

THE ISLAMIC REPUBLIC OF PAKISTAN
FEASIBILITY STUDY
ON
DEVELOPMENT OF IRRIGATION BASED UPON
FLOOD FLOWS OF D.G. KHAN HILL TORRENTS
ANNEX

OCTOBER 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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ANNEX A. METEOROLOGY / HYDROLOGY

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ANNEX A. METEOROLOGY / HYDROLOGY

1) Meteorology

There are 4 meteorological observation stations (Barkhan, Multan, D.G. Khan and Muzaffargarh) in and around the Study Area as presented in Table A-1. There are 25 rain gauge stations within the Study Area, of which 24 were installed by the Punjab Provincial Government and the available daily rainfall data were collected for 14 years (1975-1988) as presented in Table A-2.

One station (Barkhan) was installed by the Federal Meteorological Department in 1967 and the available monthly rainfall data was collected for 20 years (1967-1988) as presented in Table A-3. In order to get data for the longer period (20 years), data of Barkhan and isohyetal map of D.G. Khan hill torrents was used (see Table A-4). The estimated 20 years mean monthly areal rainfall at D.G. Khan hill torrents is presented in Table A-5.

2) Runoff Volume

There are no daily mean discharge records. Therefore the runoff volumes were calculated as follows:

$$Q = R \times A \times C \times 10^{-3}$$

where Q: Runoff Volume (MCM)
R: Areal Rainfall (mm)
A: Catchment Area (sq.km)
C: Runoff Coefficient

| | | |
|-------------|-----|------|
| Jan. - June | C = | 0.30 |
| July - Sep. | C = | 0.60 |
| Oct. - Dec. | C = | 0.30 |

The average annual runoff coefficient is about 0.50. The calculated monthly runoff volume and probable annual runoff of the D.G. Khan hill torrents are presented in Table A-6 and Table A-7.

3) Annual Maximum Peak Discharge

There are 13 stream gauge stations in the Study Area as presented in Table A-8. The probable annual maximum peak discharges of D.G. Khan hill torrents are presented

in Table A-9.

4) Sediment Runoff

The sediment runoff of D.G. Khan hill torrents was estimated by applying the Tanaka formula and the Ezaki formula as follows:

Tanaka Formula

$$Q = 9.9 \cdot X - 77 \pm 51$$

where X : Topographic Coefficient (= $X_1 \times X_2$)
X₁ : Weighted Mean of undulating Balance
X₂ : Weighted Mean of Height

Ezaki Formula

$$Q = 8.85 \cdot I \cdot S^2 + 7.83 \cdot I \cdot (Ad / A) \cdot D^2$$

where Q : Sediment Runoff (cu.m/year)
I : Mean Annual Runoff (cu.m/year)
S : River Bed Grade
Ad : Slope Failure Area (sq.km)
A : Catchment Area (sq.km)
D : Mean Grade of Slope Failure (=1/3)

The Tanaka formula is based on the observed sediment runoff from the forests in Japan. The Study Area is largely different from that of Japan, regarding rainfall intensity, the condition of vegetative cover and geological factors. Considering the above factors, the sediment runoff of D.G. Khan hill torrents was estimated by using the Ezaki Formula (see Table A-10 and Table A-11).

Table A-1 List of Meteorological Stations

| Name of Station - Organization - Latitude - Longitude - Elevation | Observed Items | Collected Period | | | | | | | | | | | | | | | | | | | |
|--|-------------------|------------------|---|---|---|--------|---|---|---|--------|---|---|---|---|---|---|---|--|--|--|--|
| | | 1960s | | | | 1970 s | | | | 1980 s | | | | | | | | | | | |
| | | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | | | | |
| <u>Barkhan</u> Meteorological Dept. Latitude : 29° 54' Longitude : 69° 32' EL. 1,113 m Monthly Data | Temperature | | | | | | | | | | | | | | | | | | | | |
| | R. Humidity | | | | | | | | | | | | | | | | | | | | |
| | Dew Point | | | | | | | | | | | | | | | | | | | | |
| | Wind Speed | | | | | | | | | | | | | | | | | | | | |
| | Rainfall | | | | | | | | | | | | | | | | | | | | |
| <u>Multan</u> Meteorological Dept. Latitude : 30° 10' Longitude : 71° 25' EL. 123 m Monthly Data | Temperature | | | | | | | | | | | | | | | | | | | | |
| | R. Humidity | | | | | | | | | | | | | | | | | | | | |
| | Dew Point | | | | | | | | | | | | | | | | | | | | |
| | Wind Speed | | | | | | | | | | | | | | | | | | | | |
| | Sunshine Duration | | | | | | | | | | | | | | | | | | | | |
| | Rainfall | | | | | | | | | | | | | | | | | | | | |
| <u>D. G. Khan</u> Agricultural Dept. Latitude : 30° 04' Longitude : 70° 38' EL. 122 m Daily Data | Temperature | | | | | | | | | | | | | | | | | | | | |
| | R. Humidity | | | | | | | | | | | | | | | | | | | | |
| | Prevailing Wind | | | | | | | | | | | | | | | | | | | | |
| <u>Muzaffargarh</u> Surface Water Hydrology, WAPDA Latitude : 30° 04' Longitude : 71° 12' EL. 116 m Daily Data | Temperature | | | | | | | | | | | | | | | | | | | | |
| | R. Humidity | | | | | | | | | | | | | | | | | | | | |
| | Dew Point | | | | | | | | | | | | | | | | | | | | |
| | Evaporation | | | | | | | | | | | | | | | | | | | | |
| | Wind Speed | | | | | | | | | | | | | | | | | | | | |
| | Rainfall | | | | | | | | | | | | | | | | | | | | |

Table A-2 List of Rainfall Stations

| Hill Torrent Basin | Name of Station | Latitude | Longitude | El. (m) | Collected Period | | | | | | | | | | | | | | | | |
|--------------------|-----------------|----------|-----------|------------|------------------|---|---|---|---|--------|---|---|---|---|------|---|---|---|---|---|---|
| | | | | | 1970 s | | | | | 1980 s | | | | | '90s | | | | | | |
| | | | | | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Vehowa | Bagu Bund | 31° 02' | 70° 14' | 905 | | | | | | | | | | | | | | | | | |
| | Nelo Har | 31° 08' | 70° 21' | 473 | | | | | | | | | | | | | | | | | |
| Sanghar | Kala Mar | 30° 46' | 70° 17' | 592 | | | | | | | | | | | | | | | | | |
| | Nokhandki | 30° 28' | 70° 18' | 686 | | | | | | | | | | | | | | | | | |
| Soli Lund | Nandi Garh | 30° 19' | 70° 21' | 610 | | | | | | | | | | | | | | | | | |
| | Zinda Peer | 30° 26' | 70° 26' | 400 | | | | | | | | | | | | | | | | | |
| Vidore | Bandlukh | 30° 10' | 70° 18' | 528 | | | | | | | | | | | | | | | | | |
| | Bandukh | 30° 09' | 70° 13' | 900 | | | | | | | | | | | | | | | | | |
| | Beira | 30° 08' | 70° 10' | 1,046 | | | | | | | | | | | | | | | | | |
| | Mard Bun | 30° 18' | 70° 07' | 1,830 | | | | | | | | | | | | | | | | | |
| | Sanga Sluf | 30° 16' | 70° 15' | 789 | | | | | | | | | | | | | | | | | |
| Sakhi Sarwar | Sakhi Sarwar | 29° 58' | 70° 18' | 580 | | | | | | | | | | | | | | | | | |
| Mithawan | Fort Munro | 29° 56' | 69° 58' | 1,983 | | | | | | | | | | | | | | | | | |
| | Mehal | 30° 05' | 70° 06' | 1,794 | | | | | | | | | | | | | | | | | |
| | Moli Bun | 29° 51' | 70° 08' | 427 | | | | | | | | | | | | | | | | | |
| | Rakhi Muhn | 29° 57' | 70° 10' | 526 | | | | | | | | | | | | | | | | | |
| Kaha | Bewata | 30° 01' | 69° 50' | 1,095 | | | | | | | | | | | | | | | | | |
| | Chacha | 29° 49' | 69° 50' | 970 | | | | | | | | | | | | | | | | | |
| | Mat | 29° 43' | 69° 41' | 854 | | | | | | | | | | | | | | | | | |
| | Morange | 29° 30' | 69° 37' | 702 | | | | | | | | | | | | | | | | | |
| | Ziarat Sheru | 29° 37' | 69° 56' | 1,419 | | | | | | | | | | | | | | | | | |
| Chachar | Chachar | 29° 23' | 69° 50' | 534 | | | | | | | | | | | | | | | | | |
| Pitok | Shadni | 29° 13' | 69° 53' | 427 | | | | | | | | | | | | | | | | | |
| Sori Shumali | Sori | 29° 07' | 69° 54' | 183 | | | | | | | | | | | | | | | | | |

Note : Operated by Irrigation and Power Department of Punjab Government

Data ; Daily Rainfall

==== ; Observed for All Season

- - - ; For Monsoon Season

Table A-3 Monthly Rainfall of Barkhan Station

(Unit : mm)

| year | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|------|------|------|------|-------|------|------|-------|-------|-------|------|------|------|--------|
| 1969 | 0.0 | 31.8 | 14.7 | 13.5 | 30.0 | 11.4 | 62.2 | 59.2 | 21.8 | 47.8 | 0.0 | 0.0 | 292.4 |
| 1970 | 15.2 | 23.1 | 33.8 | 0.0 | 3.8 | 4.8 | 64.8 | 133.4 | 160.8 | 0.0 | 0.0 | 0.0 | 439.7 |
| 1971 | 3.6 | 0.0 | 0.0 | 0.0 | 10.7 | 91.2 | 56.4 | 46.2 | 41.7 | 0.0 | 2.5 | 2.3 | 254.6 |
| 1972 | 6.4 | 14.2 | 4.3 | 99.3 | 10.9 | 16.8 | 37.9 | 77.2 | 0.0 | 0.3 | 4.1 | 17.5 | 288.9 |
| 1973 | 0.3 | 3.3 | 4.8 | 15.7 | 26.4 | 52.6 | 66.3 | 89.9 | 64.0 | 0.0 | 0.0 | 14.7 | 338.0 |
| 1974 | 5.8 | 39.3 | 2.2 | 12.5 | 18.2 | 4.4 | 121.1 | 50.3 | 72.0 | 0.0 | 0.0 | 0.0 | 325.8 |
| 1975 | 1.0 | 52.2 | 8.2 | 36.9 | 17.8 | 44.6 | 155.8 | 164.6 | 90.9 | 0.0 | 0.0 | 2.5 | 574.5 |
| 1976 | 4.6 | 15.8 | 35.4 | 9.7 | 0.0 | 40.8 | 113.9 | 149.8 | 122.8 | 20.2 | 0.0 | 0.0 | 513.0 |
| 1977 | 64.1 | 0.0 | 3.5 | 71.9 | 14.0 | 94.8 | 85.1 | 15.4 | 108.6 | 1.0 | 21.9 | 1.8 | 482.1 |
| 1978 | 13.0 | 64.3 | 25.2 | 36.8 | 0.7 | 53.2 | 276.7 | 57.3 | 53.6 | 0.0 | 21.2 | 0.0 | 602.0 |
| 1979 | 19.5 | 40.9 | 91.7 | 29.4 | 31.7 | 15.7 | 177.6 | 65.7 | 42.8 | 2.1 | 7.4 | 21.7 | 546.2 |
| 1980 | 20.4 | 3.6 | 57.5 | 6.9 | 9.3 | 11.4 | 215.5 | 29.1 | 12.2 | 15.3 | 5.7 | 0.0 | 386.9 |
| 1981 | 16.3 | 15.9 | 52.5 | 10.9 | 61.5 | 6.2 | 80.0 | 58.3 | 17.6 | 6.5 | 2.3 | 0.0 | 328.0 |
| 1982 | 19.2 | 52.7 | 47.6 | 20.2 | 25.6 | 19.1 | 66.6 | 65.6 | 0.1 | 18.5 | 17.3 | 38.3 | 390.8 |
| 1983 | 0.0 | 28.8 | 5.7 | 131.3 | 27.7 | 15.7 | 81.5 | 137.0 | 73.6 | 0.3 | 0.0 | 5.8 | 507.4 |
| 1984 | 11.4 | 0.0 | 24.5 | 23.1 | 0.0 | 9.7 | 180.6 | 294.3 | 70.4 | 0.0 | 0.0 | 0.0 | 614.0 |
| 1985 | 1.8 | 0.0 | 36.7 | 40.6 | 13.2 | 61.0 | 103.8 | 52.5 | 17.4 | 8.2 | 0.0 | 0.4 | 335.6 |
| 1986 | 3.6 | 22.4 | 14.2 | 13.1 | 18.4 | 12.5 | 23.4 | 129.1 | 6.2 | 0.0 | 1.4 | 0.0 | 244.3 |
| 1987 | 3.4 | 20.9 | 75.8 | 18.2 | 40.9 | 11.5 | 68.3 | 136.8 | 0.0 | 0.0 | 0.0 | 0.0 | 375.8 |
| 1988 | 18.0 | 12.3 | 55.9 | 9.8 | 1.4 | 51.0 | 65.5 | 31.9 | 12.7 | 0.0 | 14.1 | 5.2 | 277.8 |
| Mean | 11.4 | 22.1 | 29.7 | 30.0 | 18.1 | 31.4 | 105.1 | 92.2 | 49.5 | 6.0 | 4.9 | 5.5 | 405.9 |
| R(%) | 2.8 | 5.4 | 7.3 | 7.4 | 4.5 | 7.7 | 25.9 | 22.7 | 12.2 | 1.5 | 1.2 | 1.4 | 100.0 |

Note R : Ratio to Annual Rainfall (%)

Barkhan Station : Operated by Meteorological Department
 Latitude 29° 54' , Longitude 69° 32'
 Elevation of Station Above MSL 113 m

Table A-4 Calculation of Monthly Areal Rainfall for 20years (1969-1988)

(Unit : mm)

| Name of Hill Torrent | ① | ② | ③ |
|-------------------------|--|---|--|
| | Mean Annual Areal Rainfall by the Isohyetal Map (1975 - 1988) | Ratio of Annual Rainfall to Barkhan Station ① / (A) | Estimated Monthly Areal Rainfall for the Period of 20years(1969-1988) (B) × ② |
| Kaura | 330 | 0.75 | 305 |
| Vehowa | 385 | 0.87 | 353 |
| Sanghar | 360 | 0.82 | 333 |
| Sori Lund | 245 | 0.56 | 227 |
| Vidore *1 | | | |
| Sakhi Sarwar | 235 | 0.53 | 215 |
| Mithawan | 290 | 0.66 | 268 |
| Chachar | 260 | 0.59 | 239 |
| Pitok | 230 | 0.52 | 211 |
| Sori Shumali | 230 | 0.52 | 211 |
| Zangi | 200 | 0.45 | 183 |
| Sori Janubi | 230 | 0.52 | 211 |

*1 : To be Estimated by Thiessen Method

Mean Monthly Rainfall at Barkhan Station (Unit : mm)

(A) 14years (1975-1988) Annual 441.3 mm

(B) 20years (1969-1988) Annual 405.9 mm

| Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|------|------|------|------|------|------|-------|------|------|------|------|------|
| 11.4 | 22.1 | 29.7 | 30.0 | 18.1 | 31.4 | 105.1 | 92.2 | 49.5 | 6.0 | 4.9 | 5.5 |

Table A-5 Mean Monthly Areal Rainfall

(Unit : mm)

| Name of Hill Torrent | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|----------------------|------|------|------|------|------|------|------|------|------|------|------|------|--------|
| Kaura | 8.6 | 16.6 | 22.3 | 22.5 | 13.6 | 23.6 | 78.8 | 69.2 | 37.1 | 4.5 | 3.7 | 4.1 | 304.6 |
| Vehowa | 9.9 | 19.2 | 25.8 | 26.1 | 15.7 | 27.3 | 91.4 | 80.2 | 43.1 | 5.2 | 4.3 | 4.8 | 353.0 |
| Sanghar | 9.3 | 18.1 | 24.4 | 24.6 | 14.8 | 25.7 | 86.2 | 75.6 | 40.6 | 4.9 | 4.0 | 4.5 | 332.7 |
| Sori Lund | 6.4 | 12.4 | 16.6 | 16.8 | 10.1 | 17.6 | 58.9 | 51.6 | 27.7 | 3.4 | 2.7 | 3.1 | 227.3 |
| Vidore *1 | 6.1 | 8.6 | 21.2 | 30.2 | 18.9 | 28.8 | 82.4 | 68.7 | 36.7 | 4.9 | 1.6 | 2.1 | 310.2 |
| Sakhi Sarwar | 6.0 | 11.7 | 15.7 | 15.9 | 9.6 | 16.6 | 55.7 | 48.9 | 26.2 | 3.2 | 2.6 | 2.9 | 215.0 |
| Mithawan | 7.5 | 14.6 | 19.6 | 19.8 | 11.9 | 20.7 | 69.4 | 60.9 | 32.7 | 4.0 | 3.2 | 3.6 | 267.9 |
| Chachar | 6.7 | 13.0 | 17.5 | 17.7 | 10.7 | 18.5 | 62.0 | 54.4 | 29.2 | 3.5 | 2.9 | 3.2 | 239.3 |
| Pitok | 5.9 | 11.5 | 15.4 | 15.6 | 9.4 | 16.3 | 54.7 | 47.9 | 25.7 | 3.1 | 2.5 | 2.9 | 210.9 |
| Sori Shumali | 5.9 | 11.5 | 15.4 | 15.6 | 9.4 | 16.3 | 54.7 | 47.9 | 25.7 | 3.1 | 2.5 | 2.9 | 210.9 |
| Zangi | 5.1 | 9.9 | 13.4 | 13.5 | 8.1 | 14.1 | 47.3 | 41.5 | 22.3 | 2.7 | 2.2 | 2.5 | 182.6 |
| Sori Janubi | 5.9 | 11.5 | 15.4 | 15.6 | 9.4 | 16.3 | 54.7 | 47.9 | 25.7 | 3.1 | 2.5 | 2.9 | 210.9 |
| Average | 8.1 | 15.6 | 21.6 | 22.3 | 13.5 | 23.2 | 76.8 | 67.1 | 36.0 | 4.4 | 3.4 | 3.9 | 295.9 |
| Ratio(%) | 2.7 | 5.3 | 7.3 | 7.5 | 4.6 | 7.8 | 26.0 | 22.7 | 12.2 | 1.5 | 1.1 | 1.3 | 100.0 |

Note

Data Period : 20 years (1969-1988)

Monthly Rainfall : Estimated from the Monthly Rainfall of Barkhan Station

*1 : To be Estimated by Thiessen Method. for 10 years (1975-1984)

Table A-6 Mean Monthly Runoff

(Unit : MCM)

| Name of Hill Torrent | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|----------------------|-------|-------|-------|-------|-------|-------|--------|--------|--------|-------|-------|-------|----------|
| Kaura | 1.15 | 2.24 | 3.01 | 3.04 | 1.83 | 3.18 | 21.28 | 18.67 | 10.03 | 0.61 | 0.49 | 0.56 | 66.09 |
| Vehowa | 8.09 | 15.69 | 21.09 | 21.30 | 12.86 | 22.30 | 149.23 | 130.91 | 70.29 | 4.26 | 3.48 | 3.90 | 463.40 |
| Sanghar | 13.69 | 26.53 | 35.66 | 36.02 | 21.73 | 37.70 | 252.36 | 221.38 | 118.86 | 7.20 | 5.88 | 6.60 | 783.61 |
| Sori Lund | 1.00 | 1.93 | 2.60 | 2.62 | 1.58 | 2.75 | 18.36 | 16.11 | 8.65 | 0.52 | 0.43 | 0.48 | 57.03 |
| Vidore *1 | 2.40 | 3.33 | 8.02 | 11.22 | 6.38 | 10.61 | 31.67 | 26.94 | 16.85 | 1.63 | 0.55 | 0.73 | 120.33 |
| Sakhi Sarwar | 0.29 | 0.56 | 0.76 | 0.76 | 0.46 | 0.80 | 5.35 | 4.69 | 2.52 | 0.15 | 0.13 | 0.14 | 16.61 |
| Mithawan | 1.53 | 2.98 | 4.00 | 4.04 | 2.44 | 4.23 | 28.30 | 24.83 | 13.33 | 0.81 | 0.66 | 0.74 | 87.89 |
| Chachar | 1.61 | 3.13 | 4.21 | 4.25 | 2.56 | 4.45 | 29.77 | 26.11 | 14.02 | 0.85 | 0.69 | 0.78 | 92.43 |
| Pitok | 0.43 | 0.83 | 1.11 | 1.12 | 0.68 | 1.18 | 7.87 | 6.90 | 3.71 | 0.22 | 0.18 | 0.21 | 24.44 |
| Sori Shumali | 0.59 | 1.14 | 1.53 | 1.54 | 0.93 | 1.62 | 10.82 | 9.49 | 5.10 | 0.31 | 0.25 | 0.28 | 33.60 |
| Zangi | 0.62 | 1.19 | 1.60 | 1.62 | 0.98 | 1.69 | 11.35 | 9.96 | 5.35 | 0.32 | 0.27 | 0.30 | 35.25 |
| Sori Janubi | 2.99 | 5.79 | 7.78 | 7.86 | 4.75 | 8.23 | 55.09 | 48.33 | 25.95 | 1.57 | 1.29 | 1.44 | 171.07 |
| Total | 34.39 | 65.34 | 91.37 | 95.39 | 57.18 | 98.74 | 621.45 | 544.32 | 294.66 | 18.45 | 14.30 | 16.16 | 1,951.75 |
| Ratio(%) | 1.8 | 3.4 | 4.7 | 4.9 | 2.9 | 5.1 | 31.8 | 27.9 | 15.1 | 0.9 | 0.7 | 0.8 | 100.0 |

Note

Data Period : for 20years (1969-1988)

*1 : To be Estimated by Tank Model Method for 10years (1975-1984)

Table A-7 Average and Probable Annual Runoff

(Unit : MCM)

| Name of Hill Torrent | Average | Return Period | | | | |
|----------------------|---------|---------------|----------|----------|----------|----------|
| | | 5years | 10years | 15years | 20years | 25years |
| Kaura | 66.09 | 82.92 | 98.18 | 107.04 | 113.35 | 118.29 |
| Vehowa | 463.40 | 581.42 | 688.36 | 750.50 | 794.78 | 829.42 |
| Sanghar | 783.61 | 983.19 | 1,164.03 | 1,269.11 | 1,343.98 | 1,402.56 |
| Sori Lund | 57.03 | 71.55 | 84.71 | 92.35 | 97.80 | 102.07 |
| Vidore *1 | 120.33 | 146.35 | 176.44 | 195.12 | 208.93 | 220.02 |
| Sakhi Sarwar | 16.61 | 20.84 | 24.67 | 26.89 | 28.48 | 29.72 |
| Mithawan | 87.89 | 110.27 | 130.55 | 142.34 | 150.73 | 157.30 |
| Chachar | 92.43 | 115.97 | 137.30 | 149.69 | 158.53 | 165.44 |
| Pitok | 24.44 | 30.66 | 36.30 | 39.58 | 41.92 | 43.74 |
| Sori Shumali | 33.60 | 42.16 | 49.92 | 54.42 | 57.63 | 60.15 |
| Zangi | 35.25 | 44.23 | 52.36 | 57.09 | 60.45 | 63.09 |
| Sori Janubi | 171.07 | 214.64 | 254.12 | 277.06 | 293.41 | 306.20 |

Data Period : for 20 years (1969-1988)

*1 : To be Estimated by Tank Model Method for 10 years (1969-1988)

Table A-8 List of Stream Gauge Stations

| Name of Hill Torrent | Catchment Area (sq. km) | Collected Period | | | | | | | | | | | | | | | | | |
|----------------------|----------------------------|------------------|---|---|---|---|---|--------|---|---|---|---|---|---|---|---|--------|---|---|
| | | 1970 s | | | | | | 1980 s | | | | | | | | | 1990 s | | |
| | | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 |
| Kaura | 450 | | | | | | | | | | | | | | | | | | |
| Vehowa | 2,720 | | | | | | | | | | | | | | | | | | |
| Sanghar | 4,880 | | | | | | | | | | | | | | | | | | |
| Sori Lund | 520 | | | | | | | | | | | | | | | | | | |
| Vidore | 770 | | | | | | | | | | | | | | | | | | |
| Sakhi Sarwar | 160 | | | | | | | | | | | | | | | | | | |
| Mithawan | 680 | | | | | | | | | | | | | | | | | | |
| Kaha | 5,700 | | | | | | | | | | | | | | | | | | |
| Chachar | 800 | | | | | | | | | | | | | | | | | | |
| Pitok | 240 | | | | | | | | | | | | | | | | | | |
| Sori Shumali | 330 | | | | | | | | | | | | | | | | | | |
| Zangi | 400 | | | | | | | | | | | | | | | | | | |
| Sori Janubi | 1,680 | | | | | | | | | | | | | | | | | | |

Note : Operated by Irrigation and Power Department of Punjab Government

Data : Momentary Peak Discharge of Flood Flow

TABLE A-9 RETURN PERIOD OF ANNUAL MAXIMUM PEAK DISCHARGES (1)

| Year | Kaura CA = 450km ² | | Vehowa CA = 2,720km ² | | Sanghar CA = 4,880km ² | | Sori Lund CA = 520km ² | | Vidore CA = 770km ² | | Sokhi Sarwar CA = 160km ² | |
|------|----------------------------------|-------|-------------------------------------|-------|--------------------------------------|-------|--------------------------------------|-------|-----------------------------------|-------|---|--------|
| | Q | R.P. | Q | R.P. | Q | R.P. | Q | R.P. | Q | R.P. | Q | R.P. |
| 1958 | 227 | 1.51 | 166 | 1.14 | 1,586 | 1.72 | <640> | 2.97 | 862 | 2.90 | 165 | 1.62 |
| 1959 | 588 | 3.65 | 1,796 | 5.99 | 843 | 1.33 | 962 | 6.64 | 1,736 | 21.80 | 57 | 1.18 |
| 1960 | 151 | 1.32 | 181 | 1.16 | 1,097 | 1.45 | 82 | 2.83 | 661 | 1.95 | 48 | 1.15 |
| 1961 | 281 | 1.67 | 269 | 1.24 | 760 | 1.29 | 564 | 2.52 | 450 | 1.57 | 199 | 1.79 |
| 1962 | 171 | 1.36 | 98 | 1.08 | 825 | 1.32 | 587 | 2.66 | 525 | 1.70 | 1,233 | 203.00 |
| 1963 | 127 | 1.26 | 289 | 1.26 | 730 | 1.28 | 342 | 1.65 | 316 | 1.37 | 145 | 1.53 |
| 1964 | 219 | 1.49 | 1,306 | 3.40 | 1,461 | 1.64 | 1,172 | 11.23 | 661 | 1.95 | 400 | 4.64 |
| 1965 | (266) | 1.62 | (495) | 1.49 | (1,298) | 1.55 | (251) | 1.44 | (789) | 2.52 | (253) | 2.20 |
| 1966 | (280) | 1.66 | (780) | 1.87 | (1,400) | 1.61 | (500) | 2.15 | (600) | 1.83 | (250) | 2.16 |
| 1967 | (340) | 1.85 | (800) | 1.90 | (1,600) | 1.72 | (500) | 2.15 | (600) | 1.83 | (250) | 2.16 |
| 1968 | (350) | 1.89 | (820) | 1.93 | (1,700) | 1.78 | (500) | 2.15 | (650) | 1.93 | (250) | 2.16 |
| 1969 | (400) | 2.13 | (1,000) | 2.40 | (1,900) | 1.91 | (500) | 2.15 | (750) | 2.32 | (250) | 2.16 |
| 1970 | (500) | 2.84 | (1,200) | 2.97 | (2,300) | 2.71 | (600) | 2.73 | (800) | 2.58 | (300) | 2.79 |
| 1971 | (500) | 2.84 | (1,200) | 2.97 | (2,400) | 2.98 | (600) | 2.73 | (700) | 2.07 | (300) | 2.79 |
| 1972 | (600) | 3.77 | (1,600) | 4.79 | (2,400) | 2.98 | (700) | 3.47 | (900) | 3.14 | (300) | 2.79 |
| 1973 | (720) | 5.26 | (1,500) | 4.25 | (2,700) | 4.43 | (700) | 3.47 | (1,000) | 3.91 | (300) | 2.79 |
| 1974 | (840) | 7.29 | (1,210) | 3.00 | (3,400) | 13.37 | (749) | 3.89 | (1,010) | 3.99 | (450) | 5.97 |
| 1975 | 1,909 | 83.94 | 2,527 | 13.86 | 1,857 | 1.88 | 1,443 | 21.80 | 1,560 | 14.43 | 802 | 33.45 |
| 1976 | 981 | 10.54 | 950 | 2.26 | 3,550 | 17.50 | 680 | 3.29 | 785 | 2.50 | 453 | 6.06 |
| 1977 | 981 | 10.54 | 2,551 | 14.23 | 2,511 | 3.46 | 516 | 2.24 | 210 | 1.24 | 132 | 1.47 |
| 1978 | 513 | 2.93 | 906 | 2.13 | 3,497 | 15.89 | 603 | 2.75 | 2,278 | 75.49 | 340 | 3.41 |
| 1979 | 666 | 4.54 | 2,415 | 12.23 | 2,415 | 3.03 | 603 | 2.75 | 837 | 2.77 | 173 | 1.66 |
| 1980 | 390 | 2.06 | 997 | 2.39 | 1,644 | 1.75 | 124 | 1.20 | 502 | 1.66 | 245 | 2.10 |
| 1981 | 197 | 1.43 | 101 | 1.08 | 2,279 | 2.65 | 33 | 1.05 | 129 | 1.14 | 117 | 1.41 |
| 1982 | 146 | 1.30 | 283 | 1.26 | 2,822 | 5.25 | 616 | 2.45 | 212 | 1.24 | 532 | 9.10 |
| 1983 | 513 | 2.93 | 1,844 | 6.36 | 3,331 | 11.85 | 1,442 | 21.75 | 1,257 | 7.07 | 166 | 1.62 |
| 1984 | 759 | 5.83 | 2,216 | 9.78 | 3,058 | 7.54 | 381 | 1.74 | 1,257 | 7.07 | 149 | 1.54 |
| 1985 | 146 | 1.30 | 40 | 1.03 | 2,619 | 3.94 | 131 | 1.21 | 551 | 1.74 | 144 | 1.52 |
| 1986 | <420> | 2.27 | 891 | 2.09 | 2,619 | 3.94 | 118 | 1.19 | 551 | 1.74 | 370 | 3.95 |
| 1987 | 41 | 1.08 | 1,177 | 2.91 | 2,350 | 2.84 | 8 | 1.01 | 700 | 2.07 | 91 | 1.30 |
| 1988 | <660> | 4.46 | <1,390> | 3.74 | 2,619 | 3.94 | <760> | 3.99 | <1,020> | 4.09 | <390> | 4.41 |
| 1989 | 513 | 2.93 | <1,010> | 2.43 | 1,911 | 1.92 | 572 | 2.57 | 172 | 1.19 | <70> | 1.23 |

Return Period

| | | | | | | |
|----------|-------------------------|---------------------------|---------------------------|-------------------------|---------------------------|-------------------------|
| 5 Years | 703 m ³ /sec | 1,641 m ³ /sec | 2,791 m ³ /sec | 851 m ³ /sec | 1,109 m ³ /sec | 416 m ³ /sec |
| 10 Years | 961 | 2,237 | 3,232 | 1,126 | 1,405 | 551 |
| 15 Years | 1,122 | 2,599 | 3,465 | 1,289 | 1,577 | 632 |
| 20 Years | 1,242 | 2,864 | 3,623 | 1,407 | 1,699 | 692 |
| 25 Years | 1,338 | 3,075 | 3,742 | 1,500 | 1,795 | 739 |
| 30 Years | 1,418 | 3,249 | 3,837 | 1,577 | 1,873 | 779 |

Note CA: Catchment Area of Hill Torrent Basin
 Q: Annual Maximum Peak Discharge (m³/sec)
 R.P.: Return Period in Years

Missing Data

(): Synthetically Generated Figures, by Trend Analysis of Cumulative Maximum Peak Discharges
 < >: Synthetically Generated Figures, by the Maximum Peak Discharge of Other Hill Torrent

TABLE A-9 RETURN PERIOD OF ANNUAL MAXIMUM PEAK DISCHARGES (2)

| Year | Mithawan CA = 680km ² | | Chachar CA = 800km ² | | Pitok CA = 240km ² | | Sori Shumali CA = 330km ² | | Zangi CA = 400km ² | | Sori Janubi CA = 1,680km ² | |
|------|-------------------------------------|-------|------------------------------------|-------|----------------------------------|-------|---|-------|----------------------------------|-------|--|-------|
| | Q | R.P. | Q | R.P. | Q | R.P. | Q | R.P. | Q | R.P. | Q | R.P. |
| 1958 | 2,195 | 14.69 | 162 | 1.23 | <60> | 1.21 | <40> | 1.30 | <50> | 1.31 | <210> | 1.23 |
| 1959 | 502 | 1.40 | 1,600 | 12.74 | <590> | 46.54 | <430> | 9.17 | <520> | 9.14 | <2,060> | 16.89 |
| 1960 | 1,491 | 3.99 | 1,229 | 6.82 | <460> | 13.86 | <330> | 6.28 | <400> | 6.28 | <1,590> | 8.19 |
| 1961 | 1,271 | 2.84 | 1,054 | 5.00 | 300 | 3.55 | 549 | 13.54 | <660> | 13.36 | <1,360> | 5.68 |
| 1962 | 1,675 | 5.50 | 1,818 | 18.04 | 246 | 2.42 | 459 | 10.14 | <560> | 10.25 | <2,350> | 25.94 |
| 1963 | 968 | 1.91 | 749 | 2.90 | 220 | 1.99 | 480 | 10.88 | <580> | 10.82 | <970> | 3.04 |
| 1964 | 611 | 1.51 | 33 | 1.04 | 235 | 2.23 | 547 | 13.46 | <660> | 13.36 | <40> | 1.04 |
| 1965 | (1,620) | 4.98 | (1,055) | 5.01 | (289) | 3.25 | (365) | 7.23 | (440) | 7.17 | (1,520) | 7.34 |
| 1966 | (990) | 1.94 | (600) | 2.23 | (200) | 1.87 | (300) | 5.54 | (360) | 5.48 | (900) | 2.76 |
| 1967 | (1,190) | 2.55 | (600) | 2.23 | (200) | 1.87 | (200) | 3.48 | (240) | 3.45 | (800) | 2.38 |
| 1968 | (990) | 1.94 | (700) | 2.68 | (200) | 1.87 | (200) | 3.48 | (240) | 3.45 | (700) | 2.00 |
| 1969 | (1,080) | 2.16 | (700) | 2.68 | (250) | 2.49 | (200) | 3.48 | (240) | 3.45 | (700) | 2.00 |
| 1970 | (1,130) | 2.34 | (700) | 2.68 | (250) | 2.49 | (150) | 2.65 | (180) | 2.64 | (800) | 2.38 |
| 1971 | (1,130) | 2.34 | (650) | 2.46 | (250) | 2.49 | (150) | 2.65 | (180) | 2.64 | (800) | 2.38 |
| 1972 | (1,420) | 3.59 | (650) | 2.46 | (250) | 2.49 | (100) | 1.92 | (120) | 1.92 | (800) | 2.38 |
| 1973 | (1,420) | 3.59 | (650) | 2.46 | (250) | 2.49 | (100) | 1.92 | (120) | 1.92 | (700) | 2.00 |
| 1974 | (1,130) | 2.34 | (600) | 2.23 | (260) | 2.66 | (40) | 1.30 | (50) | 1.31 | (780) | 2.30 |
| 1975 | 1,696 | 5.70 | 302 | 1.46 | 405 | 8.47 | 31 | 1.22 | <40> | 1.24 | <390> | 1.47 |
| 1976 | 1,638 | 5.14 | 340 | 1.54 | 353 | 5.41 | 37 | 1.27 | <50> | 1.31 | 306 | 1.35 |
| 1977 | 518 | 1.41 | 387 | 1.63 | 237 | 2.26 | 36 | 1.26 | <40> | 1.24 | 859 | 2.60 |
| 1978 | 2,265 | 16.88 | 1,274 | 7.38 | 470 | 15.18 | 97 | 1.88 | <120> | 1.92 | 517 | 1.67 |
| 1979 | 730 | 1.63 | 213 | 1.31 | 237 | 2.26 | 45 | 1.34 | <50> | 1.31 | 733 | 2.12 |
| 1980 | 2,253 | 16.48 | 147 | 1.20 | 224 | 2.04 | 28 | 1.20 | <30> | 1.18 | 357 | 1.42 |
| 1981 | 110 | 1.08 | 147 | 1.20 | 60 | 1.21 | 26 | 1.18 | <30> | 1.18 | 285 | 1.32 |
| 1982 | 518 | 1.41 | 276 | 1.42 | 103 | 1.38 | 25 | 1.18 | <30> | 1.18 | 185 | 1.20 |
| 1983 | 299 | 1.22 | 2,056 | 25.93 | 147 | 1.58 | 30 | 1.22 | <40> | 1.24 | 1,849 | 12.26 |
| 1984 | 232 | 1.17 | 302 | 1.46 | <110> | 1.41 | 36 | 1.26 | <40> | 1.24 | 1,515 | 7.28 |
| 1985 | 730 | 1.63 | <470> | 1.81 | 198 | 1.85 | 35 | 1.26 | <40> | 1.24 | <640> | 1.83 |
| 1986 | 1,446 | 3.73 | <930> | 4.00 | 58 | 1.20 | <250> | 4.45 | <300> | 4.40 | 285 | 1.32 |
| 1987 | 65 | 1.04 | <40> | 1.05 | <20> | 1.06 | <10> | 1.07 | <10> | 1.06 | <50> | 1.05 |
| 1988 | <1,310> | 2.98 | <840> | 3.43 | <310> | 3.82 | <230> | 4.03 | <280> | 4.06 | <1,080> | 3.65 |
| 1989 | 1,392 | 3.43 | <890> | 3.75 | <330> | 4.49 | <240> | 4.24 | <290> | 4.23 | <1,150> | 4.05 |

Return Period

| | | | | | | |
|----------|---------------------------|---------------------------|-------------------------|-------------------------|-------------------------|---------------------------|
| 5 Years | 1,623 m ³ /sec | 1,054 m ³ /sec | 344 m ³ /sec | 277 m ³ /sec | 335 m ³ /sec | 1,282 m ³ /sec |
| 10 Years | 1,998 | 1,454 | 424 | 455 | 552 | 1,718 |
| 15 Years | 2,206 | 1,702 | 469 | 583 | 707 | 1,982 |
| 20 Years | 2,350 | 1,885 | 500 | 686 | 832 | 2,173 |
| 25 Years | 2,460 | 2,032 | 524 | 774 | 938 | 2,325 |
| 30 Years | 2,549 | 2,154 | 544 | 850 | 1,030 | 2,450 |

Note CA: Catchment Area of Hill Torrent Basin
 Q: Annual Maximum Peak Discharge (m³/sec)
 R.P.: Return Period in Years

Missing Data

(): Synthetically Generated Figures, by Trend Analysis of Cumulative Maximum Peak Discharges
 < >: Synthetically Generated Figures, by the Maximum Peak Discharge of Other Hill Torrent

Table A-10 Calculation of Sediment Runoff by EZAKI METHOD

| Hill Torrent | Catchment Area sq. km | I cum/year | S | Ad / A | Total Sediment Volume cum/year | Specific Sediment Volume cum/sq. km/year |
|--------------|--------------------------|---------------|-------|--------|-----------------------------------|---|
| Kaura | 450 | 66,090,000 | 1/40 | 0.004 | 596,000 | 1,324 |
| Vehowa | 2,720 | 463,400,000 | 1/60 | 0.006 | 3,558,000 | 1,308 |
| Sanghar | 4,880 | 783,610,000 | 1/60 | 0.003 | 3,972,000 | 814 |
| Sori Lund | 520 | 57,030,000 | 1/60 | 0.004 | 339,000 | 652 |
| Vidor | 770 | 120,330,000 | 1/60 | 0.005 | 819,000 | 1,064 |
| Sakhi Sarwar | 160 | 16,610,000 | 1/60 | 0.010 | 185,000 | 1,156 |
| Mithawan | 680 | 87,890,000 | 1/80 | 0.007 | 657,000 | 966 |
| Chachar | 800 | 92,430,000 | 1/80 | 0.005 | 530,000 | 663 |
| Pitok | 240 | 24,440,000 | 1/80 | 0.010 | 246,000 | 1,025 |
| Sori Shumali | 330 | 33,600,000 | 1/100 | 0.010 | 322,000 | 976 |
| Zangi | 400 | 35,250,000 | 1/70 | 0.003 | 156,000 | 390 |
| Sori Janubi | 1,680 | 171,070,000 | 1/150 | 0.004 | 663,000 | 395 |

$$Q_s = 8.85 \cdot I \cdot S^2 + 7.83 \cdot I \cdot (Ad / A) \cdot D^2$$

Where

- Qs : Sediment Runoff (cu. m/year)
- I : Mean Annual Runoff (cu. m/year)
- S : River Bed Grade
- Ad : Slope Failure Area (sq. km)
- A : Catchment Area (sq. km)
- D : Mean Grade of Slope Failure ; (= 1/3)

Table A-11 Estimated Sediment Volume

| Hill Torrent | Catchment Area sq. km | TANAKA METHOD | | EZAKI METHOD | | Estimated Sediment |
|--------------|--------------------------|-----------------------|--------------------------|-----------------------|--------------------------|--------------------------|
| | | Total Sediment Volume | Specific Sediment Volume | Total Sediment Volume | Specific Sediment Volume | Specific Sediment Volume |
| | | cum/year | cum/sq. km /year | cum/year | cum/sq. km /year | cum/sq. km /year |
| KAURA | 450 | 182,000 | 404 | 596,000 | 1,324 | 1,300 |
| VEHOWA | 2,720 | 1,551,000 | 570 | 3,558,000 | 1,308 | 1,300 |
| SANGHAR | 4,880 | 1,330,000 | 273 | 3,972,000 | 814 | 800 |
| SORILUND | 520 | 124,000 | 238 | 339,000 | 652 | 700 |
| VIDOR | 770 | 374,000 | 486 | 819,000 | 1,064 | 1,100 |
| SAKISARWAR | 160 | 22,000 | 138 | 185,000 | 1,156 | 1,200 |
| MITHAWAN | 680 | 270,000 | 397 | 657,000 | 966 | 1,000 |
| CHACHAR | 800 | 232,000 | 290 | 530,000 | 663 | 700 |
| PITOK | 240 | 43,000 | 179 | 246,000 | 1,025 | 1,000 |
| SORI SHUMALI | 330 | 64,000 | 194 | 322,000 | 976 | 1,000 |
| ZANGI | 400 | 38,000 | 95 | 156,000 | 390 | 400 |
| SORI JANUBI | 1,680 | 248,000 | 148 | 663,000 | 395 | 400 |

ANNEX B. TOPOGRAPHY / GEOLOGY

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ANNEX B. TOPOGRAPHY / GEOLOGY

Watershed areas of the major hill torrents are classified by elevation as shown in Table B - 1. Area by relative relief (difference between the highest and lowest points in one kilometer square) and by gradient are shown in Table B - 2 and B-3, respectively. Topographical features of the major watersheds are shown in Table B - 4. Table B - 5 shows the areas divided by geology consisting of each hill torrent watershed. Figures B - 1 through B - 12 demonstrate drainage systems of the major hill torrents.

TABLE B-1. AREA DIVIDED BY HEIGHT

| Hill Torrent | Total Area | Pachad | | | | | Catchment Area | | | | | | | | |
|--------------|------------|------------------|------------------|--------------------|--------------------|-------------------|------------------|------------------|--------------------|--------------------|-------------------|-------------|-------------|-------------|----------|
| | | Lower than 500 m | 500 m to 1,000 m | 1,000 m to 1,500 m | 1,500 m to 2,000 m | More than 2,000 m | Lower than 500 m | 500 m to 1,000 m | 1,000 m to 1,500 m | 1,500 m to 2,000 m | More than 2,000 m | | | | |
| KAURA | 564 | 114 (20%) | 44 (8%) | 268 (48%) | 56 (10%) | 51 (9%) | 31 (5%) | VEHOWA | 2,851 | 131 (5%) | 70 (2%) | 491 (17%) | 976 (34%) | 1,011 (35%) | 172 (6%) |
| SANGHAR | 4,962 | 82 (2%) | 175 (4%) | 1,085 (22%) | 2,802 (56%) | 762 (15%) | 56 (1%) | SORILUND | 659 | 139 (21%) | 108 (16%) | 361 (55%) | 29 (4%) | 17 (3%) | 5 (1%) |
| VIDOR | 966 | 196 (20%) | 104 (11%) | 394 (41%) | 116 (12%) | 151 (16%) | 5 (1%) | SAKI SARWAR | 317 | 157 (50%) | 98 (31%) | 62 (20%) | - | - | - |
| MITHAWAN | 915 | 235 (26%) | 208 (23%) | 236 (26%) | 129 (14%) | 107 (12%) | - | KAHA | 5,849 | 363 (6%) | 69 (1%) | 2,190 (37%) | 2,781 (48%) | 446 (8%) | - |
| CHACHAR | 1,032 | 232 (22%) | 139 (13%) | 576 (56%) | 85 (8%) | - | - | PITOK | 376 | 136 (36%) | 92 (24%) | 148 (39%) | - | - | - |
| SORI SHUMALI | 390 | 60 (15%) | 60 (15%) | 269 (69%) | 1 | 0% | - | ZANGI | 443 | 43 (10%) | 294 (66%) | 96 (22%) | 10 (2%) | - | - |
| SORI JANUBI | 1,744 | 64 (4%) | 687 (39%) | 986 (57%) | 7 (0%) | - | - | Total | 21,068 | 1,952 (9%) | 2,148 (10%) | 7,162 (34%) | 6,992 (33%) | 2,545 (12%) | 269 (1%) |

TABLE B-2. AREA BY RELATIVE RELIEF

(Unit: km²)

| Hill Torrent | Relative Relief | | |
|--------------|-----------------|-------------|-----------------|
| | Less than 300 m | 300 – 600 m | More than 600 m |
| KAURA | 259 | 130 | 61 |
| VEHOWA | 1,082 | 1,005 | 632 |
| SANGHAR | 3,610 | 1,025 | 244 |
| SORI LUND | 315 | 178 | 28 |
| VIDOR | 723 | 141 | 13 |
| SAKI SARWAR | 64 | 96 | 0 |
| MITHAWAN | 217 | 362 | 101 |
| KAHA | - | - | - |
| CHACHAR | 417 | 231 | 152 |
| PITOK | 0 | 240 | 0 |
| SORI SHUMALI | 0 | 330 | 0 |
| ZANGI | 300 | 100 | 0 |
| SORI JANUBI | 987 | 693 | 0 |
| Total | 7,974 | 4,531 | 1,231 |

TABLE B-3. AREA OF SLOPE LESS THAN 6 DEGREES

(Unit: km²)

| Hill Torrent | Total Drainage Area | Slope | | |
|--------------|---------------------|---------------------|----------------|---------------------|
| | | Less than 3 degrees | 3 to 6 degrees | More than 6 degrees |
| KAURA | 450 | 15 | 105 | 330 |
| VEHOWA | 2,720 | 583 | 472 | 1,665 |
| SANGHAR | 4,880 | 879 | 1,016 | 2,985 |
| SORI LUND | 520 | 36 | 227 | 257 |
| VIDOR | 877 | 123 | 198 | 556 |
| SAKI SARWAR | 160 | 64 | 9 | 87 |
| MITHAWAN | 680 | 289 | 68 | 323 |
| KAHA | - | - | - | - |
| CHACHAR | 800 | 306 | 233 | 261 |
| PITOK | 240 | 11 | 73 | 156 |
| SORI SHUMALI | 330 | 12 | 99 | 219 |
| ZANGI | 400 | 137 | 146 | 117 |
| SORI JANUBI | 1,680 | 325 | 444 | 911 |

TABLE B-4. SALIENT FEATURES BY HILL TORRENT WATERSHED

| Hill Torrent | Elevation at Peak m | Elevation at Darrah m | Length of River km | Drainage Area km ² | Perimeter of Drainage Area km | Average Riverbed Slope | Average Width of Catchment km | Form Factor | Compactness | Drainage Density km/km ² |
|--------------|---------------------------|-----------------------------|-----------------------------|-------------------------------------|--|------------------------------|--|----------------|-------------|---|
| KAURA | 2,553 | 290 | 57.9 | 450 | 126.0 | 1/26 | 7.77 | 0.13 | 0.60 | 2.79 |
| VEHOWA | 2,421 | 305 | 164.0 | 2,720 | 374.0 | 1/81 | 16.59 | 0.10 | 0.49 | 2.24 |
| SANGHAR | 2,456 | 260 | 166.0 | 4,880 | 484.0 | 1/109 | 29.40 | 0.18 | 0.51 | 2.71 |
| SORILUND | 2,300 | 250 | 58.5 | 520 | 144.0 | 1/29 | 8.89 | 0.15 | 0.56 | 2.89 |
| VIDOR | 2,106 | 260 | 58.1 | 770 | 151.0 | 1/40 | 13.25 | 0.23 | 0.65 | 2.78 |
| SAKI SARWAR | 1,031 | 280 | 22.0 | 98 | 48.6 | 1/29 | 4.45 | 0.20 | 0.72 | 2.39 |
| MITHAWAN | 2,121 | 220 | 44.8 | 680 | 122.0 | 1/26 | 15.18 | 0.34 | 0.76 | 4.86 |
| CHACHAR | 1,392 | 198 | 87.8 | 800 | 165.0 | 1/90 | 9.11 | 0.10 | 0.61 | 4.05 |
| PITOK | 945 | 175 | 42.6 | 240 | 80.0 | 1/55 | 5.63 | 0.13 | 0.69 | 3.72 |
| SORI SHUMALI | 1,014 | 152 | 51.5 | 330 | 90.0 | 1/60 | 6.41 | 0.12 | 0.72 | 3.83 |
| ZANGI | 1,265 | 137 | 40.0 | 400 | 98.0 | 1/35 | 10.00 | 0.25 | 0.72 | 3.99 |
| SORI JANUBI | 1,149 | 137 | 131.2 | 1,680 | 255.0 | 1/146 | 12.80 | 0.10 | 0.57 | 3.11 |

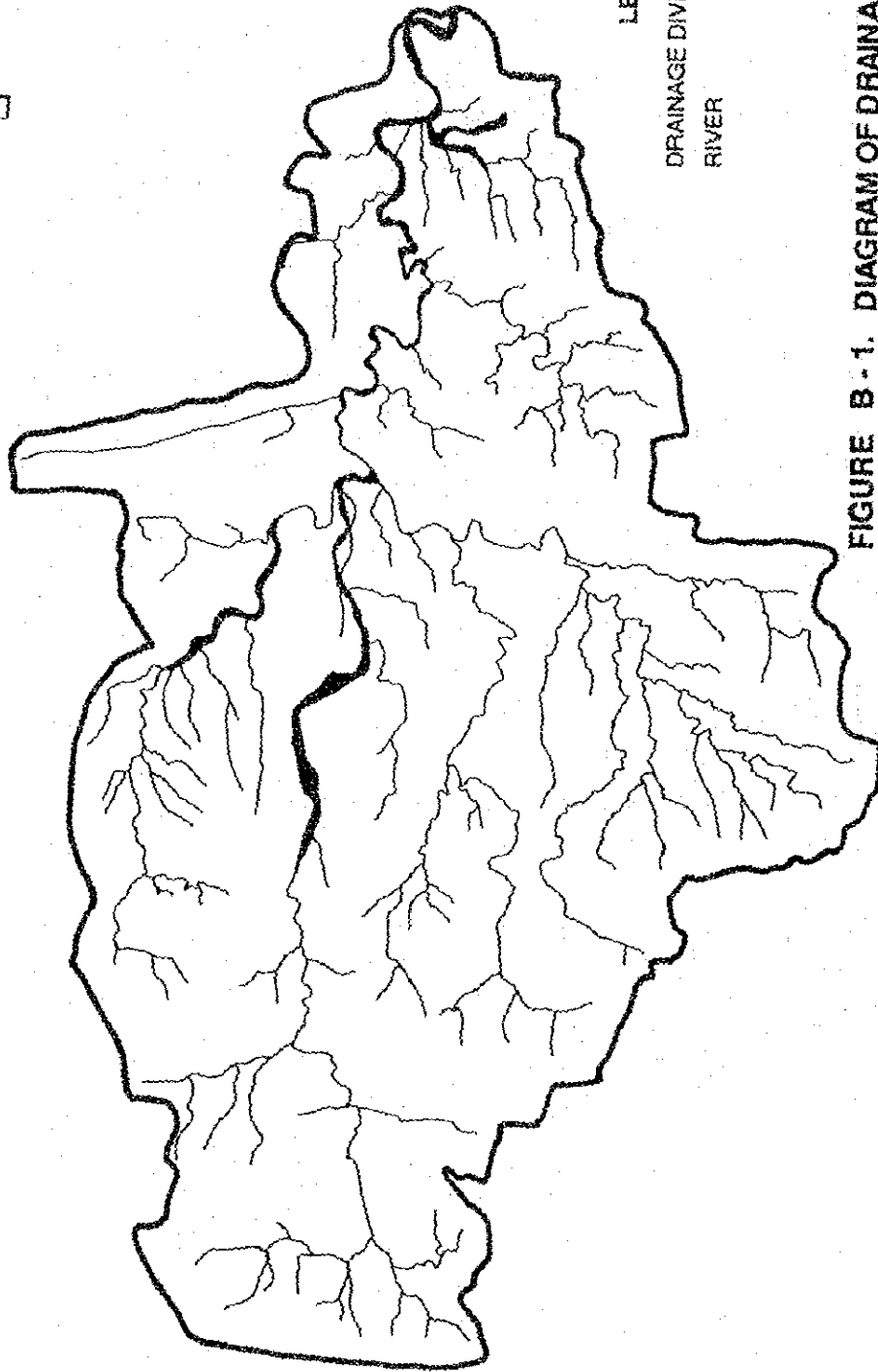
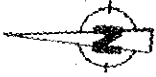
Average Width : (Drainage Area)/(Length of River)

Form Factor : (Average Width)/(Length of River)

Compactness : $(2\sqrt{\pi} \times (\text{Discharge Area})) / (\text{Perimeter of Drainage Area})$

TABLE B-5. AREA DIVIDED BY GEOLOGY

| | (Unit: km ²) | | |
|--------------|--------------------------|-------------|------------|
| Hill Torrent | Mesozoic | Tertiary | Quaternary |
| KAURA | 72 (16%) | 378 (84%) | 0 (0%) |
| VEHOWA | 1,550 (57%) | 816 (30%) | 354 (13%) |
| SANGHAR | 927 (19%) | 3,611 (74%) | 342 (7%) |
| SORI LUND | 0 (0%) | 514 (99%) | 5 (1%) |
| VIDOR | 92 (12%) | 570 (74%) | 108 (14%) |
| SAKI SARWAR | 0 (0%) | 87 (54%) | 73 (46%) |
| MITHAWAN | 102 (15%) | 313 (46%) | 265 (39%) |
| KAHA | 43 (1%) | 4,527 (84%) | 840 (16%) |
| CHACHAR | 0 (0%) | 776 (97%) | 24 (3%) |
| PITOK | 0 (0%) | 209 (94%) | 13 (6%) |
| SORI SHUMALI | 0 (0%) | 226 (94%) | 14 (6%) |
| ZANGI | 0 (0%) | 388 (97%) | 12 (3%) |
| SORI JANUBI | 0 (0%) | 1,478 (88%) | 202 (12%) |



LEGEND



DRAINAGE DIVIDE

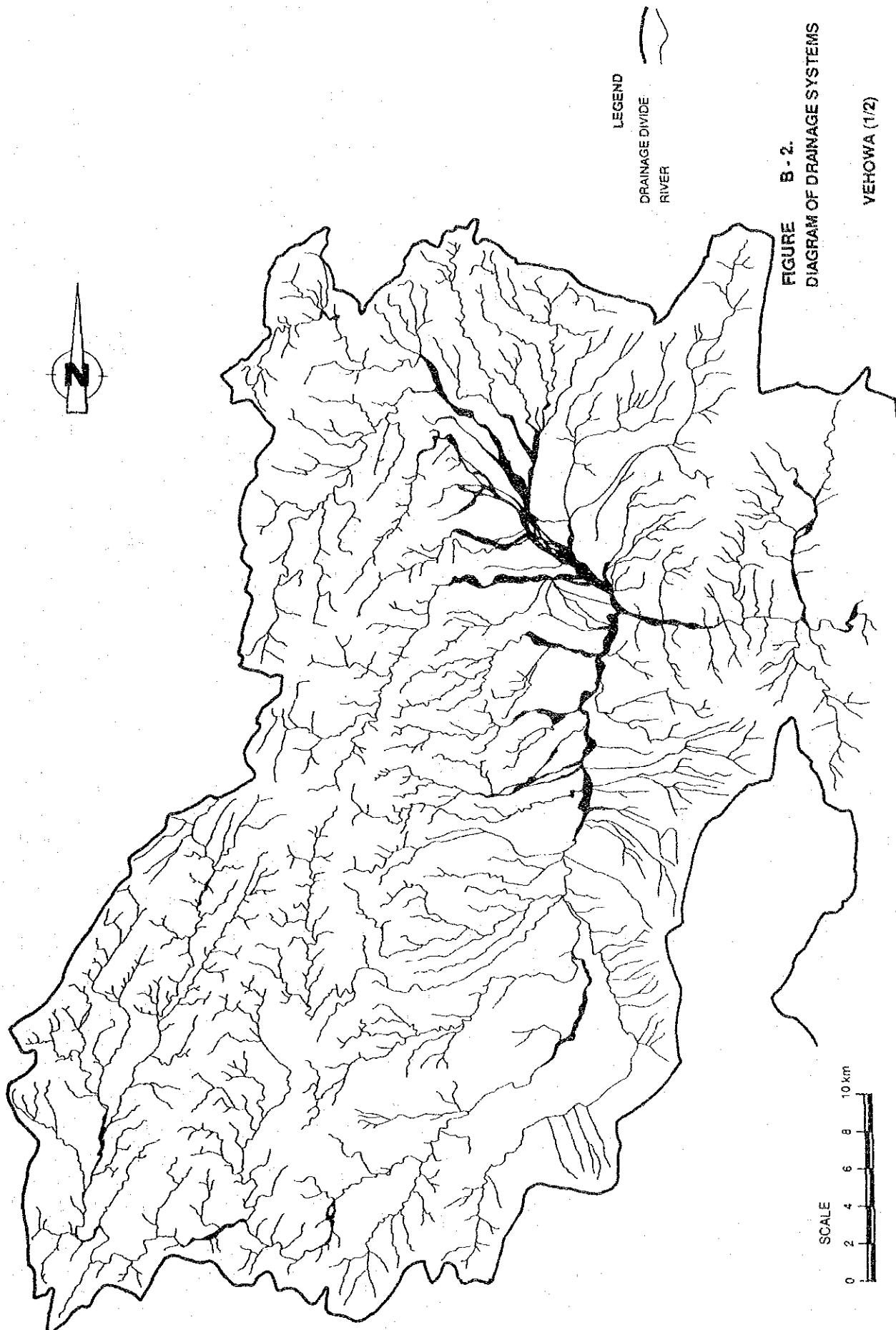
RIVER

FIGURE B-1. DIAGRAM OF DRAINAGE SYSTEMS

SCALE



KAURA



LEGEND
DRAINAGE DIVIDE
RIVER

FIGURE B - 2.
DIAGRAM OF DRAINAGE SYSTEMS
VEHOWA (1/2)

SCALE
0 2 4 6 8 10 km

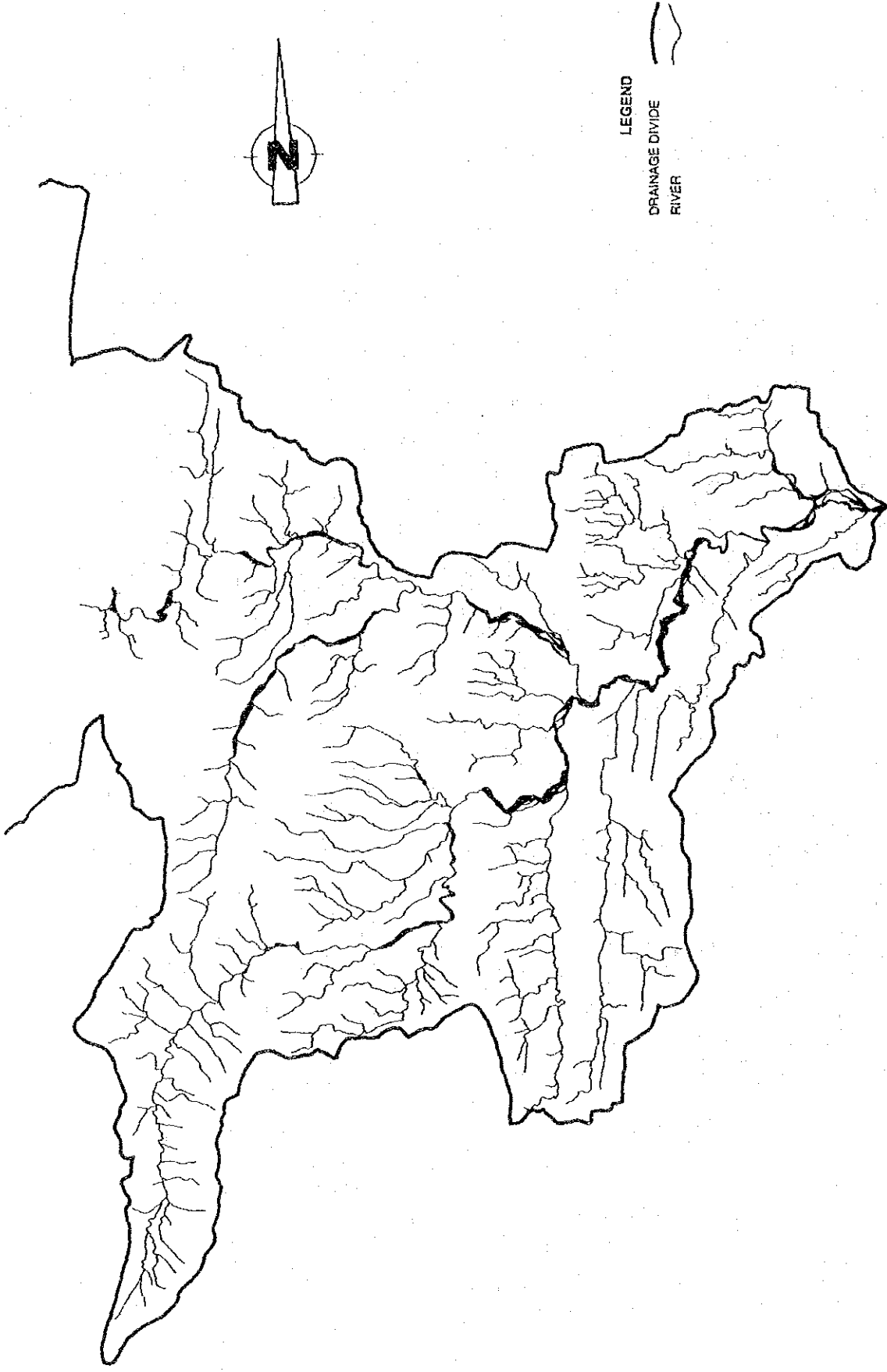


FIGURE B - 2. DIAGRAM OF DRAINAGE SYSTEMS

VEHOWA (2/2)

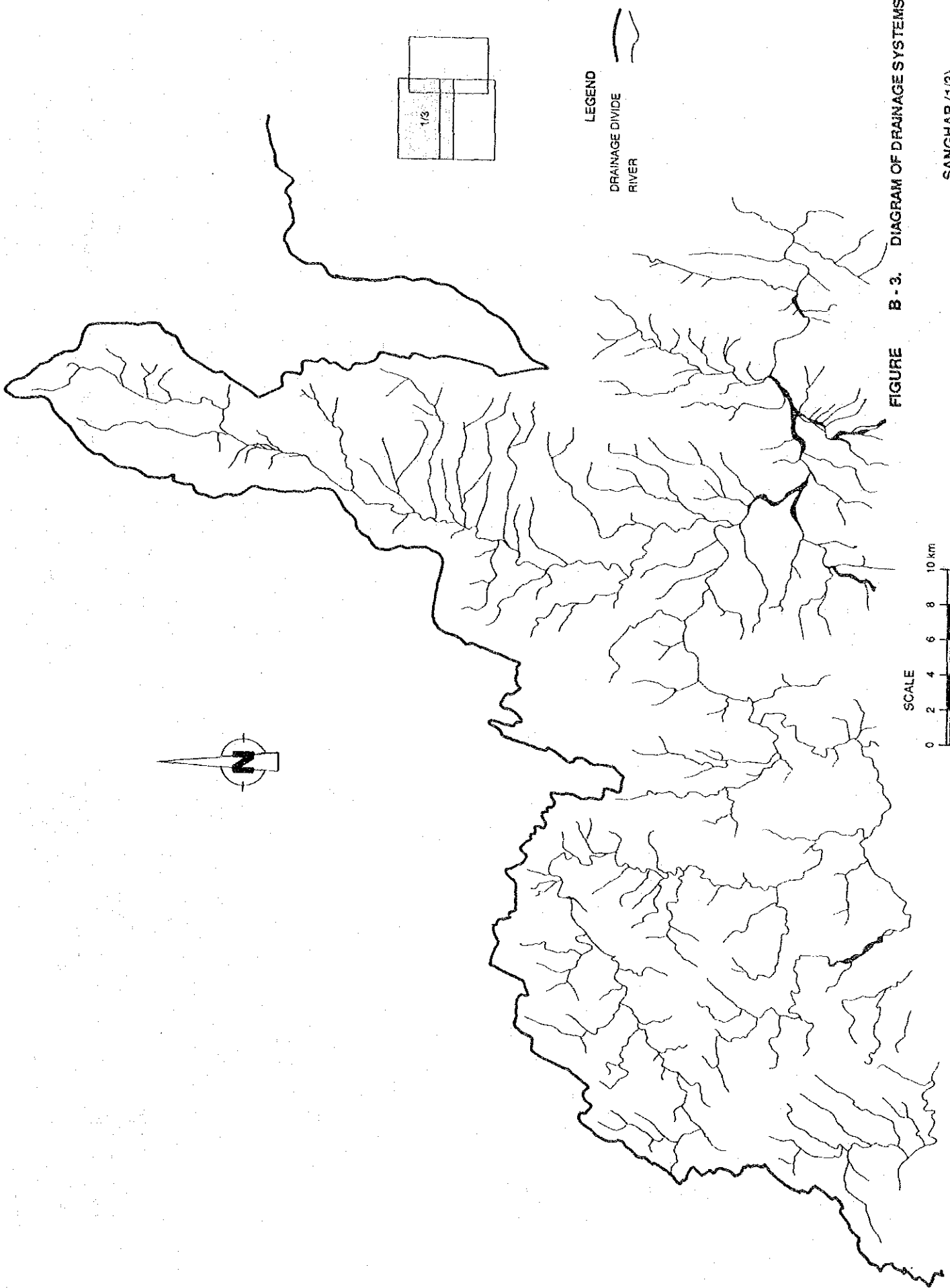


FIGURE B - 3. DIAGRAM OF DRAINAGE SYSTEMS

SANGHAR (1/3)

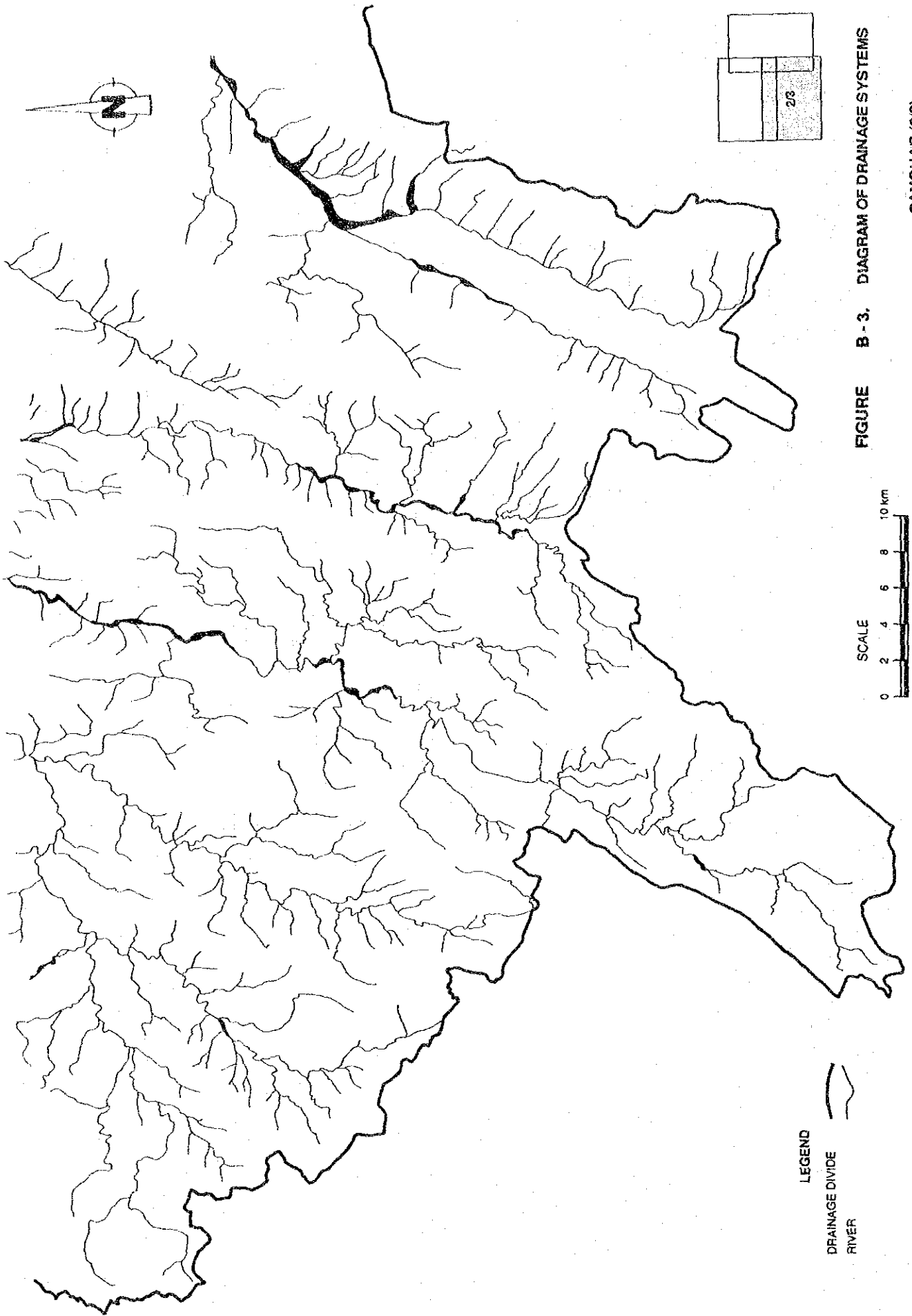


FIGURE B - 3. DIAGRAM OF DRAINAGE SYSTEMS

SANGHAR (2/3)

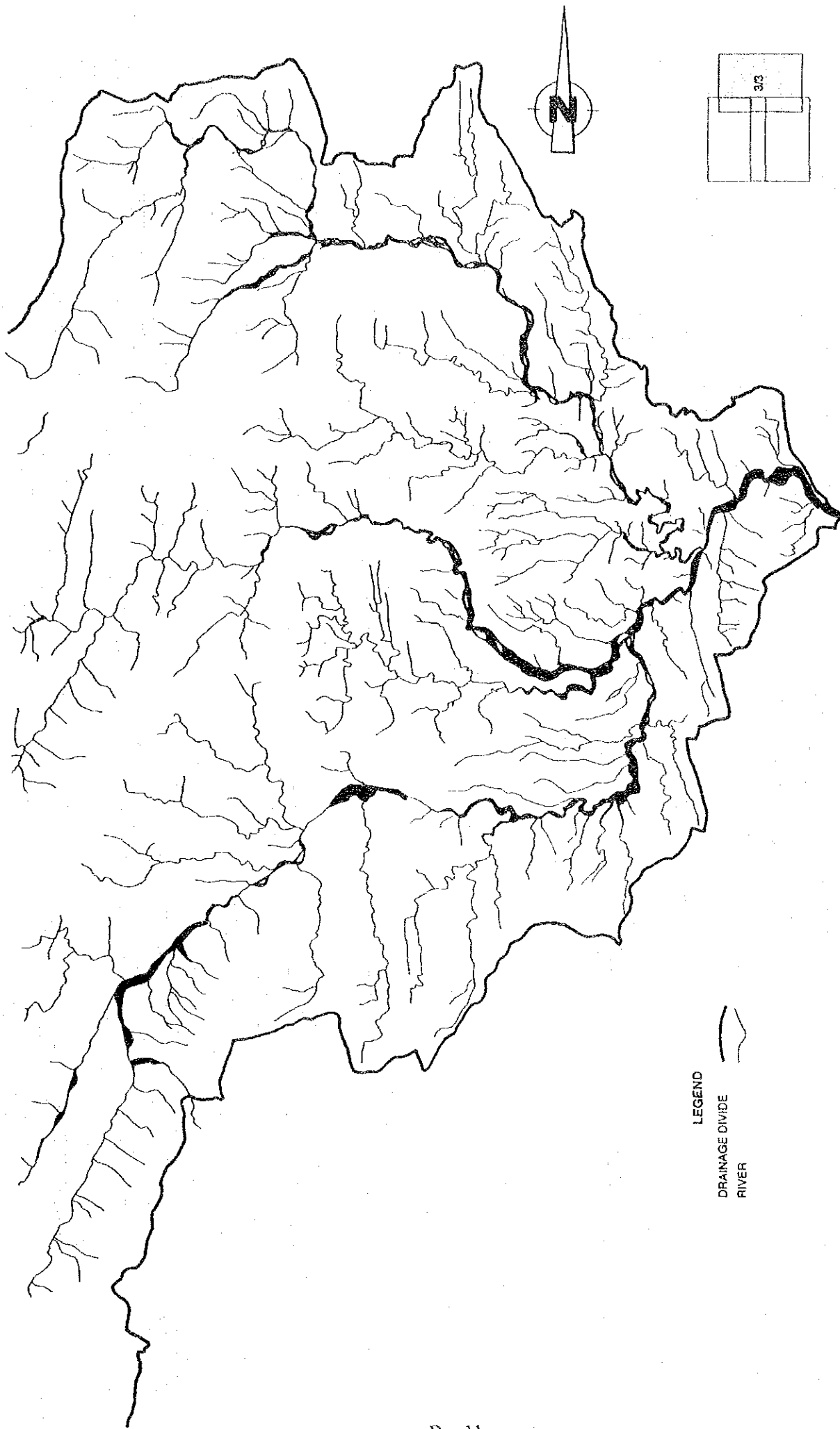


FIGURE B-3. DIAGRAM OF DRAINAGE SYSTEMS

SANGHAR (3/3)

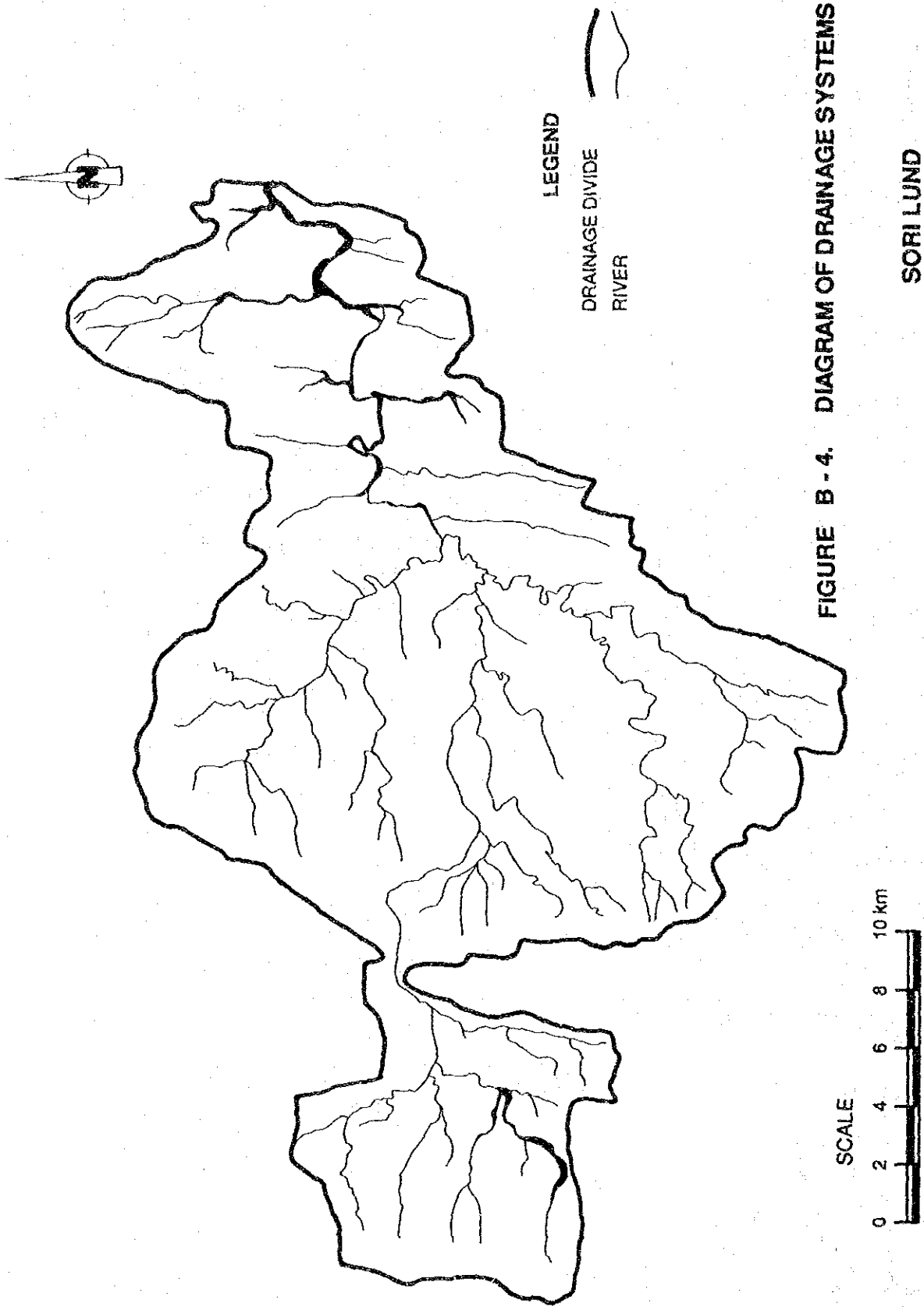
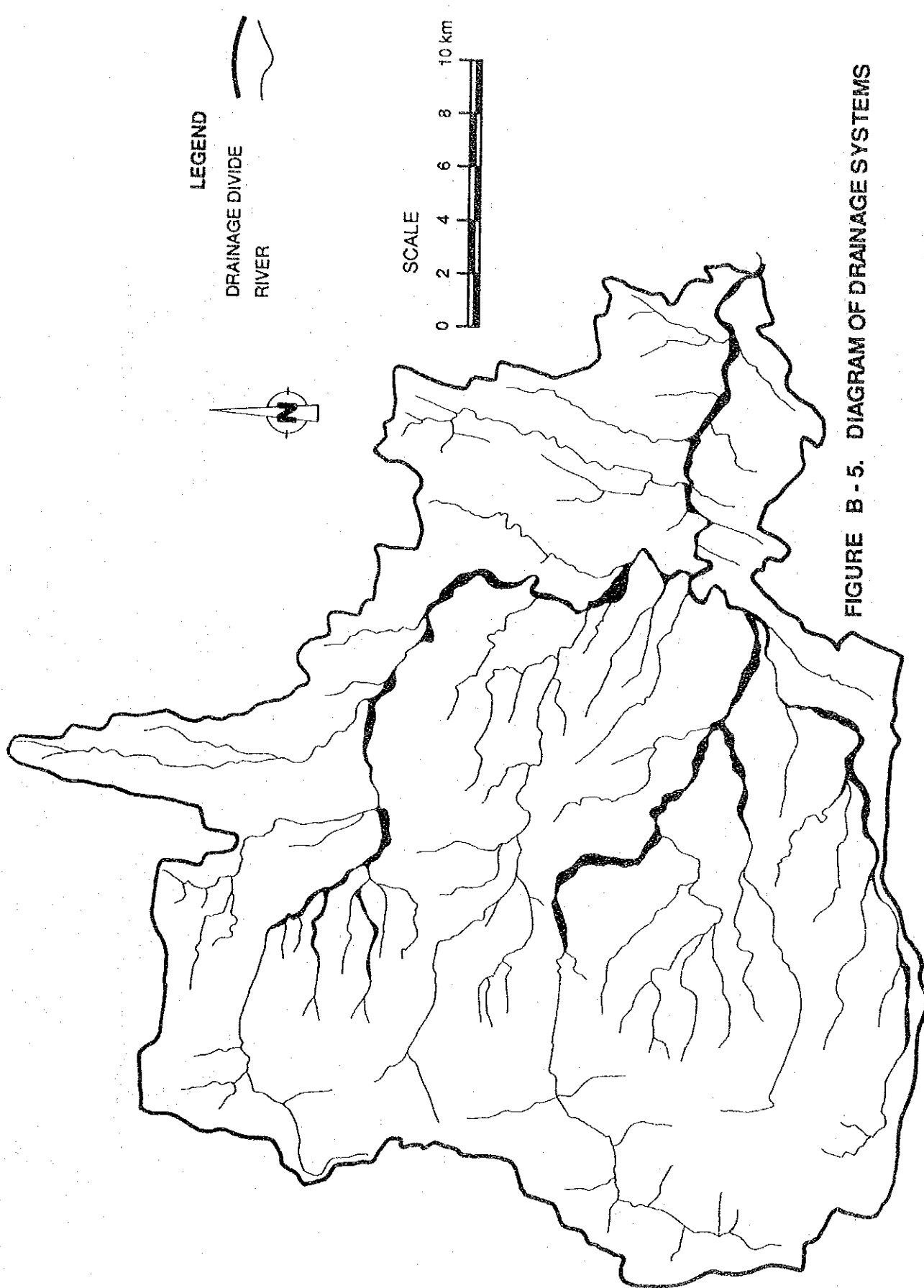


FIGURE B - 4. DIAGRAM OF DRAINAGE SYSTEMS

SORI LUND

SCALE





LEGEND

DRAINAGE DIVIDE

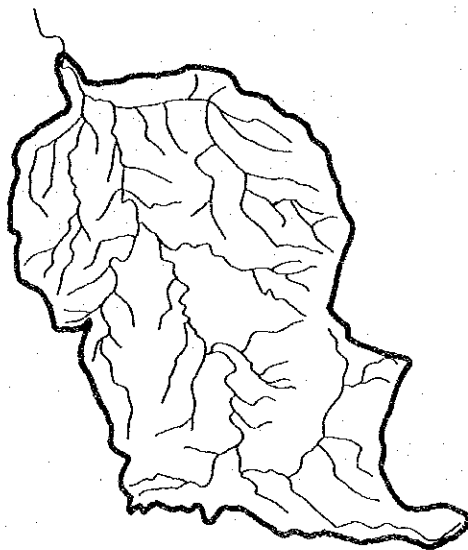
RIVER

SCALE

10 km

FIGURE B - 5. DIAGRAM OF DRAINAGE SYSTEMS

VIDOR



LEGEND

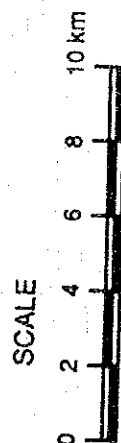
DRAINAGE DIVIDE

RIVER



FIGURE B - 6. DIAGRAM OF DRAINAGE SYSTEMS

SAKI SARWAR



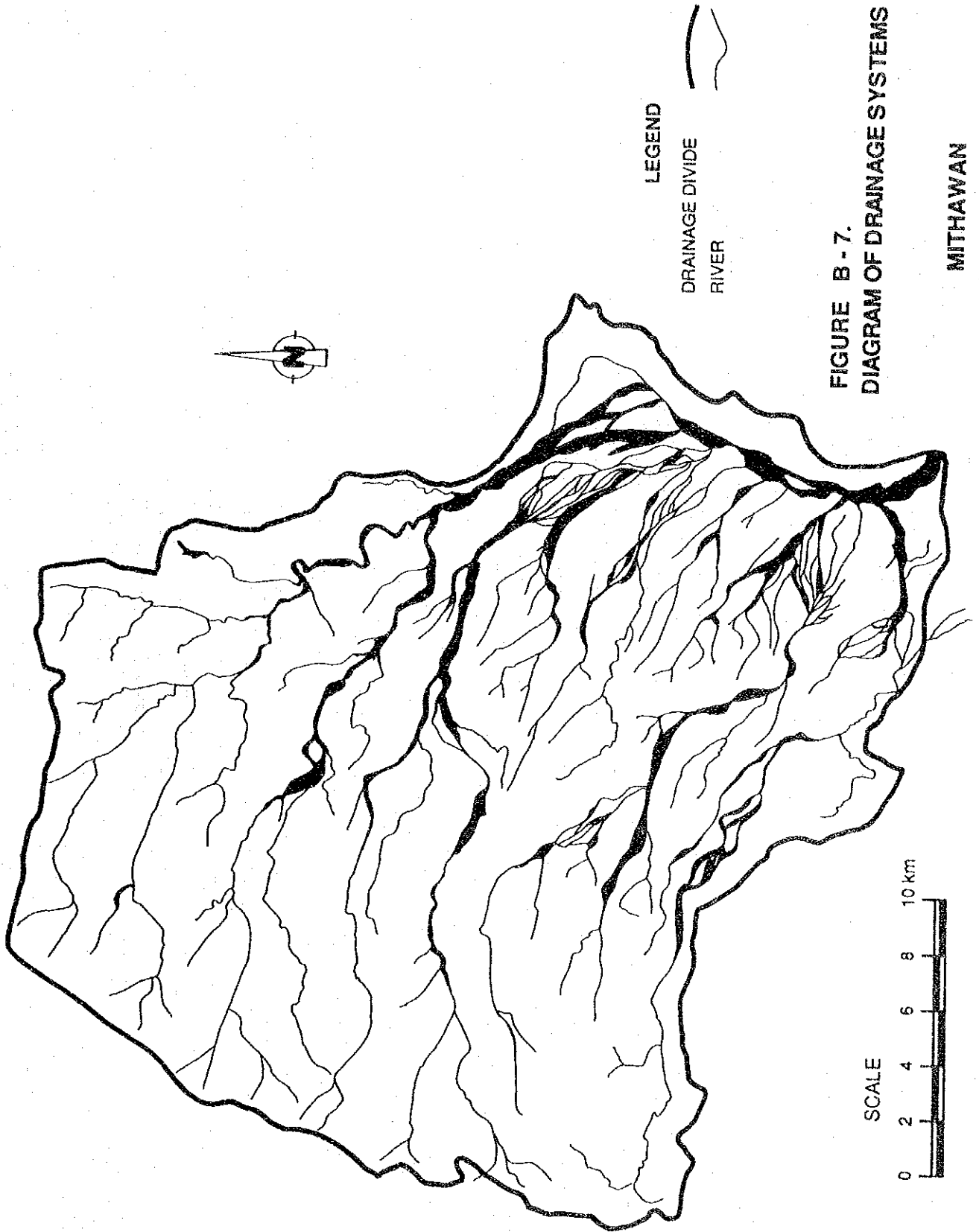


FIGURE B - 7.
DIAGRAM OF DRAINAGE SYSTEMS

MITHAWAN

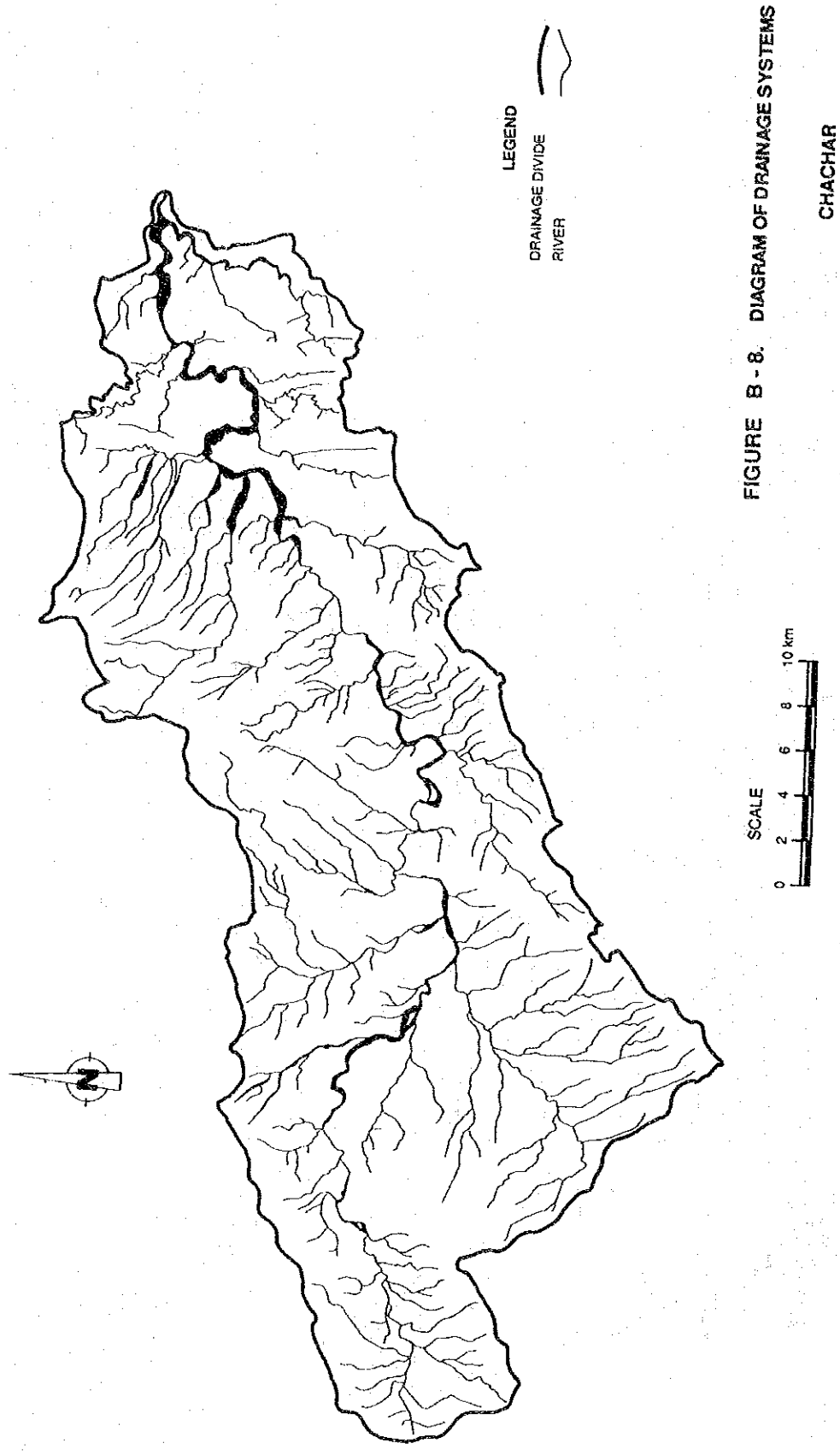


FIGURE B - 8. DIAGRAM OF DRAINAGE SYSTEMS

CHACHAR

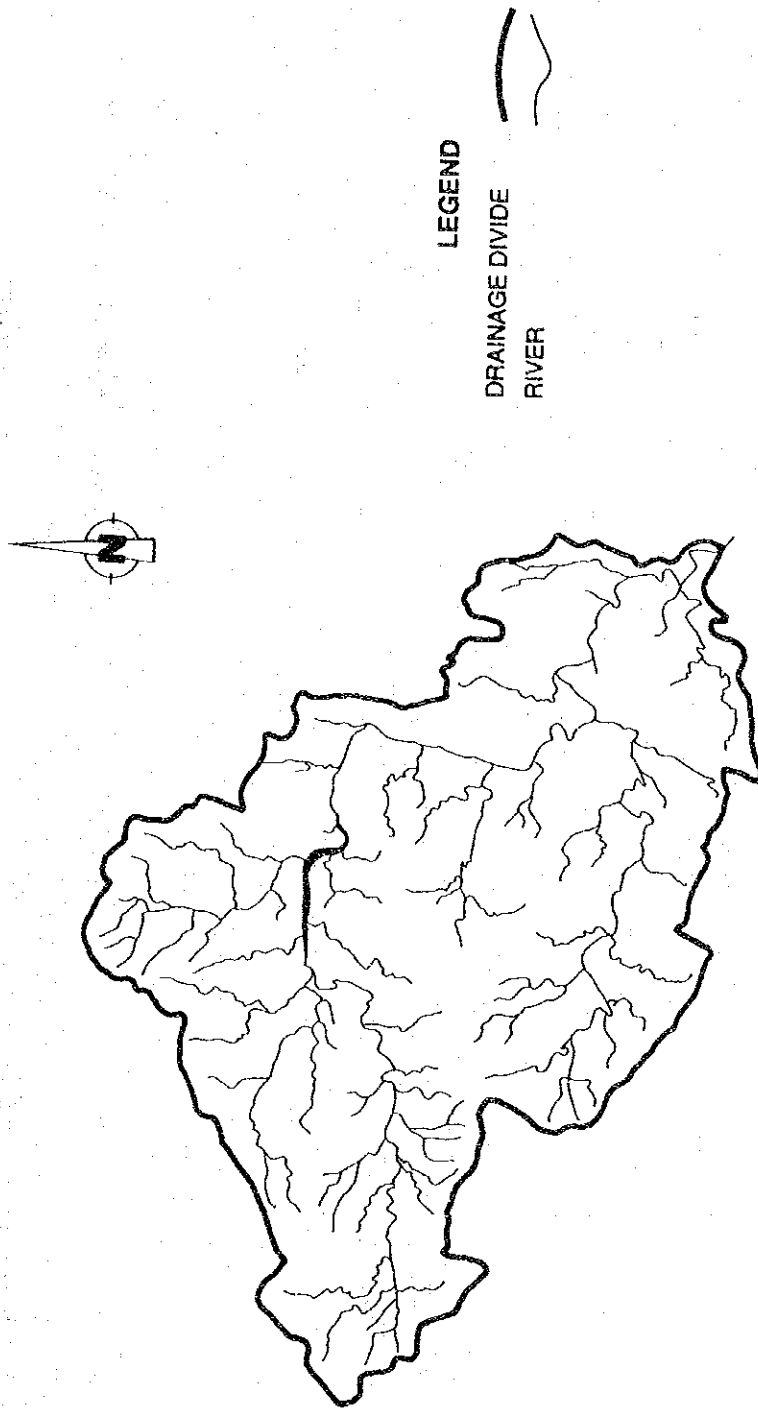


FIGURE B - 9. DIAGRAM OF DRAINAGE SYSTEMS

PITOK



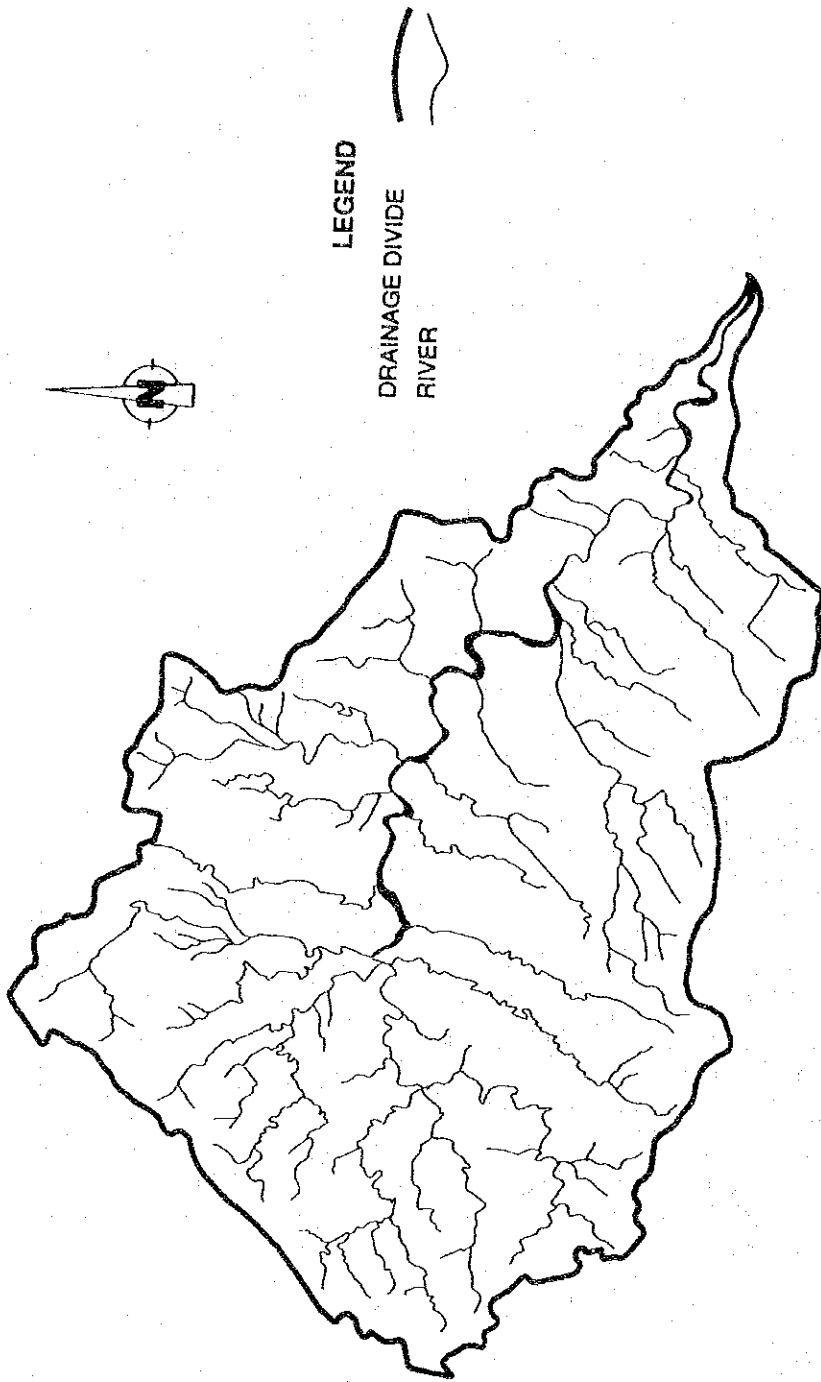
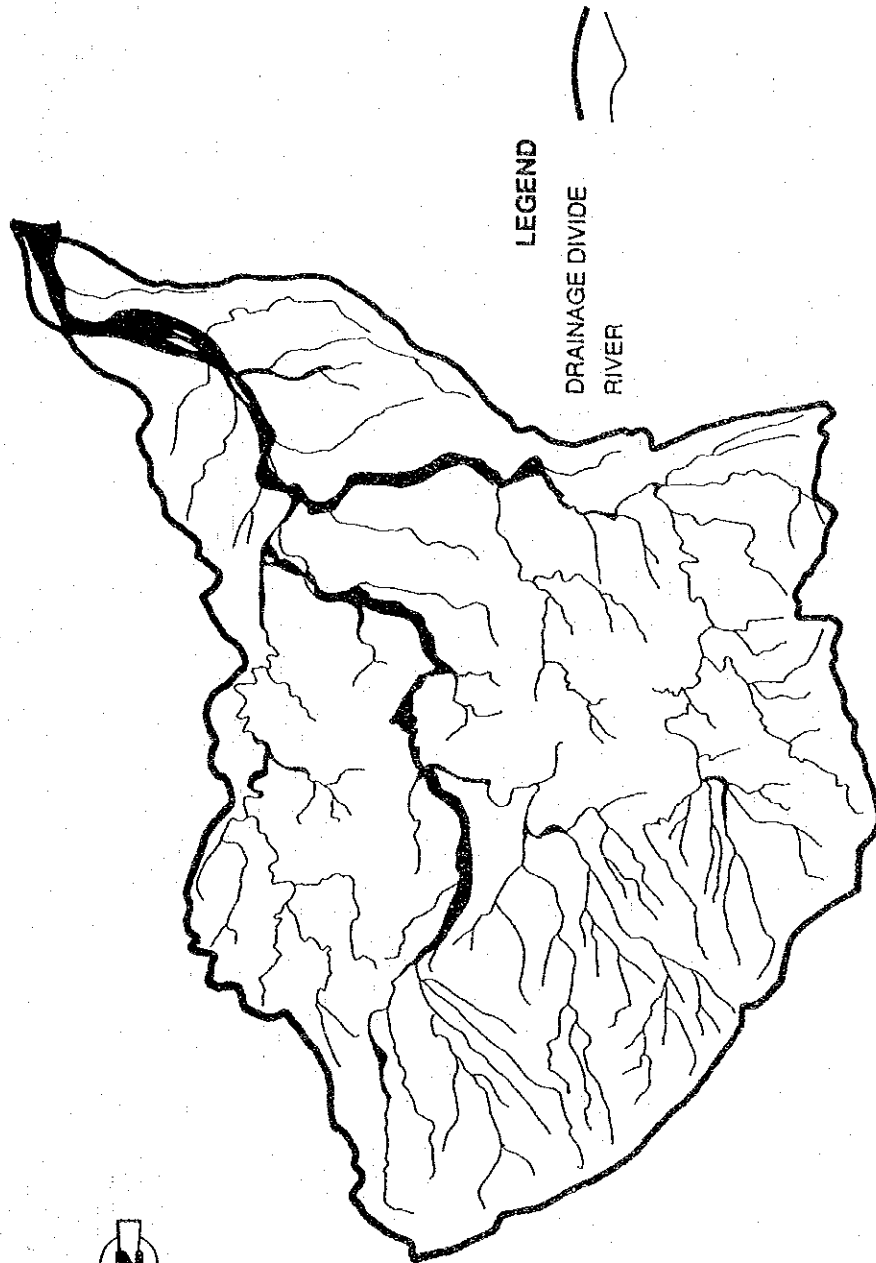


FIGURE B - 10. DIAGRAM OF DRAINAGE SYSTEMS

SORI SHUMALI



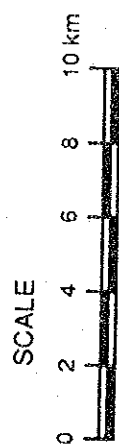
LEGEND

DRAINAGE DIVIDE

RIVER

FIGURE B - 11. DIAGRAM OF DRAINAGE SYSTEMS

ZANGI



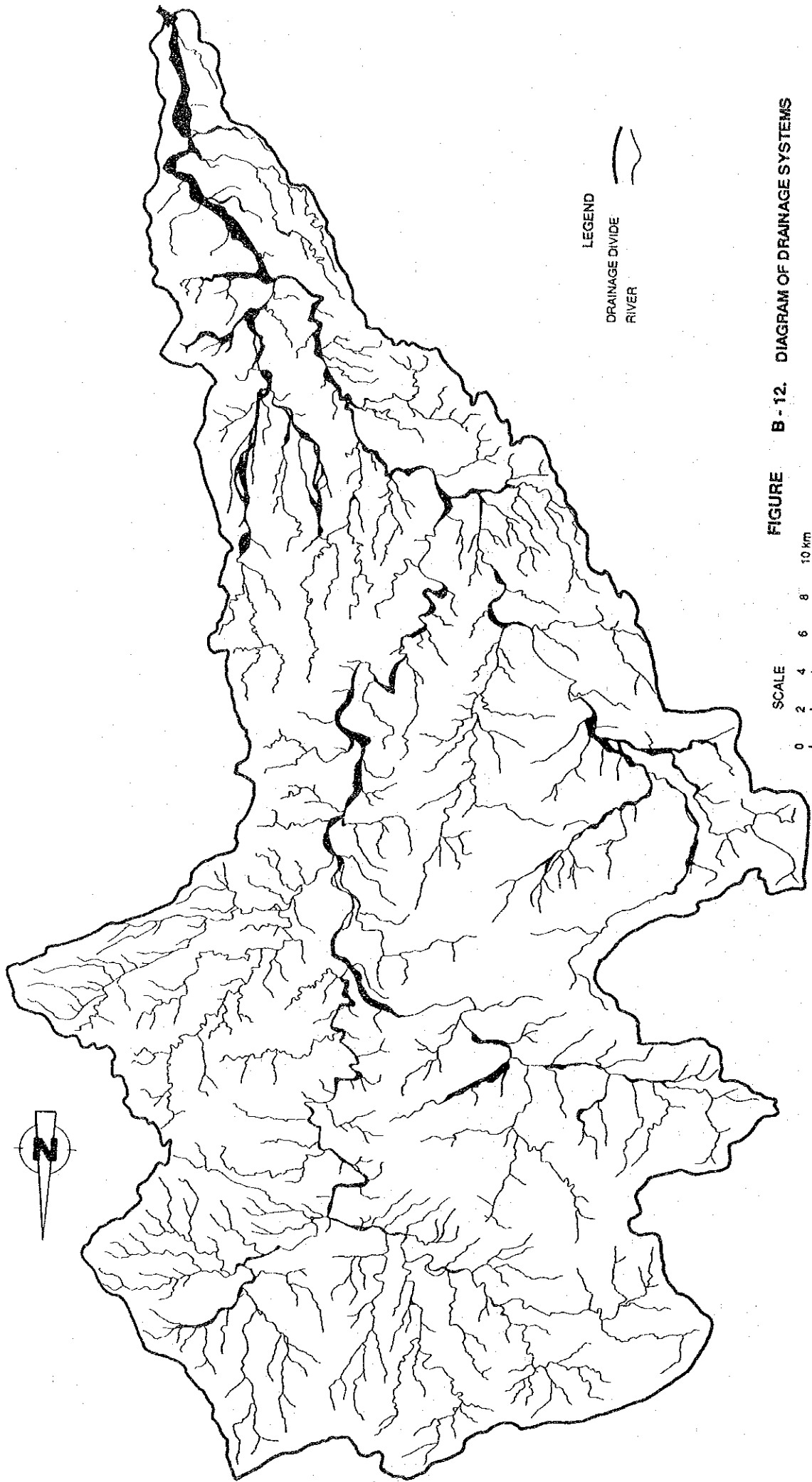


FIGURE B - 12. DIAGRAM OF DRAINAGE SYSTEMS

SORI JANUBI

ANNEX C. SOIL / LAND USE

LIST OF FIGURES

| | <u>Page</u> |
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| Figure C - 1. Land Capability Map (Kaura Hill Torrent) | C - 2 |
| Figure C - 2. Land Capability Map (Vehowa Hill Torrent) | C - 3 |
| Figure C - 3. Land Capability Map (Sanghar Hill Torrent) | C - 4 |
| Figure C - 4. Land Capability Map (Sori Lund Hill Torrent) | C - 5 |
| Figure C - 5. Land Capability Map (Vidore Hill Torrent) | C - 6 |
| Figure C - 6. Land Capability Map (Sakhi Sarwar Hill Torrent) | C - 7 |
| Figure C - 7. Land Capability Map (Mithawan Hill Torrent) | C - 8 |
| Figure C - 8. Land Capability Map (Chachar Hill Torrent) | C - 9 |
| Figure C - 9. Land Capability Map (Pitok Hill Torrent) | C - 10 |
| Figure C - 10. Land Capability Map (Sori Shumali Hill Torrent) | C - 11 |
| Figure C - 11. Land Capability Map (Zangi Hill Torrent) | C - 12 |
| Figure C - 12. Land Capability Map (Sori Janubi Hill Torrent) | C - 13 |

ANNEX C. SOIL / LAND USE

The land of the major hill torrents was classified according to the classification of land capability. The following five classes were found in the Study Area.

1. Good agricultural land
2. Moderate agricultural land
3. Marginal agricultural land
4. Poor grazing and wood lands
5. Agriculturally unproductive land

Class 1 has the least limitation for agricultural use, and relatively little effort is required to produce high yields of a wide range of crops. The suitability decreases gradually in accordance with an increase in class number. Class 5 is recognized as agriculturally unproductive.

Land capability maps were prepared according to the classifications, and are shown in Figures C - 1 to C - 12.

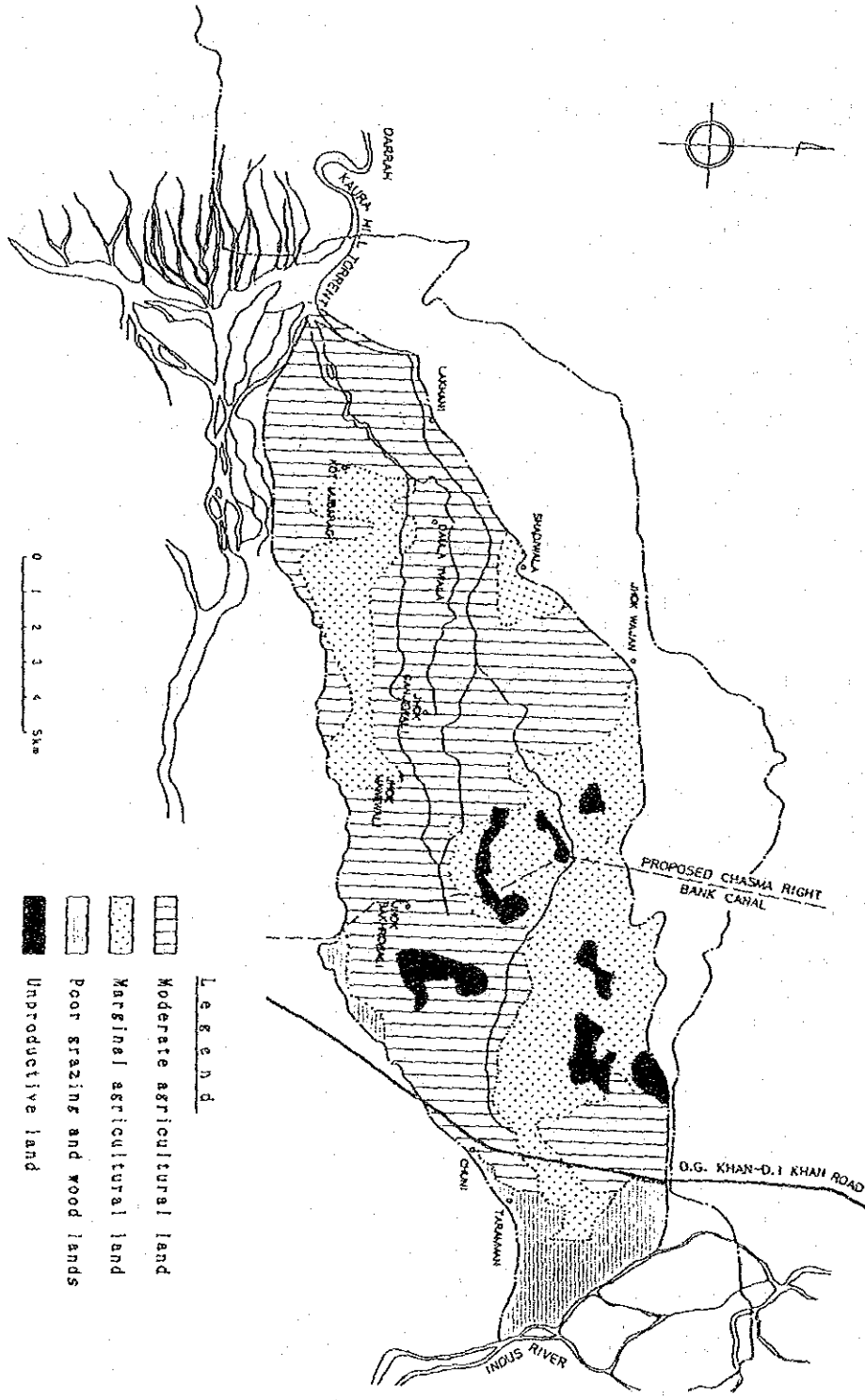


FIGURE C-1. LAND CAPABILITY MAP (KAURA HILL TORRENT)

ISLAMIC REPUBLIC OF PAKISTAN
 GOVERNMENT OF PUNJAB
 FEASIBILITY STUDY ON
 DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS
 OF D.G.KHAN HILL TORRENTS
 JAPAN INTERNATIONAL COOPERATION AGENCY

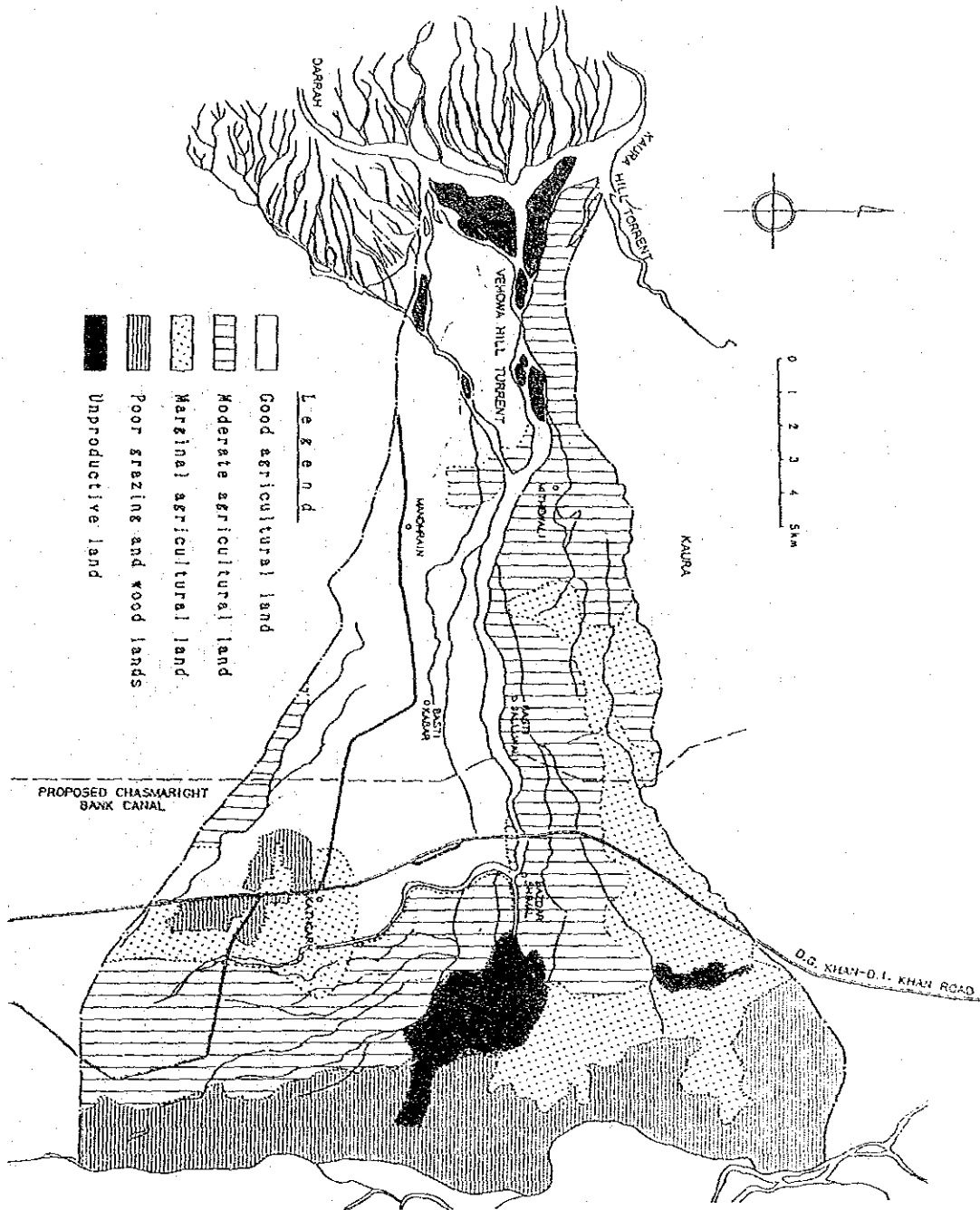


FIGURE C - 2. LAND CAPABILITY MAP (VEHOWA HILL TORRENT)

ISLAMIC REPUBLIC OF PAKISTAN
 GOVERNMENT OF PUNJAB
 FEASIBILITY STUDY ON
 DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS
 OF D.G.KHAN HILL TORRENTS
 JAPAN INTERNATIONAL COOPERATION AGENCY

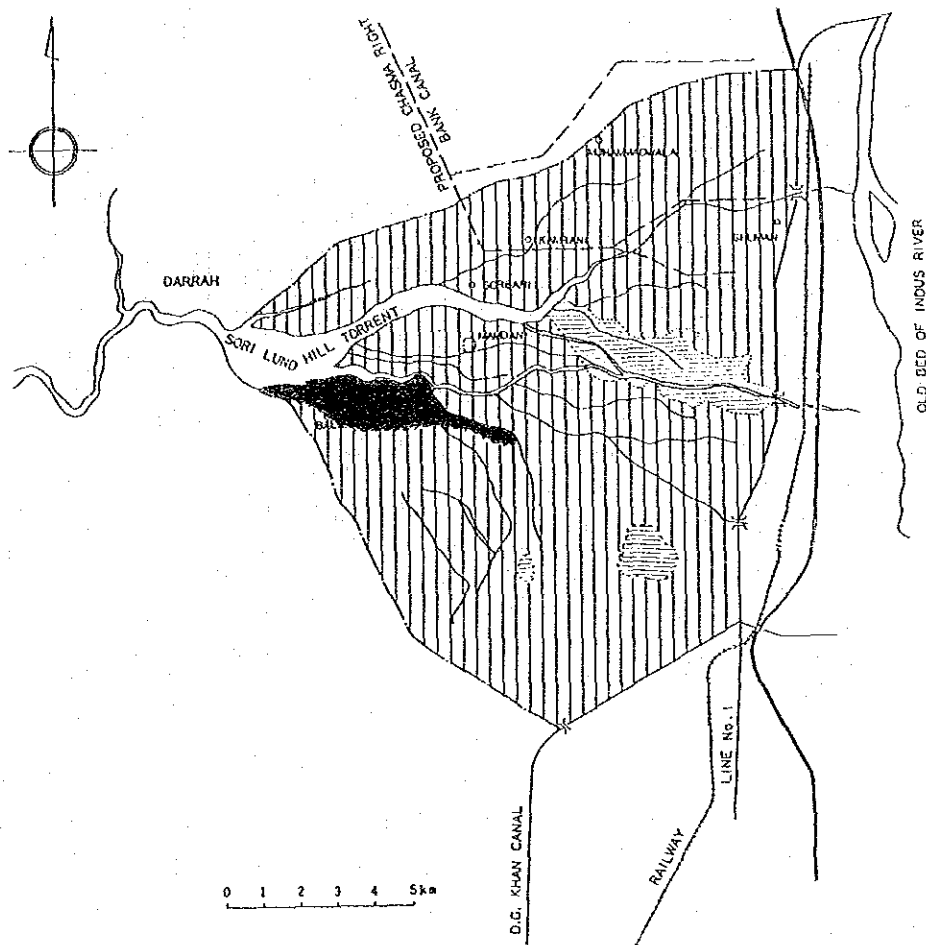


Legend

- Good agricultural land
- Poor grazing and wood lands
- Unproductive land

FIGURE C-3. LAND CAPABILITY MAP (SANGHAR HILL TORRENT)

| |
|---|
| ISLAMIC REPUBLIC OF PAKISTAN GOVERNMENT OF PUNJAB |
| FEASIBILITY STUDY ON DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS OF D.G.KHAN HILL TORRENTS |
| JAPAN INTERNATIONAL COOPERATION AGENCY |



Legend




-  Moderate agricultural land
-  Poor grazing and wood lands
-  Unproductive land

FIGURE C-4. LAND CAPABILITY MAP (SORI LUND HILL TORRENT)

| |
|---|
| ISLAMIC REPUBLIC OF PAKISTAN GOVERNMENT OF PUNJAB |
| FEASIBILITY STUDY ON DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS OF D.G.KHAN HILL TORRENTS |
| JAPAN INTERNATIONAL COOPERATION AGENCY |

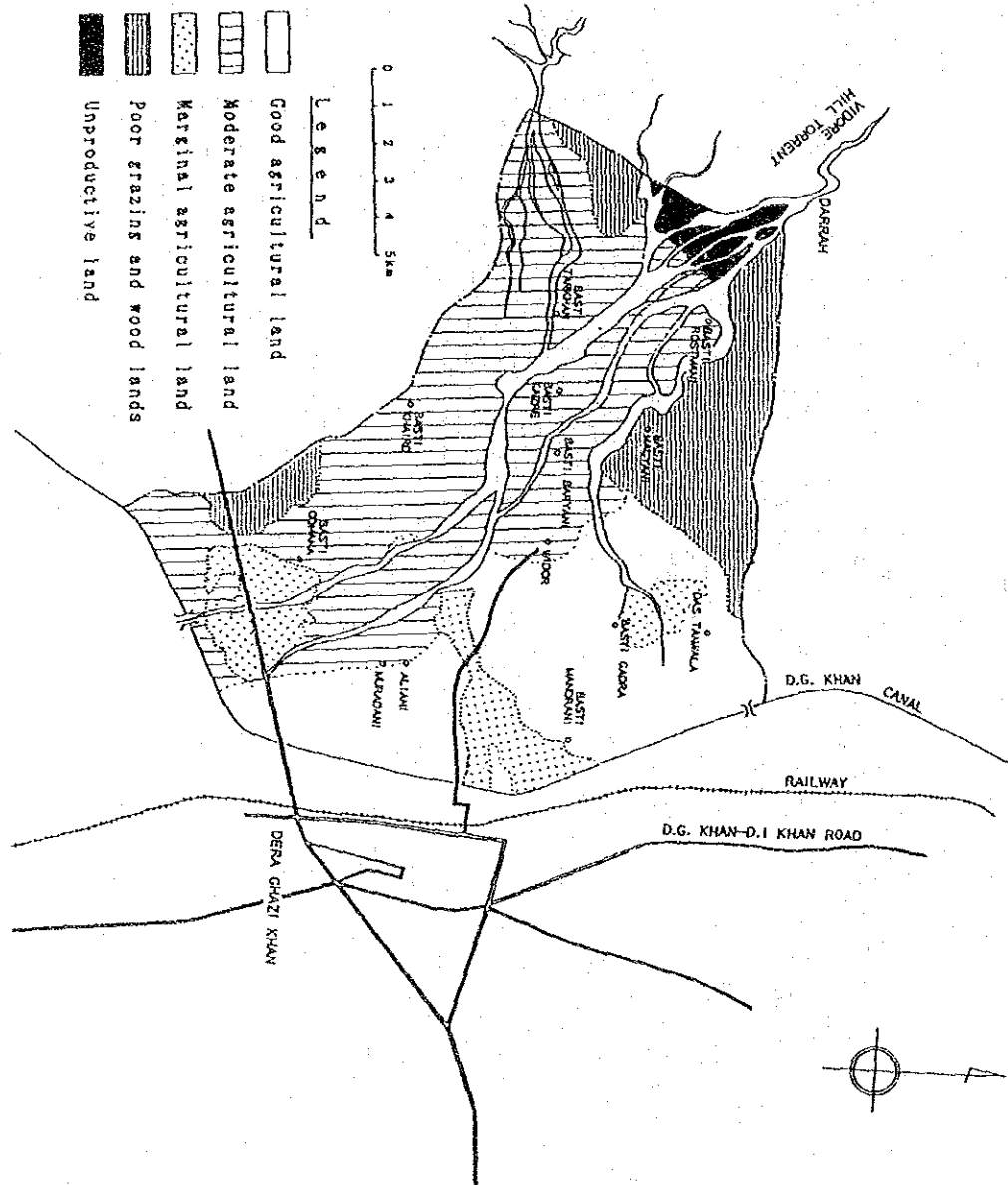


FIGURE C - 5. LAND CAPABILITY MAP (VIDORE HILL TORRENT)

| |
|---|
| ISLAMIC REPUBLIC OF PAKISTAN GOVERNMENT OF PUNJAB |
| FEASIBILITY STUDY ON DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS OF D.G.KHAN HILL TORRENTS |
| JAPAN INTERNATIONAL COOPERATION AGENCY |

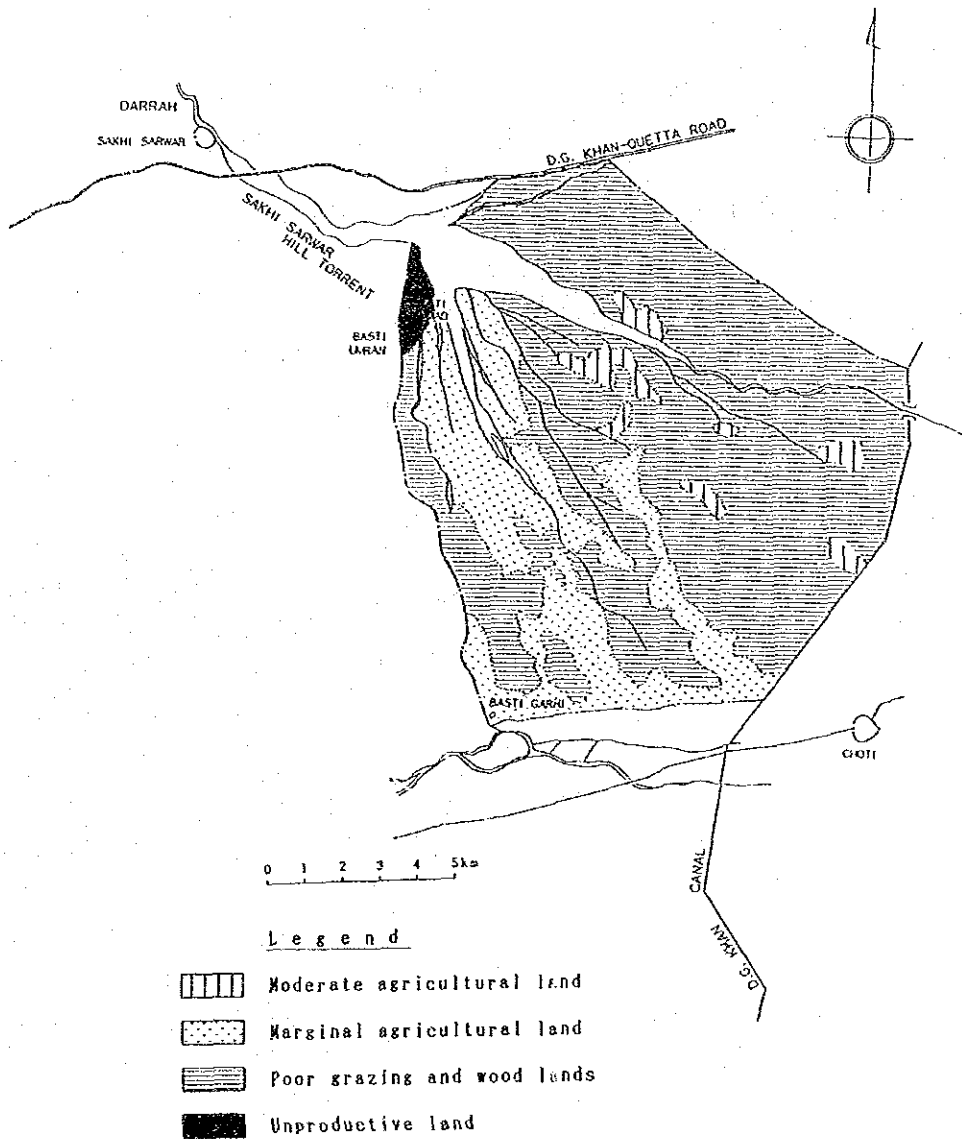
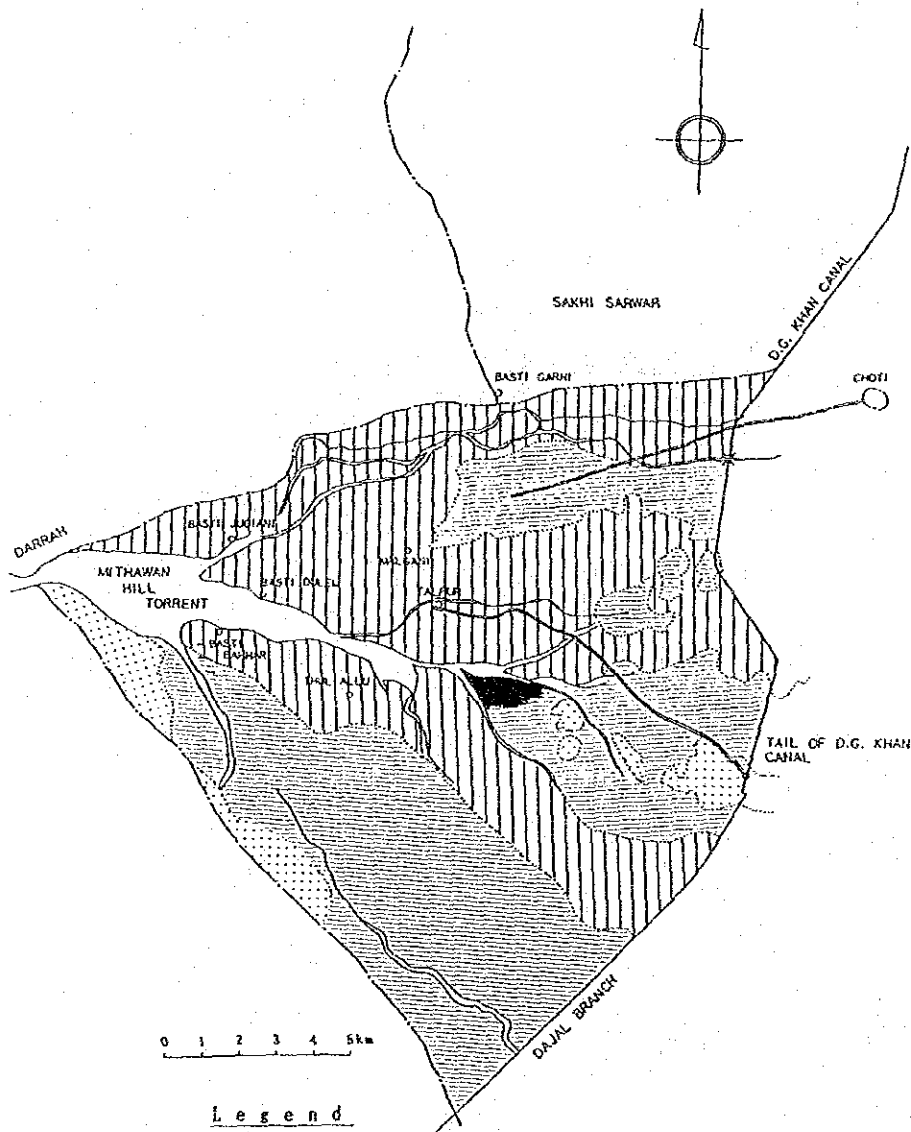


FIGURE C-6. LAND CAPABILITY MAP
(SAKHI SARWAR HILL TORRENT)

| |
|---|
| ISLAMIC REPUBLIC OF PAKISTAN GOVERNMENT OF PUNJAB |
| FEASIBILITY STUDY ON DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS OF D.G.KHAN HILL TORRENTS |
| JAPAN INTERNATIONAL COOPERATION AGENCY |



Legend





-  Moderate agricultural land
-  Marginal agricultural land
-  Poor grazing and wood lands
-  Unproductive land

FIGURE C-7. LAND CAPABILITY MAP (MITHAWAN HILL TORRENT)

| |
|---|
| ISLAMIC REPUBLIC OF PAKISTAN GOVERNMENT OF PUNJAB |
| FEASIBILITY STUDY ON DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS OF D.G.KHAN HILL TORRENTS |
| JAPAN INTERNATIONAL COOPERATION AGENCY |

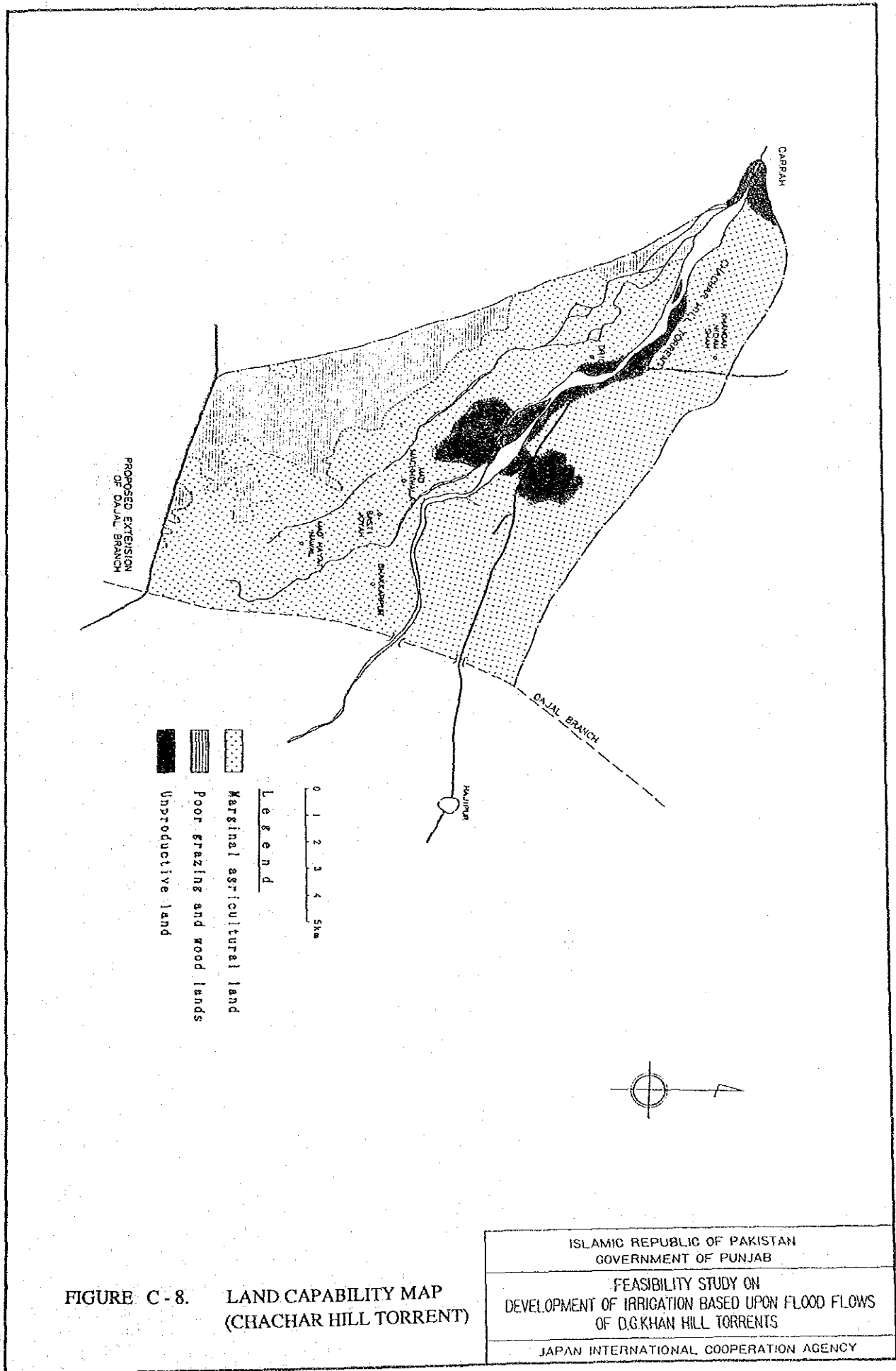


FIGURE C - 8. LAND CAPABILITY MAP (CHACHAR HILL TORRENT)

ISLAMIC REPUBLIC OF PAKISTAN
 GOVERNMENT OF PUNJAB
 FEASIBILITY STUDY ON
 DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS
 OF D.G.KHAN HILL TORRENTS
 JAPAN INTERNATIONAL COOPERATION AGENCY

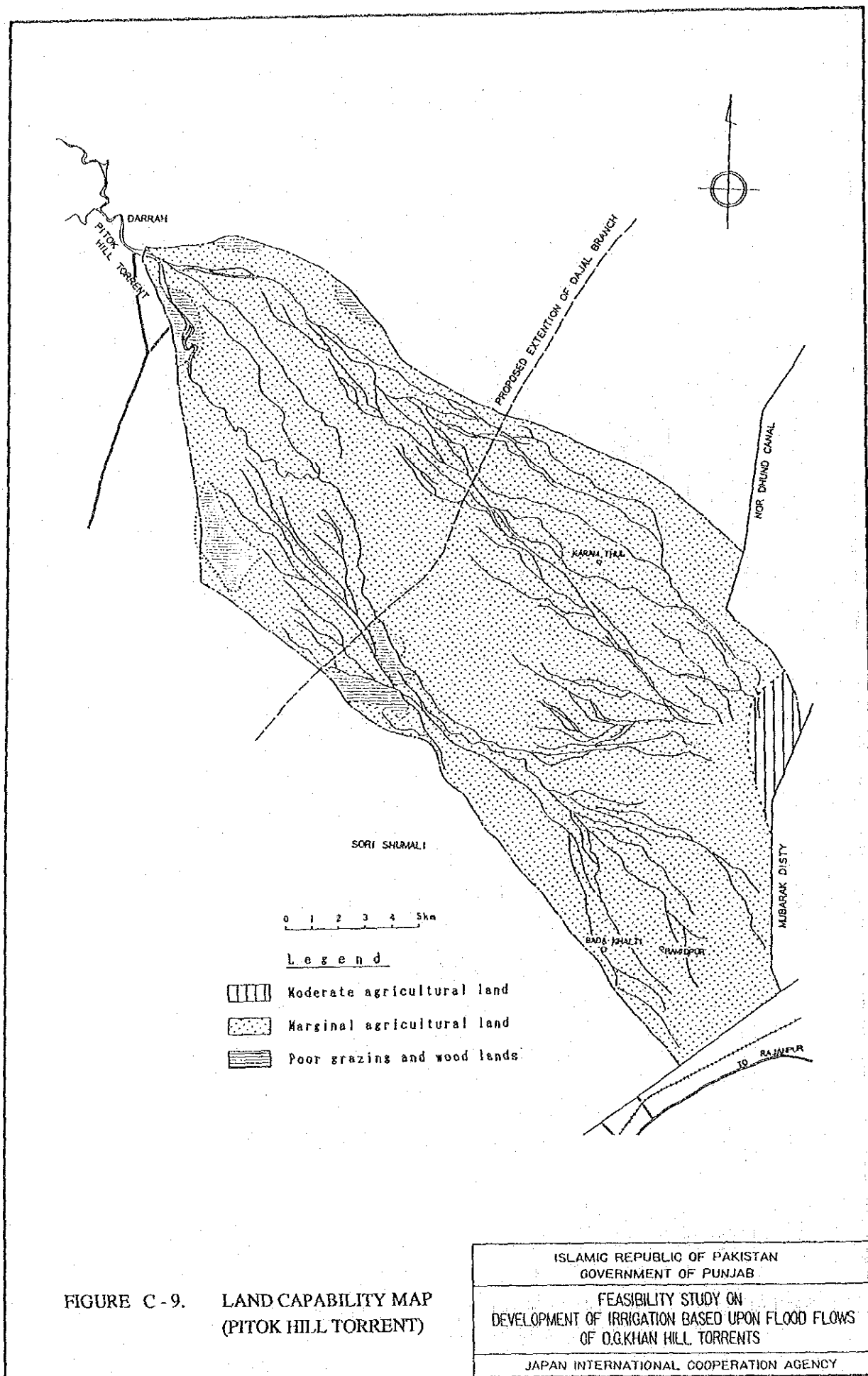


FIGURE C-9. LAND CAPABILITY MAP (PITOK HILL TORRENT)

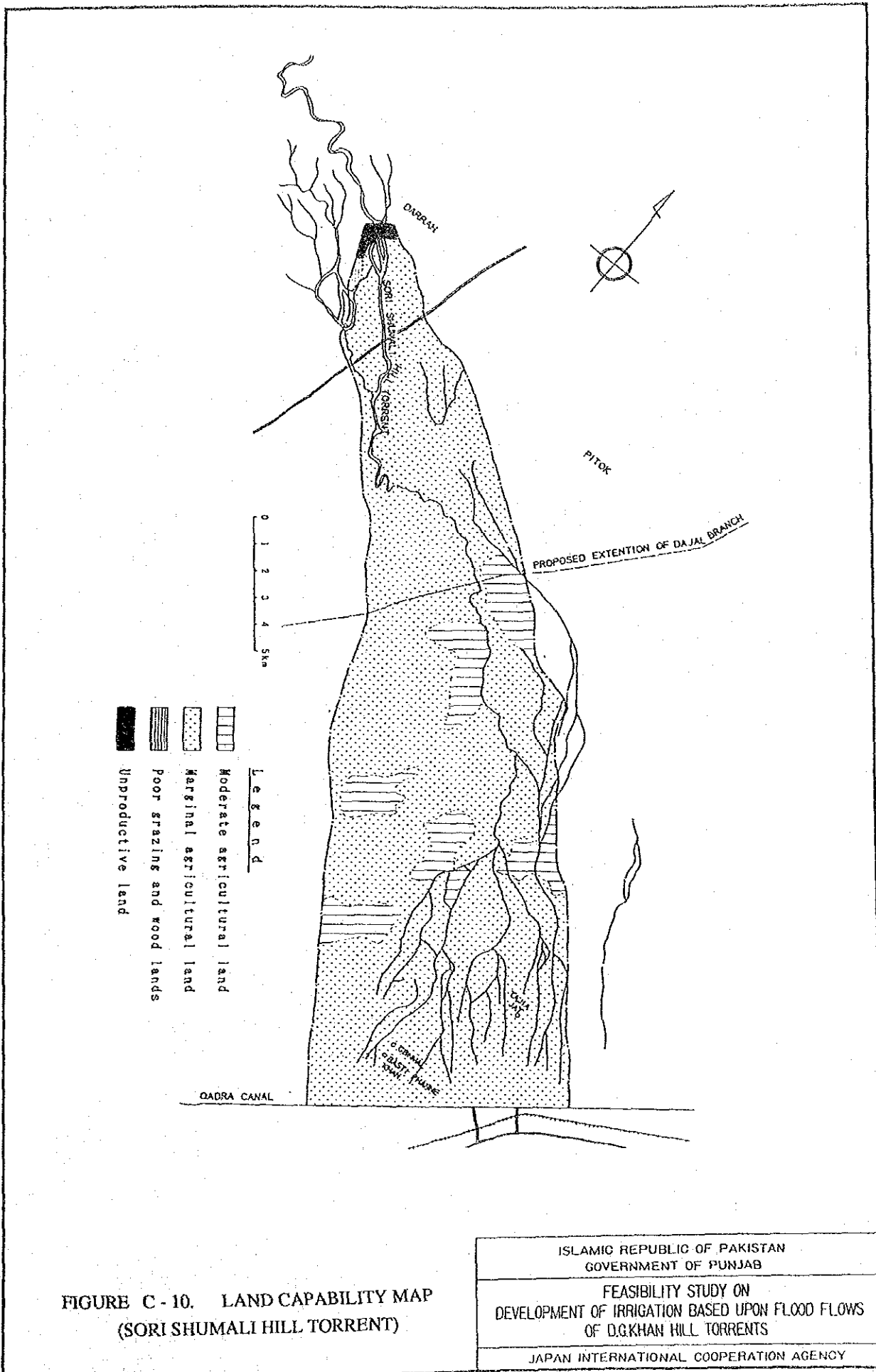
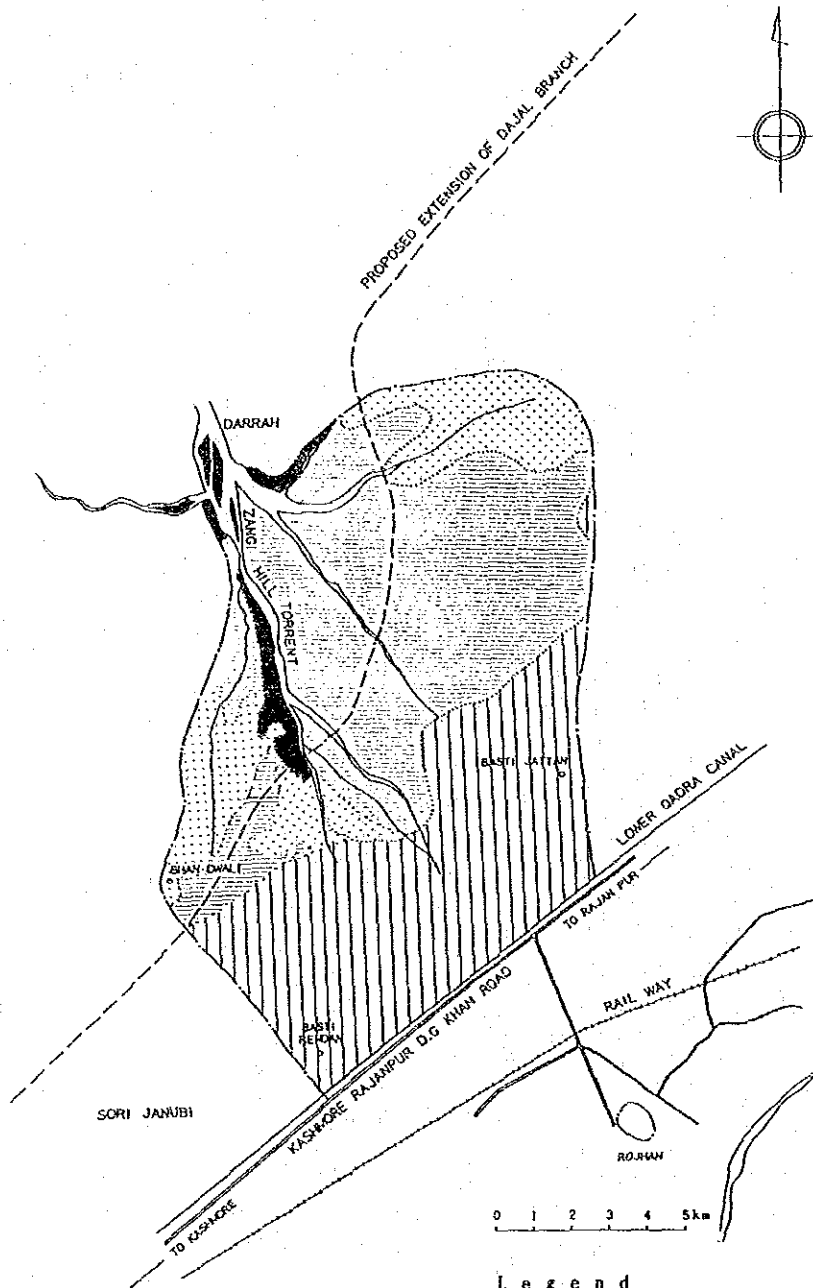


FIGURE C - 10. LAND CAPABILITY MAP
(SORI SHUMALI HILL TORRENT)

ISLAMIC REPUBLIC OF PAKISTAN
GOVERNMENT OF PUNJAB

FEASIBILITY STUDY ON
DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS
OF D.G.KHAN HILL TORRENTS

JAPAN INTERNATIONAL COOPERATION AGENCY







- Legend**
-  Moderate agricultural land
 -  Marginal agricultural land
 -  Poor grazing and wood lands
 -  Unproductive land

FIGURE C - 11. LAND CAPABILITY MAP (ZANGI HILL TORRENT)

ISLAMIC REPUBLIC OF PAKISTAN
 GOVERNMENT OF PUNJAB
 FEASIBILITY STUDY ON
 DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS
 OF D.G.KHAN HILL TORRENTS
 JAPAN INTERNATIONAL COOPERATION AGENCY

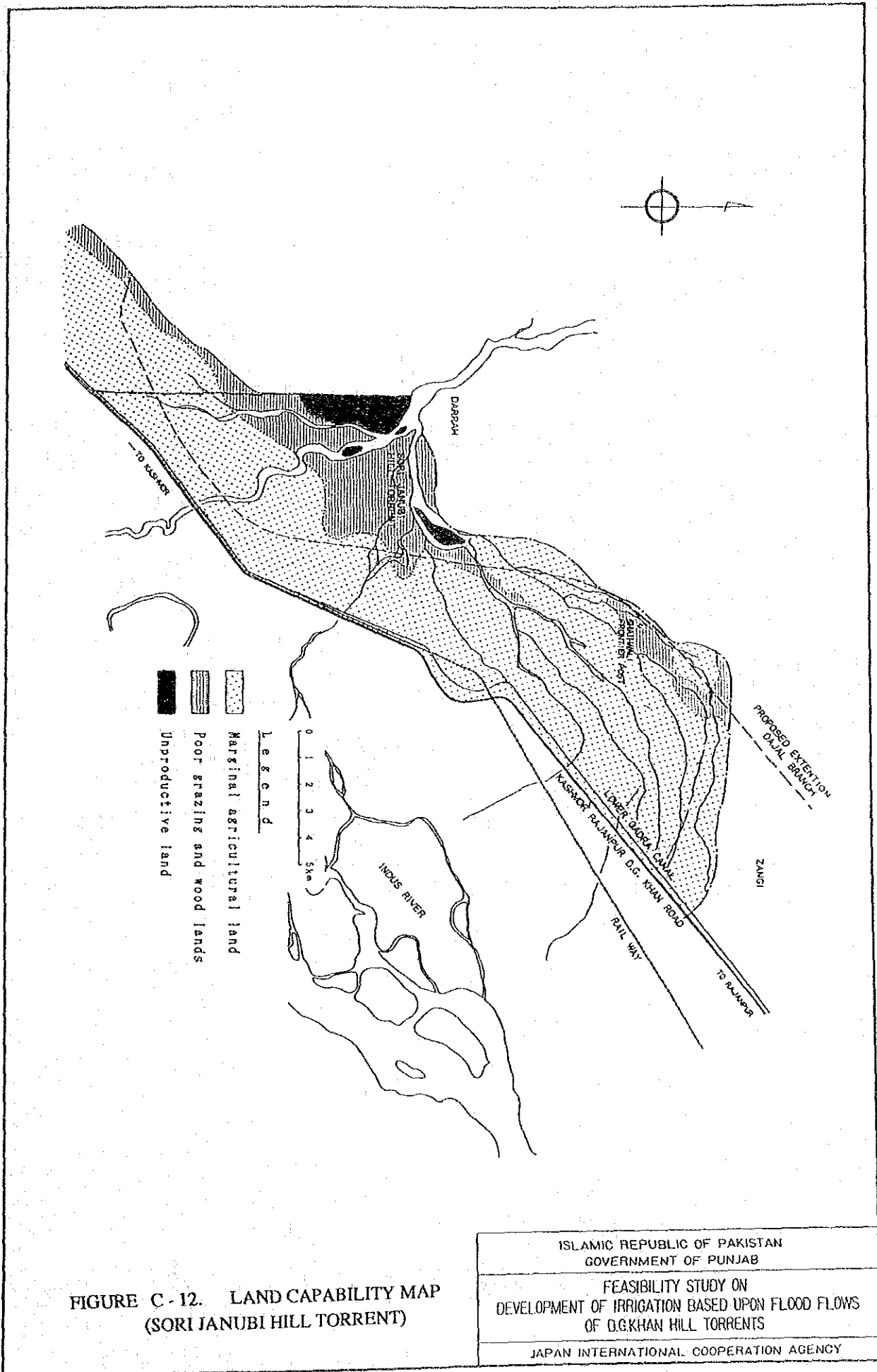


FIGURE C-12. LAND CAPABILITY MAP (SORI JANUBI HILL TORRENT)

| |
|---|
| ISLAMIC REPUBLIC OF PAKISTAN GOVERNMENT OF PUNJAB |
| FEASIBILITY STUDY ON DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS OF D.G.KHAN HILL TORRENTS |
| JAPAN INTERNATIONAL COOPERATION AGENCY |

ANNEX D. SOCIO ECONOMY

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| Table D - 2. Principal Cities in Pakistan; 1981 | D - 1 |
| Table D - 3. Development Plan Outlays in the Public Sector | D - 1 |
| Table D - 4. Export Composition | D - 2 |
| Table D - 5. Population and Labor Force in Pakistan | D - 2 |
| Table D - 6. Total Loans and Credits Contracted by Source | D - 2 |
| Table D - 7. Selected Population Statistics of Communities in the Study Area Engaged in Torrent-Watered Cultivation by Major Hill Torrent | D - 3 |

TABLE D-1. GNP PER CAPITA AND POPULATION IN FIVE SOUTH ASIAN COUNTRIES

| | GNP per capita 1989 (US\$) | GNP rank among 124 countries (1=low) | Population mid-1989 (millions) | Estimated population in 2000 (millions) | Rural population 1989 (%) | Rural population 1989 (millions) |
|---------------|-------------------------------------|---|--------------------------------------|--|------------------------------------|---|
| Bangladesh | 180 | 5 | 110.70 | 139.00 | 84.00 | 92.99 |
| India | 340 | 20 | 832.50 | 1,007.00 | 73.00 | 607.73 |
| Nepal | 180 | 8 | 18.40 | 24.00 | 91.00 | 16.74 |
| Pakistan | 370 | 24 | 109.90 | 155.00 | 68.00 | 74.73 |
| Sri Lanka | 430 | 31 | 16.80 | 19.00 | 79.00 | 13.27 |
| Total/average | N.A. | N.A. | 1088.30 | 1,344.00 | 79.00 | 859.76 |

Source: World Development Report, 1991.

TABLE D-2. PRINCIPAL CITIES IN PAKISTAN; 1981

| | Population |
|------------|------------|
| Karachi | 5,180,562 |
| Lahore | 2,952,689 |
| Faisalabad | 1,104,209 |
| Rawalpindi | 794,843 |
| Hyderabad | 751,529 |
| Multan | 722,070 |
| Gujranwala | 658,753 |
| Peshawar | 566,248 |
| Sialkot | 302,009 |
| Sargodha | 291,361 |
| Quetta | 285,719 |
| Islamabad | 204,364 |
| Jhang | 195,558 |
| Bahawalpur | 180,263 |

Source: Pakistan Statistical Yearbook, 1989.

TABLE D-3. DEVELOPMENT PLAN OUTLAYS IN THE PUBLIC SECTOR (at 1987/88 billion Rs.)

| | Sixth Plan | | Seventh Plan | |
|---------------------|------------|--------|--------------|--------|
| | Actual | % | Target | % |
| Energy | 87.80 | 31.47 | 124.30 | 35.51 |
| Transport and com | 52.20 | 18.71 | 61.50 | 17.57 |
| Water | 26.10 | 9.35 | 28.40 | 8.11 |
| Physical planning : | 27.90 | 10.00 | 20.00 | 5.71 |
| Education | 16.10 | 5.77 | 23.10 | 6.60 |
| Industry and mine | 18.10 | 6.49 | 16.00 | 4.57 |
| Health | 11.90 | 4.27 | 13.40 | 3.83 |
| Agriculture | 9.60 | 3.44 | 12.30 | 3.51 |
| Rural roads and m | 4.3 | 1.54 | 5.1 | 1.46 |
| Other sectors | 25.00 | 8.96 | 45.90 | 13.11 |
| Total | 279.00 | 100.00 | 350.00 | 100.00 |

Source: Seventh Five-Year Plan, 1988-93.

Note: The draft of the Seventh Five-Year Plan envisaged a total development outlay of Rs 616 billion, of which public sector investment was to be Rs 350 billion and private sector investment Rs 266 billion.

TABLE D-4. EXPORT COMPOSITION (percentage share)

| | July-March | |
|---------------------------|------------|---------|
| | 1989/90 | 1990/91 |
| Primary commodities | 13.30 | 8.80 |
| Cotton manufactures | 50.90 | 54.90 |
| Other traditional exports | 16.20 | 16.90 |
| Others | 19.60 | 19.40 |
| Total | 100.00 | 100.00 |

Source: Economic Survey, 1990/91.

TABLE D-5. POPULATION AND LABOR FORCE IN PAKISTAN (millions)

| | 1987/88 | 1988/89 | 1989/90 |
|--------------------------|---------|---------|---------|
| Population | 103.82 | 107.03 | 110.36 |
| Labor force | 29.93 | 30.87 | 31.82 |
| Crude activity rate (%) | 28.83 | 28.84 | 28.83 |
| Unemployment | 0.94 | 0.97 | 1.00 |
| Agriculture | 14.83 | 15.29 | 15.77 |
| Mining and manufacturing | 3.72 | 3.84 | 3.96 |
| Construction | 1.85 | 1.91 | 1.97 |
| Electricity and gas | 0.17 | 0.18 | 0.18 |
| Transport | 1.42 | 1.46 | 1.51 |
| Trade | 3.46 | 3.57 | 3.67 |
| Others | 3.54 | 3.65 | 3.77 |

Source: Economic Survey, 1990/91.

TABLE D-6. TOTAL LOANS AND CREDITS CONTRACTED BY SOURCE (US\$ million)

| | 1987/88 | 1988/89 | 1989/90 |
|----------------------------|----------|----------|----------|
| Aid to Pakistan Consortium | | | |
| • Bilateral | 653.00 | 1,126.50 | 911.00 |
| • Multilateral | 1,249.10 | 1,425.40 | 1,515.90 |
| Non-Consortium | 96.10 | 6.50 | 117.60 |
| Islamic countries | 24.90 | 8.00 | 17.70 |
| IMF Trust Fund | 0.00 | 146.50 | 216.60 |
| Total | 2,023.10 | 2,712.90 | 2,778.80 |

Source: Economic Survey, 1990/91.

TABLE D-7. SELECTED POPULATION STATISTICS OF COMMUNITIES IN THE STUDY AREA ENGAGED IN TORRENT-WATERED CULTIVATION BY MAJOR HILL TORRENT SURVEYED; 1981

| | Area in acres | Population | | |
|----------------------------|---------------|------------|--------|--------|
| | | Both sexes | Male | Female |
| Kaura Hill Torrent | | | | |
| Lakhani | 8,252 | 3,432 | 1,823 | 1,609 |
| Daulat Wala | 3,831 | 993 | 513 | 480 |
| Bhauch | 716 | 585 | 318 | 267 |
| Shadi Wala | 3,579 | 877 | 449 | 428 |
| Chuni | 8,015 | 1,277 | 655 | 622 |
| Jhangra | 26,179 | 7,353 | 3,922 | 3,431 |
| Trimin | 15,871 | 3,667 | 1,978 | 1,689 |
| Rakh Tarmin | 6,959 | 282 | 143 | 139 |
| Total | 73,402 | 18,466 | 9,801 | 8,665 |
| Vehowa Hill Torrent | | | | |
| Vehowa | 64,909 | 12,090 | 6,366 | 5,724 |
| Qaiserani Wala | 201 | n.a. | n.a. | n.a. |
| Kuhar | 8,782 | 3,070 | 1,656 | 1,414 |
| Kotani | 12,844 | 3,131 | 1,645 | 1,486 |
| Mitthe Wali | 9,794 | 3,279 | 1,705 | 1,574 |
| Jallowali | 7,347 | 2,632 | 1,350 | 1,282 |
| Buzdar | 5,245 | 881 | 460 | 421 |
| Murah | 1,530 | 517 | 271 | 246 |
| Kath Garh | 5,282 | 1,939 | 1,059 | 880 |
| Hamal | 1,137 | 612 | 330 | 282 |
| Litri Janubi | 1,999 | 678 | 365 | 313 |
| Kotla Sajawal | 2,344 | 426 | 230 | 196 |
| Kotla Ali Shah | 964 | 49 | 24 | 25 |
| Sheikh Gurda | 448 | 911 | 501 | 410 |
| Bhabhi | 11,475 | 3,737 | 2,000 | 1,737 |
| Tibi Qaisarani | 3,014 | 1,950 | 1,035 | 915 |
| Betlahoa | 4,957 | 2,494 | 1,312 | 1,182 |
| Rakh Fateh Khan | 1,190 | 1,289 | 669 | 620 |
| Nutkani | 7,511 | 5,156 | 2,707 | 2,449 |
| Gadi Shumali | 1,146 | 481 | 250 | 231 |
| Chirkin | 6,382 | 1,298 | 688 | 610 |
| Laghari | 3,031 | 871 | 463 | 408 |
| Dau | 954 | 287 | 160 | 127 |
| Jalal Khan | 1,505 | 768 | 415 | 353 |
| Fateh Khan | 8,907 | 1,553 | 806 | 747 |
| Panjgarain | 6,331 | 2,079 | 1,088 | 991 |
| Lashari | 981 | 267 | 135 | 132 |
| Total | 180,210 | 52,445 | 27,690 | 24,755 |

contin'd

| | Area in acres | Population | | |
|-----------------------------|---------------|------------|--------|--------|
| | | Both sexes | Male | Female |
| Sanghar Hill Torrent | | | | |
| Jhok Koro | 2,397 | 855 | 453 | 402 |
| Mangrotha | 8,198 | 7,699 | 3,990 | 3,709 |
| Taunsa Shumali | n.a. | n.a. | n.a. | n.a. |
| Taunsa Janubi | n.a. | n.a. | n.a. | n.a. |
| Tab | 3,076 | 1,048 | 526 | 522 |
| Qazi Wali | 675 | 533 | 284 | 249 |
| Jhok Mangla | 181 | 15 | 10 | 5 |
| Jhok Bhatta | 592 | 968 | 509 | 459 |
| Hadwar | 714 | 933 | 523 | 410 |
| Sounra | 1,779 | 525 | 257 | 268 |
| Domra Shumali | 1,996 | 213 | 101 | 112 |
| Domra Janubi | 1,955 | 164 | 89 | 75 |
| Jarh Laghari | 4,704 | 670 | 377 | 293 |
| Ghali | 311 | 12 | 6 | 6 |
| Kokowah | 2,989 | 439 | 234 | 205 |
| Jhang | 1,370 | 222 | 116 | 106 |
| Binda | 569 | 678 | 361 | 317 |
| Mundrani | 2,106 | 634 | 348 | 286 |
| Jat Ghadi | 4,407 | 1,478 | 785 | 693 |
| Bughlani | 5,021 | 3,592 | 1,897 | 1,695 |
| Sokar | 3,163 | 6,248 | 3,265 | 2,983 |
| Gadi Janubi | 4,655 | 1,594 | 838 | 756 |
| Mahnda | 718 | 534 | 299 | 235 |
| Hairo Gharbi | 562 | 1,319 | 688 | 631 |
| Hairo Sharqi | 2,085 | 1,573 | 827 | 746 |
| Bindi | 3,929 | 2,007 | 1,073 | 934 |
| Bohar | 4,384 | 3,827 | 1,999 | 1,828 |
| Jhangarra | 193 | n.a. | n.a. | n.a. |
| Behra | 2,910 | 754 | 416 | 338 |
| Lalu | 2,661 | 495 | 270 | 225 |
| Makol Kalan | 6,920 | 4,050 | 2,175 | 1,875 |
| Utra | 1,096 | 18 | 10 | 8 |
| Total | 76,316 | 43,097 | 22,726 | 20,371 |
| Sori Lund Hill Torrent | | | | |
| Ahmadani | 3,298 | 1,636 | 851 | 785 |
| Shadan Lund Chak Danda | 3,656 | 2,272 | 1,183 | 1,089 |
| Shadan Lund Chak Kandeywala | n.a. | n.a. | n.a. | n.a. |
| Shadan Lund Chak Ladan | 6,594 | 1,667 | 865 | 802 |
| Shadan Lund Chak Laman | 7,875 | 2,456 | 1,311 | 1,145 |
| Rakh Shadan Lund | 109 | 992 | 515 | 477 |
| Hota Hatwani | 2,123 | 748 | 403 | 345 |
| Kocha Kokari | 3,195 | 1,034 | 563 | 471 |
| Ghuman | 948 | 1,385 | 722 | 663 |
| Sabzani | 1,998 | 475 | 241 | 234 |
| Sohanra Zahar | 300 | 148 | 71 | 77 |

contin'd

| | Area in acres | Population | | |
|---------------------------|---------------|------------|--------|--------|
| | | Both sexes | Male | Female |
| Kala | 3,021 | 2,458 | 1,285 | 1,173 |
| Ranman | 7,017 | 2,985 | 1,614 | 1,371 |
| Gajani | 3,422 | 2,896 | 1,538 | 1,358 |
| Shero Dasti | 6,334 | 2,711 | 1,442 | 1,269 |
| Total | 49,890 | 23,863 | 12,604 | 11,259 |
| Vidore Hill Torrent | | | | |
| Bela | 4,725 | 4,963 | 2,504 | 2,459 |
| Patti Zai | 2,845 | 1,800 | 942 | 858 |
| Wadoor | 8,212 | 4,365 | 2,317 | 2,048 |
| Noor Wah | 6,926 | 1,479 | 757 | 722 |
| Gadai Gharbi | 9,053 | 10,202 | 5,369 | 4,833 |
| Chit Sarkani | 3,475 | 3,023 | 1,387 | 1,636 |
| Dodgar Chit | 7,730 | 2,575 | 1,302 | 1,273 |
| Wahi Kangrani | 470 | 478 | 248 | 230 |
| Koch Wadhani | 1,556 | 713 | 357 | 356 |
| Chabri Bala Gharbi | 8,195 | 4,192 | 2,183 | 2,009 |
| Chorotta Pachad Shumali | 7,063 | 1,925 | 995 | 930 |
| Chorotta Pachad Janubi | 978 | 1,708 | 931 | 777 |
| Dilana Patti Khas | 9,659 | 870 | 466 | 404 |
| Total | 70,887 | 38,293 | 19,758 | 18,535 |
| Sakhi Sarwar Hill Torrent | | | | |
| Sakhi Sarwar Sahib | 41,718 | 14,438 | 7,617 | 6,821 |
| Pai Ramlani | 4,626 | n.a. | n.a. | n.a. |
| Chak Rodi | 4,294 | 999 | 531 | 468 |
| Chak Salareen | 2,705 | 219 | 123 | 96 |
| Patti Bhochri | 4,104 | 502 | 276 | 226 |
| Rail Chohan | 53 | n.a. | n.a. | n.a. |
| Patti Tunmi | 12,790 | 1,805 | 972 | 833 |
| Total | 70,290 | 17,963 | 9,519 | 8,444 |
| Chachar Hill Torrent | | | | |
| Bahar Husain | 19,109 | 190 | 106 | 84 |
| Goli Wah | 1,557 | 230 | 130 | 100 |
| Illahi Wah | 709 | 157 | 78 | 79 |
| Khambi Gurang | 5,320 | 55 | 26 | 29 |
| Mirza Wah | 198 | 11 | 6 | 5 |
| Bukhara | 8,165 | 4,065 | 2,151 | 1,914 |
| Bakharpur | 6,627 | 1,405 | 747 | 658 |
| Drigri | 12,961 | 1,812 | 884 | 928 |
| Garo Lashari | 6,742 | 243 | 128 | 115 |
| Wah Mayo | 3,778 | 501 | 251 | 250 |
| Fateh Pur | 19,826 | 3,857 | 2,085 | 1,772 |
| Total | 84,992 | 12,526 | 6,592 | 5,934 |

contin'd

| | Area in acres | Population | | |
|---------------------------------|---------------|------------|-------|--------|
| | | Both sexes | Male | Female |
| Zangi Hill Torrent | | | | |
| Chak Khas | 11,520 | 3,719 | 1,982 | 1,737 |
| Total | 11,520 | 3,719 | 1,982 | 1,737 |
| Sori Janubi Hill Torrent | | | | |
| Dingri Sori | 5,576 | 10 | 10 | 0 |
| Gorri Sori | 17,688 | 851 | 439 | 412 |
| Chak Dilber | 39,038 | 4,509 | 2,655 | 1,854 |
| Total | 62,302 | 5,370 | 3,104 | 2,266 |

Source: Collector Hill Torrents, D. G. Khan, and Collector Hill Torrents, Rajanpur. Based on the 1981 District Census Report of D. G. Khan.

Note: Blanks indicate communities which, for one reason or another, were not surveyed at the time of the 1981 Census.

ANNEX E. AGRICULTURE

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CHAPTER I. AGRICULTURE

TABLE E-1. GROWTH OF AGRICULTURAL PRODUCTION (average annual percentage increase in value added)

| | 1965-80 | 1980-88 |
|------------|---------|---------|
| Pakistan | 3.30 | 4.30 |
| India | 2.50 | 2.30 |
| Bangladesh | 1.50 | 2.10 |
| China | 2.80 | 6.80 |
| Indonesia | 4.30 | 3.10 |
| Thailand | 4.60 | 3.70 |

Source: World Development Report, 1990.

TABLE E-2. FERTILIZER OFF-TAKE AND IMPORTS OF PESTICIDES

(Unit: '000 tons)

| | Fertilizer off-take | | | | Pesticide imports |
|---------|---------------------|--------|-------|----------|-------------------|
| | N | P | K | Total | |
| 1980/81 | 843.00 | 226.80 | 9.60 | 1,079.40 | 7,105.00 |
| 1981/82 | 832.60 | 225.60 | 21.80 | 1,080.00 | 5,481.00 |
| 1982/83 | 952.69 | 265.30 | 25.60 | 1,243.59 | 8,860.30 |
| 1983/84 | 914.32 | 259.81 | 28.50 | 1,202.63 | 10,662.50 |
| 1984/85 | 934.80 | 293.79 | 24.67 | 1,253.26 | 15,889.20 |
| 1985/86 | 1,128.39 | 350.07 | 33.33 | 1,511.79 | 17,498.90 |
| 1986/87 | 1,332.35 | 408.87 | 42.62 | 1,783.84 | 20,647.80 |
| 1987/88 | 1,282.08 | 392.89 | 45.03 | 1,720.00 | 15,765.40 |
| 1988/89 | 1,324.90 | 390.41 | 24.53 | 1,739.84 | 11,326.50 |
| 1989/90 | 1,467.60 | 382.43 | 40.07 | 1,890.10 | 10,543.50 |

Source: Economic Survey, 1990/91.

TABLE E-3. PRODUCTION OF IMPORTANT CROPS, PAKISTAN AND THE PUNJAB

(Unit: '000 tons)

| | 1988/89 | | | 1989/90 | | |
|---------------------|----------|--------|-----------------------|----------|--------|-----------------------|
| | Pakistan | Punjab | % share of the Punjab | Pakistan | Punjab | % share of the Punjab |
| Wheat | 14,419 | 10,517 | 72.94 | 14316 | 10518 | 73.47 |
| Cotton ('000 bales) | 8,385 | 7,275 | 86.76 | 8560 | 7454 | 87.08 |
| Sugarcane | 36,976 | 19,494 | 52.72 | 35494 | 18683 | 52.64 |
| Rice (total) | 3,200 | 1,367 | 42.72 | 3,220 | 1,482 | 46.02 |
| • Fine (Basmati) | 1,099 | 1,042 | 94.81 | 1216 | 1160 | 95.39 |
| • Medium & Coarse | 2,101 | 325 | 15.47 | 2004 | 322 | 16.07 |
| Maize | 1,204 | 455 | 37.79 | 1179 | 455 | 38.59 |
| Gram | 456 | 294 | 64.47 | 562 | 397 | 70.64 |
| Rape & Mustard | 249 | 162 | 65.06 | 233 | 147 | 63.09 |

Source: 1990 Statistical Pocket Book of the Punjab.

TABLE E-4. NUMBER OF CATTLE AND BUFFALOES BY DIVISION, THE PUNJAB

| | Cattle ('000) | | | Buffaloes ('000) | | |
|----------------------|---------------|-------|-------|------------------|-------|--------|
| | 1976 | 1980 | 1986 | 1976 | 1980 | 1986 |
| The Punjab | 8,108 | 9,256 | 8,818 | 7,980 | 8,687 | 11,150 |
| Bahawalpur | 1,060 | 1,284 | 1,102 | 767 | 915 | 1,200 |
| D. G. Khan | 1,196 | 1,361 | 1,459 | 324 | 379 | 636 |
| • D. G. Khan Dist. | 274 | 262 | 287 | 46 | 62 | 115 |
| • Layyah Dist. | 243 | 233 | 259 | 106 | 109 | 142 |
| • Muzaffargarh Dist. | 472 | 530 | 563 | 135 | 162 | 259 |
| • Rajanpur Dist. | 207 | 304 | 281 | 37 | 46 | 120 |
| Faisalabad | 986 | 1,111 | 1,119 | 1,464 | 1,579 | 2,048 |
| Gujranwala | 812 | 802 | 779 | 1,646 | 1,661 | 1,931 |
| Lahore | 788 | 811 | 739 | 1,481 | 1,572 | 1,937 |
| Multan | 1,294 | 1,558 | 1,296 | 1,408 | 1,612 | 2,088 |
| Rawalpindi* | 1,002 | 1,203 | 1,171 | 228 | 276 | 457 |
| Sargodha | 970 | 1,126 | 1,153 | 662 | 693 | 853 |

Source: 1990 Statistical Pocket Book of the Punjab.

Note: * Includes Islamabad. D. G. Khan Division (1980) includes 32,000 cattle from tribal areas of D. G. Khan and Rajanpur districts. D. G. Khan Division (1986) includes 69,000 cattle from tribal areas.

TABLE E-5. NUMBER OF SHEEP AND GOATS BY DIVISION, THE PUNJAB

| | Sheep ('000) | | | Goats ('000) | | |
|----------------------|--------------|-------|-------|--------------|-------|--------|
| | 1976 | 1980 | 1986 | 1976 | 1980 | 1986 |
| The Punjab | 8,037 | 6,307 | 6,686 | 7,767 | 7,305 | 10,755 |
| Bahawalpur | 1,075 | 1,510 | 1,097 | 1,088 | 1,244 | 1,732 |
| D. G. Khan | 2,059 | 1,380 | 1,881 | 1,335 | 848 | 1,559 |
| • D. G. Khan Dist. | 990 | 311 | 409 | 728 | 162 | 289 |
| • Layyah Dist. | 368 | 190 | 283 | 221 | 148 | 231 |
| • Muzaffargarh Dist. | 382 | 277 | 303 | 243 | 189 | 377 |
| • Rajanpur Dist. | 319 | 447 | 377 | 143 | 165 | 358 |
| Faisalabad | 757 | 612 | 760 | 800 | 885 | 1,388 |
| Gujranwala | 348 | 210 | 223 | 647 | 672 | 676 |
| Lahore | 686 | 438 | 421 | 466 | 377 | 679 |
| Multan | 1,440 | 953 | 967 | 1,049 | 1,000 | 1,696 |
| Rawalpindi* | 578 | 373 | 382 | 1,349 | 1,111 | 1,435 |
| Sargodha | 1,094 | 831 | 955 | 1,033 | 1,168 | 1,590 |

Source: 1990 Statistical Pocket Book of the Punjab.

Note: * Includes Islamabad. D. G. Khan Division (1980) includes 156,000 sheep and 363,000 goats from tribal areas of D. G. Khan and Rajanpur districts. D. G. Khan Division (1986) includes 509,000 sheep and 184,000 goats from tribal areas.

TABLE E-6. TENURE CLASSIFICATION OF FARMS AND FARM AREA BY PROVINCE

(Unit: acres)

| | Number of farms | | | | Farm area | | | |
|-------------|-----------------|------------------------|------------------------|--------------|------------|------------------------|--------------|------------|
| | Total | | Owner-cum-tenant farms | | Total | Owner-cum-tenant farms | | |
| | Total | Owner-cum-tenant farms | Owner-cum-tenant farms | Tenant farms | | Owner farms | Tenant farms | |
| | 1960 Census | | | | | | | |
| Pakistan | 4,859,000 | 1,998,000 | 835,000 | 2,026,000 | 48,926,000 | 18,721,000 | 11,011,000 | 19,194,000 |
| NWFP | 674,000 | 325,000 | 137,000 | 212,000 | 5,463,000 | 1,870,000 | 1,871,000 | 1,722,000 |
| Punjab | 3,326,000 | 1,422,000 | 623,000 | 1,281,000 | 29,212,000 | 11,168,000 | 7,180,000 | 10,864,000 |
| Sind | 694,000 | 150,000 | 61,000 | 483,000 | 10,190,000 | 3,229,000 | 1,474,000 | 5,487,000 |
| Baluchistan | 165,000 | 101,000 | 14,000 | 50,000 | 4,061,000 | 2,454,000 | 486,000 | 1,121,000 |
| | 1972 Census | | | | | | | |
| Pakistan | 3,760,000 | 1,568,000 | 896,000 | 1,296,000 | 49,058,000 | 19,398,000 | 15,160,000 | 14,500,000 |
| NWFP | 466,000 | 256,000 | 103,000 | 107,000 | 4,251,000 | 1,615,000 | 1,713,000 | 923,000 |
| Punjab | 2,375,000 | 1,008,000 | 683,000 | 684,000 | 31,029,000 | 11,950,000 | 11,051,000 | 8,028,000 |
| Sind | 747,000 | 178,000 | 97,000 | 472,000 | 9,459,000 | 2,909,000 | 1,759,000 | 4,791,000 |
| Baluchistan | 172,000 | 126,000 | 13,000 | 33,000 | 4,319,000 | 2,924,000 | 637,000 | 758,000 |
| | 1980 Census | | | | | | | |
| Pakistan | 4,070,000 | 2,227,000 | 789,000 | 1,054,000 | 47,094,000 | 24,533,000 | 12,396,000 | 10,165,000 |
| NWFP | 528,000 | 361,000 | 72,000 | 95,000 | 4,099,000 | 2,388,000 | 1,103,000 | 608,000 |
| Punjab | 2,545,000 | 1,385,000 | 618,000 | 542,000 | 29,898,000 | 14,883,000 | 9,334,000 | 5,681,000 |
| Sind | 795,000 | 323,000 | 85,000 | 387,000 | 9,206,000 | 4,350,000 | 1,528,000 | 3,328,000 |
| Baluchistan | 202,000 | 158,000 | 14,000 | 30,000 | 3,891,000 | 2,912,000 | 431,000 | 548,000 |

Source: Economic Survey, 1990/91.

TABLE E-7. SELECTED AGRICULTURAL STATISTICS OF THE STUDY AREA, 1980

(Unit: acres)

| | D. G. Khan Tehsil | Taunsa Tehsil | Rajanpur Tehsil | Jampur Tehsil |
|---|----------------------|------------------|--------------------|------------------|
| Number & area of agricultural holdings | | | | |
| • Agricultural holdings, total | 52,668 | 24,621 | 35,615 | 26,862 |
| • Livestock holdings | 14,243 | 7,099 | 4,355 | 6,517 |
| • Farms | 38,425 | 17,522 | 31,260 | 20,345 |
| • Farm area | 403,165 | 354,688 | 559,470 | 324,650 |
| • Cultivated area | 321,360 | 270,777 | 423,479 | 284,484 |
| • Net area sown | 308,842 | 254,720 | 364,306 | 227,632 |
| • Farm area uncultivated | 81,805 | 83,911 | 135,991 | 40,166 |
| Farm tenure | | | | |
| • Owner farms | 21,822 | 6,565 | 12,783 | 8,131 |
| • Owner-cum-tenant farms | 10,626 | 7,371 | 7,147 | 6,721 |
| • Tenant farms | 5,976 | 3,588 | 11,329 | 5,492 |
| • Owner farms area | 203,524 | 145,730 | 256,536 | 115,689 |
| • Owner-cum-tenant farms area | 155,699 | 167,377 | 163,515 | 146,128 |
| • Tenant farms area | 43,889 | 41,581 | 137,044 | 62,835 |
| • Owner operated area | 281,735 | 232,734 | 334,689 | 181,626 |
| • Tenant operated area | 121,376 | 121,957 | 222,405 | 143,024 |
| • Area share-cropped | 106,127 | 117,081 | 131,033 | 127,009 |
| • Area leased | 14,276 | 3,663 | 45,200 | 9,628 |
| • Other area | 973 | 1,213 | 46,172 | 6,387 |
| Average size of farms | | | | |
| • All farms | 10.50 | 20.20 | 17.80 | 16.00 |
| • Owner farms | 9.30 | 22.10 | 20.00 | 14.20 |
| • Owner-cum-tenant farms | 14.70 | 22.70 | 22.90 | 21.70 |
| • Tenant farms | 7.30 | 11.60 | 12.00 | 11.40 |
| Fragmentation of farms | | | | |
| • Farms not fragmented | 17,239 | 3,603 | 14,875 | 9,587 |
| • Fragmented farms, total | 21,185 | 13,919 | 16,384 | 10,758 |
| • With 2-3 fragments | 17,089 | 9,309 | 14,428 | 8,603 |
| • With 4-5 fragments | 2,740 | 3,039 | 1,291 | 1,506 |
| • With 6-9 fragments | 1,046 | 1,358 | 499 | 484 |
| • With 10 fragments or more | 308 | 217 | 167 | 165 |
| Intensities | | | | |
| • Average land use intensity (%) | 86.00 | 83.00 | 81.00 | 92.00 |
| • Average cropping intensity (%) | 120.00 | 96.00 | 93.00 | 99.00 |
| Irrigation | | | | |
| Cultivated area actually irrigated by: | | | | |
| • Any source | 307,340 | 215,972 | 314,506 | 227,636 |
| • Canals only | 114,312 | 640 | 200,583 | 158,772 |
| • Canals & other sources | 116,809 | 5,684 | 33,944 | 38,043 |
| • Tubewells only | 22,054 | 35,447 | 70,018 | 7,948 |
| • Wells only | 3,686 | 18,351 | 1,750 | 1,390 |
| • Karezes only | - | - | - | - |
| • Unspecified sources | 50,477 | 155,846 | 8,212 | 21,485 |
| • Area provided with irrigation facilities but not irrigated | 10,582 | 10,114 | 47,467 | 40,084 |
| • Sailaba | 319 | 30,449 | 40,222 | 460 |

contin'd

| | D. G. Khan Tehsil | Taunsa Tehsil | Rajanpur Tehsil | Jampur Tehsil |
|---|----------------------|------------------|--------------------|------------------|
| • Barani | 3,123 | 14,241 | 21,282 | 16,305 |
| Cropping | | | | |
| • Cropped area, total | 385,001 | 259,559 | 393,002 | 282,257 |
| • Irrigated | 382,458 | 220,255 | 342,625 | 281,981 |
| • Unirrigated | 2,543 | 39,304 | 50,377 | 276 |
| • Kharif crops area, total | 167,387 | 114,967 | 158,151 | 121,273 |
| • Irrigated | 166,349 | 105,035 | 146,597 | 121,109 |
| • Unirrigated | 1,038 | 9,932 | 11,554 | 164 |
| • Rabi crops area, total | 216,957 | 144,546 | 233,701 | 160,812 |
| • Irrigated | 215,455 | 115,173 | 194,878 | 160,720 |
| • Unirrigated | 1,502 | 29,373 | 38,823 | 92 |
| • Orchard area, total | 658 | 45 | 1,149 | 171 |
| • Irrigated | 658 | 45 | 1,149 | 151 |
| • Unirrigated | - | - | - | 20 |
| Crop acreages | | | | |
| • Wheat | 182,407 | 81,416 | 163,289 | 109,770 |
| • Cotton | 54,913 | 10,040 | 68,037 | 36,047 |
| • Sugarcane | 1,399 | 311 | 5,760 | 5,525 |
| • Paddy | 41,368 | 1,271 | 43,171 | 22,638 |
| • Maize | 448 | 36 | 476 | 1,229 |
| • Oilseeds | 1,878 | 33,892 | 21,668 | 21,685 |
| • Pulses | 4,013 | 26,224 | 31,991 | 11,578 |
| • Fruits | 658 | 45 | 1,149 | 171 |
| • Fodders | 48,469 | 8,486 | 31,139 | 38,322 |
| • Vegetables | 1,268 | 425 | 615 | 2,601 |
| • Other crops | 48,180 | 97,413 | 25,707 | 32,691 |
| Plant protection measures | | | | |
| • Farms reporting use of ground spray | 707 | - | 88 | 24 |
| • Area sprayed | 2,351 | - | 844 | 205 |
| Use of fertilizers & manures of farms | | | | |
| • Farms reporting use of both fertilizers & manures | 10,303 | 290 | 6,446 | 2,278 |
| • Farms reporting use of fertilizers only | 16,594 | 2,114 | 8,988 | 4,154 |
| • Farms reporting use of manures only | 2,236 | 367 | 3,597 | 244 |
| Use of fertilizers on major crops | | | | |
| • Wheat area fertilized | 164,516 | 30,362 | 105,123 | 37,009 |
| • Paddy area fertilized | 32,030 | 465 | 22,340 | 3,703 |
| • Cotton area fertilized | 52,629 | 6,003 | 59,570 | 15,076 |
| • Sugarcane area fertilized | 1,061 | 306 | 4,556 | 1,905 |
| • Maize area fertilized | 135 | - | 115 | 95 |
| Agricultural labor | | | | |
| • Households reporting permanently hired labor | 1,250 | 292 | 710 | 496 |
| • Number of permanent hired labor | 2,665 | 584 | 1,908 | 974 |
| • Family workers 10 years or above, total | 164,121 | 63,872 | 115,587 | 85,684 |
| • Male | 89,131 | 35,411 | 70,856 | 46,094 |
| • Female | 74,990 | 28,461 | 44,731 | 39,590 |

contin'd

| | D. G. Khan Tehsil | Taunsa Tehsil | Rajanpur Tehsil | Jampur Tehsil |
|--|----------------------|------------------|--------------------|------------------|
| Use of tractors & tubewells | | | | |
| • Farms reporting use of tractors | 15,063 | 676 | 2,079 | 4,025 |
| • Farms reporting use of tubewell water | 10,921 | 2,173 | 7,384 | 4,698 |
| Livestock | | | | |
| • Total number of work animals | 61,566 | 45,862 | 77,384 | 45,296 |
| • Average number of work animals per farm | 1.60 | 2.60 | 2.40 | 2.20 |
| Cattle & buffaloes by age & sex | | | | |
| • Number of cattle, total | 159,604 | 102,064 | 186,282 | 117,296 |
| • Bulls 3 years & over for breeding | 266 | 98 | 281 | 103 |
| • Bullocks 3 years & over for work | 53,368 | 35,566 | 67,309 | 40,169 |
| • Cows 3 years & over | 55,983 | 34,788 | 66,369 | 40,592 |
| • Male cattle under 3 years | 26,499 | 17,167 | 28,896 | 19,914 |
| • Female cattle under 3 years | 23,488 | 14,445 | 23,425 | 16,518 |
| • Number of buffaloes, total | 48,130 | 13,729 | 27,564 | 18,177 |
| • Buffalo bulls 3 years & over for breeding | 136 | 59 | 66 | 82 |
| • Male buffaloes 3 years & over for work | 104 | 133 | 282 | 70 |
| • Female buffaloes 3 years & over | 27,157 | 8,931 | 16,358 | 10,278 |
| • Male buffaloes under 3 years | 8,153 | 1,517 | 4,347 | 2,956 |
| • Female buffaloes under 3 years | 12,579 | 3,088 | 6,511 | 4,790 |
| • Number of milch animals, total | 83,140 | 43,719 | 82,727 | 50,870 |
| • Cows in milk | 44,183 | 26,048 | 39,492 | 28,569 |
| • Buffaloes in milk | 20,321 | 6,491 | 10,500 | 7,276 |
| • Cows dry & not calved | 11,800 | 8,740 | 26,877 | 12,023 |
| • Buffaloes dry & not calved | 6,836 | 2,440 | 5,858 | 3,002 |
| Sheep & goats | | | | |
| • Number of sheep, total | 208,299 | 102,639 | 272,942 | 173,570 |
| • Adult male | 10,503 | 3,423 | 7,679 | 9,262 |
| • Adult female | 141,441 | 73,439 | 203,696 | 122,744 |
| • Youngstock | 56,353 | 25,776 | 61,567 | 41,562 |
| • Number of goats, total | 113,451 | 49,048 | 79,759 | 85,006 |
| • Adult male | 7,379 | 2,707 | 9,219 | 6,269 |
| • Adult female | 69,721 | 31,522 | 45,945 | 55,345 |
| • Youngstock | 36,351 | 14,819 | 24,596 | 23,392 |
| Camels, horses, mules & donkeys | | | | |
| • Number of camels | 8,793 | 13,220 | 11,435 | 5,746 |
| • Number of horses | 2,057 | 928 | 3,301 | 3,357 |
| • Number of mules | 35 | 27 | 28 | 153 |
| • Number of donkeys | 13,451 | 5,872 | 6,157 | 9,589 |
| Poultry birds | | | | |
| • Number of poultry birds, total | 214,323 | 75,144 | 111,236 | 104,910 |
| • Layers | 150,578 | 50,698 | 45,523 | 67,970 |
| • Others | 63,745 | 24,446 | 65,713 | 36,940 |

Source: Pakistan Census of Agriculture, 1980, Volume III.

Note: Figures for Rojhan Tehsil included in those for Rajanpur Tehsil.

TABLE E-8. AREA OF FARMS OF THE STUDY AREA BY TENURE ARRANGEMENT, 1980 (in acres)

| | Farm area | | Owner farms | | Owner-cum-tenant farms | | Tenant farms | |
|-------------------|-----------|---------|-------------|---------|------------------------|---------|--------------|---|
| | Area | % | Area | % | Area | % | Area | % |
| D. G. Khan Tehsil | 403,165 | 203,524 | 50.48 | 155,699 | 38.62 | 43,889 | 10.89 | |
| Taunsa Tehsil | 354,688 | 145,730 | 41.09 | 167,377 | 47.19 | 41,581 | 11.72 | |
| Rajanpur Tehsil | 559,470 | 256,536 | 45.85 | 163,515 | 29.23 | 137,044 | 24.50 | |
| Jampur Tehsil | 324,650 | 115,689 | 35.63 | 146,128 | 45.01 | 62,835 | 19.35 | |
| Total | 1,641,973 | 721,479 | 43.94 | 632,719 | 38.53 | 285,349 | 17.38 | |

Source: Adapted from Pakistan Census of Agriculture, 1980, Volume III.

Note: Figures for Rojhan Tehsil included in those for Rajanpur Tehsil.

TABLE E-9. NUMBER OF FARMS OF THE STUDY AREA BY TENURE ARRANGEMENT, 1980

| | Farm number | Owner farms | | Owner-cum-tenant farms | | Tenant farms | |
|-------------------|-------------|-------------|-------|------------------------|-------|--------------|-------|
| | | Number | % | Number | % | Number | % |
| D. G. Khan Tehsil | 38,425 | 21,822 | 56.79 | 10,626 | 27.65 | 5,976 | 15.55 |
| Taunsa Tehsil | 17,522 | 6,565 | 37.47 | 7,371 | 42.07 | 3,588 | 20.48 |
| Rajanpur Tehsil | 31,260 | 12,783 | 40.89 | 7,147 | 22.86 | 11,329 | 36.24 |
| Jampur Tehsil | 20,345 | 8,131 | 39.97 | 6,721 | 33.04 | 5,492 | 26.99 |
| Total | 107,552 | 49,301 | 45.84 | 31,865 | 29.63 | 26,385 | 24.53 |

Source: Adapted from Pakistan Census of Agriculture, 1980, Volume III.

Note: Figures for Rojhan Tehsil included in those for Rajanpur Tehsil.

TABLE E-10. CROP AREA BY DISTRICT INCLUDING THE STUDY AREA

| | (Unit: '000 ha) | | | | | | | |
|------------------|-----------------|----------|---------|----------|---------|----------|---------|----------|
| | 1986/87 | | 1987/88 | | 1988/89 | | Average | |
| | IRRIG. | UNIRRIG. | IRRIG. | UNIRRIG. | IRRIG. | UNIRRIG. | IRRIG. | UNIRRIG. |
| Wheat | | | | | | | | |
| D.G.Khan | 104.0 | 6.9 | 107.6 | 5.3 | 107.2 | 10.1 | 106.3 | 7.4 |
| Rajapur | 89.0 | 8.1 | 93.1 | 6.4 | 100.0 | 7.3 | 94.0 | 7.3 |
| Total | 193.0 | 15.0 | 200.7 | 11.7 | 207.2 | 17.4 | 200.3 | 14.7 |
| Barley | | | | | | | | |
| D.G.Khan | 1.0 | 0.4 | 0.7 | 0.2 | 0.5 | 0.4 | 0.7 | 0.3 |
| Rajapur | 0.2 | 0.0 | 0.1 | 0.1 | 0.2 | 0.0 | 0.2 | 0.0 |
| Total | 1.2 | 0.4 | 0.8 | 0.3 | 0.7 | 0.4 | 0.9 | 0.4 |
| Jowar | | | | | | | | |
| D.G.Khan | 28.8 | 3.0 | 3.7 | 9.3 | 8.1 | 24.1 | 13.5 | 12.1 |
| Rajapur | 11.1 | 20.7 | 4.7 | 2.6 | 4.6 | 15.4 | 6.8 | 12.9 |
| Total | 39.9 | 23.7 | 8.4 | 11.9 | 12.7 | 39.5 | 20.3 | 25.0 |
| Bajra | | | | | | | | |
| D.G.Khan | 5.3 | 0.9 | 1.2 | 0.6 | 1.1 | 3.1 | 2.5 | 1.5 |
| Rajapur | 1.9 | 1.4 | 2.1 | 0.2 | 1.9 | 0.7 | 2.0 | 0.8 |
| Total | 7.2 | 2.3 | 3.3 | 0.8 | 3.0 | 3.8 | 4.5 | 2.3 |
| Gram | | | | | | | | |
| D.G.Khan | 2.9 | 4.8 | 2.8 | 2.5 | 1.9 | 5.1 | 2.5 | 4.1 |
| Rajapur | 5.1 | 2.6 | 4.9 | 2.6 | 4.8 | 2.1 | 4.9 | 2.4 |
| Total | 8.0 | 7.4 | 7.7 | 5.1 | 6.7 | 7.2 | 7.5 | 6.6 |
| R & M | | | | | | | | |
| D.G.Khan | 1.6 | 2.1 | 1.6 | 0.7 | 2.2 | 3.2 | 1.8 | 2.0 |
| Rajapur | 7.5 | 1.6 | 6.4 | 0.6 | 7.3 | 3.0 | 7.1 | 1.7 |
| Total | 9.1 | 3.7 | 8.0 | 1.3 | 9.5 | 6.2 | 8.9 | 3.7 |

TABLE E-11. CROP PRODUCTION BY DISTRICT INCLUDING THE STUDY AREA

| | (Unit: '000 ha) | | | | | | | |
|------------------|-----------------|----------|---------|----------|---------|----------|---------|----------|
| | 1986/87 | | 1987/88 | | 1988/89 | | Average | |
| | IRRIG. | UNIRRIG. | IRRIG. | UNIRRIG. | IRRIG. | UNIRRIG. | IRRIG. | UNIRRIG. |
| Wheat | | | | | | | | |
| D.G.Khan | 207.6 | 7.5 | 208.1 | 5.7 | 216.3 | 11.6 | 210.7 | 8.3 |
| Rajapur | 118.7 | 9.1 | 155.5 | 6.9 | 195.3 | 8.2 | 156.5 | 8.1 |
| Total | 326.3 | 16.6 | 363.6 | 12.6 | 411.6 | 19.8 | 367.2 | 16.3 |
| Barley | | | | | | | | |
| D.G.Khan | 0.8 | 0.2 | 0.6 | 0.1 | 0.5 | 0.2 | 0.6 | 0.2 |
| Rajapur | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 |
| Total | 0.9 | 0.2 | 0.7 | 0.1 | 0.6 | 0.2 | 0.7 | 0.2 |
| Jowar | | | | | | | | |
| D.G.Khan | 19.3 | 1.4 | 2.4 | 2.5 | 6.0 | 7.8 | 9.2 | 3.9 |
| Rajapur | 7.4 | 9.6 | 3.1 | 0.7 | 3.3 | 5.0 | 4.6 | 5.1 |
| Total | 26.7 | 11.0 | 5.5 | 3.2 | 9.3 | 12.8 | 13.8 | 9.0 |
| Bajra | | | | | | | | |
| D.G.Khan | 3.6 | 0.4 | 0.9 | 0.1 | 0.7 | 0.4 | 1.7 | 0.3 |
| Rajapur | 1.3 | 0.6 | 1.4 | 0.0 | 1.6 | 0.1 | 1.4 | 0.2 |
| Total | 4.9 | 1.0 | 2.3 | 0.1 | 2.3 | 0.5 | 3.2 | 0.5 |
| Gram | | | | | | | | |
| D.G.Khan | 2.0 | 2.4 | 1.9 | 0.9 | 1.4 | 1.9 | 1.8 | 1.7 |
| Rajapur | 3.7 | 1.4 | 3.4 | 0.9 | 3.3 | 0.8 | 3.5 | 1.0 |
| Total | 5.7 | 3.8 | 5.3 | 1.8 | 4.7 | 2.7 | 5.2 | 2.8 |
| R & M | | | | | | | | |
| D.G.Khan | 1.5 | 1.2 | 1.6 | 0.4 | 2.2 | 1.8 | 1.8 | 1.1 |
| Rajapur | 6.9 | 0.9 | 6.6 | 0.3 | 7.4 | 2.1 | 7.0 | 1.1 |
| Total | 8.4 | 2.1 | 8.2 | 0.7 | 9.6 | 3.9 | 8.7 | 2.2 |

TABLE E-12. CREDIT OUTLAYS TO THE STUDY AREA BY THE AGRICULTURAL DEVELOPMENT BANK OF PAKISTAN
(July 1, 1990 to April 30, 1991; amounts in Rupees)

| | Long-term loans | | Medium-term loans | | Short-term loans | | Total |
|----------------------------|-----------------|------------|-------------------|------------|------------------|------------|------------|
| | Sub-total | % of total | Sub-total | % of total | Sub-total | % of total | |
| Taunsa Tehsil | | | | | | | |
| • Number of loans | 109 | 26.14 | 90 | 21.58 | 218 | 52.28 | 417 |
| • Total amount disbursed | 15,819,000 | 55.82 | 2,510,000 | 8.86 | 10,011,000 | 35.32 | 28,340,000 |
| • Average amount disbursed | 145,128 | N.A. | 27,889 | N.A. | 45,922 | N.A. | N.A. |
| D. G. Khan Tehsil | | | | | | | |
| • Number of loans | 59 | 8.99 | 238 | 36.28 | 359 | 54.73 | 656 |
| • Total amount disbursed | 33,801,000 | 60.90 | 3,174,000 | 5.72 | 18,529,000 | 33.38 | 55,504,000 |
| • Average amount disbursed | 572,898 | N.A. | 13,336 | N.A. | 51,613 | N.A. | N.A. |
| Choti Village | | | | | | | |
| • Number of loans | 68 | 20.92 | 85 | 26.15 | 172 | 52.92 | 325 |
| • Total amount disbursed | 13,783,000 | 43.71 | 4,250,000 | 13.48 | 13,502,000 | 42.82 | 31,535,000 |
| • Average amount disbursed | 202,691 | N.A. | 50,000 | N.A. | 78,500 | N.A. | N.A. |
| Jampur Tehsil | | | | | | | |
| • Number of loans | 103 | 28.61 | 52 | 14.44 | 205 | 56.94 | 360 |
| • Total amount disbursed | 21,420,000 | 56.58 | 1,910,000 | 5.04 | 14,531,000 | 38.38 | 37,861,000 |
| • Average amount disbursed | 207,961 | N.A. | 36,731 | N.A. | 70,883 | N.A. | N.A. |
| Rajanpur Tehsil | | | | | | | |
| • Number of loans | 111 | 32.36 | 37 | 10.79 | 195 | 56.85 | 343 |
| • Total amount disbursed | 21,293,000 | 58.47 | 1,975,000 | 5.42 | 13,147,000 | 36.10 | 36,415,000 |
| • Average amount disbursed | 191,829 | N.A. | 53,378 | N.A. | 67,421 | N.A. | N.A. |
| Rojhan Tehsil | | | | | | | |
| • Number of loans | 26 | 23.21 | 11 | 9.82 | 75 | 66.96 | 112 |
| • Total amount disbursed | 7,944,000 | 44.72 | 852,000 | 4.80 | 8,969,000 | 50.49 | 17,765,000 |
| • Average amount disbursed | 305,538 | N.A. | 77,455 | N.A. | 119,587 | N.A. | N.A. |

Source: ADBP Regional Office, D. G. Khan.

Note: Figures for Choti Village are given separately because of the large number of defaults on loan repayments in that area.

CHAPTER II. FARMER INTENTION SURVEY

A Farmer Intention Survey, covering the major hill torrent areas of the districts of D. G. Khan and Rajanpur except Mithawan, Kaha, Pitok and Sori Shumali, was carried out in Phase I of the Study. The aim of the Survey was to ascertain the receptiveness of local farmers and identify the major constraints to agricultural production in the pachad. The Survey envisaged taking a sample of 12 households per hill torrent area, and further divided each area into three zones, namely upper, middle and lower, in order to obtain a broad sample reasonably free from biases. It was proposed to select 4 households per zone by the random sampling method. However, except for Sanghar and Vidor, for which a full quota of samples was obtained, problems of accessibility dictated a sample size of 9 households per hill torrent area. The number of samples gathered under the Survey therefore totalled 87. Each household was requested to answer eight questions (see Table E-13) and responses are available for all except Question 7, to which only a few households in Kaura, Vehowa and Sanghar answered (see Table E-14).

The Study Area is exceedingly large and it was not feasible, within the duration of Phase I of the Study, to obtain a sample large enough to allow a comprehensive socio-economic analysis of each hill torrent. The following attempt at such an analysis owes much to conjecture but it is possible, on the basis of the data at hand, to classify the nine hill torrents surveyed into three groups. The first of these may include Kaura, Vehowa and Sanghar; the second Sori Lund, Vidor and Sakhi Sarwar; and the third Chachar, Zangi and Sori Janubi.

Kaura, Vehowa and Sanghar are characterized by regular agricultural activities in which crop production dominates and livestock rearing plays a relatively minor role, though income from other activities there as elsewhere supplements family income. With the notable exception of Sanghar, the households surveyed appear more or less satisfied with the acreage of land cultivated, a fact which suggests a relatively stable and secure environment. Water supply is not a major constraint and farm operations are not unduly affected by transportation bottlenecks (see Table E-15 (1) to E-15 (6)).

Sori Lund, Vidore and Sakhi Sarwar, further to the south, are characterized by more extensive livestock rearing practices, particularly in Vidore, and a high proportion of the households surveyed in Sakhi Sarwar rely on income from other activities, namely trading and services. The communities established in these three hill torrent areas are anxious to increase the acreage of land cultivated, especially in Sori Lund, and nine in ten households find the water supply to be insufficient in both the Kharif and the Rabi

seasons, while all households in Sori Lund and Vidor experience difficulties in distributing water to each plot. Transporting farm inputs and outputs proves more difficult than in the northern areas, arguably because the road network is less satisfactory (see Table E-15 (7) to E-15 (9)).

Chachar, Zangi and Sori Janubi are characterized by widespread livestock rearing activities and work as a laborer for other farmers is a necessity which reflects the precariousness of crop production in these areas. All households surveyed wish to increase the acreage of land cultivated but find irrigation water to be insufficient throughout the year. The distribution of water to each plot is a major problem blamed on field and embankment erosion, and transportation bottlenecks are acute (see Table E-15 (10) to E-15 (12)).

Because Question 7 was largely ignored by the households sampled it is difficult to name with any certainty the crops most likely to be grown by the households surveyed in the advent of additional irrigation water. The data available nevertheless suggests that cotton, jowar and bajra, in that order, would be the priority crops grown in the Kharif season. Wheat, gram and oilseeds, in that order, would be the priority crops grown in the Rabi season.