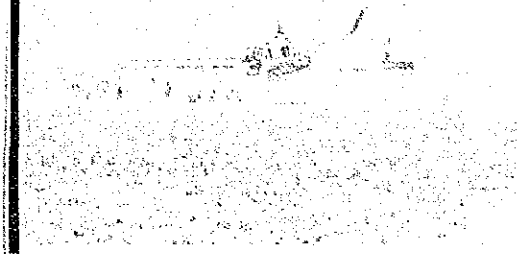
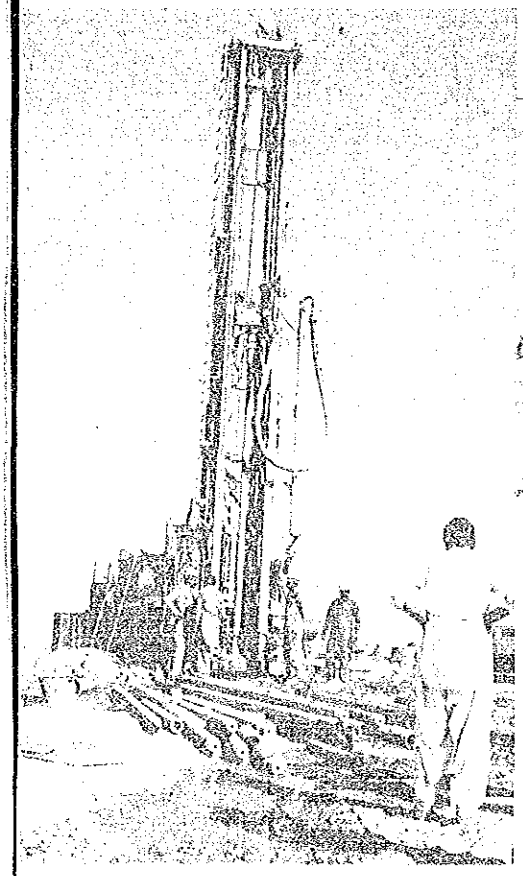
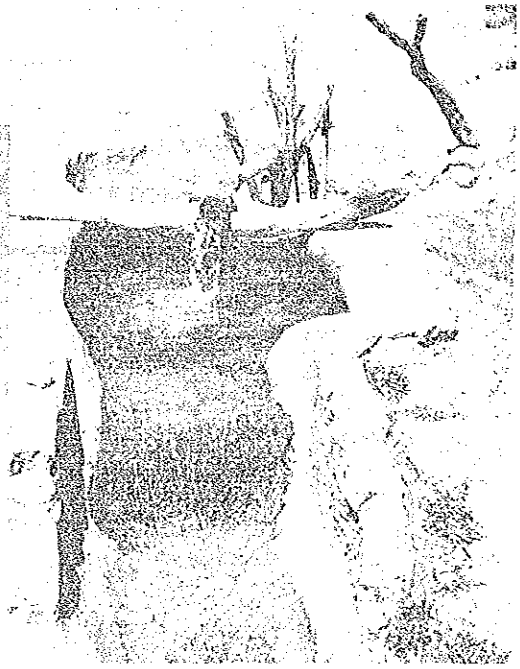
THE ISLAMIC REPUBLIC OF PAKISTAN



MASTER PLAN STUDY ON
BALUCHISTAN IRRIGATION DEVELOPMENT PROJECT
THROUGH GROUNDWATER DEVELOPMENT





FINAL REPORT

VOLUME I

MAIN REPORT

MARCH 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

THE ISLAMIC REPUBLIC OF PAKISTAN

MASTER PLAN STUDY ON
BALUCHISTAN IRRIGATION DEVELOPMENT PROJECT
THROUGH GROUNDWATER DEVELOPMENT

FINAL REPORT

VOLUME I

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JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the request of the Government of the Islamic Republic of Pakistan, the Japanese Government has decided to conduct a survey on the Baluchistan Irrigation Development Project through Groundwater Development and entrusted the survey to the Japan International Cooperation Agency. The JICA sent to Pakistan a survey team headed by Mr. Masahito Yamanaka, Pacific Consultants International, four times in the period from June 1986 to January 1988.

The team exchanged views with the officials concerned of the Government of Pakistan and conducted a field survey (Phases I and II) in the Quetta and Kalat areas of Baluchistan Province. After the team returned to Japan, further studies were made and the present report has been prepared.

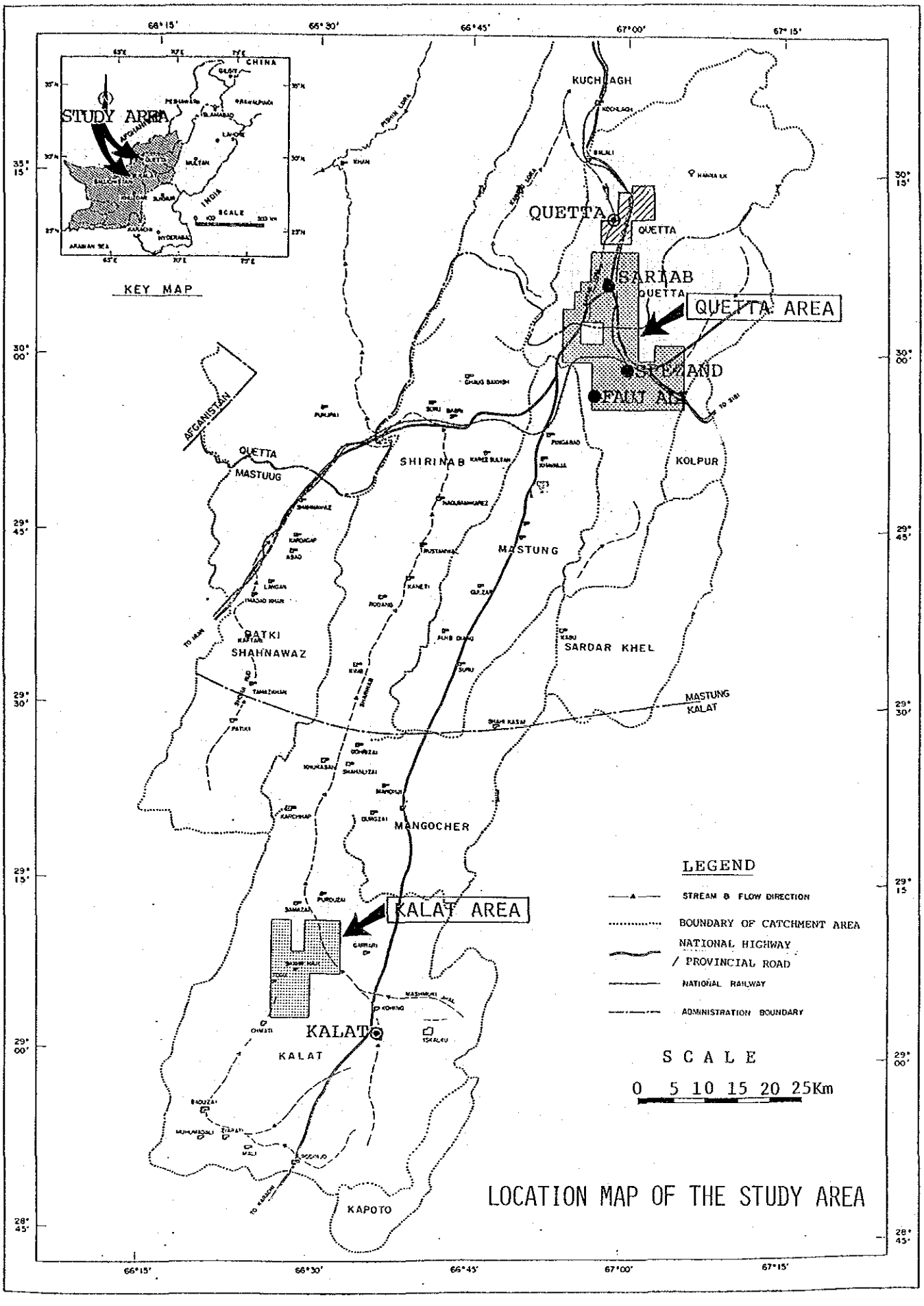
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

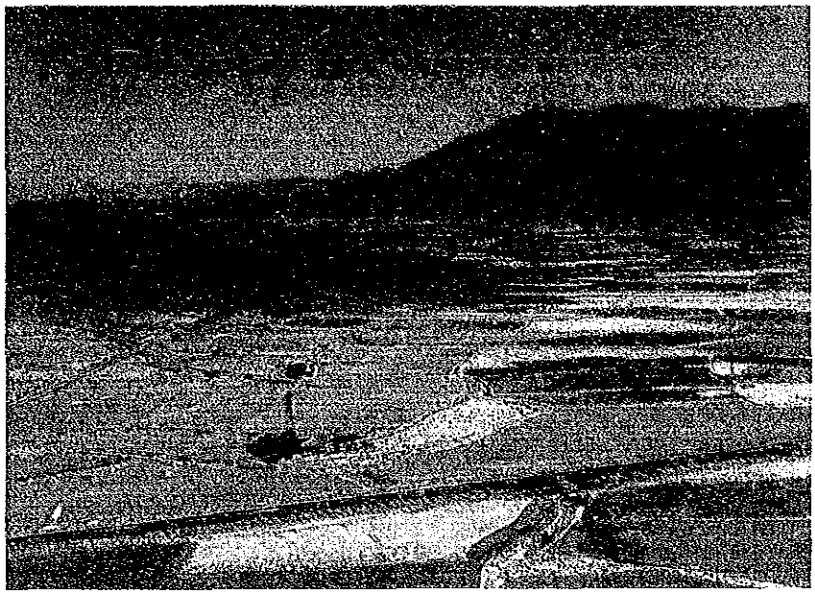
I wish to express my deep appreciation to the officials concerned of the Government of the Islamic Republic of Pakistan for their close cooperation extended to the team.

March 1988

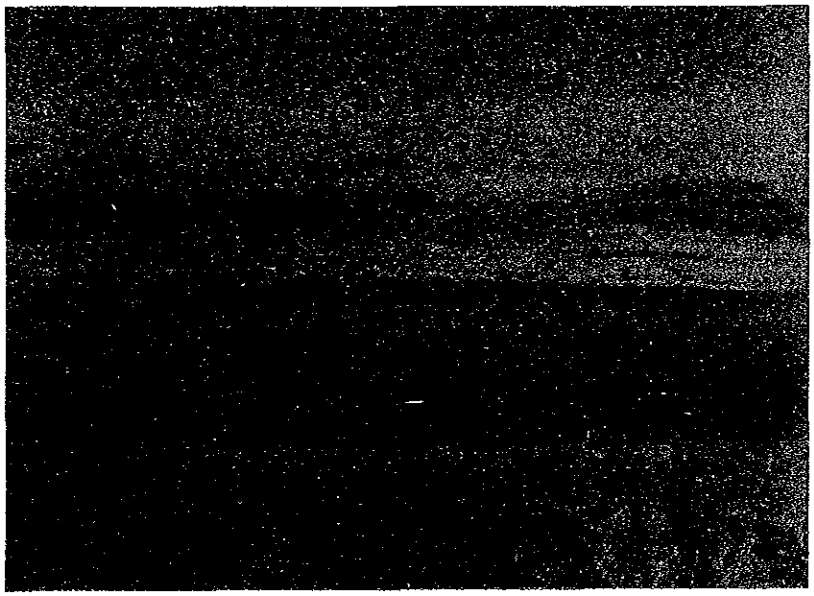
Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

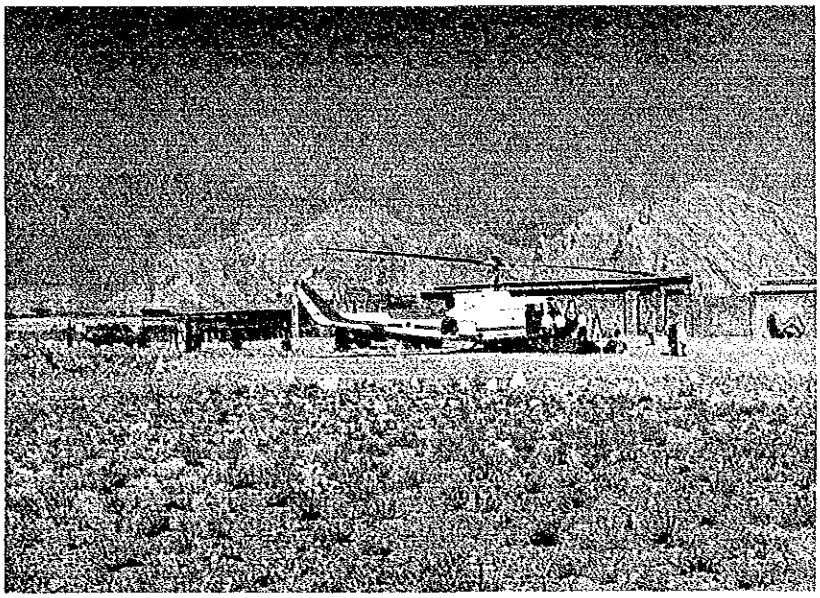

KEY MAP
STUDY AREA
CHINA
INDIA
AFGHANISTAN
ARABIAN SEA
SCALE
KUCHLAGH
QUETTA
SARIAB
QUETTA AREA
SPEZAND
FAUJ ALI
AFGANISTAN
QUETTA
MASTUUG
SHIRINAB
KOLPUR
MASTUNG
PATKI
SHAHNAWAZ
SARDAR KHEL
MASTUNG
KALAT
MANGOCHER
KALAT AREA
KALAT
KAPOTO
LEGEND
STREAM & FLOW DIRECTION
BOUNDARY OF CATCHMENT AREA
NATIONAL HIGHWAY
/ PROVINCIAL ROAD
NATIONAL RAILWAY
ADMINISTRATION BOUNDARY
S C A L E
0 5 10 15 20 25Km
LOCATION MAP OF THE STUDY AREA



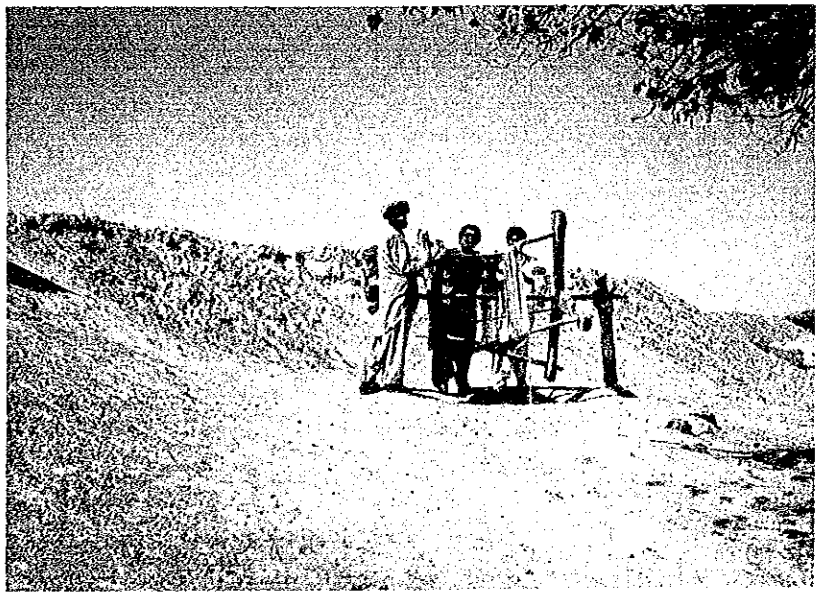
QUETTA AREA



KALAT AREA



SURVEY HELICOPTER



EXISTING OPEN WELL

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

1. INTRODUCTION

1.1 This is a summary of the Master Plan Study on Baluchistan Irrigation Development Project through Groundwater Development. The report of this study consists of the following three volumes:

Volume I : Main Report
Volume II : Appendices
Volume III: Aerial Gamma-ray Spectro Prospecting

1.2 The Study aims to survey groundwater resources in Quetta and Kalat Districts of Baluchistan, and to formulate the Master Plan for an irrigation development project based on the development of groundwater resources.

2. BACKGROUND

2.1 The Sixth National Economic Plan attached great importance to the agricultural development programme in this region which has a high potential in the agricultural production at the preceded objective in order to catch up with the latest progress and to facilitate the Province of Baluchistan to play an important role in the national economy.

2.2 To increase the agricultural production of the area, it is indispensable to develop the groundwater resources, although the investigation method so far applied has not brought a successful result of finding the fractured and fissured groundwater veins which are widely distributed in the area.

2.3 The Government of Baluchistan came to know that a survey method with the helicopter-borne aerial gamma-ray spectro prospecting apparatus, which has given satisfactory results in Japan, may be effective for the investigation in the widely spread area.

2.4 The Government of Pakistan requested the Government of Japan in January 1986 to conduct the Master Plan Study on Baluchistan Irrigation Development Project through Groundwater Development by heli-borne aerial gamma-ray spectro prospecting.

2.5 In response to the request, the Government of Japan through Japan International Cooperation Agency (JICA) dispatched the preliminary survey mission to Pakistan in March 1986 to discuss and conclude the Scope of Work (S/W) for the requested master plan study. In accordance with the S/W, the study was conducted during the period of September 1986 - December 1987.

3. THE STUDY AREA

3.1 The Study Area selected for the aerial gamma-ray spectro prospecting is summarized as follows:

- Quetta Area (located south of Quetta City, both in Quetta and Kalat Districts):	28,000 ha
- Kalat Area (located approx. 15 km northwest of Kalat Town, in Kalat District):	12,000 ha
- Total:	40,000 ha

3.2 The Quetta Area is divided into two drainage areas by Landi Mountain (EL. 2,354 m) which is located in the centre of the Quetta Valley. The altitudes of the northern part and southern part of the Area are 1,700 m ASL with slope of 1.0% and 1,800 m ASL with slope of 0.3 - 1.0%, respectively. On the other hand, the altitude of the Kalat Area is 1,800 m ASL with slope of 1.0 - 2.0%.

3.3 The Study Area is characterized by cold winter, cool summer, and frequent fog and dry climate with mean annual rainfall of about 200 mm occurring mostly in winter.

The annual rainfalls in the Study Area estimated with probability of non-exceedance are 75 - 163 mm and 56 - 136 mm for 5 year and 10 year return periods, respectively.

3.4 In the highlands surrounding the Quetta Area, the Chiltan Formation of Mesozoic era is widely developed. The Shrinab and Parh Group Formations distribute in the western and eastern parts of the Area with small scale. The Brewery Formation of Tertiary era is found in a limited section in the eastern part of the Area. The Quaternary Formation overlaying them expands in the Quetta valley and in lowlands of Dasht-i-Khuni area.

The Shirinab Formation of Mesozoic era is outcropped widely in the highlands of the Kalat Area. The Chiltan Formation is also found in many places of the eastern part of the Area. However, the Parh Series Formation is outcropped with small scale in north-eastern part of the Area. The Spintangi and Wakabi Formations of Tertiary era spread in the eastern and western part of the Area, respectively. The Quaternary Formation is widely developed in lowlands of the Area.

3.5 Most of the area surveyed in Quetta Area has got very high potential for irrigated agriculture. Nearly 64% of the area falls under class-I, II and III lands which are either free from physical and chemical limitations of requiring only slight to moderate corrective measures. The remaining 36% of the areas suffers from excessive slopes and may be used for grazing or forest purpose.

The soils of the Kalat Area are inherently productive, deep, well drained, free from excessive salts and capable of producing all climatically suited crops.

3.6 The number of villages in the Study Area is 10 and the total population of the Study Area is estimated at 11,500 persons, while the total number of households is approximately 1,530, of which farm households represent 1,400. The average household size is 7.7 in Quetta and 6.9 in Kalat Districts.

3.7 The main findings of the farm household economic survey of the Study Area are:

(1) Nearly half of the planted area among the sample households is under wheat followed by cumin, fodder crops, apple, potato and onion, and their yields are 1.6, 0.2, 9.0, 5.5, 8.3 and 12.5 t/ha, respectively.

(2) Average size of land holding is 52.5 ha, consisting of 5.4 ha for wheat, 2.6 ha for field crops, 2.1 ha for permanent crops (fruit) and 42.4 ha for pasture/fallow area. Pasture land includes common tribal land which is occasionally unsettled.

(3) Those without irrigated land supplement their meager farm income with off-farm employment. The average per capital income for the whole sample households turned out to be US$445, which is somewhat larger than national average of US$340 while the per capita income for those without irrigated land remained at the poverty line.

3.8 The Quetta Area of 28,000 ha includes the cultivated land of 13,705 ha (49%) of which 13,626 ha is ordinary upland field and 79 ha is orchard.

The Kalat Area of 12,000 ha includes the cultivated area of 2,793 ha (23.3%) of which 2,778 ha is ordinary upland field and 15 ha is orchard.

3.9 Agriculture in the Study Area is summarized as follows:

Major summer crops (Khari crops) are sorghum (grain and green), maize (grain and green), onion, potato, vegetables and melon.

Winter crops (Rabi crops) include wheat, cumin, vegetables and alfalfa (under fruit trees).

Rainfed field (Barani/Sailaba) is dominant in the Study Area and sorghum and melon as summer crops and wheat and cumin as winter crops occupy the maximum hectarage.

The farmers having the supply of irrigation water grow cash crops like vegetables and fruits which give good return to them.

3.10 Average yields of main crops in the Study Area are summarized as follows:

(Unit: 10^3 ton)

Area	Wheat	Cumin	Onion	Potato
Baluchistan Prov.	376.6	2.0	88.9	68.4
Quetta Div.	61.6	1.1	15.9	24.6
Quetta Dis.	2.4	0.1	3.4	0.5
Kalat Div.	67.2	0.8	62.5	41.5
Kalat Dis.	31.1	0.7	56.4	41.3

3.11 The present crop budget for representative crops in the Study Area (unirrigated land only) is estimated as follows:

Crop	Farmgate Price (Rs/kg)	Yield (kg/ha)	GPV (Rs/ha)	Production Cost (Rs/ha)	NPV (Rs/ha)	NPV Ratio (%)
Wheat	2.0	1,050	2,100	1,049	1,051	50
Cumin	19.6	284	5,566	3,798	1,768	32
Sorghum	1.5	472	708	666	42	6
Barley	2.0	632	1,264	856	405	32

3.12 Vegetables and fruit trees are mostly irrigated with a basin method. The average size of a basin is 8 x 8 m. Furrow irrigation with 30 cm high and 1 m interval is widely adopted for vegetable cultivation. In order to prevent the surface runoff of rain water and to store the surface runoff and also to prevent the top soil and gully erosions, a kind of flood irrigation method 'Bundats' is widely adopted for wheat cultivation during winter by making a bund at the downstream edge of the field.

The average irrigation intervals for the vegetable cultivation and fruit trees are reportedly 7 to 10 days and 2 to 4 weeks, respectively.

3.13 Three (3) delay action dams were constructed at the end of gorge near the Quetta Area and one (1) near the east entrance of the Kalat Area, aiming at the recharge of groundwater and to minimize the flood peak discharge and debris runoff. No artificial drainage facilities are found in the Study Area.

4. GROUNDWATER RESOURCES

4.1 In the Quetta Area, approx. 25 tube wells and approx. 170 open wells exist in the Quetta Area and almost all these wells concentrate to the northern part of the Area. In the southern part of the Area, the groundwater which is collected from open wells by manual or with camel is used only for domestic purpose only except at Fauj Ali area in the western part. Eight (8) tube wells have been constructed in the Area recently.

In the Kalat Area, total 22 open wells in respective villages are supplying domestic water to the villagers. The Dudran spring located approx. 5 km east of the Area is supplying irrigation water to the field of approx. 200 ha in the eastern part of the Area and also domestic water to the villagers living near by.

4.2 Baluchistan Ordinance No. IX of 1978 entitled "The Baluchistan Ground Water Rights Administration Ordinance, 1978" provides the means for the water rights of administery tube well projects except in tribal area. Though this ordinance has been in force since 1978, there is little evidence that has been enforced.

4.3 The present extraction amount of groundwater is estimated to be 7 million and 8 million m^3 per year in the Quetta and Kalat Areas.

The balance in the northern part of the Quetta Area is minus and there will be no more allowance for future groundwater development. However, there will be still big allowance in the southern part of the Quetta Area.

There will be still big allowance in the Kalat Area (2% and 27% are used in western and eastern part, respectively).

4.4 According to the Department of Agriculture, Baluchistan, the groundwater in the Study Area can be defined as Class II water. On the other hand, according to the USDA Salinity Laboratory's Grouping, it is defined as C3-S1.

Area	EC (us/cm)	pH	SAR
Quetta, Northern Part	905	8.2	2.2
Quetta, Southern Part	895	7.9	2.0
Kalat	1,175	7.5	3.0

4.5 The results of the groundwater investigation in the Study Area conducted by the heli-borne aerial gamma-ray spectro prospecting are:

- In the Quetta Area, four (4) moving groundwater veins (A, B, C and E) have been detected. Veins A and B are located on both sides of Quetta Valley and the groundwater is flowing in the direction of Quetta City. Vein C is situated at the end portion of Vein A and Vein E is along the Zarakhu Nala. In addition to these veins, there are ten (10) stagnant groundwater zones.

- In the Kalat Area, three (3) moving groundwater veins (veins A, B and C) have been detected. Vein A runs through the central part of the Area and meets with Vein B at the northern part of the Area. Vein C is located at the west side of Mt. Chhappai. The groundwater flow of all these veins is to the north. Additionally, there are two (2) stagnant groundwater zones on both sides of Vein A.

- The specific capacities of respective veins are estimated as 40 - 70 m^3/day/m in the Quetta Area and 130 - 150 m^3/day/m in the Kalat Area based on the detected intensity of gamma-ray.

- The total possible yields of moving groundwater are estimated to be 17,730 m^3/day (153.2 1/sec) and 13,470 m^3/day (116.4 1/sec) in the Quetta Area and the Kalat Area, respectively.

- On the other hand, the possible yields of stagnant groundwater estimated on the basis of the estimated specific capacities in respective groundwater zones are 7,880 m^3/day (68.1 1/sec) and 3,880 m^3/day (33.5 1/sec) in the Quetta Area and the Kalat Area, respectively.

4.6 In order to verify the depth of basement at the sites that had been detected to have the high potential for groundwater development through field aerial gamma-ray spectro prospecting, the seismic prospecting was conducted on three lines totalling 6,000 m. At D-zone and E-vein of the Quetta Area and A-vein in the Kalat Area, the prospecting was performed, the depth to the base rock is estimated 200 - 250, 150 and 70 m, respectively. Also some fissured rock zones are expected in the base rock.

4.7 The field well test was carried out to confirm the results obtained through the aerial gamma-ray spectro prospecting at 7 ground veins/zones.

The tentative test results are summarized below:

Area	Quetta		Kalat		
Vein/Zone	QT-D	QT-E	KL-A	KL-B	KL-C
Name of Well	QT-JICA-2	QT-JICA-1	KL-JICA-1	KL-JICA-2	KL-JICA-3
Alluvium Depth (m)	163	105	103	150	205
Base Rock Penetration (m)	100	100	197	150	95
Total Well Depth (m)	263	205	300	300	300
Static Water Level (m BGL)	65.0	110.0	57.0	44.1	51.7
Pumping Rate (l/sec)	-	-	-	-	-
Specific Discharge (m^3/day/mdd)	**	**	1.5	17	78
Base Rock Lithology	Limestone	Limestone	Shale with minor limestone	Shale with little limestone	Upper portion limestone then shale
Possibility of groundwater in fissured zone	100%	100%	less	less	few

5. THE PROJECT

5.1 The Project is formulated with the intention of improving the living standards of the farmers in the Study Area by introducing the irrigation farming system and improving the marketing and transportation systems in order to cope with the factors that prevent the agriculture development in and around the Study Area.

5.2 Based on the results of aerial gamma-ray spectro prospecting, well tests, seismic prospecting, field investigations of existing wells, analyzed present groundwater conditions and natural conditions, four (4) areas, QT-D and QT-E in Quetta Area and KL-B and KL-C in Kalat Area, are selected as the Project Area.

5.3 The groundwater development plan is established based on the results of the aerial gamma-ray spectro prospecting. Well tests and seismic prospecting as shown in the following table.

Item	QT-D	QT-E	KL-B	KL-C	Total
Alluvium Depth (m)	150	100	150	200	-
Base Rock Penetration (m)	100	100	100	100	-
Total Well Depth (m)	250	200	250	300	-
Total Pumping Head (m)	100	150	100	100	-
Pumping Rate (1/sec/well)	15	5	5	15	-
Number of Wells (incl. test wells)	4	5	4	3	16
Estimated Total Extraction Amount (m^3/day)*/	3,888	1,620	1,296	2,916	9,720

*/ Pumping: 18 hr/day

5.4 The basin irrigation method is proposed in the Project considering the adaptability, easiness of implementation and construction, O/M cost, etc.

In consideration of kind of crops to be irrigated, water losses in the canal and field, and pump operation hour (18 hr/day), the maximum irrigation water requirements on the 10 ha model farm unit are estimated to be 10.2 and 9.9 1/sec for the Quetta and Kalat Project Areas, respectively.

5.5 Irrigation system which is composed of the following facilities from farm pond to the field is planned.

Item	Description (for 10 ha model farm)		
Farm Pond	. Storage capacity:	360 m^3	
	. Pump operation:	18 ha/day	
	. Irrigation hour:	8 hr/day	
	. Brick with mortar surfacing		
		Main	Branch
Irrigation Canal	. Design discharge:	23.1 1/sec	5.8 1/sec
	. Lining:	Mortar	Earth
	. Total length:	1.0 km	3.0 km
		Main	Branch
Farm Road	. With:	3.5 m	2.5 m
	. Pavement:	Gravel	none
	. Total length:	1.6 km	1.0 km
Commund Water Tank	. Storage capacity:	m^3	
	. Brick with mortar surfacing		

5.6 In the Project, connection roads with 5.0 m wide, 26.5 km in total as the access to the Project Area from existing Provincial/National roads, installation of electricity feeder lines of 22.0 km in total to the tube wells are also planned.

5.7 The agriculture plan with three-year rotation cropping pattern of vegetables and orchard is prepared.

The target yields of main crops are set as 0.7, 30.0, 18.0, 15.0 and 17.0 t/ha for cumin, alfalfa, apple, potato and onion, respectively.

Total annual yields of respective irrigation unit farm in each Area is estimated as follows:

Area	5 ha		10 ha		15 ha	
	Vegetables (t)	Fruits (t)	Vegetables (t)	Fruits (t)	Vegetables (t)	Fruits (t)
Quetta	106.5	19.4	213.3	38.8	319.8	58.2
Kalat	88.9	31.0	177.8	62.0	266.7	93.0

6. PROJECT IMPLEMENTATION AND OPERATION AND MAINTENANCE

6.1 Hydrogeology Project WAPDA, Quetta, plays the role as the executing agency which will be responsible for the implementation of the Project.

It is also advised that I & P Department of the GOB assists the Hydrogeology Project WAPDA, Quetta in the implementation of the Project.

6.2 The overall construction period is about one year. The final design of production wells will be made on the basis of the results of the actual drilling and well tests. The construction drawings for irrigation facilities based on the detailed topo-survey will also be carried out after the construction of a well is successful and it is converted to a production well.

6.3 It is proposed that the whole construction works be executed directly by the Hydrogeology Project WAPDA, Quetta; the Executing Agency of the Project.

6.4 Total Project cost is summarized as follows:

(Unit: 10^3 Rs)

Item	QT-D	QT-E	KL-B	KL-C	Total
(1) Construction Works	7,671.8	6,282.1	6,196.5	6,504.5	26,604.9
Groundwater Development Facilities	3,988.2	4540.2	3,768.2	3,378.1	15,674.7
Irrigation Facilities	3,119.1	1,412.2	1,155.6	2,397.5	8,084.4
Roads and Electricity Supply Works	564.5	329.7	1,222.7	728.9	2,845.8
(2) Land Acquisition	279.2	127.9	119.4	204.5	731.0
(3) Sub Total	7,951.0	6,410.0	6,265.8	6,709.0	27,335.9
(4) Contingencies (Physical & Cost Escale.)	1,342.9	1,080.7	1,056.3	1,132.5	4,612.4
(5) Grand Total	9,293.9	7,490.7	7,322.1	7,841.5	31,948.3

6.5 The daily operation and maintenance work should be done by the Mastung and Kalat Agricultural Extension Offices under the direction of the Agriculture Department of GOB. Regarding the monitoring of the groundwater level, the assistance and advice of the Hydrogeology Project WAPDA, Quetta will be definitely required.

Annual operation and maintenance cost and replacement cost for each Project Area is tabulated as follows:

(Unit: 10^3 Rs)

Item	QT-D	QT-E	KL-B	KL-C	Total
Annual O/M Cost	39.2	35.8	21.9	30.1	127.0
Replacement Cost (every 10 year)	876.0	1,150.0	656.0	657.0	3,339.0

7. PROJECT EVALUATION

7.1 Financial and economic construction costs of each Project Area are summarized as follows:

(Unit: 10^3 Rs)

Area	Financial Cost	Economic Cost
QT-D	9,293.9	7,938.2
QT-E	7,490.7	6,403.9
KL-B	7,322.1	6,260.1
KL-C	7,841.5	6,699.6
Total	31,948.2	27,301.8

7.2 The operation and maintenance cost is estimated as follows:

Annual O/M cost

(Unit: 10^3 Rs)

Area	Financial Cost	Economic Cost
QT-D	39.2	34.1
QT-E	35.8	31.1
KL-B	21.9	19.1
KL-C	30.1	26.2
Total	127.0	110.5

Replacement cost for every 10 years

(Unit: 10^3 Rs)

Area	Financial Cost	Economic Cost
QT-D	876.0	762.1
QT-E	1,150.0	1,000.5
KL-B	656.0	570.7
KL-C	657.0	571.6
Total	3,339.0	2,904.9

7.3 The life of the Project is assumed to be thirty (30) years, while the Project works should be completed over one-year implementation period.

7.4 Annual project economic benefit for the representative cases is summarized below:

Item	QT-D		QT-E		KL-B		KL-C	
	W/O	W/	W/O	W/	W/O	W/	W/O	W/
Crops	67.1	2,201.2	28.1	917.2	22.4	664.6	50.3	1,495.2
Water Supply	-	76.8	-	96.0	-	76.8	-	57.6
Total	67.1	2,278.0	28.1	1,013.2	22.4	741.4	50.3	1,552.8
Project Benefit		2,210.9		985.1		719.0		1,502.5

7.5 The economic internal rate of return (EIRR), the economic net present value (ENPV) and the benefit-cost ratio at 10% discount rate for the representative four cases are estimated as follows:

Project Area	EIRR (%)	ENPV (10%) (10^3 Rs)	B/C Ratio (10%)
QT-D	18.1	7,600	1.88
QT-E	10.2	140	1.02
KL-B	6.9	-1,842	0.73
KL-C	13.5	2,749	1.38
Overall	12.9	8,627	1.29

The EIRR shows that with the possible pump discharge of 5 1/sec, KL-B may not be economically feasible if considered independently. The pump discharge of 10 1/sec would be the criteria that possibly sustains the economic feasibility of each Project Area.

7.6 As a financial analysis, the farm budget analysis is performed. Incremental income on individual farm unit in each Project Area is summarized as follows:

Farm Income (10^3 Rs)	QT-D (14.7 ha)	QT-E (4.9 ha)	KL-B (5.1 ha)	KL-C (15.2 ha)
Without Project	16.2	5.4	5.4	16.2
With Project	525.4	175.1	156.4	469.5
Increment	509.2	169.7	151.0	453.3

Assuming that the developed farm unit is allocated to, say, ten (10) non-irrigated farm households for the representative cases, the project implementation would help substantially raise the standard of living above the possible poverty line of Rs.20,000 per household especially among those in QT-D and KL-C Areas.

7.7 With the grace period of 5 years, repayment period of 25 years and interest rate of 10%, the cost-recovering charge inclusive of project cost, O & M, and replacement cost for each farm unit of the four representative cases is estimated below. This corresponds to 80% to 210% of the net revenue as follows:

Case	Farm Unit Area (ha)	Water Charge (Rs1,000/year)	NPV (10^3 Rs/year)	Ratio (%)
QT-D	14.7	421.6	525.4	80
QT-E	4.9	280.8	175.1	160
KL-B	5.1	328.1	156.4	210
KL-C	15.2	470.5	469.5	100

It is confirmed that with the pump discharge is 5 l/sec or so, cases QT-E and KL-B will not be financially feasible.

7.8 In addition to the project benefit that can be quantified and valued in monetary terms, every project entails cost and benefit that are intangible and do not lend themselves to valuation. Because these cost and benefit are factors for project selection, it is important that these are identified and, if possible, quantified. Probable impacts are as follows:

a. Reduction in Regional Disparity
b. Improvement in Farming Practice
c. Development of Local Transportation System
d. Improvement in Health and Sanitary Conditions
e. Social Impacts

7.9 The Project implementation is within the technical and managerial capability of the local government, and it is also economically viable as a whole. However, unless the pump discharge is possibly higher than 10 l/sec in average, an individual project may not be economically nor financially feasible.

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DEFINITION

1.	the Study Area:	the area of both Quetta and Kalat selected for aerial gamma-ray spectro prospecting
2.	the Quetta Area:	the study area in Quetta
	the Kalat Area:	the study area in Kalat
3.	the Area:	the Quetta Area or the Kalat Area to be used in the case of avoidance of repetition of them
4.	QT-C Area:	the area of vein C in the Quetta Area
	KL-B Area:	the area of vein B in the Kalat Area
5.	the Project Area:	the area which will receive the benefits from the Project
6.	the Province:	Baluchistan Province

ABBREVIATION

ADP	:	Annual Development Programme
BDA	:	Baluchistan Development Authority
BGL	:	Below Ground Level
BIAD	:	Baluchistan Integrated Area Development
BMIAD	:	Baluchistan Minor Irrigation and Agriculture Development
CCA	:	Cultivable Command Area
EC	:	Electric Conductivity
EIRR	:	Economic Internal Rate of Return
ENPV	:	Economic Net Present Value
FAO	:	Food and Agriculture Organization
FBS	:	Federal Bureau of Statistics
FIRR	:	Financial Internal Rate of Return
FNPV	:	Financial Net Present Value
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
GOB	:	Government of Baluchistan
GOP	:	Government of Pakistan
GSP	:	Geological Survey of Pakistan
I&P	:	Irrigation & Power Department of Baluchistan
IRR	:	Internal Rate of return
JICA	:	Japan International Cooperation Agency
MET	:	Pakistan Meteorological Department
MVA	:	Megavolt Ampere (= Million Volt Ampere)

NPV	:	Net Present Value
NWD	:	National Wide Dialling
pH	:	Hydrogen Ion Concentration
QDA	:	Quetta Development Authority
RSC	:	Residual Sodium Chloride
SAR	:	Sodium Adsorption Ratio
SFYP	:	Sixth Five Year Plan
SOP	:	Survey of Pakistan
STD	:	Subscribers Trunk Dialling
TDS	:	Total Dissolved Solids
TSS	:	Total Soluble Salts
UNDP	:	United Nations Development Programme
UNICEF	:	United Nations International Children's Emergency Fund
USAID	:	United States Agency for International Development
USDA	:	United States Department of Agriculture
WAPDA	:	Water and Power Development Authority

CONVERSION FACTORS

LENGTH

1 inch (")	=	0.0254 meter (m)
1 foot (', ft)	=	0.3048 meter (m)
1 yard (yd)	=	0.9144 meter (m)
1 mile (M)	=	1.6093 kilometer (km)

AREA

1 sq. yd (yd^2)	=	0.3861 sq. meter(m^2)
1 acre (ac)	=	4,046.9 sq. meter (m^2)
1 sq. mile (M^2)	=	2.590 sq. kilometer (km^2)
1 hectare (ha)	=	10,000 sq. meter (m^2)

VOLUME

1 US gallon	=	3.785 liter (l)
1 cub. inch	=	4,046.9 cub. centimeter (cm^3)
1 cub. foot (ft^3)	=	28,317 liter (l)
1 cub. yard (yd^3)	=	0.7645 cub. meter (m^3)
1 acre feet (ac. ft)	=	1,233.5 cub. meter (m^3)

WEIGHT

1 ton (t)	=	1,000 kilogram (kg)
1 pound (lb)	=	0.454 kilogram (kg)

DISCHARGE

1 US gallon per minute (US gpm)	=	3.785 l/min
	=	0.063 l/sec
1 US gallon per day (US gpd)	=	5.45 m^3/d
1 cusec (ft^3/sec)	=	724 ac.ft/yr
	=	28.317 l/sec
	=	893,004.9 m^3/yr
1 acre feet per year (ac. ft/yr)	=	1,233.5 m^3/yr

VELOCITY

1 cm/sec	=	0.3937 inch/sec
1 knot	=	1.944 m/sec
1 mile per hour (M/hr)	=	1.237 m/sec
	=	0.6214 km/hr

TRANSMISSIBILITY

1 gpd/ft	=	0.0124 m^3/day/m
1 gpm/ft	=	0.028 1/min/m

SPECIFIC CAPACITY

1 US gpm/ft.d.d	=	0.207 1/sec.m d.d.
	=	17.88 m3/day/m d.d.

CONCENTRATION OF DISSOLVED SALTS

1 parts per million (ppm)	=	1 milligram per liter (mg/1)
	=	1.560 milli mhos/cm
	=	1,560 micro mhos/cm (mhos/cm)
	=	1,560 micro siemen/cm (μS/cm)
1 μ mhos/cm	=	1 μS/cm

TEMPERATURE

$$°C = \frac{5}{9} \times (°F - 32)$$

0 °C = 32 °F

100 °C = 212 °F

CHAPTER-1 INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The Government of the Islamic Republic of Pakistan (hereinafter referred to as "Pakistan") emphasizes a balanced rural development in the National Economic Development Plan. However, the Province of Baluchistan has not been developed as expected due to its social and economic reasons. The Sixth National Economic Plan attached great importance to the agricultural development program in this region which has a high potential in the agricultural production at the preceded objective in order to catch up with the latest progress and to facilitate the Province of Baluchistan to play an important role in the national economy.

The Government of Baluchistan has selected the area adjacent to the capital of Quetta and northern and northeastern areas as the priority development areas in the 6th Five Year Plan of the Province. However, it is difficult to set up the comprehensive land use plan due to scarcity of water, the only water source available is the groundwater. To increase the agricultural production of the area, it is indispensable to develop the groundwater resources, although the investigation method so far applied has not brought a successful result of finding the fractured and fissured groundwater veins which are widely distributed in the area.

The Government of Baluchistan came to know that a survey method with the helicopter-borne aerial gamma-ray spectro prospecting apparatus, which has given satisfactory results in Japan, may be effective for the investigation in the widely spread area.

The Government of Pakistan requested the Government of Japan in January 1986 to conduct the Master Plan Study on Baluchistan Irrigation Development Project through Groundwater Development by heli-borne aerial gamma-ray spectro prospecting. In response to the request, the Government of Japan through Japan International Cooperation Agency (JICA) dispatched the preliminary survey mission to Pakistan in March 1986 to discuss and conclude the Scope of Work (S/W) for the requested master plan study (refer to ANNEX).

1.2 OBJECTIVES OF THE STUDY

This study aims to survey groundwater resources in Quetta and Kalat Districts of Baluchistan, and to formulate the Master Plan for an irrigation development project based on the development of groundwater resources. The groundwater survey is to be carried out by the heli-borne aerial gamma-ray spectro prospecting, seismic prospecting and well tests in the prospected areas in parallel with the analysis of existing geological and hydrogeological data available.

1.3 SCOPE OF THE STUDY

The Study consists of two phases and the scope of work in respective phases is as follows:

(1) Phase-I Study

1) To collect and analyse the existing data and information in connection with geology, hydrogeology and irrigation development in and around the Study Area;

2) To select the areas (the Study Area) to be surveyed with aerial gamma-ray spectro prospecting;

3) To conduct aerial gamma-ray spectro prospecting survey and to grasp the fissured veins/zones and their distribution;

4) To select the area to be surveyed with the seismic prospecting based on the analysis of the existing geological and hydrogeological data and the field finding through the aerial gamma-ray spectro prospecting;

5) To conduct the seismic prospecting in the areas selected in 4), and to make clear the geological structure of the surveyed areas by supplementing the existing geological data and information;

6) To collect and review the existing data and information necessary for the formulation of an irrigation development plan and to conduct a preliminary survey of the Study Area; and

7) to make preliminary selection of the possible irrigation areas through the above surveys for groundwater development and to formulate the basic policy for an irrigation development.

(2) Phase-II Study

1) To study the groundwater with well tests in the possible irrigation areas proposed in Phase-I study. Test boring and well tests shall be executed under the responsibility of the Government of Pakistan. Location, number, depth, etc. of the test wells shall also be determined by the Government of Pakistan through discussions with the JICA Study Team on the basis of the results of Phase-I study;

2) To conduct required additional reconnaissance on the groundwater resources development based on the results of Phase-I study and the above well tests, and to evaluate the possible yield of groundwater estimated in Phase-II study;

3) To select the irrigation development areas (the Project Area) based on the above consideration; and

4) To conduct collection and review of the required additional data and site reconnaissance on irrigation development and to formulate the Master Plan of an Irrigation Development Project.

1.4 THE STUDY AREA

The Study Area to be surveyed with the heli-borne aerial gamma-ray spectro prospecting was selected through discussions between the agencies concerned of the Government of Baluchistan and the JICA Study Team, keeping in view of the following;

a) Priority for future irrigation development;

b) Possibility of groundwater resources development based on the existing data; and

c) Flight limitation and efficiency of survey works with a helicopter due to the topography and geography of the area.

The selected Study Area shown in FIGs 1.4.1 and 1.4.2 is summarized as follows:

- Quetta Area (both in Quetta and Kalat Districts):	28,000 ha
- Kalat Area (in Kalat District only):	12,000 ha
- Total:	40,000 ha

The Project Area for irrigation development is determined on the basis of the results of groundwater survey, meteorological and soil conditions, etc. keeping in view the estimated possible yield of the available groundwater resources.

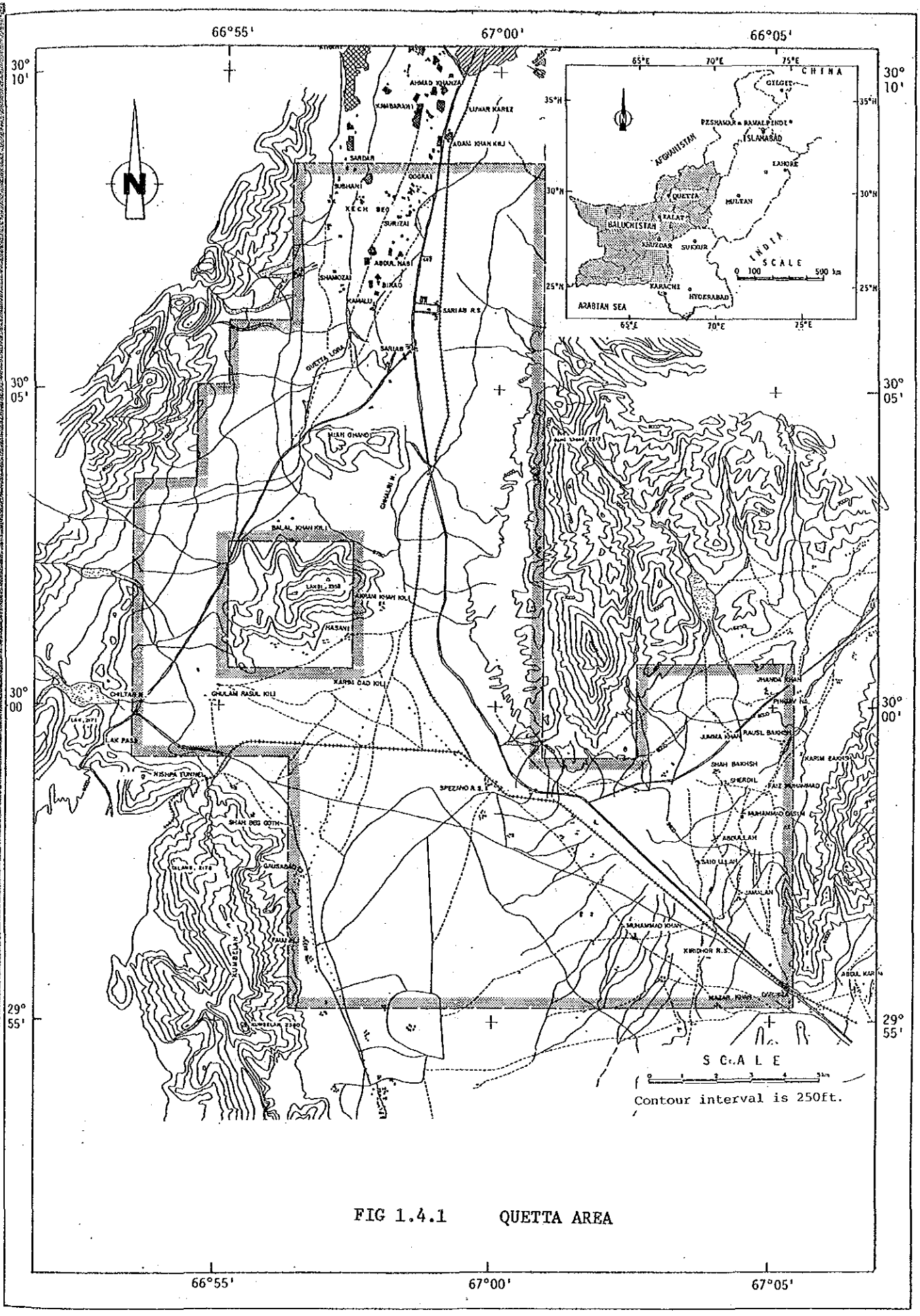


FIG 1.4.1 QUETTA AREA

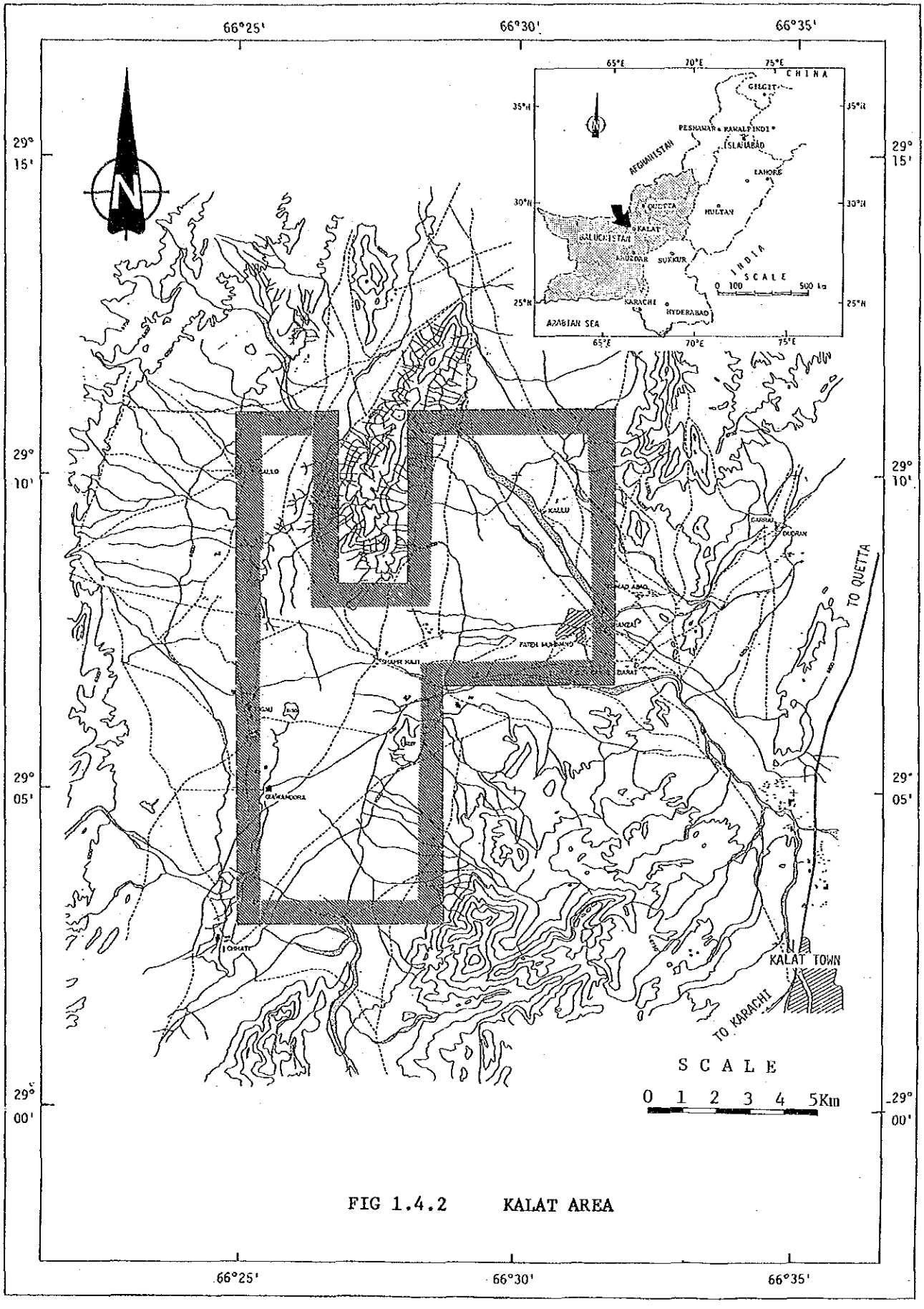


FIG 1.4.2 KALAT AREA

CHAPTER-2 BACKGROUND

CHAPTER 2 BACKGROUND

2.1 BRIEF DESCRIPTION OF THE COUNTRY

Pakistan gained independence as a sovereign state on August 14, 1947 as a result of the division of the former British India.

Pakistan lies in the north western part of the South Asian Subcontinent and extends from 23°42' to 36°55', north latitude and from 60°45' to 75°20' east longitude. It is surrounded by Afghanistan in the north and northwest, Iran in the west, Arabian Sea in the south and India in the east and southeast. There is a common border with the People's Republic of China in the north and northeast alongside Gilgit Agency and Jammu & Kashimir State (Disputed Area), while close across the Afghan border is the Soviet Union.

The total area of Pakistan is 796 x 10^3 km^2, with the north-south length of about 1,600 km and the maximum east-west width of about 1,000 km.

Pakistan has a wide variety of topographical features comprising

1) mountainous and hilly areas mainly found in the north and west,
2) plateaus, i.e., Baluchistan plateau and Potwar plateau,
3) plains mostly formed by the Indus and its tributaries, and
4) desert areas along the south eastern border.

The country has a climate of continental type varying from arid and semi-arid to sub-tropical. It is characterized by extreme variation of temperature both seasonally and daily with variable annual precipitation of 100 to 2,000 mm.

Pakistan comprises four provinces and two areas; namely, North-West Frontier Province (NWFP), Punjab, Sind, Baluchistan, and Federal Capital of Islamabad and Federally Administered Tribal Areas (FATA). These Provinces are divided into 20 Divisions, and 78 Districts and 262 Tehsils as of 1986. Total population of Pakistan according to 1981 Population Census is 84.25 million. It is estimated to be 97.7 million in 1986 with an estimated annual growth rate of 3.06 %. About 72% of the total population resides in rural areas.

2.2 NATIONAL ECONOMY AND AGRICULTURE

2.2.1 National Economy

Pakistan's economy made a considerable growth during the early 1980's. Over the past five years (FY1980 - 85), GDP has grown by 5.1% per annum. Annual growth rate in the agricultural sector stood at 2.5% while it was impressive 7.5% in the manufacturing sector during the same period.

As of 1985/86, agriculture and manufacturing sectors constitute 26% and 20% of GDP and employ 54% and 13% of the labor force, respectively.

Average income per capita in 1985/86 is estimated at about US$340 per annum (US$1 = Rs17.5). However, about 30 - 40% of the population live with income below the absolute poverty line of US$150 (The World Bank estimate in 1980).

Pakistan's exports have been declining in the recent years with a real growth rate of 11% in 1960's, 6% in 1970's and 3% in the first half of 1980's. This is attributed to the erratic terms of trade, world recession and shortfalls in the output of major export items. Export share of primary commodities accounts for 35%, semi-manufactured goods 16% and manufactured goods 49%. The major export items are cotton (raw, cloth, yarn), rice, ready-made garments and leather.

Pakistan's imports are almost twice as large as its exports. Imports grew at an annual real growth rate of 2% in 1960's, 6% in the 1970's and 2% in the first half of 1980's.

The major import items are petroleum and its products, machinery, transport equipment, chemicals, and grain and pulses.

Under the Sixth Five-Year Plan (1983 - 88), sectoral national budgets are allocated in the priority order among energy (38%), transport/communication (19%), water (11%), health/education (11%), agriculture (5%) and other items (16%).

2.2.2 Agriculture

(1) Land Use, Size and Production

Pakistan's total cultivated area is estimated at 20.6 million ha, which constitutes about 87% of the total farm area. Out of this area, about 12 million ha are irrigated by canal, while another 4 million ha are irrigated by small streams, springs, wells, Karezes or flood water. The remaining only 4.6 million ha are cultivated under rainfed conditions.

With the estimated 4.5 million farm households in 1985/86, the average cultivated area per household is 4.6 ha. About 74% of the total number of farms are held by small farmers of less than 5 ha, while these farmers cultivate only 38% of the total cultivated area.

Wheat and rice contribute about 43% and 13% to the total value of farm production, while cash crops of cotton and sugarcane contribute respectively about 25% and 11%. Nearly 50% of the farm households are livestock raisers. With tremendous increase in availability and use of various agricultural inputs since early 1970's, all major crops such as cotton, wheat, gram have performed well in recent years. The shortage still remains, however, in such inputs as water

supply, improved seeds, plant protection chemicals and fertilizer, which is the cause of a low level of crop yield at present.

(2) Agriculture Development Plan

During the period between the latter part of the 1970's and early 1980's, the success in attaining self sufficiency in agricultural products largely resulted from price support policies both in inputs and outputs. However, owing to the technical and economic limitations in the beneficial interaction between inputs and incentives, the emphasis in the development strategy in recent years has been shifted to the institutional arrangement and improvement in physical infrastructure such as suitable policy packages, crop diversification, provision of rural roads and electricity. The strategy will focus on increasing the productivity of small farmers and supporting this with modernized marketing and agro-services. The GOP's strategy in the agricultural sector is conceived in the Sixth Five Year Plan (SFYP) (1983/88) as follows;

1) Spreading use of optimum combination of modern inputs (chemical fertilizer, pesticides, improved seeds, etc.) with adequate availability of agricultural credit;

2) Improvement of on-farm management;

3) Modernization of extension services;

4) Extending the system of support prices to new high value crops for crop diversification;

5) Focus on the small and medium farmers;

6) Development of barani (rainfed) areas; and

7) Development of agro-based export industry.

In addition to the traditional crops such as wheat, rice and cotton, the crop production target in the Sixth Plan is given to the production of oilseeds (presently in deficit) and high-value cash crops like fruit and vegetable for export market.

The Government subsidy on fertilizer was previously over 50% but with its present wide-spread use and relation to support prices of crops, fertilizer subsidy has completely been eliminated by June 1985. Due to the limited supply of improved seed, subsidies and import of high quality varieties of seeds will continue until the local production can be expanded. Improved seed production projects assisted by the World Bank are under way since 1983/84, which are capable of providing 71% of all the seed requirement in Sind and Punjab Provinces. During the SFYP period, it is envisaged that 50,000 additional tractors per annum will be made available through import and gradually through domestic manufacturing.

Adequate availability of farm credit for inputs and investment will be given continuously attention under the present practice of providing the input credit mainly through the commercial banks and the Federal Bank for Cooperatives and the investment credit through the Agricultural Development Bank of Pakistan. Present credit coverage of 12% of total number of farms is envisaged to double over the SFYP period.

Marketing measures that the GOP continues to adopt include 1) price support for wheat, rice, sugarcane, cotton, onion, potatoes, and non-traditional oilseeds, 2) establishment of quality standards of commodities particularly with high export potential, 3) farm-to-market road construction as well as repair programme, 4) investment in storage capacity and management.

2.3 REGIONAL ECONOMY AND AGRICULTURE

2.3.1 Regional Economy

Baluchistan is the Pakistan's largest province with an area of 347,000 km^2 accounting for about 44% of the total national area. Its population of 4.33 million in 1981, however, accounts for mere 5% of the national total. About 84% of the provincial population lives in rural areas where the majority predominantly follow nomadic and tribal mode of life and traditional customs.

The Province is still in the initial stage of development and, therefore, its level of income and infrastructure base remain considerably lower than its national average with its income reportedly close to Pakistan's absolute poverty line.

Agriculture remains as the predominant sector in the Province's economy, contributing about 56% (estimated) of gross provincial product and employing 68% of total labor force, which are considerably higher than the respective national average of 26% and 54%.

Industrial sector remains at low level due to lack of various production incentives and of sufficient internal demand. Potential industries are being identified on the basis of indigeous raw materials and rich mineral resources.

In spite of its state of under-development, the Province is strategically located and has promising development potential with such untapped resources such as cultivable 6 million ha of land, groundwater, minerals and climatic conditions.

2.3.2 Agriculture

Out of the Province's total area of 34.7 million ha, about 18.5 million ha are reported as used, of which about 17.0 million ha are uncultivated; either cultivable waste, forest or not available for cultivation.

The cultivated area in the Province thus is about 1.5 million ha with an actual net sown area of 563,000 ha (1985/86) and the remaining fallow area. The uncultivated area is extensively used for grazing livestock.

Irrigated area in the Province is about 510,000 ha at present, with about 67% by canal, 22% by wells/tubewells and the remaining by karezes, springs, etc. Nearly 90% of the canal irrigated area, however, is in the Pat Feeder Canal Project area in Nasirabad District.

Agricultural production in the Province is low and fluctuating and thus the Province remains as a net importer of food. More than half of the cultivated area is under wheat, followed by rice and sorghum. Cash crops such as vegetables, fruits and nuts are also common especially when irrigation water is available.

Average area per farm is 10 ha but the cultivated area is estimated at about 5 ha due to shortage of water supply and farming force. Owner-operated farm accounts for 73% of the total farms with the remaining either owner-cum-tenant operated (8%) or tenant operated (19%). Various agricultural support services are provided but they all require substantial improvement and expansion.

2.4 REGIONAL DEVELOPMENT PLAN

Due to its relative poverty, the Province has been given high priority in the GOP's national development effort, which is reflected in additional allocation out of the national budget for such plans as Baluchistan's Special Development Plan (mid 1980) and Annual Development Plan.

Highest priorities under these plans as well as the Provincial's Sixth Five Year Plan (1983 - 88) are given to the following broad sectors:

1) Water Resource Development for drinking, agriculture and livestock use;

2) Electricity Expansion;

3) Land and Air Communication Improvement; and

4) Human Resource Development by way of expanding Health and Educational Services.

The GOB's current priority concern, through the accelerated development of the above sectors, is to ensure fulfillment of basic needs through founding and strengthening physical and social infrastructures.

The major elements of agriculture program, addition to the irrigatiin water development, include 1) agricultural research and 2) extension and marketing. Research priority is given to the on-farm water management and the development of crop research farms. Strengthening in agriculture marketing is planned for high-value fruit and vegetables.

Water resource development programs envisaged under the Provincial SFYP include expansion of present surface water irrigation, expansion of canal discharge, construction of delay action dam, rehabilitation of silted irrigation works and recharge of groundwater.

CHAPTER-3 THE STUDY AREA

CHAPTER 3 THE STUDY AREA

3.1 LOCATION AND GENERAL FEATURES

3.1.1 Location

The Study Area of 40,000 ha is divided into two sections; the Quetta Area of 28,000 ha and the Kalat Area of 12,000 ha.

The Quetta Area is located south of Quetta City. The Quetta Area is shown in FIG 1.4.1 and summarized below:

South edge	:	Darwaza to Fauj Ali Village
North edge	:	Tut But to Kech Beg
West edge	:	Fauj Ali Village to Chiltan Range
East edge	:	Jhanda Khan to the Takhtan Nala

The maximum width of the area (east to west) is 20 km (longitude 66°53' - 67°05'E) and maximum length (south to north) is 25 km (latitude 29°55' - 30°05'N). The Quetta Area is located both in Quetta Tehsil of Quetta District and Mastung Tehsil of Kalat District.

On the other hand, the Kalat Area is located approx. 15 km northwest of Kalat Town, the capital town of Kalat District; 15 km wide south to north (latitude 29°03' - 29°12'N) and 11 km wide east to west (longitude 66°25' - 66°33'E), as shown in FIG 1.4.2. The Kalat Area is included in Kalat Tehsil of Kalat District.

3.1.2 Topography

The Study Area is covered by the topographic maps prepared by the Survey of Pakistan at the scale 1:50,000 and 1:250,000. These are based on the survey carried out in 1909 - 14 and corrected based on the aerial photographs taken at the scale 1:40,000 in 1952 - 54 and verified on the ground for main points in 1957. The revision work of these maps has been continued.

(1) Quetta Area

The Quetta Area is located in the middle of Quetta Valley surrounded by Murdar, Daghari, Dhik Mountain ranges on the east and Chiltan and Kumbela Mountain ranges on the west. The elevation of these mountain ranges is 2,100 to 3,300 m above sea level.

The Area is divided into two drainage areas by Landi Mountain (EL. 2,354 m) which is located in the centre of the Quetta Valley. The northern area, headwaters of the Quetta drainage area, continues to Quetta City along the Sariab Lora River flowing south to north. In the valley floor of the Area, the elevation ranges 1,650 to 1,750 m above sea level with a gentle slope about 1% and many open/tube wells and karezes are constructed for both irrigation and drinking purposes. The gravelly piedmont area with slope about 6% is used as range area. Some karezes originate from this area.

The southern area is a part of a closed Dasht-i-Khuni drainage area. The Zarakhu Nala (Pinghov Nala) from northeast and the Chiltan Nala from northwest runs into the low plain area located adjacent to the southern boundary of the Area and formulates a seasonal lake combining the water of the Zahrig Chat Nala from south end of the basin. The elevation of the area is 1,750 - 1,850 m above sea level with a slope 0.3 to 1% along dry drain channels. Some part of the plain along the railway line is covered with gravel carried by many tributaries of main drains. The development of groundwater in the southern area is very slow and a few open/tube wells are only used for supplying drinking water to the villagers.

(2) Kalat Area

The Kalat Area is located near the junction point of the Rod Kalan from southwest and the Madian Jhal and Giawandara from south. These tributaries continue to run north which is called the Shirinab River. Western border of the Area is blocked by the Unalath Mountain range. At the southern boundary, the skirt of the Chandrum Mountain (EL. 2,426 m) and the Siah Koh Mountains separate the Area from Kalat basin at the southeast boundary of the Area. The Chhappai Mountains are located in the Kalat Area at the centre of northern part.

The southwestern plain of the Area is located in the north end of the Dasht-i-Goran and formulates a triangular plain of the Giawandara River with a slope 1 to 2% towards northwest. Other part of the Area is almost 1% with elevation 1,750 to 1,850 m above sea level. Near the north and south boundaries of the Area, natural drains cut the plain sharply with 2 - 3 m depth.

3.1.3 Meteo-hydrology

(1) Climate

From the climatic viewpoint, the Study Area is classified as "Sub-tropical Continental Highlands". The Study Area is characterized by cold snowy winter, cool summer, and frequent fog and dry climate with mean annual rainfall of about 200 mm occurring mostly in winter. North and northwest winds known as 'gorich' blow from October to February and are piercingly cold. General features of climate in Quetta and Kalat are shown in FIG 3.1.1 and TABLE 3.1.1.

(2) Meteo-hydrological Observation Networks

Within the Study Area including adjacent areas, there are 4 climatological stations and 4 rainfall stations which are established and observed by Pakistan Meteorological Department (MET) and Provincial Agencies (PROV) such as Irrigation and Power Department and Pakistan Water & Power Development Authority (WAPDA). They are tabulated in TABLE 3.1.2 and shown in FIG 3.1.2. Except Quetta Samungli station, the observation is not sufficient or only for a short period (TABLE 3.1.2). All data are sent to the centre of each agency. Therefore, detailed data have to be collected from their central offices.

(3) Precipitation

Precipitation includes rainfall and snowfall. Usually snow is melted and melted-water is counted as rain. At Quetta Murree Brewery station, there are 3 to 4 occasions of snowfall a year between November to March. The term "precipitation" hereinafter means rainfall, because snow is converted into depth of rainfall.

Rainfall in the Study Area greatly varies year to year. Recent 100 years' record in Quetta shows that the maximum annual rainfall was 950 mm in 1982 and the minimum was 102 m in 1925 (FIGs 3.1.3 and 3.1.4).

Mean annual rainfall in Quetta (Samungli), Sariab, Spezand, Kalat, Mangocha and Mastung are 224 mm, 160 mm, 135 mm, 193 mm, 133 mm and 187 mm, respectively. Based on the annual rainfall pattern, one year can be divided into two seasons, i.e. winter from November to May and summer from June to October. More than 80% of annual rainfall is concentrated in winter. The annual rainfalls estimated with probability of non-exceedance are 75 - 163 mm and 56 - 136 mm for 5 year and 10 year return periods, respectively (TABLE 3.1.3).

Daily rainfall is observed at all rainfall stations. However, hourly rainfall record for the period of more than 10 years is available only at Quetta Samungli station. Based on the previous analysis, rainfall intensities at respective return periods are shown in TABLE 3.1.4.

(4) Drainage

The Study Area is located in the catchment area of the Pishin Lora which runs jointly with the Shaga Rud or Shirinab from the Kalat Area and the Sariab Lora from the Quetta Area and it flows into Afghanistan once, then comes back to Pakistan, finally it disappears at Hamun-e-Lora desert. There is no perennial flow in the Study Area and channel is seen as a wadi. Most of the catchment area is not covered with vegetation except lower plain area where the agricultural area is extended.

The general features of drainage of the Study Area based on the topographic maps at a scale 1 to 250,000 and 1 to 50,000 are summarized below:

The Quetta Area is divided into two catchment areas which are separated by the Landi Mountain. The northern area is a headwater of the Sariab Lora basin of 180 km^2. The southern part is a closed catchment area of 870 km^2. In southern area, the Pingav or Zarakhu Nala runs from northeast corner, the Chiltan Nala from northwest corner and Zahri Chat from southwest corner gather each other and create a seasonal lake at Dasht-i-Khuni just southern boundary of the Area. Due to the torrential rain in August 1986[1/], the seasonal lake expanded more than 10 km^2 and it did not disappear until May 1987.

1/ Quetta (Samungli) and Kalat stations recorded the rainfall of 66 mm and 76 mm for the period of 6 days from August 9 to 14, respectively.

The Kalat Area is located at a junction point of the Khani Jhal flowing from east and the Rod Kalan from south whose catchment areas are 620 km^2 and 1,010 km^2 at the boundary of the Area, respectively. They become a stream which is called the Shirinab River. The Mashmunki Jhal coming from east which flows through Iskalku Village joints with the Rud Kalan coming from south through Chotta Kapoto area at Malghuzar village and drains through Kalat Town.

The Khani Jhal originated from Dasht-i-Daddur joins with the Mhodian Jhal at Mali and drains into Chappar area from south through Dasht-i-Goran. Near Chhati Village, it diminishes and it develops again at the western part of Chappar Hills. Then it passes through Jammanzai, Purdu area, and trends toward Mangochar.

Both catchment areas of the Quetta and Kalat Areas are shown in FIGs 3.1.6 and 3.1.7, respectively.

3.1.4 Geology

(1) General

Pishin Lora basin including the Study Area belongs to central movement area in Pakistan earth division and is laid on the geological structure stretched from Himalayan orogenic zone. All the formations from Recent to Jura system of Mesozoic era except Paleocene system are distributed in the Study Area and formed mainly with marine sediments but only Quaternary system is of terrestrial sediments.

The thick continuous formations are widely distributed generally forming big synclinorium structure and the Study Area is located on the western border of them. The directions of fold structure are NNE-SSW. The topography of the Study Area is controlled by this structure. Therefore, the ranges of mountain and basins are also developed to the directions of about N-S, and especially the mountain areas

are usually composed of hard rocks that are resistable against the erosion.

Stratigraphy and geological sketch of the Study Area are shown in TABLE 3.1.5 and FIGs 3.1.8 to 3.1.11.

(2) Quetta Area

In the highlands surrounding the Quetta Area, the Chiltan Formation of Mesozoic era is widely developed. The Shrinab and Parh Group Formations distribute in the western and eastern parts of the Area with small scale. The Brewery Formation of Tertiary era is found in a limited section in the eastern part of the Area. The Quaternary Formation overlaying them expands in the Quetta valley and in lowlands of Dasht-i-Khuni area. The textures of the Mesozoic and Tertiary Formations are limestone and shale. They are hard due to their old age and form the basement in the Area.

On the other hand, the Quaternary Formation of the plain area is formed with clay, silt, sand and gravel, and is not hard due to its new age. Among them, the coarse sediment of sand, gravel, etc. is distributed mostly in the piedmont and it shifts gradually to fine sediment of clay and silt, etc. towards the centre of the plain.

On the underground geology, the well logs of many test borings and electric prospecting in the past show a tendency that gravel is remarkable in the piedmont and that it changes to clay in the center of the plain like the surface geology. Especially in the center of Dasht-i-Khuni area, clay sediment continues to the deep portion.

(3) Kalat Area

The Shirinab Formation of Mesozoic era is outcropped widely in the highlands. The Chiltan Formation is also found in many places of the eastern part of the Kalat Area. However, the Parh Series Formation is outcropped with small scale in

northeastern part of the Area. The Spintangi and Wakabi Formations of Tertiary era spread in the eastern and western part of the Area, respectively. The Quaternary Formation is widely developed in lowlands of the Area. The textures of these formations in the Area show the similar tendency as in the Quetta Area. Namely, the Mesozoic and Tertiary Formations of the basement are hard limestone and shale. The Quaternary Formation is unconsolidated sediment with clay, silt, sand and gravel, and its distribution tendency shows that gravel is much in the piedmont and that it changes to clay in the center of the plain.

Concerning the geological structure, there are some anticline and syncline passing the northern highlands and the lowland to the direction of NE to SW, respectively. Also many small faults run in the eastern part and it is estimated that a high fault passes under the central part of the lowland.

On the underground geology, it is interpreted that the Quaternary Formation is not so thick judging from the past test boring and electric prospecting data.

3.1.5 Soil

The characteristics of soil in the Study Area are summarized as follows:

(1) Quetta Area

Most of the area surveyed in Quetta Valley has got very high potential for irrigated agriculture. Nearly 64% of the area falls under Class-I, II and III lands which are free from physical and chemical limitations and require only slight to moderate corrective measures. The remaining 36% of the areas suffer from excessive slopes and may be used for grazing or forest purpose.

QT-C Area is absolutely fit for a national park and is already being converted into one. If groundwater is developed, it may augment the quantity of water already available for planting the trees.

QT-D Area is suitable for irrigated agriculture. It is already under rainfed cropping and high quality wheat is grown here whenever sufficient water pours down. The northern part of the Area, however, requires extensive levelling.

QT-E Area is currently dry cropped and wheat, cumin and water melons are grown here. The Area is almost level to nearly level. It is recommended for irrigated agriculture.

So far as QT-A Area is concerned, it is already producing high quality apples and cherry. People are using shallow groundwater for planting orchards. More groundwater may increase the fruit area.

(2) Kalat Area

The soils of the Kalat Area are inherently productive, deep, well drained, free from excessive salts and capable of producing all climatically suited crops.

KL-A Area contains one patch of 264 ha in the south of Shahr Haji which falls under Class-I land. This patch is readily cultivable and needs little reclamation measures. In planning an irrigation scheme, this patch may be granted first priority. Rest of KL-A Area suffers from slight uneven surface or erosion of small streams. This may require a little levelling before bringing it under cultivation.

KL-B Area also suffers from slight undulating and uneven surface. Otherwise it is suitable for all kinds of crops.

Central part of KL-C Area has been badly damaged by water and can not be economically reclaimed. Similarly northern part of KL-C Area suffers from 20 to 30% grit and gravel on the surface as well as in the profile. First preference may be granted to the "IIe" lands which may easily be brought under cultivation after a little bulldozing.

TABLE 3.1.1 MEAN MONTHLY CLIMATOLOGICAL DATA

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL/MEAN
	QUETTA (SAMUNGLI)													
1.	Rainfall (mm)	37	44	42	12	7	1	18	4	1	1	6	23	196
2.	Max. temperature (°C)	10.8	13.4	18.4	24.7	30.4	34.2	35.4	34.3	31.2	25.1	18.3	13.2	24.1
3.	Min. temperature (°C)	-2.8	-1.2	3.1	7.3	10.8	14.2	18.9	16.4	9.8	3.2	-1.8	-3.7	6.2
4.	Mean temperature (°C)	4.0	6.0	10.8	16.0	20.6	24.2	27.2	25.4	20.5	14.2	8.3	4.8	15.2
5.	Relative humidity (%)	69	61	59	49	40	37	44	49	41	40	51	66	51
6.	Wind speed (km/hr)	9.1	10.7	11.5	10.2	10.9	10.9	12.1	10.6	8.5	7.4	6.5	6.7	9.6
7.	Bright sunshine (hr)	213.7	209.2	229.3	271.0	336.6	344.1	324.4	319.6	294.5	279.8	279.8	231.8	3,159.8
8.	Rainy days (day)	3.9	4.1	4.7	1.3	0.8	0.2	1.5	0.6	0.1	0.2	0.7	2.1	20.2
9	Evaporation (mm) 1/	73.4	83.6	143.0	177.3	257.6	341.4	315.7	288.5	241.3	184.9	108.2	83.8	2,298.7
	KALAT													
1.	Rainfall (mm)	55.4	47.5	37.1	15.2	6.1	3.3	30.7	14.2	2.0	0.0	3.0	18.5	233.0
2.	Max. temperature (°C)	9.4	12.1	16.3	21.7	27.2	31.3	32.3	31.4	28.4	22.9	17.4	12.8	21.9
3.	Min. temperature (°C)	-3.8	-1.9	1.9	6.2	10.3	13.3	16.4	14.8	9.4	3.7	-0.9	-3.6	5.5
4.	Mean temperature (°C)	2.8	5.1	9.1	14.0	18.8	22.3	24.4	23.1	18.9	13.3	8.3	4.6	13.7
5.	Relative humidity (%)	65	58	50	42	38	33	41	40	35	35	44	55	44.7
6.	Wind speed (km/hr)	7.6	9.1	9.8	9.5	9.5	9.5	8.2	7.6	8.2	8.2	7.8	7.6	8.6
7.	Bright sunshine (hr)	-	-	-	-	-	-	-	-	-	-	-	-	-
8.	Rainy days (day)	4.6	3.9	3.4	1.9	0.7	0.4	2.3	1.2	0.1	0.0	0.4	1.9	20.8
9	Evaporation (mm)	-	-	-	-	-	-	-	-	-	-	-	-	-

Sources: Meteorological Department, Karachi,

1/ UNDP/WAPDA, Report on Hydrometeorology of Baluchistan, 1980

TABLE 3.1.2 CLIMATOLOGY, RAINFALL AND EVAPORATION RECORDS

Item	Station Name	Killi Kotwal	Quetta Samungli	Quetta Murree Brewery	Sariab	Spezand	Kolpur	Mangochar	Kalat
Location									
Latitude (N)		30° - 15'	30° - 11'	30° - 12'	30° - 05'	29° - 58'	29° - 54'	29° - 22'	29° - 02'
Longitude (E)		67° - 01'	67° - 00'	67° - 01'	66° - 58'	67° - 01'	67° - 08'	66° - 37'	66° - 35'
Altitude (ASL, m)		-	1,589	1,673	1,719	1,786	1.798	1,766	2,017
Opened/Closed Year		1970-	1944-	1898 (1951)-	1900-1972 1975-	1903-1972 1975-	1891-1954	1912-	1876-1984
Operation Agency		WAPDA	MET	MET	PRO/MET WAPDA	PRO/MET WAPDA	PRO/MET	PRO/MET	MET
Precipitation	Hourly	1971-	1951-	1966-					
	Daily	1970-	1944-	1981-	1900-	1903-	1981-1954	1912-	1891-
	Monthly	1970-	1944-	1891-	1900-	1903-	1891-1954	1912-	1876-
Evaporation	Daily	1970-	1952-					1970-	1052-
	Monthly	1970-	1952-	1891-	1974-			1970-	1952-
Temperature	Daily	1971-							
	Monthly	1971-	1974-	1891-					
Relative Humidity	Daily	1971-							
	Monthly	1971-	1974-	1891-					
Wind Speed	Daily	1971-							
	Monthly	1971-	1952-	1891-					

Notes: MET: Meteorological Department
WAPDA: Water and Power Development Authority
PRO: Provincial Agencies

TABLE 3.1.3 ANNUAL RAINFALL PROBABILITY

(Unit: mm)

Rainfall Station	Quetta	Sariab	Spezand	Kalat	Mangochar	Mastung
Observation Period	1911 - 1949	1911 - 1949	1911 - 1949	1911 - 1949	1911 - 1949	1911 - 1949
Mean annual	224	160	135	193	133	187
Probable Rainfall (non-excedance)						
2 year 1/	231	156	127	170	120	166
5 year	163	105	88	104	75	118
10 year	136	81	59	78	56	100
20 year	117	63	44	59	42	88
50 year	98	44	28	41	37	78

1/ Return Period

TABLE 3.1.4 SHORT DURATION RAINFALL INTENSITY

(Unit: mm)

Station Name	Duration (hr)	Return Period(Year)					Highest Record
		2	5	10	50	100	
Kalat	24	37	53	65	92	104	102
	6	27	39	47	66	75	
	1	17	24	29	41	47	
Mangochar	24	31	44	53	75	84	170
	6	23	32	38	54	60	
	1	14	20	24	34	37	
Quetta Murre Brewery	24	35	44	59	66	72	55
	6	25	32	36	47	52	
	1	16	20	23	30	33	
Sariab	24	36	59	74	109	124	152
	6	26	42	53	78	90	
	1	16	26	33	49	56	
Spezand	24	29	45	56	81	92	76
	6	21	33	40	58	66	
	1	13	21	25	37	41	

Source: UNDP/WAPDA,
Report on the Hydrometeorology of Baluchistan, 1980

TABLE 3.1.5 STRATIGRAPHY OF STUDY AREA

System			Formation				Solidity
			Quetta		Kalat		
Cenozoic	Quarternary	Recent and Pleistocene	Alluvium (valley floor deposits, piedmont deposit, dune sand)	Clay, silt, sand and gravel	Alluvium (valley floor deposit, pied. deposits)	Gravel, sand, silt & clay	Unconsolidated rock
			Older Alluvium	Gravel, sand, silt and clay	-	-	
	Tertiary	Oligocene	-	-	Wakabi	Shale with limestone	Consolidated rock
		Eocene	-	-	Spintangi	Nodular limestone	
		Paleocene	Brewery	Limestone	-	-	
Mesozoic		Cretaceous	Parh Group	Limestone and shale	Parh series	Shale with limestone	
		Jurassic	Chiltan	Limestone	Chiltan	Limestone with shale	
		Triassic	Shirinab	Limestone and shale	Shirinab	Shale with limestone	

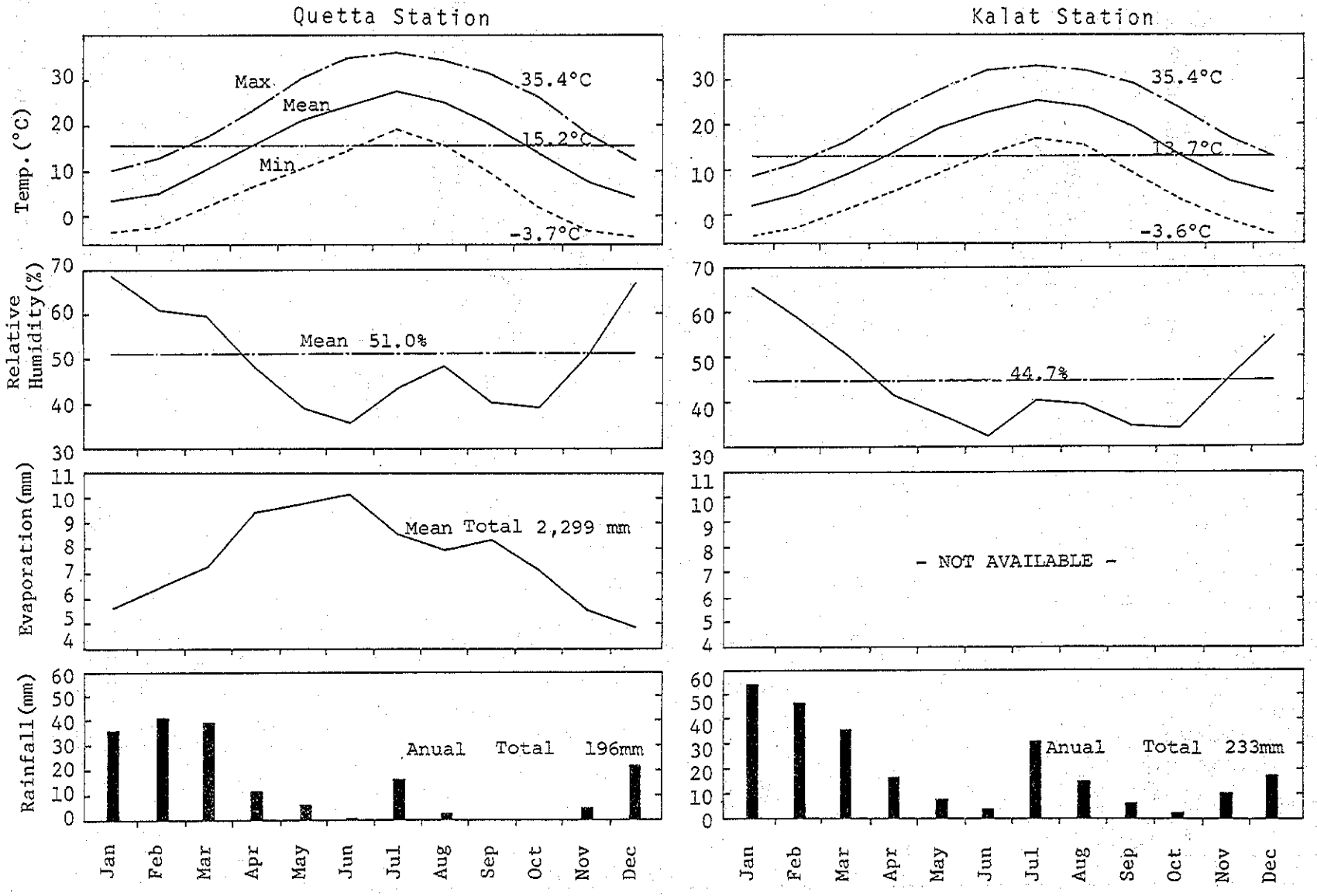


FIG 3.1.1 MEAN MONTHLY CLIMATOLOGICAL DATA

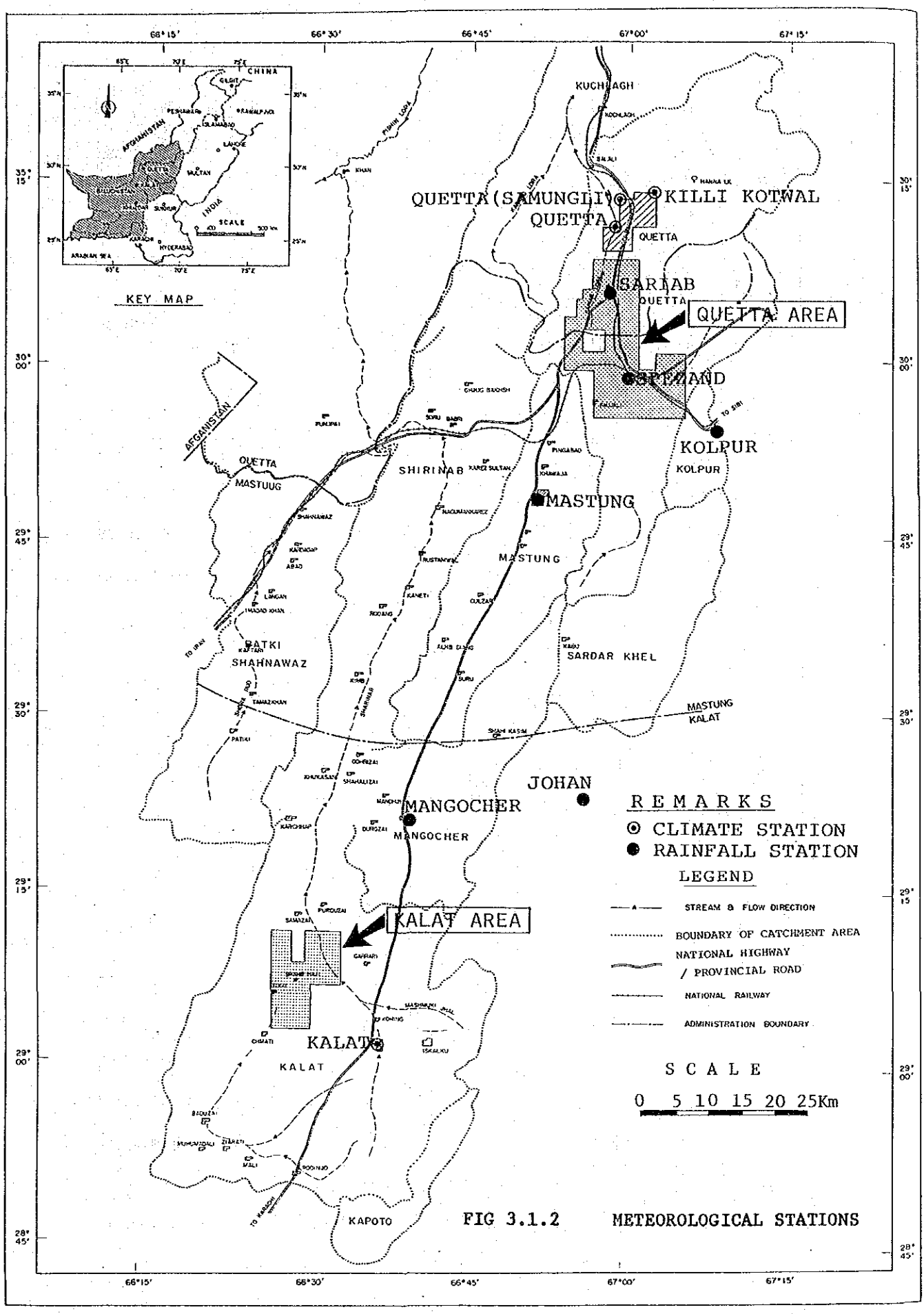
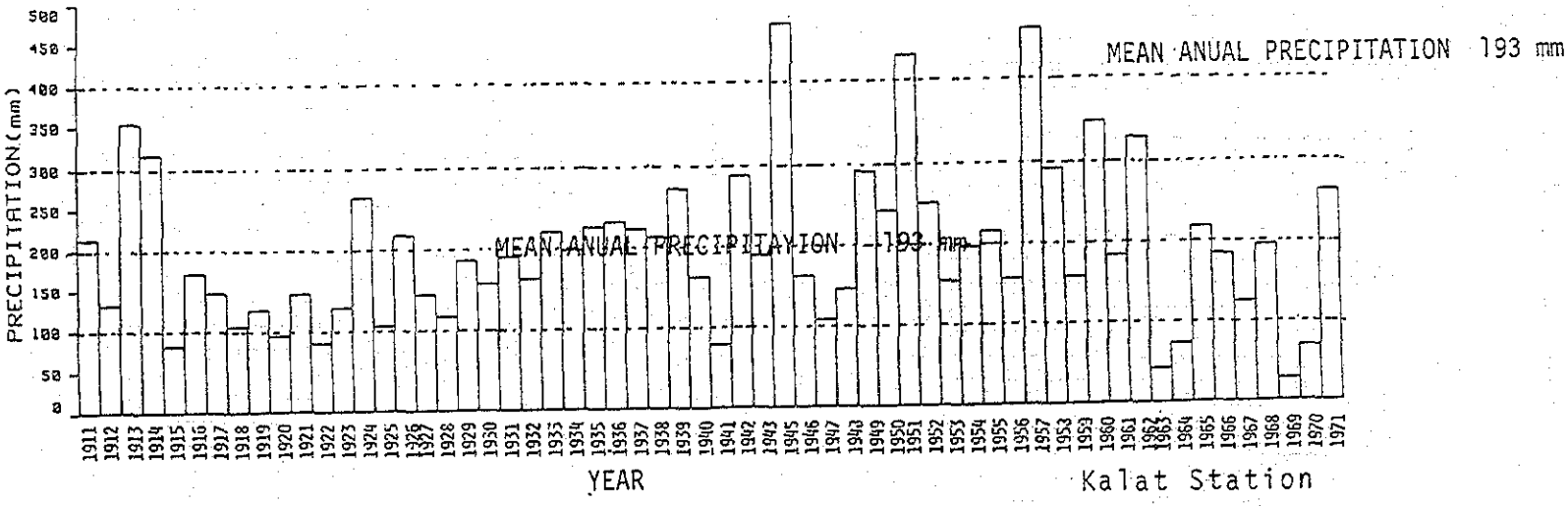


FIG 3.1.2 METEOROLOGICAL STATIONS



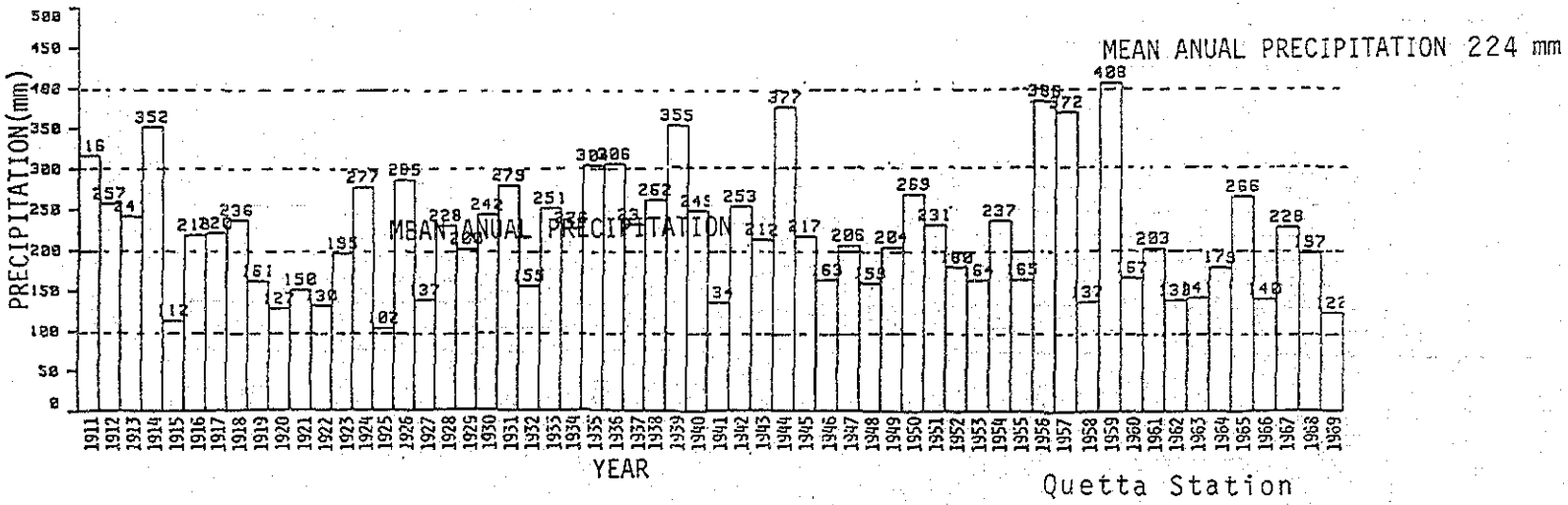


FIG 3.1.3 ANNUAL PRECIPITATION (1/2)

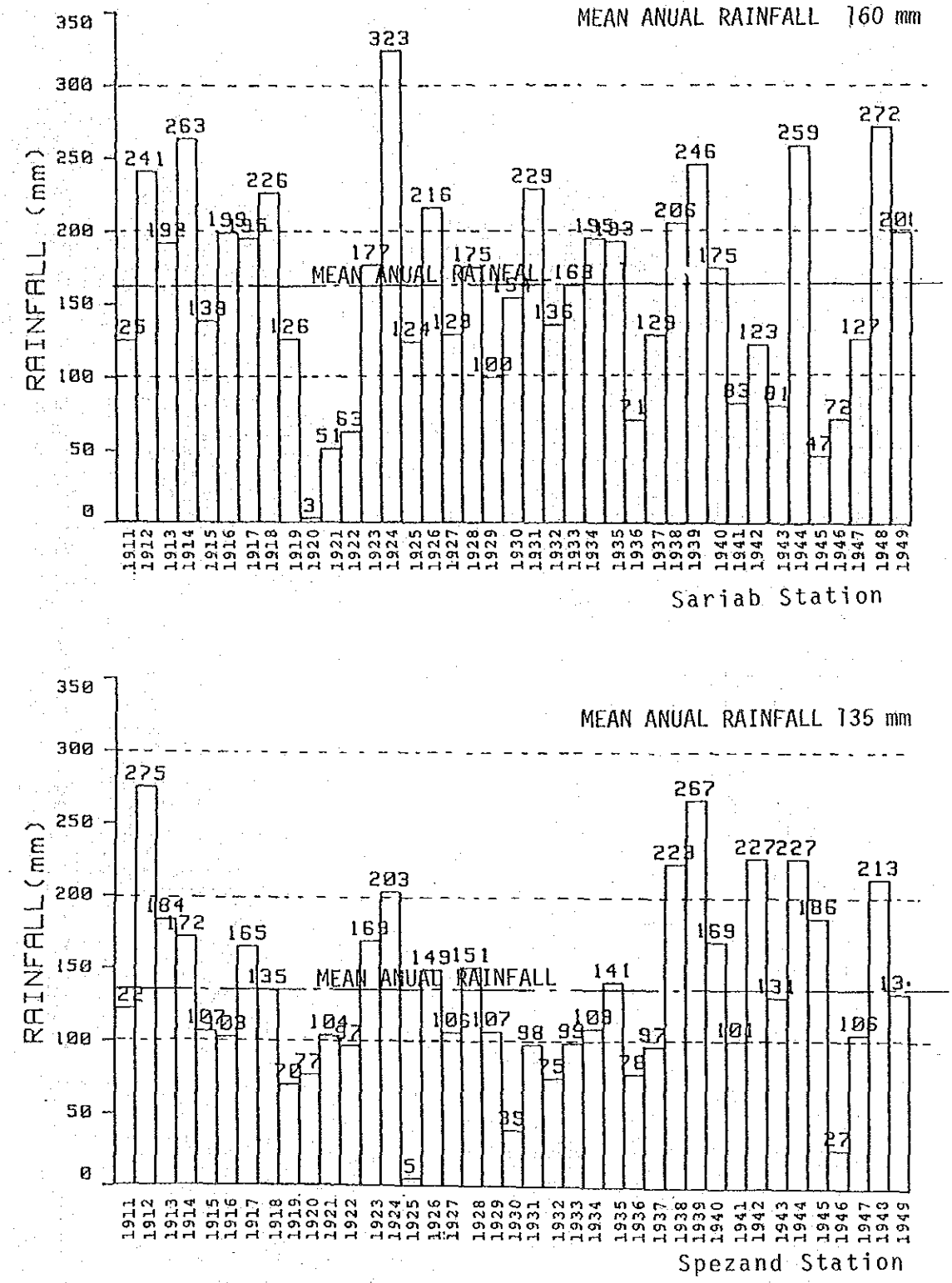


FIG 3.1.4 ANNUAL PRECIPITATION (2/2)

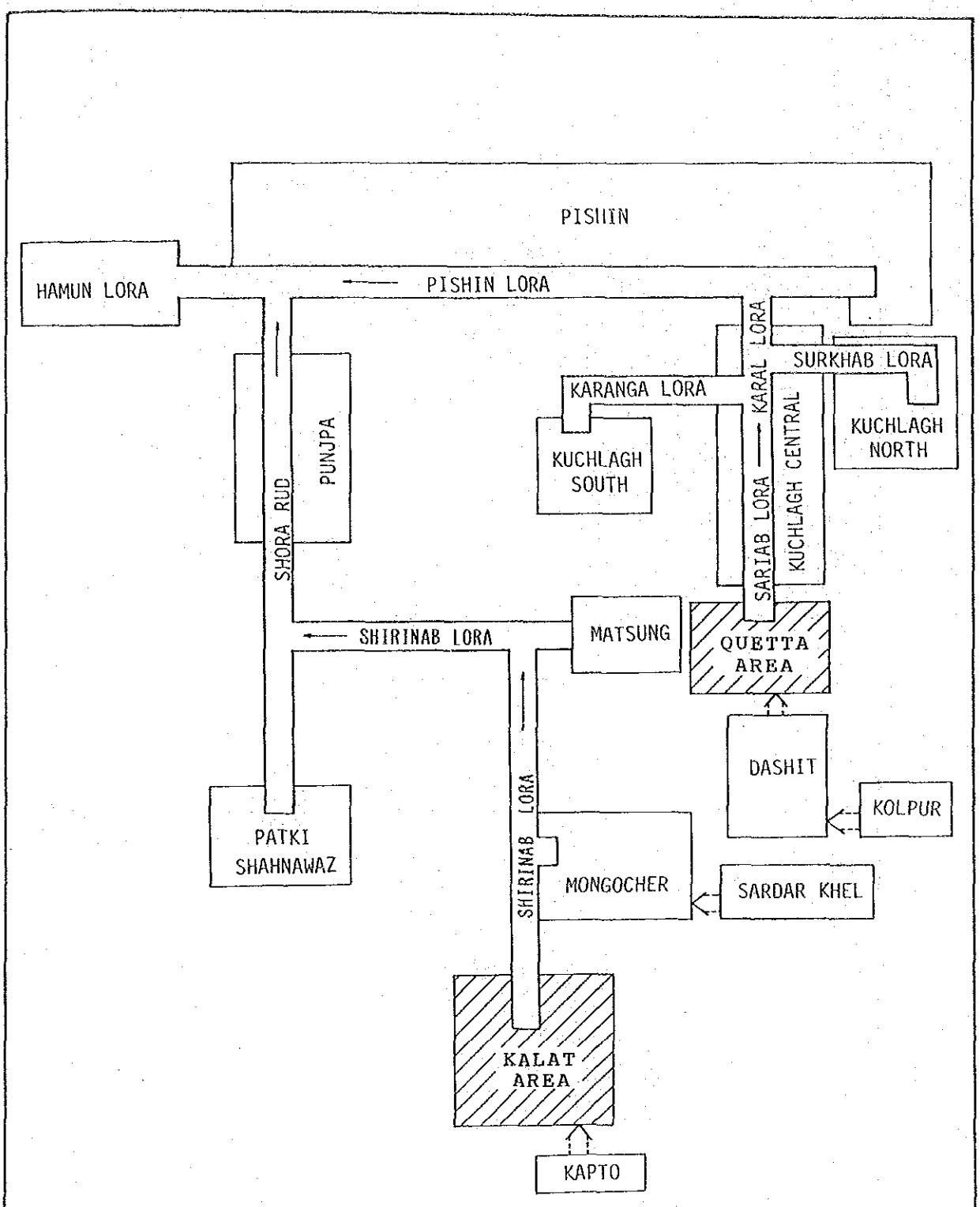


FIG 3.1.5 SCHEMATIC CHART OF PISHIN LORA BASIN

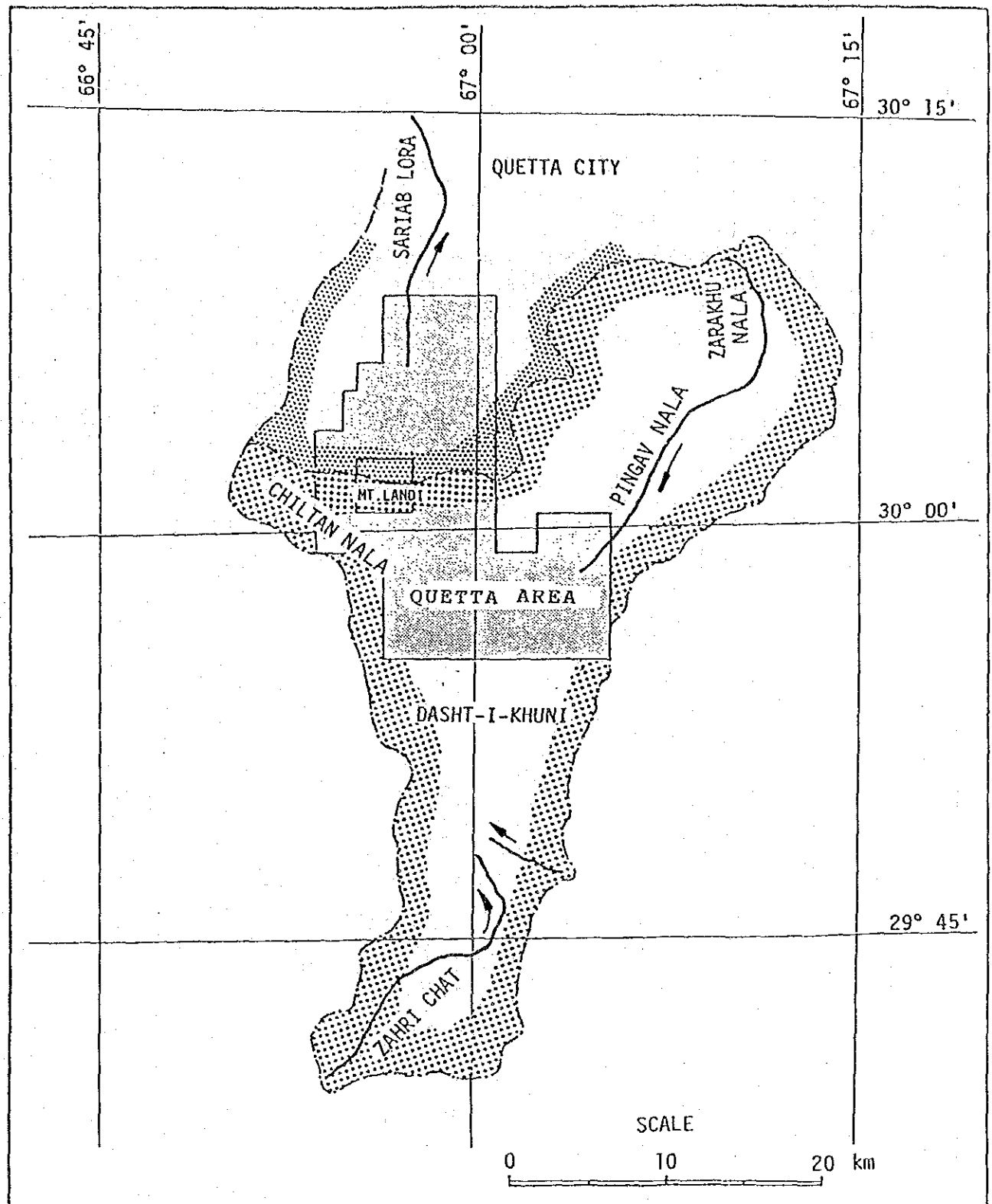


FIG 3.1.6 CATCHMENT AREA OF QUETTA AREA

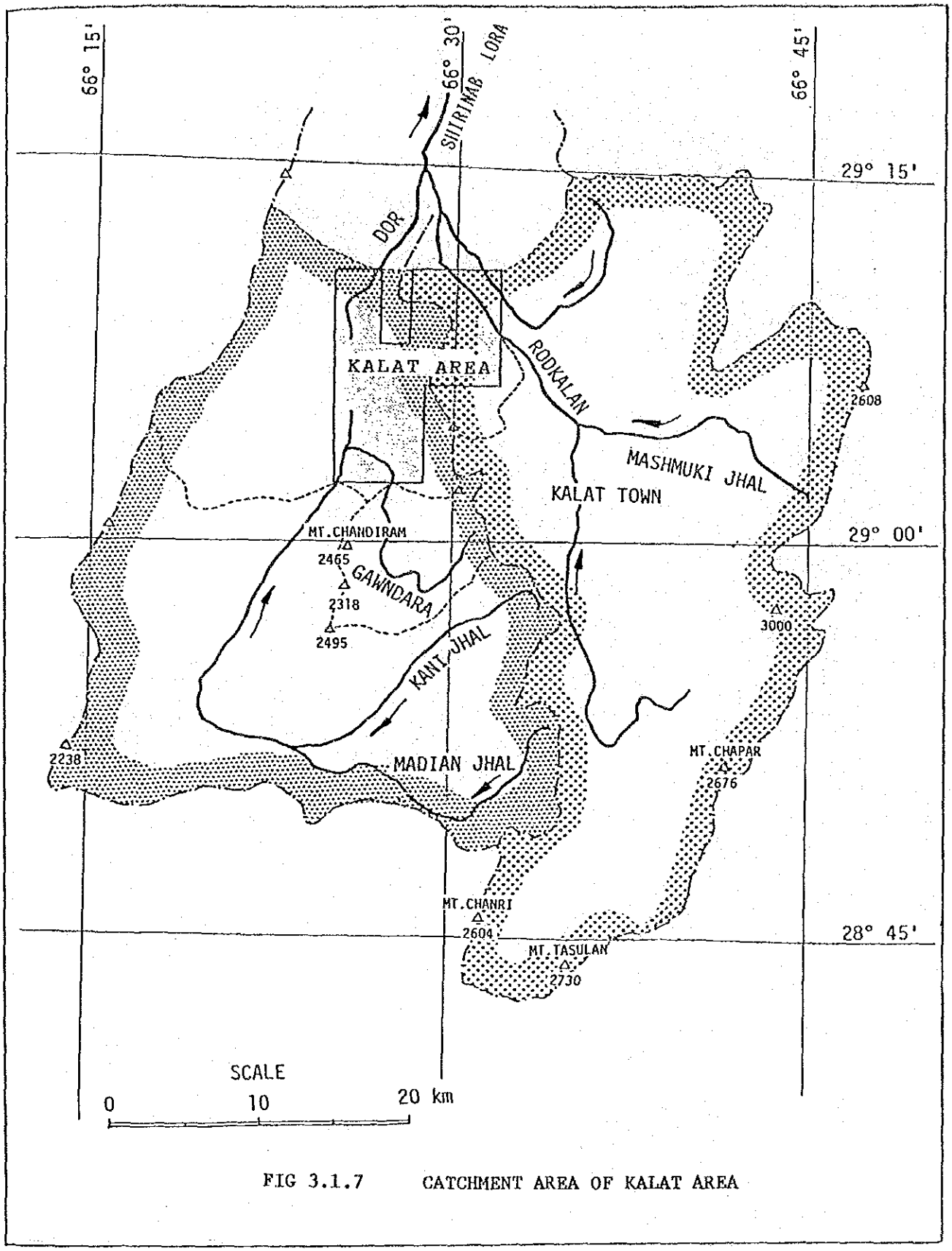


FIG 3.1.7 CATCHMENT AREA OF KALAT AREA

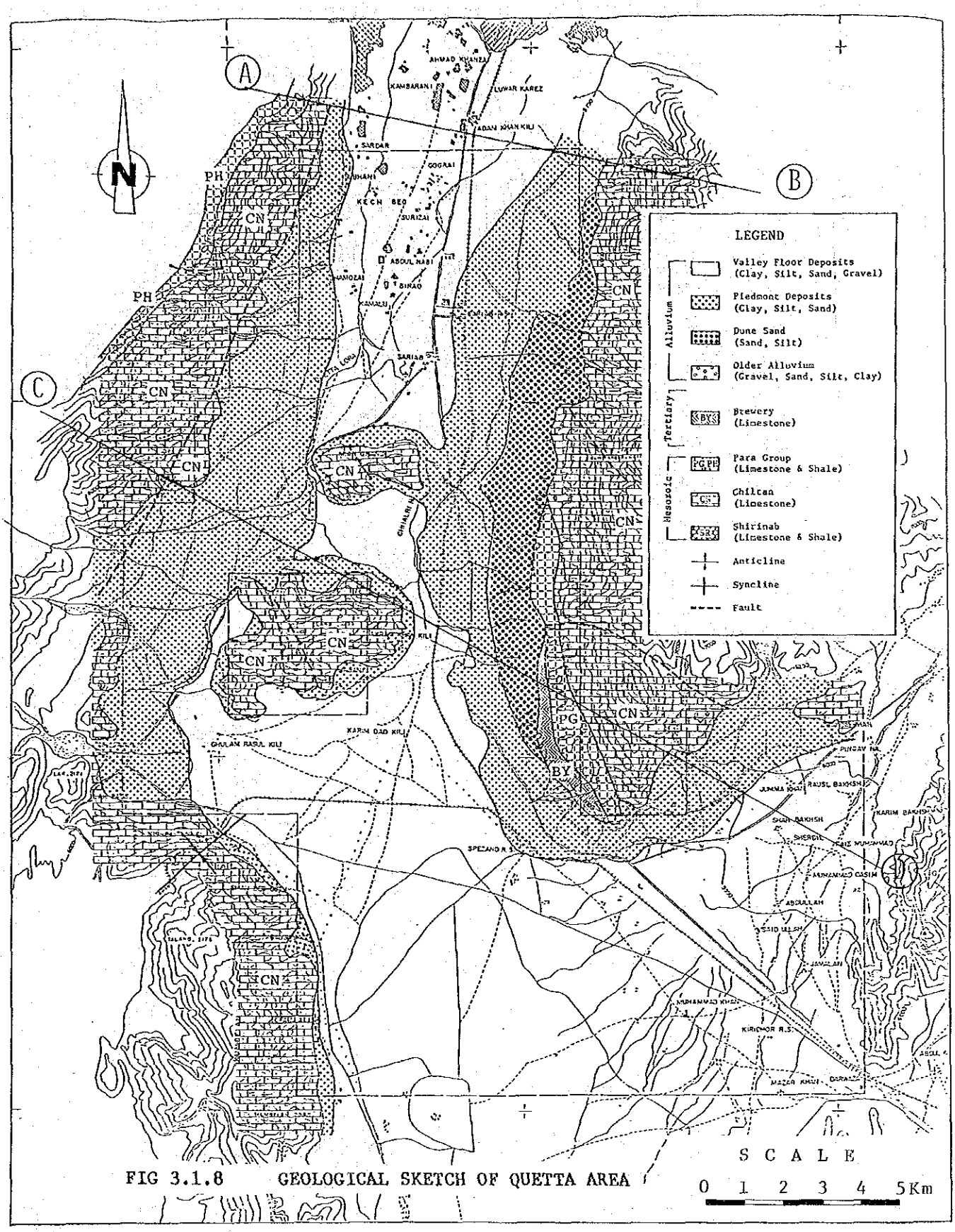


FIG 3.1.8 GEOLOGICAL SKETCH OF QUETTA AREA

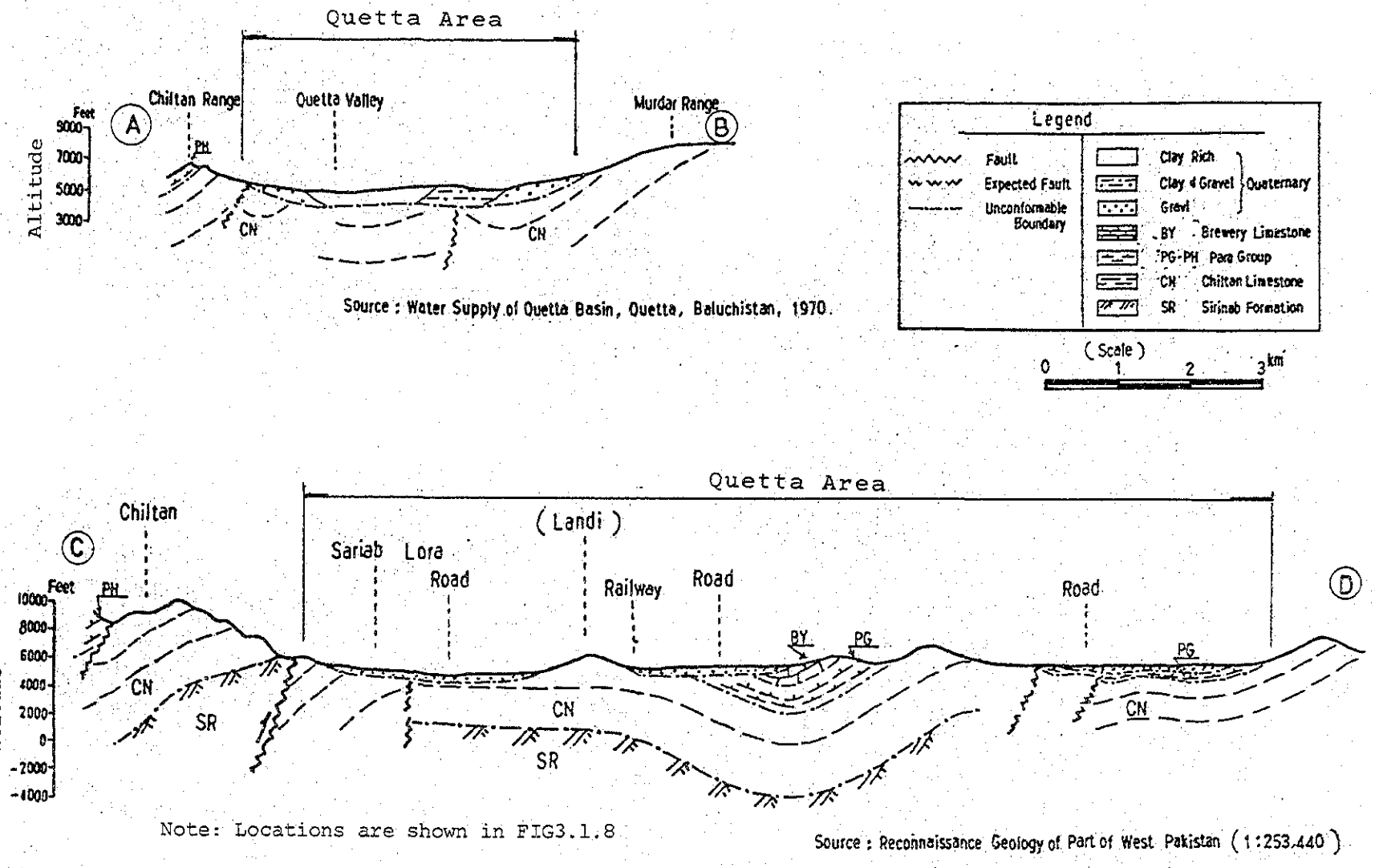


FIG 3.1.9 GEOLOGICAL CROSS SECTION IN QUETTA AREA

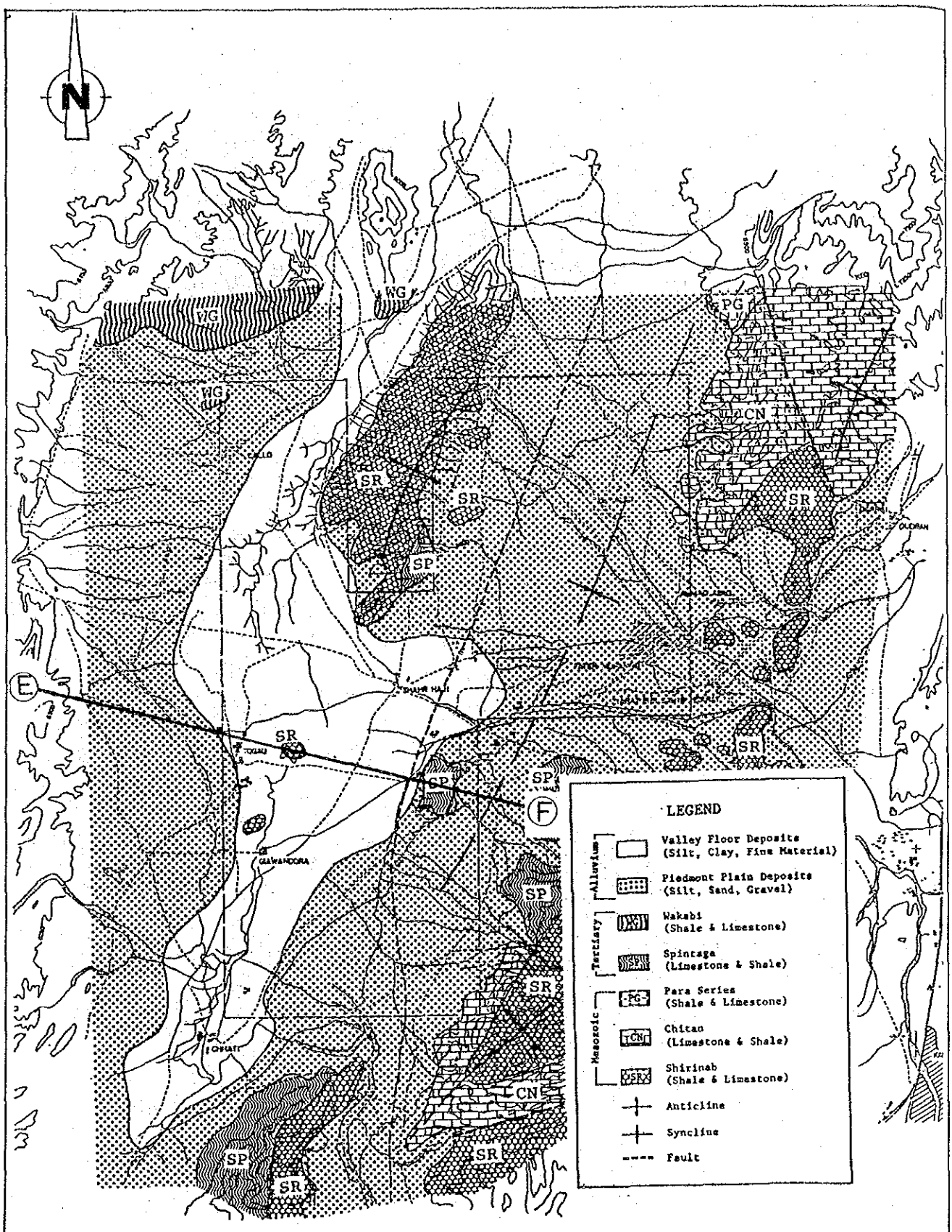


FIG 3.1.10 GEOLOGICAL SKETCH OF KALAT AREA

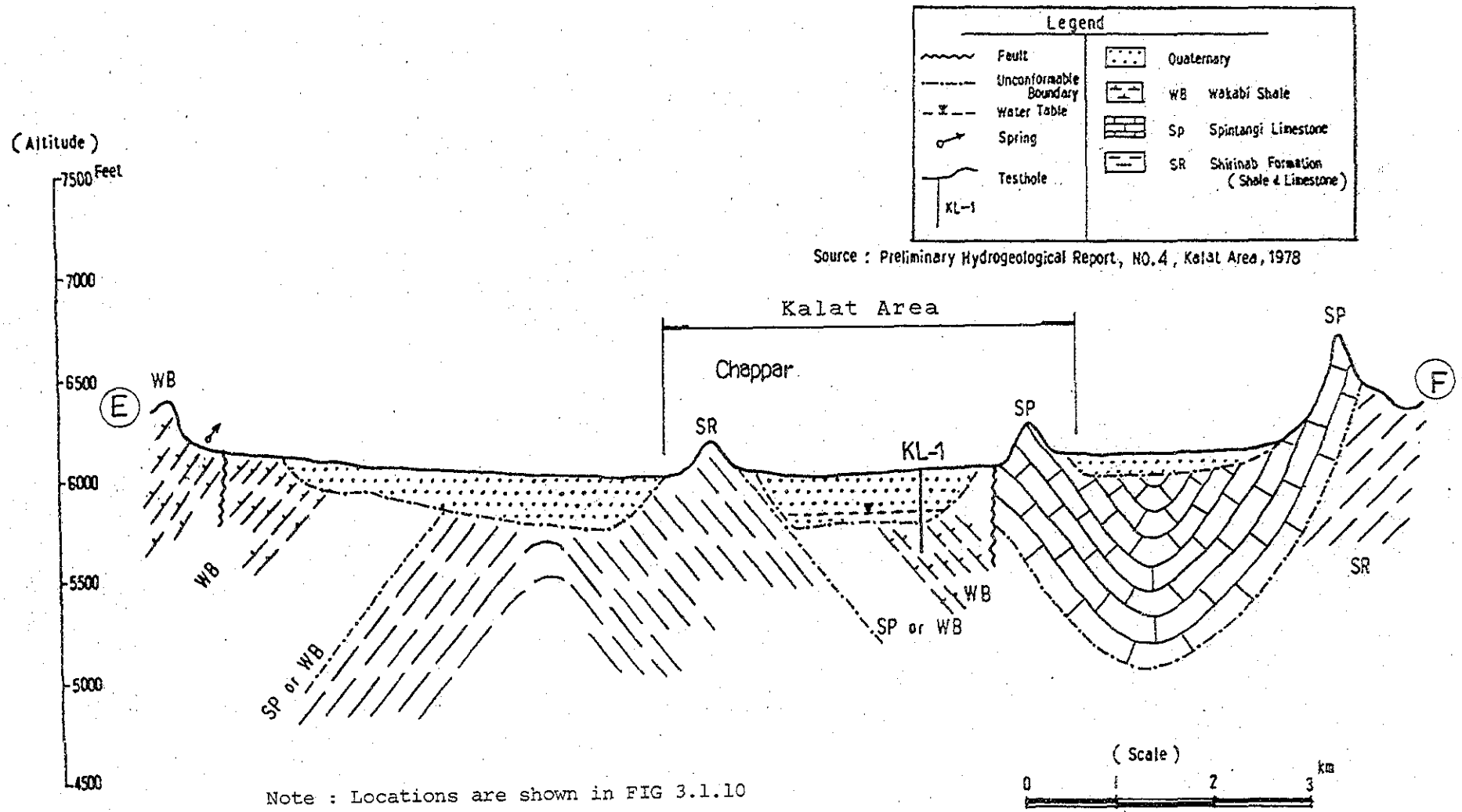


FIG 3.1.11 GEOLOGICAL CROSS SECTION IN KALAT AREA

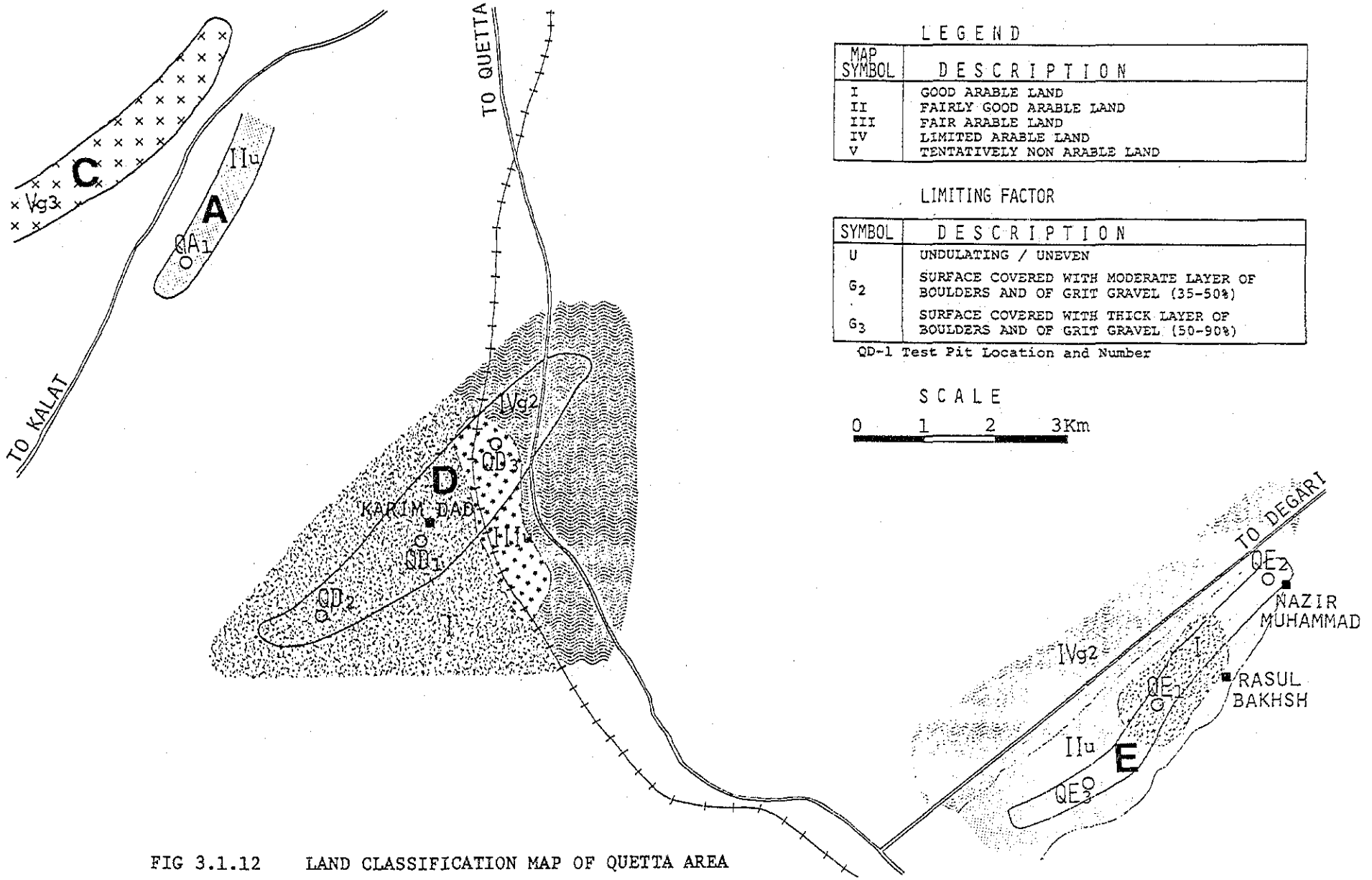
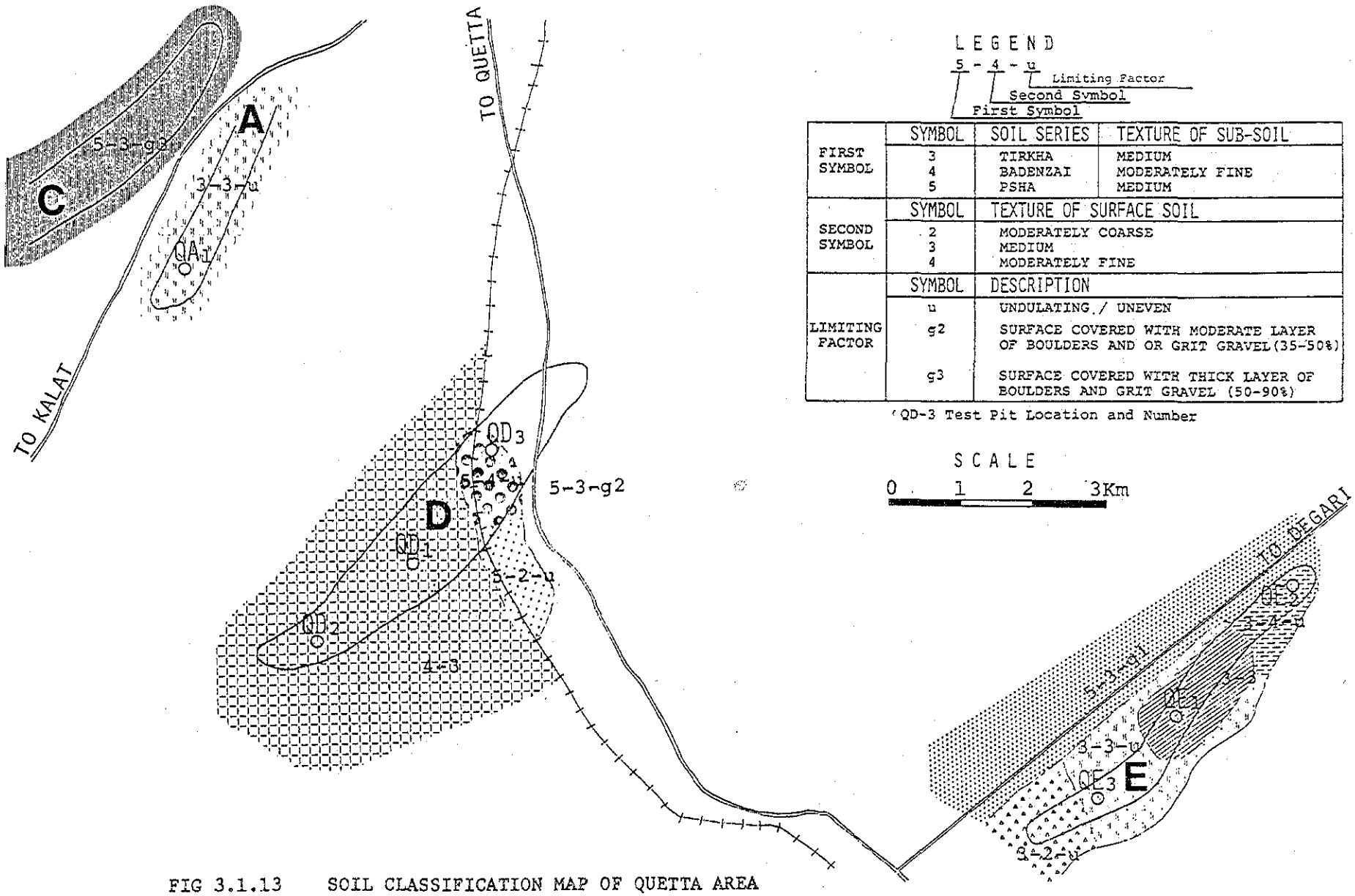


FIG 3.1.12 LAND CLASSIFICATION MAP OF QUETTA AREA



	SYMBOL	SOIL SERIES	TEXTURE OF SUB-SOIL
FIRST SYMBOL	3	TIRKHA	MEDIUM
	4	BADENZAI	MODERATELY FINE
	5	PSHA	MEDIUM
	SYMBOL	TEXTURE OF SURFACE SOIL	
SECOND SYMBOL	2	MODERATELY COARSE	
	3	MEDIUM	
	4	MODERATELY FINE	
	SYMBOL	DESCRIPTION	
LIMITING FACTOR	u	UNDULATING / UNEVEN	
	g2	SURFACE COVERED WITH MODERATE LAYER OF BOULDERS AND OR GRIT GRAVEL(35-50%)	
	g3	SURFACE COVERED WITH THICK LAYER OF BOULDERS AND GRIT GRAVEL (50-90%)	

FIG 3.1.13 SOIL CLASSIFICATION MAP OF QUETTA AREA

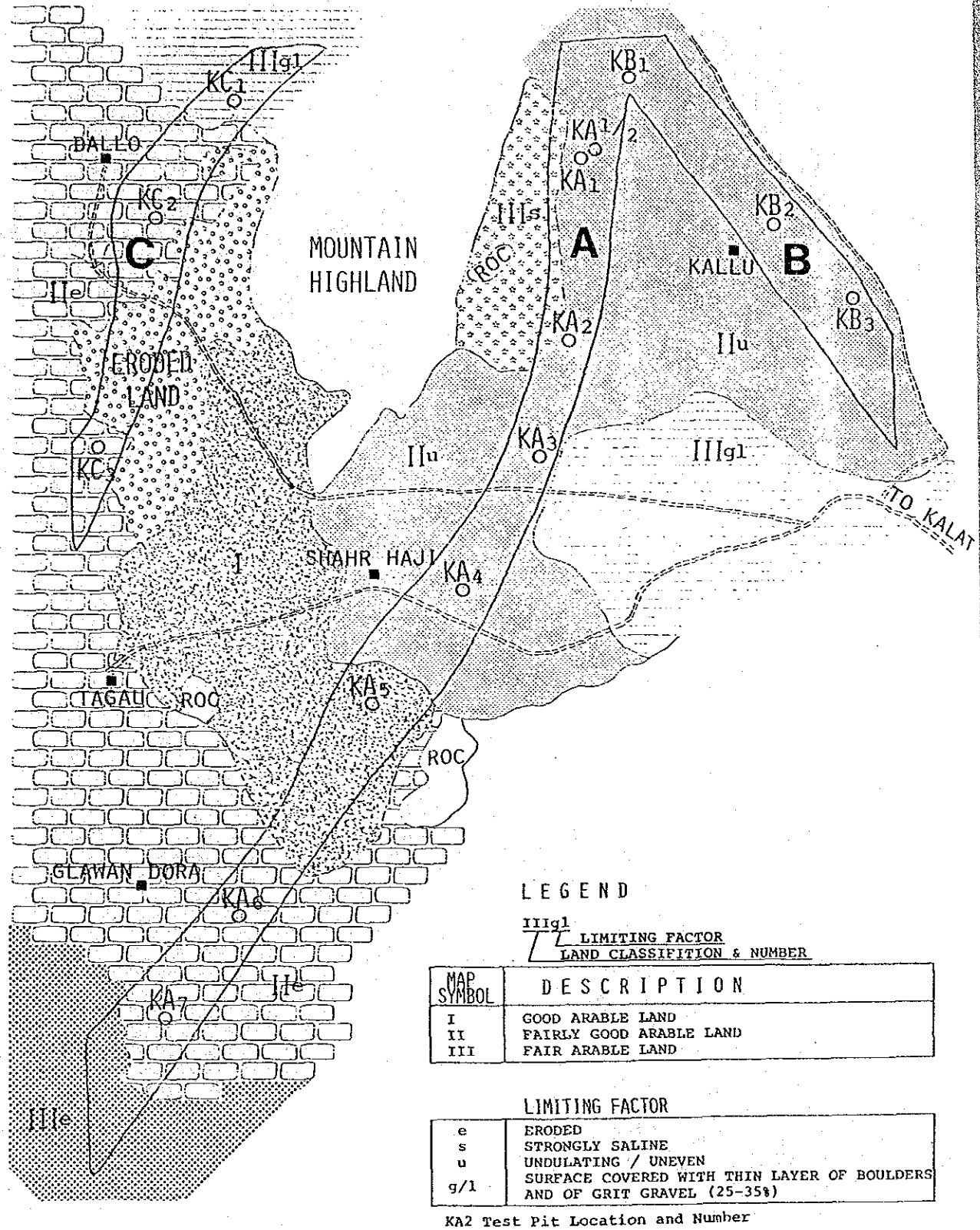
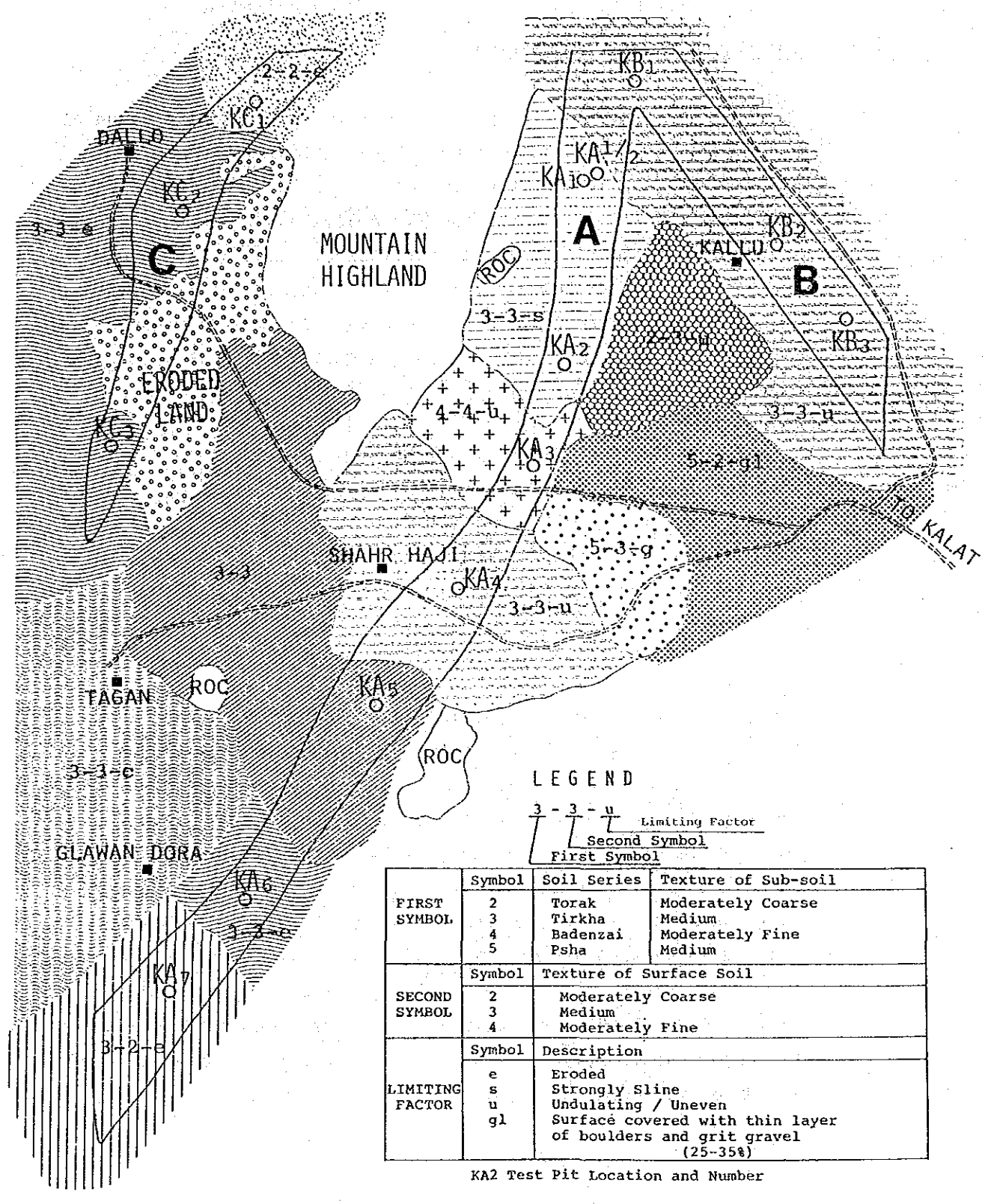


FIG 3.1.14 LAND CLASSIFICATION MAP OF KALAT AREA



	Symbol	Soil Series	Texture of Sub-soil
FIRST SYMBOL	2	Torak	Moderately Coarse
	3	Tirkha	Medium
	4	Badenzai	Moderately Fine
	5	Psha	Medium

	Symbol	Texture of Surface Soil
SECOND SYMBOL	2	Moderately Coarse
	3	Medium
	4	Moderately Fine

	Symbol	Description
LIMITING FACTOR	e	Eroded
	s	Strongly Sline
	u	Undulating / Uneven
	gl	Surface covered with thin layer of boulders and grit gravel (25-35%)

FIG 3.1.15 SOIL CLASSIFICATION MAP OF KALAT AREA

3.2 SOCIO-ECONOMIC CHARACTERISTICS

3.2.1 Administration and Population

The Study Area is administratively located in the jurisdiction of Quetta and Kalat Districts in Quetta and Kalat Divisions, respectively, of Baluchistan Province. Quetta District includes Quetta City which is the provincial capital and the center of all political, economic, and social activities. Each of the Project Area lies in the following administrative area. Tehsil/Sub-Tehsil shown below is further divided in Qanungo Circles and Qanungo Circle into Patwar Circles or Union Councils and these are further divided into mouzas or villages.

Province	Division	District	Sub-Division	Tehsil/ Sub-Tehsil	Area
Baluchistan	Kalat	Kalat	Mastung	Mastung	QT-D,E
	Kalat	Kalat	Kalat	Kalat	KL-B,C

According to 1981 Census, population of Quetta and Kalat Districts is 382,000 and 341,000, respectively. Annual average growth rate between 1972 and 1981 is 4.7% and 9.5%, respectively. Population density of Quetta and Kalat Districts is 144 and 27 persons per km^2; while Pakistan's average density is 106 persons per km^2. The urban population accounts for 75% in Quetta District and only 8% in Kalat District. The average household size is 7.7 in Quetta and 6.9 in Kalat District. The number of villages concerned in the Study Area is 10 and the total population of the Study Area is estimated at 11,500 persons; while the total number of households is approximately 1,530, of which farm households represent 1,400 or 90% of the total households.

3.2.2 Economic Characteristics

(1) Agriculture

Agriculture, the mainstay of the area, is carried out mostly on the barani (rainfed) area under traditional practices. Irrigation is done traditionally by karazes and springs. Use of tubewell with supply of electricity and mechanization have started only lately. Major crops cultivated are vegetables, fruits (apple, grape, apricot), wheat and melon in Quetta District and wheat, fodder, onion, fruit, potato in Kalat District. The actual cropped area is generally about 30 - 50% of the cultivated area. Sheep and goat breeding is commonly practiced in uncultivated area in both Districts.

(2) Industry

As of 1986, there are 103 industrial establishments with 1,645 employees in Quetta District and 96 establishments with 206 employees in Kalat District. Most of the establishments are cottage or household type industry employing a few family members or workers.

Common types of establishments are flour mills, brick mills, workshops, food processing, embroidery work, woolen carpet, rugs, shoe making, ice factory, wood work/furniture, soap factory and stone crushing. Relatively large scale plants employing several hundred workers are pharmaceutical, fruit preservation, coal mining, textile and ghee mills industries.

(3) Labor Force

The labor force participation rate for the male in Kalat District is about 56% which is considerably higher than its counterpart in Quetta District of about 40%, presumably because in the former the population joins the labor force at younger ages. The female labor constitutes only 1% or so of the total labor force. The rate of unemployment is a relatively high of 4.5% in Quetta District where the urban population dominates. The major occupational sector is service sector in Quetta District, while it is agricultural sector in Kalat District.

(4) Migration

1981 Census Report indicates that out of the total population in the respective District, 28% in Quetta and 1.6% in Kalat have immigrated in the last ten years. In addition, there is a seasonal migration of population in the Study Area. In Quetta City area, for instance, many migrants come and set up the camps feeding camels and sheep in summer and return to nearby hot areas like Sind and Nasirabad in winter. In rural areas, many houses or villages are deserted seasonally due to the drought and climatic reasons, seeking farm and non-farm employment opportunities elsewhere.

3.2.3 Social Characteristics

(1) Education and Literacy

In the Study Area, primary school is located in every two or three villages and is supplemented by mosque school (for male only) in every five villages in average. Male primary school in two Districts represents about 73% of total primary schools. In Quetta District, there are one university (15 - 16th grade) and several colleges (11 - 14th grade), while there are a few colleges in Kalat District. It is estimated that enrollment ratio at primary school in two Districts is 45% for boys and 31% for girls.

Literacy ratio among the population of 10 years and above is estimated at 37% in Quetta and 6% in Kalat District. Literacy ratio among the rural female is mere 1.5%.

Educational attainment among the total population of 10 years and above in the two Districts is that 8% attained the primary level (5th grade), 6% the middle level (8th grade), 5% the matriculation (10th grade) and 4% the higher level.

(2) Health

There are 65 and 45 medical institutions of various kinds in Quetta and Kalat Districts. with 52 and 560 villages, respectively. It is estimated that there is at least one health institution in every few villages in Quetta and in every 10 villages or so in Kalat District. Average population served by medical officer (doctor) is about 3,700 and by para-medical staff is about 2,800. The common diseases treated in Baluchistan are dysentry, diarrhoea, malaria, typhoid and T.B.

(3) Socio-Cultural Aspects

The dominant languages spoken are Pushto (68%) in Quetta Division and Brahui (55%) and Baluchi (28%) in Kalat Division. Urdu is spoken only by 1.4% of the households among the educated persons and the tribal leaders who are needed to communicate with government officials. The religion is almost Islam of the Sunni sect(98%).

The salient feature of social structure in the Study Area is the tribal system among the different races. The main races are Afghans (Kakars and Tarins) and Brahuis in Quetta and Brahuis and Baluch in Kalat. These races are all organized into tribes, each having a multitude of sub-divisions, clans, sections, and sub-sections.

The bond of union among the races is either the feeling of kinship among those descended from the common ancestor or the political entity composed of those separate origin clustering around the head group. Land ownership is accorded as the most favored and prestigeous status in the Study Area.

Reportedly, the land has originally been divided into groups of holdings among the different tribal sub-divisions, resulting in the commonly-held tribal (undivided) land. Uncultivated land is often of this type where grazing is the most common use.

In recent time, individual ownership under the nuclear family is also common. However, the correct boundaries of land among the tribal sub-sections are often not clear, and thus confirmation of boundary is still being undertaken among the tribes and in the negotiation with the government for the unsettled area.

The Land Settlement Office of the Province now confirms that the boundary of about 80% of the reported land is settled. There was a case nearby the Study Area where the irrigation scheme had to be stopped because some payments were requested to the government by the dwellers in the area.

Regarding the water right, the tradition dictates that newly developed groundwater resources belong either totally to the land holder where the resource is newly developed or is shared proportionally in terms of the size of holding among the holders of a certain given area.

In any case, tube well development especially in the unsettled area may turn out to be a sensitive matter and thus requires special attention and arrangement. Land settlement and water right status can be identified by scrutinizing the land revenue record in the Tehsil Office.

Tribal laws and customs that place great emphasis on rules of honor often predominate in the unsettled area, but their authority is increasingly replaced by the government regulations.

(4) Farmers' Organizations

1) Cooperatives

There are reportedly 61 agricultural cooperatives with 1,158 members in Quetta District and 80 similar cooperatives with 1,655 members in Kalat District. The organizational ratios are 10% and 4% in Quetta and Kalat Districts, respectively (as of 1984).

More than half of these are multipurpose agriculture and rural development cooperatives and the remaining are those related with tube well management, input supply, fruit and vegetable marketing and livestock production.

The activities of multipurpose cooperatives are, however, confined to provision of credit. Assistance in marketing of products is almost non-existent. Cooperatives deal with the short-term (6 - 8 months) loan for input materials such as fertilizer, chemical and seed as well as with the medium-term (5 - 8 years) loan for vehicles, machinery and wells. The credit is loaned by the Federal Bank for Cooperative through its provincial branch with 9 to 11.5% annual rate of service charge (interest).

2) Kareze Water Users' Association

Other than these registered cooperatives, there seems to be no active farmer's organizations existing in the Study Area, which is attributed to the ignorance and no interest on the part of farmers. One exception is traditional kareze water users' associations among the local farmers.

The kareze water users' association may provide some idea as a model in establishing a water users' association under the Project. Tribal system suggests, however, that in the allocation of water and land resources, the rivalry relationship may arise among the different tribal subsections or even among the cousins.

3.2.4 Farm Household Economic Survey

The farm household economic survey was conducted in September 1987 in about two weeks for 23 farm households and 6 village leaders with assistance of the Hydrogeology Project, WAPDA. The sample households were randomly selected in and nearby the Study Area. Size of the sample is quite limited for such reasons as difficult access to the scattered villages, occasionally deserted villages, communication problem and limited number of enumerators. The major findings of the survey results are presented below and details are given in Volume II: Appendices.

(1) Area, Production and Yield

Nearly half of the planted area among the sample households is under wheat followed by cumin, fodder crops, apple, potato, onion, etc. Reported production and yield show significant variations among the samples partly because of drought conditions. Average figures, thus, are occasionally significantly different from the probable ones. The summary of the survey.

TABLE 3.2.1 PRESENT CROPS AND YIELD

Crop	Planted Area (ha)	Harvested Area (ha)	Production (t)	Yield (t/ha)
Wheat	117	101	157.0	1.6
Cumin	29	28	4.9	0.2
Sorghum	10	3	6.6	2.2
Potato	15	13	107.8	8.3
Onion	10	10	122.6	12.3
Alfalfa	24	24	216.0	9.0
Apple	18	18	98.7	5.5
Melon	8	2	16.9	8.5
Vegetable	4	4	39.5	9.9
Others 1/	4	1	-	-
Total	239	204	-	-

Note: 1/ includes maize, apricot, water melon, sunflower, etc.

(2) Farmland Size

Average size of land holding is 52.5 ha, consisting of 5.4 ha for wheat, 2.6 ha for field crops, 2.1 ha for permanent crops (fruit) and 42.4 ha for pasture/fallow area. Pasture land includes common tribal land which is occasionally unsettled (refer to VOLUME II APPENDICES).

(3) Farming Practice

Among those surveyed, no household is renting the land from other operators. But renting out land to others is practiced only among 4 households, accounting for about 13% of the total wheat and field crop area. Typical rent is received in kind (wheat, vegetables, etc), varying from 50% to 75% of the products.

Primary source of irrigation water is rain for wheat and wells for vegetables and fruits.

Since most of the area is flood or rain-fed area, use of input materials at present is quite minimal. About one fourth of wheat producers use limited amount of fertilizer and almost no pesticide.

Hired labor is also used among one fourth of wheat producers while every producer makes use of either draft animal or machinery (tractor) for land preparation.

For field (cash) crops such as potato, onion, vegetables and apple, almost all producers apply fertilizer and pesticide.

Except wheat which is consumed mostly half by farmers themselves, most of agricultural products flow into the market and some of the products is assumed to be a rent of tenancy.

(4) Farm Gate Price

Farm gate prices of crops collected in the farm economic survey are shown below. In determining the prices for evaluation, these are referred together with the prices obtained at Dept. of Agriculture.

Wheat	:	2.2 Rs/kg	Alfalfa	:	0.75 Rs/kg
Cumin	:	20.3 Rs/kg	Sorghum	:	2.5 Rs/kg
Potato	:	2.4 Rs/kg	Vegetables	:	1.7 Rs/kg
Onion	:	5.1 Rs/kg	Apple	:	6.0 Rs/kg

(5) Livestock

Farmers in the Study Area raise a variety of livestock with the majority owning 29 sheep, 17 goat and 2 camels on an average. Camels are used for farming and transportation work.

(6) Household Inventory

Structures and farm equipment held by the sample farms are confined to house for dwelling, warehouse, animal shed and animal plow. Machinery such as tractor, pump and sprayer are owned by only 10 to 20% of the sample households. Holding of the equipment by sample households is quite limited and the equipment itself is very primitive.

(7) Domestic Water Supply

The sample households obtain domestic water mostly from either open well or tube well. For lifting the water, a pulley is used manually or with assistance of draft animal.

Therefore, even though the wells are located only some hundred meters away, it typically takes an average 6 man-hours/day or so to obtain daily water requirement.

(8) Debt Status

More than 80% of the sample households make a loan for various purposes. The source of loan tends to be a relative in case the amount is small, while a larger amount is often borrowed from the bank.

(9) Household Income and Expenditure

The income data collected in the survey must be treated with caution, since the sample size is quite small and the data from irrigated land tend to grossly bias the likely average figures.

About one third of the sample households have no income from crops, while about one fourth (those with irrigated land) make a considerably high income from field crops and fruit.

Those without irrigated land supplement their meager farm income with off-farm employment. The average per capital income for the whole sample households turns out to be US$445, which is somewhat larger than national average of US$340. However, the per capita income for those without irrigated land remains at the poverty line.

The household expenditure data appear to be under-reported as compared with the reported income. The reported data indicate that nearly two-thirds of the expenditure is spent on food items.