3. *PRESENT CONDITIONS OF THE STUDY AREA*

3.1 Location and Administration

The Study Area is located in a northern part of the Balochistan Province, which covers 5 districts, i.e. Qila Abdullah, Pishin, Quetta, Mastung and Kalat of Quetta and Kalat divisions. The total land area of the districts is 26,282 sq.km. The districts of Qila Abdullah and Mastung are newly separated from Pishin district in August 1993 and from Kalat district in February 1992, respectively. The administrative structure is briefly given in the following table.

Administrative Structure of the Study Area

District	Sub-Division	Tehsil	Sub-Tehsil	No. of Municipal/Town Committee	No. of Union Council
Qila Abdullah	Gulistan Chaman	Chaman	Gulistan Dobandi	1 (Municipal)	15
Pishin	Pishin Barshor	Pishin	Karazat Hurramzai Barshor	1 (Municipal)	22
Quetta	Quetta City Quetta Sadar	Quetta City Quetta Sadar	Panjpai	1 (Municipal)	8
Mastung	Mastung	Mastung	Kirdagab Dasht Kad Kocha	1 (Municipal)	8
Kalat	Kalat	Kalat	Surab Mangocher Johan Gazg	2 (Town)	13

Source: Agricultural Statistics of Balochistan, 1993-94, and Local Government of Balochistan Province

The proposed delay action dams to be studied and the existing DADs to be reviewed in the Study are scattered in the 5 districts as shown in the following table.

Study Delay Action Dams by District

Division	District	Proposed DAD	Constructed DAD
Quetta	Qila Abdullah	Arambi (Ghazlona and Samaki)	
	Pishin	Jigda Sanzali	Bostan Khushab Tirkha
	Quetta	Brewary Ghutai Shela Wali Dad Dara Murgi Kotal Kach	Khora Manda Marium
Kalat	Mastung	Sakhol Kad Kocha II	Amach Kad Kocha I
	Kalat	Mangi Iskalkoo	Gorpad Laghmgir Sarbund

Source: Irrigation and Power Department, Balochistan

3.2 Demography and Sociology

3.2.1 Demography

According to the population census held in 1981, the total population of 5 districts including the Study Area was about 1.1 million which is 25.4 % of the population of the Province. The average population density was about 42 person/sq.km. The latest population projection by district in Balochistan was conducted in 1995 by the Bureau of Statistics of the Provincial Government. According to this projection, the population in 1981 population census and population estimation in 1995 by district concerning the Study Area is given below (Each regional details of the 1995 estimation were projected by JICA Study Team):

Population Estimation by District

(1000 persons, %)

District		1981 Census	1995 Estimation	Annual Growth Rate
Quetta	Total	381.6	676.9	4.18
	Rural	95.8	155.6	3.52
	Urban	285.7	521.4	4.39
Qila Abdullah	Total	176.3	272.2	3.15
	Rural	146.5	222.3	3.02
	Urban	29.8	49.9	3.76
Pishin	Total	202.3	312.2	3.15
	Rural	187.5	287.6	3.10
	Urban	14.7	24.7	3.76
Mastung	Total	132.0	200.0	3.01
	Rural	115.6	172.5	2.90
	Urban	16.5	27.6	3.76
Kalat	Total	209.1	316.8	3.01
	Rural	198.1	298.0	2.96
	Urban	11.0	18.8	3.86
Total	Total	1,101.4	1,778.2	3.48
	Rural	743.6	1,135.9	3.07
	Urban	357.7	642.3	4.27
Balochistan	Total	4,332.4	7,357.9	3.85
	Rural	3,655.6	6,137.1	3.77
	Urban	676.8	1,220.2	4.30

Source: Population Census 1981: Population Census Organization
Population Estimation: Provincial Bureau of Statistics and JICA Study Team

According to above table, the estimated population by district in 1995 is from 1.8 to 1.5 times comparing to the census population in 1981. The annual growth rate of Quetta district is considerably high being an urban area, while those of the other districts are lower than the provincial average. The urbanization of Quetta city is likely to attract more people from the surrounding areas. Current average population density of these 5 districts is about 68 person /sq.km which is considerably higher than 21 of the provincial average.

3.2.2 Sociology

Pashtun mainly lives in northern part of the Study Area, i.e. Pishin, Qila Abdullah and Quetta districts, and Brahui and Baloch in southern part, i.e. Mastung and Kalat districts. The ethnic territorial boundaries are not very rigid, especially in urban areas because of the development of social groupings, the intermingling through the seasonal movements, and the recent influx of Afghan Refugees. However, the characteristic of social structure of each ethnic group is still very distinct. Each group has their traditions and rules of social organization.

There are several nomadic groups in Balochistan. During summer season, the main groups stay at relatively cooler highlands including the Study Area, and move to southern districts or other warmer areas in winter. Some of them come from Afghanistan. Some of them work as the seasonal wage labours at the farm fields of the local sedentary farmers for wheat harvesting, fruits harvesting, etc., or in other economic sectors. In the Study Area, considerable nomads camping here and there are observed. Out of beneficial areas of proposed delay action dams, especially in and around the areas of Jigda, Murgi Kotal, Sakhol, Kad Kocha and Mangi, nomadic people come and return every year, and supply the seasonal labour force to the beneficiaries. In return they can graze their animals at the surrounding hilly areas and get crop residues as the fodder.

According to the Census of Agriculture in 1990, average household size in the five districts including the Study Area, is about 8.2 that is equal to the provincial average. Generally a household size is much larger in agricultural sector due to the traditional life style. It is not unusual that more than 20 persons live together in a walled house or make an economic living unit. The power of family chief is very strong and man-dominated atmosphere is distinct. In tribal areas, the custom of early marriages is common.

In Balochistan many parents still have not been convinced to give school education to their children. School enrollment ratio (number of students to school age population) by level in the Province in 1991 - 92 is as follows:

School Enrollment Ratio by Level & Sex (1991 - 1992)

(%)

School level	Age	Both Sex	Male	Female
Primary	6 - 10	37.4	55.1	17.5
Middle	11 - 13	16.5	24.0	6.0
High	14 - 15	9.4	13.3	3.3

Source: Bureau of Statistics, P.D.D. Government of Balochistan

According to above table, about 45 % of school age boys and 82 % of school age girls do not or can not enroll even in primary school. In primary education, there is an abnormally high dropout rates. On the other hand, teachers are untrained or poorly trained and the shortage of woman teachers in rural area is a major problem.

The health condition of the Balochistan is lower than in the rest of Pakistan. Infant mortality (around 200 per 1000 live births), fertility, and maternal mortality (5-7 per 1000) are very high. Incidence of malnutrition, infectious and parasitic diseases are larger. Twenty-eight percent of expectant mothers, 46 % of lactating mothers and one third of pre-school children consume less than 70 % of recommended daily allowance of calories. In the Province, out of the morbidity of out-patient in 1992, about 17 % was the respiratory tract infections, followed by 16 % of other infectious diseases, 11 % of gastrointestinal infections, and 8 % of other diseases of the digestive tract.

Historically tribal societies in Balochistan are so patriarchal that male play predominant role and women's role is very limited in these communities. The position of women in agricultural sector varies strongly due to the difference of ethnic background. In Pashtun tribal societies, women seldom work on the farm. Contrary to this, in Baloch and Brahui societies, women work on the farm mainly at harvesting seasons, though they are not involved in activities of polishing, seeding, fertilizer application, irrigation, etc. These women usually work a unpaid family labour.

The major economic activity in the Study Area is the crop production and animal husbandry, and most of the industries are unregistered micro and small scale units. For medium and large scale industries in Balochistan, about 90 % are established in Lasbela district and 10 % in Quetta district. The percentage of un-employed civilian labour force in the Province is very low (1.6 %) compared to the national average (6.3 %) in 1990-91.

According to the Household Income and Expenditure Survey of 1987, average monthly income per household in Balochistan was Rs. 2,898 which is slightly lower than the national average of Rs. 3,590. Similarly, the monthly average consumption expenditure per household for this Province was Rs. 2,649 that is also less than Rs. 3,485 in the whole country. Percentage distribution of food, beverage, fuel, etc., in the Province is higher than national average.

3.3 Natural Condition

3.3.1 Topography

The study area is located in the north-eastern region of the Balochistan Province which is called as Quetta-Pishin uplands. It consists of a number of ranges merging into Quetta-Pishin uplands and associated with series of narrow valleys with rivers draining towards the main river channels.

The main river channel of the area is Pishin Lora whose total basin area including branch channel is approximately 17,000 sq.km. The Basin is mainly composed of highlands and valley floor, etc., bounded by mountain ranges mainly in NNE-SSW direction, and can be subdivided into eleven sub-basins.

The altitude of the highest peak in the area is 3,637 m above the mean sea level, which is located north-eastward of Quetta. The eastern watershed of the area is bounded by the high mountain ranges of over 3,000 m above mean sea level. The altitude is gradually declining to the west, and the western watershed of the area called Khwaja Amran Range lies between 2,300 - 2,700 m in the northern side and lower than 2,000 m in the southern side. While, the valley floors are between elevation 1,500 - 1,800 m in the eastern side and 1,400 - 1,700 m in the western side.

Alluvial deposits and sedimentation of the material has given rise to the following physiographic units.

(a) Alluvial fans: They comprise very coarse material deposited by the torrents immediately in the foot of the mountains.

(b) Piedmont plain: They are located down of fans and aprons and consist of relatively finer alluvial material.

(c) Basins and playas: Having deposited the coarser material earlier, the spills collect in the depressions, shed their fine material and stagnate. Due to close nature of the basins with no external drainage, the run-off water on evaporation leaves a thick crust of salts on the soils.

(d) Stream flood plains: These result from the sedimentation of silty and fine silty material from the slow moving river spills. Surface is nearly level. Part of the area is subject to seasonal flooding.

(e) Loess deposit area: Loess is postulated to have been blown out of broad sandy river beds and river plains-such as Indus plain-and deposited in this region during last glaciation period. Remnants of loess cap some shale-sandstone mountains.

The eleven sub-basins are called 1) Pishin, 2) Kuchlagh, 3) Quetta, 4) Kolpur, 5) Sardar Khel, 6) Mastung, 7) Mangocher, 8) Shirinab, 9) Patki Shah Nawaz, 10) Kalat, and 11) Kapoto. These are laying from north side to the south, and are elongated in a north-south direction. The largest one is Pishin sub-basin, the area of which is approximately 7,000 sq.km. The area of highlands and lowlands of the respective sub-basins are shown in table below.

Topography by Sub-Basin (Unit: sq.km)

Land Form	Sub-Basins										Pishin Lora Basin	
	Pishin	Kuchlagh	Quetta	Kolpur	Sardar Khel	Mastung	Mango -cher	Shirinab	Patki Shah Nawaz	Kalat	Kapot	Total
Lowland												
Valley Floor	2,570	250	430	20	?	260	130	440	130	280	50	4,540
Piedmont Slope	490	520	440	30	?	180	200	300	360	810	20	3,340
Sub-Total	3,060	760	870	40	260	440	330	740	490	1,090	60	7,870
Highlands												
Sub-catchment	1,410	440	-	-	?	-	-	-	-	-	-	1,850
Un-allocated	2,390	550	920	70	240	350	340	590	510	1,150	110	7,210
Sub-Total	3,890	980	920	70	240	350	340	590	510	1,150	110	9,050
Total Area	6,860	1,750	1,790	110	490	790	670	1,320	1,000	2,240	170	16,930

Information extracted from UNDP Groundwater Studies in Selected Areas of Balochistan 1982

3.3.2 Climate

The Province of Balochistan is classified in semi-arid. The weather systems which determine the climate of the Province can be divided into two seasons, winter and summer. Winter is dominated by the extensive anticyclonic system which lies over the southern and central part of Asia. Western disturbances, which arise in the Mediterranean, travel in an eastern direction and pass into the region between November and March. These disturbances bring widespread and low intensity of precipitation in the form of rainfall or snow on the higher ground. The disturbances also bring in their wake cold north-western airstreams which make the climate of upland Balochistan cold, frosts of considerable intensity being common.

During the period from June to August, monsoonal depressions which develop in the Bay of Bengal travel in a west and north direction over the Subcontinent often depositing large quantities of rainfall along their tracks. The eastern portion of the Province can expect several substantial amount of rainfall from this source, whereas the western areas receive significant summer rainfalls infrequently. Temperatures during the summer are generally hot throughout the Province. There are two transitional periods between these two primary seasons. The Autumn transitional period in particular (during September and October) has very low rainfall.

The climatic data pertaining to rainfall, temperature, humidity and wind velocity are available at the several meteorological stations observed by the Department of Meteorological Services, Government of Pakistan. The records of Surface Water Hydrology Project (SWHP) undertaken by WAPDA are also available, of which the role has been taken over by the Bureau of Water Resources, Irrigation Department. Available climatic stations and their data regarding the Study Area are shown in Fig. 3.3.1 and Table 3.3.1.

The meteorological factors of Quetta station as a most common values in the Study Area are shown in Table 3.3.2.2. Annual rainfall which is major factor for available water varies year

by year with large deviation. Minimum probability annual rainfall analysis was carried out. Results of the probable minimum annual rainfall in each return period are as follows:

Probable Minimum Annual Rainfall

(mm)

Return period	Probable Minimum Annual Rainfall
2 Years	246.5
5 Years	176.5
10 Years	148.2
20 Years	128.3
30 Years	119.1
50 Years	109.1
100 Years	97.9
200 Years	88.7

Note: Probable analysis above were using records of the Quetta Station during 1961 to 1995.

3.3.3 Hydrology

Notable characteristics on hydrology in the Study Area are scarce perennial flow and short termed flush of water during flood. This phenomena is generally caused by poor cover of vegetation on the watershed as well as small quantity of precipitation.

Runoff coefficient is considerably low of 5 to 10 % per year. However, the runoff coefficient varies by season. While lower value of the coefficient is observed during winter due to low intensity and long duration of rainfall, higher value of the coefficient is recognized owing to short termed and high intensity rainfall in summer. Evaporation is quite high in the Study Area. Except for contribution to runoff and recharge, the rest of the precipitation must be wastefully evaporated. General water economy in the Study Area by seasons are shown in the following table.

General Water Economy by Season

Components	Winter	Summer	through year
Runoff*	5 - 8 %	10 - 15 %	5 - 10 %
Evaporation**	60 - 70 %	80 - 90 %	60 - 70 %
Recharge**	20 - 35 %	0 - 5 %	20 - 35 %
Rainfall	100 %	100 %	100 %

Notes: * Runoff factor is an estimation using runoff records of Chapper Lift Station.
** These figures were derived through a simulation by recharging model as shown in ANNEX B.

The current river gauging stations in operation in Balochistan have been established, and observed by the Surface Water Hydrology Project of WAPDA. Four stations of Sariab Lora (Brewary Bridge), Beleli River (Check Post), Pishin Lora (Burj Aziz Khan) and Khost River (Chapper Rift) among these stations are concerned with the Study Area. However, only intermittent record is available in these 4 stations.

3.3.4 Geology

The geologic province around the Study Area is the central part of the Axial Belt which consists of Sulaiman - Kirtar Range and their sequence mountains, and a part of the Zhob province. Stratigraphically, Calcareous zone, Arenaceous zone and a part of Eruptive zone can be recognized from east to west. The stratigraphy of Pishin Lora Basin are as follows:

Stratigraphy of the Pishin Lora Basin

Age	Formations	Lithology
Recent ~ Pleistocene	•Talus deposits	•Gravel, Pebble, coarse Sand
	•Alluvial fan deposits	
	•River deposits, Flood deposit &Piedmont Plain deposits	•Silt, Clay, and Sand
	•Subrecent deposits	•Sand & Gravel, Silt, Clay
	•Bostan Formation	•Clays and Silt
	•Dada Conglomerate	•Conglomerate
Tertiary	•Urak Group	•Shale, calcareous Sandstone, Conglomerate, and Limestone
	•Shaigalu Sandstone	
	•Murgha Faqirzai Shale and Wakabi Limestone	•red and green Shale with layer of Sand stone and Limestone; upper part mostly Volcanic Ash; thickness over 1200 m
	•Spintangi Limestone (Kirthar Lime stone)	•foraminiferal, cream, yellow, light gray, pinkish white or chalky white Limestone, in some places contains breccia structure.
	•Nimargh Limestone, Marap conglomerate, and Nisai Group	•Alternating Shale, Sandstone, and Lime stone; thickness up to 1200 m
	•Gazij Shale	•Shale
	•Rodangi Formation	•Limestone, Marl, Shale and subordinate Sandstone
	•Dunghan Group and its equivalents	•blue or grey Limestone with some Shale and Sandstone in the basal portion; thickness up to 750 m
	•Brewary Limestone	
	•Gidar Dhor group	•Shale, Conglomerate, Limestone, and Sandstone; thickness up to 1500 m
E. Pal. to L.C.	•Hindu Bagh Ultra basic Intrusives	•Ultra basic Intrusive Rocks
Cretaceous ~ Triassic	•Fort Munro Limestone	•dark grey Dolomite thick bedded
	•Parh Group Series	•mostly Limestone, some Marl, shale and Sandstone
	•Karakh Group	•Limestone, limestone Conglomerate, Marl, Shale, Sandstone and minor Volcanics
	•Belemnites Shale	•Shale, Sandstone and Conglomerate
	•Loralai Limestone, Moro Formation and Chiltan Limestone	•mainly dark Limestone with minor amount of black Shale
	•Shirinab Formation	•mostly Limestone and interbedded Shale; thickness over 1500 m
	•Alozai Group	•mainly interbedded Limestone and Shale

The central part of the basement complex of Pishin Lora Basin is mainly composed of Triassic to Cretaceous marine series, which is overlain by Tertiary series widely distributed on both wings but the Pliocene deposit is deficit. The Study Area is located at one of the western periphery of Kachhi geosynclinorium so that the basement rocks are suffered by tectonic

movement resulting remarkable folding and thrust, etc. Their land-forms have the direction showing typically NNE-SSW to NE-SW.

The wide basins bounded by hills and mountains are covered with alluvial soils. So are the narrow river valleys which wind through and run between hills and mountains. The foothills are covered with talus cones and alluvial fans generally composed of gravels, pebbles, and coarse sands. Beyond foothills, the valley floors are covered with silt and loam, and undrained playa lake area are covered by alternated clay and silt, and show sometimes saline characteristics.

The distributing stratigraphy in the respective sub-basins are shown in the following table.

Stratigraphy of the Respective Sub-basins

System	Sub-Basins							
	Pishin	Kuchlagh	Quetta (Kolpur)	Patki Shah Nawaz	Shirinab	Mastung	Mangocher (SardarKhel)	Kalat (Kapoto)
Recent and Pleistocene	Recent Subrecent Bostan Fm.	Recent Subrecent Bostan Fm.	Recent Subrecent	Recent Subrecent Bostan Fm.	Recent Subrecent Bostan Fm.	Recent Subrecent Bostan Fm.	Recent Subrecent Bostan Fm.	Recent Subrecent Dada Cg.
Pliocene	-	-	-	-	-	-	-	-
Miocene	Shaigalu Ss.	Shaigalu Ss. Urak Gr.	Urak Gr.	Shaigalu Ss.				
Oligocene	M.Faqir. Sh.			M.Faqir. Sh. Wakabi Ls.	Wakabi Ls.			Wakabi Ls.
Eocene	Nisai Gr. Nimargh Ls.	Nisai Gr. Nimargh Ls. Ghazij Sh.	SpintangiLs Ghazij Sh. Ghazij Sh.	Wakabi Ls. Nimargh Ls.	Wakabi Ls. Nimargh Ls. RodangiFm.	SpintangiLs Ghazij Sh. Ghazij Sh.	SpintangiLs Ghazij Sh. Ghazij Sh.	Wakabi Ls. SpintangiLs Mp.Cg.Nm.Ls. Ghazij Sh.
Paleocene		Brewery Ls.	Dungan Gr. Brewery Ls.		RodangiFm.			GidarDhorGr
E.Pal.toL.C	Hind. Int.	Hind. Int.						
Cretaceous	Parh Gr.	Parh Gr.	Fort Munro Parh Gr. Belem.Sh.				Parh Gr.	Parh Gr.
Jurassic	Loralai Ls. ShirinabFm. Alozai Gr.	Chiltan LS. ShirinabFm. Alozai Gr.	Chiltan LS. ShirinabFm.	ShirinabFm.	Chiltan LS. ShirinabFm.	Chiltan LS. ShirinabFm.	Chiltan LS. ShirinabFm.	Chiltan LS. ShirinabFm.
Tr. & P.C.	Alozai Gr.	Alozai Gr.						

Notes: Tr. & P.C.: Triassic and Permo-Carboniferous.
E.Pal.toL.C.: Early Paleocene to Late Cretaceous.
Hind. Int.: Hindubagh Intrusives.
Mp.Cg.Nm.Ls.: Marap Conglomerate, Nimargh Limestone.
M.Faqir.Sh.: Murgha Faqirzai Shale.

Source: Table "Stratigraphy of the Respective Sub-Basins" extracted from UNDP/WAPDA Groundwater Studies in Selected Areas of Balochistan (1982)

3.3.5 Hydrogeology and Groundwater

(1) Hydrogeology

The occurrence of groundwater could be grouped usually into two systems as follows:

i) Granular and porous aquifer

Groundwater usually occurs in the unconsolidated deposits found in the piedmont plains and valley floors and these are the most abundant aquifer groundwater resources. Layers of gravel with sand, silt and clay constitute the aquifers. Groundwater occurs in the interstices or pore spaces between the granular sedimentary particles constituting the groundwater reservoirs.

Consolidated rocks like Urak conglomerate, Marap conglomerate are found to have intergranular porosity and yield water, therefore, serve as porous aquifers. These formations may have wide aerial extent but their productivity as aquifer is confined to only in areas of favorable recharge.

ii) Fractured and fissured aquifer

These types of aquifers exist in hard rocks where joints, fractures, faults and solution cavity permit storage and movement of water. Under favorable structure in hard rock, groundwater is discharged as natural springs.

Spintangi Limestone has a fractured nature as breccia at some part, and fissures, solution cavity may develop well so that this formation may be treated partly aquifer.

However, in other parts mostly the consolidated rocks are generally impermeable and serve as barrier to groundwater.

From the above description, the hydrogeology of Pishin Lora Basin is shown in the Fig. 2.3.2.

The formations in Pishin Lora Basin may be divided into the following five categories depending upon the compositions, structures and distributions, etc.

1) Mainly Aquifers
   - Gravely to sandy portion of alluvial deposit.
   - Dada Conglomerate of Pleistocene age.
   - Upper Urak Group of Miocene age (mainly conglomerates).
   - Marap Conglomerate of lower Oligocene age.

2) Partly Aquifers, Partly Aquitards (mainly granular)
   - gravely sandy silt of alluvial and subrecent deposit.

- Bostan Formation of Pleistocene age (partly conglomerate and sandstone).
- Shaigalu Sandstone of uppermost Eocene age, upper part is shale.

3) Partly Aquifers, Partly Aquitards (mainly Fractured)
   - Nisai Group of lower Oligocene to lower Eocene (marly limestone interbedding sandstone layers).
   - Spintangi Limestone of lower to medium Oligocene age (brecciated, partly shale).
   - Nimargh Limestone of Oligocene age (nodular to massive).
   - Dungan Group of uppermost Cretaceous to lower Oligocene age (mainly nodular to conglomeratic limestone).
   - Brewary limestone of uppermost Cretaceous to Paleocene age.
   - Hindu Bagh ultrabasic intrusives of upper Cretaceous to lower Paleocene age.

4) Mainly Aquitards (Granular)
   - Silt and clay of alluvial deposit.
   - Murgha Faqirzai shale, Ghazij shale of Oligocene to Eocene age.
   - Belmnite shale and Karkh Group of Cretaceous age.

5) Mainly Aquitards (Fractured)
   - Wakabi Limestone of Oligocene to Eocene age.
   - Rodangi Formation and Gidar Dhor Group of Paleocene.
   - Parh Group Series and Karkh Group of Cretaceous age (limestone, shale).
   - Loralai Limestone, Moro formation, Chiltan Limestone, Shirinab Formation and Alozai Group of Jurassic age (limestone, shale).

Delay action dams of this project are located in Pishin, Kuchlagh, Quetta Northern, Mastung, Kalat, and Patki Shah Nawaz Sub-Basins of Pishin Lora Basin. The hydrogeology of respective sub-basins characterizing the groundwater basin is as follows:

1) Pishin Sub-Basin

The mountain ranges are composed of shales and sandstones, and eastern hills are of Pleistocene silts/clay strata. These strata form the impervious bed of the Sub-Basin. Along the piedmont of the north-eastern to the north-western, alluvial fans are widely extended, and forms an excellent groundwater recharging media. However, valley floor deposits are generally rich in low permeable fine material. The surface of valley floor is usually covered with silts/clay of low infiltration capacity.

The areas having Specific Yield of more than 20 % are in the north-eastern to northern piedmont, and the eastern Subrecent deposited area. Among them, the northern piedmonts show partly Specific Yield around 25 %.

Transmissivity is: 10 to 20 m^2/day in small scale of alluvial fan area (Coefficient of Permeability 7 x 10^{-4} to 2 x 10^{-3} cm/sec); 100 to 1500 m^2/day in large scale of alluvial fan of the northern (Coefficient of Permeability 3 x 10^{-3} to 2 x 10^{-2} cm/sec); approximately 100m^2/day to a little less than 300 m^2/day along the front in the northern to north-eastern alluvial fan (Coefficient of Permeability 2 - 8 x 10^{-3} cm/sec) {50 to 150 m^2/day in alluvial fan locating the eastern side of K.K Bund (Coefficient of Permeability 2 - 5 x 10^{-3} cm/sec)}, around 500 m^2/day along the periphery (Coefficient of Permeability 1 to 2 x 10^{-2} cm/sec); Subrecent deposits show evenly approximately 100 m^2/day (Coefficient of Permeability 3 - 7 x 10^{-3} cm/sec); approximately 20 m^2/day in the center of valley floor (Coefficient of Permeability approximately 1 x 10^{-3} cm/sec); Pleistocene silts/clay strata are very low showing approximately 5 m^2/day (Coefficient of Permeability approximately 5 x 10^{-5} cm/sec).

2) Kuchlagh Sub-Basin

The Sub-Basin lays in the the NE-SW direction narrow and long area drained mainly by 3 stream, that is, Surkhab Lora and Bostan Lora flowing from NE to SW and Karonga Lora from south to north.

South-eastern mountain ranges are composed mainly of Mesozoic limestone and Miocene conglomerate and partly of ultrabasic intrusives. While in the case of north-western mountain ranges, the northern is composed of limestone, sandstone, and shale of Eocene to Miocene age, the middle is of silts/clay strata of Pleistocene age, and the southern is of Jurassic system.

Mesozoic group to Neogene system and silts/clay strata of Pleistocene series form the impervious bed of the Sub-Basin. Middle to southern lowland along rivers is composed of impervious valley floor deposit. However the middle to the northern is of Subrecent deposits and Fan deposits from the piedmont up to river banks forming main aquifers in the Sub-Basin.

Specific Yield of Alluviums is more than 20 % along south-eastern piedmont, among them around the apex of alluvial fan of the southern is approximately 25 %. That along the rivers is around 15 % in the northern, and less than 10 % around valley floor in the southern.

Transmissivity is: a little less than 100 to 200 m^2/day along south-eastern piedmont (Coefficient of Permeability 1.5 to 3 x 10^{-3} cm/sec); 300 to 700 m^2/day in middle scale of alluvial fan around Bostan (Coefficient of Permeability 5 x 10^{-3} to 1 x 10^{-2} cm/sec); 20 to 30 m^2/day along the upstream side of river channel (Coefficient of Permeability 6 x 10^{-4} to 1 x 10^{-3} cm/sec), and less than 10 m^2/day in the downstream side (Coefficient of Permeability less than x 10^{-4} cm/sec).

3) Quetta Northern Sub-Basin

The Sub-Basin is drained mainly by Hanna - Urak River and Sariab Lora drainage systems. The former drainage basin is composed almost of Miocene conglomerate and Subrecent deposit around midstream area. While the latter is of Miocene limestone and partly shale. Along the piedmonts, Fan deposits are widely extent in general. Among them, that of Hanna-Urak river system and the south-western piedmont of Sariab Lora system have large scales. Limestones and shales of Mesozoic age form the impervious bed of the Sub-Basin. Fan deposits are forms the excellent groundwater recharging media. However, valley floor deposits are in general rich in low permeable fine material. The surface of valley floor is usually covered with silts/clay of low infiltration capacity.

Specific Yield of Alluvium shows in general more than 20% in the upstream area.

Transmissivity shows relatively large in alluvial fan area, that is, mostly 20 to 80 m^2/day (Coefficient of Permeability 5 x 10^{-4} to 2 x 10^{-4} cm/sec) and partly 100 to 600 m^2/day (Coefficient of Permeability 7 x 10^{-3} to 3 x 10^{-2} cm/sec). However in the valley floor area, it is low showing 4 to 5 m^2/day (Coefficient of Permeability 2 to 3 x 10^{-4} cm/sec).

4) Mastung Sub-Basin

The Sub-Basin is the North to south directing narrow and long valley surrounded by steep mountain ranges mainly composed of limestones. Along the piedmonts, Fan deposits are widely extent in general. Among them, that along eastern and the southern mountain piedmonts have relatively large scale. Besides, sand dune deposits are extent partly.

Basement rocks form the impervious bed of the Sub-Basin. Fan deposits are forms the excellent groundwater recharging media. However, valley floor deposits are in general rich in low permeable fine material. The surface of valley floor is usually covered with silts/clay of low infiltration capacity.

Specific Yield of Alluvium is more than 20 % in the mountain side of the northern, the eastern, and the southern alluvial fan area. That along the eastern Fan front is relatively

small showing approximately 10 %. In the case of valley floor area, it is less than 10 %, and less than 5 % in the center area.
Transmissivity is in the range of a little less than 100 to 250 m^2/day in the northern, the eastern, and the southern alluvial fan area (Coefficient of Permeability 5 - 6 x 10^{-3} cm/sec), approximately 40 m^2/day (Coefficient of Permeability approximately 3 x 10^{-3} cm/sec), and in general very low in the other area, usually less than 10 m^2/day (Coefficient of Permeability 5 x 10^{-5} to 1 x 10^{-4} cm/sec), mostly 2 to 3 m^2/day.

5) Kalat Sub-Basin
Limestone of Eocene age is widely extent in the eastern side of the Sub-Basin. While in the area from the center to the west, mainly Paleozoic to Mesozoic Group and partly Eocene limestone are dispersed. The basement underlying in the lowland may be shale. Along the piedmont, alluvial fan deposits are widely extent, and in the center area of lowland is composed of low permeable valley floor deposits.
Eocene limestone develops fissures and cavities, and forming one of the prominent aquifers in the Sub-Basin springing out at some places. Though Fan deposits are also forming aquifers, their thickness is relatively thin in the eastern side of the Sub-Basin. Valley floor deposits are in general rich in low permeable fine material. The surface of valley floor is usually covered with silts/clay of low infiltration capacity.
Specific Yield of Alluvium showing more than 20 % distribute in the upstream side of the north-eastern to the northern piedmont and the eastern. Especially in the northern area, some part show around 25 %.
Transmissivity is in the range of 15 to 50 m^2/day in the area of valley floor to piedmont (Coefficient of Permeability 2 x 10^{-4} to 4 x 10^{-3} cm/sec). In the case of the aquifer existing in the Eocene limestone, groundwater may be cavities-conduit flow, and transmissivity is very large showing a little less than 100 m^2/day (Coefficient of Permeability approximately 2 x 10^{-2} cm/sec).

6) Patki Shah Nawaz Sub-Basin
The basement rocks in the Sub-Basin are Jurassic Group and limestone and shale of Neogene System in the eastern mountain ranges, and sandstone of Miocene Series in the western ranges directing north to south. Shale may underlie in the lowland. alluvial fan deposits are widely extent along the piedmont, and form aquifers. Valley floors distribute rarely.
Specific Yield of Alluvium is relatively large in the piedmont along the eastern mountain ranges showing usually more than 20 %.
Transmissivity is in the range of 50 to 500 m^2/day in alluvial fan area (Coefficient of Permeability 1 x 10^{-3} to 1 x 10^{-2} cm/sec), and very small in valley floor area showing approximately 3 m^2/day (Coefficient of Permeability 7 x 10^{-5} to 1 x 10^{-2} cm/sec) because of thin strata, though it is difficult to grasp the general distribution tendency on account of shortage of data.

(2) Groundwater

Very important groundwater resources in this Basin are mostly mined from the aquifers in alluvial fan deposits, and partly from subsoil water in the river deposits or from springs out of the fissures and cavities in the limestones of new age mainly in Kalat Sub-Basin situating in the southern part of the Basin.

The distribution pattern of the alluvial deposits as an important groundwater storage basin is in general of following description:

- Piedmont area mainly composed of alluvial fan deposits consists of highly permeable sands/gravels strata forming excellent unconfined aquifers and groundwater recharging capacity.

- The area several kilometers away from mountain foots is composed of the inter-fingering strata of silts/clay and sands/gravel which consist of confined or semi-confined aquifers.

- The proportion of silty/clayey strata is gradually larger as proceeding to the downstream side, and the lower reaches of the valley floor are composed of almost all silty/clayey strata forming impervious barrier like underground dam. The discharge as the groundwater runoff to other sub-basins may be relatively little.

The recovery of water from the aquifer in the area of alluvial fan is carried out mainly by the pumping with tubewells through out the year. In the case of the utilization of subsoil water of river deposits or springs out of rock fissures, etc., it is extracted by karezes which are the traditional methods in the Province as the groundwater intake facilities. So many tubewells have been installed recently in the area, that the excessive pumping has resulted into significant drawdown of groundwater level in the Basin.

According to the groundwater monitoring, recent changes of groundwater levels of Pishin, Quetta Northern, and Mastung Sub-Basins are shown in the following table.

Change of Groundwater Level in Pishin, Quetta Northern and Mastung Sub-Basins

(Unit: m)

Duration	Pishin					Quetta Northern					Mastung		
	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii
85/86~88/89*	-4~-5	-11~-12	-6~-7	-4~-4.5	0~1	-1~-3	-0.2~-0.5	0~-1	-3~-4	0~2	-3~-5	-2~-3	-1~-2
88/89~91/92	-1.9	5~8	5~7	-0.1~1.5	-0.8~1	-2~-3	0~-2	0~-5	-4~-6	0~2	-4~-4.5	-3~-4	0~-1.5
91/92~94/95	-4.9~-5.5	0~4	3~8	-0.2~-0.7	0~0	-4~-7	0~-2	0~-5	-5~-6	0~2	-9~-10	-2~-3	-1~-1.5
Total	-9~-10	-2~-4.5	-5~6	-3~-5	0~2	-10~-14	0~-3	0~-4	-14~-15	0~3	-10~-16	-8~-10	-5~-6

Note:

Pishin
i : Western Foot Slopes
ii : Northern Piedmont
iii : North-Eastern Piedmont
iv : South-Eastern Piedmont
v : Central Valley Floor
* : (Pishin: 75/76~88/89)

Quetta Northern
i : Southern Area
ii : Western Piedmont
iii : Eastern Piedmont
iv : along Hanna-Urak River
v : Central Valley Floor

Mastung
i : Kad Kocha Area
ii : around Pringabad Town
iii : around Mastung Town

As a result of the groundwater monitoring, the areas showing higher drawdown of groundwater have been identified.

In Pishin Sub-Basin, groundwater level changes occur largely around piedmont slope where excellent aquifers are available. However recently, there has been a slight temporary rise in the water table due to stoppage of pumping. This has perhaps happened due to lowering of water table beyond economic exploitation. In order not to be misguided by such temporary and partial changes in ground water levels, 2 years data from 1922/93 to 94/95 were analyzed. Except the northern piedmont area where groundwater level has risen, basin-wides groundwater level per annum during 6 years from 1988/89 to 94/95 showed no significant

variation. The local groundwater level rising may be influenced by delay action dams and so on.

In Quetta Northern Sub-Basin, both eastern and western piedmont areas with Landi and Mian Ghundi as the central point, and the area around Hanna - Urak River to Baleli Gap show large drawdown. Especially in the latter, drawdown is very large at an average of 2 m annually. On the other hand, the groundwater level changes of the central part of the Sub-Basin where the municipal area of Quetta city is located, is very rare.

In Mastung Sub-Basin, relatively large drawdown have been observed in three areas as shown in the above table. Among them, Kad Kocha area shows characteristic drawdown such that it is very remarkable during recent three years at an average of 3 to 4 m annually. Pringabad Town area, it is at an average rate of 1 to 2 m annually, and around Mastung Town area it is around 0.5 m annually. Generally, drawdown of the groundwater level is large around piedmont slopes, and is further extending towards downstream, the less change of groundwater level occurs.

The deficits of the recharge against discharge in the respective sub-basins were computed and the following results were obtained.

- Pishin Sub-Basin
  574 MCM deficit during 13 years from 1975/76 to 88/89 (av. 44 MCM per annum)
  26 MCM deficit during 2 years from 1992/93 to 94/95 (av. 13 MCM per annum)

- Quetta Northern Sub-Basin
  57 MCM deficit during 3 years from 1985/86 to 88/89 (av. 19 MCM per annum)
  63 MCM deficit during 3 years from 1988/89 to 91/92 (av. 21 MCM per annum)
  51 MCM deficit during 3 years from 1991/92 to 94/95 (av. 17 MCM per annum)

- Mastung Sub-Basin
  43 MCM deficit during 3 years from 1985/86 to 88/89 (av. 14 MCM per annum)
  39 MCM deficit during 3 years from 1988/89 to 91/92 (av. 13 MCM per annum)
  65 MCM deficit during 3 years from 1991/92 to 94/95 (av. 22 MCM per annum)

3.3.6 Soils

(1) Characteristics of the Soils

A field survey was conducted by the Study team during the Phase I period. Prior to the field survey, existing soil survey reports were studied in detail. One hundred soil test pits were excavated in the selected locations for detailed morphological description and sampling of different horizon or layers. Soil samples were sent to the National Agricultural Research Centre (NARC) laboratory in Islamabad for physical and chemical analyses.

Soils of the area are formed in five different types of parent material as follows: a) mainly limestone with some shells, b) red clay, silt, sandstone and conglomerates, c) old re-deposited loess, d) limestone, shales and volcanic rocks, and e) shale, sandstone and limestone. The following landforms in each parent material have been formed due to alluvial sorting out and/or decomposition; 1) alluvial fans, 2) piedmont plains, 3) basins, and 4) gently undulating loess plains.

The soils of the area are mainly piedmont alluvium derived from limestone, shales and sandstones. Eight major soil series are found in the area, along with eleven minor soil series. The characteristics of the major soil series are shown as below:

Soil Series in the Study Area

Soil Series	Soil Texture	FAO classification	USDA classification
MAJOR SOIL SERIES			
Barshore	Silt loam & very fine sandy loam	Haplic Yermosols	Typic Camborthids
Pinakai	Loam, very fine sandy loam & silt loam	Haplic Yermosols	Typic Camborthids
Pishin	Fine sandy loam and sandy loam	Haplic Yermosols	Typic Camborthids
Pringabad	Very fine sandy loam	Haplic Yermosols	Xerollic Camborthids
Sariab	Loam & silt loam	Haplic Yermosols	Typic Camborthids
Shabak	Gravely clay loam	Calcic Serosols	Xerollic Calciorthids
Shomozai	Silt loam, loam & very fine sandy loam	Haplic Yermosols	Typic Camborthids
Zard	Silt loam and very fine sandy loam	Haplic Yermosols	Typic Camborthids
MINOR SOIL SEREIES			
Azam	Silty clay and clay	Haplic Yermosols	Typic Camborthids
Chiltan	Gravely loam	Haplic Yermosols	Typic Camborthids
Ghaza	Silty clay loam & clay loam	Orthic Solonchake	Salorthids
Hathiara	Silt loam and very fine sandy loam	Haplic Yermosols	Typic Eutrochrepts
Injira	Gravely loam	Haplic Yermosols	Xerollic Camborthids
Kaftari	Silt loam and very fine sandy loam	Haplic Yermosols	Typic Eutrochrepts
Lajwar	Silty clay loam & clay loam	Haplic Yermosols	Typic Camborthids
Maslakh	Gravely clay loam	Calcic Serosols	Xerollic Calciorthids
Quetta	Silty clay loam & clay loam	Haplic Yermosols	Typic Camborthids
Taleri	Loam and very fine sandy loam	Haplic Yermosols	Typic Camborthids
Toba	Gravely clay loam	Calcic Serosols	Xerollic Calciorthids

The soil analysis data reveals that the soil texture varies from loamy sand to silty clay, however, most of soils in the area have silt loam texture. Majority of the soils have organic matter content between 0.2 to 0.4 %. The soil pH in the area ranges from 7.5 to 8.5, which shows availability of phosphorus, iron, manganese, zinc and boron will not be affected. The soils are mostly non saline or very slightly saline. The salinity is not a severe problem in most of the surveyed area. Total nitrogen is very poor ranging from 0.001 to 0.1%. Especially, the un-cultivated soils have extremely low. Plant available phosphorous is low to very low, which decreased with profile depth.

(2) Land Capability

Land capability of the area was estimated with and without irrigation conditions. Land capability class is shown as below;

Class I	Very good agricultural land
Class II	Good agricultural land
Class III	Moderate agricultural land
Class IV	Poor (marginal) agricultural land
Class VI	Land with fair grazing or wood land potential
Class VII	Land with poor grazing or wood land potential
Class VIII	Agriculturally unproductive land

Class I has the least limitation for agricultural use, and relatively little effort is required to produce high yields of wide range of crops. The suitability decreases gradually in accordance with increase in class number. Class IV is recognized as agriculturally unproductive. No irrigation is assumed in class VI to VIII. Land capability of the major soils are classified accordingly and the extent of summarized as follows:

Land Capability Class

Class	Quetta/Pishin/Qila Abdullah	Mastung/Kalat	Total
Class 1	36,500 (2.6 %)	56,500 (4.5 %)	93,000 (3.6 %)
Class 2	33,200 (2.4 %)	67,000 (5.4 %)	100,200 (3.8 %)
Class 3	64,200 (4.7 %)	18,100 (1.4 %)	82,300 (3.1 %)
Class 4	17,700 (1.3 %)	40,300 (3.2 %)	58,000 (2.2 %)
Class 6	126,500 (9.2 %)	313,900 (25.1 %)	440,400 (16.8 %)
Class 7	1,058,200 (76.9 %)	601,000 (48.0 %)	1,659,200 (63.1 %)
Class 8	40,100 (2.9 %)	154,900 (12.4 %)	195,000 (7.4 %)

Crop suitability classification is a method of rating soils in terms of their relative suitability for the sustained production of specified crops. Sustained production does not necessary mean that the same crop should be produced on the same piece of land year after year. In most cases, the crop should be produced in rotation with other crops. The ratings are called crop suitability classes and range from Class 1 (S1) for the most suitable soils to Class 4 (NS) for the least suitable. Crop suitability of the major soils are shown in the following table.

Soil Series	Crop Suitability									
	Under Irrigation	Without Irrigation		Rabi Crop			Kharif Crop			Fruit
		Dry Farming	Grazing	Wheat Barley	Berseem	Vege	Maize Melon Tobacco	Vege	Lucern	Apple Appricot Grape Almond
MAJOR SOIL SERIES										
Bashore	irIIs	dIVc	VIIc	1	1	1	1	1	1	1
Pinakai	irI	-	VIIc	1	1	1	1	1	1	1
Pishin	irIIs	-	VIIc	2	2	2	2	1	2	1
Pringabad	irI	dIVc	VIIc	1	1	1	1	1	1	1
Sariab	irI	dIVc	VIIc	1	1	1	1	1	1	1
Shabak	-	-	VIIc	NS	NS	NS	NS	NS	NS	NS
Shomozai	irI	dIVc	VIIc	1	1	1	1	1	1	1
Zard	irI	dIVc	-	1	1	1	1	1	1	1
MINOR SOIL SERIES										
Azam	irIIs	-	VIIc	2	1	2	2	2	1	2
Chiltan	-	-	VIIc	NS	NS	NS	NS	NS	NS	NS
Ghaza	irIIIa	-	VIIIa	3	3	4	4	4	3	4
Hathiara	irI	dIVc	-	1	1	1	1	1	1	1
Ingera	-	-	VIIc	NS	NS	NS	NS	NS	NS	NS
Kaftari	irI	dIVc	-	1	1	1	1	1	1	1
Lajwar	irI	-	VIIc	1	1	1	1	1	1	1
Maslakh	-	-	VIIc	NS	NS	NS	NS	NS	NS	NS
Quetta	irI	dIVc	VIIc	1	1	1	1	1	1	1
Taleri	irIIs	-	VIIc	2	2	2	2	2	2	2
Toba	-	-	VIIc	NS	NS	NS	NS	NS	NS	NS

Notes: ir = under irrigation, d = under dry farming. s = soil restricted in use due to shallow soil depth, stoniness, slow or rapid permeability. a = soils restricted in use due to salinity or alkalinity. c = soils restricted in use due to unfavorable climate.

3.4 Rural Infrastructures

(1) Domestic water supply and sanitation

In Balochistan the rural water supply coverage has been nearly 45 % as of 1993 compared to the national average of 48 %. On the other side, sanitation coverage in rural area remains still 10% compared to the national average of 14 %. It is estimated that the urban water supply in Balochistan extends to nearly 90 % of the urban population, and sanitation coverage is about 50 %. However this figures conceal the quality of service. Because, for instance, the water supply service varies from piped household connections to community taps. Groundwater is a source for about 80 % of all existing water supply schemes.

In the five districts including the Study Area, most of water sources of public rural water supply are tubewell as in all of the Province, while there is no water supply scheme which utilizes dam reservoirs or river streams. In the rural areas of five districts, there are 218 piped water supply systems and 577 community water tanks. Water consumption ratio in rural area is about 83 % for households, 7 % for industries and 10 % for other purposes.

(2) Electricity

In 1977, Balochistan was connected with the National Grid through a 272 km of 220 KV high voltage transmission line from Guddu (Sind Province) to Sibi, and 163 km of 132 KV double circuit transmission line was linked from Sibi to the existing 75 MW power station of Quetta in 1979. These power generation capacities are total of about 240 MW. In addition, 19 separate diesel mini grids (generating average 1 MW) have been established in various areas. At present the total length of lines and number of grid stations by KV in Balochistan is shown below:

Electric Supply in Balochistan

Voltage	Transmission Lines (km)	Grid Stations (Nos) *	Distribution Lines (km)
220 KV	272	1	-
132 KV	1,283	27	-
66 KV	291	7	-
33 KV	624	13	-
11 KV	-	-	7,580
0.4 KV	-	-	3,383
Total	2,424	47	10,963

Note: * excluding diesel mini grids stations.
Source: WAPDA Power Wing, Quetta

There are the great number of small and scattered villages and settlements in Balochistan. Therefore, despite considerable increase of electric facilities, rural electrification is still insufficient as shown in following table, though the electrification rate in the Study Area is a little higher.

Electrification in the Study Area

	Main Villages	Sub Villages	Total	Electrified Villages	Percentage
Study Area	1,383	1,407	2,790	926	33.2%
Balochistan	5,596	7,127	12,723	2,488	19.6%

Source: WAPDA power wing, Quetta ,1995

The per capita consumption of electricity in the Province is about 240 KWHs. A major problem is the big arrears of payment, especially for agricultural consumers (for tubewells) whose average annual non-collection payments reportedly come up to about 46%, or more than Rs 80,000 per consumer per annum.

(3) Roads and transportation

Though Balochistan accounts for 43.6% of the land area of Pakistan, total length of roads is only 19 % of total road length in the country. The road density 0.09 is very low compared to average 0.21 of Pakistan. Only 23.3% is high type (paved) roads compared to 52 % of

Pakistan. Total length of the roads in Balochistan is about 21,700 km in 1955 in which about 2,600 km is National highway, 1,700 km is Central Importance road, and 17,400 km is Provincial road. The road length by type in the Study Area is as follows:

Roads in the Study Area

(km)

Type	Quetta	Qila Abdullah	Pishin	Mastung	Kalat	Total
National Highway	45	64	162	80	112	463
Central Importance Road*	100	476	0	0	0	576
Provincial Road	552	697	1,557	252	558	3,616
Total	697	1,237	1,719	332	670	4,655

Source: Communication and Works Department, Balochistan, 1994-95
* Roads for Defense on the National Border

Almost all National highway is paved, but in the Provincial road, only 11 % is paved. Road density of Quetta District is considerably high, while that of Kalat and Mastung Districts is very low. Besides these, there are lots of local roads that are passable in fair weather and neither controlled by governments nor reported about current conditions. However, these informal roads practically play the important role for access to remote villages.

(4) Education facilities

In Balochistan, the education facilities have increased a little in recent years. There are 8,011 primary schools, 623 middle schools, 332 high schools, 44 intermediate and degree collages as of 1995. 1,762 primary schools, 166 middle schools, 109 high schools and 16 collages are located in the Study Area. In addition, there are some private schools, Federal Government schools, and Mosque schools.

Number of enrollment of primary schools in Balochistan amounts to about 520,000 out of which 71 % is for male and 29 % is for female. In the Study Area, number of enrollment of primary schools is about 194,000 out of which 67 % is male and 33 % is female. Number of enrollment of middle schools is about 90,000 in the Province and about 33,000 in the Study Area, and for high schools it is about 36,000 and about 11,000, respectively.

Number of teaching staff is about 19,500 in primary schools, 6,200 in middle schools and 2,700 in high schools in the whole Province. In the Study Area, these are 5,700, 1,600 and 1,100 teaching staff, respectively.

According to above figures, it is computed that the number of average enrollment per school is 110 for primary school, 200 for middle school and 100 for high school in the Study Area. The number of average teaching staff per school is 3.2 for primary school, 9.6 for middle school and 10 for high school. Number of average students per teacher is, therefore, 34 in primary school, 21 in middle school and 10 in high school. Most of primary schools are shelterless or

dilapidated and basic facilities such as water supply, sanitation, electricity, furnishing, text books, training materials, etc., is quite scanty.

(5) Health facilities

In 1995, there are 40 hospitals with 2,560 beds, 539 dispensaries with 40 beds and 46 rural health centres (R.H.C.s) with 470 beds in Balochistan. Besides these, 459 basic health units (BHUs), 78 municipal committee health centres (MCH centres), and 18 tuberculosis clinics (T.B. clinics) are established as of 1993. Out of total of about 1,200 health outlets, about 1,050 outlets are the public sector, while private sectors are very small, poor and located all in Quetta City. Generally these health sectors have inadequate facilities as well as insufficient medical services. In the Study Area there are 10 hospitals with 1,540 beds, 95 dispensaries with 10 beds and 9 B.H.C.s with 90 beds are located. Recently the numbers of health facilities have not been increased.

Number of doctors is about 900 in the Province and 453 in the Study Area. Number of nurses is only 251 in the Province, out of which 240 is in the Study Area, mostly in Quetta. Besides these, total of 164 lady health visitors (L.H.V.s) and 697 midwives are working in the Province. Seventy-seven L. H. V.s and 160 midwives are in the Study Area. According to above figures, the number of staff for health services per 1,000 inhabitants is estimated at 0.3 doctors, 0.1 nurses and 0.5 the other health workers in the Study Area.

The locations of health service outlets are often inadequate and the distribution of health facilities is not equitable between districts. In Eighth Five Year Plan, it is emphasized that the highly centralized nature of health service organization needs to be corrected through a process of decentralization, and additional services should be provided in view of equalizing provision with respect to size of population between districts.

3.5 Agriculture

3.5.1 Farm Size Distribution and Land Tenure

According to the Agricultural Census in 1990, total farm area, total cultivated area, total number of farms and average acreage of the farms are 357,619 ha, 209,239 ha, 47,931, and 7.5 ha, respectively in the Study Area. The census also shows merely 8 % of large scale farmers with more than 20 ha farms occupy some 42 % of the total farm area. On the other hand, about 60 % of the total farms is held by small farmers with less than 5 ha farms, while these farmers cultivate only 19 % of the total farm area.

Farm Size Distribution in the Study Area

Size of Farm	< 1ha	1 - 5ha	5 - 10ha	10 - 20ha	> 20ha	Total
Number of Farms	5,508	23,496	8.942	6,036	3,949	47,931
(%)	11.5	49.0	18.7	12.6	8.2	100
Cultivated Area (ha)	2,517	44,102	37,400	46,421	78,799	209,239
(%)	1.2	21.1	17.9	22.2	37.6	100
Farm Area (ha)	3,053	64,452	62,763	77,908	149,443	357,619
(%)	0.9	18.0	17.6	21.8	41.8	100
Average (ha/Farm)	0.6	2.7	7.0	12.9	37.8	7.5

Source: Agricultural Census 1990, Agricultural Census Organization.

Three different land tenure systems exist in the area as follows:

1) Owner Occupier

Owner occupiers are farmers who have their own land and cultivate it by themselves, mostly using family labour and occasionally engaging casual or daily wage labour.

2) Owner-cum-tenant

This category includes small farm owners who cultivate their own lands, and also lease other owners' land on a share basis.

3) Tenant

Tenants are further divided into two categories, occupancy tenant (Lathband Bazgar) and tenant at will (Tab-e-Marzi), and they are described below.

Occupancy Tenant (Lathband Bazgar)

A tenant who has permanent and heredity occupancy rights based on the Tenancy Act. Under the agreement, the tenant bears all expenses, such as labours and other agricultural inputs. The owner gets 1/6 share of crop production. The tenant can not be deprived from the land.

Tenant at will (Tab-e-Marzi)

A tenant who has not any permanent rights and can be ejected at any time from the land that he cultivates. The owner is responsible to provide all necessary inputs and production costs. The tenant works on the land and receives a fixed share (1/3 share of crop production). Generally, medium and large farmers engage tenant-at-will.

According to the Agricultural Census, number of owners, owner-cum-tenants and tenants are 86.3 %, 8.4 % and 5.3 %, respectively in the Study Area.

Land Tenure in the Study Area

LAND TENURE	Owner	Owner-cum-Tenant	Tenant	Total
Number of Farms	41,380	4,021	2,534	47,931
(%)	86.3	8.4	5.3	
Farm Area (ha)	291,709	52,550	13,551	357,619
(%)	81.5	14.7	3.8	

Source : Agricultural Census 1990, Agricultural Census Organization.

3.5.2 Land Use

The present land use in the Study Area is summarized as follows. Figures are the average taken from the Agricultural Statistics for the years 1990/91 to 1994/95.

Present Land Use in the Study Area

(Unit: ha)

DISTRICT	Quetta	Pishin	Kalat	TOTAL
Geographical Area	265,287	1,111,159	1,251,733	2,628,179
Reported Area (1)=(2)+(3)	139,857	265,514	956,332	1,361,703
Cultivated Area (2)	38,559	96,015	125,495	260,069
Irrigated Area	10,746	34,591	45,638	90,975
Un-irrigated Area	598	13,786	17,206	31,590
Current Fallow	27,215	47,638	62,651	137,504
Un-cultivated Area (3)	101,288	169,485	830,079	1,100,852
Cultivable Waste	40,347	14,270	191,789	246,406
Forest	39,088	73,065	63,181	175,334
N.A. for Cultivation	21,853	82,150	575,109	679,112

Source : Agricultural Statistics 1990/91 - 1994/95, Department of Agriculture, Balochistan.
("Pishin" includes Qila Abdullah District, and "Kalat" includes Mastung District.)

The table shows cultivated area which covers 9.9 % (260,069 ha) of the total area. The figure does not agree to the result of Agricultural Census 1990, which is due to the difference in survey method or survey year. Among the cultivated area, some 47 % (122,565 ha) is under cultivation, while the rest of 53 % remains fallow land.

Remarkable change in the cultivated area is increasing the extent of the irrigated area during these 5 years in the Study Area. The area irrigated was 71,083 ha in 1990/91, which increased by 46 % and reached to 105,946 ha in 1994/95. Tremendous increase occurred especially in Kalat District, where the irrigated area increased by 54 % in these 5 years, followed by Pishin (47 %) and Quetta (35 %) Districts. This increase is mainly due to the expansion of fruits growing area, which was increased by 120 %, from 13,575 ha (1990/91) to 29,890 ha (1994/95). Historical change in the expansion of the irrigated area is shown as follows:

Historical Change in Irrigated Area in the Study Area

District	1974/75 (ha)	1979/80 (ha)	1984/85 (ha)	1989/90 (ha)	1994/95 (ha)
Quetta	6,889	8,087	7,738	8,718	12,138
	(100)	(117)	(112)	(127)	(176)
Pishin	12,534	18,986	22,853	26,224	40,730
	(100)	(151)	(182)	(209)	(325)
Kalat	11,204	14,737	25,569	33,674	53,078
	(100)	(132)	(228)	(301)	(474)
Total	30,627	41,810	56,160	68,616	105,946
	(100)	(137)	(183)	(224)	(346)

Source : Agricultural Statistics, Agriculture Department of Balochistan.

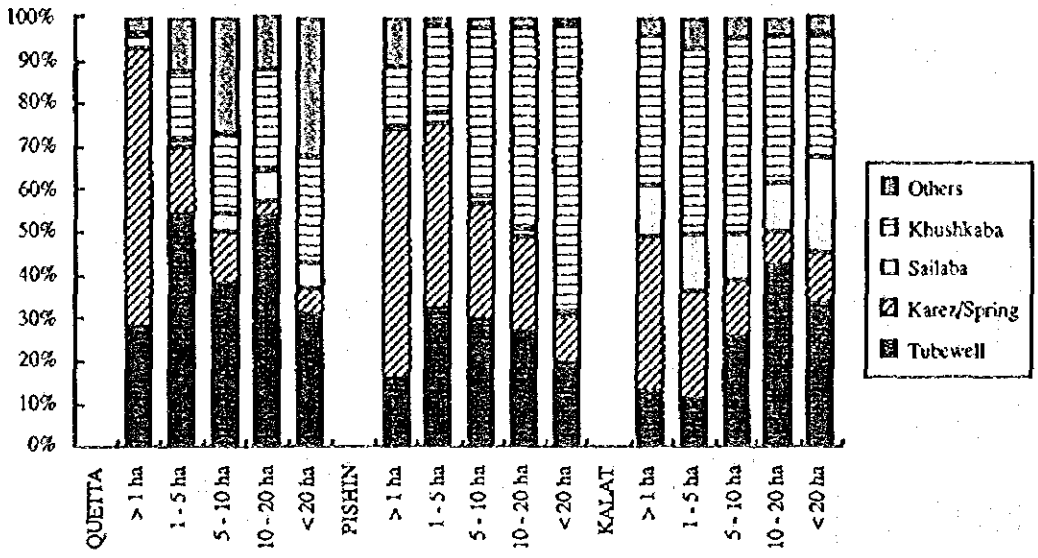
Share of different irrigation status by size of farm is shown as follows. The table indicates that small farmers with less than 1ha farms have the highest share of irrigated area, where is mainly irrigated by karez followed by tubewells. Larger farmers tend to have higher share of un-irrigated area, where is sailaba or khushkaba area.

Irrigation Status in the Study Area

(Unit: ha, %)

Farm Size	< 1ha	1 - 5ha	5 - 10ha	10 - 20ha	> 20ha	Total
Quetta						
Tubewell	45 (27)	849 (54)	576 (38)	1,439(54)	2,482 (31)	5,391
Karez/Spring	107 (64)	239 (16)	(12)	100 (4)	455 (6)	1,083
Sailaba	1(0.6)	32 (2)	67 (4)	194 (7)	500 (6)	794
Khushkaba	6 (3)	245 (16)	276 (18)	632(24)	2,019 (25)	3,178
Others	6 (3)	193 (12)	419 (28)	324(13)	2,590 (31)	3,531
Pishin						
Tubewell	198 (16)	6,360 (32)	3,897 (30)	3,111(26)	4,954 (26)	18,520
Karez/Spring	713 (57)	8,528 (43)	3,506 (27)	2,629(22)	2,715 (22)	18,091
Sailaba	11 (1)	347 (2)	279 (2)	232 (2)	309 (1)	1,177
Khushkaba	166 (13)	3,967 (20)	5,075 (39)	5,504(47)	17,091 (67)	31,803
Others	146 (11)	477 (2)	367 (3)	300 (2)	407 (1)	1,700
Kalat						
Tubewell	145 (13)	2,575 (11)	5,698 (25)	13,533(42)	14,844 (33)	36,794
Karez/Spring	403 (36)	5,707 (25)	3,103 (13)	2,395 (8)	5,567 (13)	17,176
Sailaba	135 (12)	2,979 (13)	10,445 (11)	3,688(12)	10,202 (23)	19,446
Khushkaba	387 (35)	9,888 (43)	10,445 (46)	10,955(34)	13,067 (29)	44,742
Others	49 (4)	1,712 (8)	1,067 (4)	1,385 (5)	1,596 (4)	5,809

Source : Agricultural Census 1990, Agricultural Census Organization.



Share of Different Irrigation Status by Size of Farm

3.5.3 Crops and Cropping Pattern

The cropping calendar in the Study Area is divided into two characteristic crop seasons, Rabi (winter) and Kharif (summer). Cropped lands consist of irrigated area and un-irrigated area. The sources of irrigation are tubewell, well, karez and others. The un-irrigated area is depending upon unreliable water resource, unpredictable rainfall and flood water.

The most important cash crops in the Study Area are fruit crops such as apple, apricot and grapes, which are only grown in the irrigated area. Major irrigated winter crops are wheat, cumin, vegetables and fodder. Summer crops include sorghum, maize, onion, potato, other vegetables and melon in the irrigated area. On the other hand, wheat, barley and cumin are important winter crops in the un-irrigated area. Un-irrigated summer crops are only melon and some fodder.

The present cropping calendar for major crops in the area is shown as follows:

Present Cropping Calendar for Major Crops

CROP	SOWING	HARVESTING
RABI CROPS		
Wheat	October - December	May - June
Barley	October - December	May - June
Cumin	February	May
Vegetables	October - January	May - June
Fodder		
Alfalfa	November - February	May (1st harvest)
Berseem	October - November	December - May
KHARIF CROPS		
Fruits		
Apple	February - March	September - November
Apricot	February - March	May - July
Grape	February - March	September - October
Onion	February	September -October
Potato	April - May	August
Vegetables	April - May	June - July
Melon	April	June - August
Fodder		
Maize	April - May	July - September
Sorghum	May	June - July
Millet	May	August
Tobacco	April - May	September

Source : Agriculture Department of Balochistan.

Crop rotation is recommended by the Agriculture Department such as wheat-fallow-wheat, wheat-fallow-vegetables, or onion-cumin-tomato, and some farmers have practiced the rotation. However, the availability of irrigation water is one of the largest limiting factor to the ideal crop rotation. Wheat, fodder and vegetables are inter-cropped with orchard especially in non-bearing orchard gardens.

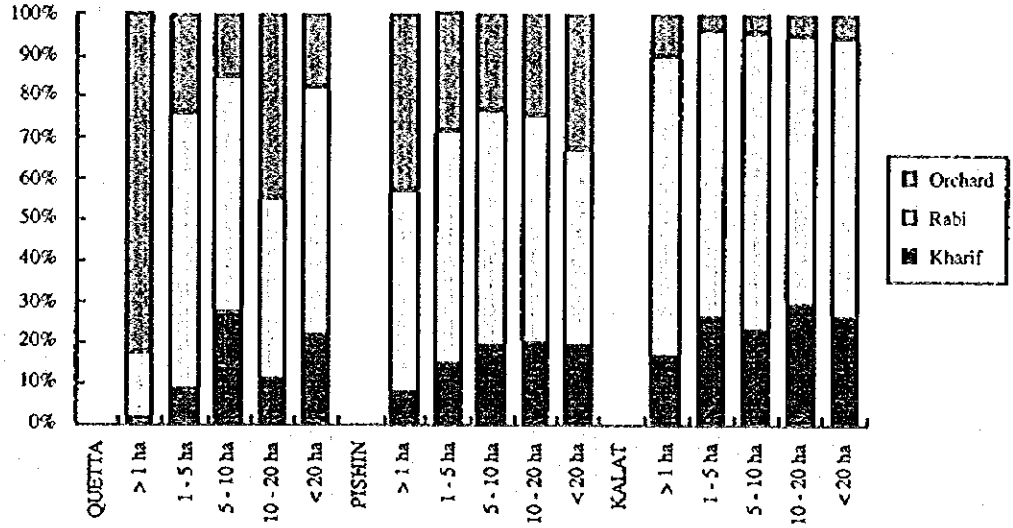
The annual cropped area and overall cropping intensity in the Study Area are summarized below.

Annual Cropped and Cropping Intensity in the Study Area

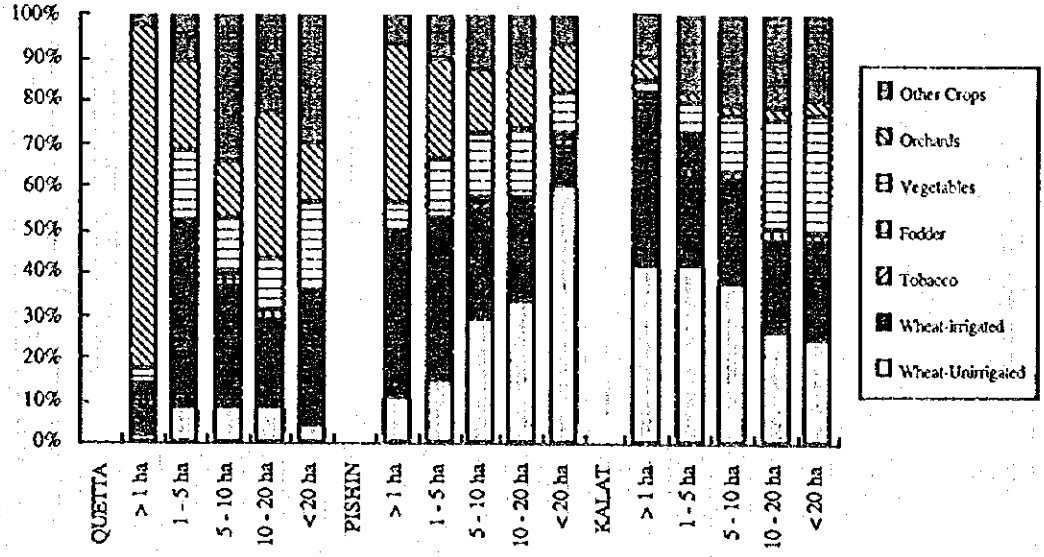
Crop	Irrigated Area		Un-irrigated Area		Total	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
RABI CROPS						
Wheat	33,219	35.6	22,655	12.7	55,874	20.6
Barley	3,837	4.1	2,498	1.4	6,335	2.3
Cumin	3,419	3.7	3,149	1.8	6,568	2.4
Vegetables	1,008	1.1	3	0.0	1,011	0.4
Fodder	4,400	4.7	1,970	1.1	6,370	2.3
Sub-total (1)	45,883	49.2	30,275	17.0	76,158	28.1
KHARIF CROPS						
Fruits	22,147	23.7	0	0.0	22,147	8.2
Onion	7,342	7.9	0	0.0	7,342	2.7
Potato	4,171	4.5	0	0.0	4,171	1.5
Vegetables	3,575	3.8	0	0.0	3,575	1.3
Melon	4,452	4.8	1,036	0.6	5,488	2.0
Fodder	1,709	1.8	230	0.1	1,939	0.7
Tobacco	1,647	1.8	0	0.0	1,647	0.6
Others	48	0.1	47	0.1	95	
Sub-total (2)	45,091	48.3	1,313	0.8	46,404	17.1
Total (1+2)	90,975	97.5	31,590	17.8	122,565	45.1
Total Cultivated Area	93,323		178,170		271,493	

Source : Agricultural Statistics, Agriculture Department of Balochistan.
(Figures are the average of 5 years data from 1990/91 to 1994/95.)

Following figures show the share of different crops in total cropped area by size of farm and the share of cropped area by crop season and by size of farm. The data is based on 1990 Agricultural Census. It is clear that orchard is most dominant in small farmers with less than 1ha farms in Quetta and Pishin Districts, and larger farmers have higher share of vegetable cropped area. In addition, wheat, both irrigated and un-irrigated, is important crop especially in Pishin and Kalat Districts. It is notable that large scale vegetable production (mainly onion and potato) is prevailing in Kalat District.



Share of Cropped Area by Crop Season and by Size of Farm



Share of Different Crops in Total Cropped Area by Size of Farm

3.5.4 Crop Yield and Production

Average unit yield of major crops is calculated based on the Agricultural Statistics. The unit yield of the crops in the Study Area is summarized as follows:

Unit Yield of Major Crops in the Study Area

(Unit : ton / ha)

Crop	Irrigated	Un-irrigated	Average
RABI CROPS			
Wheat	2.51	1.13	1.95
Barley	1.77	1.22	1.50
Cumin	0.66	0.46	0.56
Vegetables	15.96	-	15.90
Fodder	22.58	11.02	19.01
KHARIF CROPS			
Fruits	10.97	-	10.97
Apple	15.50	-	15.50
Apricot	18.78	-	18.78
Grape	11.07	-	11.07
Onion	21.92	-	21.92
Potato	15.37	-	15.37
Vegetables	13.83	-	13.83
Melon	17.91	10.22	16.46
Fodder	56.40	20.02	52.09
Tobacco	1.69	-	1.69

Source : Agricultural Statistics, Agriculture Department of Balochistan.

On the other hand, results of yield trial of major crops of the area are shown below. Those figures are obtained in experimental stations such as Agriculture Research Institute (ARI) and Deciduous Fruit Development Centre (DFDC), and are expected as maximum yields in the area.

Results of Yield Trial of Major Crops

Crop	Variety	Yield (ton/ha)	Source	Remarks
Wheat	PAK-81	5.3	ARI	Variety Trial; NPK=145-85-0 kg/ha
	Zarghoon-79	5.5		- do -
	K.Noor	5.9		- do -
	Sarhad-87	6.2		- do -
	Zamindar-80	6.4		- do -
Onion	Local Pink	35.8	ARI	Fertilizer Trial; NPK=150-100-100 kg/ha
		30.7		- do -
		29.6		Fertilizer Trial; NPK=100-50-0 kg/ha
		26.7		- do -
	Local	36.0		Spacing Trial; NPK=150-75-75 kg/ha
	Local	41.1		Weed Control; NPK=150-75-75 kg/ha
Potato	Local	39.1	ARI	Fertilizer Trial; NPK=175-125-125 kg/ha
		35.9		- do -
		26.8		Fertilizer Trial; NPK=125-75-0 kg/ha
		24.6		- do -
	Patrones	17.4	ARI	Variety Trial
	Diamont	16.5		- do -
Lucerne	8/9 (fresh)	80.6	ARI	Fertilizer Trial; NPK=30-100-0 kg/ha
	8/9 (dry matter)	19.5		Fertilizer Trial; NPK=60-150-0 kg/ha
	Kandhari (fresh)	74.6		Fertilizer Trial; NPK=30-100-0 kg/ha
	Kandhari (dry)	19.1		Fertilizer Trial; NPK=30-30-0 kg/ha
	8/9 (fresh)	40.0	ARI	Variety Trial
	Sundor (fresh)	46.3		- do -
Apple	Red Delicious	30.0	DFDC	Variety Trial
	Katja	35.0		- do -
	Golden Delicious	45.0		- do -
Apricot	Charmaghg	20.0	DFDC	Variety Trial
	Sardai	15.0		- do -
Grape	Kishmish	20.0	DFDC	Variety Trial
	Haita	15.0		- do -

Annual crop production of major crops in the Study Area is calculated based on the 5 years average from 1990/91 to 1994/95, and shown below:

Annual Production of Major Crops in the Study Area

(Unit : ton)

District	Quetta		Pishin		Kalat		TOTAL	
	Irri.	*Un-irri.*	*Irri.*	*Un-irri.*	*Irri.*	*Un-irri.*	*Irri.*	*Un-irri.*
RABI CROPS								
Wheat	5,774	642	34,800	13,526	42,690	11,204	83,264	25,372
Barley	318	-	1,738	1,006	4,498	2,075	6,554	3,081
Cumin	83	-	547	175	1,621	1,289	2,251	1,465
Vegetables	4,602	-	5,649	-	5,853	2	16,104	2
Fodder	4,100	-	8,694	-	86,562	21,726	99,356	21,726
KHARIF CROPS								
Fruits	60,208	-	113,140	-	68,251	-	241,599	-
Apple	30,007	-	62,265	-	34,648	-	126,920	-
Apricot	8,411	-	19,811	-	9,140	-	37,362	-
Grape	8,711	-	15,564	-	4,261	-	28,536	-
Onion	6,318	-	5,040	-	150,266	-	161,624	-
Potato	1,132	-	27,088	-	35,558	-	63,778	-
Vegetables	16,452	-	21,502	-	11,528	-	49,482	-
Melon	10,842	136	62,162	4,750	6,700	5,708	79,704	10,594
Fodder	15,656	-	29,198	1,176	51,544	3,410	96,398	4,586
Tobacco	-	-	2,784	-	-	-	2,784	-

Source : Agricultural Statistics, Agriculture Department of Balochistan.
("Pishin" includes Qila Abdullah District, and "Kalat" includes Mastung District.)

3.5.5 Farming Practice and Farm Inputs

The present cultivated lands are closely related to topographic and soil conditions along with availability of water. According to the 5 years average (1990/91-1994/95) of the Agricultural Statistics, some 74% (90,975 ha) of the cropped area is irrigated, and the rest of 26% (31,590 ha) remains un-irrigated in the Study Area. The extent of un-irrigated area, however, depends upon availability of water from year to year. Major sources of irrigation are tubewells (89%), karez & spring (9%), and wells (1%) in the irrigated area.

There are two types of farming system in the un-irrigated area, Khushkaba and Sailaba. Khushkaba is a rainfed agriculture system in which the field receives moisture directly from rainfall or from localized run off. Sailaba is a flood water irrigation system, which is based on the diverted torrent water into bunded fields. Average yields are low under these systems, and often fields are not planted due to water deficiency. Khushkaba is more dominant than Sailaba in the Study Area, although it is difficult to differentiate areas covered by these two systems so far.

Major characteristics of agricultural production in the Study Area is described district-wise as follows:

Quetta District:
Major irrigated crops of the area are orchard, wheat and Kharif vegetables. Total cropped area is less comparing to other districts in the Study Area. Most of the cropped area is irrigated, which is also major characteristics of the area,

although other districts have huge acreage of un-irrigated land (mainly Khushkaba land).

Pishin and Qila Abdullah Districts:

Wheat is dominant in the area, followed by orchard as irrigated crops. Tobacco is also grown in the area. Most important rainfed crop is wheat, which acreage is almost same as the irrigated wheat.

Kalat and Mastung Districts:

Farmers do grow orchard in the area as well, however, most important cash crops of the area are onion and wheat. Fodder is also important reflecting larger number of livestock population in the area. Un-irrigated crops are wheat, barley, cumin and melon.

Fertilizer application can increase the yield of many crops, although the farmers are applying fertilizers mostly to the high value crops such as fruits and some vegetables. The fertilizer amount used is usually lower than the recommended doses. Fertilizer are not used in the un-irrigated area. Plant protection is also an important measure to enhance crop yields. At present the farmers use pesticides preferably on orchards and vegetables, while seed treatment, mechanical and manual weed control measures are undertaken on a very minor scale. Recommended dosage of farm inputs and labour requirement are shown as follows:

Recommended Dosage of Farm Inputs and Labor Inputs

(Per ha)

ITEM	UNIT	WHEAT		APPLE	ONION	POTATO	MELON	CUMIN
		Irri.	Un-irri.					
A. FARM INPUT								
1. Seeds	kg	100 - 125	87.5	-	15 - 20	2500-3250	5 - 6	15
2. FYM / Compost	ton	12.5 - 25	12.5	25 kg/plant	25	25	-	-
3. Fertilizer								
- Urea (N = 46%)	kg	115	30	5 kg NPK	115	180	75	30
- TSP (P = 46%)	kg	115	57.5	- do -	115	180	75	57.5
- SOP (K = 50%)	kg	62.5	-	- do -	62.5	62.5	-	-
4. Agro-Chemicals								
- Insecticide	kg	seed treatment		4-6 sprays	2 sprays	4 sprays	4 sprays	seed treatment
- Pesticide	litter	- do -	- do -	- do -	- do -	- do -	- do -	- do
B. MACHINERY AND ANIMAL POWER REQUIREMENT								
- Land Preparation	hours	17.5	10.0	10.0	10.0	10.0	10.0	7.5
- Drill for Sowing	hours	2.5	2.5					
- Threshing by Tractor	hours	5.0	5.0					
C. LABOUR								
1. Land Preparation	man-day	15	-	20	25	37.5	37.5	15
2. Nursery / Sowing	man-day	-	-	50	5	-	-	-
3. T.planting / Sowing	man-day	5	5	10	5	25	5	5
4. Fertilizer Application	man-day	5	-	5	5	5	-	-
5. Weeding	man-day	5	-	50	150	150	25	50
6. Water Management	man-day	30	-	45	120	100	30	15
7. Harvesting	man-day	25	25	50	100	100	75	50
8. Threshing, others	man-day	15	15	-	-	-	-	15

Note : FYM = Farm Yard Manure

According to the Agricultural Census, the percentage of the farmers applying fertilizer to their growing crops is:

22 % for the farmers using both of chemical fertilizers and manure,

5 % for the farmers using exclusively chemical fertilizers,

12 % for the farmers using only manure, and

61 % for the farmers not using any fertilizers.

The ratio of the farmers applying agro-chemicals to protect their plants is 29 % on average that is higher than 18 % of provincial average.

The percentage of the farmers using only tractor for cultivation is about 47 %, the ones using both of tractor and draught animal is 31 %, and the ones using only draught animal is 22 %. In Pishin and Quetta Districts, mechanization of farming is well advanced, while in Kalat and Mastung Districts, about 40 % of the farmers do not use tractors.

3.5.6 Livestock

Balochistan is the largest province of Pakistan in area, which mainly consists of mountainous ranges, plains and deserts. The Province receives very little rainfall and majority of the area consists of sparsely vegetated rangelands. Therefore livestock raising is very important and the Province is rich in livestock resources. According to the livestock census of 1986, it maintains 11.1 million heads of sheep and 7.3 million goats and these figures represents 48 % and 24 % of the national population, respectively. There are 1.2 million cattle, 6.0 million poultry and 0.75 million other livestock. The population of livestock in the Study Area is shown as below:

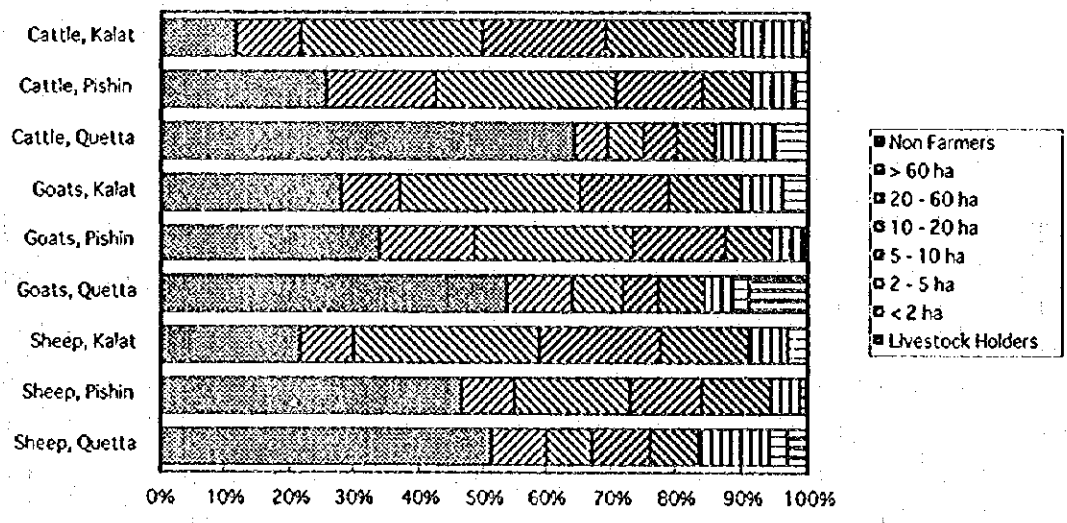
Population of Livestock in the Study Area

District	Quetta	Pishin	Kalat
Cattle	5,715	55,988	24,742
Buffalo	5,015	4,305	213
Sheep	90,272	749,702	1,219,872
Goat	47,083	560,636	638,6923
Camel	1,608	7,398	27,007
Horse	151	3,152	129
Donkey	2,143	27,419	23,291
Mule	66	1,154	40
Poultry	279,222	373,708	246,866

Source : Agricultural Census 1990, Agricultural Census Organization.
("Pishin" includes Qila Abdullah District, and "Kalat" includes Mastung District.)

According to the agricultural census, the ratio of total heads of cattle, sheep and goats in the Study Area is 9 %, 22 % and 18 % to the provincial total respectively. Especially 76 % of sheep and 72 % of goats in the Study Area are raised in Kalat and Mastung Districts. Eighty

percent of cattle, 72 % of sheep and 70 % of goats are raised by farmers practicing together with crop farming. The farmers specialized to livestock raising are not so many. Middle sized farmers such as 3-5 ha and 5-10 ha in farm size, are mainly raising livestock (see following figure). Sixty-eight percent of the farmers raise one or two cattle, 21 % of the farmers raise 3-4 cattle, but, in contrast, a few farmers are the big livestock holders. In case of sheep and goats, the holding size of herd is relatively large, such as 28 % of farmers holding 5-15 heads, 21 % holding 16-30 heads, 12 % holding 31-50 heads, and 14 % holding 51-100 heads. Incidentally, the ratio of farmers growing fodder crops is only 8 % to the total farmers, and average cropping intensity of the fodder crops of the growers is about 9 %.



Share of Cattle, Goats and Sheep by Growers

Being an arid province and having traditionally range based livestock population, sheep and goat are more important. The Harnai, Bivragh, Baloch and Rakhshani are famous sheep breeds of the province and are reared for mutton and carpet wool production. The famous Bhagnari cattle are kept in the Kachhi plains. They are popular in the country for pulling heavy loads and tilling hardest soils. Red Sindhi cattle are found in Lasbella District, and are one of the best milk breed of the country capable of thriving well in hot and arid climate conditions and processing export potentials. In recent years, Frisian cattle have been successfully introduced in the colder areas to increase the milk production of non-discript native dairy cattle with cross-breeding by imported exotic cattle and semen. Commercial poultry production in the Province has been successfully introduced by provision of demonstration units in various districts of the Province. Rural poultry is being up-graded by introduction of exotic rural chicken.

Livestock management, especially that of small ruminants is one of the major economic activities in the area. The three main raising systems of sheep and goats are sedentary,

transhumant and nomadic types. Transhumants and nomads move to warmer areas of southern Balochistan, Sind and Punjab in winter. They return to uplands of Balochistan and Afghanistan in summer. It is estimated that small stock mainly depends on rangelands for their food. However, forage crops such as lucerne and sorghum and crop residues are also important feed resources. According to the farmers in the area, even weeds on crop land do play an significant role as "fodder".

3.6 Irrigation and Drainage

3.6.1 Irrigated Area

In the Study Area consisting of 5 districts concerning the Pishin Lora Basin, irrigation is by all means necessary for cultivation especially in the dry season from April to October due to scarcity of rainfall. Flood irrigation called as *Sailaba* has been traditionally practiced for cereal cultivation, moreover karezes had been played a dominant role in irrigation in the Study Area. In recent decades, irrigation by groundwater through tubewells and open hand dug wells has been practiced by farmers particularly for profitable fruit production.

Present irrigated area in each concerned district by several irrigation is summarized as follows:

Present Irrigated Area by Type

(ha)

Category	Pishin	Quetta	Mastung	Kalat	Total
Sailaba *	1,320	990	610	2,020	4,940
Karezes	6,380	520	1,950	2,240	11,090
Dug wells	120	0	530	370	1,020
Tubewells	24,030	8,940	28,190	17,950	79,110
Others **	1,160	600	170	360	2,290
Sub-total ***	31,690	10,060	30,840	20,920	93,510
Total	33,010	11,050	31,450	22,940	98,450

*: Irrigated area by Sailaba is the area under flood irrigation schemes.
**: Irrigated area in the 'Others' is canal irrigation area under the perennial irrigation schemes.
***: Total irrigated area are averaged figures in latest 5 years.

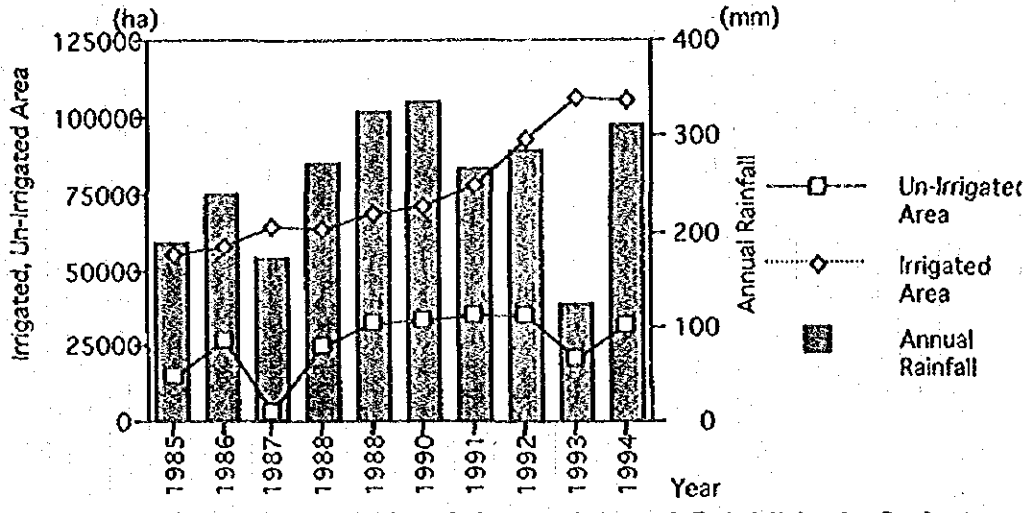
Changes of irrigated area year by year was investigated in the Study Area, and deduced its significant acquaintance. Annual irrigated and non-irrigated area in each district concerning in the Study Area based upon existing agricultural statistics are shown in the following table.

Irrigated Area, Annual Rainfall and Number of Tubewells in the Study Area

Year	Non-irrigated area (ha)	Irrigated area (ha)	Annual Rainfall (mm)	Number of Tubewells
1974/75	-	30,627	195.3	2,798
1879/80	-	41,810	266.2	4,625
1984/85	-	56,160	240.7	5,718
1985/86	14,966	55,387	188.5	5,805
1986/87	26,739	58,013	239.8	5,981
1987/88	2,990	64,423	172.6	7,395
1988/89	24,837	64,175	270.4	7,923
1989/90	32,698	68,616	326.4	8,182
1990/91	33,825	71,083	335.8	8,365
1991/92	35,339	78,405	267.1	8,452
1992/93	35,600	92,898	285.1	7,264
1993/94	21,248	106,545	122.8	7,425
1994/95	31,987	105,946	310.9	7,601

Source: Agricultural Statistics in Balochistan.

Correlation coefficient between data sequences of annual rainfall and the non-irrigated area shows much significant having correlation coefficient at 0.759, while showing no correlation relation having correlation coefficient at -0.009 for the data between annual rainfall and the irrigated area, as shown in the figure below.



Irrigated and Un-Irrigated Area and Annual Rainfall in the Study Area

On the other hand, a correlation coefficient between data sequences of number of well and the irrigated area shows very much significant having correlation coefficient at 0.807. Inferring from the correlation relation, major irrigation must be pumping attempt in the Study Area.

By these results, it is identified that non-irrigated agriculture relying upon rainfall might be unstable and unpredictable vocation, besides gaining low unit yield. On the contrary, irrigated agriculture through groundwater use is much relief and stable as far as necessary groundwater can be exploited.

3.6.2 Irrigation Schemes

(1) Karezes

Karezes are the systems which are the most ancient manner of obtaining groundwater for domestic and irrigation purposes in northern and central Balochistan. The karezes are essentially man-made, sub-surface horizontal tunnels and galleries constructed to tap groundwater in the upper limits of valley floor or piedmont plain and eventually deliver it at lower level lands by gravity. A mother well, front extraction well, is dug near the foot of the mountain where groundwater is available. The mother well is followed by a series of wells at intervals of 60 to 100 m, dug to depths at which the water surface encountered in the mother well is met strictly in accordance with the ground-surface gradient. All of these wells are connected by an underground tunnel. From the last well an open channel leads to the areas where need water.

The most common type of karez which is rather deep draws water from gravel fans. Such karezes originate in the piedmont plain. In the areas with shallow groundwater level, mother well starts in the valley floor and taps shallow groundwater. Besides these cases, there are karezes drawing water from aquifer in hard, consolidated rocks, generally fractured or fissured limestone, which can usually be expected high yield.

Average discharge of these karezes varies from less than 50 to 150 m^3/hour (0.5 to 3.0 cusec). With the introduction of modern techniques of tube-wells and requiring costly cleaning regularly to remain operative, the karez system of groundwater supply has been gradually diminished. There were reported to be 791 functional karezes in the Balochistan Province in 1990. However, the effectiveness of this water supply system is real in some areas having small availability of tube-wells. Efforts through certain users organization should be made to maintain and improve the karez system by periodic inspection and maintenance.

Karezes in the Study Area have been maintained by beneficiary farmers' group in a tribal, which were constructed by themselves since 800 years before. According to the Report of the Plan for Rehabilitation & Improvement of karezes in Balochistan, average number of farmer of the users group of karez is 28.6. Failing of function as decreasing available discharge has been found in almost all existing karezes, which seems to be caused by inadequate facility of karez, insufficient maintaining, besides lowing of groundwater level by increasing of tube-wells, and draught by climate change. As to the former causes, periodical karez cleaning is much effective for avoiding such failing, while karez cleaning has not been conducted regularly due to lack of budget.

(2) Irrigation status in the Study Area

Though there is no irrigation system providing surface water with dam and reservoir due to lack of economic site for construction, numerous number of small irrigation schemes have been completed and operated.

Irrigation schemes constructed through the Irrigation Department so far, and karezes established by farmers in each concerned district are listed as follows:

Irrigation Schemes in the Study Area

Category	Pishin	Quetta	Mastung	Kalat	Total
Perennial Irrigation schemes	11	4	1	3	19
Flood Irrigation Schemes	4	4	1	3	12
Delay Action Dams	29	6	7	10	52
Karezes (Existing)	256	29	99	6	390
(Operational)	216	24	8	4	252
Private Tube-wells	2,570	950	1,670	2,230	7,420

Karez which had been major source for irrigation water supply, almost shifted to dug wells owing of increasing availability of electricity in the Study Area. Operation of karezes has been difficult due to lowering of groundwater and necessary expenditures for its maintenance.

Major irrigation in the Study Area is by wells providing groundwater. These wells are privately constructed and operated. While exact number of the wells has been not investigated, the numbers of the wells in the above table are estimated in consideration of circumstances of the irrigation practice.

3.6.3 Irrigation Method

The current irrigation methods broadly adopted in the Study Area are border and basin methods which are the practices of controlled flood irrigation skill. The border irrigation method is to irrigate the field divided into strips by parallel border ridged. Sheet flowing water advance by gravity in the border-strip guided by two border ridges, and partly infiltrates into soil as it advances towards the lower end of the strip. The basin irrigation method is widely practiced in the Study Area particularly for the irrigation of orchards. For the method, field is divided into several level plots surrounded by dikes or bunds. Irrigation water covers the entire area of each plot and ponds on the surface until the desired infiltrates and saturates the soil.

For these traditional methods, much water losses are inevitable due to flooding. Irrigation efficiency seems to be 0.4 - 0.5 in consideration of whole circumstances on irrigation practices. In the DFDP of FAO, irrigation efficiency of 0.4 - 0.45 is adopted for the traditional irrigation

practice in the fruits cultivation. Drip irrigation having supreme irrigation efficiency at around 0.9 has been made to spread through an effort of agencies concerned in the required areas where being possibly applicable. According to the interview responses for farmers equipped drip irrigation facilities by governmental technical and financial support, the farmers have not yet held a sense of necessity and importance for the introduce of drip irrigation much less for saving water, as far as continuing present non-quantitative charging system for electricity supply. Present irrigation method could be applicable for the present time being in areas nearly all excluding in area where practically needed to introduce such modern irrigation method due to facing physical difficulties. Over-irrigation has been generally seen for pumping irrigation in this season in the Study Area in which some areas irrigated at the rate of more than 16 mm/day that is around 150 % of adequate irrigation rate. Exceeding irrigation over adequate irrigation water supply should be left off through necessary measures such as enlightening farmers a sense of saving water, revising charging system for electricity supply as described in section Water Management.

3.6.4 Drainage Condition

The streams in the Study Area are usually small and torrential, which flow while high intensity rainfall occurs. Despite of scarce amount of rainfall, short termed rainfall with high intensity occurs particularly in summer season. Probable rainfall intensities within the Study Area are analyzed using each duration rainfall record at Killi Kotwal Station as follows. According to the result of the analysis, significant difference in the probable rainfall intensities between both seasons are recognized.

Probable Rainfall Intensity in the Study Area

(mm/hr)

Return period	Rainfall Duration									
	1hr		3hr		6hr		12hr		24hr	
	W	S	W	S	W	S	W	S	W	S
2 Years	*8.5*	15.5	*4.5*	8.3	*3.1*	4.3	*2.1*	2.5	*1.2*	1.3
5 Years	*13.1*	20.9	*5.9*	12.2	*4.1*	6.1	*3.1*	4.3	*1.8*	2.4
10 Years	*16.1*	24.5	*6.9*	14.8	*4.8*	7.4	*3.7*	5.5	*2.2*	3.1
20 Years	*19.0*	28.0	*7.8*	17.3	*5.4*	8.6	*4.4*	6.6	*2.5*	3.7
30 Years	*20.6*	30.0	*8.3*	18.7	*5.8*	9.3	*4.7*	7.2	*2.7*	4.1
50 Years	*22.7*	32.5	*9.0*	20.5	*6.2*	10.1	*5.2*	8.0	*3.0*	4.6
100 Years	*25.5*	35.8	*9.8*	22.9	*6.9*	11.3	*5.8*	9.1	*3.4*	5.3
200 Years	*28.3*	39.2	*10.7*	25.4	*7.5*	12.5	*6.4*	10.2	*3.7*	5.9

W = Winter, S = Summer

Provable analysis above were using records of the Killi Kotwal Station.

The flood problems generally arise in hill torrents from severe local rainfalls during the months of July and August. These hill torrents usually have steep gradients. The flood flow debauch

into the plain areas, and has spread sheet flow used to damage lands and houses. Urgent measures against the flood have been desired.

In Quetta, the flood problems have been particularly aggravated by increase in population and consequent encroachment into the active flood plains of the hill torrents.

3.7 Agricultural Support Services and Farmers' Training

3.7.1 Agricultural Research

(1) Agricultural Research Institute (ARI)

Agricultural Research Institute, Sariab, Quetta is the only multi-disciplinary institute functioning under the Agriculture Department of Balochistan. Some research staff has been posted at the following stations/farms to look after the research work on those locations.

- Government Farm, Gidder (Kalat)
- Government Farm, Wayaro (Lasbela)
- Model Farm, Sibi (Sibi)
- Government Seed Farm, Usta Muhammad (Nasirabad)
- Agriculture Development Institute, Khan Pur (Nasirabad)

Presently, ARI is comprised of thirteen research sections out of which nine are busy in crop production, two are conducting research on plant protection and remaining two are engaged in social scientific research. The staff and land of the institute is as follows:

Outline of Agricultural Research Institute

STAFF	
Designation	Number
Chief Scientific Officer	1
Director	4
Project Director (DFDC)	1
Technical Officer	
Senior Research Officer	17
Assistant Research Officer	17
Research Officer	26
Ministerial	58
Skilled Labour	179
Un-skilled Labour	122

NOTES : Technical = Scientists up to the level of Research Officer.
Ministerial = Clerks, office assistants, and store keepers.

LAND

Item	Area (ha)
Area available for Experiments	17.6
Area under offices, laboratory and houses	4.4
TOTAL AREA	22.0

(2) Arid Zone Research Institute (AZRI)

Arid Zone Research Institute is one of the federal agricultural research organizations which forms a part of the Pakistan Agricultural Research Council's national network of agricultural support agencies. AZRI's headquarters are located at Quetta, and it has three sub-stations at Umerkot (Sindh), at Bahawalpur (Punjab) and at D.I. Khan (NWFP). AZRI's ecological mandate in Pakistan encompasses two zones, the arid zone with annual rainfall of less than 150 mm, and the semi-arid zone with less than 350 mm. These zones constitute about 85% of the country's total area. A substantial part of this dryland, amounting to about 14 million ha, is presently served by canal and other sources of irrigation and thus does not come within AZRI's sphere of responsibility. However, 40 million ha or about half of Pakistan is nominally serviced by research from the Institute. The objectives of AZRI are as follows:

a) To plan and conduct agricultural research in order to generate appropriate technologies for improving small ruminant production and dryland cropping in the arid and semi-arid zones where the potential for irrigation is either undeveloped or non-existent.

b) To develop solutions to problems in the arid and semi-arid zones, while improving the sustainability of the biological systems and lessening the dangers of further environmental degradation of the fragile ecology of these arid areas.

c) To establish strong linkages between federal, provincial and international agencies, so that Pakistan can develop an integrated research effort to truckle the problems in these zones.

d) To generate and acquire information relating to dryland agriculture, and disseminate it to potential users.

AZRI has multi-disciplinary approach for working on different problems of arid highlands of Balochistan. With interdisciplinary working strategy, the institute has six sections or research groups as Germplasm Evaluation, Agronomy, Range Management, Livestock, Agricultural Economics & Farming Systems, and Agricultural Extension & Communication.

(3) Model Farm, Sariab

Model Farm, Sariab was established in 1983. The purpose of the farm is to demonstrate modern agriculture techniques and meet present day requirements in the field of agriculture.

The farm is comprised of 18 ha of land which includes roads and buildings. About 14 ha of land is under cultivation which includes orchard of various fruit plants, nurseries and demonstration plots. About 6 ha of land has been established under various modern systems of irrigation. Presently the farm is used as the headquarters of the Trickle Irrigation Project. The project was launched in 1990/91 sponsored by ADB. Major objectives of the project is to introduce high efficiency irrigation system especially in orchard growing areas to save water. Under the project, 173 ha of farmers' fields were installed with trickle irrigation system on 75% subsidy at 95 different sites.

(4) Deciduous Fruit Development Centre (DFDC)

Having recognized the economic importance of deciduous fruits and realizing the urgent need for developing modern fruit industry, UNDP financed Fruit Development in Balochistan Project executed by FAO started in 1979. The project assisted the establishment of a Deciduous Fruit Development Centre as a part of the existing Agricultural Research Institute. Major activities of the Centre is research and training in various fruit cultural practices such as plant nutrition, plant protection, irrigation, storage and marketing. Improving irrigation systems using trickle irrigation is also an important component of the research.

Urgently, two similar projects have been conducted to introduce trickle irrigation system in orchard growing areas in Balochistan. Roughly speaking, Model Farm Sariab puts priority on extension of the system to the farmers, while DFDC is rather in a research side. More collaborate works between these two organizations will be inevitable to apply results of the research to the farmers efficiently in order to enhance the fruit production of the area.

3.7.2 Agriculture Extension

Agricultural extension has crucial role to enhance agricultural production of the area through dissemination of improved and localized technologies to farmers. Under the Director of Extension, DDAs and EADAs have administrative responsibility for different geographical areas. The actual extension work is done by AOs and FAs. FAs are front line officers who have the main contact with grass-roots level. They are supposed to visit their own territory on a regular basis to find farmers' problems and to solve them with up-dated training and technical information. Transmission and dissemination of agricultural messages are usually conducted through contact farmers to local communities. Contact farmers are selected among the larger and more influential growers of the area. They may include farm managers, contractors, Chairmen of Union Councils and any progressive growers. These contact farmers must be

respected by the local community, willing to meet AO and FA on a regular basis, and interested in adopting or promoting new technology.

Establishing "Demonstration Plots" in farmers' fields is one of the way to provide farmers with an opportunity to compare traditional practices with recommended practices of the Department of Agriculture. The demonstration plots will be planned by DDA of the district, assisted by EADAs and SMSs. AOs are responsible for organizing the plots. The day-to-day management of these plots will be carried out by FAs. The spread of extension services is shown in the table given below.

Agricultural Officers and Field Assistants in the Study Area

		Quetta	Pishin	Kalat	Total
Number of Farms	1)	3,131	20,871	23,929	47,931
Farm Area (ha)	2)	38,559	96,015	125,495	260,069
Number of AOs	3)	5	5	6	16
Number of FAs	3)	87	74	81	242
(Farm / FA)		36	282	295	198
(Area / FA)		443	1,298	1,549	1,075

Source : 1) Agricultural Census 1990, Agricultural Census Organization.
2) Agricultural Statistics 1990/91 - 1994/95, Department of Agriculture, Balochistan.
3) Agriculture Extension, Department of Agriculture of Balochistan.
("Pishin" includes Qila Abdullah District, and "Kalat" includes Mastung District.)

The table shows that one Field Assistant serves some 200 farmers or 1,075 ha of farm lands on average in the Study Area.

3.7.3 Livestock & Dairy Development Department

The set up of Livestock & Dairy Development Department in Balochistan is comprised of the Secretary, Deputy Secretary, Under Secretary at Secretariat level. The technical department is headed by the Director General, Livestock Department Balochistan, there are five Directors and one Project Director under his control to run the various functions relating to animal health, production and research. The Livestock Department presently has three main administrative sections; the Directorate of Animal Health, the Directorate of Farms and the Directorate of Research. The main objectives of the Department are as follows:

- Provision of veterinary aid to livestock breeders,
- Control and eradication of contagious animal diseases, and
- Breed improvement of local indigenous livestock and introduction of exotic strains for increased production.

Animal Health

Major activity of this unit is providing veterinary services to livestock holders in the Province. The section maintains numbers of veterinary hospitals and dispensaries as follows:

Veterinary Hospitals and Dispensaries in the Study Area

	Quetta	Pishin	Kalat
Veterinary hospitals	3	4	3
Veterinary dispensaries	12	62	30

Note : "Pishin" includes Qila Abdullah District, and "Kalat" includes Mastung District.

Farms

This section is maintaining various farms for preserving and propagation of nucleus germplasm of various breeds of cattle, sheep, goat and poultry. In the Study Area, dairy farms are operating in Quetta, Pishin, Mastung and Kalat Districts. Poultry farms are running in Quetta, Pishin and Kalat Districts.

Research

The Livestock Department established its research section in the early nineties to enhance the production of livestock. The following institutions of research have been established in the Study Area.

- Veterinary Research Institute, Quetta
- Paraveterinary Training Institute, Quetta
- Karakul Sheep Breeding Farm at Maslakh, Pishin
- Wool Research Laboratory, Mastung

In addition, some projects related to livestock development are running as follows:

- Feed Resources Development in Balochistan (FAO/UNDP)
- Livestock Development Project in Balochistan (ADB)

3.7.4 Forest and Wildlife Department

Major activities of the Forest Department are conservation of existing natural vegetation and wildlife, watershed management, rangeland management, and afforestation. A pilot project for improvement and rehabilitation of rangeland has been carried out in Maslagh area, which is a successful and encouraging example of rangeland management in the Province. Maslagh state forest is situated about 40 km west of Quetta city, which belongs to Pishin District. The project

was started in 1954 with the technical and financial assistance of USAID. Some 46,000 ha of rangeland has been protected by fencing with watchmen. After the decades of controlled grazing and zero grazing, significant improvement in the vegetation cover and forage production was recorded. A part of the area is now leased to the Livestock Department, and Karakul Sheep Breeding Project has been under operation since 1981.

3.7.5 Farmers' Associations

(1) Agricultural cooperative

The most common farmers' associations are agricultural cooperatives. A cooperative can be organized by a group of more than 10 farmers who shall be above the 18 years old and live in same town or village. The objective of the cooperative is to encourage thrift, self-help and cooperation among the persons of limited means so as to improve their social and economic conditions. Cooperatives are financed by the Provincial Cooperative Bank that is funded by the Federal Cooperative Bank.

At present, there are 608 agricultural cooperatives and 203 non-agricultural cooperatives in Balochistan, out of which 303 agricultural cooperatives and 93 non-agricultural cooperatives are located in the five districts of the Study Area. Most popular type of agricultural cooperative is multi-purpose cooperative followed by cooperative for tubewell and credit cooperative. Besides these, there are the cooperatives established based on the Integral Rural Development Programme, development cooperative, marketing cooperative, etc.

However average number of member ship per cooperative is only 23 that is very small compared to total number of farm households, and share capital and working capital are also very limited. There is no cooperative union in the Province. Generally the existing cooperatives have been established in village size, and most of the cooperatives are organized only by a few farmers in a village.

(2) Water users' association

Another major farmers' organization is the Water Users' Association (WUA). Formerly there were traditional groups of water users in several irrigated areas. In these areas tribal custom was still so prevailing that the head of such a group was usually occupied by the person who constructed the irrigation facilities, his successor or the big land owner. He and or his assistants operated and maintained the facilities, collected the irrigation fee as demanded.

However, these informal water users' groups were not well managed because of their weak organizations.

In 1981, " Balochistan Water User's Associations Ordinance" was enforced. After that, formal WUAs have been newly established together with implementation of the several irrigation projects assisted by the foreign countries. In the beneficial areas of proposed delay action dams, where the traditional karez irrigation system was declining, while private tubewell irrigation was increasing accordingly, the formal WUAs have not yet been organized.

(3) A participatory approach in watershed management and rangeland management

There is an interesting project with participatory approach practiced by the Government under the assistance of FAO and UNDP. This project mainly aims to develop participatory based watershed rehabilitation and management plans and undertake watershed rehabilitation works in northern part of Balochistan. Through this project, continuous training has been conducted at the village level, and local communities have been actively involved in all stages of watershed rehabilitation. For these projects a total of 30 village organizations and 13 women's associations have been established in the 7 districts including the Study Area by 1995.

(4) Non-government organization (NGO) in Balochistan

In Balochistan the biggest and most active NGO is the Balochistan Rural Support Programme (BRSP). This organization aims to improve the quality of life of the disadvantaged rural population in Balochistan, presently funded by the Governments of Pakistan and Germany. Now their activity covers 7 regions, 13 districts of the Province, including 4 districts (Pishin, Quetta, Mastung and Kalat) out of the Study Area. It has about 170 of staffs including several technical staffs and social staffs to establish village organizations, women's organizations, etc., and provides several services packaged to self-help of villagers.

3.7.6 Agricultural Credit

The farmers generally need some external monetary budget for farming, purchasing machinery, installing tubewells, and so on. According to Census of Agriculture in 1990, about 21% of the farmers in the Study Area was situated in debt. The total amount of debt to them was Rs. 342 million. The average debt amount per household was Rs. 7,150 and debt per cropped area was

Rs. 1,780 /ha in the Study Area. The institutional and non-institutional source supplied 23 % and 77 % of the loan amount, respectively. The non-institutional source, such as family or individuals of the same tribal group or from money lenders, played greater role in a local credit system.

The institutional agricultural loans are distributed to farmers through 3 major channels. First, Agricultural Development Bank of Pakistan (ADBP) under State Bank of Pakistan provides agricultural loans to individual farmers as their request. ADBP has at least one branch office in each district in the Study Area. The loans can be divided into production loan, development loan, short, medium and long-term loans. The predominant types of loans in Balochistan are development loan and long term loans which are mainly used to purchase farm machinery and to install tubewells.

Second channel is Balochistan Cooperative Bank Ltd. which provides agricultural loan to the cooperative societies. The two type of loans are generally advanced. One is short term loan for the purchase of seeds, fertilizer and pesticides to be recovered within a year. Another is medium term loan for installation of tubewells and purchase of tractors with repayment period of 5 to 10 years. The amount of agricultural credit provided by Balochistan Cooperative Bank Ltd. ranges from Rs. 10 to 15 million in the Province.

Finally, commercial banks also supply agricultural loans, as short term production loans, to individual farmers. The loans by the three channels amount to about Rs. 300 million in the Balochistan Province or Rs. 400 /ha of cropped area. This amount is too small to apply the advanced farming technologies to their farms.

3.8 Marketing and Prices

3.8.1 Marketing of Agricultural Products

In agricultural marketing system, the public sector plays of fair price control, price support and regulation of marketing activities. In this area, only wheat and some authorized commodities is procured by the Pakistan Agricultural Storage and Supplies Corporation at the support prices under control by the Provincial Food Department. The private sector primarily acts as functionaries in various stage of marketing of common farm products.

There exists great marketable surplus of fruits and vegetables in the area. Asian Development Bank estimated that Pishin Lora Basin, overlapping the Study Area, produces about 460,000 ton of tradable agricultural commodities a year. Commodity group of fruits is dominant amounting to 262,000 ton or 57 % of the total surplus. The vegetable group follows it at

185,000 ton a year. Pishin Sub-Basin is a leading area to export fruits, and Pishin and Quetta Sub-Basins are a major vegetable export area.

Most of deciduous fruits crops and some kinds of vegetables are marketed through some functionaries, while cereal crops such as wheat are consumed or sold in the local market. Specially deciduous fruits such as apples, apricots and grapes are exported to other provinces in Pakistan. The quantitative marketing direction of the fruits are as follows.

Apple:	Quetta (25%), Karachi (25%), Lahore (40%), Islamabad (10%)
Apricot & Grapes:	Quetta (50%), Karachi (20%), Lahore (20%), Islamabad (10%)

In harvest time of the fruits, a large amount of fruits is exported to other provinces. After several months of storage there, the fruits are re-imported to Balochistan during the higher price season, because the capacity of cold storage in Balochistan is very limited.

Typical trading stream of the fruit is as follows:

Farmers --> Pre-harvest Contractor --> Wholesaler --> Retailer --> Consumers
(Commissioner)

Most farmers make contract with so-called "pre-harvest contractors" at the blooming period or pre-harvest period of fruits. The pre-harvest contractors, who are commonly local people, manage the orchards at their own expenses up to the harvesting and marketing of fruits. The analysis of fruits price structure shows that more than 30 % of the wholesale prices are earned by the pre-harvest contractor.

The marketing practices of livestock is much less developed, compared with the marketing of other crops. Open market, the most primitive marketing system, is most popular in the area. The open livestock markets are held once a week on a fixed day. The rural market commonly is a simple open air space with no facilities available, and located at a distance from settlement area, usually on a hilltop. As the most livestock holders do not have any market information, they are forced to sell their animals to the buyers at the unduly low price.

3.8.2 Marketing of Farm Input

The physical post-harvest facilities, such as transportation, cold storage warehousing, processing and packing are not sufficient in Balochistan. Traditional practices of post-harvest are common, even though the Department of Agriculture of Balochistan and international agencies have experimented and disseminated post-harvest technologies.

A private cold storage facility for fruits and vegetables is available at Quetta, although its storage capacity of 20,000 crates is very limited, compared with production volume of fruits in the Province. The Government of Balochistan insists on installation of cold storages for fruit and vegetable under productivity enhancement program. The public storage will have a capacity of 600 tons and be located in Loralai outside of the Study Area.

Private sector plays great roles in distribution of farm inputs such as seeds, fertilizer and agro-chemicals. Fertilizer is marketed by fertilizer manufacturers through their appointed dealers, while pesticides are marketed by manufacturers/formulators and importers through their appointed dealers. The dealers generally handle fertilizer, pesticides, and traditional and HYV seeds. The dealers normally combine the function of input dealers as well as wholesales and commission agents for the agricultural products.

The dealers normally supply these inputs to farmers on credit, along with some cash advances to meet consumption needs. The borrowers are obliged to sell their produce through the dealer/commission agent against a pre-determined rate, or commission charged on the sale proceeds sold on their behalf.

As to feed for livestock, there exist various types of farmers depending upon range land, fodder crops and purchased forage, but few depending upon concentrate yet. The feed source is so hard to be acquired that some animals fall in malnutrition especially in the winter season.

3.8.3 Post-Harvest and Marketing Facilities

The physical post-harvest facilities, such as transportation, cold storage warehousing, processing and packing are not sufficient in Balochistan. Traditional practices of post-harvest are common, even though the Department of Agriculture of Balochistan and international agencies have experimented and disseminated post-harvest technologies.

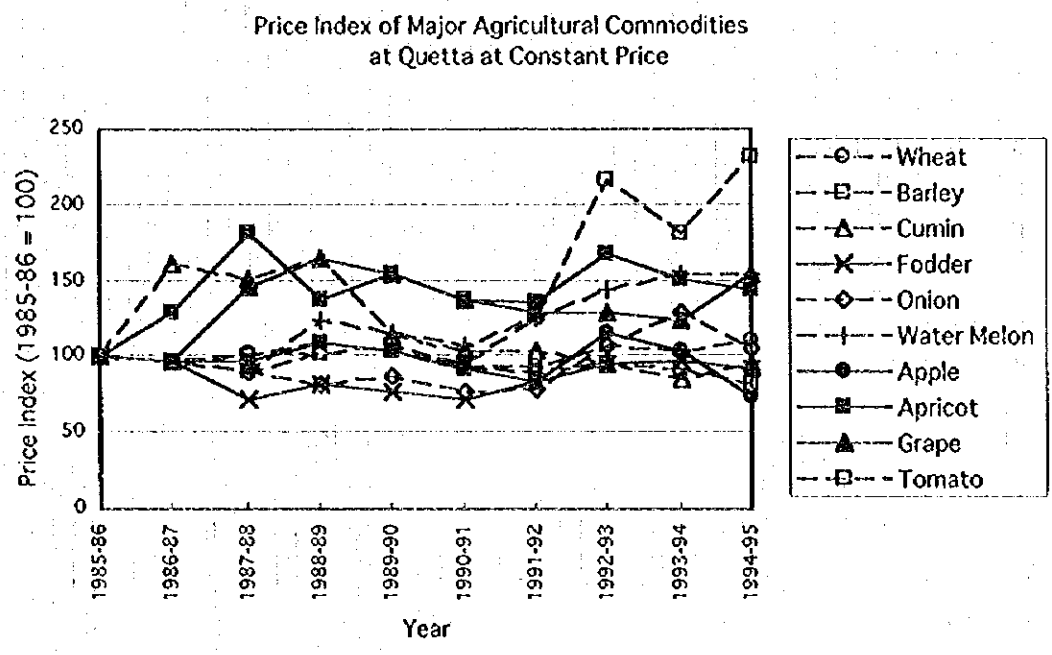
There is only one public wholesale market in Quetta city in Balochistan. This market is not sufficient for growing amount of agricultural products in marketing capacity and facilities. The wholesale market will be shifted to a new location where it is under construction under the Fruit and Vegetable Marketing Project Balochistan supported by ADB, UNDP and the Government of Balochistan. The new market will be furnished with 255 big shops and 55 small shops in an area of 15 ha. In addition, another wholesale market is planned to be installed at Dera Murad Jamali of Nasirabad supported by ADB, but it is outside of the Study Area.

3.8.4 Prices of Agricultural Products

All agricultural products except wheat are marketed under free market prices in the Study Area. Wheat is subjected to a support price which is fixed at much lower price than free market price by the Agricultural Prices Commission, a Federal Government authority.

The wholesale prices of agricultural commodities at Quetta are reported monthly by the Department of Agriculture. The seasonal price fluctuation of fruits and vegetables are very significant. The prices are much higher in the off-season. For example, wholesale price of golden apples rise to about Rs. 1,000 per 40 kg during off-season, while the price is only Rs. 200 per 40 kg during harvesting season of September to October. On the other hand, wheat and potatoes show relatively stable price trend because their storage is technically and economically easier.

To analyze the annual average prices at Quetta, wholesale market was studied for 10 years from 1985-86 to 1994-95. The price level is adjusted to 1994-95 price using a deflator of general Wholesale Price Index of Pakistan. The price index for the 10 major crops in the beneficiary areas are shown in the following chart.



Source: Agricultural Statistics in Balochistan.

3.9 Environment

3.9.1 Prominent Environmental Issues

(1) Physical environment

Desertification is the most salient and serious issues regarding the physical environment in the Study Area. Its symptoms are seen in not only severe climate of arid or semi-arid but also devegetation, groundwater depletion, soil erosion and loss, and declining bio-diversity which is being caused by over-exploitation of natural resources by the ever increasing numbers of humans and livestock. The desertification has prevented a sustainable development scheme in the area. Especially, both groundwater depletion, soil erosion and loss are precluding any perspective for sustainable economic development directly. The depletion is accelerated by a shift from gravity irrigation (Karez) system to lift irrigation by tubewell and centrifugal pumps from dug wells, and leads to a collapse of largest sector of the economy such as irrigated agriculture and domestic water supply. As for soil erosion and loss, the natural or geological erosion on mountain slopes is more pronounced in the Study Area than the man-made erosion caused by inappropriate soil management in the rainfed croplands. Actual or potential impacts caused by soil erosion are (i) irreversible losses of natural pasture and of the dependent livestock industry, (ii) Shortening of life span of water control structures (including delay action dam) and changes of the downstream hydrology, (iii) reduced soil fertility, water holding capacity and eventually low crop yields, and (vi) occurrence of large flush floods.

Contamination hazards of soil and water have been misgiven in the Study Area. Spraying of pesticides is mostly done by the farmers or pre-harvest contractors. It is reported that persistent pesticides with human and environmental health hazards which are brought by contractors and even prohibited to use by regulation are invested in the orchards considerably.

In addition, an air pollution such as smoke and dust emitted from increasing vehicles and brick kilns and stone crushers has been serious year by year. It has been reported that huge population of Quetta and the suburbs suffer from throat and respiratory diseases, and agricultural crops are damaged in the Study Area.

(2) Biotic environment

The decline of bio-diversity in the Study Area is a component of desertification process mentioned above. Bio-diversity conservation has a low provincial priority as it is hardly important for the economy, not even in directly. Only the development of tourism such as Hazarganji-Chiltan National Park could give bio-diversity provincial economic significance.

As a result, sparse bio-diversity in the Study Area has been lost corresponding to a rapid degradation of forest and rangeland vegetation due to illicit cutting of trees and overgrazing.

In fact that the forest legislation exists to product necessary yields of the timber and wood commodity without certain policy for protection of the forest ecosystem. Consequently potential watershed and erosion control functions have been disproportionally diminished even in publicly owned woods. About 3 % (1 million ha) of total area of Balochistan gazetted as State Forest by the Balochistan Forest Regulation of 1890 has been narrowed. Even the remaining State Forest of 230,000 ha are sparse to open coniferous woods, riverine forest and widely scattered shrub in the northern half of Balochistan. Approximately the State Forest of 125,000 ha is included in the Study Area, of which 65% is scattered shrub. In the State Forest green trees and wildlife are protected completely. However, exploitation rights such as utilization as fuelwood and grazing are specifically and/or partly included in the notification of each area of the State Forest. Moreover in most area the prohibition on cutting green trees can not be fulfilled in practice. While in the southern half of Balochistan, particular in Kalat, the land of approximately 90,000 ha is gazetted as Protected Forest under the Pakistan Forest Act of 1927. However, the Protected Forest classified as forest lands had actually been lost but as only degraded rangelands in Balochistan. In the Protected Forest, green trees and wildlife have been protected, but unlike manners for the State Forests, the use of rights are not part and parcel of the Protected Forest notification and are at the discretion of the Conservator of Forests. In Protected Forests everything expect cutting of green trees and wildlife hunting is allowed unless specifically prohibited. Therefore, almost of the sparse forest resources in the Study Area, which are not protected by State Forests and/or Protected Forests, have been degraded the watershed causing soil erosion, floods and reduction of groundwater recharge.

On the other hand, the rangelands have been also degraded severely both by devegetation and conversion into unpalatable vegetation. Such degraded ranges are the result of millennia of over-exploitation for fuelwood and forage. In particular, livestock production is the major economic activity in most rural communities of the Study Area, and rangelands are the primary source of feed for the animals. Long-run over-exploitation by increasing human and livestock populations have generally led to deterioration of these essential resources, first qualitatively due to disappearance of more palatable plant species, later also quantively when the total vegetation cover declined. Presently, in order to improve the condition of degraded rangelands and to introduce appropriate management systems based on participatory approach for their sustainable use, Integrated Area Development Programme (IADP) has been handled by Food and Agriculture Organization (FAO) of the United Nations.

(3) Human environment

Salient feature for the human environmental issues in the Study Area includes deteriorated health and sanitation, water right determined by customary tribal law and social life and customs for the pastoralism.

The health indicators, infant mortality and maternal mortality, are extremely poor in the Study Area. The main cause of those death is related to the lack of potable water, giving rise to waterborne diseases and unsanitary condition. Furthermore, the high mortality is associated with undermourishment and lack of immunization. Malaria is a disease strongly related to the human health in the Study Area. Karat located in southern parts in the Study Area is renowned for malaria. In Kalat, the mosquito habitats are the groundwater pumping facilities, karez and fruits and vegetable garden irrigated by groundwater. In Pishin and Quetta, a recent increase of malaria has been seen and is attributed to Afghan refugees. A tropical disease of note is Leishmaniasis, though not lethal, it is disfiguring on the face or other exposed parts of the body. Leishmaniasi vector is sandfly which takes shelter in the burrows of rodents, and breed in the soil and water such as karez, canal and well.

On the other hand, hygienic problems are lack of domestic water and sanitation. Sewer system is not almost set up and the sewerage is discharged untreated into the river or channel or soil. Vegetable irrigation by untreated sewerage is probably a main source of roundworm and tapeworm infection. In the rural area Echinococcosis represents an enormous environmental health hazard through slaughtering.

The water rights in Study Area are completely determined by customary tribal law and differ among the groups. The Pathan live in the northern parts in the Study Area. Their irrigation water rights are decided by each resources such as river, flood, run-off, spring, karez and well. As for the water right for tubewell, the right to develop and exploit the groundwater belongs to the land owner, but recently some restriction have been imposed. This restriction is mostly ignored and sometimes this leads to a dispute.

The Brahui inhabit mainly southern parts in the Study Area. The political organization of the Brahui tribes is similar to that of the Balochi who live in the southwestern, western and eastern parts of the Province that is out of the Study Area, and also live in Quetta that is involved in the Study Area. The water use rights in the central Balochistan (mixed Brahui/Balochi) are similar to those of Pathan with roughly three differences. These are that the lower riparians are not fully established, that to allow others to lay out a karez in one's land is customary and that they have the repair or maintenance system of karez by an outsider for a share in the water. Also in case of the central Balochistan water rights, some troubles arise when a tubewell is installed.

Nomadic pastoralism is widespread in Balochistan and singularly traditional involving camels for household transport and tents for housing. Nomadic livestock accounts for 5-10 % of the total livestock in Balochistan. The nomads generally stay over summer in the highlands of Balochistan and during the winter in the highlands of Balochistan or Sind (mainly Afghan Pathan tribe). Most of Balochistan's small stock is transhumant, estimates between sources vary widely from 50-80 %. The transhumant pastoralists migrate between particular summer and winter areas and are actually agro-pastoralists, cultivating human and animal purpose grain crops. (mainly Baloch and Brahui tribe) Sedentary agro-pastoralism (10-40 % of small stock) implies livestock remaining in the same area year-round, although their summer and winter grazing ground may be apart, but both within a day's walking distance of permanent village (mainly Pathan tribe). Nomadic pastoralism, transhumant agro-pastoralism and sedentary agro-pastoralism occur side by side in Balochistan. Intermediate practices were reported such as semi-nomadism, semi-sedentary transhumance etc. Correspondingly with occurrence of such different pastoralists, human environmental impacts originated in the conflicts or disputes regarding land and/or water have been created when the territory between each group and other groups or agriculturists is overlapped.

3.9.2 Organization and Cooperation for Environmental Management

(1) Environment Department

The Government of Balochistan declared to create a new administrative department namely "Environment Department" by notification dated 21st October, 1996. Consequently the work relating to the subject presently being carried out by the Urban Planing and Development Department (UPD) and Planning and Development Department (PDD), which are upper department of the Environmental Protection Agency (EPA) and the Environmental Section, respectively, has been transferred to the newly created administrative department. It implies that two administrative organizations for environmental management should accomplish the responsibilities and duties effectively, recognizing the distinct demarcation and internal cooperation. It is expected to address more positive actions and activities for the environmental conservation. At present, the Environment Department has not functioned yet due to slow appointing of the upper classes of the Department. The background, duties and responsibilities provided for two organizations are as follows:

1) Environmental Section

The Environmental Section is established as environmental management body of the Planning and Development Department and as institutional development for Balochistan

Natural Resource Management Project which is funded by World Bank during six years from 1994 until 1999, and which is a part of the Environmental Protection and Resource Conservation Project engrossed in each province in order to contribute to environmental conservation in Pakistan. The section is responsible for: (i) reviewing provincial development proposals taking into account of GOP and GOB environmental policies, (ii) monitoring natural resource management, and when necessary, liaising and coordinating with provincial line agencies, and (iii) to introduce economically viable and ecologically sound natural resource management practices.

2) Environmental Protection Agency (EPA)

EPA, Balochistan has principally executed implementation and regulation of the national and provincial policies regarding prevention and control against pollution since preliminary established in 1992. EPA has improved by World Bank Project mentioned above since 1994. As a result, the main objective of EPA is improved implementing and enforcing national and provincial environmental protection legislation and regulations, particularly regarding industrial, urban and agricultural discharge into the air, water and soils. Therefore, EPA is responsible for: (i) undertaking mass awareness programs concerning environmental issues, (ii) measuring and monitoring industrial, urban and agricultural pollutant discharges into the province's air, water and soil and legally enforcing national/provincial environmental quality standard, and (iii) instituting provincial Environmental Impact Assessment (EIA) procedure for reviewing public development proposals, and monitoring any subsequent expenditures or action taken to alleviate possible environmentally damaging impacts.

(2) Balochistan Forest Department

The Balochistan Forest Department (BFD) has handled planning, management, research and training regarding a number of projects and programmes for the forest sector which includes forestry, watershed and range management, sand dune stabilization and wildlife and parks management. In order to attain the sustainable use of natural resources, BFD has just tackled to development and conservation projects adapting to the human environmental situation in the social community. Out of five (5) projects involved in the "Integrated Area Development Programme" assisted by FAO, three (3) projects are accomplished by BFD, the title of which are "Integrated Range-Livestock Development Project", "Watershed Planning and Management Project" and "Inter-Regional Participatory Upland Conservation and Development Project".

(3) Other related organization for environment

In the environmental concept of Eighth Five Year Plan 1993-98 the Government of Balochistan imposes the responsibility to the environmental issues on the almost public administration.

(4) International agencies and donors

Many bilateral and multilateral international agencies and donors are supporting environmental conservation work in Balochistan. The more active and viable groups include: World Bank which has financed for "Balochistan Natural Resources Management Project", CIDA in

association with the International Union for the Conservation of Nature and Natural Resources (IUCN) and the United Nations Development Program (UNDP) which have assisted to prepare the National Conservation Strategy (NCS) and its implementation including institutional strengthening, ADB which financed for "Strengthening of Environmental Management" and FAO / UNDP which is currently assisting for "Integrated Area Development Programme (IADP)". Particularly the IADP, as which five on-going projects executed by FAO were concentrated in June 1996, covers a total of eight sites in three districts and contributes substantially to environmental conservation at the regional area in Balochistan. In case that each on-going project areas before concentrated are taken into consideration, it implies that four districts, which are Quetta, Pishin, Qila Abdullah and Mastung, of five districts over the Study Area are involved in FAO projects. IADP is related to environmental conservation plan and to measures for the delay action dam projects.

(5) NGO

As NGO for the improvement of rural environment Balochistan Rural Support Program (BRSP) is bestowed highly appreciate besides IUCN mentioned above. BRSP is currently covering 12 districts including 5 districts of the Study Area, offering 5 integrated programs to village men and women through organized section in the areas of income generation, rural finance, human resource development, infrastructures, health education, and formal and informal education. The World Wide Fund for Nature (WWF) has reviewed government wildlife conservation efforts, and has proposed wildlife management strategies in Balochistan.

3.10 Present Condition of Groundwater Use and the Institution

3.10.1 Present Condition of Groundwater Use

Surface water is very limited and ephemeral in the Study Area, and groundwater from karez or spring has been played a very important role as valuable and irreplaceable resources for agriculture and regional development. Irrigation sector has consumed the majority of groundwater use. Recently, water supply projects are rapidly extending in rural areas, they are minority compared with irrigation, even in Quetta District.

Water sources of karez, open well, tubewell, spring and surface water quench 72 % of the population in the Balochistan Province. Apart from the quality of services, water supply projects cover 45 % of rural population and entire area of Quetta city in 1993. Eighty percent of the water source has been exploited by tubewells. The costs of both construction and O&M are expensive, while the collection rate of water charge is very low.

The rapid diffusion of tubewells has greatly contributed to the expansion of high beneficial orchard farming as well as to improve living condition through drinking water supply in rural area in Balochistan, especially in Pishin Lora basin. Thus it has resulted into the decline of groundwater table of the basin, caused by the destruction of the groundwater balance between recharge and extraction.

To cope with the groundwater decline, the Government of Balochistan has planned the Delay Action Dam (DAD) Program, and constructed about 110 DADs. The project made a great effort to recharge the groundwater, but the lowering groundwater table still continues in Quetta, Mastung and southern Pishin sub-basins by 1 to 2 m per annum. However the project has some technical tasks to be solved on planning, designing and construction as well as O&M including the reduction of recharging function, so that appropriate development schemes of DADs encourages more effective and efficient project implementation contributing to groundwater presentation.

Proper groundwater management such as mining control is another vital means together with administrative, political and institutional issues. An encouragement of water saving of groundwater pumping by administrative means, for instance, electricity charging system has two alternatives of flat rate and meter reading, and the former one is clearly economical and kills intention of water saving. According to the Islamic tradition, groundwater right including extraction of the water belongs to the land owner. Though a pertinent ordinance prescribes for sanction from authority, perfect control of groundwater including rejection is hardly possible to the administration.

3.10.2 Organization of Groundwater Management

The irrigation and Power Department is responsible for water resources development including groundwater exploitation for irrigation, drainage and water works. Organization chart is shown in Fig. 3.10.1. Planning and Development Department is headed by the Additional Chief Secretary (ACS) and responsible for planning and coordinating all resources development in the Province. Deputy Commissioners are responsible for both civil administration, law and order with magistrates powers in each district, also responsible for licensing groundwater abstraction. In connection with water resources development, the Public Health Engineering Department is responsible for water supply, the Agriculture Department for farm development, the Forestry Department for range land management and the Environment Protection Agency for environmental legislation.

Under above administrative jurisdictions, the Government of Balochistan has established and enforced "The Balochistan Groundwater Right Ordinance" in 1978. The areas of the enforced

ordinance is entire province except tribal areas, and the outline is as follows. The Provincial Water Board is established and consists of ACS, member of the Board of Revenue, Secretary of the Irrigation and Power Department, two non-official members appointed by GOB. The Board will lay down policies for conserving and developing the groundwater resources in Balochistan, acting as a supervising and controlling authorities of the various water committees.

The Water Committee is established in each district, and the Committee works under the district supervision and over-all control of the Provincial Water Board for the purpose of carrying out the objectives of this Ordinance. The Committee will have the power to implement the policies and directions given to it by the Provincial Water Board from time to time. The main function of the Committee is to issue water permits to various water use and arbitrate groundwater dispute. The establishment of the Ordinance seems to be not strongly intended in those days to control entire basin wide groundwater with forecast of present groundwater crisis.

Beside above Ordinance, legal background of the water management and groundwater utilization is as follows:

- Balochistan Groundwater Right Administration, 1980/1984/1985
- The Balochistan Canal and Drainage Ordinance, 1980/1985
- The Balochistan Water User's Association Ordinance, 1981/1985
- Tribal and Customary Water Right
- Islamic Provisions and Traditions Pertaining to Water

Under the pressure of the groundwater problems, the Government of Balochistan established the Bureau of Water Resources under the Irrigation and Power Department for the strengthening of water management administration, and transferred the function of analysis of meteorological and hydrological data and monitoring of groundwater from WAPDA since 1994. The Bureau handles data collection, investigation and planning pertaining to water resources development, and recommends engineering and institutional issues on groundwater problems to the Government. The Bureau struggles with the problems and will implement following studies.

Re-Assessment of the Groundwater Resources Project, completed in March 1996

Hydrometric Network Project, on going from 1994 to September 1997

Management of Groundwater Resources of Balochistan by Developing Mathematical Model Method, preparation for proposal March 1996

Upgrading Monitoring System of Groundwater Resources Project, newly proposed

Flood Forecasting Project, newly proposed

Amongst above, "Re-assessment of the Groundwater Resources Project" assisted by ADB is one of the prominent studies and instructive to alleviate/solve the groundwater problems. The study of the Reassessment includes analysis of groundwater requirement, present condition of groundwater development and study of alternative scenarios of groundwater management together with control based on the potential of groundwater recharge.

The detail of the study deals present conditions and problems on land resources, population and tribes, groundwater resources development, hydrogeology, groundwater recharge, agriculture, electricity supply, environment, administration, institution and law. Through various possible scenarios such as big movement of population and industry due to a shortage of water, destruction of social order due to an abrogation of governmental responsibility or exercise of forcible measure to blockade of illegal well, following scenario is quoted as viable alternative. Through a process of development plan study by participatory approach, and public relation and education, the Government may give communicates with awareness inducing their effort of water saving spirit.

The study of the Reassessment recommends to establish a certain institution of action body for development plan of Provincial and groundwater basin level at groundwater management by means of participatory approach, public relation and education. The study also encourages importance of the role of "Water Resources Bureau", improvement of electricity charging system to conduce groundwater saving and effective use of resources and investment for efficient use of irrigation and domestic water.

3.10.3 Groundwater Economy Study in the Pishin Lora Basin

Global groundwater economy by each sub-basin of the Pishin Lora Basin was studied in this section. On the groundwater economy study, water demand and water supply were independently estimated and compared each other. Water demands are, namely, irrigation water supply and drinking water supply especially in city zone as Quetta, while no industrial water is supplied in the Study Area. Major water demand, irrigation water, can be estimated through the data for irrigated area, unit irrigation water requirement estimated in the condition of present cropping pattern in each district, and irrigation factors. The relation between irrigation area in each sub-basin and the same in each district was investigated consulting available land use map. The unit irrigation water requirement was estimated on the basis of reference evapo-transpiration by modified Penman method, as shown in ANNEX H. Moreover, domestic water supply in rural area was considered at 5.0 % of total amount of

irrigation water. Drinking water supply in urban area such as Quetta, was estimated by urban population projected as of 1995, and applying unit water demand per capita.

On the other hand, groundwater recharge was estimated through two phases. One was to recharge through ground in flat area, the other was to feed groundwater by mountainous area through alluvial fans, in which recharge rate was adopted the results of typical ground water simulation.

In Table 3.10.1, estimated water demand and groundwater recharge were compared. The simulation indicates that all sub-basins of the Pishin Lora Basin need urgent countermeasures because conspicuous water deficits are recognized.

3.10.4 Evaluation of an Effect of Existing Delay Action Dams

Presently, 110 number of delay action dams were constructed in Balochistan, in which 64 delay action dams were located in the Pisin Lola Basin. Essential groundwater recharge effect has been not yet presented in basinwide, due to relatively small number of completed dams comparing wide area of the basin, and scattered location of the dams all over the basin. Meanwhile, some evidences on recharging effect of the delay action dams were obtained in existing data, as follows:

1) Monitoring data of groundwater level in some points of Pishin District where some delay action dams were constructed have shown recovering water stage.

2) Rising groundwater stage had been observed at a monitor well in Quetta Valley, located at downstream of existing Habib Dara Dam.

3) In existing Amach dam, certain contribution on recharge by the delay action dam can be recognized by the karezes flow records even having a time-lag on karez flow with runoff events

As there are some indications showing contribution of the delay action dam even in limited available data, it is assured that a delay action dam is effective for groundwater recharging as far as selecting suitable site, and taking adequate design of the dam.

Table 3.3.1 Rainfall Stations and Their Mean Monthly Rainfall Concerning the Study

Station	Ob.	Elev. (feet)	Duration	Lat.	Long.	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*Jun.*	*Jul.*	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*	Total
(Quetta District)																		
Beleli	UK	-	1891 - 1946	30-15'	66-57'	45.0	43.4	35.6	17.5	4.1	2.8	5.8	5.6	0.5	2.3	5.6	25.9	193.8
Dirgi	UK	-	1891 - 1937	30-19'	67-31'	36.6	47.2	37.1	19.6	8.6	8.9	25.7	17.0	4.8	4.6	5.1	23.6	238.3
Kach **	SU	6,350	1891 -	30-26'	67-18'	51.1	53.1	49.8	21.3	7.4	3.8	13.5	7.4	1.3	1.8	6.4	26.4	244.3
Killi Kotwal*,**	SW	5,700	1970-	30-15'	67-01'	44.4	38.9	56.4	17.8	4.3	4.1	8.4	12.7	0.8	0.0	2.5	23.1	221.2
Mangi	UK	-	1891 - 1937	30-21'	67-30'	34.0	48.0	42.4	16.5	6.9	6.4	17.3	9.9	3.0	3.6	4.8	22.1	213.6
Mud Gorge	UK	-	1891 - 1908	30-23'	67-24'	45.5	46.2	55.1	18.5	10.7	7.4	9.7	6.9	1.3	2.0	8.4	22.9	240.8
Quetta**	PM	5,253	1891 -	30-15'	66-53'	49.8	49.5	40.4	21.1	9.4	4.3	11.2	7.4	1.0	2.8	6.1	28.2	230.1
Sariab	SU	5,640	1900 -	30-06'	66-59'	36.6	32.0	35.1	15.5	4.8	3.3	9.9	8.4	0.8	1.3	3.3	17.8	168.7
Urak	UK	-	1914 - 1946	30-16'	67-11'	58.2	62.5	50.5	27.9	14.7	7.4	31.0	16.0	3.0	4.3	5.8	35.3	312.4
Wali Tangi *	SW	9,000	1961-	30-15'	67-15'	33.8	31.5	84.3	27.2	7.4	3.6	23.1	24.9	3.0	0.3	5.1	34.2	283.5
(Qila Abdullah District)																		
Chaman	OT	-	1893 -	30-56'	66-27'	52.6	46.5	38.1	18.3	3.0	0.5	3.0	1.0	0.5	3.0	5.3	32.5	211.8
Gulistan	UK	-	1891 - 1949	30-36'	66-35'	55.1	44.4	34.3	10.2	1.8	0.5	4.1	0.8	0.3	1.8	5.3	27.9	181.4
Qila Abdullah**	SU	-	1891 -	30-43'	66-37'	63.2	54.4	43.9	14.5	3.0	0.5	3.6	0.8	2.3	2.3	7.1	33.3	227.1
Shela Bagh	UK	-	1892 - 1948	30-49'	66-35'	79.0	74.2	76.7	29.0	5.8	1.8	6.4	2.5	0.0	2.8	9.9	48.5	337.1
(Pishin District)																		
Bandat Jungle**	SW	1,500	1969-	30-29'	67-25'	48.0	50.8	57.9	17.0	4.8	1.8	21.6	18.8	1.5	0.8	5.6	21.3	258.3
Barshore	UK	-	1909 - 1921	30-46'	67-13'	63.8	40.6	54.6	25.1	5.6	7.1	7.1	7.6	0.0	5.3	11.4	46.5	285.5
Bund K. Khan	SU	-	1909 -	30-40'	66-58'	66.5	48.5	43.9	19.1	4.3	1.0	5.8	3.6	0.3	2.0	4.1	32.0	229.4
Bostan	UK	-	1891 - 1950	30-26'	67-01'	50.5	46.2	41.9	17.5	5.8	1.8	6.1	4.1	0.5	2.3	5.6	26.6	208.8
Fullers Camp	UK	-	1891 - 1907	30-27'	67-13'	50.8	57.9	67.3	28.7	10.2	4.6	8.1	2.5	1.0	2.5	8.6	29.0	269.7
Khanai	UK	-	1891 - 1946	30-29'	67-09'	43.4	47.5	38.6	14.5	3.0	3.3	6.1	3.0	0.3	2.5	5.1	26.9	195.1
Kuchlak	UK	-	1891 - 1950	30-21'	66-56'	47.5	39.1	36.6	15.2	5.3	1.5	7.1	2.8	1.3	2.3	5.6	26.4	191.0
Pishin**	UK	-	1891 - 1950	30-35'	66-59'	58.7	53.6	45.7	20.8	5.8	1.3	4.8	4.6	0.5	3.0	6.6	34.0	238.5
Sabura	UK	-	1913 - 1919	31-03'	67-16'	26.4	65.0	68.1	35.3	26.2	0.5	1.0	29.2	0.0	0.5	16.3	21.6	282.2
Saranan	UK	-	1895 - 1950	30-34'	66-52'	51.3	42.4	35.3	15.0	3.0	1.0	4.8	1.8	0.0	2.8	7.1	30.7	193.3
Shebo	UK	-	1930 - 1946	30-32'	66-56'	67.6	54.9	32.5	16.0	3.8	2.0	9.4	3.3	0.3	1.0	2.3	28.7	213.9
Siran Tangi	SW	6,900	1961-	30-24'	67-12'	41.4	45.5	63.0	22.1	7.1	3.6	20.1	15.0	1.0	0.5	4.6	28.4	258.6
Surkhab h/w	UK	-	1930 - 1946	30-35'	67-05'	74.7	51.1	36.1	23.4	6.4	2.0	12.9	5.6	0.0	0.3	2.8	29.7	249.2
Syad Hamid	UK	-	1891 - 1915	30-35'	66-45'	48.5	53.3	41.9	15.5	15.2	1.0	1.0	1.0	0.0	2.3	11.4	31.8	210.8
Tor Morga h/w	UK	-	1930 - 1946	30-42'	67-04'	77.0	54.1	40.1	20.3	5.1	2.0	8.9	2.3	0.0	0.3	2.3	29.7	242.1
Yaru Karez	UK	-	1891 - 1946	30-31'	66-57'	42.2	40.1	35.3	16.8	4.6	0.8	4.6	3.3	0.0	1.8	4.3	29.7	186.2
(Mastung District)																		
Abigum	UK	-	1896 - 1946	29-49'	67-21'	22.1	23.1	16.8	6.9	2.0	5.1	19.8	20.1	3.3	0.8	2.0	9.7	133.9
Hirok	UK	-	1891 - 1946	29-56'	67-14'	64.3	75.2	20.6	18.3	1.0	15.0	39.4	29.0	8.4	2.8	6.6	22.8	309.9
Kanak	UK	-	1906 - 1950	29-58'	66-46'	32.3	36.6	22.9	10.4	3.6	2.0	8.9	9.1	0.8	1.8	2.8	18.8	152.1
Kirda Gap	UK	-	1906 - 1946	29-44'	66-27'	41.7	43.7	23.1	9.9	1.8	0.8	8.6	3.8	0.8	1.8	2.8	24.4	162.3
Kolpur	UK	-	1891 - 1950	29-54'	67-08'	45.5	37.3	31.5	11.7	4.3	3.8	19.3	13.0	2.8	2.8	4.1	20.8	196.6
Mach **	SU	3,200	1892 -	29-52'	67-20'	32.8	32.5	25.1	10.9	6.6	5.6	32.5	32.5	7.6	1.3	2.3	15.0	207.0
Mastung Road**	PM	-	1906 - 1960	29-51'	66-50'	37.1	42.4	22.9	11.2	3.0	2.0	4.1	2.8	0.8	1.8	3.6	17.5	151.1
Mastung	UK	-	1911 - 1950	29-48'	66-50'	48.5	39.4	30.7	17.3	7.6	3.6	7.4	4.3	2.8	2.3	4.8	23.9	191.3
Shaikhwasil	UK	-	1907 - 1950	29-52'	66-34'	58.9	43.2	24.4	12.7	1.5	0.8	7.6	3.6	0.0	2.0	3.3	34.8	190.5
Spezand	SU	5,850	1901 -	29-59'	67-00'	40.4	35.8	33.0	11.9	3.6	1.0	10.2	4.3	0.8	0.8	2.3	17.2	160.8
(Kalat District)																		
Kalat **	PM	6,617	1891 -	29-02'	66-35'	39.1	37.1	28.4	11.9	4.8	4.1	18.5	10.7	2.5	2.0	5.8	18.0	190.8
Mangochar	UK	-	1912 - 1950	29-22'	66-37'	29.2	25.4	20.3	7.9	1.0	1.5	15.2	5.8	2.3	2.3	5.3	19.8	136.9
Surab	SU	5,700	1925 -	28-30'	66-15'	49.3	40.4	33.3	16.3	7.1	3.6	36.1	12.7	0.8	1.3	6.4	22.4	232.2

Ob.: Observing Agencies
PM -- Pakistan Meteorological Office, Government of Pakistan
SW -- Surface Water Hydrology Project undertaken by WAPDA, now being taken over by BWR
SU -- Same as above stations succeeded from UK
UK -- Old colonial rainfall recording office
OT -- Other agency

*: *Hourly rainfall data are available.*
**: Climatological data are available.

Table 3.3.2 Meteorological Factors of Quetta Station

Name of station: Quetta Observed year: 1891 - 1995 (vary depend upon factors)

Items	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Precipitation	mm	49.8	49.5	40.4	21.1	9.4	4.3	11.2	7.4	1.0	2.8	6.1	28.2	230.1
Temperature														
Monthly Max.	C	10.8	12.9	18.7	24.8	30.4	35.3	35.9	34.8	31.4	25.5	19.2	13.3	24.4
Monthly Mean	C	3.7	6.0	11.1	16.6	21.0	25.6	27.9	26.4	21.2	14.7	9.2	5.1	15.7
Monthly Min.	C	-3.4	-0.9	3.4	8.3	11.5	15.9	19.9	17.9	10.9	3.8	-0.9	-3.2	6.9
Bright Sunshine	Hrs	221.6	208.5	232.6	272.5	334.2	325.6	313.5	312.5	294.4	307.2	278.2	238.7	278.3
Solar Radiation	MJ/M	12.0	14.3	17.0	20.9	24.4	26.3	25.2	24.1	22.5	19.7	16.3	12.0	19.5
Wind Mean Speed	Knots	3.0	3.5	3.9	4.0	3.8	4.4	5.3	3.8	2.8	2.2	2.5	2.2	3.4
Relative humidity	%	50.0	50.0	43.0	35.0	27.0	21.0	26.0	24.0	22.0	24.0	29.0	43.0	33.0
Pan Evaporation	mm	116.0	138.0	183.0	240.0	265.0	297.0	427.0	384.0	250.0	150.0	121.0	109.0	223.3

Mean Monthly Rainfall of Quetta Station

(Unit:mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1891													
I	38.0	34.0	33.0	15.0	5.0	0.0	3.0	0.0	0.0	0.0	1.0	19.0	210.0
1946													
1947													
I	80.2	114.8	35.2	24.8	33.5	29.8	38.1	28.1	0.7	11.7	29.8	54.9	481.5
1960													
1961	19.1	36.3	11.2	73.2	2.3	4.8	10.9	1.3	0.0	0.0	8.6	33.5	201.2
1962	0.5	7.6	78.0	59.7	5.3	0.0	2.5	0.0	0.0	0.0	0.0	7.9	161.5
1963	0.0	30.0	23.1	41.9	39.9	0.0	0.0	0.0	0.0	0.0	7.1	9.4	151.4
1964	85.9	11.7	38.1	28.2	0.3	0.0	7.4	0.0	0.0	0.0	0.0	7.1	178.7
1965	49.0	15.0	17.3	118.9	0.0	0.0	2.5	0.0	0.0	0.0	25.4	38.4	266.5
1966	1.8	52.6	10.2	38.9	0.0	0.0	25.1	0.0	0.0	10.4	0.0	0.0	139.0
1967	7.1	82.8	63.2	36.1	0.5	0.0	3.0	2.5	0.0	0.0	4.3	44.7	244.2
1968	67.6	77.2	11.9	7.1	16.3	0.0	3.0	0.0	0.0	0.0	0.0	42.9	226.0
1969	18.5	22.1	6.1	34.5	18.0	0.0	23.1	0.0	0.0	0.0	1.8	13.7	137.8
1970	96.0	15.2	33.5	2.0	0.0	0.0	1.5	15.5	7.6	0.0	0.0	7.1	178.4
1971	7.4	21.8	16.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	15.7	62.2
1972	87.6	22.4	52.3	44.7	2.6	2.5	1.3	0.0	0.0	0.0	0.0	40.9	254.3
1973	82.8	18.0	9.7	0.8	1.3	0.0	38.1	0.0	0.0	0.0	0.0	56.9	207.6
1974	69.6	120.3	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.9	210.6
1975	78.2	45.2	46.9	7.1	0.0	0.0	7.3	28.0	1.0	0.0	0.0	18.6	232.3
1976	31.2	74.4	136.8	24.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	274.2
1977	91.5	6.0	0.6	10.4	16.0	19.2	48.1	14.0	0.0	0.0	25.2	8.6	239.6
1978	68.0	58.3	18.2	16.5	0.0	0.0	121.8	1.1	0.0	0.0	23.1	10.5	317.5
1979	70.8	90.2	112.3	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	68.1	348.9
1980	69.9	30.0	95.5	2.7	0.0	5.2	0.0	0.0	0.0	24.8	13.1	3.6	244.8
1981	111.9	105.1	63.5	0.0	17.0	0.0	2.0	0.0	0.0	13.0	0.0	35.0	347.5
1982	178.0	189.2	232.4	30.4	23.0	0.0	0.0	50.0	0.0	68.8	16.0	162.0	949.8
1983	61.0	61.0	68.1	148.0	29.0	0.0	22.0	173.0	0.0	0.0	0.0	71.2	633.3
1984	58.2	19.4	40.5	5.8	0.0	0.0	0.0	1.3	0.0	0.0	0.0	18.0	143.2
1985	54.6	0.0	78.0	88.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.7	257.1
1986	4.2	102.8	45.8	0.0	0.0	0.0	1.0	66.0	0.0	0.0	19.6	4.5	243.9
1987	18.4	30.2	93.1	2.0	5.0	0.0	0.0	7.1	0.0	0.0	0.0	0.0	155.8
1988	29.6	14.8	121.1	0.0	0.0	0.0	59.5	0.0	0.0	0.0	0.0	34.0	259.0
1989	46.7	30.4	86.2	13.0	0.0	0.6	1.2	0.6	0.0	0.0	13.0	51.4	243.1
1990	137.1	79.5	40.8	2.8	0.0	0.0	0.0	1.6	0.0	0.0	1.0	50.4	313.2
1991	76.6	41.7	104.8	38.0	21.8	0.0	0.0	0.0	7.6	0.0	8.5	16.8	315.7
1992	46.0	53.6	32.2	89.2	13.2	0.0	0.0	15.4	0.0	12.2	0.0	48.4	310.2
1993	110.0	28.9	51.9	12.1	4.1	2.1	0.5	0.0	0.0	0.0	0.0	0.0	209.6
1994	20.6	47.1	26.6	8.3	19.7	0.0	67.6	6.2	78.8	0.0	0.4	21.1	296.4
1995	23.5	45.5	35.5	32.3	0.0	0.0	25.7	0.0	0.0	1.2	0.0	128.9	292.6
Mean	49.8	49.5	40.4	21.1	9.4	4.3	11.2	7.4	1.0	2.8	6.1	28.2	230.1

Table 3.10.1 Groundwater Economy in Each Sub-Basin

Irrigation Water Volume in Each Sub-Basin

Districts / Basin/Sub-Basin	Pishin			Quetta			Mastung			Kilat			Total		
	Irr.Area (ha)	818.33 762.68	(mm) 55.65	Irr.Area (ha)	986.10 850.02	(mm) 135.08	Irr.Area (ha)	773.67 754.33	(mm) 19.34	Irr.Area (ha)	872.09 781.39	(mm) 90.70	Irr.Area (ha)		
Pishin Lora Basin															
Pishin	19,790	**150.94**	*11.01*	480	**4.08**	*0.03*							20,270	**155.02**	*11.05*
Kuchlagh	3,710	**28.30**	*2.06*	4,400	**37.40**	*0.32*	1,070	**8.07**	*0.21*				9,180	**73.77**	*2.59*
Quetta				5,180	**44.03**	*0.37*	3,210	**24.21**	*0.62*				8,390	**68.24**	*1.00*
Kolpur							910	**6.86**	*0.18*				910	**6.86**	*0.18*
Mastung							5,200	**39.23**	*1.01*				5,200	**39.23**	*1.01*
Shirinab							6,400	**48.28**	*1.24*	330	**2.58**	*0.30*	6,730	**50.86**	*1.54*
Mangochar							250	**1.89**	*0.05*	2,230	**17.43**	*2.02*	2,480	**19.31**	*2.07*
Sardar Khel							1,890	**14.26**	*0.37*				1,890	**14.26**	*0.37*
Patki Shah Nawaz										2,630	**20.55**	*2.39*	2,630	**20.55**	*2.39*
Kalat										11,750	**91.81**	*10.66*	11,750	**91.81**	*10.66*
Kopoto										1,070	**8.36**	*0.97*	1,070	**8.36**	*0.97*
Sub-total	23,500	**179.23**	*13.08*	10,060	**85.51**	*0.73*	18,930	**142.79**	*3.66*	18,010	**140.73**	*16.33*	70,500	**548.27**	*33.80*
Other Basin	8,190	**62.46**	*4.56*	0	**0.00**	*0.00*	11,910	**89.84**	*2.30*	2,910	**22.74**	*2.64*	23,010	**175.04**	*9.50*
Total	31,690	**241.69**	*17.63*	10,060	**85.51**	*0.73*	30,840	**232.63**	*5.96*	20,920	**163.47**	*18.97*	93,510	**723.31**	*43.30*

Figuirs in bold letter are the quantity of irrigated water by groundwater at the unit of MCM.
Figuirs in *italic* letter are the quantity of irrigated water by surface water at the unit of MCM.

Groundwater Economy in Each Sub-Basin

Items	(unit)	Pishin	Kuchlagh	Quetta	Kolpur	Mastung	Shirinab	Mangocha r	Sardar Khel	Patki Shah Nawaz	Kalat	Kopoto	Remarks
Annual Rainfall	(mm)	238.5	208.8	230.1	196.6	151.1	162.3	136.9	151.1	162.3	190.8	190.8	
Lowland Area	Km2	3,060	760	870	40	440	740	330	260	490	1,090	60	
Aquifer	Km2	565	520	440	30	210	300	200	100	120	810	20	
Aquitard	Km2	2,495	240	430	10	230	440	130	160	370	280	40	
Highland Area	Km2	3,890	980	920	70	350	590	340	240	510	1,150	110	
Total Area	Km2	6,950	1,740	1,790	110	790	1,330	670	500	1,000	2,240	170	
Spec. Recharge (1)	(mm)	71.6	62.6	69.0	59.0	45.3	48.7	41.1	45.3	48.7	57.2	57.2	
Effective Area (1)	Km2	565	520	380	30	210	300	200	100	120	810	20	
Recharge (1)	MCM	40.4	32.6	26.2	1.8	9.5	14.6	8.2	4.5	5.8	46.4	1.1	
Spec. Recharge (2)	(mm)	71.6	62.6	69.0	59.0	45.3	48.7	41.1	45.3	48.7	57.2	57.2	
Effective Area (2)	Km2	1,167	392	460	42	210	295	136	72	153	460	66	
Recharge (2)	MCM	83.5	24.6	31.8	2.5	9.5	14.4	5.6	3.3	7.4	26.3	3.8	
Total Natural Recharge	MCM	123.9	57.1	58.0	4.2	19.0	29.0	13.8	7.8	13.3	72.7	4.9	403.8
Catchment of DADs	Km2	310	144	57	0	47	2	5	0	35	55	0	
Existing DADs' effect *	MCM	7.4	3.0	1.3	0.0	0.7	0.0	0.1	0.0	0.6	1.0	0.0	
Total Recharge	MCM	131.3	60.1	59.3	4.2	19.7	29.0	13.9	7.8	13.9	73.7	4.9	417.9
Irrigated Water	MCM	155.02	73.77	68.24	6.86	39.23	50.86	19.31	14.26	20.55	91.81	8.36	
Return of Irrg.water **	MCM	-7.75	-3.69	-3.41	-0.34	-1.96	-2.54	-0.97	-0.71	-1.03	-4.59	-0.42	
Rural water	MCM	4.65	2.21	2.05	0.21	1.18	1.53	0.58	0.43	0.62	2.75	0.25	
Arban Population	1,000Psn.	25	20	537	5	26	5	5	5	5	18	5	
Drinking Water	MCM	0.55	0.44	11.76	0.11	0.57	0.11	0.11	0.11	0.11	0.39	0.11	
Total Groundwater	MCM	152.5	72.7	78.6	6.8	39.0	49.9	19.0	14.1	20.2	90.4	8.3	551.7
Water Deficit	MCM	-21.1	-12.6	-19.3	-2.6	-19.3	-21.0	-5.2	-6.3	-6.4	-16.6	-3.4	-133.8
Observed Deficit ***		(-13.0)		(-17.0)		(-18.4)							
	%	-13.9%	-17.3%	-24.6%	-37.9%	-49.4%	-41.9%	-27.2%	-44.6%	-31.6%	-18.4%	-40.7%	-24.2%

* : The recharging effect by existing DADs was estimated multiplying total catchment area of DADs by 10% of annual rainfall.
** : The return water on irrigation water supply was estimated assuming 5% of the irrigated water.
*** : The observed deficit of groundwater was an estimated water deficit using monitored data of groundwater level.
(The figure of Quetta is an estimated water deficit for the Quetta Northea Sub-Basin.)

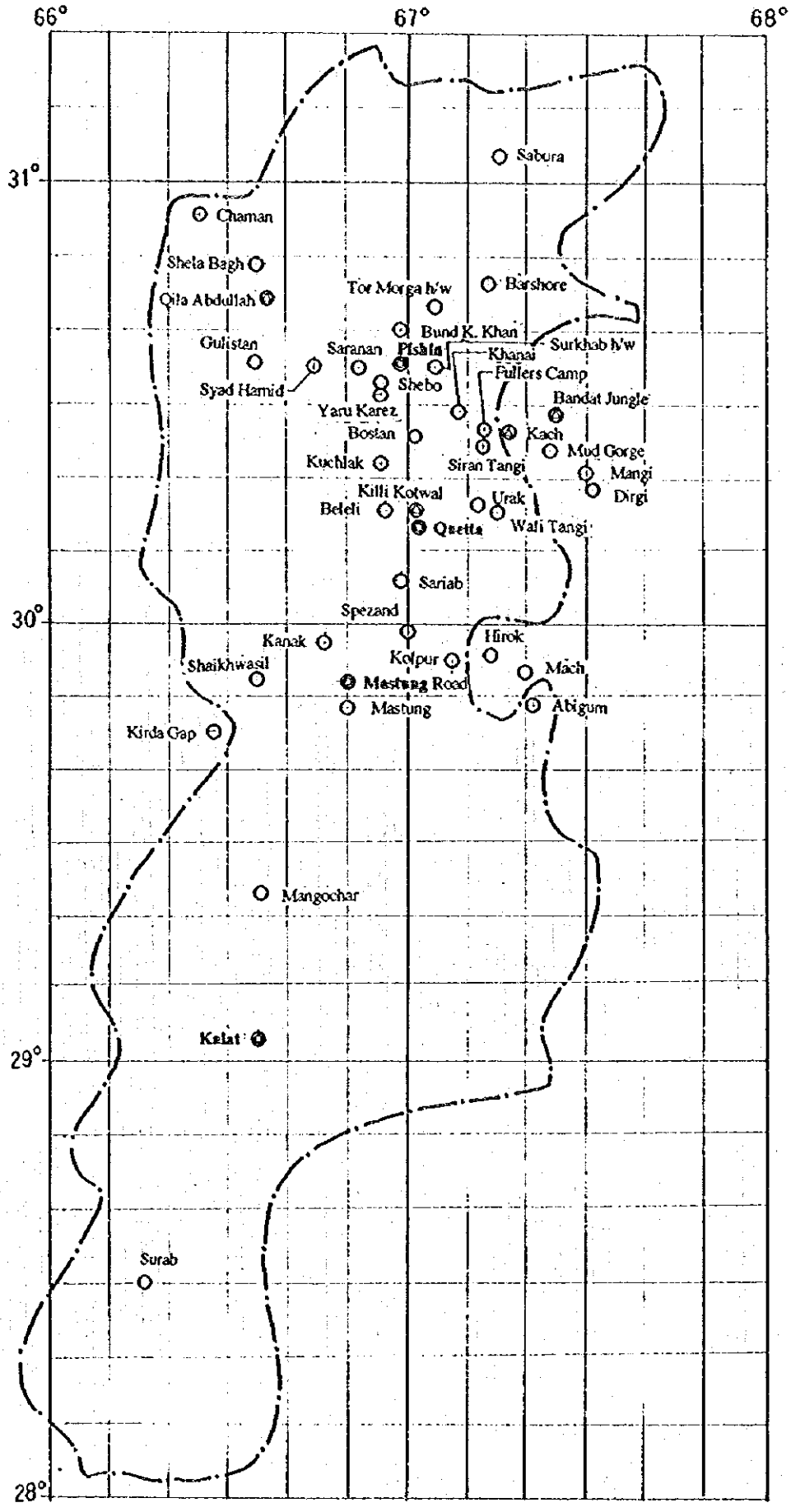


Fig.3.3.1 Climatic Stations in the Study Area

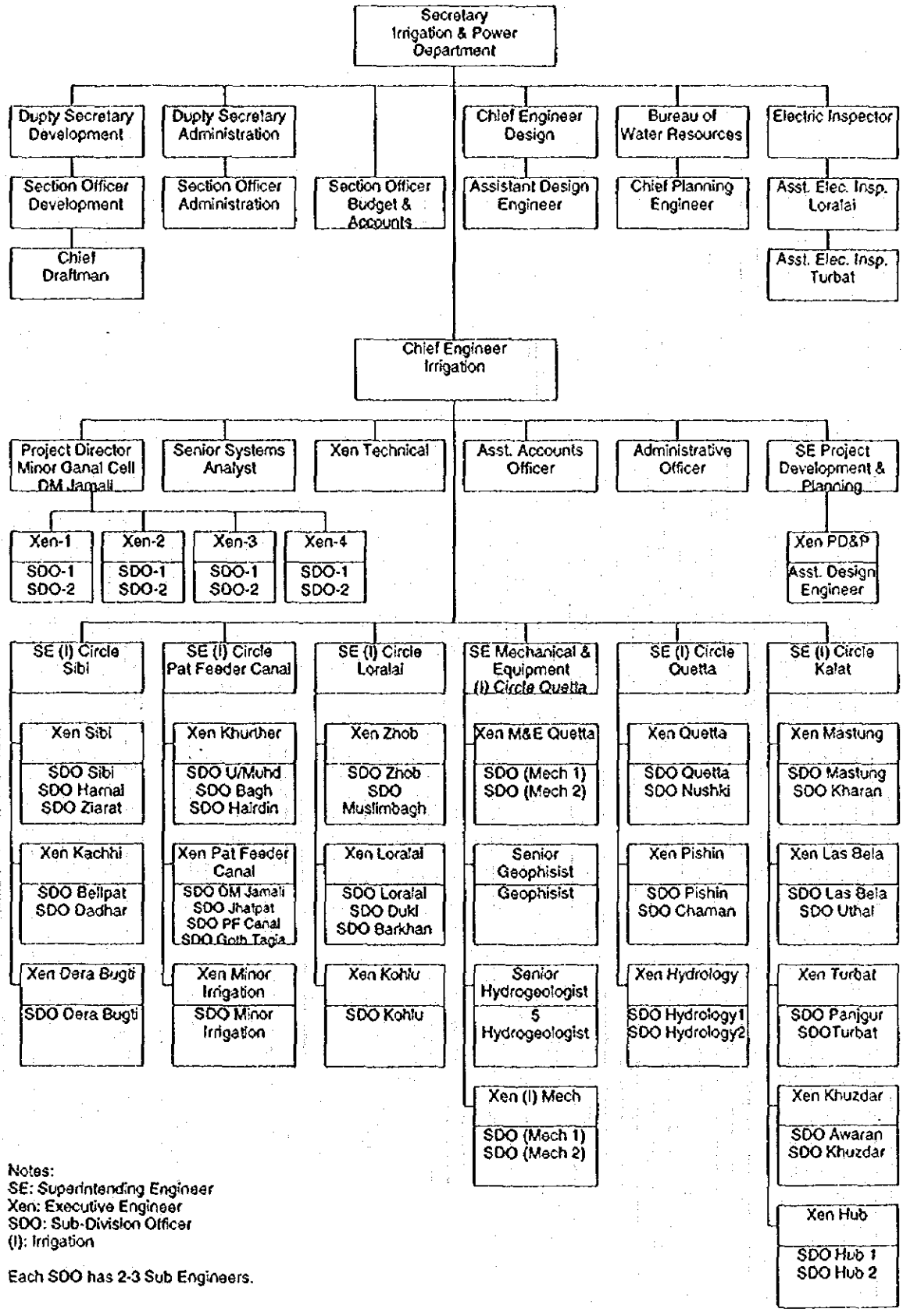


Fig. 3.10.1

Organization Chart of Irrigation and Power Department of Balochistan