the development of dug wells in order to irrigate orchards conjunctively by ground water and surface flow from the Sawar River.

6.3 LEASE AND SALE OF LAND AND WATER RIGHTS

6.3.1 Sale of Land and Water Rights

There are strong cultural impediments against the sale of land and water rights, particularly in Pathan communities, because it is considered as selling the family's birthright. But families are selling plots of land with or without corresponding water rights occasionally, mainly due to poverty or indebtedness.

However, the sale of land and water rights is normally subjected to a number of rules. In many communities in Balochistan, it is common that the land for sale has to be offered firstly to the owners of the adjacent plots, which is practically the preferred sale to relatives of the selling family. If the adjacent landowners are not interested to purchase the land, the other water shareholders have the first right before it could be sold to someone from the same community without water title in the perennial irrigation source. Especially in Pathan communities, it is very rare that land and water rights could be sold to a person from outside the community, in particular if he belongs to another clan or tribe.

The actual price paid for a water share mainly depends upon the actual available discharge and its reliability, as well as in which agro-climatic zone the scheme is located. The possibility to develop other perennial water resources, such as dugwells and tubewells, will also influence the sale price for water in a community irrigation system. In Table 6.3, the sale prices for different water shares for a number of schemes in areas above 1,000 metres and below are given. The sale price for a one hour water share per cusec in schemes above 1,000m varies from Rs 8,300 in Maluk Kareze to Rs 30,000 in Mana Kuz Kareze, whereas approximately Rs 6,700 and Rs 6,000 has to be paid in Khari and Koshk, respectively.

The availability of suitable land is not usually a constraint for the development of irrigated agriculture, except in the mountainous areas in the northern part of the Province, where the arable land is confined to small pockets in the valley bottoms. In schemes with sufficient arable land, the sale price ranges between Rs 20,000 in Mina Bazar for one acre in an *awara* that can be irrigated only once every four years to Rs 30,000 in Lakharo and Rs 50,000 in Khari. However, the sale prices are significantly higher in community irrigation schemes with limited amounts of cultivable land. A sum of Rs 80,000 had to be paid in 1992 for one acre of undeveloped land in Lel Gat & Spezandai scheme, which is situated in the Ziarat Valley, and in Killi Oras Rs 200,000 was paid for 0.5 acre in 1990.

Table 6.3. Sale prices for water shares for a number of community irrigation systems in Balochistan.

Scheme	District	Discharge	Price/hour
Above 1,000m altitude (apple-growing area)			
Maluk Kareze	Pishin	3 cusecs (summer) 8 cusecs (winter)	Rs 25,000
Munara Kalan Kareze	Loralai	4.5 cusecs	Rs 40,000
Bizni	Mastung	1.8 cusecs	Rs 18,300
Sargarh & Zakhpel Kareze	Loralai	1.84 cusecs	Rs 50,000
Kudazai Karezes	Loralai	3 to 4 cusecs	Rs 58,000
Mana Kuz Kareze	Ziarat	1.4 to 2.9 cusecs	Rs 60,000
Below 1,000m altitude (non apple-growing area)			
Koshk	Turbat	3 to 6 cusecs	Rs 30,000
Khari	Jhal Magsi	4.5 cusecs	Rs 26,700

6.3.2 Lease of Water Shares

A demand for (additional) irrigation water by one group of farmers and the supply of (surplus) irrigation water by water shareholders are two conditions for the development of an active market for trade in water rights. There could be a demand for (additional) irrigation water if farmers do not have a water share in a perennial irrigation source or if they have more land than they can irrigate with their own water share or water from another perennial irrigation source, such as a dugwell or tubewell. Water shareholders could decide to lease their full water share or a portion of it, because they have more water than they need to irrigate their lands sufficiently, or they are unable to divert the water supply to their fields due to heavy seepage losses in the unlined channel, or frequent flood damage to the conveyance system. Water rights are also leased because the owners and their family are not permanently resident in the community, or they are not able to cultivate their fields themselves due to sickness or old age.

In Pandran, for instance, 62 families without water shares in the spring are leasing water from water shareholders to irrigate their own lands, especially during the summer season when water cannot be diverted to the lower command area. Water is also leased from a group of water shareholders, because they work as tenants and labourers in other areas of Balochistan during the winter season, whereas others are not resident in the village. Normally, the owner of the water receives 25% of the harvested crop for the utilisation of his water share, but sometimes the lessee prefers to pay the water shareholder in cash. As the water shares are not equal in time, the prices range from Rs 500 to Rs 2,000 per *pass*[41] per season.

About 16% of all water rights were leased during the winter season of 1992/93 in Maluk Kareze, because a number of water shareholders with land at the tail end of the system prefer to lease their water rights rather than to try to convey the kareze water through the unlined channel over a long distance. Approximately Rs 20,000 was paid for the lease of a 24 hour water share during the *rabi* season.

Leasing of water is also very common in Khari, because there are many families whose male members are migrating temporarily to work as labourers in other parts of Pakistan, or they accompany their livestock to other parts of Balochistan during the summer months. A number of families also have to lease their water shares because they do not possess their own bullocks to prepare the fields. During the winter season, a water share of one *ghari* (45 minutes) is leased for Rs 500, whereas only Rs 100 to Rs 200 has to be paid during the *kharif* season.

The price to be paid for leasing water is determined by different factors, such as the actual discharge and reliability of the water supply, the cropping season and the cropping pattern, as well as the demand and supply of irrigation water for lease. In Kudazai Kareze with a discharge of 3 to 4 cusecs, one hour of water is leased for Rs 500 during the summer months and Rs 200 in winter. A sum of Rs 3,500 was paid for a 12 hour water share per season in one of the four branch channels of the Wahar scheme, which had a measured discharge of 2.8 cusecs in June 1995. In Kan Adnyazai (Qila Saifullah District), a 3 hour water share in a kareze with an estimated discharge of less than one cusec was leased for Rs 1,200 during the *kharif* season. A 12 hour water share with land was leased for Rs 7,000 a year in Bizni, whereas Rs 400 was paid for 1 hour of water for three months during the summer season in Sargarh and Zakhpel Kareze, which had a measured discharge of 1.84 cusecs in June 1995.

6.3.3 Tenancy

As for the whole Province of Balochistan, tenancy is not the dominant form of land tenure in most community irrigation systems. But its significance varies considerably from scheme to scheme. Only four tenants were cultivating the land of a few landowners in Lakharo with 126 water shareholders, whereas three tenants were hired in Bizni, which has 83 families with water titles in the kareze. Tenancy is important in Pandran and Munara Kalan Kareze, where respectively 33% and 40% of the water shareholders lease their land and water to tenants. Both command areas in Ahmad Wal are partly operated as an agricultural estate with two *rais* on the Gorandi Kareze and one *rais* for Muradabad Kareze, who are responsible to arrange the cleaning and repair of the both karezes and the channels and to engage 35 tenants to work on the land.

---

[41] *Pass* have different time lengths ranging from 3 to 9 hours.

One of the reasons to hire tenants is that the landowners are permanently resident somewhere else, such as in Ahmad Wal, Kunara and Churmi Kareze. Another reason is the temporary migration of small landowners to other areas with their livestock or to work as labourers or tenants themselves, which occurs in Khari and Pandran. A few landowners in Lakharo and Khari are leasing their land and water to tenants, because they are unable to prepare their own land due to lack of animal traction. Tenants are also engaged if the landowner has insufficient family labour to cultivate all of his land himself, which is reported in Koshk. In Sanzala Kareze, many water shareholders hire tenants to cultivate their fields, because they are involved in off-farm activities, such as business and transport.

Sharecropping is the most common form of tenancy in community irrigation systems throughout the Province. Under normal tenancy arrangements, land and water are provided by the landowner, whereas all field work is undertaken by the tenant. The preparation of land is either the responsibility of the landowner or the tenant and sometimes the costs are shared between both parties. In most schemes, the tenant is also responsible to contribute labour for scheme maintenance, whereas seeds are normally provided by the landowner. If fertilisers are used, it is common that the tenant pays in proportion to his share of the crop, although in a few schemes, such as Maluk Kareze and Pandran, tenants have to arrange for all of the fertiliser. If the tenant only provides labour, he normally receives one-third of the wheat or vegetable harvest; if he also arranges half of the seeds and/or fertiliser, his share increases to 50%. Tenancy arrangement are unfavourable for tenants in Koshk with only 25% of the vegetable or wheat harvest and in Ahmad Wal, Pandran and Bizni where the tenant's share ranges between 25% and 38% even if he provides one-third or all of the fertiliser. Although tenants in Narezai only provide the labour, they are entitled to two-thirds of the wheat harvest due to a shortage of labour.

The exact terms of the prevalent tenancy arrangements differ considerably within the different villages and regions of Balochistan. The tenancy arrangements for 19 community irrigation schemes that have been studied in detail under the BCIA Project are summarised in Table 6.4.

In Kunara, the tractor is arranged by the landlord, but it is operated by the tenant, if the diesel for the dugwell is provided by the owner, then the tenant's share drops to 20% of the harvested crop. At the moment of distribution of the crop in Pandran, the landlord receives 25% of the crop as owner of the water and the remaining 75% of the harvested crop is subsequently divided equally between the landowner and the tenant. After the vegetables have been sold, a tenant in Mara Tangi receives 50% of the first half of the total net cash income and 33% of the second half. In addition to the provision of all labour, including land preparation and channel cleaning, and 50% of the seeds and fertiliser, a tenant in Khari also arranges half of the water by leasing it from the same or another water shareholder.

In a number of areas in the northern parts of the Province, such as Pishin, Qila Saifullah and Loralai Districts, many Afghan refugees have found employment as tenants, especially in the cultivation of vegetables. For instance, almost all tenants in Munara Kalan Kareze and Sanzala Kareze have the Afghan nationality.

Table 6.4. Tenancy arrangements in 19 BCIAP Community Irrigation Schemes in Balochistan.

Scheme	Crop	Tenant's Share	Tenant's Obligations: Land Preparation	Channel Cleaning	Other Labour	Seeds	Fertiliser
Killi Oras	Fruit	16%	0	1	1	0	0
	Vegetables	50%	0	1	1	0.5	0
	Wheat	25%	0	1	1	0.5	0
Lel Gat & Spezandai	Vegetables	50%	0.5	1	1	0	0.5
	Maize	50%	0.5	1	1	0	0.5
Lakharo	Wheat	50%	1	1	1	0	0.5
Kunara	Wheat	40%	0.5	0	1	0.5	0.5
Koshk	Vegetables	25%	0	1	1	0	0
	Wheat	25%	0	1	1	0	0
Mina Bazar	Fruit	16-50%	1	0.5	1	-	0 - 1
	Vegetables	50%	1	0.5	1	0	0.5 - 1
	Wheat	50%	1	0.5	1	0	0.5 - 1
Ahmad Wal	Vegetables	33%	1	0.5	1	0	0.33
	Wheat	33%	1	0.5	1	0	0.33
Maluk Kareze	Vegetables	50%	1	1	1	0	1
Yousuf Kach	Fruit	33%	1	1	1	0	0
Pandran	Wheat	38%	1	unknown	1	0	1
Munara Kalan Kareze	Fruit	11%	0	1	1	0	0
	Vegetables	33%	0	1	1	0	0
	Wheat	33%	0	1	1	0	0
Khari	Wheat Sorghum	50%	1	1	1	0.5	0.5
Domandi	Wheat	50%	1	unknown	1	1	n/a
Mirjanzai	Wheat and	50%	1	1	1	0	1
	Barley	33%	0.33	1	1	0	0
Bizni	Onion	33%	1	1	1	0	0.33
	Wheat	33%	1	1	1	0	0.33
Zerin Hasoi	Wheat	50%	1	1	1	0	0.5
	Rice	50%	1	1	1	0	0.5
Mara Tangi	Vegetables	42%	0	1	1	0	0
	Wheat	33%	0	1	1	0	0
Narezai	Vegetables	50%	1	1	1	0	0
	Wheat	66%	1	1	1	0	0
Sanzala Kareze	Vegetables	33%	0	1	1	0	0 - 0.33
	Wheat	50%	0	1	1	0	0 - 0.5

n/a = not applied.

In a number of areas throughout the Province, the landowners have to offer additional forms of remuneration to attract tenants. These additional tenancy conditions could include free housing if the tenants are coming from other areas, fodder for the tenant's livestock and small interest-free loans at the beginning of the cropping season that are paid back at harvest time. The different additional tenancy conditions offered by landlords in 10 community irrigation schemes studied under the BCIA Project are given in Table 6.5 below.

Table 6.5. Additional tenancy conditions in 10 BCIAP Community Irrigation Schemes in Balochistan.

Scheme	Additional Tenancy Conditions
Killi Oras	Housing Short term interest-free loans
Kunara	Short term loans
Koshk	Food rations Housing Short term loans
Munara Kalan Kareze	Fodder Housing
Mirjanzai	Fodder
Bizni	Fodder Housing
Zerin Hasoi	Fodder
Mara Tangi	Site for housing Fodder Small interest-free loans
Narezai	Fodder Short term interest-free loans
Sanzala Kareze	Fodder Housing Small interest-free loans

7 OPERATION AND MAINTENANCE ARRANGEMENTS

IRRIGATION SYSTEMS IN BALOCHISTAN

Most community irrigation systems in Balochistan have been developed by the farmers themselves and the management of the farmer-developed small-scale irrigation systems has remained the responsibility of the community of water shareholders. The livelihood and prosperity of many rural communities throughout the Province depends largely on the availability of water for irrigation purposes. Therefore, complex sets of rules and regulations have evolved since the development of many community irrigation systems in Balochistan in order to assure the proper operation and maintenance of the water sources and the irrigation infrastructure. Different rules and regulations regarding the operation and maintenance of farmer-managed irrigation systems are described in the following sections of this chapter and illustrated with examples from existing community irrigation systems.

7.1 WATER DISTRIBUTION

In community irrigation schemes in Balochistan, the distribution of water is the collective responsibility of the water shareholders. Entitlement to water in the perennial irrigation source is normally regulated through individual water rights, which clearly refer to the exact amount of time that an individual water shareholder is allowed to utilise water during the original irrigation cycle. The individual water rights have been mostly registered with the Government in the Records of Rights.

7.1.1 Irrigation Cycle

In most community irrigation schemes, the individual water rights were established many generations ago and the length of the irrigation cycle was mostly based on the water requirements of wheat, which was the most dominant crop grown in many perennial irrigation systems in the past. However, with the introduction of new crops, such as different fruit crops and a large variety of vegetables, during the last ten to twenty years, the original irrigation cycle of 30 or even 40 days had to be adjusted by shortening its duration in response to the water requirements of the newly introduced crops.

Presently, the actual distribution of irrigation water in many community irrigation systems is more flexible, allowing farmers to adjust the length of the irrigation cycle to the availability of water and the specific water requirements of the dominant crops. Mutual exchange of water shares and temporary transactions, such as lease of irrigation water, between farmers even increase the opportunity for individual farmers to satisfy their specific needs for irrigation.

Based on information from about 90 community irrigation schemes throughout Balochistan, the average irrigation cycle has been calculated for three different cropping patterns. In community irrigation systems with predominantly apple orchards, the irrigation cycle has an average length of 12½ days. However, the actual irrigation cycle in schemes with apple orchards can be as short as 5 to 8 days and as long as 20 days. In schemes where the cultivation of summer vegetables is important, the average irrigation cycle is 9 days long. In wheat-growing schemes, a 20-day irrigation cycle in applied on average, although there are a number of schemes with an irrigation cycle of 30 or even 40 days. The different irrigation cycles for 19 community irrigation schemes that have been studied in detail under the BCIA Project are outlined in Table 7.1.

Table 7.1. Irrigation cycles for 19 BCIAP Community Irrigation Schemes in Balochistan.

Scheme	District	Irrigation Cycle (days) winter season	summer season	Remarks
Killi Oras	Loralai	9	9	Cycle applied from February to December.
Lel Gat & Spezandai	Ziarat	10	10	If low flow, cycle is extended to 18 or 19 days.
Lakharo	Khuzdar	13.5	13.5	Cycle is flexible.
Kunara	Jhal Magsi	40	40	Cycle is very flexible with exchange of water shares.
Mina Bazar:				
Sawar		30	30	
Mazghar		11	11	
Pakha Plan	Zhob	8	8	
Ahmad Wal	Chagai	32	8	
Maluk Kareze	Pishin	17	17	5 separate command areas, but only 3 receive water in summer season.
Yousuf Kach: Right Bank Left Bank	Pishin	12 10	12 10	March to June: on demand; LB fluctuates between 8 and 14 days and RB between 12 and 16 days.
Pandran	Kalat	demand	8	Pooling of water shares during winter season.
Munara Kalan Kareze	Loralai	13.5	9	
Khari	Jhal Magsi	27	13.5	Sometimes a communal share of 24 or 36 hours is added to existing cycle.
Domandi	Chaman	demand	15.5	Cycle from March/April to beginning of October.
Mirjanzai	Loralai	10	no irrigation	From October until early March water is distributed on demand.
Bizni	Mastung	24	12	
Zerin Hasoi	Khuzdar	3	3	Only limited number of farmers are irrigating during one cycle: actual cycle is 9 to 12 days.
Mara Tangi	Loralai	14.5	7.5	
Narezai	Zhob	40	5	Water distributed between user groups.
Takri-Khojakzai	Zhob	demand	demand	Water distributed according to size of fields and crop water requirements.
Sanzala Kareze	Pishin	6	6	If flow decreases, cycle is extended to 8 or even 12 days.

In most community irrigation systems in the Province, the same irrigation cycle is used during both cropping seasons. But there are also schemes, where a longer irrigation cycle is applied during the *rabi* season in order to grow wheat and a shorter cycle during the summer months to irrigate their orchards and vegetable fields more frequently. Farmers in Munara Kalan Kareze are practising two different water cycles to be able to grow different crops with variable water requirements. During the *rabi* season (from November to March) a long water cycle (*Uzd War*) of 13½ days is applied for the cultivation of winter wheat. But during the *kharif* season (from April to October), the water cycle is reduced to a shorter cycle (*Lund War*) of 6½ days in order to grow orchard crops and summer vegetables. The same system is also applied in Ahmad Wal, Khari, Bizni and Mara Tangi. In Narezai (Zhob District), a 40-day irrigation cycle is used during the winter season to grow wheat, whereas it is shortened to only 5 days during the summer months when most farmers are growing tomatoes and other vegetables.

When there is an abundance of water at certain times of the year and the crop water requirements are low, it is possible that the existing irrigation cycle is temporarily suspended and water is distributed on demand. Especially in the mountainous areas in northern Balochistan, which are benefiting from winter rains, the temporary suspension of the irrigation cycle during the cultivation of winter wheat occurs. Water is distributed on demand in Domandi from the beginning of October to the end of March or the beginning of April, because there is more than sufficient surface flow in the river to irrigate the total command area. The irrigation cycles are also temporarily suspended in Killi Oras for three months and in Yousuf Kach from March to June.

But in low altitude areas, it also occurs that irrigation water is distributed on demand. In Mirjanzai, for instance, from the month of October until March water is distributed on demand, locally called *bewar*, and from the beginning of March until both diversion spurs are washed away by the first monsoon floods in June or July a 10-day irrigation cycle is applied because the demand for irrigation water is higher. A fixed irrigation cycle is not used during either cropping season in Takri-Khojakzai scheme in Zhob District, but water is distributed according to the size of individual fields and the water requirements of the standing crops.

Although it is not very common, a lottery is organised in some schemes at the beginning of the cropping season to determine the irrigation schedule. Immediately after the earthen diversion spur has been reconstructed during the month of March or April, the farmers in Domandi organise a lottery to decide which of the three sub-clans with water rights in the scheme has the first and second right to divert the restored water flow to their fields in the command areas. The main reason to have a lottery is to avoid a dispute between the three sub-clans about the question who will have the first right to irrigate the wilting crops. For the same reason, the distribution of irrigation water between the different user groups in Khari is determined during a annual lottery at the beginning of the cultivation of winter wheat in the month of November. The organisation of a lottery to settle the water distribution schedule is also reported in Singiali-Kakoor scheme in Barkhan District and in the Karkh irrigation system in Khuzdar District.

7.1.2 Role of Water Bailiff in Water Distribution

Since the introduction of watches, the distribution of water is normally arranged by the individual farmers themselves. However, there are still community irrigation systems in the Province with village officials, who are responsible for organising and supervising the allocation of water.

In a few schemes, the start of irrigation turns is still determined by the position of the sun and stars. Special persons, locally called *mir-i-aab* or *rais*, are responsible for reading sun-dials and watching the stars in order to inform the farmers of their imminent irrigation turns. The complex water distribution system in Pandran is described in detail in Box 6.

Box 6. Complex water distribution system in pandran.

The village of Pandran is located 22 miles southeast of Kalat town in Kalat District on the left bank of the Malghawe Jhal, which is a tributary of the Soinda Jhal. The perennial source of irrigation water is a spring, called *Chashma Chut*, with a measured discharge ranging between 3.3 and 4.0 cusecs. The total number of water shareholders is 94.

The existing water distribution system is very complex and it is still based on the position of the stars and the sun. The existing irrigation cycle is eight days long and each day is divided into five *pass* (portions), which differ in duration. The names and time schedule of the five *pass* are as follows: *Sham* (from sunset to 11pm), *Panah Paghi* (from 11pm to 10am), *Khul* (from 10am to 1 pm), *Shooki* (from 1pm to 4pm) and *Gurut* (from 4pm to sunset).

The order of the first and fifth day of the irrigation cycle is not changeable, whereas days two to four are changed with days six to eight after every eight-day irrigation cycle. For example, a water shareholder who receives water on the eight day of the current irrigation cycle, will receive his share on the fourth day of the next cycle.

Shares in *Sham* do not change throughout the year or between the years, but the shares in the other four *pass* are divided into two groups: the first group consisting of *Panah Paghi* and *Khul* and the second group of *Shooki* and *Gurut*. Every individual water shareholder takes his share one year in the first group and will change automatically to the second group the next year. Within each group, an individual's water shares will alternate between two *pass* after each eight-day irrigation cycle. For example, a farmer who has his irrigation turn in *Panah Paghi* during the current eight-day cycle, will have his next turn in *Khul* during the following eight-day cycle and he will have a turn in *Panah Paghi* again during the third eight-day cycle.

The water distribution becomes even more complicated as each *pass* during an eight-day irrigation cycle is used either by one farmer or it is shared by up to five farmers at the same time using a combination of time and flow division. The eight-day irrigation cycle is practised from May until the beginning of October for irrigating the land in and around the village. From October to May, water is being distributed according to the needs of the individual farmers to irrigate their wheat fields.

A sun-dial is also used in Koshk (Turbat District) to divide the period from dawn to dusk in equal parts or *hangam*. In the summer, a *hangam* equals one hour and forty-five minutes during day time and one hour at night, whereas in the winter it is reversed. To measure the time during the night, a water clock is used. The time a standard perforated bowl requires to sink in a basin with water is called *tas* and there are four *tas* in one *hangam*.

An important reason to make a water bailiff responsible to supervise the distribution of water is to avoid disputes between individual water shareholders or group of farmers. The Yousuf Kach scheme has two water bailiffs (*hisab gar*), who are responsible to supervise the irrigation cycle on both channels and each user group in Khari appoints a *munshi* for one year to supervise the water distribution between the individual members. A watchman has been appointed in Sanzala Kareze in order to supervise the water distribution between both main channels at the main flow division structure to assure that each channel receives it due share of the water supply from the kareze. Due to the absence of most water shareholders in Churmi Kareze (Pishin District), nearly all of the land is cultivated by tenants and a water bailiff (*saab gar*) is appointed to supervise the allocation of water, for which he receives a monthly salary of Rs 600 to Rs 1,200. The water bailiff in Brunjh (Zhob District) has to supervise the water distribution in the lower command area, which is located a few kilometres from the village and is only irrigated during the rabi season to grow wheat. For his services, the *mir-i-au* receives one-twentieth of the wheat harvest from each farmer. The supervision of the water distribution is also reported in Garam Ab, Maighatti, Raiko, Zerin Hasoi and Khosobai Gharbi in Khuzdar District, Gurgut in Kalat District, Ziaba Khushan Kareze in Chaman District and Mana Kuz Kareze in Ziarat District.

Due to the absence of cadastral records in Koshk, individual water rights are exclusively administered at the village level by the water bailiff, locally called *sharista*, who also has the right, after informing the local administration, to deny a person his water share if that person fails to contribute to the maintenance of the scheme. Normally, the water distribution is self-regulating as each water shareholder knows the timing of his irrigation turn. But in case of doubt, the *sharista* is consulted.

7.1.3 Water Distribution System

Irrigation water can be distributed according to time and/or flow division. In community irrigation systems with a small water supply (less than 1 to 2 cusecs), water is normally distributed according to time division, whereby one water shareholder receives the full flow during his irrigation turn. If the water flow is larger, it is unlikely that one farmer will be able to manage it and some form of flow division will be applied whereby a farmer only receives a fixed portion of the total available water supply. Time division is practised in Killi Oras, because the water flow from both infiltration galleries is 1.1 cusec, which can be easily managed by one single farmer. Irrigation water is also exclusively distributed according to time division in Lel Gat & Spezandai, Domandi and Bizni, which have measured discharges of less than 2 cusecs. However, it is also possible that time division is applied if the water flow is significantly more than 2 cusecs. In Mirjanzai, for instance, farmers distribute water by time division although 4 cusecs of water reached the command area in the lower channel. Under these circumstances, one farmer is normally irrigating different fields simultaneously.

In the Sawar scheme, with a discharge of 5 to 6 cusecs, a flow division structure divides the water into two equal parts between the left and right branch channel. The total water flow of 2 to 3 cusecs in Yousuf Kach is also equally divided between the left bank and right bank channel, whereas time division is practised on both channels to distribute the water between the individual water shareholders. Although the water flow in Wahar is not that large with 2.8 cusecs, it is distributed equally between four branch channels throughout the year.

Quite commonly farmers utilise flow division during a certain period of a year when the total water supply is larger than one water shareholder can manage and that they switch to time division as soon as the discharge decreases. During the winter, the discharge of Maluk Kareze is about three times larger than the summer flow and flow division is practised to distribute the kareze water between five separate command areas. In summer, when the water supply from the kareze reduces and the demand for irrigation water is high, water is distributed by time division. In Sanzala Kareze, flow division is normally practised to distribute irrigation water from the kareze between two main channels at the top of the system. However, as soon as the available flow decreases during the summer months and the apple orchards require more water, time division is applied by diverting the total flow for two days into the Tareen channel and subsequently for four days in the channel belonging to the Syeds.

7.2 MAINTENANCE OF WATER SOURCES AND CONVEYANCE SYSTEM

The routine maintenance and repair of the water sources and the conveyance system is normally undertaken by the water shareholders themselves. The costs in labour and cash to maintain the irrigation system and to undertake repair works differ from scheme to scheme, but it can be very substantial as repair often means the reconstruction of the damaged structures. Maintenance and repair works are usually labour-intensive, but a substantial amount of money is regularly spent in many community irrigation schemes as well.

There are different ways to organise scheme maintenance and repair of damaged structures, but in most cases, it is done on a collective basis, locally called *asher*, whereby each water shareholder contributes labour in proportion to the size of his individual water share. Normally, the *asher* system is utilised to maintain and repair the water source and the collective section of the conveyance system up to the first field outlet structure. After the first field outlet, the channel is either maintained by all farmers with land below each field outlet or it is divided into different sections and each section is cleaned by an individual water shareholder.

7.2.1 Maintenance of Water Sources

Each perennial water source requires maintenance in order to assure that the water supply is sufficient and reliable. The maintenance requirements of each type of water source are different in terms of labour and/or cash inputs. In this section, the maintenance of karezes and diversion spurs will be described in more detail, because they normally require substantial investment in labour and cash at regular intervals.

Karezes have to be cleaned regularly and the cleaning of the kareze tunnel is normally undertaken by skilled labourers or *karezgar*, who are usually paid in cash. In Balozai Kareze (Pishin District), a team of *karezgar* asked Rs 3,000 to clean the kareze from well to well. It is also possible that kareze cleaners receive a lump sum from the kareze owners to maintain the kareze over its full length. Based on data from ten community irrigation systems with a kareze as the main source of irrigation water, the average annual cost to maintain a kareze is Rs 46,500. However, the total cost depends upon the total length of the kareze tunnel as well as if the kareze has been built in compact or loose soils. Farmers in Killi Hangama (Loralai District) only spent Rs 11,000 annually for the maintenance of two small karezes, whereas Rs 100,000 is required every year to clean the Kunastar Kareze (Loralai District). Most karezes are cleaned annually and Churmi Kareze is even cleaned twice a year, but there are also karezes that are maintained once every three years, such as Balozai Kareze and Sanzala Kareze in Pishin District.

The main problem with diversion spurs is that they are washed out very frequently by floods. Many community irrigation systems with free intake structures are only able to maintain a diversion spur during the *rabi* season, because the floods in the rivers are too frequent and powerful during the summer months. Although floods are less frequent and severe during the winter season, the diversion spurs are washed away 4 to 8 times. The farmers in Raiko (Khuzdar District) can only grow wheat during the winter season when they are able to maintain their spur in the Mula River.

In schemes where farmers manage to reconstruct their diversion spurs during the flood season, the diversion structures are washed out more frequently. For instance, farmers in Takri-Khojakzai and Narezai reported that they have to reconstruct their diversion spurs in the Zhob River 15 to 20 times a year, whereas the spur of the Harnai Viala scheme (Sibi District) has to be reconstructed weekly and the farmers in Zerin Hasoi are working almost continuously on their spur in the Mula River for three months during the monsoon season.

The reconstruction of most diversion spurs is labour intensive. If the diversion spur in Zerin Hasoi has to be rebuilt completely, a group of 30 to 40 farmers needs about 10 days, while 23 farmers in Ghar Sheen Kach (Musa Khel District) require 18 days to rebuild their spur in the Kingri Rud.

Farmers are increasingly using tractors with blades to reconstruct the diversion spurs as quickly as possible after they have been washed out by floods in order to restore the water supply to the standing crops in the fields. The advantage of using tractors is illustrated by the example from Hatachi in Khuzdar District. Farmers reported that they need 20 to 25 days to reconstruct the spur and the upper reach of the main channel if they do not use a tractor, whereas only 7 to 8 days are required when they hire a tractor from a neighbouring village. The consequence of this development is that farmers have to collect money to pay the tractor owners in addition to the input of their labour during the reconstruction of the spurs. Based on information collected in seven community irrigation schemes with diversion spurs, an average sum of nearly Rs 20,000 is spent annually by the farmers to hire tractors.

7.2.2 Maintenance of Conveyance System

The farmer-built conveyance systems usually consist of earthen channels and they have to be cleaned regularly to assure that irrigation water is reaching the farmers fields. Maintenance of the conveyance system normally involves desilting of the channels and the repair of flood-damaged sections.

Normally, the main channel is maintained collectively from head to tail, whereas the branch channels are cleaned by only those farmers whose land is commanded by the respective branch channel. It is, however, also possible that the main channel is cleaned collectively from the water source as far as the first field outlet (*nucca*) and beyond the first *nucca* each water shareholder is responsible to maintain a particular section of the channel. In Pandran, Yousuf Kach, Maluk Kareze and Churmian Kareze, each farmer has to clean the channel between his outlet and the *nucca* immediately upstream, whereas in Domandi, Mando Viala and Churmi Kareze each water shareholder has to maintain that portion of the channel that crosses his fields. In Khosobai Gharbi, the upper section of the main channel is cleaned monthly by those farmers with fields in the upper command area, while water shareholders with land in the lower command area are responsible to maintain the downstream section. The main channel in Barkohi Essote (Musa Khel District) is subdivided into 15 sections and farmers sharing one day of the 15 day irrigation cycle have to clean one section.

The frequency of channel cleaning is usually less in irrigation systems with a silt-free source, such as karezes, springs and infiltration galleries than in schemes that divert surface water with large contents of silt from rivers into their conveyance system and the channels are silting up easier. In 31 community irrigation schemes with relatively clean water sources, the conveyance systems are cleaned 2.8 times a year on average, whereas in 27 schemes with diversion structures the average frequency of channel cleaning is 3.9 times a year. However, the frequency of channel maintenance is significantly higher in schemes where the channels get silted up very easy or if they are prone to flood damage. The main channel in Khosobai Gharbi (Khuzdar District) diverting water from a kareze to separate small command areas has to be cleaned 12 times a year, because grasses are growing rapidly in the earthen channel and blocking the water flow. Both main channels in Mirjanzai are cleaned 10 to 15 times during the rabi season, because floods in the Narechi River can enter freely into the conveyance system, while fast growing reed and bushes are obstructing the water supply to the wheat fields regularly.

The total input of labour that is required to maintain the conveyance system depends largely upon the size and the length of the channels, as well as the frequency of channel cleaning and repair. In 14 community irrigation systems with a kareze, spring or infiltration gallery as the main water source, an average number of 450 man-days a year were required for maintenance of the conveyance system. In Killi Hangama (Loralai District), only 88 man-days are required annually to maintain the conveyance system, because the 3 kilometre long channel is cleaned twice a year by a group of 22 farmers within two days. The 5,000ft long main channel in Kachhi Pasra (Loralai District) is also cleaned two times a year and 16 farmers only require 4 days to desilt it from head to tail. The farmers from Zargai (Ziarat District), however, have to clean their 3,600ft long channel at least six times every year requiring a minimum annual input of 1,260 man-days, because floods in the Urak Nullah enter regularly into the conveyance system.

The total input of labour that is required to maintain the conveyance systems in 14 community irrigation schemes diverting surface flow in rivers for irrigation purposes is with approximately 670 man-days per year, significantly higher than for schemes with 'clean' water sources. Farmers in Sabakzai (Zhob District) only require 180 man-days a year to clean both channels with a total length of 10,000ft two times per annum by a team of 30 farmers within 3 days. About 1,450 man-days are required annually in Mirjanzai to maintain both main channels with a total length of 12,000ft, which are cleaned 10 to 15 times a year by a team of 18 farmers. The first cleaning is undertaken immediately after the monsoon season and it requires 20 to 30 days to desilt both channels from head to tail, whereas only five days are needed for subsequent cleanings. The maintenance of the 17,000ft long main channel in Khari even requires 2,340 man-days annually as it is cleaned three times a year and 54 farmers need 10 to 20 days each time. The maintenance requirements of the Kunara schemes are described in Box 7.

Box 7. Maintenance of main channel in Kunara.

Every year in September and October, a group of 65 farmers work for two months to reconstruct the main channel over a total length of approximately 30,000ft. The first 9,600ft is situated in the river bed of the Kashok River and is always washed out completely by the monsoon floods. The work is organised and supervised by a hereditary water bailiff (*rais*), who receives a special water share for his services. To mobilise the villagers, he asks a special messenger (*lori morassi*) to inform the people on the eve of the rehabilitation work. The messenger is rewarded by donations of wheat at harvest time.

Every able man is expected to contribute labour for the maintenance work on the main channel. Individual contributions are in accordance with the water shares. Each family has to provide a labourer on every twentieth day for each water share of 25 minutes.

In addition to the annual reconstruction of the channel, repair work is also required after every flood in the Kashok River throughout the *rabi* season. The *rais* estimates that an additional 40 days are required for subsequent repair to the channel. Therefore, a total of approximately 6,500 man-days are required annually to maintain the main conveyance channel.

Particularly in gravelly river beds where seepage is high, farmers sometimes import silt or mix earth with cow dung to reduce the water losses. In Kunara, for instance, several sections of the channel in the river bed are plastered with cow dung and clay to prevent seepage into the gravels. Long sheets of plastic are used by farmers in Sarkan Killi (Sibi District) to reduce seepage losses at several places of the 15,000ft long Palari Viala.

The maintenance and repair of the conveyance system normally involves labour only, which is provided by the water shareholders themselves or members of their families. Although it is not common, routine maintenance of the channels can also be undertaken by hired labourers. When the water shareholders in Tandwani (Loralai District) are too busy with their work in the fields, labourers are hired to execute the maintenance works. In 1995, for instance, each water shareholder had to contribute Rs 50 per water share of 45 minutes to raise Rs 20,000, which was spent on hired labourers.

Money is sometimes also required to hire tractors during the reconstruction of damaged sections of the channels. The water shareholders in Maighatti spent an average of Rs 2,000 every year for tractor hire and the farmers in Garam Auf (Khuzdar District) even spent Rs 19,000 in 1994 for the lease of a tractor and hired labourers after their channel was seriously damaged by a flood.

In a number of community irrigation schemes in the Province, farmers have constructed and are maintaining special conveyance structures to divert irrigation water along steep, rocky hill sides, or across rivers and flood drainage channels. In Wuli Kach (Qila Saifullah District), one of the channels is aligned along a very steep mountain slope and at some places farmers have constructed wooden structures at a height of 20 to 30ft to support the channel. Farmers in Lukh Qamarabad (Khuzdar District) have constructed a wooden aqueduct with woven palm mats (*chattai*) as a trough across the Lukh Jhal to divert water from the right bank to a small command area on the left bank. The aqueduct is however frequently washed away by floods during the monsoon season. A number of farmers with water rights in Marhati Kareze (Loralai District) have built a pipe aqueduct across the Marai Manda and they are pumping water from a small reservoir on the left bank through the aqueduct to a small command area on the right bank of the river.

7.2.3 Contribution of Labour and Money for Scheme Maintenance

In almost all of Balochistan's community irrigation systems, labour for scheme maintenance is contributed by individual water shareholders in accordance with the size of their water shares. The most common way to mobilise labour for routine maintenance is that water shareholders sharing one day of the irrigation (*shabanaroz*) have to contribute one or two labourers, but it could be even up to 4 persons per *shabanaroz* as in Killi Hangama Karezes and Jangi Khezai (Qila Saifullah District).

However, there are also small-scale, farmer-managed irrigation systems in the Province, such as Gharshin Sar Mand in Pishin District, Grang Kareze in Chaman District, and Raiko and Garam Auf in Khuzdar District, where each family with water rights has to provide labour irrespective of the size of the individual water shares. In Zerin Hasoi and Androi Sheikhan (Musa Khel District), water shareholders are only entitled to utilise channel water for irrigation purposes if they have contributed labour during the reconstruction of the diversion spur and the cleaning of the main channel. A very peculiar mechanism is applied in Tandwani (Ziarat District), where the existing five-day irrigation cycle is extended with an additional day, which can be exclusively used by those water shareholders who have participated in the maintenance of the conveyance system.

Normally, each water shareholder has to contribute labour for the maintenance of the irrigation scheme, but it occurs that certain persons are exempted from labour contributions. In Killi Oras, Rigora Kareze, Tandwani and Kachhi Pasra in Loralai District and in Killi Sabakzai and Narezai in Zhob District, the water bailiffs are formally exempted as a reward for their services. The village *mullah* in Munara Kalan Kareze is also exempted for contributing labour during scheme maintenance, as well as families belonging to the Syeds and the *sardar* of the Lehri tribe with special water shares in Sanni (Kachhi District).

If land is cultivated by a tenant, it is common that he also provides labour for the maintenance of the irrigation scheme on behalf of the water shareholder.

In many community irrigation systems throughout Balochistan, individual water shareholders have to pay a fine for each day that they have not contributed labour for scheme maintenance. Fines can range from Rs 50 per day in Balozai Kareze to Rs 120 per day in Ziaba Khushan.

Money is almost always contributed in accordance with the size of the different water shares. Usually, the exact amount is calculated on the basis of the actual costs, but it is also possible that the existing irrigation cycle is extended temporarily and the additional water is leased to raise money for scheme maintenance. The use of communal water shares for scheme maintenance has been reported in Section 6.1.1.

7.2.4 Role of Water Bailiff in Scheme Maintenance

Based on information from 58 community irrigation systems, about half of all schemes still have one or more hereditary or appointed water bailiffs. Most schemes only have one water bailiff, whose main task is the organisation and supervision of maintenance work. It is, however, not uncommon that schemes with two or more main channels have two or more *mir-i-aab* or *rais* as well. Two water bailiffs are appointed from April to August in Sanzala Kareze to inspect both main channels daily and there are also two *mir-i-au* in Killi Sabakzai for the maintenance of the left bank and right bank channel, respectively. The Tandwani scheme has a different *mir-i-aab* for each day of its 5-day irrigation cycle. Killi Hangama and Takri-Khojakzai have three and four water bailiffs, respectively, but only one of them is responsible to organise and supervise the scheme maintenance each year.

The specific tasks of a water bailiff regarding scheme maintenance may include the regular inspection of the water source and conveyance system, fixing the exact date on which maintenance work has to start, mobilisation of labour by informing the water shareholders or hiring labourers, day-to-day supervision of maintenance work undertaken by the water shareholders and/or hired labourers, preparation of cost estimates for repair works, collection and administration of money for scheme maintenance, and imposing and collecting fines from water shareholders who did not provide labour as required.

The compensation of water bailiffs varies from scheme to scheme. In a number of irrigation systems, the *mir-i-aab* or *rais* is not compensated at all for his services. Although the water bailiffs in Spezandai Kareze, Tazi Kach, Mana Kuz Kareze, Kuz Kareze, Garam Auf, Raiko and Khosobai Gharbi are responsible for the supervision of water distribution and the organisation of scheme maintenance, they are not rewarded apart from being respected. In other community irrigation systems, such as Narezai, Rigora Kareze, Kachhi Pasra, Killi Hangama, Tandwani and Killi Sabakzai, water bailiffs are only exempted from labour contributions as a reward for the organisation of maintenance works, whereas they receive special water shares in Kunara, Mina Bazar, Ahmad Wal, Pandran and Bizni. The *rais* in Gurgut (Kalat District) receives one-twentieth of the wheat harvest and the *mir-i-aab* in Takri-Khojakzai is rewarded with 4 kg of wheat per acre for organising the maintenance of both schemes, whereas the water bailiff in Mullazai is paid Rs 3,000 monthly for the operation and maintenance of all four infiltration galleries and their conveyance systems.

8 AGRICULTURAL SYSTEMS

BALOCHISTAN

The agro-climatic conditions in Balochistan are very closely related to the altitude and it is, therefore, possible to classify the different agricultural systems in the Province into two main systems. The first main agricultural system is situated in areas above 4,000ft altitude where the cultivation of deciduous fruit crops (apple and apricot) is possible due to cold winters and cool to mild summers. The second main agricultural system in Balochistan is found in areas below 4,000ft altitude and the main crops are (sub) tropical fruits and winter vegetables and to a lesser extent fodder crops (sorghum and barley). The cultivation of winter wheat is important in both agricultural systems.

The description of both agricultural systems is predominantly based on information that has been collected during the screening studies for 18 community irrigation schemes under the BCIA Project. Therefore, it is not possible to draw conclusions for the whole of the Province of Balochistan, but its should be considered primarily as an illustration of the agricultural diversity in Balochistan.

8.1 AGRICULTURAL SYSTEM IN HIGHER ALTITUDE AREAS

Eleven BCIAP community irrigation schemes are located in areas above 4,000ft altitude. The average elevation is approximately 5,700ft, ranging from 4,400ft in Mara Tangi to 7,550ft in Lel Gat & Spezandai. The climatic conditions of the 11 BCIAP schemes are outlined in Table 8.1.

The average cropped area is about 168 acres, but it varies from 66 acres in Domandi to 437 acres in Mina Bazar. About 71 acres or 42.5% of total cropped area is under orchards, in particular under apple and apricot and to a lesser extent under almond, plum and cherry. Grapes were only grown in Maluk Kareze with about 32% of the cropped area, whereas pomegranates are only important in Munara Kalan Kareze with 22 acres (9% of total cropped area). The average area under summer vegetables and onions is about 16 acres and 8.5 acres, respectively. Summer vegetables are mainly grown in Mara Tanga where farmers had 27 acres under cauliflower and 16 acres under tomato, whereas 40 acres were under tomato in Munara Kalan Kareze. Except in Lel Gat & Spezandai and Yousuf Kach, winter wheat was grown in all other schemes with an average of 71 acres. Only in Munara Kalan Kareze and Bizni, farmers grew different fodder crops, such as barley, wheat and alfalfa, at a larger scale, whereas maize covered a significant area in Lel Gat & Spezandai, Mina Bazar and Domandi. The different cropping patterns for all 11 BCIAP schemes are given in Table 8.2.

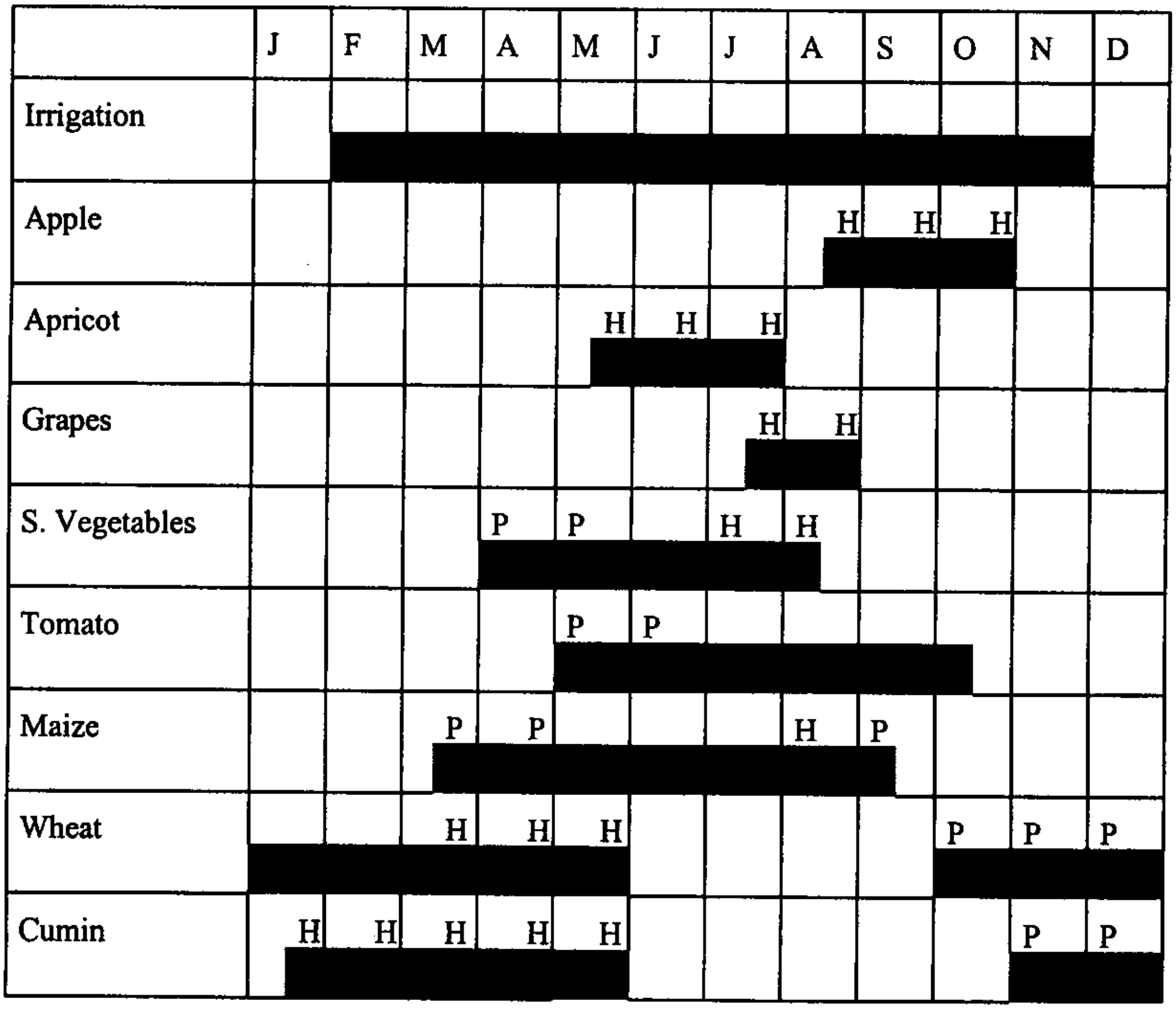
Table 8.1. Climatic conditions for 11 BCIAP Community Irrigation Schemes above 4,000ft altitude in Balochistan.

Scheme	Altitude (feet)	Mean Monthly Temperature (C)		Median Annual Rainfall (mm)	Remarks
		January	July		
Killi Oras	5,530	5.7	27.3	216	Wettest month is July with 29mm
Lel Gat & Spezandai	7,550	0.1	23.9	189	75% of rainfall from January to March
Mina Bazar	4,850	5.8	29.9	257	March and June/July are wettest months
Maluk Kareze	5,400	4.0	27.1	216	Most rainfall occurs during winter months
Yousuf Kach	7,000	1.0	24.8	218	Most rainfall occurs during winter months
Pandran	6,050	4.0	25.6	175	Most rainfall occurs during winter months
Munara Kalan Kareze	5,300	4.4	26.1	211	Most rainfall occurs during winter months
Domandi	5,500	3.9	27.6	165	Most rainfall occurs during winter months
Bizni	5,300	6.8	30.7	137	Virtually all rainfall occurs during winter months
Mara Tangi	4,400	6.3	28.0	203	60% of rainfall occurs during winter months
Sanzala Kareze	5,400	4.0	27.1	216	Most rainfall occurs during winter months

A typical crop calender for community irrigation schemes in higher altitude areas is presented in Figure 8.1. The irrigation period starts in February with light applications of water and ends in November. Summer vegetables are normally planted in April and harvested in July, although the harvesting of tomatoes in Maluk Kareze starts in September and last until mid-October. The picking of apricots occurs from mid-May to June in Killi Oras, and from mid-June to the end of July in Maluk Kareze, whereas the harvesting of apples takes place from mid-August to the end of October. Wheat is planted during the months of October to December and the harvesting is undertaken from March to the end of May, but in Killi Oras, wheat is also harvested during the month of June. The cultivation of maize as a fodder crop starts with planting from mid-March until the end of April and the harvesting occurs from the beginning of August to mid-September.

Onions are planted and harvested at different times of the year. Farmers in Mina Bazar plant their onion crop in October and November and the harvesting is undertaken from

March to mid-April, whereas in Maluk Kareze onions are planted from mid-May to June and harvested from November to mid-December. The farmers in Lel Gat & Spezandai grow onions for the production of seed and they plant in March and the seeds are collected from July to mid-August. The harvesting of grapes in Maluk Kareze starts mid-July and lasts until the end of August, whereas cumin is planted during the months of November and December and harvested from mid-January to April.



P = Planting
H = Harvesting

Figure 8.1. Crop calender for 4 BCIAP Community Irrigation Schemes above 4,000ft altitude in Balochistan.

Table 8.2. Cropping patterns for 11 BCIAP Community Irrigation Schemes above 4,000ft altitude in Balochistan.

Scheme	Type of Water Source	Altitude	Existing Water Supply (cusecs)	Cropped Area (acres)	Cropping Pattern Crop	 Acres
Killi Oras	Infiltration Gallery	5,530ft	0.9	123	Apple	43
					Apricot	38
					Peach/Apple	4
					Pomegranate	2
					Onion	9
					Summer Vegetables	17
					Wheat	16
Lel Gat & Spezandai	Surface and kareze	7,550ft	2.0	91	Apple	76
					Apricot/Peach	2
					Maize	19
					Summer Vegetables	1
					Fodder	9
Mina Bazar	2 existing weirs and spring	4,850ft	4.7	437	Apple	91
					Mixed Orchard	149
					Maize	50
					Wheat	131
					Onion	5
					Summer Vegetables	11
Maluk Kareze	Kareze	5,400ft	1.8 to 4.8	114	Apple	5
					Mixed Orchard	8
					Grapes	36
					Summer Vegetables	1
					Wheat	59
					Cumin	5
Yousuf Kach	2 karezes and river flow	7,000ft	1.0	100	Mixed Orchard	82
					Summer vegetables	13
					Maize	4
					Fodder	1
Pandran	Spring	6,050ft	2.1	197	Mixed Orchard	27
					Summer vegetables	7
					Rice	13
					Pulses	10
					Lucerne	5
					Wheat	130
					Fodder wheat	5

Table 8.2 (continued)

Scheme	Type of Water Source	Altitude	Existing Water Supply (cusecs)	Cropped Area (acres)	Cropping Pattern	
Munara Kalan Kareze	Kareze	5,300ft	2.8	244	Apple	22
					Almond	47
					Apricot	31
					Pomegranate	22
					Mixed Orchard	8
					Tomato	40
					Onion	8
					Summer Vegetables	12
					Wheat	50
					Fodder	32
Domandi	Surface flow	5,500ft	0.8	66	Apple	12
					Mixed Orchard	2
					Summer Vegetables	2
					Maize	23
					Wheat	23
					Fodder	4
Bizni	Kareze	5,300ft	1.1	102	Apple	8
					Onion	12
					Wheat	50
					Cumin	8
					Fodder	24
Mara Tangi	Existing weir	4,400ft	1.5	203	Apple	19
					Mixed Orchard	14
					Summer Vegetables	39
					Winter Vegetables	14
					Wheat	107
					Fodder	10

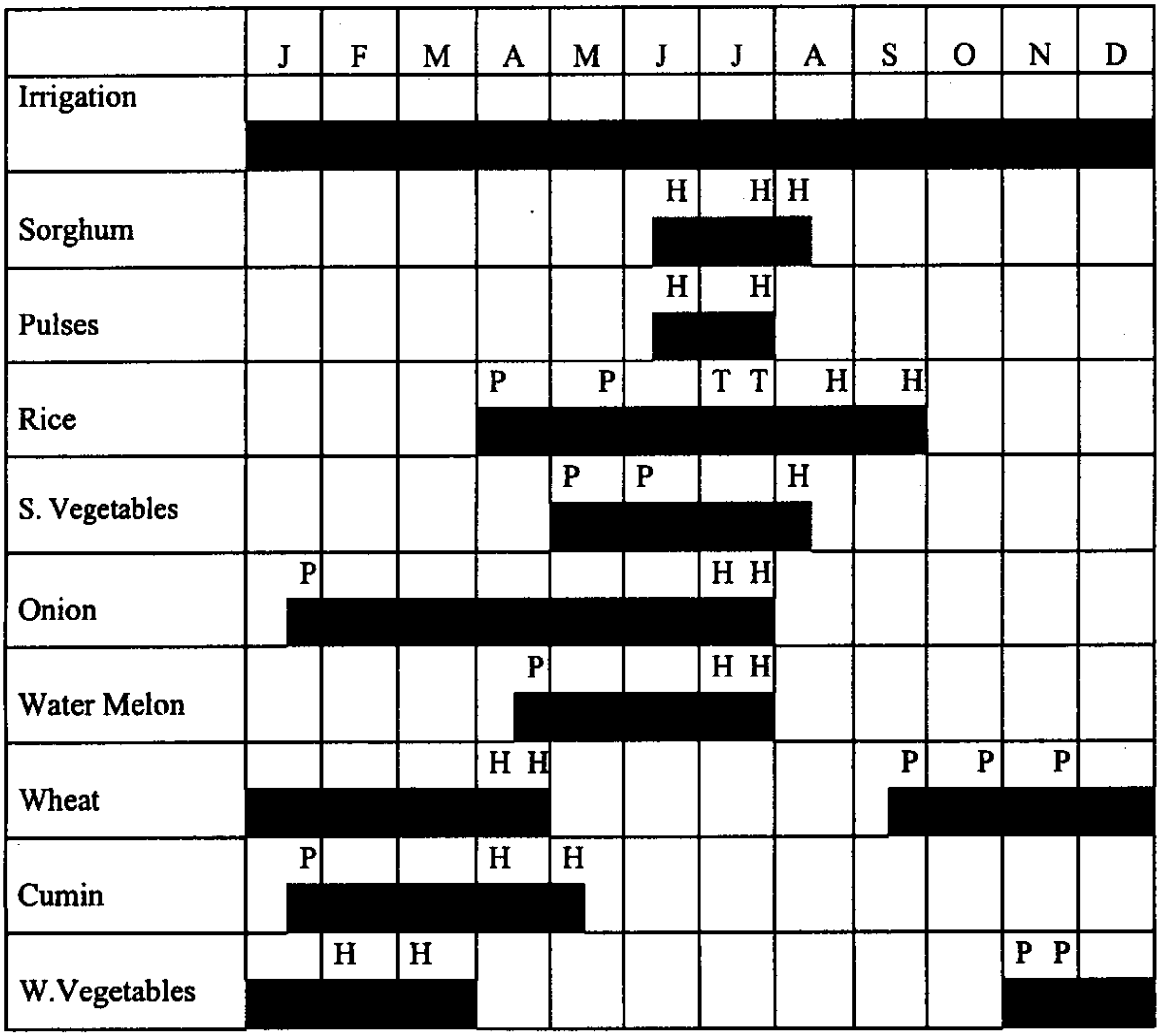
8.2 AGRICULTURAL SYSTEM IN LOWER ALTITUDE AREAS

Eight BCIAP community irrigation schemes are situated in areas below 4,000ft and their average altitude is about 2,150ft. The climatic conditions of these eight lower altitude irrigation systems are outlined in Table 8.3.

Table 8.3. Climatic conditions for 8 BCIAP Community Irrigation Schemes below 4,000ft altitude in Balochistan.

Scheme	Altitude (feet)	Mean Monthly Temperature (C)		Median Annual Rainfall (mm)	Remarks
		January	July		
Lakharo	2,700	12.4	34.0	178	Slightly less than half of rainfall occurs during summer monsoon season
Kunara	300	13.8	38.1	104	Most rainfall occurs during summer monsoon season
Koshk	1,630	15.7	34.1	135	75% of rainfall occurs during January and February
Ahmad Wal	2,950	12.0	35.9	137	Virtually all rainfall occurs during winter months
Khari	325	13.8	38.1	104	Most rainfall occurs during summer monsoon season
Mirjanzai	3,170	10.8	32.0	280	60% of rainfall occurs during summer monsoon season
Zerin Hasoi	2,200	12.2	33.8	178	Slightly less than half of rainfall occurs during summer monsoon season
Narezai	3,900	8.0	31.0	257	January and June/July are the wettest months

A typical crop calender based on four BCIAP community irrigation schemes in lower altitude areas is given in Figure 8.2. Normally, the irrigation period lasts throughout the year. Wheat is planted from mid-September to November and it is harvested from March to April and sometimes even in May. Farmers in Ahmad Wal also cut wheat during the months of December and January for fodder. Winter vegetables are planted in November and the farmers start harvesting at the beginning of February until the end of March. Both cumin and onions are planted during the second half of January. The harvest of cumin takes place from April to mid-May and onions are harvested in July. Rice is planted from April to May and transplanted during the month of July, whereas the harvest starts mid-August and stops at the end of September. Water melons and summer vegetables are planted during the second half of April and during the month of May, respectively, whereas the water melon harvest occurs in July and the summer vegetables are picked from July to mid-August. Sorghum and pulses are frequently intercropped and both crops are harvested from mid-June to mid-August.



P = Planting
T = Transplanting
H = Harvesting

Figure 8.2. Crop calender for 4 BCIAP Community Irrigation Schemes below 4,000ft altitude in Balochistan.

The average cropped area for seven BCIAP community irrigation schemes below 4,000ft altitude is 169 acres, of which about 120 acres or 71% of the total cropped area is under winter wheat, ranging from only 13 acres (21%) in Koshk to 362 acres (91%) in Mirjanzai. Rice and sorghum are only grown in three schemes with an average cropped area of 19 acres and 28 acres, respectively. In Khari, 64 acres is intercropped with sesamum and sorghum, while 39 acres are intercropped with cumin and onion in Ahmad Wal. Pulses are intercropped with sorghum in Lakharo and Khari on 17 acres and 13 acres, respectively. The cultivation of *kharif* vegetables is undertaken on a total area of 30 acres by farmers in Narezai, whereas in Koshk dates and bakala beans are grown on 17 acres and 10 acres, respectively. The cultivation of fodder crops is only important in Mirjanzai with 30 acres.

The different cropping patterns of seven BCIAP community irrigation systems in lower altitude areas are given in Table 8.4.

Table 8.4. Cropping patterns for 7 BCIAP Community Irrigation Schemes below 4,000ft altitude in Balochistan.

Scheme	Type of Water Source	Altitude (feet)	Existing Water Supply (cusecs)	Cropped Area (acres)	Cropping Pattern	
					Crop	Acres
Lakharo	Infiltration Gallery	2,700	1.6	130	Wheat	85
					Rice	16
					Pulses/Sorghum	17
					Sorghum	4
					Summer Vegetables	3
					Fodder	5
Koshk	Surface flow	1,630	1.7	63	Dates	17
					Wheat	13
					Rice	19
					Sorghum	2
					Fodder	2
					Bakala beans	10
Ahmad Wal	2 karezes	2,950	0.5	118	Wheat	75
					Summer Vegetables	4
					Cumin/Onion	39
Khari	Existing weir	325	3.7	298	Mixed Orchard	12
					Sesamum/Sorghum	64
					Sorghum/Mung	13
					Sunflower	9
					Wheat	198
					Fodder	2
Mirjanzai	Surface flow	3,170	10.4	397	Pomegranate	2
					Wheat/Barley	362
					Winter Vegetables	3
					Fodder 30	
Zerin Hasoi	Surface flow	2,200	1.1	88	Mixed Orchard	2
					Rice	23
					Wheat	47
					Winter vegetables	1
					Fallow	15
Narezai	Existing weir	3,900	3.2	90	Wheat	59
					Summer vegetables	30
					Mixed Orchard	1

8.3 AVERAGE YIELDS FOR MAIN CROPS

The cultivation of orchard crops and grapes gives undoubtedly the largest financial returns to farmers, followed by onions and summer vegetables and to a lesser extent by growing cumin and fodder crops. The financial gross margins for food grains is low. The average yield, financial gross revenue and financial gross margin[42] for different crops are given in Table 8.5.

Table 8.5. Average Yield, Financial Gross Revenue and Financial Gross Margin per acre for main crops in 16 BCIAP Community Irrigation Schemes in Balochistan.

Crop	Yield per Acre (kg)	Gross Revenue per Acre (Rs)	Gross Margins Per Acre (Rs)
Apple	4,280	64,910	59,235
Apricot	4,667	45,905	42,165
Mixed Orchard	3,667	44,290	40,490
Grapes	4,200	62,575	60,300
Onion	4,325	20,400	16,800
Summer Vegetables	4,140	18,290	15,050
Wheat	530	2,220	1,410
Maize	360	1,550	932
Rice	675	2,170	1,240
Sorghum	290	1,535	745
Fodder	9,750	7,785	5,535
Cumin	200	10,725	9,555

The average yield for mature apple orchards is ranging between 4,000 kg and 4,500 kg per acre and the average financial gross margin is almost Rs 60,000 per acre, whereas mature apricot orchards give an average yield of 4,500 kg to 5,000 kg per acre and the average financial gross margin is about Rs 42,000. Red and Golden Delicious (*Tor Kulu* and *Sheen Kulu*) varieties are generally preferred by the farmers, although orchards with local varieties (Kashmiri, Mashdi and Amri) can still be found as well. Most root stock is sold from private nurseries. In addition to organic fertiliser, farmers are increasingly applying chemical fertilisers but the quantities are very variable. In Killi Oras, for instance, 10 to 25 kg of fertiliser per acre were used in orchards. Most orchards are sprayed three to five times a year to protect the crop against attacks of codling moth, aphids, hairy caterpillar, mites and powdery mildew. Bark splitting is another major problem that is reported in Munara Kalan Kareze.

Mature mixed orchards have an average yield of 3,667 kg per acre, but it ranges from 2,500 kg in Domandi to 5,000 kg in Pandran, while the average financial gross margin is

[42] The Financial Gross Revenue is calculated by multiplying the yield with the financial price of the crop and to calculate the Financial Gross Margin the total costs, including planting material, fertiliser, spraying and labour, are subtracted from the Financial Gross Revenue.

about Rs 40,450. The yields of apricot orchards are negatively affected by attacks of shot hole borer, aphids and gum, whereas almond trees suffer from attacks by scale.

The vines in Maluk Kareze produce 4,200 kg per acre on average with a financial gross margin of Rs 60,000. Local root stock is used and only sulphur dust is applied in spring to reduce the incidence of mildew attacks.

The average yield for summer vegetables is 4,140 kg per acre, but it varies considerably from scheme to scheme. Consequently, the average financial gross margin ranges from less than Rs 9,000 per acre in Domandi to nearly Rs 22,000 in Maluk Kareze. Onions have an average production of 4,325 kg per acre and the average financial gross margin is Rs 16,800, but in Mina Bazar the average yield is only 3,500 kg while farmers in Killi Oras produce 5,500 kg of onions per acre. Farmers in Munara Kalan Kareze produce 4,500 kg of tomatoes per acre, whereas in Mara Tangi the production is only 2,500 kg per acre. Self-selected seed and seed bought from the markets are used by the farmers. Vegetables are normally sprayed twice a year, but the yields are affected by attacks of fruit fly, aphids, thrips, cut worm, purple blotch, blight and collar root rot. Farmers in Maluk Kareze have developed a system which enables them to compete with early vegetables, mainly tomatoes, imported from other Provinces. They collectively rent land near Sukkur in the Sindh Province and employ a farmer to produce tomato seedlings, which are transported to the scheme for transplanting in early May.

Cumin is a profitable *rabi* crop with an average yield of 200 kg per acre and a financial gross margin of about Rs 9,500 per acre. Farmers in Ahmad Wal use seed from Iran, because it is considered to give a higher yield than Pakistani seed and is also thought to be more suitable for the harsh conditions in the area. The cultivation of sorghum, wheat, barley and maize as green fodder is also financially attractive for farmers. Wheat is an important fodder crop in Pandran, Munara Kalan Kareze and Bizni with yields of 6,000 to 9,000 kg per acre and the financial gross margin ranges from Rs 4,200 in Bizni to Rs 6,700 in the other two schemes. In Ahmad Wal and Pandran, wheat is normally cut for fodder or grazed when it is approximately one to two months old and is then allowed to regrow as a grain crop. Maize is another important green fodder crop grown by farmers in Munara Kalan Kareze, Lel Gat & Spezandai and Yousuf Kach. The average yield ranges between 9,000 kg per acre in Munara Kalan Kareze and 12,000 kg per acre in the other two schemes. The financial gross margin for maize as a green fodder is nearly Rs 14,000 in Munara Kalan Kareze. Alfalfa is also grown at a small scale in many community irrigation systems, especially intercropped in young orchards.

Wheat is the most important grain crop and it is mainly grown for home consumption. However, farmers with surpluses also sell wheat on the local markets or to nomads staying temporarily with their livestock in the area. The average yield is only 530 kg per acre, ranging from 300 kg per acre in Kunara to 650 kg in Pandran. Maize is only grown as a grain crop in community irrigation schemes above 4,000ft altitude and the average yield is about 360 kg per acre. Almost all farmers are still using local varieties and the seed is normally selected during the harvest. Normally, fertilisers are not applied or only small amounts are used. Some progressive farmers in Pandran have successfully used an improved variety (PAK 81), which was bought from the Department of Agriculture. The yields are reportedly around 2,000 kg per acre if fertiliser is also used, which is significantly higher than for traditional varieties. The Department of Agriculture has also introduced another improved wheat variety (Zargoon) in Ahmad Wal, but the farmers are reluctant to adopt the new variety due to its later planting date. Farmers in Domandi are utilising chemical fertilisers for their maize crop, but pesticides are not applied, while root worm and rust are affecting the maize yields seriously.

Sorghum and rice are predominantly cultivated in lower altitude schemes, such as Lakharo and Koshk. Farmers in Lakharo have an average of 500 kg of rice per acre, whereas in Koshk 800 kg could be produced on one acre of irrigated land. The average financial gross margins for wheat and rice varies between Rs 900 and Rs 2,500 per acre, whereas it is less than Rs 1,000 for maize and sorghum.

BIBLIOGRAPHY

Agricultural Census Organization: Pakistan Census of Agriculture 1972, Province Report Baluchistan, Volume II, Part 4; Ministry of Food and Agriculture, Government of Pakistan, Lahore.

Pakistan Census of Agriculture 1980, Province Report Baluchistan, Volume II, Part 4; Statistics Division, Government of Pakistan, Lahore.

Agriculture Department Balochistan: Agricultural Statistics Baluchistan 1985-86; Statistics Wing, Directorate General of Agriculture Department Baluchistan, Quetta.

Agricultural Statistics Balochistan 1989-90; Statistics Wing, Directorate of Agriculture (Extension), Quetta.

Agricultural Statistics of Balochistan 1992-93, Statistical Wing, Directorate General of Agriculture Department Balochistan, Quetta.

Agricultural Statistics of Balochistan 1994-95; Statistics Wing, Directorate General of Agriculture Department Balochistan, Quetta.

Arif, Syed M. (1991): Agricultural Economy of Balochistan; Quetta.

Balochistan Community Irrigation Screening Reports 11 to 17 (October 1995 to November and Agriculture Project: 1996); Quetta.

Balochistan Minor Irrigation and Agricultural Development Project; Quetta. Phase II: Project Preparation Report, Volumes 1, 2, 3 and 4 (June 1993). Screening Reports 1 to 10 (July 1992 to December 1993), Phase II Preparation Studies Perennial Irrigation Scheme; Quetta.

Government of Balochistan (1986): The Gazetteer of Baluchistan, 12 Volumes (first published: 1906); Quetta.

Government of Balochistan (1995): Balochistan Community Irrigation and Agriculture Project, Planning Commission PC-1, Planning and Development Department, Quetta.

Planning and Development Department (June 1994): Concept Eighth Five Year Plan 1993-1998 Government of Balochistan; Pakistan/Netherlands Project Strengthening of Planning and Development Department, Quetta.

Scholz, Fred (1974): Belutschistan (Pakistan), eine sozialgeographische Studie des Wandels in einem Nomandenland seit Beginn der Kolonialzeit; Göttinger Geographische Abhandlungen, Heft 63, Göttingen.

Siddiqi, Akhtar Husain (1991): Baluchistan (Pakistan): Its Society, Resources and Development, University Press of America.

Sir William Halcrow & Partners Ltd. (May 1995): Balochistan Community Irrigation and Agriculture Project, Technical Proposal, Volume 1 Main Report, Quetta.

Van Gils (ed) (1992): Environmental Profile Balochistan, Pakistan; International Institute for Aerospace Survey and Earth Sciences, Enschede, The Netherlands.

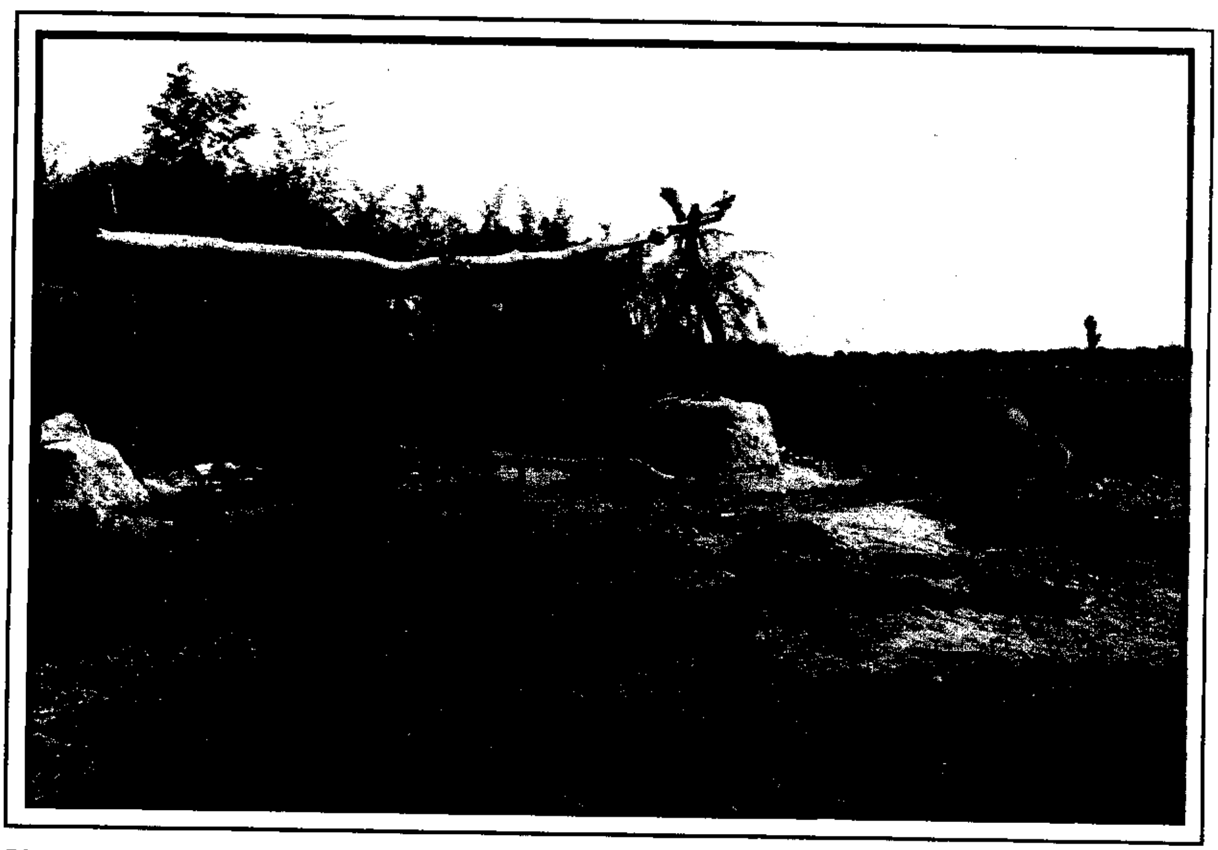
Van Steenbergen, Frank (draft): The Frontier Problem in Incipient Groundwater Management Regimes in Balochistan (Pakistan).

World Bank (August 1995): Staff Appraisal Report: Pakistan, Balochistan Community Irrigation and Agriculture Project (Report No. 13597-PAK); South Asian Region, Country Department, Agriculture and Natural Resources Operations Division,

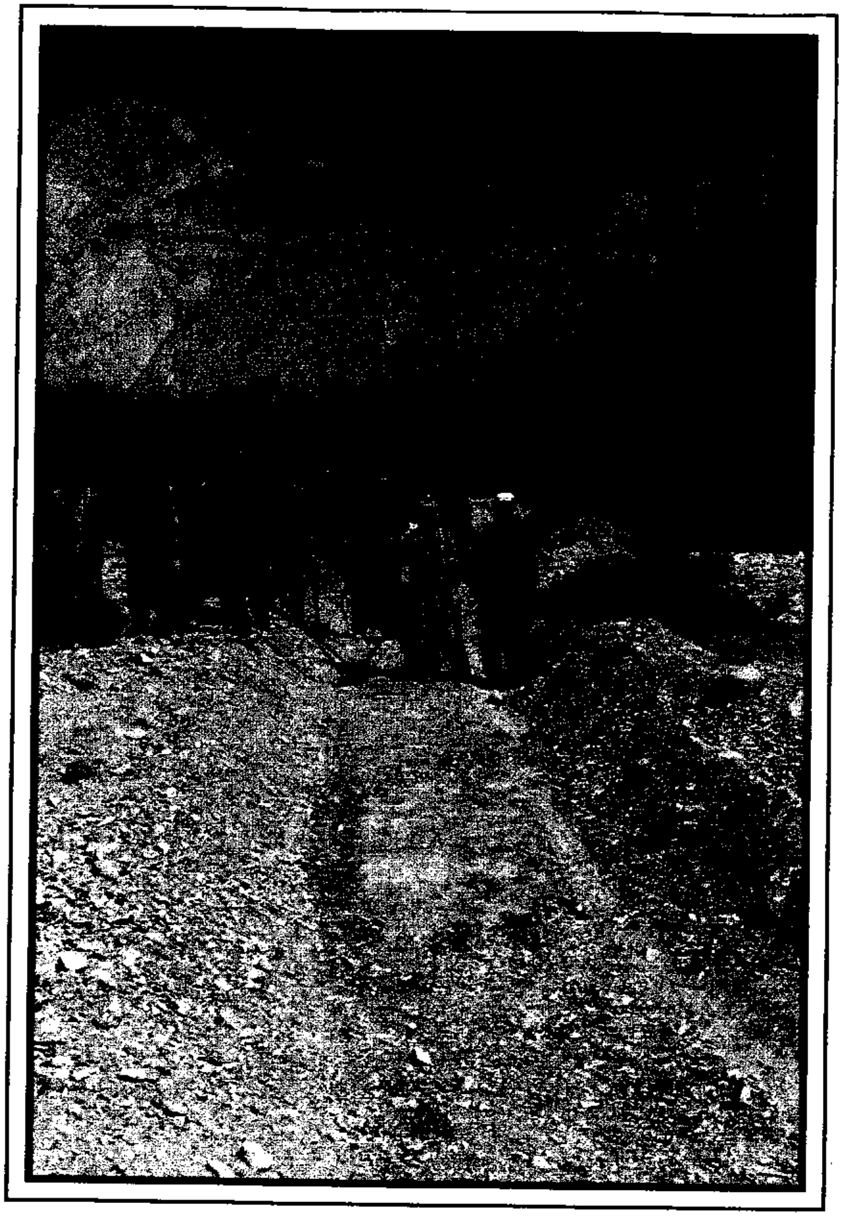
APPENDIX

PHOTOGRAPHS

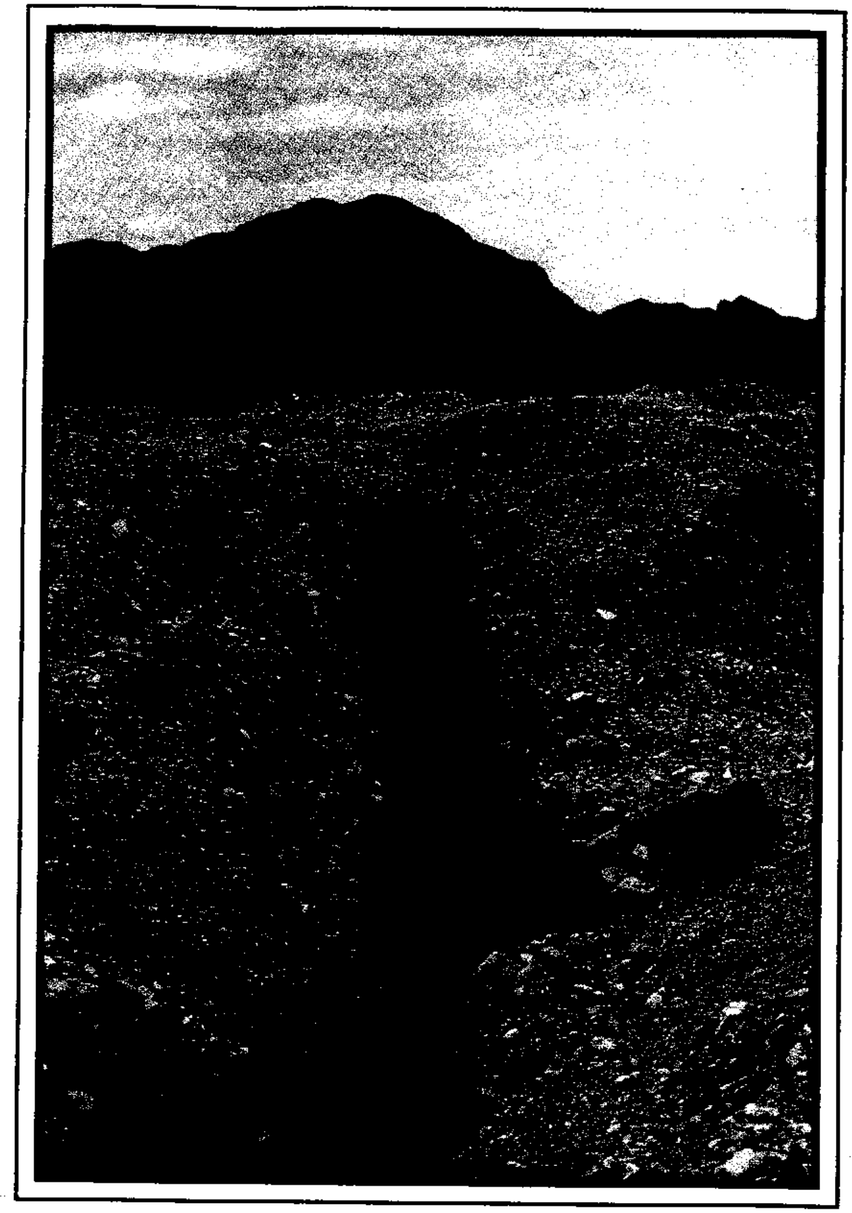
Photograph A. Wooden field inlet structure in Kachhi Pasra (Loralai District).



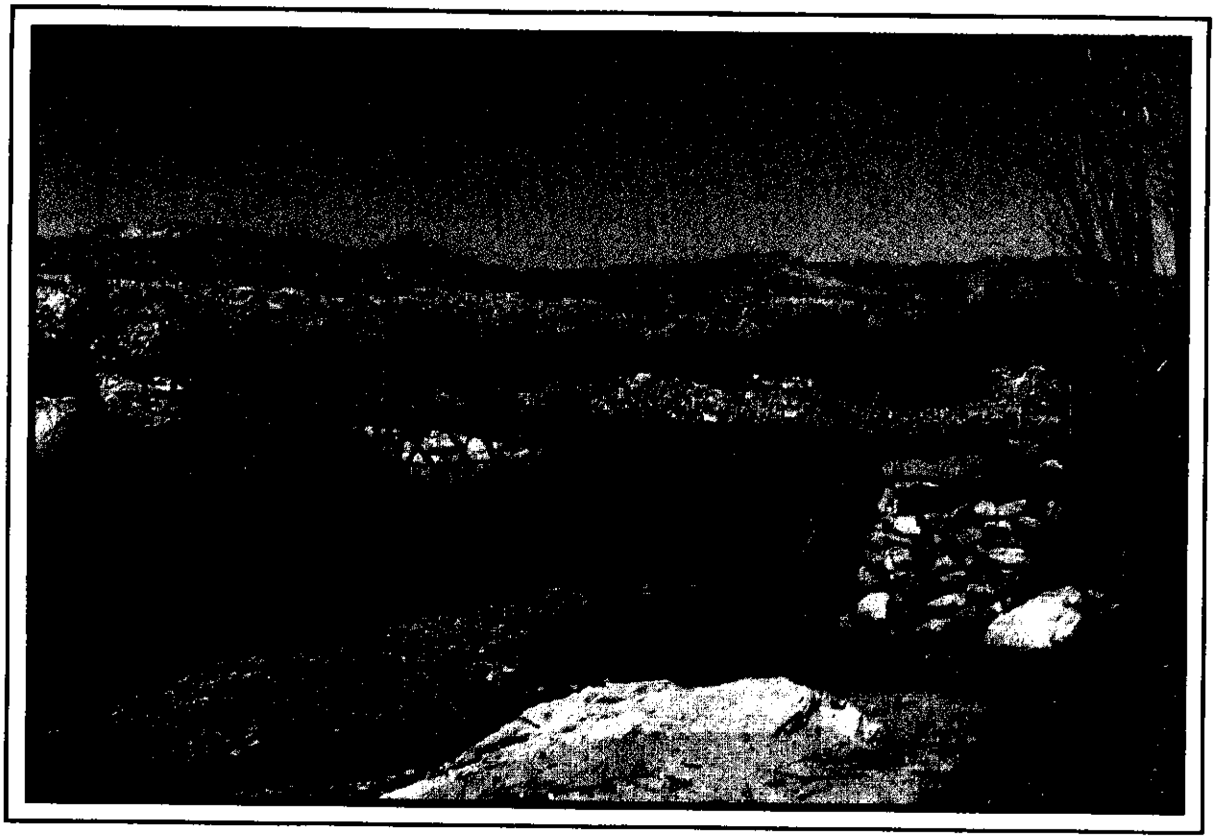
Photograph B. Camel-driven Persian wheel in Kunara (Jhal Magsi District).



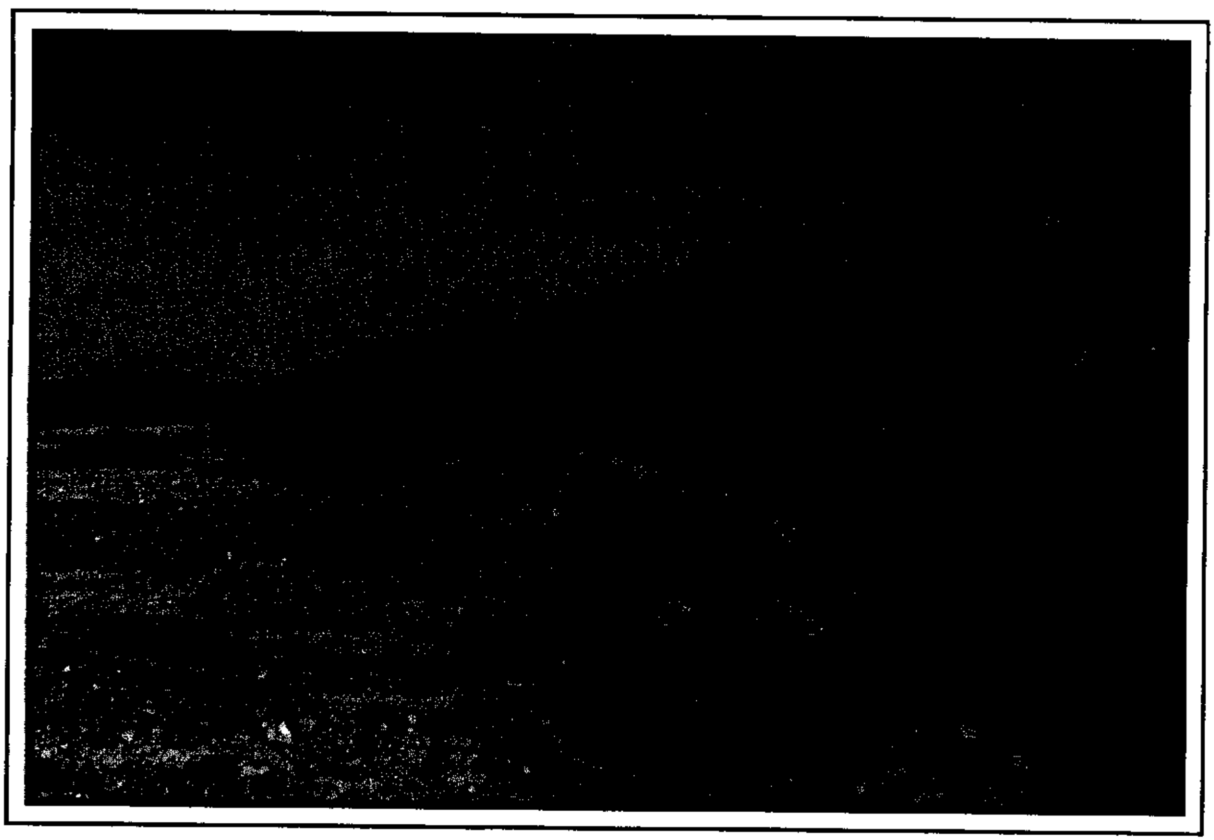
Photograph C. Cleaning of main channel by farmers in Raiko (Khuzdar District).



Photograph D. Daylight point of infilteration gallery in Khazkai (Loralai District).

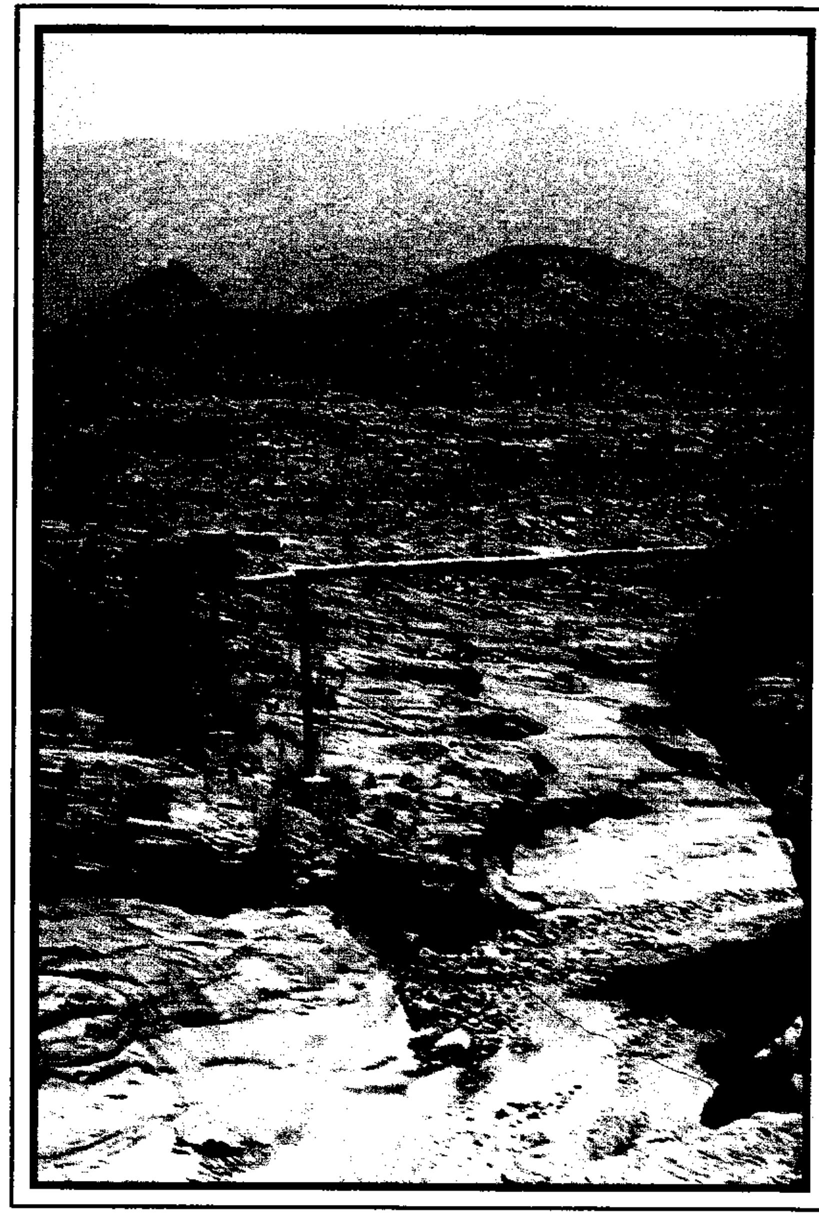


Photograph E. Farmer-constructed aqueduct in Qamarabad (Khuzdar District).

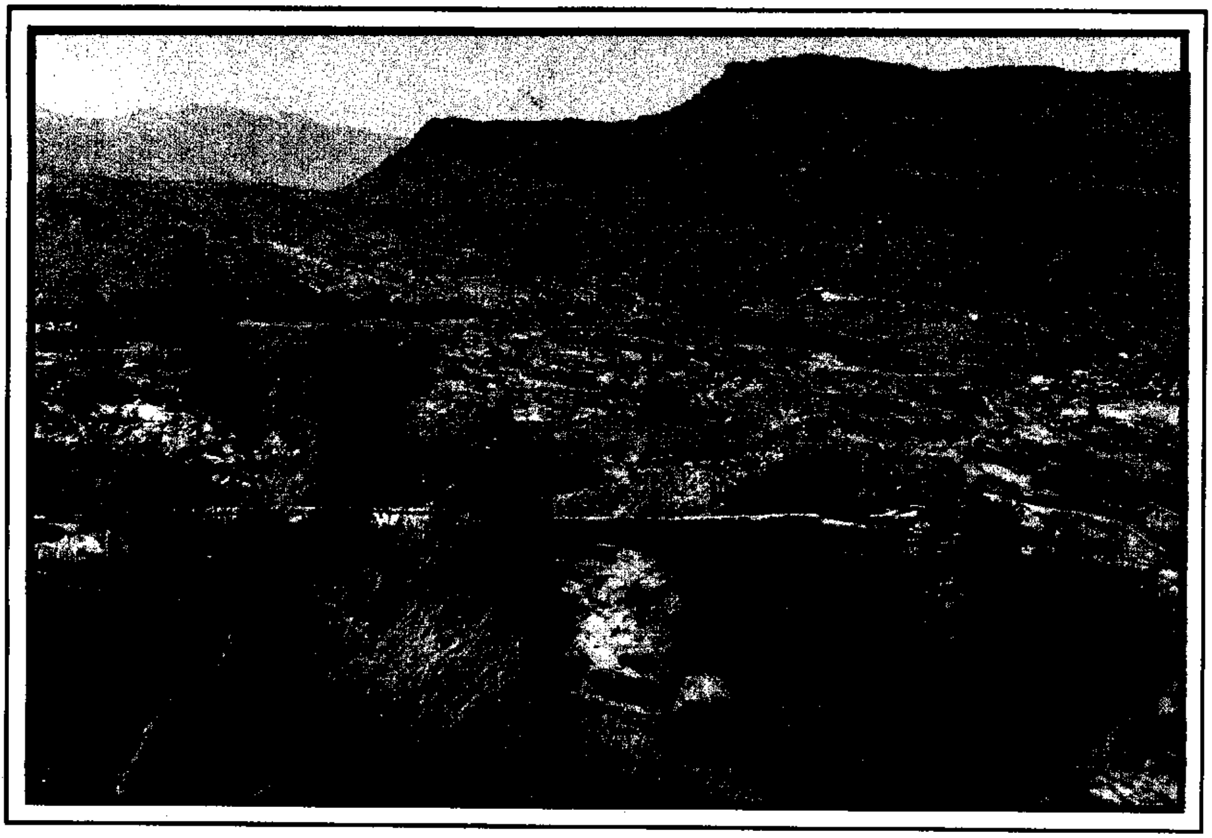


Photograph F. Diversion spur in Jug Zidi (Khuzdar District).

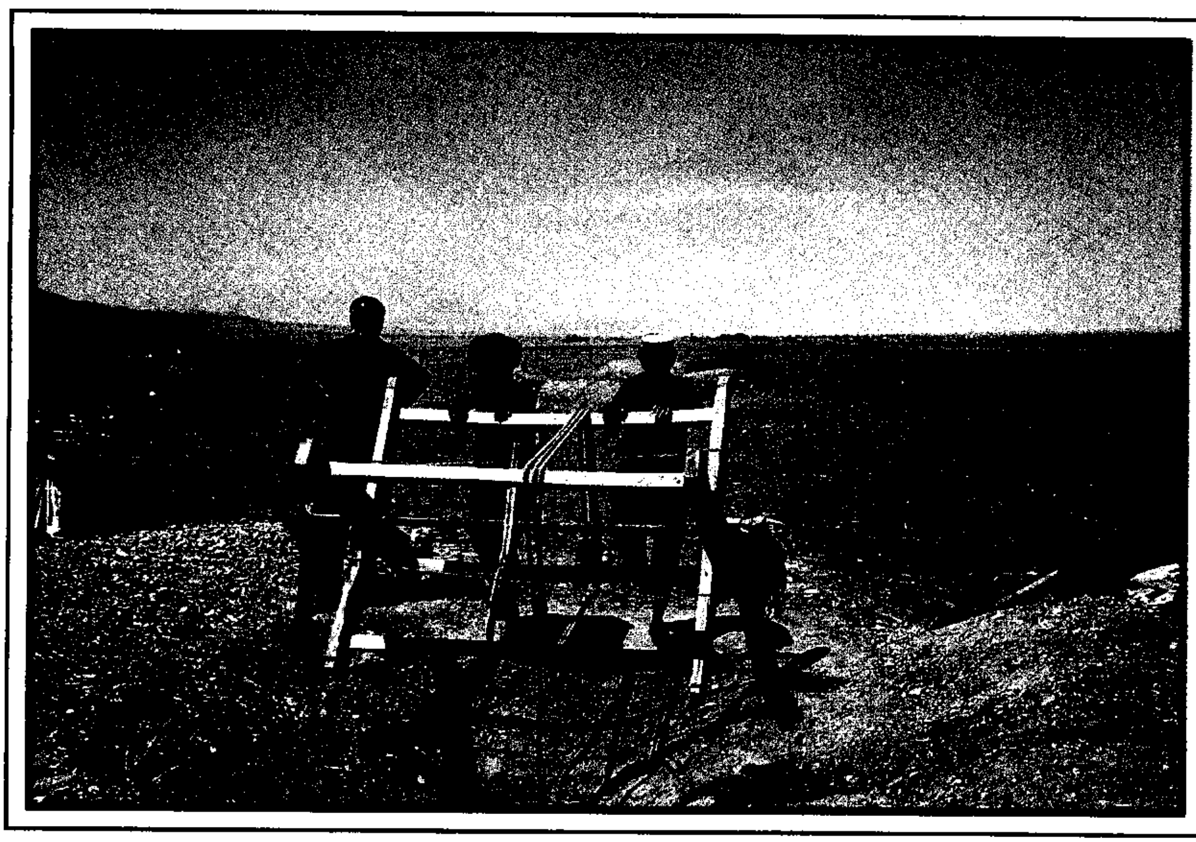
Photograph G. Farmers using plastic sheets to reduce seepage losses in Chashma Sheikhan (Zhob District).



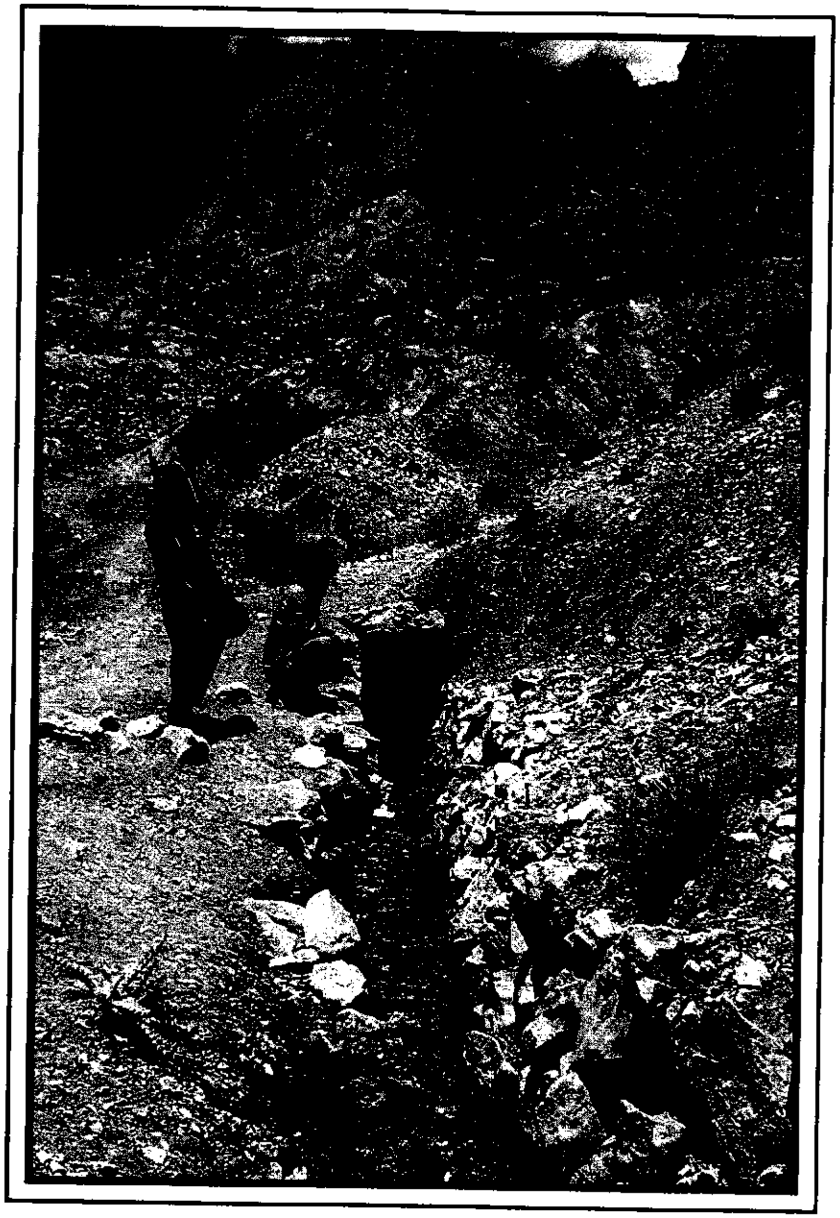
Photograph H1. Farmer-constructed aqueduct in Gastoi Jani Khel (Zhon District).



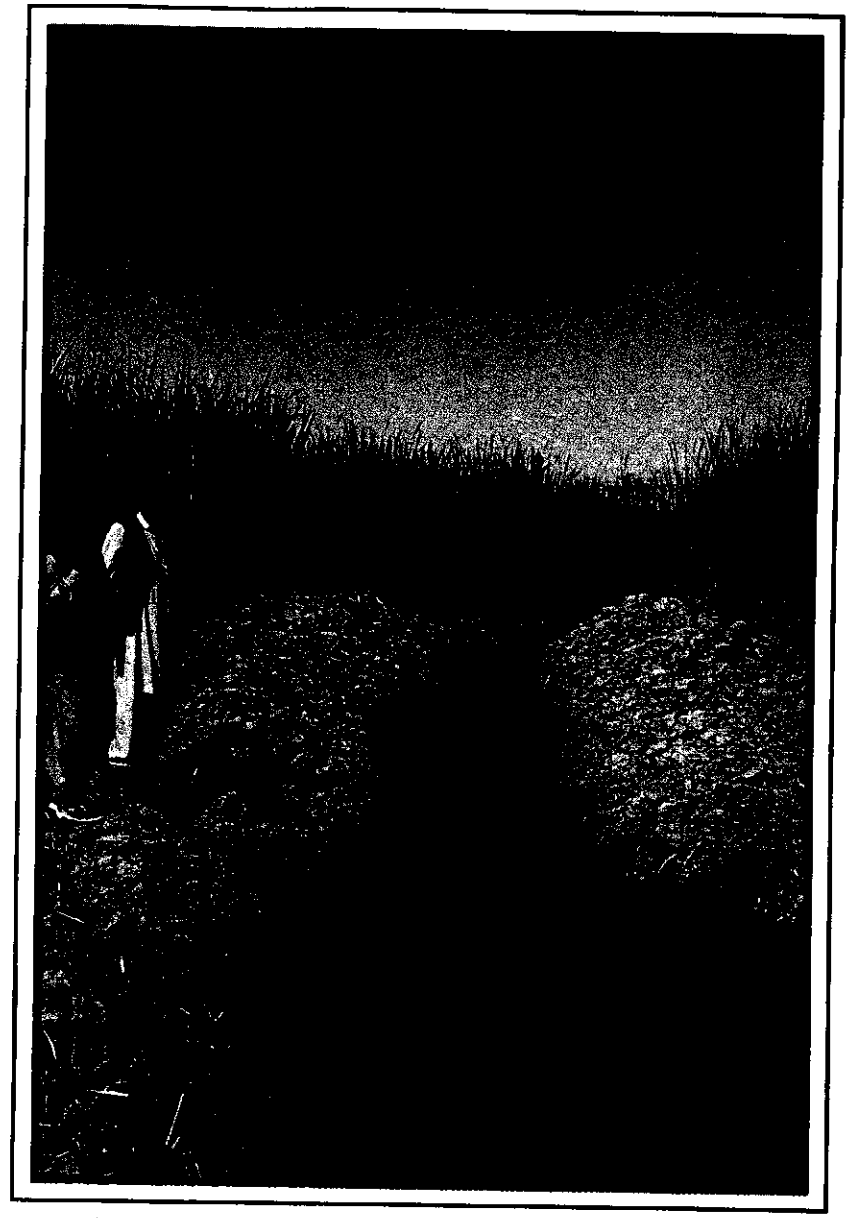
Photograph H2. Farmer-constructed aqueduct in Gastoi Jani Khel (Zhon District).



Photograph I. Cleaning of kareze in Ahmed Wal (Chagai District).



Photograph J. Daylight point of Spezandai Khareze (Ziarat District).



Photograph K. Head of main channel in Mirjanzai (Loralai District).

IIMI-PAKISTAN PUBLICATIONS
RESEARCH REPORTS

Report No.	Title	Author	Year
R-1	**Crop-Based Irrigation Operations Study in the North West Frontier Province of Pakistan** Volume I: Synthesis of Findings and Recommendations	Carlos Garces-R D.J. Bandaragoda Pierre Strosser	June 1994
	Volume II: Research Approach and Interpretation	Carlos Garces-R Ms. Zaigham Habib Pierre Strosser Tissa Bandaragoda Rana M. Afaq Saeed ur Rehman Abdul Hakim Khan	June 1994
	Volume III: Data Collection Procedures and Data Sets	Rana M. Afaq Pierre Strosser Saeed ur Rehman Abdul Hakim Khan Carlos Garces-R	June 1994
R-2	Salinity and Sodicity Research in Pakistan - Proceedings of a one-day Workshop	J.W. Kijne Marcel Kuper Muhammad Aslam	Mar 1995
R-3	Farmers' Perceptions on Salinity and Sodicity: A case study into farmers' knowledge of salinity and sodicity, and their strategies and practices to deal with salinity and sodicity in their farming systems	Neeltje Kielen	May 1996
R-4	Modelling the Effects of Irrigation Management on Soil Salinity and Crop Transpiration at the Field Level (M.Sc Thesis - published as Research Report)	S.M.P. Smets	June 1996
R-5	Water Distribution at the Secondary Level in the Chishtian Sub-division	M. Amin K. Tareen Khalid Mahmood Anwar Iqbal Mushtaq Khan Marcel Kuper	July 1996
R-6	Farmers Ability to Cope with Salinity and Sodicity: Farmers' perceptions, strategies and practices for dealing with salinity and sodicity in their farming systems	Neeltje Kielen	Aug 1996
R-7	Salinity and Sodicity Effects on Soils and Crops in the Chishtian Sub-Division: Documentation of a Restitution Process	Neeltje Kielen Muhammad Aslam Rafique Khan Marcel Kuper	Sept 1996
R-8	Tertiary Sub-System Management: (Workshop proceedings)	Khalid Riaz Robina Wahaj	Sept 1996
R-9	Mobilizing Social Organization Volunteers: An Initial Methodological Step Towards Establishing Effective Water Users Organization	Mehmoodul Hassan Zafar Iqbal Mirza D.J. Bandaragoda	Oct 1996
R-10	Canal Water Distribution at the Secondary Level in the Punjab, Pakistan (M.Sc Thesis published as Research Report)	Steven Visser	Oct 1996
R-11	Development of Sediment Transport Technology in Pakistan: An Annotated Bibliography	M. Hasnain Khan	Oct 1996

Report No.	Title	Author	Year
R-12	Modeling of Sediment Transport in Irrigation Canals of Pakistan: Examples of Application (M.Sc Thesis published as Research Report)	Gilles Belaud	Oct 1996
R-13	Methodologies for Design, Operation and Maintenance of Irrigation Canals subject to Sediment Problems: Application to Pakistan (M.Sc Thesis published as Research Report)	Alexandre Vabre	Oct 1996
R-14	Government Interventions in Social Organization for Water Resource Management: Experience of a Command Water Management Project in the Punjab, Pakistan	Waheed uz Zaman D.J.Bandaragoda	Oct 1996
R-15	Applying Rapid Appraisal of Agricultural Knowledge Systems (RAAKS) for Building Inter-Agency Collaboration	Derk Kuiper Mushtaq A. Khan Jos van Oostrum M. Rafique Khan Nathalie Roovers Mehmood ul Hassan	Nov 1996
R-16	Hydraulic Characteristics of Chishtian Sub-division, Fordwah Canal Division	Anwar Iqbal	Nov 1996
R-17	Hydraulic Characteristics of Irrigation Channels in the Malik Sub-Division, Sadiqia Division, Fordwah Eastern Sadiqia Irrigation and Drainage Project	Khalid Mahmood	Nov 1996
R-18	**Proceedings of National Conference on Managing Irrigation for Environmentally Sustainable Agriculture in Pakistan**	M. Badruddin Gaylord V. Skogerboe M.S. Shafique (Editors for all volumes)	Nov 1996
R-18.1	Volume-I: Inauguration and Deliberations		
R-18.2	Volume-II: Papers on the Theme: Managing Canal Operations		
R-18.3	Volume-III: Papers on the Theme: Water Management Below the Mogha		
R-18.4	Volume-IV: Papers on the Theme: Environmental Management of Irrigated Lands		
R-18.5	Volume-V: Papers on the Theme: Institutional Development		
R-19	Detailed Soil Survey of Eight Sample Watercourse Command Areas in Chishtian and Hasilpur Tehsils	Soil Survey of Pakistan IIMI-Pakistan	Nov 1996
R-20	Unsteady Flow Simulation of the Designed Pehur High-Level Canal and Proposed Remodeling of Machai and Miara Branch Canals, North West Frontier Province, Pakistan	Zaigham Habib Kobkiat Pongput Gaylord V. Skogerboe	Dec 1996
R-21	**Salinity Management Alternatives for the Rechna Doab, Punjab, Pakistan**		
R-21.1	Volume One: Principal Findings and Implications for Sustainable Irrigated Agriculture	Gauhar Rehman Waqar A. Jehangir Abdul Rehman Muhammad Aslam Gaylord V. Skogerboe	May 1997
R-21.2	Volume Two: History of Irrigated Agriculture: A Select Appraisal	Gauhar Rehman Hassan Zia Munawwar Asghar Hussain	Jan 1997

Report No.	Title	Author	Year
R-21.3	Volume Three: Development of Procedural and Analytical Liniks	Gauhar Rehman Muhammad Aslam Waqar A. Jehangir Abdul Rehman Asghar Hussain Nazim Ali Hassan Zia Munawwar	Jan 1997
R-21.4	Volume Four: Field Data Collection and Processing	Gauhar Rehman Muhammad Aslam Waqar A. Jehangir Mobin Ud Din Ahmed Hassan Zia Munawwar Asghar Hussain Nazim Ali Faizan Ali Samia Ali	Jan 1997
R-21.5	Volume Five: Predicting Future Tubewell Salinity Discharges	Muhammad Aslam	Jan 1997
R-21.6	Volume Six: Resource Use and Productivity Potential in the Irrigated Agriculture	Waqar A. Jehangir Nazim Ali	Feb 1997
R-21.7	Volume Seven: Initiative for Upscaling: Irrigation Subdivision as the Building Block	Gauhar Rehman Asghar Hussain Hassan Zia Munawwar	Apr 1997
R-21.8	Volume Eight: Options for Sustainability: Sector-Level Allocations and Investments	Abdul Rehman Gauhar Rehman Hassan Zia Munawar	Apr 1997
R-22	Salinisation, Alkalinisation and Sodification on Irrigated Areas in Pakistan: Characterisation of the geochemical and physical processes and the impact of irrigation water on these processes by the use of a hydro-geochemical model (M.Sc Thesis published as Research Report)	Nicolas Condom	Mar 1997
R-23	Alternative Scenarios for Improved Operations at the Main Canal Level: A Study of Fordwah Branch, Chishtian Sub-Division Using A Mathematical Flow simulation Model(M.Sc Thesis published as Research Report)	Xavier Litrico	Mar 1997
R-24	Surface Irrigation Methods and Practices: Field Evaluation of the Irrigation Processes for Selected Basin Irrigation Systems during Rabi 1995-96 Season	Ineke Margot Kalwij	Mar 1997
R-25	Organizing Water Users for Distributary Management: Preliminary Results from a Pilot Study in the Hakra 4-R Distributary of the Eastern Sadiqia Canal System of Pakistan's Punjab Province	D.J. Bandaragoda Mehmood Ul Hassan Zafar Iqbal Mirza M. Asghar Cheema Waheed uz Zaman	Apr 1997
R-26	Moving Towards Participatory Irrigation Management	D.J. Bandaragoda Yameen Memon	May 1997
R-27	Fluctuations in Canal Water Supplies: A Case Study	Shahid Sarwar H.M. Nafees M.S. Shafique	June 1997
R-28	Hydraulic Characteristics of Pilot Distributaries in the Mirpurkhas, Sanghar and Nawabshah Districts, Sindh, Pakistan	Bakhshal Lashari Gaylord V. Skogerboe Rubina Siddiqui	June 1997

Report No.	Title	Author	Year
R-29	Integration of Agricultural Commodity Markets in the South Punjab, Pakistan	Zubair Tahir	July 1997
R-30	Impact of Irrigation, Salinity and Cultural Practices on Wheat Yields in Southeastern Punjab, Pakistan	Florence Pintus	Aug 1997
R-31	Relating Farmers' Practices to Cotton Yields in Southeastern Punjab, Pakistan	P.D.B.J. Meerbach	Aug 1997
R-32	An Evaluation of Outlet Calibration Methods: A contribution to the study on Collective Action for Water Management below the Outlet, Hakra 6-R Distributary	Arjen During	Aug 1997
R-33	Farmers' use of Basin, Furrow and Bed-and-Furrow Irrigation Systems and the possibilities for traditional farmers to adopt the Bed-and-Furrow Irrigation Method.	Nanda M. Berkhout Farhat Yasmeen Rakhshanda Maqsood Ineke M. Kalwij	Sep 1997
R-34	Financial Feasibility Analysis of Operation and Maintenance Costs for Water Users Federations on three distributaries in Province of Sindh, Pakistan.	Amin Sohani	Sep 1997
R-35	Assessing the Field Irrigation Performance and Alternative Management Options for Basin Surface Irrigation Systems through Hydrodynamic Modelling.	Ineke Margot Kalwij	Oct 1997
R-36	Socio-Economic Baseline Survey for Three Pilot Distributaries in Sindh Province, Pakistan.	Yameen Memon Mehmood Ul Hassan Don Jayatissa Bandaragoda	Nov 1997
R-37	Socio-Economic Basline Survey for a Pilot Project on Water Users Organizations in the Hakra 4-R Distributary Command Area, Punjab.	Muhammad Asghar Cheema Zafar Iqbal Mirza Mehmood Ul Hassan Don Jayatissa Bandaragoda	Dec 1997
R-38	Baseline Survey for Farmers Organizations of Shahpur and Mirwal Small Dams, Punjab, Pakistan.	Muhammad Asghar Cheema Don Jayatissa Bandaragoda	Dec 1997
R-39	**Monitoring and Evaluation of Irrigation and Drainage Facilities for Pilot Distributaries in Sindh Province, Pakistan**		
R-39.1	Volume One: Objectives, Stakeholders, Approaches and Methodology	M.S. Shafique B.K. Lashari M. Akhtar Bhatti Gaylord V. Skogerboe	Dec 1997
R-39.2	Volume Two: Bareji Distributary, Mirpurkhas District	B.K. Lashari Waryam Balouch Ghulam Mustafa Talpur Muhammad Nadeem Asghar Ali Memon Badrul Hassan Memon M. Akhtar Bhatti M.S. Shafique Gaylord V. Skogerboe	Dec 1997
R-39.3	Volume Three: Dhoro Naro Minor, Nawabshah District	B.K. Lashari Abdul Rehman Soomro Nizamuddin Bharchoond Muneer Ahmed Mangrio Parvez Ahmed Pirzado Fateh Mohammad Mari M. Akhtar Bhatti M.S. Shafique Gaylord V. Skogerboe	Dec 1997

Report No.	Title	Author	Year
R-39.4	Volume Four: Heran Distributary, Sanghar District	B.K. Lashari M. Naveed Khayal Niaz Hussain Sial Abdul Majeed Ansari Abdul Jalil Ursani Ghulam Shabir Soomoro M. Ghous Laghari M. Akhtar Bhatti M.S. Shafique Gaylord V. Skogerboe	Dec 1997
R-40	**Maintenane Plans for Irrigation Facilities of Pilot Distributaties in Sindh Province, Pakistan.**		
R-40.1	Volume One: Dhoro Naro Minor, Nawabshah District	Abdul Rehman Soomro Munir Ahmed Mangrio Nizamuddin Bharchoond Fateh Muhammad Mari Parvez Ahmed Pirzado Bakhshal Lashari M. Akhtar Bhatti Gaylord V. Skogerboe	Dec 1997
R-40.2	Volume Two: Heran Distributary, Sanghar District	Abdul Majeed Ansari Niaz Hussain Sial Abdul Jalil Ursani Ghulam Shabir M. Ghous Laghari M. Naveed Khayal Bakhshal Lashari M. Akhtar Bhatti Gaylord V. Skogerboe	Dec 1997
R-40.3	Volume Three: Bareji Distributary, Mirpurkhas District	Asghar Ali Memon Waryam Balouch Ghulam Mustafa Talpur Muhammad Nadeem Badrul Hassan Memon Bakhshal Lashari M. Akhtar Bhatti Gaylord V. Skogerboe	Dec 1997
R-41 R-41.1	**Preliminary Business Plans** Volume One: Dhoro Naro Minor, Nawabshah District	Pervaiz Ahmad Pirzada Mohsin Khatri Syed Daniyal Haider	Dec 1997
R-41.2	Volume Two: Bareji Distributary, Mirpurkhas District	Muhammad Nadeem Mohsin Khatri Syed Daniyal Haider	Dec 1997
R-41.3	Volume Three: Heran Distributary, Sanghar District	Niaz Hussain Sial Mohsin Khatri Syed Daniyal Haider	Dec 1997
R-42	Prospects of Farmer-Managed Irrigated Agriculture in the Sindh Province of Pakistan. LBOD Project Final Report	D.J. Bandaragoda Yameen Memon Gaylord V. Skogerboe	Dec 1997
R-43	Study Tour of Pakistani Pilot Project Farmer-Leaders to Nepal	Mehmood Ul Hassan Yameen Memon	Jan 1998
R-44	Self-Help Maintenance Activities by the Water Users Federation of Hakra 4-R Distributary	Waheed uz Zaman	Feb 1998

Report No.	Title	Author	Year
R-45	Semi-Detailed Soil Survey of Chishtian Irrigation Sub-Division	Soil Survey of Pakistan IIMI-Pakistan	Mar 1998
R-46	Tenancy and Water Management in South-Eastern Punjab, Pakistan	Annemiek Terpstra	Mar 1998
R-47	The Collaboration between the International Irrigation Management Institute and Cemagref in Pakistan: Proceeding of a one-day workshop	IIMI Cemagref	Apr 1998
R-48	Methodologies for Developing Downstream Gauge Ratings for Operating Canal Discharge Regulating Structures	Paul Willem Vehmeyer Raza ur Rehman Abbasi Mushtaq A. Khan Abdul Hakeem Khan Gaylord V. Skogerboe	Apr 1998
R-49	Community Irrigation Systems in the Province of Balochistan	Olaf Verheijen	Apr 1998
R-50	Modelling Soil Salinity and Sodicity Processes in an Unsaturated Zone using LEACHM: A Case Study from the Chishtian Irrigation Sub-Division	M. Aslam J.C. van Dam	Apr 1998
R-51	Water Measurement Training for Subsystem Management of Hakra 4-R Distributary by the Water Users Federation	Waheed-uz-Zaman Anwar Iqbal Abdul Hamid Gaylord V. Skogerboe	May 1998
R-52	Comparison of Different Tools to Assess the Water Distribution in Secondary Canals with Ungated Outlets	Mobin ud Din Ahmad E.G. van Waijjen Marcel Kuper Steven Visser	May 1998
R-53	Sediment Behavior of Sangro Distributary, Mirpurkhas Sub-division, Sindh	Gilles Belaud Abdul Hakeem Khan Ghulam Nabi	May 1998
R-54	Evaluation of the Integrated Approach Developed in the Context of the IIMI-CEMAGREF Collaboration in Pakistan	Patrice Garin Marcel Kuper Frederic Labbe Pierre Strosser	May 1998