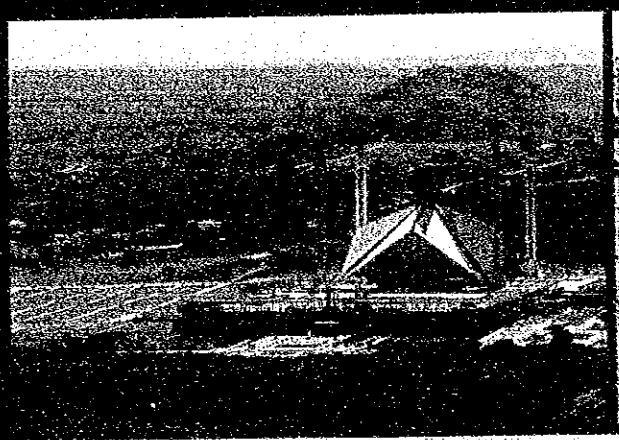
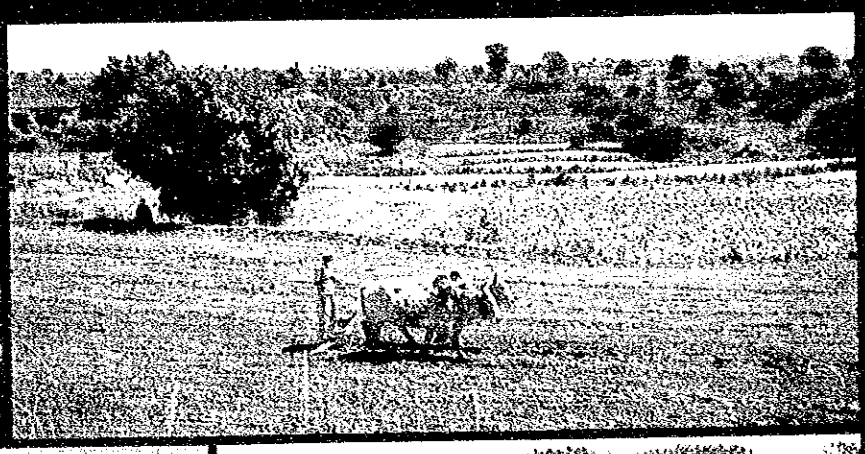
THE ISLAMIC REPUBLIC OF PAKISTAN

THE FEASIBILITY STUDY ON UPPER KURANG RIVER IRRIGATION PROJECT

MAIN REPORT





JUNE, 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

THE ISLAMIC REPUBLIC OF PAKISTAN

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MAIN REPORT

JUNE, 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the request of the Government of the Islamic Republic of Pakistan, the Government of Japan has decided to conduct a survey on the Upper Kurang River Irrigation Project and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Pakistan a survey team headed by Mr. Seiji Takeuchi, Sanyu Consultants Inc., in 1987 and 1988.

The team exchanged views with the officials concerned of the Government of Pakistan and conducted a field survey in Islamabad Capital Territory Area. After the team returned to Japan, further studies were made and the present report has been prepared.

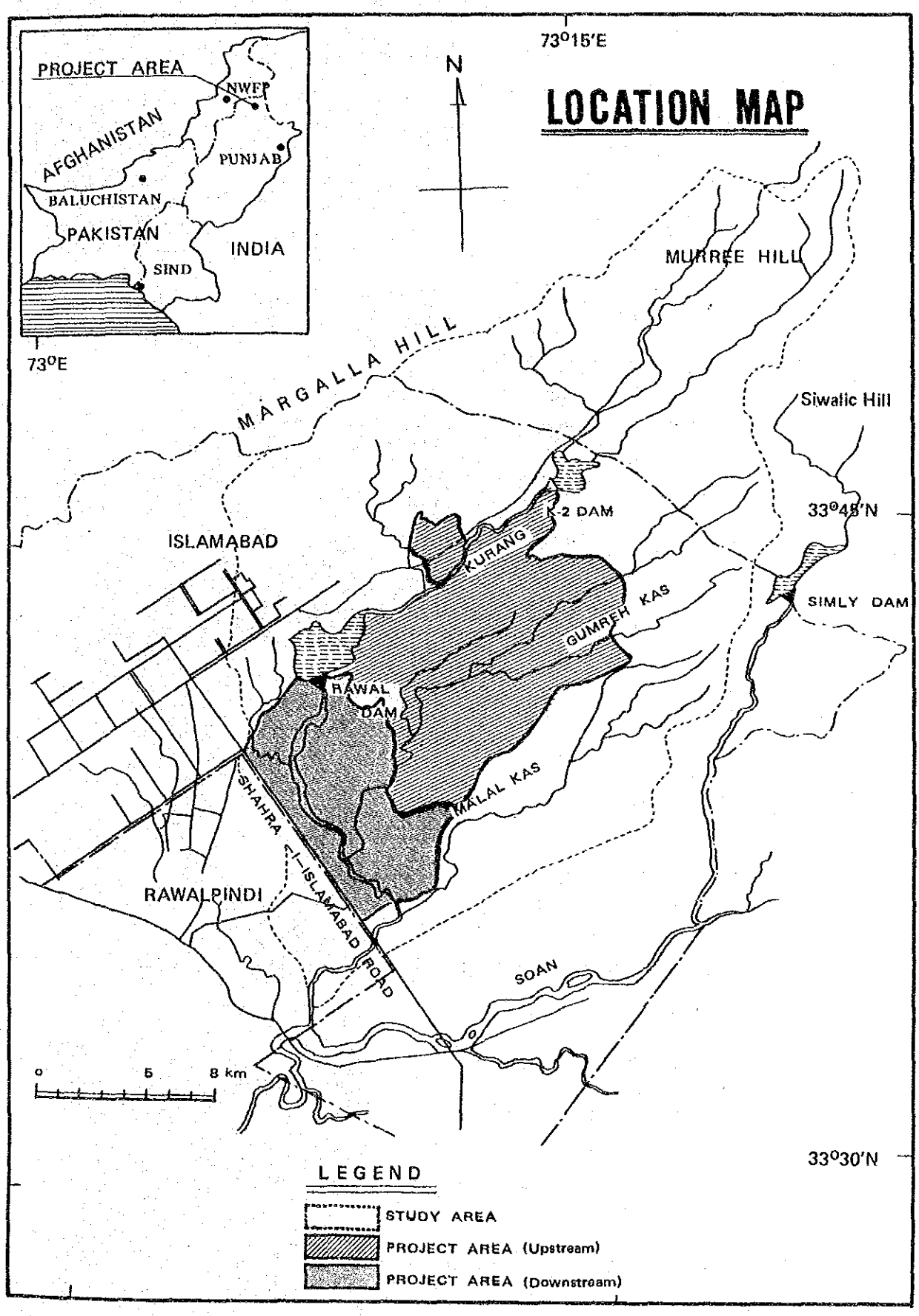
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

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.

June, 1988

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

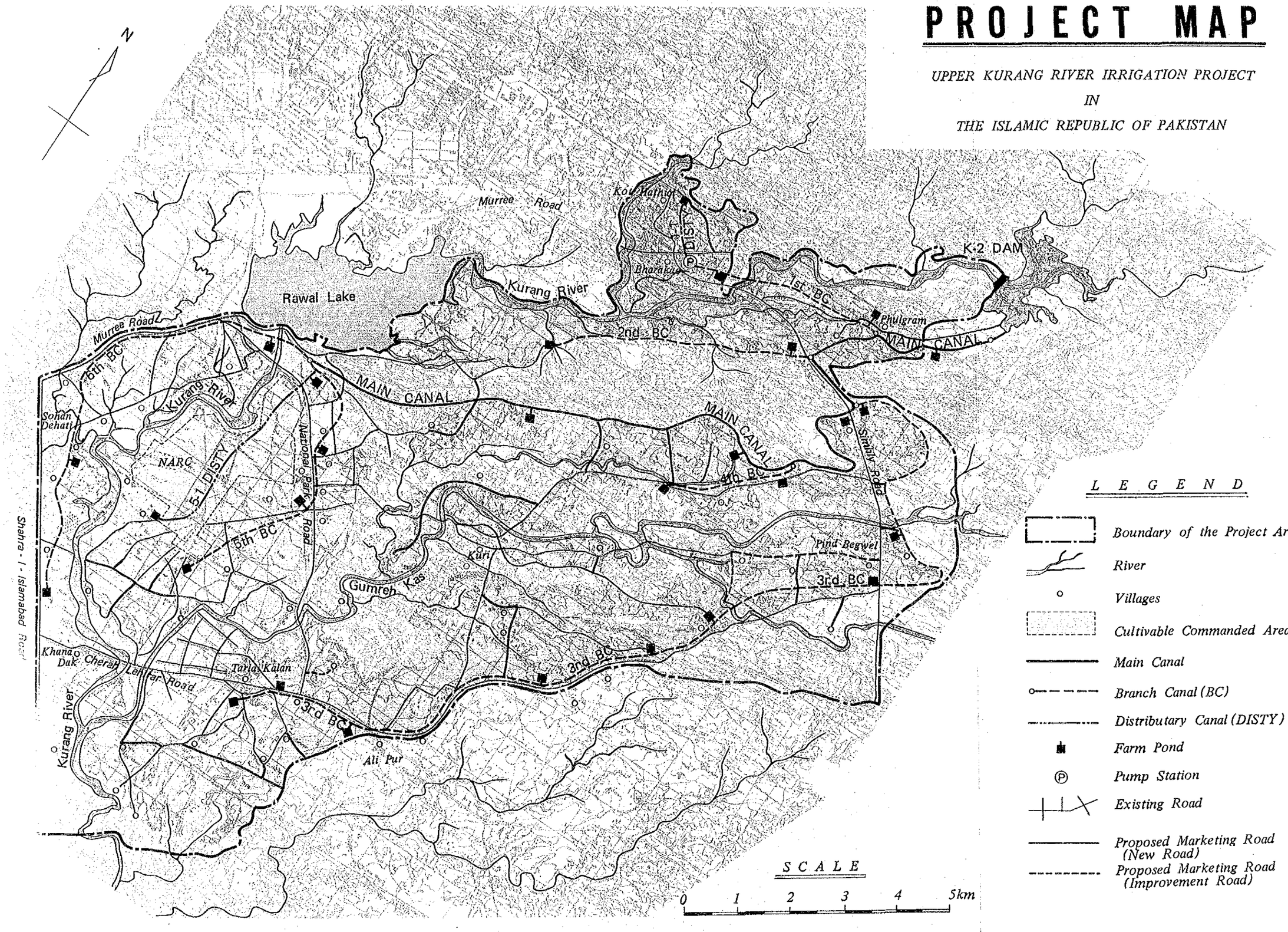

LOCATION MAP
PROJECT AREA
NWFP
AFGHANISTAN
PUNJAB
BALUCHISTAN
PAKISTAN
INDIA
SIND
73°E
73°15'E
N
MURREE HILL
MARGALLA HILL
Siwalic Hill
33°45'N
ISLAMABAD
KURANG
K-2 DAM
GUMREH KAS
SIMLY DAM
RAWAL
DAM
MALAL KAS
SHAHRA-I-ISLAMABAD ROAD
RAWALPINDI
SOAN
0
5
8 km
33°30'N
LEGEND
STUDY AREA
PROJECT AREA (Upstream)
PROJECT AREA (Downstream)

PROJECT MAP

UPPER KURANG RIVER IRRIGATION PROJECT

IN

THE ISLAMIC REPUBLIC OF PAKISTAN



L E G E N D

- *Boundary of the Project Area*
- *River*
- *Villages*
- *Cultivable Commanded Area*
- *Main Canal*
- *Branch Canal (BC)*
- *Distributary Canal (DISTY)*
- *Farm Pond*
- *Pump Station*
- *Existing Road*
- *Proposed Marketing Road (New Road)*
- *Proposed Marketing Road (Improvement Road)*

S C A L E

0 1 2 3 4 5km

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G. AGRICULTURE AND REGIONAL ECONOMY

H. DAM AND CANALS

I. ON-FARM DEVELOPMENT WORKS

J. COST ESTIMATE

K. PROJECT ECONOMY

L. PRE-ENGINEERING WORKS

M. COLLECTED DATA AND PAKISTAN GOVERNMENT OFFICIALS CONTACTED BY STUDY TEAM

ABBREVIATIONS AND GLOSSARY

1) Agencies

ABAD	Agency for Barani Areas Development
ADBP	Agricultural Development Bank of Pakistan
BARD	Barani Agricultural Research and Development Project
CDA	Capital Development Authority
EAD	Economic Affairs Division
ICTA	Islamabad Capital Territory Administration
IDWP	Islamabad Development Working Party
JICA	Japan International Cooperation Agency
LGRD	Local Government and Rural Development, ICTA
MFAC	Ministry of Food, Agriculture & Cooperative
NARC	National Agricultural Research Center
NCRD	National Center for Rural Development
PADSC	Punjab Agricultural Development and Supplies Corporation
PARC	Pakistan Agricultural Research Council
PSC	Punjab Seed Corporation
PERI	Punjab Economic Research Institute
PHED	Public Health Engineering Department
RACC	Rural Area Coordinating Committee
RMC	Regional Meteorological Center
SDO	Small Dams Organization
UC	Union Council
WAPDA	Water and Power Development Authority

2) Others

ASTM	American Society for Testing and Materials
Barani	Rainfed Farming Area
CCA	Cultivable Commanded Area
ICT	Islamabad Capital Territory
IRDP	Integrated Rural Development Programme
Katcha	Unmetalled or unpaved canal
Kharif	Summer season

Markaz	Integrated rural development center
Master Plan	Master Plan for Integrated Rural Development Project
MIRAD	Model Integrated Rural Area Development
Pacca	Paved canal by stone masonry
Panchayat	Elected local body at grassroots level
Project Area	Area of 12,900 ha located on both banks of the Kurang River and Gumreh Kas River
Rabi	Winter season
RHC	Rural Health Center
Sarpanch	Head of the Panchayat
Study Area	Total catchment area of the Kurang River, 580 sq.km
Study Team	JICA Study Team assigned to the Feasibility Study

3) Units of Measurement

mm	millimeter
cm	centimeter
m	meter
km	kilometer
sq.cm	square centimeter
sq.m	square meter
sq.km	square kilometer
MSM	million square meter
l, lit.	liter
cu.m	cubic meter
MCM	million cubic meter
gal	gallon
A.F	acre feet
lit/sec	liter per second
m/sec	meter per second
cusec	cubic feet per second
MGD	million gallon per day
ppm	part per million
ms/cm	million siemens per centimeter
pH	potential of hydrogen
EC	electric conductivity
g	gram
kg	kilogram
ton, m.t.	metric ton

EL	elevation above mean sea level
MSL	mean sea level
FWL	full water level
HWL	high water level
LWL	low water level
TRAM	total readily available moisture
sec.	second
min.	minute
hr.	hour
min.	minimum
max.	maximum
%	percent
No.	number
°C	degree centigrade
°F	degree fahrenheit
Cl	chlorine
HP	horse power
ET	evapotranspiration
N	nitrogen
P	phosphate
K	potassium
O & M	operation and maintenance
KWh	Kilowatt hour
EIRR	economic internal rate of return
B/C	benefit cost ratio
FY	fiscal year
Rs	Rupees (currency of Pakistan)
US$	US Dollar

4) Conversion Factors

Unit		Comparison	English Equivalent
Unit of Length:			
Millimeter	(mm)	0.001 meter	0.0394 inch
Centimeter	(cm)	0.01 meter	0.3937 inch
Meter	(m)		3.2800 foot
Kilometer	(km)	1,000 meter	0.6213 mile
Unit of Area:			
Square centimeter	(sq.cm)	0.0001 sq.m	0.155 square inch
Square meter	(sq.m)		10.764 square feet
Hectare	(ha)	10,000 sq.m	2.471 acres
Square kilometer	(sq.km)	1,000,000 sq.m	0.386 square mile
Unit of Volume:			
Cubic centimeter	(cu.cm)		0.061 cubic inch
Liter	(lit)	0.001 cu.m	1.0567 quarts (liquid)
Cubic meter	(cu.m)	1,000 liters	35.3145 cubic feet
			0.811×10^{-3} acre foot

Unit of Weight:		
Gram (g)		0.0353 ounce
Kilogram (kg)	1,000 grams	2.2046 pounds
Metric Ton (mt)	1,000 kg	2,204.6 pounds
Unit of Flow:		
Liter per second (lit/sec)		0.0353 cusecs
Cubic meter per second (cu.m/sec)		35.310 cusecs

CHAPTER I. INTRODUCTION

CHAPTER I. INTRODUCTION

1.1. Background of the Study

The Government of the Islamic Republic of Pakistan has formulated its Five-Year National Development Plan, upon which the development policies are being positively executed in a variety of fields. The current Sixth Five-Year Plan (July 1983 - June 1988) has taken up the rural area development as cornerstone of the national development in view that its rural area having almost 80 percent of the national population is the very base of the economic development of the country.

The Government of Pakistan, with such background, requested the Government of Japan for technical cooperation in the Master Plan Study for Integrated Rural Development Project to realize the rural area development around Islamabad, the Metropolis, and the Japan International Cooperation Agency (JICA) as executing body of the Government of Japan carried out the said Master Plan Study from 1985 to 1986.

The current study has resulted from the aforesaid Master Plan Study with a promisingly high priority. The proposed development plan aims to effectively utilize the Kurang River water in both bank tracts of the river for irrigation of farmlands which are presently rainfed fields, or the so-called "Barani area", extending in the peripheral rural areas of Islamabad.

In answer to the request by the Government of Pakistan for the technical cooperation of the Feasibility Study on the Upper Kurang River Irrigation Project, which was made in May 1986, the Government of Japan dispatched the Preliminary Survey Team in February 1987 through the Japan International Cooperation Agency (JICA), and decided to extend cooperation according to the results of the above survey. And the Scope of Work (S/W) for the further study of the Project was concluded between the Islamabad Capital Territory Administration (ICTA) and JICA.

1.2. Implementation of the Study

The Feasibility Study of the project was made in phases, Phase I and Phase II, starting from the end of July 1987.

The Phase I study aiming at delineation of the basic project plan was commenced from the end of July 1987 and completed in the end of November 1987. During this period, the survey for basic data collection on topography, geology, hydrology, soil, etc. and the study for delineation of basic project plan of irrigation, agriculture, dam, canals, farm management, etc. were conducted as Phase I field work, in accordance with the discussion with ICTA for the Inception Report. The detailed survey and study have been carried out in cooperation with the Pakistani Government Offices concerned, and the Field Report was prepared and submitted to the Pakistani Government at the beginning of October 1987.

After submitting the Field Report, Phase I home office work was conducted in Japan for the detailed study on basic project plan till the end of November 1987, and the study results were compiled into the Interim Report.

The Phase II study aiming at the formulation of project plan was commenced from the beginning of December 1987 and completed by the end of March 1988. The Phase II field work and home office work were carried out as well for the formulation of project plan. And Progress Report and Draft Final Report were prepared by Study Team at the end of each stage of study work.

Following the elaborate discussion between Study Team and Pakistani Government Officials concerned for Draft Final Report in March 1988, the Final Report of the Project was prepared in June 1988.

The Report covers the results of studies carried out by the Study Team in collaboration with the Pakistani Government Officials concerned, and also incorporates all the provisions in respect of interim discussions held among the Pakistani Officials, the JICA Advisory Committee and the Study Team.

1.3. Objectives of the Study

The objectives of the study can be summarized as follows:

- To formulate a plan of the Kurang River water resources development and irrigated agriculture development in the currently rainfed farm fields around Islamabad by effective use of the water resources, and to carry out the Feasibility Study of the Project in terms of technology and economy as well as to make the Project evaluation;
- To formulate an agricultural development plan for raising agricultural production, increasing employment opportunities, and improving/stabilizing the living standards of local inhabitants through the introduction of irrigated agriculture, and to formulate an institutional development plan involving the establishment of farmers' organizations, which will make operation and maintenance of system facilities and conduct adequate water management, and agricultural supporting services.
- To transfer knowledge and technology to the Pakistani counterpart personnel through execution of the aforesaid survey and study.

Member of the Advisory Committee and the Study Team assigned to the project are listed below;

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1.	Mr. Takeshi Ishida	Leader, Project Manager, land Improvement Engineering Service Center, Tokai Regional Agricultural Administration Office, Ministry of Agriculture, Forestry and Fisheries (MAFF)
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5.	Mr. Masami Mizuno	Project Evaluation, National Research Institute of Agricultural Economics

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8.	Mr. Kazuki Muta	Implementation Plan and Cost Estimation, SCI
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10.	Mr. Mitsutomo Anai	Agricultural Economy, SCI
11.	Mr. Toshiki Kuroiwa	Survey Supervision, NGI

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1.	Mr. Naguibullah Malik	Project Director/Deputy Commissioner, ICTA
2.	Mr. Shahid Najam	Director, Development and Finance, ICTA
3.	Mr. Rja Abdul Hameed	Coordinator/Assistant Director, LGRD, ICTA
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5.	Mr. Arshad Khan	Assistant Agricultural Engineer, Soil Conservation, NARC
6.	Mr. Malik Ahmad Khan	Deputy Director, SDO
7.	Mr. Abdul Gahffar	Assistant Director, SDO
8.	Mr. A. R Javaid	Deputy Director General, CDA
9.	Mr. A. Q Nomani	Director, CDA
10.	Mr. Khalid Masud	Agricultural Extension Director, NARC
11.	Mr. Mohammad Iqbad Shah	Executive Engineer, PHED
12.	Mr. Arshad Mohmood Khan	Development Officer, Rural Development Markaz center

CHAPTER II. BACKGROUND OF THE PROJECT

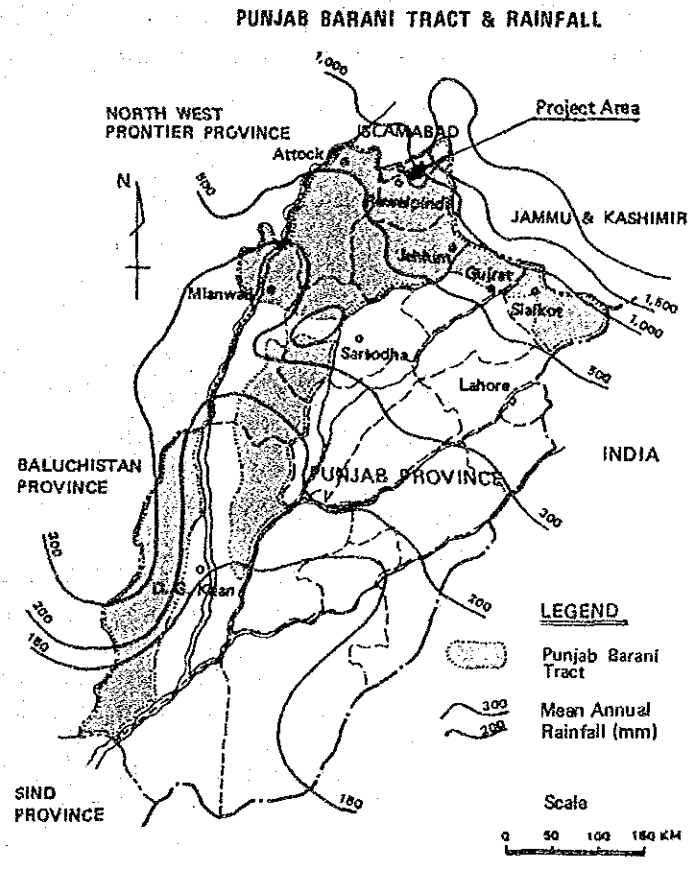
CHAPTER II. BACKGROUND OF THE PROJECT

2.1. General Situation of Punjab Barani Tract

2.1.1. Geography

According to the Agricultural Census of Pakistan, 1980, the Barani Tract is defined as the cultivated area not being artificially irrigated but dependent solely on rainfall. The Barani Tract in Pakistan is extensively distributed in the northern and western parts of the Punjab Province, including Islamabad Capital Territory (ICT) and eight Districts in Punjab. The gross area is estimated at 86,000 sq.km (33,196 sq.mi), which is equivalent to 11 percent of the whole Pakistan and 41 percent of the Punjab Province.

An annual rainfall in the Punjab Barani Tract fluctuates by location in the Indus Plain of the south western part and the Himalayan foot plain including Potwar Plateau of the northern part. An average annual rainfall of these areas is from 100 to 200 mm (3.9 - 7.9 in) and 500 to 1,800 mm (19.7 - 70.9 in), respectively. In the Barani area, rainfall is characterized by its limited and irregular distribution.



Agriculture is the main industry in Punjab Barani Tract excluding four Districts of Rawalpindi, Jhelum, Gujrat, and Sialkot in the northern part. The Barani Area, being a rainfed agricultural area with low productivity, is identified as one of the poor areas. However, compared with the other Barani areas, the Project Area has favorable weather conditions with an average annual rainfall of 1,200 mm (47.3 in), although fluctuation in rainfall is remarkable, ranging from 700 to 1,600 mm (27.5 to 63.0 in).

2.1.2. Socio-Economic Status

1) Land Use

The ratio of cultivated land to the total land in the Punjab Barani Tract inclusive of the Project Area is 57 percent, which is about 20 percent lower than that of the other areas, i.e. by 76 percent. The potential farming land in the Barani Tract seems to be extremely limited in acreage.

Land Use in Barani Tract in 1983

(units: '000 ha, and %)

Items	Islamabad & Punjab Province		Whole Country
	Barani Area	Other Area	
- Total Area[1/]	7,003	10,074	56,710
- Cultivated Area	3,960	7,648	20,280
(Total Area = 100)	(56.5)	(75.9)	(35.8)
- Uncultivable Area	3,043	2,426	36,430

Note : 1/ ... excluding the area unreported

Source: 1. "Pakistan Statistical Year Book, 1986" Federal Bureau of Statistics, Government of Pakistan.

2. "Punjab Barani Tract in Figures, 1986" Agency for Barani Area Development, Government of Punjab.

2) Population

The total population of the Punjab Barani Tract in 1981 was estimated at 9.8 million which shared 12 percent of the national total. The population density in the Punjab Barani Tract is 114 persons/sq.km. The value is considerably lower than that of the other areas.

The annual growth rate of population of the Punjab Barani Tract had remained comparatively low by 2.3 percent during the period of ten years (1972 - 1981), as compared with 2.7 percent in the peripheral areas of the Barani Tract and also 3.1 percent of the national average. This is attributable to that a low level of agricultural land productivity in the Barani Tract cannot maintain more population.

Population in Barani Tract

Items	Islamabad & Punjab Province		Whole Country
	Barani Area	Other Area	
Total Population ('000 persons)			
a. 1961	5,432	20,187	42,978
b. 1972	8,041	29,806	65,321
c. 1981 - Total	9,829	37,804	84,254
- Urban	2,465	10,790	23,840
- Rural	7,364	27,013	60,413
Total Area (sq.km)	86,391	119,859	796,095
Annual Population Increase (%)			
a. 1961-72	3.6	3.6	3.7
b. 1972-81	2.3	2.7	3.1
Population Density (person/sq.km, 1981)	114	315	106

Source: "Population Census, 1981"
Population Census Organization, Government of Pakistan

3) Industrial Situation

In Pakistan, Punjab Province is a commercial and industrial center as well as Sind Province. However, the registered factories in the Punjab Barani Tract are fewer in numbers than those in the outside areas of Barani Tract, and agriculture is the main industry of this Tract.

On the other side, the number of workers, discharging from Punjab Barani Tract for ten years from 1972 to 1981, is as large as 140,000. This is the same level as that in the outside areas of Barani Tract.

Number of Factories Registered & Employees

Items	Barani Area	Other Area	Total
Registered Factory, 1984	504 (16%)1/	2,704 (84%)	3,208
Number of Factory Employees ('000 persons)	70.4 (22%)	251.6 (78%)	322.0
Total Number of Pakistani Worker in abroad, 1972-81('000 persons)	138.9 (24%)	437.6 (76%)	576.5

Note : 1/ ... Whole Country = 100

Source: "Punjab Development Statistics, 1985"
Bureau of Statistics, Government of Punjab

2.1.3. Agricultural Status

1) Agricultural Land Use

The cultivated land ratio to the total land area in Punjab Barani Tract is 57 percent. The cropping intensity of the total cultivation area is 97 percent while that of the net sown area is 114 percent. All of these figures are 20 percent lower than those of the outside areas, which is attributable to the present rainfed farming in Punjab Barani Tract.

Agricultural Land Use in Barani Tract

(unit: '000 ha, %)

Items	Islamabad and Punjab Province		Whole Country
	Barani Area	Other Area	
Total Area (excluding the unreported area)	7,003	10,074	56,710
Cultivated Area - Net Sown	3,368	7,103	15,690
- Current Fallow	592	544	4,590
Sub-total	3,960	7,648	20,280
Uncultivable Area	3,043	2,426	36,430
Cropped Area (Kharif & Rabi)	3,843	9,733	20,130
Rate of Cultivated Area	57	76	36
Cropping Intensity			
- Total Cultivated Area = 100	97	127	99
- Net Sown = 100	114	137	128

Source: 1. Pakistan Statistical Year Book, 1986
Federal Bureau of Statistics, Government of Pakistan
2. Punjab Development Statistics, 1985
Bureau of Statistics, Government of Punjab

2) Number of Farms and Average Farm Size

The number of farms in Punjab Barani Tract is estimated at 848,000 which accounts about 20 percent of the total. The average farm size is 4.7 ha (11.6 acres) in Barani Tract. It is at the same level as that of the outside areas of Barani Tract in Punjab Province and the national average.

Number and Area of the Farms

Items	Islamabad & Punjab Province		Whole Country
	Barani Area	Other Area	
1. Number of Farm ('000 household)	848	1,696	4,070
2. Farm Area ('000 ha)	3,960	7,648	19,059
3. Average Farm Area (ha/household)	4.7	4.5	4.7

Source: 1. "Agricultural Census, 1980"
Agricultural Census Organization, Government of Pakistan
2. "Punjab Development Statistics, 1985"
Bureau of Statistics, Government of Punjab

3) Agricultural Production

The major crops in Punjab Barani Tract at present are wheat, gram, rapes and mustard in the Rabi season and maize in the Kharif season. Especially wheat is an important crop.

The farmers in the Barani area have practised their farming under various harsh conditions like limitation of crop varieties, low level of cropping intensity and crop yield, etc.

TABLE 2-1. AGRICULTURE AND LIVESTOCK PRODUCTION IN BARANI AREA

Items	Islamabad & Punjab Province		Whole Country
	Barani Area	Other Area	
Number of Farms, 1980 ('000 household)	848 (21)[1/]	1,696 (42)[1/]	4,070
Crop Production, Average of 1980-85			
- Cropping Area ('000 ha)			
° Wheat	1,587 (22)	3,582 (49)	7,241
° Gram	563 (62)	142 (16)	915
° Rapeseed & Mustard	72 (19)	133 (36)	371
° Maize	78 (10)	259 (33)	781
- Production ('000 tons)			
° Wheat	1,885 (16)	6,474 (29)	11,556
° Gram	227 (52)	74 (17)	434
° Rapeseed & Mustard	40 (17)	107 (45)	238
° Maize	83 (8)	359 (36)	989
- Yield (tons/ha)			
° Wheat	1.19 (74)	1.81(113)	1.60
° Gram	0.40 (85)	0.52(111)	0.47
° Rapeseed & Mustard	0.56 (88)	0.80(125)	0.64
° Maize	1.06 (83)	1.39(109)	1.27
Livestock Population, 1981 ('000 head)			
° Cattle	3,063 (26)	6,191 (52)	11,900
° Buffalo	1,681 (11)	7,006 (44)	15,800
° Sheep	1,907 (9)	4,402 (20)	22,100
° Goat	2,671 (10)	1,696 (7)	25,800

Note : 1/ ... Whole Country = 100

Source: 1. "Economic Survey, 1986-87" Economic Adviser's Wing, Ministry of Finance

2. "Punjab Development Statistics, 1985" Bureau of Statistics, Government of Punjab

3. "Punjab Barani Tract in Figure, 1986" Agency for Barani Area Development, Government of Punjab.

2.2. National Policy of Agriculture

Although agriculture in Pakistan is the main industry in the regional socio-economy, the base of agriculture still remains in traditional crop production and livestock breeding with low productivity. As agriculture is the base of national economy in the Sixth Five-Year Plan (1983-1988), the Government of Pakistan put an emphasis on the development of rural areas where the majority of the poverty problems still remain.

The Sixth Plan strategies are summarized as follows;

i) To carry further notably the combination of modern inputs such as chemical fertilizer, and pesticides with improved seeds and adequate availability of agricultural credit.

ii) To organize, train and encourage farmers to utilize irrigation water for improvement in the use and application of water.

iii) To provide a new basis for intensive farming on medium and small farms by introducing small tractors and small farm machineries.

iv) To modernize and diversify extension services.

v) To diversify agriculture.

vi) To devise a system to reach the small and medium farmers which constitute the majority of farmers with a special package of inputs and credit combined with essential social services.

vii) To develop Barani areas of which preponderance of irrigated agriculture in Pakistan has resulted in relative neglect of these areas in the past which present fairly large pocket of rural poverty.

viii) To expand export of agricultural products and domestic production of presently imported crops.

ix) To exploit the potential of forests and fishery.

In Pakistan, the share of the agricultural sector in the gross domestic products (GDP) in 1986 occupied 25.5 percent which is the largest of all industries. Although GDP was increased by 80 percent for ten years from 1977 to 1986, the production of agriculture was increased by 46 percent only. Considering the low growth in the agricultural sector with percentage remaining by around 55 percent of workers engaged in agriculture, there is still a gap in income level between rural and urban areas.

The project will give a significant impact to solve the problems prevailing as low productivity of Barani agriculture and to develop the Barani area, and such measures will alleviate poverty, and introduce diversified agriculture to cope with varied food demands in the urban areas of Islamabad and Rawalpindi as a national plan.

CHAPTER III. THE PROJECT AREA

CHAPTER III. THE PROJECT AREA

3.1. General Features

3.1.1. Location and Geography

The Study Area, which is located on the northwestern edge of the Potwar Plateau, is referred to as the rural area of Islamabad Capital Territory and lies adjacent to the urban area of Rawalpindi with a population of about 800,000. The Study Area extends in a range of Lat. 33°35' - 33°49' N and Long. 73°05' - 73°45'E, and bounded by the Murree Hills in the northeast, by the Margalla Hills in the north and northwest, by the Siwalik Hills in the east, and by the Shahra-I-Islamabad Road in the west and south.

The total catchment area extending along the Kurang River is about 580 sq.km (224 sq.mi) at the confluence with the Soan River, and involves the cultivable commanded area of about 7,300 ha (16,300 acres) under the Project.

Topographically the Study Area has a gentle slope in the direction from northwest to southeast, and is covered by a vast reticulated gullied land. The eroded land is still expanding due to natural conditions such as hot and dry summer followed by heavy rain in the monsoon season, geological features as deposits of wind-laid materials, and human activities such as over-grazing and destruction of vegetation. Such land erosion has required serious soil conservation and caused social problems in the area.

In the Study Area, there are many rivers and streams running from north or northeast to south or southwest, and all of them pour themselves into the Soan River flowing through the Study Area. These tributaries of the Soan River run through the hilly areas or lower part of mountains in the area, and their discharges fluctuate

heavily by season (wet and dry) or by year (drought and wet). It is quite difficult to utilize such flowing water for irrigation consequently.

3.1.2. Administrative Division and Social Conditions

1) Administrative Division

Administratively the rural area of ICT is divided into 11 Union Councils (UC). They are sub-divided into 133 villages.

The number of UCs and villages in the Project Area is 6 for UCs and 43 for villages including the urban area as shown below and their administrative location is shown in Figure 3-1.

UC	Villages in the Project Area
- Rural Area	
Bharakao	2
Phulgran	4
Kuri	7
Kirpa	4
Tarlai	9
Sohan	13
- Urban Area	4
Total	43

2) Local Government System

a) Panchayat at Village Level

Panchayat is a grassroot level organization and a council system in the rural area. The Panchayat consists of five to seven members headed by Sarpanch or Chairman who resides in village and elected under inhabitants' consensus. It assists the administrative affairs of the Union Council (see Figure 3-2).

b) Union Council

An Union Council is formed of a group of villages, the basic administrative units in the rural area. The Councilors are elected by ballot with an average of one Councilor for every 1,000 residents. The Union Council has various functions of general administrative affairs, provision, maintenance, improvement and management of public structures such as roads, streets, culverts, bridges etc., as well as formulation of union development programs and promotion of various cooperative associations. The Union Council shall play an important role in promoting the Upper Kurang River Irrigation Project.

c) Rural Areas Coordination Committee

The Rural Areas Coordination Committee (RACC) is a local governmental institution at the District level. The members consist of the elected Chairmen of the 11 UCs and ex-officio members such as representatives of CDA, WAPDA, PARC and heads of various other nation-building departments, including engineers and directors.

The RACC mainly coordinates the activities of all Union Councils and of all government and semi-government departments or institutions in the rural area of ICT.

Therefore, the RACC will also play an important role in promoting the Upper Kurang River Irrigation Project.

d) Institutional Agency for Rural Development

The Local Government and Rural Development Department (LGRD), ICTA organizes three Markaz of Tarlai, Sihala and Bharakau. As regards the historical background of Integrated Rural Development Markaz, Tarlai Markaz was set up at Tarlai village as a pilot project in 1974. Sihala Markaz and Bharakao Markaz were added in 1977 and 1978, respectively.

The functions of Markaz are to coordinate, to render services and to make development as follows;

- Markaz coordinates all activities of nation-building departments at the Markaz level with regard to development projects.
- Markaz serves as a training center for upgrading the skills of field functionaries, councilors, progressive farmers, group leaders, etc.
- Markaz offers the possibility for the effective involvement of the local population in the decision-making process, financing and execution of development projects. Markaz provides hiring services of agro-machinery at subsidized rates, and promotes an effective delivery system of agricultural inputs as well as provides facilities for medical and health services.

3) Population, Household and Employment Opportunity

a) Population and Household

The population growth rate in ICT was 2.65 times of that in the urban area and 0.86 times of that in the rural area during 1972 to 1981.

Population in 43 villages of the Project Area in 1981 and 1987 is estimated at 58,000 and 79,000, respectively. And, the total household in the Project Area in 1987 is estimated at 12,900 (6.1 persons/household).

Population in the Project Area

UC	Population (persons) 1981	1987 -estimated-	(1981 = 100)	Household 1987 -estimated-
Rural Area				
Bharakao	7,742	12,300	159	2,000
Phulgran	9,185	11,500	125	1,900
Kuri	9,308	11,600	125	2,000
Kirpa	4,084	5,200	127	900
Tarlai	12,206	16,500	135	2,600
Sohan	12,850	17,700	138	2,800
Urban Area	3,153	4,200	133	700
Total	58,528	79,000	135	12,900

Source: "Population Census, 1981", Population Census Organization
"Village Profile Survey, 1986", LGRD, ICTA.

The number of persons recorded abroad is 433 based on the Village Profile Survey, 1986. The figures are calculated at 0.5 percent of population of villages concerned to the Project excluding the urban area.

The mobility of population in ICT is estimated as follows:

Mobility of Population during 1972 to 1981

Item		In-migrant (%)	Out-migrant (%)
ICT	- Rural Area	6.6	3.3
	- Urban Area	38.9	3.2
Punjab	- Male	11.0	9% of rural population
	- Female	21.0	7% of total population
Pakistan	- Male	8.0	12% of rural population
	- Female	22.0	8% of total population

Source: ICT; "Population Census, 1981", Population Census Organization.
Punjab and Pakistan; "Master Plan for Barani, Area Development Project, Volume II, 1987", ABAD.

The above table shows very high percentages of in-migrant to the urban area, ICT, while a comparative low percentage of out-migrant from the rural area, ICT.

b) Employment Opportunity

The active population over 10 years of age for the total population 79,000 in 43 villages concerned to the Project Area (excluding the urban area) amounts to 53,000 persons (67.0%). The working population is estimated at 21,000 persons (26.1%), approximately. According to the 1981 Population Census Report, the total labor force is 35,500 in the rural areas of Islamabad, so that labor force in the 43 villages concerned occupies about 40 percent of total labor force.

Labor Force in the Project Area

(unit: 1,000 persons)

Items	Total Population		Active Population		Working Population	
	1981	1987	1981	1987	1981	1987
Villages in the Project Area	59	79e	40	53e	15	21e
Rural Area of Islamabad	138		92		36	

Note : e .... estimated
Source: "Population Census, 1981", Population Census Organization.

According to the 1981 Population Census Report, the percentage of working population by occupations is as follows;

Occupation in Rural Area of Islamabad

Occupation	Percentage (%)
Agriculture, forestry, hunting and fishing	38.8
Community, social and personal service 1/	19.9
Manufacturing	9.1
Construction	8.7
Wholesale and retail trades	5.9
Transport, storage and communication	5.9
Electricity, gas, banks and others	3.5
Unclassified	8.2
Total	100.0

1/: Government employees occupy a large percentage.

The Union Council Offices reported the outline of occupations as shown below through the Village Profile Survey.

Profile of Occupations in the Project Area

Government Employees	:	4,337 persons
Carpenters	:	375 "
Shops	:	483 stores
Chakki Flour	:	16 places
Banks	:	5 "
Post Office	:	9 "
Taxis and Buses	:	127 cars

The major working opportunities are provided by agriculture, governmental service and retail business. The Government employees show a high rate by 36 percent of the total working population.

4) Infrastructure

a) Domestic Water Supply

The source for a domestic water supply are wells and springs. The number of wells and springs in 36 villages out of 43 villages in the Project Area amounts to 353 and 29, respectively. The diffusion rate of wells and springs is estimated at 152 persons per one facility on an average in UC Bharakau, and UC Tamair shows a low diffusion rate.

b) Rural Electrification

The electrification of aforesaid 36 villages is under progress. The present electrification conditions in the Project Area are as follows:

Complete electrification	:	69%
Partial electrification	:	22%
No electrification	:	9%

Note: According to the Master Plan Report, the above electrification levels in the rural area, ICT are 44 percent, 21 percent and 35 percent respectively.

c) Road Networks

Since the Project Area is located in Islamabad Capital Territory, main roads are well developed. However, due to the poor conditions of the on-farm road and connecting road between villages and main road, marketing of farm inputs and outputs and communication of the inhabitants are greatly affected.

Present Road Conditions

Name of Road	Length km	Length mile
- Main Road		
Shahra-I-Islamabad Road	2.7	(1.7)
Murree Road	1.7	(1.1)
National Park Road	2.6	(1.6)
Simly Road	2.2	(1.4)
Lethrar Road	3.3	(2.1)
Sub-total	12.5	(7.9)
- Other Road	30.9	(19.2)
Total	43.4	(27.1)

d) Communication

Mail services are handled by post offices at Kot Hathia (Bharakau), Chak Shazad (Sohan), Tarlai Kalan (Tarlai) and Khana Dak (Tarlai) and the sub-post offices at Phulgran (phulgran), Kuri (Phulgran) and Pind Pegawal (Tamir). It means that one post office serves about 10,000 peoples. The number of post offices is insufficient to meet the minimum requirement (3,000 - 6,000 peoples) according to the Universal Post Union, respectively.

About 150 telephones have been presently installed in the rural area, ICT, of which 18 are in UC Bharakau and 60 in UC Tarlai and 50 in Sihala. The telephone service in the Project Area is comparatively favorable as compared with the other rural areas.

e) Public Health

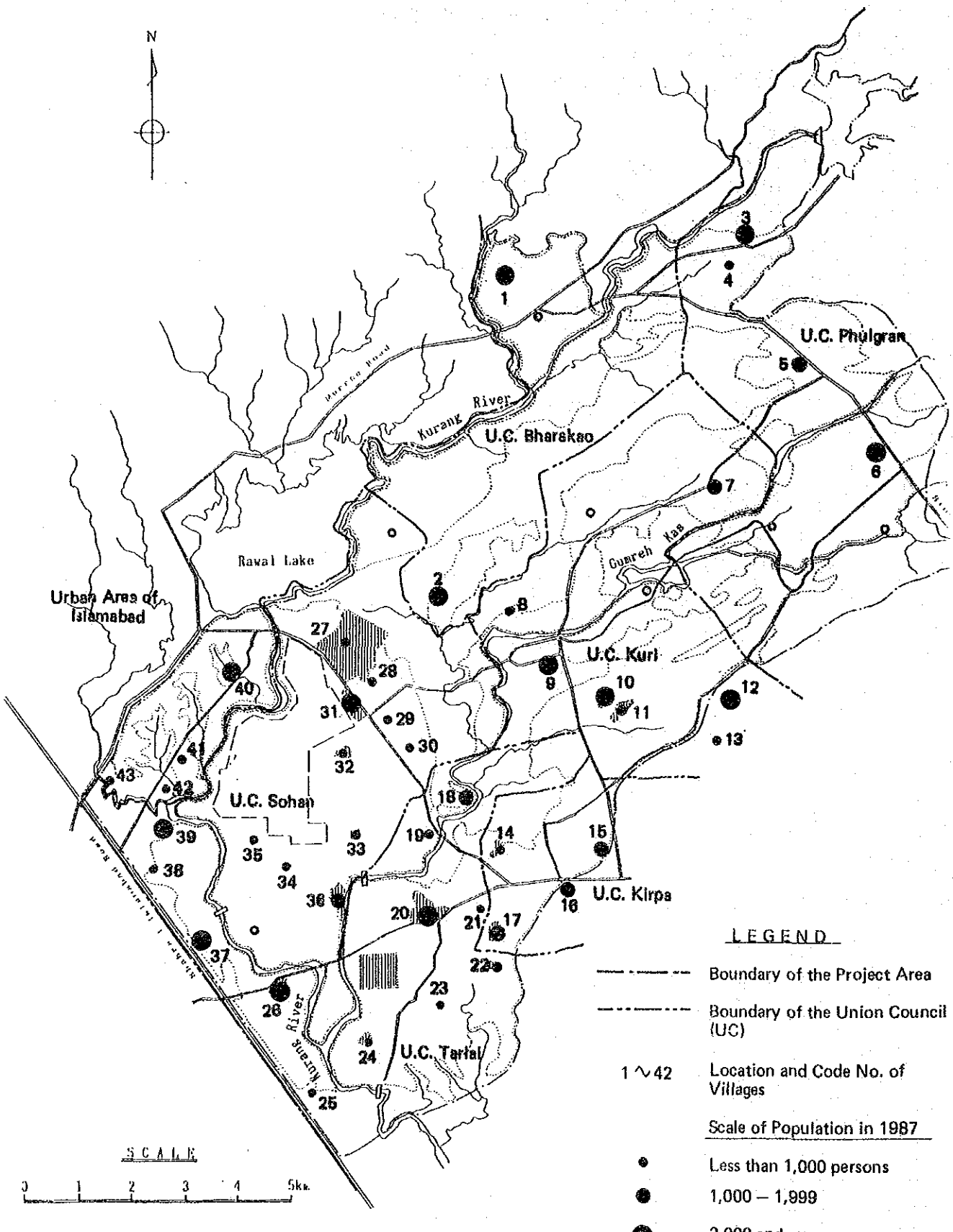
The public health facilities distributed in 36 villages out of 43 villages in the Project Area are Rural Health Centers at two places and Basic Health Units at four places.

Public Health Facilities and Number of Doctors, Midwife

UC	Basic Health Unit	Rural Health Center	Doctor (persons)	Midwife (persons)
Bharakao	-	Kot Hathial	3	6
Phulgran	Dohala	-	-	6
Phulgran	Pind Pegaural	-	-	4
Kuri	Jagoit	-	2	4
Sohan	Sohan	-	1	1
Tarlai	-	Tarlai Kalan	2	4

Note : Private health facilities are not included.
Source: "Village Profile Survey, 1986", LGRD, ICTA.

FIGURE 3-1. ADMINISTRATIVE DISTRICT AND POPULATION



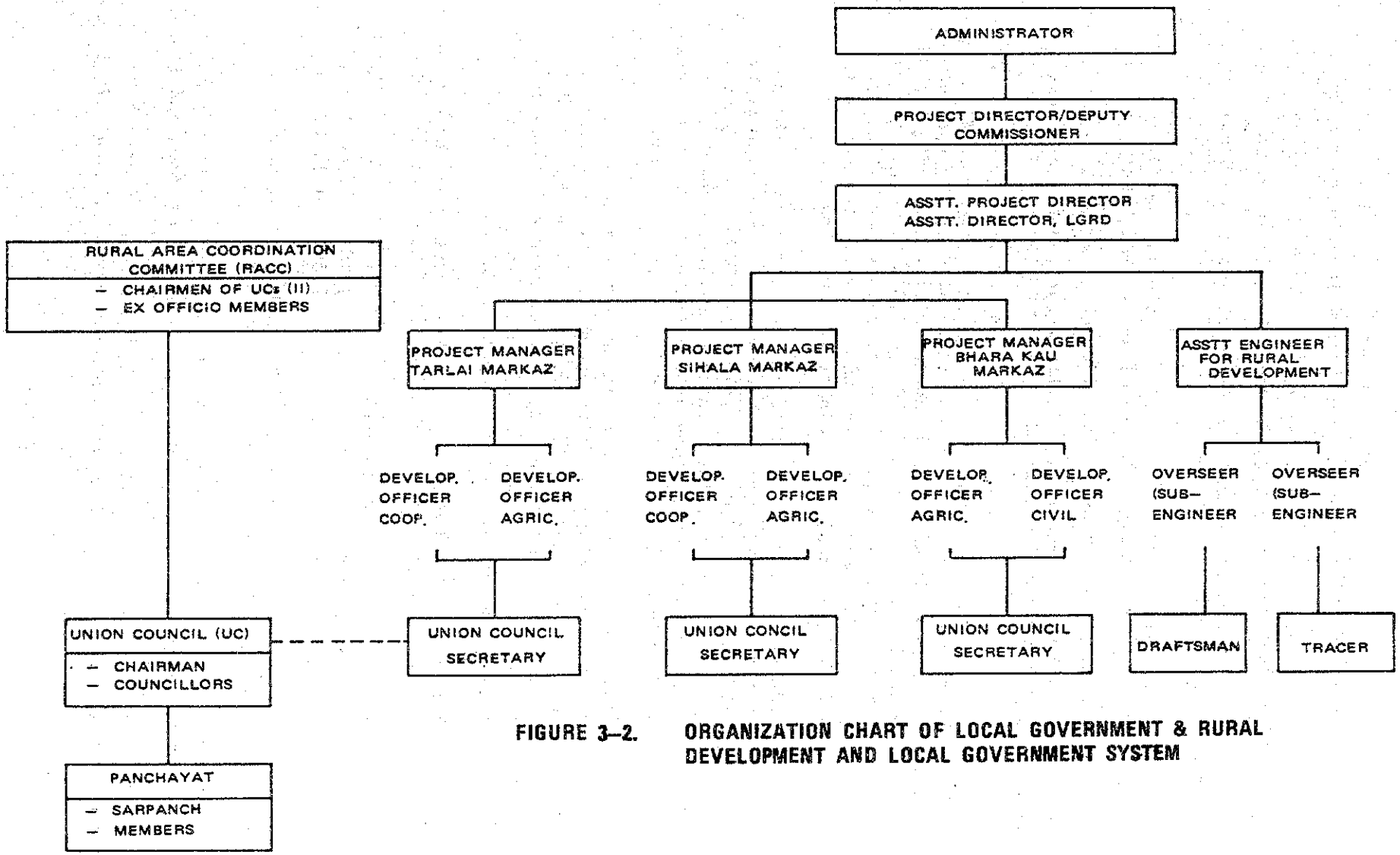


FIGURE 3–2. ORGANIZATION CHART OF LOCAL GOVERNMENT & RURAL DEVELOPMENT AND LOCAL GOVERNMENT SYSTEM

3.2. Physical Conditions

3.2.1. Topography and River System

1) Topography

The catchment area of the Kurang River is about 580 sq.km (224 sq.mi) in acreage, and can be divided into three areas in a topographical view with mountainous/hilly areas, undulated areas and plain areas.

- Mountainous and hilly areas are located on the upstream of the proposed K-2 damsite and their elevation ranges from about 2,500 m to 620 m (8,200 to 2,034 ft) above the sea level. Land surface of these areas has scarce forest except some, and causes serious sediment problems in the Kurang River basin, especially at Rawal Dam.

- Undulated areas are located on the land between the K-2 damsite and Rawal Dam. Its elevation ranges from about 620 m to 510 m (2,034 to 1,673 ft). These lands have cultivable lands under rainfed conditions, however, due to severe weather conditions during the wet and hot seasons, a large part of areas is affected by gully erosion.

- Plain areas mostly located in the downstream of Rawal Dam are alluvial plain in flat topography with a relatively fertile soil, and the limited areas of them are used for upland crop production relying upon rainfall and pump irrigation. The elevation of these lands ranges from 510 m to 480 m (1,673 to 1,574 ft) as a whole.

- The average land slope of the above mentioned three areas are as follows;

  ° Mountainous/Hilly Area : 1/15
  ° Undulated Area : 1/100 ~ 1/300
  ° Plain Area : 1/500 ~ 1/1,000

2) River System

The Kurang River is the main stream in the Study Area and its annual average runoff discharge at Rawal damsite is estimated at 103.0 MCM (84 x 10^3 acre ft) with a catchment area of about 275.1

sq.km (106 sq.mi), of which details are discussed subsequently in more detail. Rawal Dam is presently provided near the Islamabad Capital Area for supplying urban domestic water to Rawalpindi. The major features of the Kurang River are as follows.

- Catchment Area : 580 sq.km
- River Length : 132 km
- River Slope : 1/85

As for the tributaries of the Kurang River, many small streams such as Malal Kas, Gumreh Kas, Sohan Nala and Chang Kas run in the Kurang River basin. Out of these tributaries, Malal Kas is located outside the Project Area. The catchment areas of these tributaries are as follows;

- Malal Kas : 87.7 sq.km
- Gumreh Kas : 129.3 "
- Sohan Nala : 26.8 "
- Chang Kas : 43.7 "

3.2.2. Meteorology

1) Available Data

The meteorological data of the Kurang River basin and its vicinity are recorded by the Regional Meteorological Center (RMC), the Water and Power Development Authority (WAPDA) and the National Agricultural Research Center (NARC) as shown in Figure B-1 and Figure B-2.

The present functions of these stations are as follows;

- Meteorological stations under RMC, which mainly observe rainfall, started observation in 1952, but most of these stations have been closed at present as accurate data are not observed. However, synthetic observation at Chaklala and Murree has been continued until now under good conditions.

- At Rawal Dam and its vicinity, synthesized meteorological stations are observing the meteorology under the WAPDA and NARC.

- Collected rainfall record for the Study is of 22 stations as shown in Figure B-1, and out of these stations, the following seven stations are located in the Kurang River basin.

Stations	Collected Duration	Remarks
Rawal Dam	1963 - 1979	Daily Basis
NARC	1982 - 1986	Daily Basis
Kuri	1952 - 1968	Monthly Basis
Bharakao	1952 - 1969	Monthly Basis
Kirpa	1952 - 1968	Monthly Basis
Tamir	1952 - 1968	Monthly Basis
Tret	1952 - 1968	Monthly Basis

- Temperature, humidity, sunshine hour and wind speed records are obtained at the following stations, and they are collected in the Study.

Station	Temperature.	Humidity	Sunshine	Wind Speed	Duration
Chaklala	o	o	o	o	1954-1986
Murree	o	o	-	o	1954-1986
Rawal Dam	o	o	-	o	1963-1979
NARC	o	o	o	o	1982-1986

2) General Climatology

The Study Area for the Project extends an elevation of about 500 m to 2,500 m (1,640 to 8,200 ft) above the sea level and the cultivable commanded areas extend at an elevation of 500 to 600 m (1,640 to 1,968 ft). General climatological features in these areas belonging to the Barani area are shown below and their characteristics are indicated in Figure 3-3.

- According to the rainfall record observed at Chaklala with an elevation of 510 m (317 ft) above sea level, average rainfall is about 1,090 mm (43 in), and this rainfall is quite different from the rainfall observed at Murree having an average rainfall of 1,750 mm (69 in) with relative high elevation of about 2,200 m (7,216 ft) in the mountainous area. Probable rainfall at Chaklala and Murree stations is given as follows;

Probable Rainfall (1952 - 1986)

(unit: mm)

Probability	Probable Annual Rainfall	
	Chaklala	Murree
1/2	1,039	1,722
1/5	864	1,516
1/10	792	1,421

- Most of the rainfall concentrates during the wet season lasting from July to September. About 60 percent of the annual rainfall is observed during the wet season at Chaklala. Rainfall is characterized by its high intensity in a short time, and it does not continue through a day.

- An annual average temperature is 21.5°C in accordance with the Chaklala record, and its maximum and minimum records are 31.6°C in July and 10.0°C in January, respectively. During the period of Phase I field works in 1987, temperature of about 45°C was continuously observed from the end of July to the beginning of August in Islamabad. On the other hand, It snows sometime at Murree which has a low temperature less than 0°C during the winter season from December to February.

- Annual average relative humidity is recorded at 62.5 percent with the maximum of 74.7 percent in August and the minimum of about 40 percent in May and July, respectively.

- Annual average sunshine hour is recorded at 8.2 hrs and those in May and July during summer season are the longest with about 10 hrs, while those in the period from December to March are comparatively shorter with about 7 hrs.

- Annual average wind speed is observed at 1.3 m/sec with the maximum of 1.8 m/sec in May and the minimum of 0.9 m/sec in the period from October to December.

3) Rainfall

a) Correlation of Rainfall

Monthly rainfall records at Chaklala and Murree located in the low land and the mountainous area, respectively, are shown as follows, and as described previously, about 60 percent of annual

rainfall concentrates to those three months July through September at Chaklala, while relative small by eight percent only occurs October through December. In Murree, almost the same tendency is observed although with a little rainfall concentration by 50 percent in the aforesaid three months.

Monthly Rainfall

(unit: mm)

Month	Chaklala	Murree	Month	Chaklala	Murree
Jan.	62	132	July	254	348
Feb.	68	129	Aug.	288	338
Mar.	78	158	Sep.	102	150
Apr.	57	125	Oct.	30	69
May	38	86	Nov.	20	34
Jun.	57	121	Dec.	32	60
Total				1,086	1,750

The correlation of monthly rainfalls in Chaklala, Murree, Rawal Dam and Barkot is analyzed below, and its result has revealed that the correlation of rainfalls at these stations is high with a correlation coefficient of more than 0.76.

Correlation of Monthly Rainfall

Station (Y)	Station (X)	Correlation Coefficient	Correlation Equation
Barkot	Chaklala	0.81	Y = 0.828X + 1.426
Barkot	Murree	0.85	Y = 0.797X - 0.066
Barkot	Rawal Dam	0.86	Y = 0.762X + 1.223
Rawal Dam	Chaklala	0.92	Y = 1.054X + 0.366
Rawal Dam	Murree	0.82	Y = 0.872X - 0.827
Chaklala	Murree	0.76	Y = 0.667X - 0.236

Note: The period of collection of data is as follows;

Chaklala (1952 - 1986), Murree (1952 - 1986)
Barkot (1962 - 1979), Rawal Dam (1963 - 1977)

Based on the correlation study, non-observed daily rainfall at Barkot and Rawal Dam is supplemented for 35 years from 1952 to 1986 in applying the daily rainfalls observed at Murree and Chaklala.

b) Areal Rainfall and Probable Maximum Daily Rainfall

Areal rainfall in two areas which are the Upstream Areas of Rawal Dam, exclusive of K-2 Dam catchment area, and the catchment area of K-2 Dam, was estimated by applying Thiessen method on the daily basis using the above mentioned rainfall data to estimate the runoff discharges from each catchment area. The following table indicates the areal rainfall so estimated.

Areal Rainfall in Kurang River Basin

River Basin	Thiessen Polygon (%)	Average Annual Rainfall (mm)
Upstream of Rawal Dam (138.1 sq.km)1/	Barkot : 31 Rawal Dam: 69	1,267
Upstream of K-2 Dam (137.0 sq.km)	Murree : 48 Barkot : 51 Rawal Dam: 1	1,556

Note: 1/; Areal monthly rainfall in each basin is given in Tables B-39 to B-41.

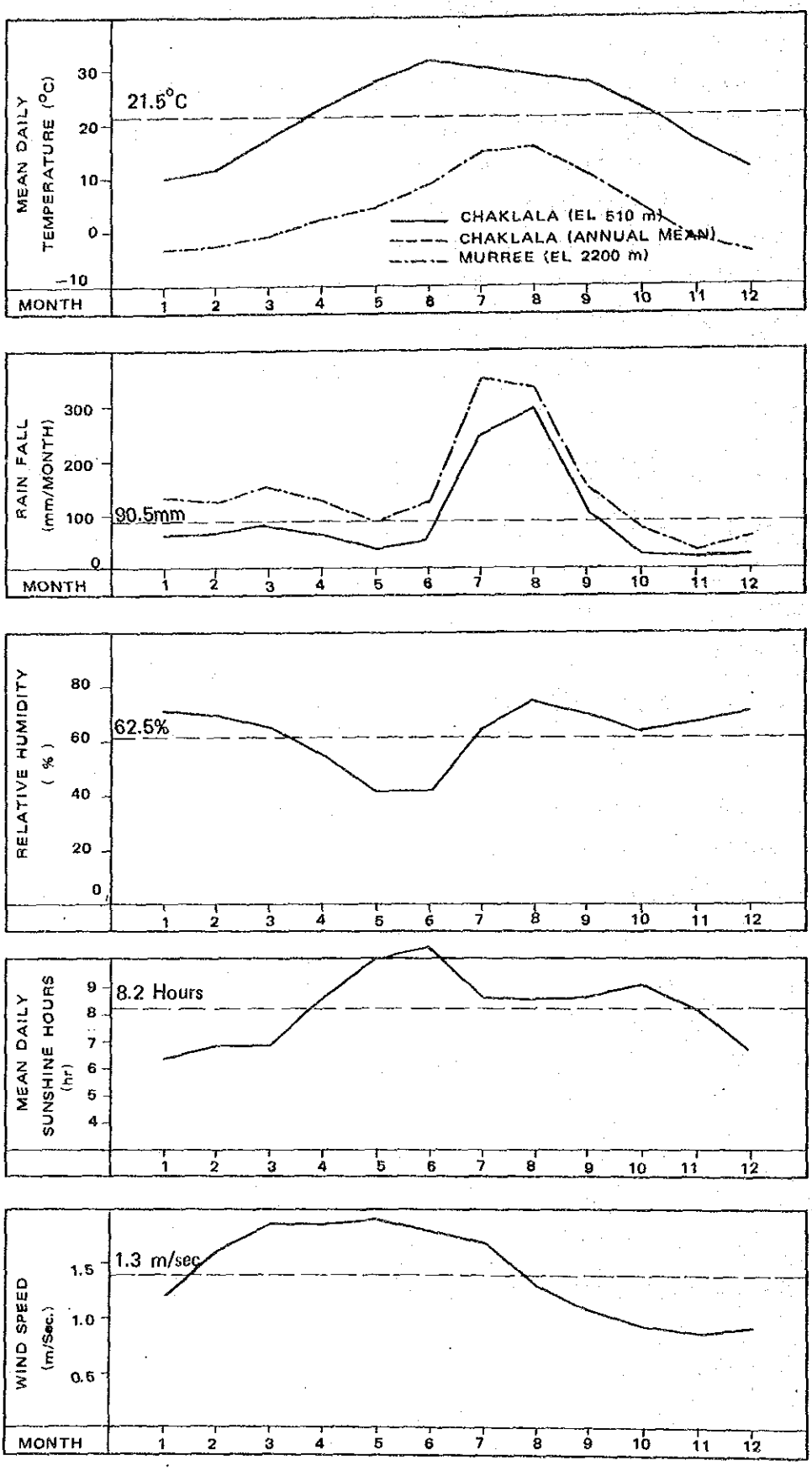
Probable maximum daily rainfall was estimated based on the estimated daily areal rainfall for 35-year as shown below;

Probable Maximum Daily Rainfall

(unit: mm)

Probability	Upstream of Rawal Dam	Upstream of K-2 Dam
1/2	82	89
1/5	94	123
1/10	127	149
1/20	145	176
1/100	190	274
1/200	210	281
1/500	239	329
1/1,000	261	369

FIGURE 3-3. GENERAL METEOROLOGY



3.2.3. Hydrology

1) Available Data

The runoff discharges of the Kurang River and its vicinity area have been observed by WAPDA and the Irrigation and Power Department of Punjab Province as shown in Figure B-3 and Figure B-4, and they could be described as follows;

- The Irrigation and Power Department has observed, since 1971, the runoff discharges of the Kurang River at two stations of Chattar and Bari Kangran which are located on the upstream of the proposed K-2 damsite for the purpose of flood discharge measurements. However, these data cannot be used for analyzing runoff discharges of the Kurang River due to their inaccuracy as many non-observed data are included in the data.

- According to the Rawal Dam operation record having been observed by the Small Dams Organization since 1962, daily observation data such as water level of the reservoir, inflow and released discharge are recorded. But inflow discharges are calculated based on the decreased storage volume of Rawal reservoir and released discharge, and then negative inflow discharges are tabulated in the record. This fact suggests that the inflow discharges have been underestimated.

- Intermittent observation of river runoff discharges at the following points, that is, immediate downstream of the Rawal Dam, immediate upstream of the confluence of the Kurang River and Gumreh Kas, and the lowest reaches of the Gumreh Kas has been carried out by WAPDA since 1965.

- In addition to above mentioned runoff discharges, those in the other rivers basins such as the Haro, Soan and Sil Rivers located adjacent to the Kurang River basin are collected.

2) Runoff Analysis

a) Runoff Analysis Procedure

As mentioned in 4.2.2 entitled "Water Balance Study of Rawal Reservoir", the runoff discharges of the Kurang River at the proposed sites such as the Rawal and K-2 damsites would be estimated by applying theoretical method as described subsequently.

The catchment area of the Kurang River has a fault between the Kurang River and Margalla Hill. Northern parts of the fault in the Kurang River basin consist of limestone in geology and are quite similar to those of upstream area of Khanpur in the Haro River basin. On the other hand, southern parts of the fault consist of sand stone and mudstone, and their topography is formed complicately by mountain and alluvial plain. These mountainous areas are similar to those in the upstream of Cherah in the Soan River. Furthermore, alluvial plain areas are similar to those in Chahan of the Sil River.

Taking into consideration the above facts, the runoff discharges of the Kurang River were analyzed for 35 years from 1952 to 1986 by the Tank Model Method, which was designed for the stations of Khanpur in the Haro River, Cherah in the Soan River and Chahan in the Sil River. Their results were applied to estimate the runoff discharge of the Kurang River, considering the following elements of each river basin.

Element of Run-off Discharge Estimation

Classification of Kurang River Basin	Catchment Area (sq.km)	Areal Rainfall (mm)	Northern Parts of Fault Mountainous Area Haro River, Khanpur Model (%)	Southern Parts of Fault Mountainous Area Soan River, Cherah Model (%)	Southern Parts of Fault Plain Area Sil River, Chahan Model (%)
Upstream of Rawal Dam[1/]	138.1	1,267	33.1	26.6	40.3
Upstream of K-2 Dam	137.0	1,556	22.0	67.7	10.3

1/: exclusive of K-2 Dam catchment area.

b) Estimated Runoff Discharge

Runoff Discharge at Rawal Damsite

The runoff discharges at Rawal damsite having the total catchment area of 275.1 sq.km (106 sq.mi) were estimated on the daily basis by applying above mentioned procedures for the period of 35-year, and monthly average runoff discharges are shown as follows;

Average Runoff Discharge at Rawal Damsite

Month	Runoff Discharge (MCM)	(%)	Month	Runoff Discharge (MCM)	(%)
Jan.	8.11	7.9	July	18.21	17.7
Feb.	8.77	8.5	Aug.	26.56	25.8
Mar.	8.84	8.6	Sep.	10.20	9.9
Apr.	5.28	5.1	Oct.	4.65	4.5
May	2.46	2.4	Nov.	2.83	2.7
June	3.06	3.0	Dec.	4.02	3.9
Total				102.99	100.0

Note: Details are shown in Table B-39.

As it is seen in the above table, average runoff discharges at Rawal damsite are 103.0 MCM(*1), resulting in runoff coefficient of 27 percent with an areal rainfall of 1,411 mm (55.6 in) in the catchment area.

Runoff Discharge at K-2 Damsite

Runoff discharges at the proposed K-2 damsite with a catchment area of 137.0 sq.km (53 sq.mi) were estimated for 35-years and summarized as follows;

Average Runoff Discharge at K-2 Damsite

Month	Runoff Discharge (MCM)	(%)	Month	Runoff Discharge (MCM)	(%)
Jan.	5.37	8.6	July	10.91	17.6
Feb.	5.80	9.3	Aug.	14.68	23.6
Mar.	5.99	9.6	Sep.	5.71	9.2
Apr.	3.48	5.6	Oct.	2.72	4.4
May	1.56	2.5	Nov.	1.54	2.5
June	1.96	3.2	Dec.	2.39	3.9
Total				62.11	100.0

Note: Details are shown in Table B-40.

Note: *1 ... According to the SDOs' estimated runoff discharge based on the observed discharge released from the Rawal Dam, an annual average runoff discharge at the Rawal damsite is 100.9 MCM (82 x 10^3 acre ft), of which details are given in Table B-34 to Table B-38.

Average runoff discharges were estimated at 62.1 MCM (50,363 acre ft), equivalent to about 60 percent of the total runoff discharges estimated at the Rawal damsite in the Kurang River. Runoff coefficient of discharges is estimated at 29 percent of the annual average rainfall of 1,556 mm (61.3 in).

3) Runoff Discharges at Downstream of Rawal Dam and Gumreh Kas

According to the discharge measurements at the downstream of Rawal Dam, a remarkable river flow is observed without spilled discharges from Rawal Dam. These discharges are considered to be the base flow by groundwater constantly discharged throughout the year.

The total discharges at three head works sites proposed in the Master Plan Study for Integrated Rural Development Project amount to about 1.0 cu.m/sec (35.3 cusecs) as shown below;

Runoff Discharge at Proposed Head Works Sites

Station	Name of River	Catchment Area (sq.km)	Discharge (cu.m/sec)
Kc-1	Kurang River	24.9	0.62
Kc-2	Kurang River	18.0	0.22
Gc-2	Gumreh Kas	125.0	0.13
Total			0.97

4) Flood Discharge

Flood discharge for planning spillway capacity of K-2 Dam was estimated by applying Creager equation as shown below;

$$Q = 0.502966 \times C \times (0.38613 \times A)^{\alpha - 1} \cdot A$$

where;

Q : Peak Flood Discharge (cu.m/sec)
A : Catchment Area, 137.0 sq.km
C : Catchment Coefficient, 75
α : $0.93578 \times A^{-0.048}$

$Q = 1,834 \fallingdotseq 1,840$ cu.m/sec (66.1×10^3 cusecs)

On the other hand, design peak flood discharge for planning diversion works of K-2 Dam was estimated based upon the Rational Equation as shown below;

$Q = F \times r \times A \times 1/3.6$

where;

Q : Peak Flood Discharge (cu.m/sec)
F : Runoff Coefficient, 0.80
r : Rainfall Intensity (mm/hr)
$r = R24/24 \times (24/Tc)^{2/3}$
R24 : Daily Max. Design Rainfall (mm/day)
Tc : Time of Concentration (hr)
$Tc = (11.9 \times L^3/H)^{0.385} \times 1/3,600$
L : Length of River (m)
H : Difference of Elevation in River Length (m)

$Tc = (11.9 \times 18,000^3/1,600)^{0.385} \times 1/3,600 = 3.5$ hr

Peak flood discharges in the return period of 1/5, 1/10 and 1/10 year are calculated as follows;

Peak Flood Discharge at K-2 Damsite

Probability	Daily Max. Design Rainfall (mm)	Rainfall Intensity (mm/hr)	Peak Flood Discharge (cu.m/sec)
1/5	123	18.5	563.0
1/10	149	22.4	682.0
1/20	176	26.5	807.0

In the project, 690.0 cu.m/sec (24.8×10^3 cusecs) of discharge corresponding to return period of 1/10-year was adopted for planning diversion works of K-2 Dam.

5) Water Quality Analysis

a) Water Quality for Irrigation Purposes

Water quality of the Kurang River was analyzed for the irrigation purposes by sampling the river water at two sites in August 1987, one sample (No. 1) at a little upstream of the proposed K-2 damsite and the other sample (No. 2) at the proposed Kc-2 head work site located on the downstream of Rawal Dam.

Water quality analyses of sampled water were made by the National Agricultural Research Center and their results are indicated as follows;

Results of Water Quality Analysis

Analyzed Item	Unit	No. 1 Sample	No. 2 Sample
pH		8.3	7.8
Conductivity	mmhos/cm	0.29	0.32
Nitrate (N)	ppm	0.50	1.20
Phosphate (P)	ppm	0.003	0.050
Potassium (K)	ppm	21.0	28.0
Natrium (Na)	ppm	1.40	1.40
Iron	ppm	0.20	0.01
Calcium + Magnesium (Ca + Mg)	mg/lit	0.40	0.44
Chloride	mg/lit	1.80	3.00

With the result of analyses, the sodium absorption ratio (SAR) of No. 1 and No. 2 sample water is estimated at 3.1 and 3.0, respectively. Therefore, according to the criteria for the classification of irrigation water in reference to Agricultural Handbook 60, U.S Department of Agriculture, the Kurang River water is classified into C_2-S_1 group. This suggests that no special measurement of salinity control will be needed for crop cultivation.

b) Water Quality for Domestic Use

Water quality analyses related with the Kurang River especially from viewpoint of hygienic aspect were made by Study Team in December 1987 to January 1988, in order to make study on the present water quality for the purposes of domestic water uses.

In this connection, two kinds of data are collected; analysis results of the Kurang River water inclusive of Rawal reservoir and those of conveyed water to water tank in Rawalpindi. The former analysis of ten samples was made by CDA, while the latter of four samples by PHED respectively (see Table B-46 to Table B-49).

As a result, the Kurang River water in the ordinary periods is found available for human consumption with algae-chlorination treatment for a few light green plants observed in the water. However, the records of water quality analysis made for the samples in severe drought periods have suggested that an adequate water treatment should be provided to filter the water for human consumption because the water samples in the period in question carry some coliform bacteria once in a while.

3.2.4. Geology and Seismology

1) Geology

The geological distributions in the area consist of Pre-Neogene series, Murree-Formation of Miocene Age, Lei Conglomerate and Terrace Deposit of Pliocene and Pleistcene Age, Wind Deposit (Loess), Alluvial Deposit and Residial Deposit of Holocene Age in the order from the older (See Figure 3-4 and Figure H-3, Annex H).

Pre-Neogene series are composed of limestone, sandstone, shale etc. from Paleocene Age to Paleogene Age in the area from Margala Hills to the north.

a) Classification of Geology

Murree-Formation (Rawalpindi Group)

The base rock in the Project Area mainly consists of Sandstone interbedded with Mudstone, containing intercalated Pseudo-Conglomerate(*2) and some of cross-bedding(*3) sandstone. The between rock properties of sandstone and mudstone make much difference.

Sandstone is generally very hard and strong against weathering, even it is exposed. the intervals of Joints(*4) or Cracks are wide

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Note: *2 ... Although Pseudo-conglomerate appears as conglomerate, the composition of original gravels were unconsolidated or semiconsolidated mass of sand and/or clay. They were sedimented and consolidated simultaneously together with surrounding sand and clay.

*3 ... The arrangement of laminations of strata transverse or oblique to the main plane of stratification.

*4 ... A set of discontinuity in the rock caused by the tension of induration or release of in-situ stress due to un-loading or transformable movement.

as three to five meter long. On the other hand, mudstone undergoes so strong such weathering as slaking(*5) that it generally exist red-colored gravelly soil near the ground surface. As mentioned above, due to much difference of the weathering by rain and/or wind between two rocks, topographical feature as formed as "ridge and trough" or "horseback", and a company with bedding at steep angle. This is the distinctive feature of the outcrops.

Lei Conglomerate

Lei Conglomerates are scattered between Ramal Lake and Margala Hills as a small hill range. It is composed of boulders and pebbles originated from Eocene rocks in major parts, and pebbles from older sedimentary and igneous rocks in minor parts, and is contained some intercalated sandstone and clay. It was effected intensive folding and/or faulting action as a consequence of Late Himalayan Orogenic Phase.

Terrace Deposit

The River Terrace found at both bank of Kurang River is divided into Upper, Middle and Lower Terrace.

The Upper Terrace is characterized as Table-shaped Hill scattered along the Kurang River. The height from the river bed is 50 to 60 m. Its deposit consists mainly of hard gravel derived from Pre-Neogene sedimentary and igenous rocks, matrix being silty soil and sand rarely included.

The Middle Terrace is found at the upper part of both bank of the Kurang River, and is distributed relatively wide range. The height is 20 to 30 m from the river bed. And the Lower Terrace distributes near the river, and it extends smaller than the Middle. The height is 10 to 20 m from the river bed.

Note: *5 ... The crumbling and disintegration of earth materials when exposed to air or moisture, due either to compression of entrapped air by inwardly migrating capilary water.

The deposits of Middle and Lower Terrace are composed mainly of gravel comprising cobble and pebble derived from Pre-Neogne rocks, and boulder and cobble from sandstone of Murree formation. Matrix is silt and sand being rarely included.

Wind Deposit (Loess), Alluvial Deposit, Residiual Deposit

Loessic soil is deposited widely and thickly by the wind action. The soil is formed of fine particles resulted from strong weathering and derived mainly from mudstone under the conditions of semi-arid climate of this province.

The range of constituent is from very fine sand to clay, and its majority is silt.

The topography of this distributing area is flat, but a rude vertical parting in this layer is common at many places, and there is a trend to come fall vertically near the river.

Alluvial Deposit distributes between Gumreh Kas River and Kurang River at the downstream of Rawal Dam, and forms a wide flat plain. Gravel layer and sand layer having thickness from one to five meter are alternated or interfingered. The soil particles have a tendency to vary finer in proportion to the distance from the river. The groundwater is abundant and wells are made a lot in this area.

Residual Deposit distributes around the outcrop of Murree formation and is composed of hard rock-blocks of sandstone, brittle rock-fragments of mudstone and fine particle soil as a result of strong weathering and decomposition of mudstone.

Especially, the majority of Loess or Residual Deposit including clay is called Potwar Clay widely utilized as a brick material.

b) Geologic Structure

The geologic structure of the base rock is that major strike is generally ENE-WSW in direction and it demonstrates the isoclinal structure dipping to the north tilled at steep angle. But the actual situations in the overfolding(*6) structure accompanied with faults. Both limbs of overfolding show the same strike and dip. Some parts of project area have received remarkable disturbance(*7), and complexly folded and faulted. Dip angles are 30 to 40 degrees near Rawal Dam and about 80 degrees at the K-2 damsite.

Relatively small scale of but complexly folded structure are found from K-2 damsite to its backside mountain ridge at the left bank. Also the big scale of folding axis runs along the northern side of the Kurang River starting from the north of Bharakau in the direction of ENE. Another one in Rakhmara area runs ENE-SWS direction. And other minor foldings are sporadically scattered in the area.

The main fault is striking in the direction of NE-SW, demonstrating the thrustic(*8) structure crossing at a acute angle to the bedding and folding axis, and there exist many fault striking in the direction of NW-SE which supposed to conjugate(*9) the main fault.

Lei Conglomerate is also faulted and folded. Terrace Deposit, Wind Deposit (Loess) and Alluvial Deposit have a flat layer.

Note: *6 ... A fold in which the beds on one limb are overturned, i.e. have been bended through more than 90 degree, so that they are inverted.
*7 ... The bending or faulting of rock, or stratum from its original position.
*8 ... Fault occurring in place of the overturned limb of a fold.
*9 ... Two sets of perpendicular faults which have the same strike, but dip in opposite directions.

2) Seismology

Figure H-4 in Annex H "Seismic Risk Map of Northern Pakistan" issued by Geological Survey of Pakistan shows the year and the distribution of the seismic event in Northern Pakistan.

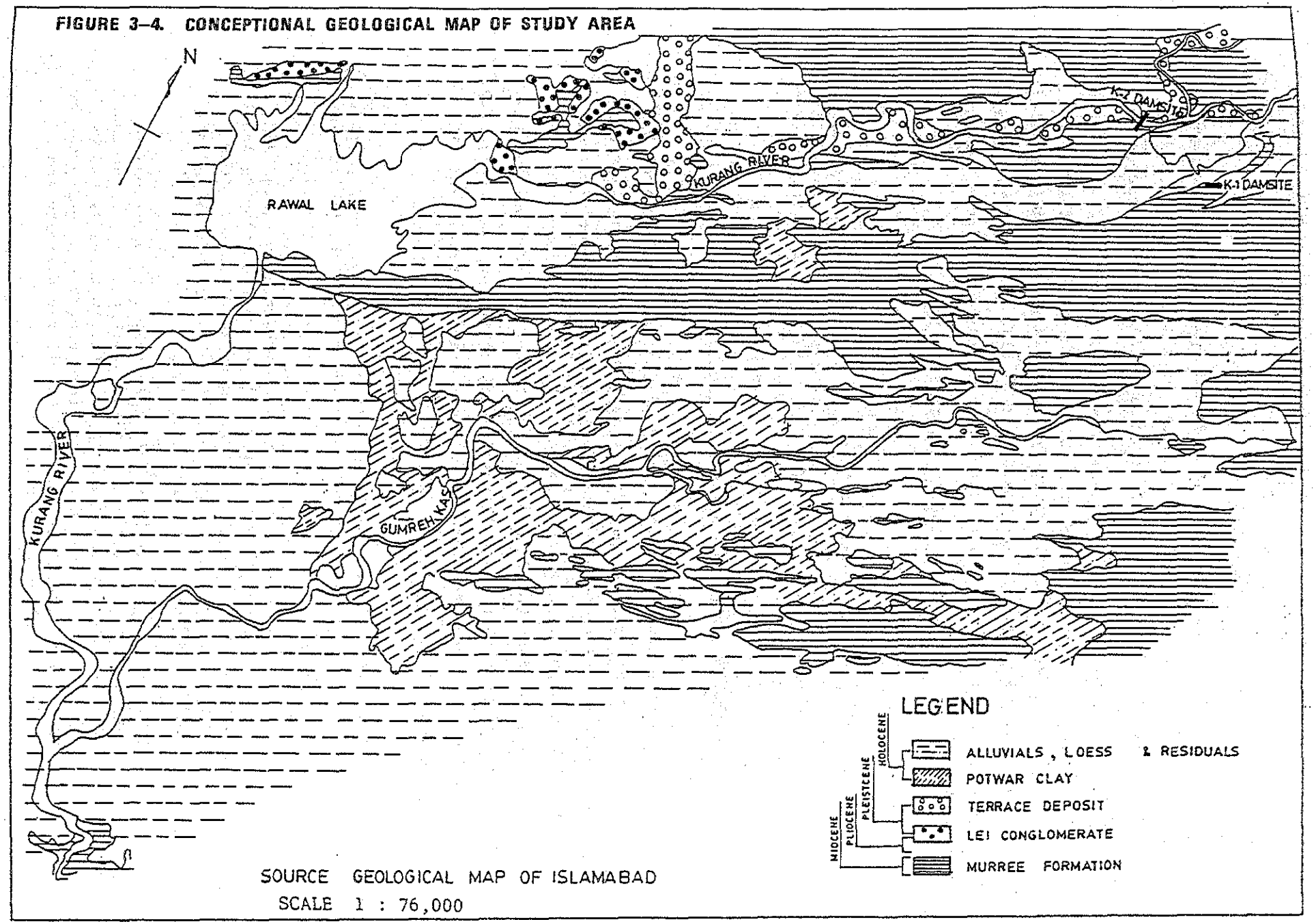
The seismic distribution is concerned with orographic units and tectonic line consisting Earth's crust.

In tectonically, the northern half of the area represents marginal part of the Himalayan Collision Zone, and main orographic units and tectonic lines are as the following table.

Orographic Units		Tectonic Line and Fault
Asiatic Mass		Main Karakoram Thrust (MKT)
Kohistan Island ARC		Main Mantle Thrust (MMT)
Indo-Pakistan Mass	Nanga Parbot-Haramosh Massif	Tarbela Fault Panjal Fault
	Himalayan Crystalline Schuppen Zone	Main Boundary Thrust (MBT)
	Himalayan Fold Belt	Bannu Basin Fault Margala Fault Kalabagh Fault Jhelum Fault
Unconsolidated Sediments		Salt Range Trhust

From north, the orographic units are classified into Asiatic Mass, Kohistan Island Arc, Indo-Palostam Mass and Umcpmsp;odated Sediments, They are bounded respectively by MKT, MMT and Salt Range Thrust (Tahirkheli-1979, Kazmi and Rana-1982). Indo-Pakistan Mass is subdivided into three units, Nanga Parbot-Haramosh massif, Himalayan Crystalline Schuppen Zone and Himalayan Fold Belt, bounded between the latter two by MBT.

FIGURE 3–4. CONCEPTIONAL GEOLOGICAL MAP OF STUDY AREA



SOURCE GEOLOGICAL MAP OF ISLAMABAD

SCALE 1 : 76,000