No. 2

[illegible] (N.P.)

[illegible] (C.R.Q.)

[illegible] STUDY
ON
THE [illegible] INTEGRATED
AGRICULTURAL DEVELOPMENT PROJECT

FINAL REPORT
(ANNEX)

[illegible] AGENCY

[illegible] BASIN INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT FINAL REPORT (ANNEX) JULY 1991

THE REPUBLIC OF COLOMBIA

NATIONAL PLANNING DEPARTMENT (D.N.P.)

REGIONAL AUTONOMOUS CORPORATION OF QUINDIO (C.R.Q.)

THE FEASIBILITY STUDY ON THE QUINDIO BASIN INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT

FINAL REPORT (ANNEX)

JULY 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

(JICA)

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A.1 Characterization of the Republic of Colombia

A.1.1 General

The Republic of Colombia lies to the north-western edge of the South American Continent with the latitude 4 13'30"S - 12 26'46"N and the longitude 66 50'54"W - 79 02'33". The territorial extension is 1,142 thousand km2, which is divided into 23 departments, 4 intendancies and 5 commissaries.

According to topography and climate, the country can split up into six regions: Caribe, Pacific, Andean, Amazon, Eastern Plains and San Andres y Providencia. These regions are delimited by Eastern, Central and Western Mountain Ranges that stretch the country from north to south. Colombia, located in the torrid zone, has no clearly distinguished seasons. But it offers several different climates which vary depending on altitude. The hot region, from sea level to 1,000 m above sea level, has an average temperature of 24 to 26 C. Temperate zone with an altitude in the range of 1,000 - 2,000 m above sea level has an average temperature between 17 C and 24 C. The cold region, which altitude varies from 2,000m to 3,000 m above sea level is featured by an average temperature of 8 - 17 C. There are also perpetual snow region located higher than 4,000 m a.s.l.

A.1.2 Physical and Socioeconomic Features

Referring to the information of DANE (Colombia Estadistica, 1989), Colombia had a population of 30,062 thousand which had growing at an annual rate of 2.05% since 1973. The demographic growth for the previous inter-census period was 3.05% 1964-1973 and 3.24% 1951-1964 a year respectively. The distribution ofColombian

population by age group as of 1985 is as follows: 36.1% (0-14 years old), 57.9% (15-60 years old), and 6.0% (older than 60 years old). An economically active population (in Colombia people older than 12 years are taken into account) was estimated to be 19,336 thousand in 1985. The rate of unemployment in four largest cities of the country (Bogota, Medellin, Cali, and Barranquilla) was in the level of 10.7% as of March, 1989.

Colombian Gross Domestic Product (GDP) had grown at an average rate of 5.7% yearly in the 1970s, but from 1979 to 1983, as a consequence of world-wide recession, its growth was decelerated to as low as 2.2% per annum at constant price of 1975. Nevertheless, during subsequent period of 1984-1989, the Colombian economy recovered from the said sluggish performance obtaining an annual growth rate of 4.2%.

An estimate of DANE indicates that major sectors which contributed greatly to GDP formation in 1989 are: agriculture, forestry and fishery (21.7%), manufacturing (20.9%), personal and public services (13.5%), and commerce (11.6%). And higher annual increase was recorded during 1980 and 1988 in the order of: mining (18.8%), government service (4.9%), construction (4.7%) and electricity, gas and water (4.6%). Agriculture, forestry and fishery and manufacturing-the two core sectors of the Colombian economy-had been slack in the period obtaining such an inferior growth rate as 2.7 and 2.5% each. These figures are below GDP's average rate of 3.3%.

External trade in Colombia is represented by agriculture and mining products for exports and raw materials and capital goods for imports. From 1981 to 1984 , deficit in trade had been registered due to depressed price of coffee in the international market, but in 1985 the government's import control policy had driven the trade balance positive. Furthermore, the largest surplus in foreign trade of US$1,922 million was recorded in 1986 owing to "coffee bonanza"-sharp appreciation of international

price associated with worsened output of Brazilian products. This surplus in trade balance had been maintained from 1984 to 1989. In 1989, despite falling down of coffee's international price and although an economic adjustment program was employed by the Government of Venezuela, the trade surplus had been increased from the previous year due to an expansion of export for non-traditional products-petroleum and minerals as well as low demand for imports. The current balance, which comprises services and transfers in addition to trade of goods, resulted in negative in 1989 on account of substantial deficit in service balance. The balance of payment for the same year accounted for a surplus of US$57 million-reduced at approximately US$30 million from the previous year.

The net international reserve as of May 1990 was US$3,857 million, which is US$1,755 million fewer than the historically high level of 1981. The external debt has been increasing in Colombia with higher pace than the growth of GDP and the debt service ratio as of 1987 was estimated to be 67%.

Since 1967 the Government of Colombia has employed a crawling peg system, under which the exchange rate is set at the discretion of the Central Bank. An average exchange rate of Colombian peso against US dollar in September 1990 was 527.73. It is forecasted that, in par with the rate of inflation, the devaluation of Colombian peso against US dollar will exceed 30% for the year of 1990-the highest level since 1967 with an exception of 1985 when accounted for 46.9%.

Since the middle of the 1970s, a major concern of the Colombian government been directed toward braking an acceleration of inflation of consumer price. The rate of inflation, although it is by no means low, had been maintained in relatively modest level in comparison with other Latin American countries. Nevertheless, the annual rate of inflation was hiked to the record level in 1989 with 26.5% and it is predicted that this rate would

be further accelerated to exceed 30% in 1990. Faced with such situation, the Administration of the President Cesar Gaviria, which has just organized in August 1990, have announced that they would make efforts to lower the rate of inflation within the context of their policies and have decided to take measures for achieving this foal represented by freezing of supporting prices for agro-products and easing restriction on import of materials and goods.

A.1.3 Agricultural Aspects

(1) GDP and the agricultural sector

In 1989, according to the provisional estimates of DANE, the agricultural sector including forestry and fishery generated Col$152,025 million at the constant price of 1975, which is equivalent to 21.7% of the GDP. As stated in the previous section, the growth of the sector for the last decade had been lower than the average rate of the GDP. Consequently, the participation of the sector in the GDP declined from 38% in 1950 and 29% in 1970 to 22% in 1989.

(2) Land use and land tenure

It is estimated that about 14.4 million ha of land in Colombia, or equivalent to 12.6% of the national territory is arable for agricultural purpose, whereas land capable for pasture corresponds to 19.3 million ha (16.9% of the national territory). On the other hand, in 1988 crop harvest and grazing land areas accounted for 3.9 million and 22.6 million ha, which intimates that there remains considerable margin of arable land for expansion of agricultural production, and that some portion of these lands are actually used as grazing land without being realized intensified use.

Land tenure by size of holding in the national level is, like in

other Latin American countries, characterized by imbalanced distribution; small and medium land owners with holding below 10 ha represent 78% of the total number of owners but only 9% of the total rural lands, while 61% of the total rural lands are held by only 3% of land owners with holding more than 100 ha.

(3) Agricultural output

Coffee, the mainstay of the Colombian economy, accounted for close to 15% of the total value of crop production in 1989. Next to coffee, following crops registered higher contribution to the national production value of crops: sugarcane (9.4%), plantain (7.9%), potato (7.6%), "panela" (7.6%), and rice (7.6%).

Crops which showed a higher growth in production for the period of 1985-1989 are: soybean (170%), oil palm (169%), kidneybean (162%), fruits (147%), and potato (141%). Of these crops, the growth of soybean, oil palm and fruits are attributable to an expansion of harvest area, while an improvement of unit yield has brought an increase of production for the case of kidneybean and potato. On the other hand, a stagnation or recession in production was reported in connection with cotton, panela and sugarcane. The inactivity of these crops is due to sluggish performance of cultivated area.

(4) Trade in agricultural products

In 1988, the trade surplus of agricultural sector reached close to US$2 million. This surplus owned in its great majority to coffee; if coffee is exclude from consideration, the surplus in agricultural sector would be reduced to as little as US$355 thousand.

Up to 1960, the participation of coffee in the national exports had been more than 90% in value terms, but it had declined gradually thereafter and fluctuated around 50% in the period of 1982-1985

because of an expansion of exports other than agro-products. Despite this background, coffee's share was recovered up to 59% in 1986 attributable to upsurge of price in the international market. In contrast, in the subsequent years of 1987 and 1988, the contribution of coffee to the total exports was reduced to the lowest level (32.9% and 32.6%) in the history because of reverse phenomenon in the international market (coffee's price averaged US$1.43/pound in 1988 against US$1.96/pound in 1986).

So far as other agro-products are concerned, there has been a large increase in exportation of banana and cut flower, while cotton, sugar and beef have reduced their volume of exportation recently.

The importation of foods and agricultural-related materials and inputs accounted for 7.2 and 7.9% of the total imports in value terms for years 1988 and 1989, which were declined from an average rate (9.1%) for the previous four years 1984-1987. A drop of food and agriculture related materials and inputs in respect of their participation in the total inputs in both 1987 and 1988 is due to the government policy of import control. A single product which recorded the largest participation in the total import value of agro-products was wheat with a share of 21.2% in 1988; subsequently, soybean (15.7%), beef fat (6.2%) and soybean oil (4.2%) were much imported in the same year.

(5) Labor force

The agricultural sector provides the greatest opportunity of employment within the country's labor market; it accounted for 33% of the total employment in 1984-the latest year available this kind information. As the case of contribution to the GDP, the importance of the agricultural sector were reduced relatively in recent years; the participation of the sector, which recorded 56% of the nation's total employment in 1951, declined to 49% in 1964, 35% in 1980, and 33% in 1984, as sited above.

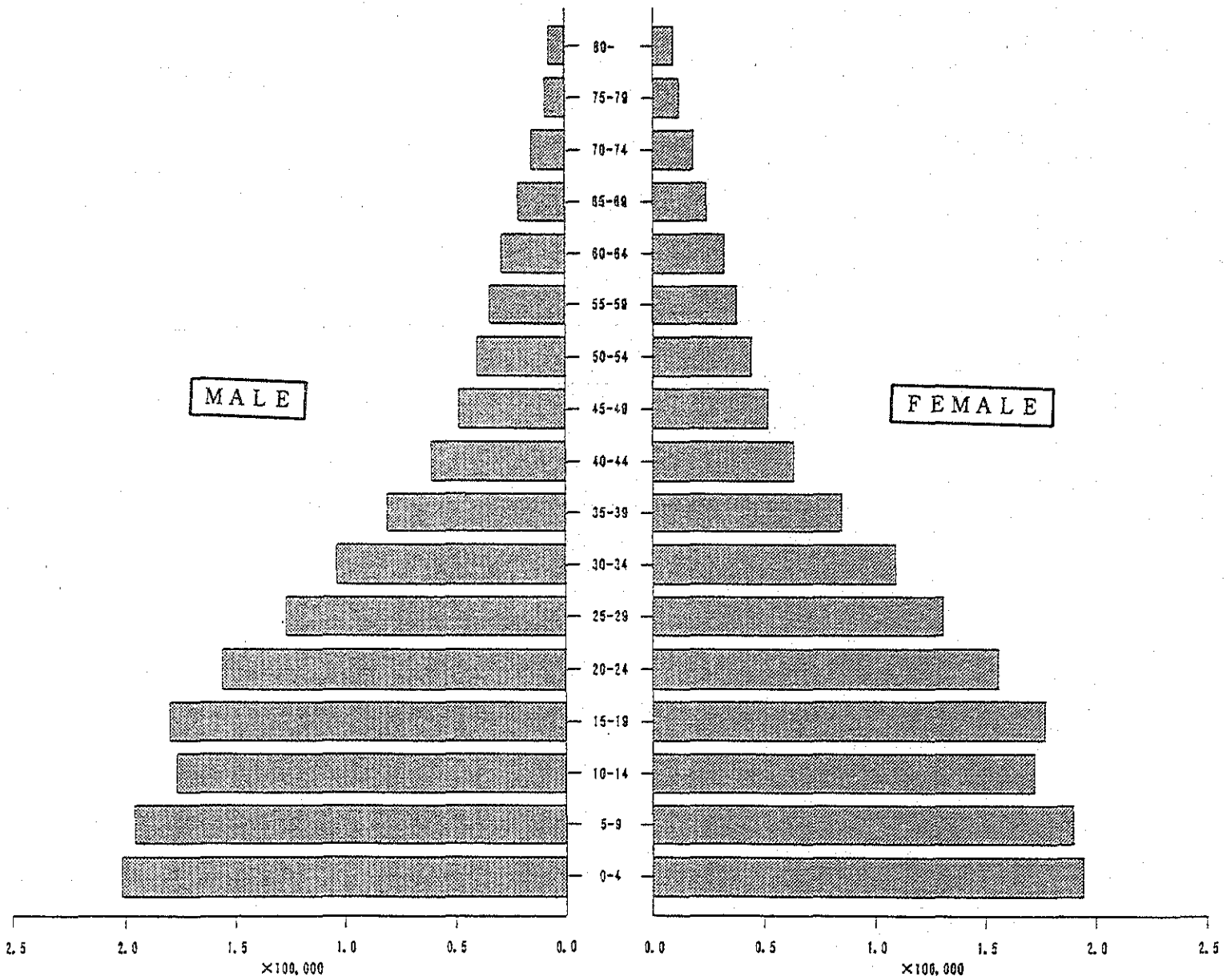

FIG A.1.1 POPULATION PYRAMID IN COLOMBIA (1985)

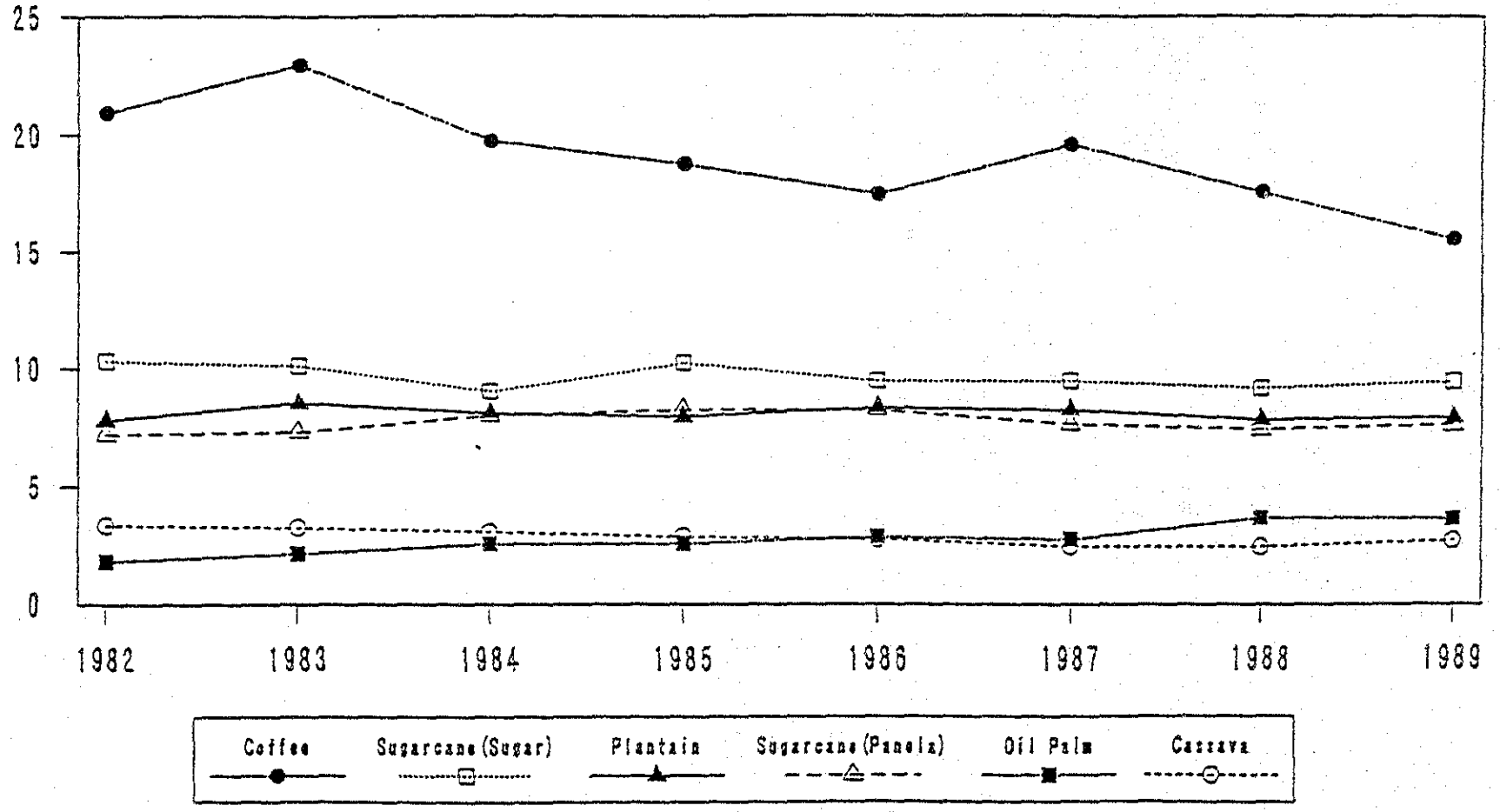

FIG. A.1.2 SHARE OF CROP'S PRODUCTION VALUE IN TOTAL VALUE OF AGRO-PRODUCTS (1)

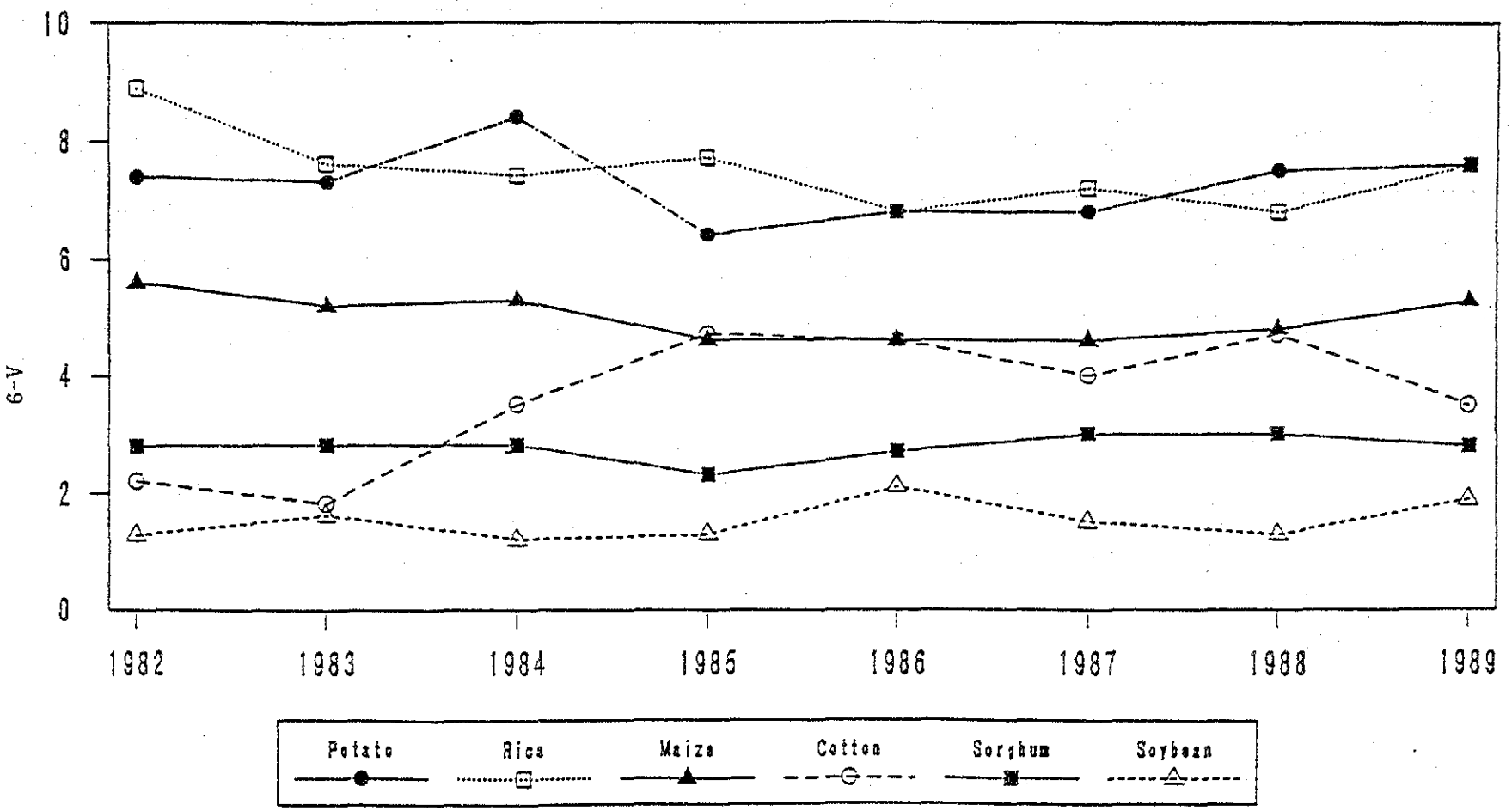

FIG. A.1.2 SHARE OF CROP'S PRODUCTION VALUE IN TOTAL VALUE OF AGRO-PRODUCTS (2)

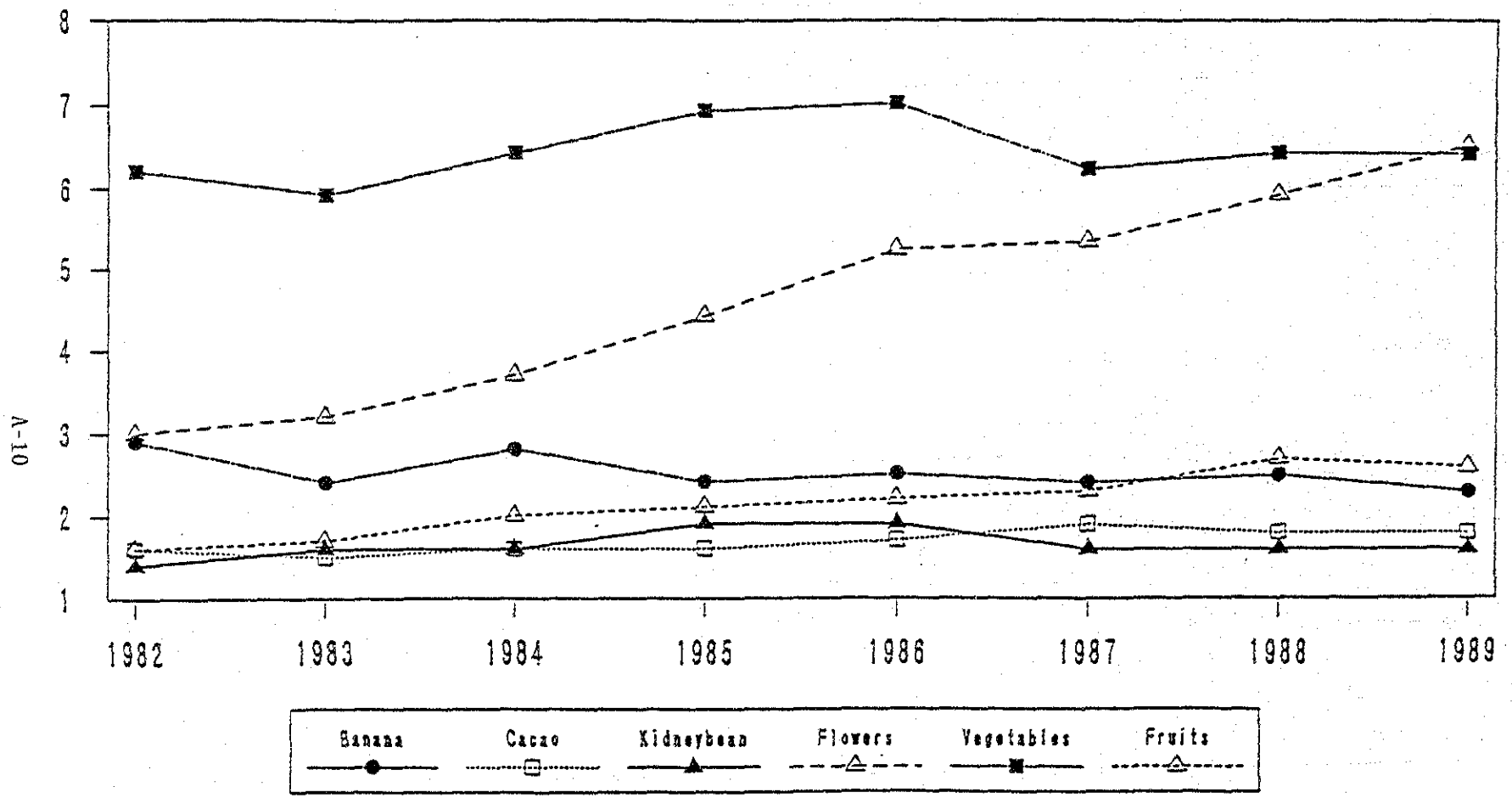

FIG. A.1.2 SHARE OF CROP'S PRODUCTION VALUE IN TOTAL VALUE OF AGRO-PRODUCTS (3)

Table A.1.1 POPULATION OF COLOMBIA

YEAR	POPULATION	ANNUAL GROWTH RATE (%)
1938	8,701,816	
1951	11,548,172	2.20 (1938-51)
1964	17,484,508	3.24 (1951-64)
1973	22,915,229	3.05 (1964-73)
1985	30,062,200	2.29 (1973-85)

Source: COLOMBIA ESTADISTICA 1989, DANE

Table A.1.2 CONTRIBUTION TO GDP AND GROWTH RATE BY SECTOR

	CONTRIBUTION TO GROSS DOMESTIC PRODUCT										GROWTH RATE		
Econimic Activities	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1980-1984	1985-1989	1980-1989
Agriculture, forestry and fishery	22.69%	22.90%	22.25%	22.52%	22.18%	21.86%	21.36%	21.56%	21.33%	21.67%	1.45%	4.30%	2.73%
Mining	1.27%	1.31%	1.32%	1.48%	1.75%	2.34%	3.74%	4.22%	4.17%	4.47%	10.55%	22.96%	18.80%
Manufacturing	22.38%	21.30%	20.80%	20.71%	21.24%	21.21%	21.23%	21.40%	21.09%	20.90%	0.71%	4.15%	2.47%
Electricity, gas and water	0.99%	1.00%	1.02%	1.02%	1.04%	1.04%	1.04%	1.08%	1.10%	1.12%	3.29%	6.37%	4.62%
Construction and public works	3.35%	3.51%	3.62%	4.02%	4.14%	4.36%	4.32%	3.69%	3.87%	3.79%	7.57%	0.93%	4.68%
Commerce, restaurant and hotels	12.68%	12.61%	12.69%	12.44%	12.28%	12.12%	11.87%	11.76%	11.86%	11.62%	1.22%	3.44%	2.26%
Transport and communications	9.32%	9.39%	9.87%	9.54%	9.56%	9.37%	8.94%	8.77%	8.71%	8.72%	2.69%	2.67%	2.50%
Banking, insurance, real estate and services to enterprize	13.97%	14.54%	14.86%	15.29%	14.35%	14.18%	13.98%	13.98%	14.21%	14.55%	2.71%	5.22%	3.72%
Personal services	4.91%	4.96%	5.03%	5.07%	4.95%	4.82%	4.73%	4.72%	4.66%	4.61%	2.25%	3.35%	2.53%
Government services	7.77%	8.04%	8.15%	7.87%	8.29%	8.39%	8.41%	8.55%	8.86%	8.97%	3.71%	6.29%	4.91%
Adjustment	0.66%	0.45%	0.39%	-0.06%	0.23%	0.31%	0.37%	0.28%	0.14%	-0.42%			
Gross Domestic Product	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	2.03%	4.53%	3.26%

Note: Calculation based on the constant price of 1975

Source: Revista de la Banco de la Republica, junio 1989

Table A.1.3 BALANCE OF PAYMENT

Unit: in million of US$

ITEM/YEAR	1983	1984	1985	1986	1987	1988(p)	1989(e)
I. CURRENT ACCOUNT	-2,826	-2,088	-1,586	463	-22	-356	-180
A. Trade Balance	-1,317	-404	109	1,922	1,460	824	1,252
Export	3,147	3,623	3,782	5,331	5,254	5,339	5,978
Import	4,464	4,027	3,673	3,409	3,794	4,515	4,726
B. Services Balance	-1,673	-1,983	-2,156	-2,244	-2,483	-2,145	-2,540
Financial Services	-739	-1,070	-1,202	-1,183	-1,692	-1,597	-1,838
Others	-934	-913	-954	-1,061	-791	-548	-702
C. Transfers	164	299	461	785	1,001	965	1,108
II. CAPITAL ACCOUNT	1,436	944	2,220	1,079	-9	1,086	524
A. Long-term Capital	1,528	1,822	2,350	2,629	185	851	690
B. Short-term Capital	-92	-878	-130	-1,550	-194	235	-166
III. RESERVE ADJUSTMENT	-67	20	-39	51	90	-70	27
IV. ERRORS AND OMISIONS	-266	-137	-311	-129	-82	-301	-314
CHANGE IN NET RESERVE	-1,723	-1,261	284	1,464	-23	359	57

Note: 1988(p): Provisional amount
1989(e): Estimated amount

Source: Revista del Banco de la Republica, December 1989

Table A.1.4 OFFICIAL EXCHANGE RATE OF COL$ AGAINST US$

MES / AÑO	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC	Devaluacion Anual %
1950	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	0.00
1951	1.96	1.96	2.15	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	28.06
1952	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	0.00
1953	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	0.00
1954	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	0.00
1955	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	0.00
1956	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	0.00
1957	2.51	2.51	2.51	2.51	2.51	2.51	4.81	4.90	5.12	5.10	5.20	5.39	114.34
1958	5.61	6.01	6.11	6.64	6.77	6.89	6.74	6.52	6.36	6.40	6.42	6.40	18.96
1959	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	0.00
1960	6.40	6.40	6.52	6.70	6.70	6.70	6.70	6.70	6.70	6.70	6.70	6.70	4.69
1961	6.70	6.70	6.70	6.70	6.70	6.70	6.70	6.70	6.70	6.70	6.70	6.70	0.00
1962	6.70	6.70	6.70	6.70	6.70	6.70	6.70	6.70	6.70	6.70	7.54	9.00	34.33
1963	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00
1964	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	0.00
1965	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	13.00	13.50	13.50	13.50	50.00
1966	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	0.00
1967	13.50	13.50	13.50	13.80	14.07	14.41	14.59	14.85	15.13	15.40	15.63	15.74	16.59
1968	15.77	15.84	15.94	16.06	16.19	16.27	16.31	16.39	16.49	16.62	16.76	16.86	7.12
1969	16.83	16.94	17.04	17.13	17.17	17.27	17.33	17.44	17.55	17.62	17.69	17.80	5.58
1970	17.90	18.06	18.09	18.20	18.28	18.38	18.48	18.55	18.68	18.82	18.92	19.03	6.91
1971	19.15	19.28	19.41	19.56	19.68	19.80	19.97	20.14	20.31	20.46	20.63	20.81	9.35
1972	20.99	21.17	21.33	21.50	21.67	21.82	21.96	21.09	22.25	22.39	22.53	22.70	9.08
1973	22.88	23.02	23.13	23.25	23.36	23.47	23.60	23.76	23.97	24.18	24.37	24.65	8.59
1974	24.95	25.22	25.42	25.50	25.54	25.58	25.64	25.81	26.28	27.01	27.56	28.26	14.65
1975	28.87	29.24	29.66	30.05	30.42	30.82	31.18	31.52	31.85	32.17	32.51	32.84	16.21
1976	33.10	33.49	33.79	34.10	34.45	34.65	34.89	35.20	35.25	35.41	35.81	36.20	10.23
1977	36.38	36.39	36.46	36.50	36.50	36.50	36.51	36.67	36.97	37.23	37.45	37.71	4.17
1978	38.03	38.14	38.33	38.49	38.66	38.81	38.95	39.11	39.45	39.97	40.40	40.79	8.17
1979	41.15	41.44	41.79	42.21	42.56	42.69	42.74	42.80	42.87	43.14	43.38	43.79	7.35
1980	44.16	44.68	45.32	45.82	46.44	47.10	47.52	48.02	48.56	49.23	49.93	50.56	15.46
1981	51.08	51.71	52.24	52.71	53.24	53.90	54.57	55.30	56.03	56.79	57.66	58.64	15.98
1982	59.50	60.24	60.99	61.82	62.63	63.52	64.25	65.18	65.98	66.99	68.34	69.59	18.67
1983	70.90	72.06	73.48	74.89	76.36	77.78	79.22	80.88	82.52	84.26	86.11	87.83	26.21
1984	89.79	91.57	93.46	95.42	97.46	99.40	101.73	103.73	105.93	108.13	110.43	112.76	28.38
1985	115.17	118.25	123.15	127.62	135.95	140.73	145.51	150.03	155.30	160.26	164.58	169.19	50.04
1986	173.70	176.59	179.74	184.43	188.53	192.35	195.80	199.17	203.24	208.05	212.56	216.97	28.24
1987	221.03	224.82	229.67	233.17	237.44	241.39	245.55	249.35	252.84	255.85	258.74	262.08	20.79
1988	265.82	270.91	276.92	283.45	289.56	296.36	302.36	308.40	314.85	321.07	327.01	332.97	27.05
1989	339.62	346.83	354.12	361.83	369.93	377.92	385.71	393.43	401.80	410.55	419.76	429.30	28.93
1990	440.08	451.72	463.40	474.62	485.99	497.31	508.35	519.94					

Table A.1.5 CONSUMER PRICE INDEX IN COLOMBIA

Base: Dec. 1988 = 100

MES / AÑO	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC	Inflac Anual %
1954							0.5694	0.5694	0.5694	0.5694	0.5694	0.5694	
1955	0.5694	0.5694	0.5694	0.5694	0.5694	0.5694	0.5694	0.5694	0.5694	0.5694	0.5694	0.5815	2.13
1956	0.5815	0.5815	0.5815	0.5815	0.5936	0.6057	0.6057	0.6057	0.6057	0.6178	0.6178	0.6178	6.25
1957	0.6299	0.6421	0.6542	0.6735	0.6784	0.7026	0.7268	0.7268	0.7390	0.7511	0.7511	0.7511	21.57
1958	0.7511	0.7632	0.7753	0.7874	0.7995	0.7995	0.7995	0.8116	0.8116	0.8116	0.8116	0.8116	8.06
1959	0.8238	0.8359	0.8359	0.8480	0.8601	0.8601	0.8722	0.8722	0.8722	0.8722	0.8722	0.8843	8.96
1960	0.8843	0.8843	0.8964	0.8964	0.9086	0.9086	0.9086	0.9086	0.9207	0.9207	0.9328	0.9449	6.85
1961	0.9449	0.9570	0.9691	0.9934	0.9934	1.0055	1.0055	0.9934	0.9812	0.9812	0.9934	0.9934	5.13
1962	1.0055	1.0055	1.0176	1.0297	1.0297	1.0297	1.0418	1.0418	1.0418	1.0418	1.0539	1.0660	7.32
1963	1.1024	1.1630	1.2235	1.2841	1.2962	1.3204	1.3326	1.3447	1.3568	1.3810	1.4052	1.4174	32.95
1964	1.4416	1.4416	1.4779	1.5143	1.5627	1.5870	1.5748	1.5506	1.5385	1.5264	1.5385	1.5385	8.55
1965	1.5627	1.5506	1.5749	1.5991	1.6233	1.6475	1.6475	1.6475	1.6596	1.6960	1.7202	1.7687	14.96
1966	1.7929	1.8050	1.8535	1.9140	1.9383	1.9262	1.9383	1.9262	1.9504	1.9746	1.9746	1.9867	12.33
1967	1.9988	2.0110	2.0352	2.0473	2.0594	2.0958	2.0958	2.0958	2.0958	2.1200	2.1200	2.1321	7.32
1968	2.1563	2.1563	2.1805	2.2169	2.2290	2.2411	2.2532	2.2532	2.2532	2.2653	2.2775	2.2775	6.82
1969	2.3017	2.2896	2.3139	2.3501	2.3744	2.3865	2.3986	2.3986	2.4228	2.4471	2.4592	2.4713	8.51
1970	2.4713	2.4713	2.4955	2.5319	2.5440	2.5682	2.5682	2.5561	2.5803	2.5803	2.6045	2.6288	6.37
1971	2.6772	2.7015	2.7257	2.7741	2.8105	2.8226	2.8589	2.8953	2.9195	2.9559	2.9922	3.0043	14.29
1972	3.0407	3.0649	3.1012	3.1497	3.1739	3.2103	3.2466	3.2587	3.3072	3.3799	3.4162	3.4283	14.11
1973	3.4647	3.5252	3.6464	3.7796	3.9613	3.9734	4.0461	4.0340	4.0825	4.0825	4.1915	4.2521	24.03
1974	4.3732	4.4822	4.6276	4.7486	4.8093	4.8578	4.9062	4.9062	4.9910	4.9910	5.2697	5.3666	26.21
1975	5.5241	5.6089	5.7542	5.9117	6.0207	6.0329	6.0813	6.0934	6.1782	6.1782	6.2751	6.3236	17.83
1976	6.4690	6.6143	6.7476	6.8808	6.9656	7.1352	7.3291	7.4260	7.5592	7.5592	7.8621	7.9469	25.67
1977	8.1286	8.4315	8.7707	9.4006	9.8125	10.1153	10.2122	10.1639	10.1880	10.1880	10.1880	10.2244	28.66
1978	10.3334	10.4909	10.8301	10.9997	11.2541	11.5448	11.5085	11.5206	11.5690	11.5690	11.9809	12.1142	18.48
1979	12.5139	12.7441	13.2650	13.5073	13.7980	14.1009	14.2099	14.4643	14.7793	14.9731	15.3365	15.6030	28.80
1980	15.7121	15.9059	16.2207	16.7175	17.2627	17.4323	17.6867	17.8442	18.1107	18.5226	18.8860	19.6492	25.93
1981	20.0611	20.6425	21.2240	21.7328	22.3022	22.9079	23.3319	23.6347	23.8043	24.0951	24.4706	24.8340	26.39
1982	25.2823	25.8395	26.4331	27.1115	27.8262	28.4441	28.8196	29.1709	29.6312	30.1885	30.5398	30.7942	24.00
1983	31.1213	31.4969	32.2116	33.1928	25.3065	34.2710	34.5496	34.5133	34.8040	35.3734	35.7489	35.9185	16.64
1984	36.4273	36.9119	37.5660	38.3050	38.8501	39.4679	39.9525	40.0979	40.5461	40.7763	41.6000	42.4844	18.28
1985	43.4414	44.7376	46.1307	47.4270	49.5712	50.4918	50.2011	49.9952	50.4313	50.8674	51.3762	51.9819	22.36
1986	53.6857	55.3617	56.5853	58.1238	57.7603	57.2879	57.2794	58.0814	58.9051	60.1226	61.3825	62.6423	20.51
1987	64.9889	66.3093	68.1058	69.6443	70.8315	71.5099	72.5891	72.7589	73.6444	75.0254	76.6148	78.0491	24.59
1988	80.3944	83.6362	86.0566	89.4231	90.9677	93.1507	94.4977	94.3209	94.9981	96.4845	97.8219	100.0000	28.12
1989	102.0300	106.2500	108.9000	111.6400	113.6000	115.1600	116.9500	118.5600	121.2200	122.1500	124.3200	126.1200	26.12
1990	130.2800	135.0600	138.9800	142.6900	145.6800	146.5300	150.5500	152.9400					

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Table A.1.6 CROP PRODUCTION IN COLOMBIA

CROPS	Cultivated Area(ha) 1985	1989	Variation (89/85)	Production Volume(t) 1985	1989	Variation (89/85)	Unit Yield(t/ha) 1985	1989	Variation (89/85)
Annual Crops									
Corn	540600	759200	1.40	762600	1043800	1.37	1.41	1.37	0.97
Rice	386400	515300	1.33	1798200	2101800	1.17	4.65	4.07	0.88
Sorghum	192300	223900	1.24	499400	695200	1.39	2.60	2.91	1.12
Cotton	196050	186900	0.95	339570	294500	0.87	1.73	1.58	0.91
Potato	139100	172500	1.24	1910360	2696700	1.41	13.73	15.63	1.14
Kidneybean	131864	132400	1.00	60400	97700	1.62	0.46	0.74	1.61
Soybean	54440	92600	1.70	104181	177400	1.70	1.91	1.92	1.00
Vegetables	97450	109570	1.12	1427740	1602800	1.12	14.65	14.63	1.00
Permanent Crops									
Plantain	357860	393530	1.10	2092540	2442870	1.17	5.85	6.21	1.06
Panela	228150	242880	1.03	1161200	1270500	1.09	4.92	5.23	1.06
Cassava	154200	174000	1.13	1367350	1541200	1.13	8.87	8.86	1.00
Cacao	91533	119440	1.30	998620	1115920	1.12	10.90	9.34	0.86
Sugarcane	109800	110350	1.01	1366892	1487490	1.09	12.45	13.48	1.08
Oil Palm	43840	69270	1.58	125250	211300	1.69	2.86	3.05	1.07
Fruits	37705	63500	1.68	666175	980600	1.47	17.67	15.44	0.87

Table A.1.7 TRADE OF AGROPRODUCTS

Unit : US$1,000

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
A. EXPORTS										
Coffee (a)	2.005.086	2.360.509	1.243.264	1.561.494	1.506.187	1.764.504	1.745.521	2.990.530	1.650.648	1.640.656
Banana	79.612	94.141	122.430	151.119	147.096	197.915	156.115	199.842	210.333	251.960
Cut Flower	68.179	97.016	108.573	111.482	120.557	129.492	132.054	148.532	145.033	188.043
Beef	28.083	15.590	12.871	45.386	30.529	10.520	6.228	17.389	22.981	7.553
Sugar	42.634	164.676	76.881	54.720	68.922	28.617	36.857	36.218	15.826	55.838
Cotton	37.951	82.291	93.419	26.515	23.062	48.095	59.472	44.672	46.706	64.032
Others	105.251	162.072	101.345	158.830	155.425	184.455	183.770	216.526	181.715	182.885
Total Agro-Products (b)	2.366.796	2.976.295	1.758.783	2.109.546	2.051.778	2.363.598	2.320.017	3.653.709	2.273.242	2.390.967
Total Exports (c)	3.300.443	3.945.058	2.956.400	3.094.967	3.080.392	3.483.140	3.551.886	5.107.936	5.024.422	5.026.371
(b)/(c)*100	71.7	75.4	59.5	68.2	66.6	67.9	65.3	71.5	45.2	47.6
(a)/(c)*100	60.8	59.8	42.1	50.5	48.9	50.7	49.1	58.5	32.9	32.6
B. IMPORTS										
Wheat	52.553	128.797	71.405	104.321	127.441	119.166	98.552	84.810	78.557	83.875
Soybean	-	-	-	-	27.018	24.473	34.785	9.585	39.168	-
Maize	8.671	30.389	15.234	17.175	11.133	1.384	4.692	4.800	208	5.491
Sorghum	483	26.153	1.635	8.440	26.666	6.649	11.807	6.105	-	2.807
Apple	8.892	12.890	12.204	13.763	15.434	6.678	4.683	8.141	10.701	14.699
Pea	5.315	10.247	9.700	10.119	12.388	2.478	6.997	6.563	10.900	9.003
Lentil	5.406	11.447	9.542	7.935	12.026	5.608	5.344	10.626	14.801	11.204
Crude Soybean Oil	46.454	52.423	10.235	75.821	47.809	49.511	34.649	27.158	13.306	16.884
Beef Fat	18.501	20.357	12.780	12.806	15.750	16.605	19.129	13.618	17.337	24.470
Others	148.075	112.601	242.960	141.982	71.961	203.157	162.873	160.630	119.764	226.547
Total Agro-Products (d)	294.350	405.304	385.695	392.362	367.626	435.709	383.511	332.036	304.742	394.980
Total Imports (e)	3.232.194	4.660.604	6.199.156	5.477.701	4.477.968	4.492.391	4.130.686	3.954.520	4.249.181	5.005.260
(d)/(e)*100	9.1	8.7	6.2	7.2	8.2	9.7	9.3	8.4	7.2	7.9
C. TRADE BALANCE OF AGRO-PRODUCTS										
(b)-(d)	2.072.446	2.570.991	1.373.088	1.717.184	1.684.152	1.927.889	1.936.506	3.321.673	1.968.500	1.995.987

A.2 The Department of Quindio

A.2.1 Location and Topography

The Department of Quindio is located in the western slope of the Central Range and is situated at 4°04' - 44' latitude N and 75°26' - 54' longitude W. Its territory covers approximately 70 km from North to South and approximately 40 km from East to West. The topography of Quindio can be divided into the following categories:

The Lower Area : This area can be found out western margin of the alluvial fan and ranges approximately from 900 m to 1,250 m above sea level. It extends along the La Vieja river which passes its western extreme and constitutes the boundary with the Department of Valle del Cauca. Undulated land, which is eroded by large and small rivers, can be found in this category, except around the lower part of the Quindio river.

The Coffee Area : This area extends from the western margin of the alluvial fan to eastern mountain foot ranging approximately from 1,250 m to 1,800 m above sea level. In this category, undulating land also can be found out but it is the most adequate area for the cultivation of coffee.

The Upper Area : This area extends from the eastern mountain foot to approximately 2,500 m above sea level. From the view point of meteorology, this category is limit area for agriculture.

The Mountain Area : This area is the mountain areas; they are found in land over 2,500 m above sea level.

The land areas and land elevations in the Department are given in Table A.2.1.

The Quindian climate is characterized by wet season (April-May and october-December) and dry season (January-February and June - August); an annual precipitation is averaged at around 2,000 mm and mean temperature, which depends on land elevation, varies from 3 to 22°C.

Table A.2.1 Area by Altitude

Altitude (m)	Area (km2)	Portion (%)
Lower than 1,000	11.0	0.6
1,000 - 1,500	674.1	34.6
1,500 - 2,000	416.5	21.4
2,000 - 2,500	258.6	13.3
2,500 - 3,000	205.8	10.6
3,000 - 3,500	166.5	8.5
3,500 - 4,000	205.5	10.5
4,000 - 4,500	7.4	0.4
Higher than 4,500	1.3	0.1
ToTal	1,946.7	100.0

(Source : The Master Plan Report)

A.2.2 Social Situation

The Department of Quindio was created in January 1966, being separated from "Old Caldas". The capital city of the department is Armenia and there are another 11 municipalities. According to the National Census conducted in 1985, Quindio had a total population of 378 thousand and half of which is represented by Armenia. Population growth averaged 1.2% yearly inter-census period of 1973-1985, which is inferior to that of the national average (2.5%). 81% of inhabitants in Quindio lived in the urban area in 1985.

Being endowed with natural resources (soil and climate) much suitable for agricultural production, especially for coffee,

Quindio is considered to be one of the most socio-economically developed departments in Colombia. The coverage of social infrastructure is as high as to be ranked 2nd for water supply and sewerage and 3rd for electricity in the national level, and as a consequence, families with unsatisfactory basic needs is the lowest (23.0%) among the country's 23 department-the national average including figures of the Special District of Bogota, Intendancies and commissaries is 39.5%. The literacy and university education rates are also high, but school attendance and house ownership rates are inferior to the country's average (refer to Table A.2.1). In spite of high level of achievement both economically and socially, it is no doubt that there exists marked disparity among sub-regions in Quindio, this is to say, between central or lower area comprising municipalities of Armenia, Calarca, Circasia, La Tebaida, Montenegro and Quimbaya and north-southern or higher area represented by municipalities of Buenavista, Cordoba, Filandia, Genova, Pijao and Salento. The first group corresponds to major coffee production zone with higher percentage of coffee area against total cropping acreage. Average farm size of second group is larger than that of the first group, but it is worth while to indicate that the greater portion of large farms of the second group is used for extensive grazing land without being realized better use of them under unfavorable climatic and topographic conditions.

An out-migration of people is a notable phenomenon in the north-southern area resulting in decrease of population for the period of 1973-1985. The coverage of social infrastructure and the education level corresponding to the said area in inferior to the central area of the Department.

A.2.3 Economic Performance

Similar to the case of the GDP, the Gross Regional Products (GRP) of Quindio is dominated by manufacturing and agricultural sectors, which accounted for 30% and 23% of the GRP in 1988 (DANE, Cuentas Regionales de Colombia). These two sectors are followed by

transport and communications and commerce, which shared 13% and 11% respectively. The agricultural sector had been the largest contributor of the GRP up to the first half of the 1980s, but its importance has been reduced recently: the sector's participation in the GRP declined from 37% in 1970, 32% in 1975, and 27% in 1980 to 23% in 1988.

Coffee is almost the only exportable product in the Department covering 99.4% of foreign exchange earning in 1989. Meanwhile, imports of goods flown to the Department are represented by spare parts for vehicles.

The economically active population reached 137,811 and unemployment rate was 5.0% (National Census in 1985). According with information of SENA, agricultural sector dominate the leading position in the departmental labor market with a participation of 46%, while the manufacturing sector-the other staple sector of the GRP accounted for as few as 6%.

A.2.4 Agricultural Production

(1) Permanent and annual crops

An agricultural production is dominated by coffee tillage which is cultivated in one-third of the total territory and more than 80% of the total area for crops.

The cultivated area of coffee passed from 59,839 ha (coffee period of 1984/85) to 66,820 ha (1987/88) and thanks to an elevated unit yield linked to an introduction of improved varieties (Colombia and Catura), the output was escalated in the period. Plantain's cultivated area had been maintained in almost the same level during 1985-1988; its independent plants had increased by 50% in the period, while plants inter-cropped with coffee or cultivated in a traditional manner had been decreased. Area for citrus was increased by 50% between 1985 and 1988 and that for cacao was quadrupled in the same period. In line with diversification

programs undertaken by the Bureau of Agriculture and Departmental Coffee Committee, cultivation of such permanent crops as pitahya, tree tomato, papaya, blackberry, and lulo has been started in the Department, but areas for these crops remain in negligible (0.5% of the total cultivated area).

Annual crops showed a declining tendency in terms of their cultivated area from 1985 (6,867 ha) to 1987 (4,000 ha), but they recovered dynamics a bit in 1988. The majority of this phenomenon is due to the behavior of cassava; the tillage of this crop is controlled by CRQ starting 1986 in view of conserving potential productivity of soils and cultivated area of the product shrunk from 3,000 ha in 1985 to only 1,055 ha in 1987 accordingly. In the presence of decline or stagnation in cultivated area of annual crops, only soybean attained growth in the corresponding period (from 473 ha to 1,348 ha).

In Quindio, beans other than soybean as well as vegetables are not cultivated, because marketing circumstances for these crops are unstable, and they are usually cultivated in coffee farms only when coffee's plants are small. Of these crops, tomato is the only crop with substantial cultivated area (373 ha in 1988).

(2) Livestock

The production of cattle in the Department has been consistent more or less in these years, although some increase both in number of heads and an extension of pasture were made in the period of 1983-1985. In 1985, the total acreage of pasture reached 68,000 ha and the number of head of cattle was 73,440, thus the carrying capacity was 1.08 head on the average.

There are two major areas of cattle farming in Quindio: on the valley of the Vieja River comprising municipalities of La Tebaida, Montenegro and Quimbaya for mainly meat production and the mountain area of Salento-Calarca-Pijao-Genova for mainly dairy production. In these two areas, close to three-quarters of the total number of cattle are kept.

The stagnation of cattle farming in Quindio is reflected in low level of productivity (an increase of live weight is as few as 400 kg in four or more years and production of milk is 883.3 l/head/year. Furthermore, birth and fecundity rates are interior and mortality rate is high; these circumstances have discouraged farmers to invest their resources into cattle farming. This problem is more outstanding in mountain area where adequate technology in under-developed.

According to information of Caja Agricola, a total of 15,260 heads of swine and 781,000 heads of poultry are kept in Quindio and these farmings are concentrated in the central zone of the region-in municipalities of Armenia, Calarca and Circasia.

In connection with pisciculture, there is only one fish farm in Salento where rainbow trout is cultivated in a commercial base. Annual output of the fish is estimated to be 36 tons and the product is sold in markets of Bogota, Medellin, Cali and other major cities of the country, and some portion is to U.S.A.

A.2.5 Agricultural Development Strategies and Plans

The "Agricultural Development Plan in Quindio 1987-1990" was prepared by the Regional Unit for Agricultural Planning (URPA) in June 1987. This Plan was presented in need of stimulating and orienting an agricultural sector-the leading sector for development of regional economy. In the same plan, a total of eighteen (18) programs and projects were proposed and some of which are carried out at present.

Despite it is expected that the same task should be continued for production of the next four-year (1991-1994) agricultural plan, it has not come true up to date, because of lack of both human and financial resources. Actually, URPA's activity is limited to editing an agricultural report which comprises no other information but statistics of the agricultural sector of the Department.

Although, as stated before, an integrated agricultural development has not been formulated in Quindio, various public agencies and guilds have taken plains in proposing and formulating agricultural development programs and projects for socio-economic growth of the Department. Of programs and projects facilitated by these agencies and guilds, the following may be highlighted.

1) Five-year Diversification Plan 1990-1994, Departmental Committee of Coffee Growers in Quindio

2) Agricultural Investigation Project, Bureau of Agriculture, Governmental Office of Quindio

The former pretends to develop programs other than coffee, in other word, to proceed with establishment of crop and livestock programs that may be developed within coffee farming zone; to be more concrete, the plan comprises four main programs (plantain, livestock, citrus and reforestation) answer in shorter period to the necessity and anxiety of agronomists and farmers in promoting and diversifying cropping activity of fruits and vegetables as well as animal husbandry in marginal zones for coffee tillage. Both plans coincide in such aspect that the success of diversification of farming activity relies its major portion of how adequately conduct investigation on crops and how efficiently transfer the result of investigation to farmers. Consequently, struggle shall be made for attaining these aspects.

Apart from those cited above, the Quindian leaders are aware that stagnation of the agricultural sector is due to an absence of better marketing infrastructure and less development of agro-industry. Under the circumstances, an "Agro-industry Promotion Committee" has been established with a participation of concerned organizations for development of the sector including universities of La Gran Colombia and Quindio. The committee is expected to formulate an agro-industry development plan for the Department of Quindio.

A.2.6 Natural Resources Improvement and Conservation Plan

In the Department of Quindio, improvement and conservation of natural resources is in charge of CRQ which received delegation from INDERENA (Colombian Institute for Natural Resources and Environment) in such duties as reforestation, conservation of soils and water, control of erosion, and promotion of pisciculture and ecological education. In this context, CRQ has been developed and undertaken programs related to conservation of natural resources and environment. In addition, in 1984 CRQ was nominated as "Water Resources Management Agency" to be responsible for control of contaminated and polluted water. As a consequence, CRQ has developed programs to control industrial affluents and domestic sewage and to investigate on treatment of coffee-related waste water. Regarding coffee-related waste water, CRQ has been realized since 1978 an investigation on easing the problem, and after attempting various field and laboratory test, two pilot plant have been installed in the farm within the Department in 1989.

Through initiative of CRQ "Five-year Action Plan of Natural Resources and Environment 1989-1993" which includes programs for conservation of water, soil, forest and animals is under way. Water resources conservation program of the plan envisages to formulate and develop plan for recovery and conservation of water resources that will aim at treatment of domestic, agro-industrial and industrial sewage.

Table A. 2. 2 Socio-Economic Index of the Department of Quindo

Item		Quindio/ Colombia	Rank	National Average
Area	1,947 km2	0.2%	24	-
Population	377,860	1.36%	21	-
Unemployment	8.1%	-	14	9.3%
Birth rate	23.1%	-	-	25.0%
Fertility rate	1.9%	-	-	2.0%
Infaant mortality	19.0%	-	(Lowest) 1	-
Literacy rate	91.6%	-	3	87.8%
School attendancy	50.7%	-	12	53.1%
University education	4.5%	-	3.5	4.4%
Water supply (1)	93.6%	-	2	70.2%
Electricity (2)	96.2%	-	3	76.2%
Sewage (3)	87.2%	-	2	59.2%
(1)+(2)+(3)	84.7%	-	2	56.6%
House ownership	54.6%	-	24	67.6%
Coffee area (a)	61,950 ha	6.1%	8	-
Area:Catura+Colombia(b)	28,891 ha	8.4%	4	-
(b)/(a)	46.6%	-	4	34.1%
Volume of Production	798,308Carga	8.9%	5	-
Unit yield (carga/ha)	12.89	-	1	8.85

Source: CENSO 1985, URPA

Table A.2.3 Socio-Economic Data by Municipality

	Armenia	B/vista	Calarca	Circasia	Cordoba	F/dia	Genova	La T/da	M/negro	Pijao	Q/vaja	Salento
Total Population												
% of rural Population *	2.7	61.2	22.7	33.9	43.0	56.5	47.9	8.6	18.1	41.2	24.8	55.3
Population Density (Person/km2)	1,910.6	80.0	245.9	241.3	38.0	111.7	31.4	261.0	222.0	36.3	271.0	16.1
Average No. of Familiy Member	4.4	5.9	5.0	4.6	4.6	4.4	4.4	5.1	4.5	5.0	4.8	4.4
Population Growth Rate	1.85	-1.70	0.10	2.43	-4.53	-0.07	-1.90	1.72	1.22	-1.06	0.73	-1.25
Literacy Rate **	88.1	88.3	85.1	85.3	86.0	89.1	88.6	91.3	88.4	77.7	86.2	78.4
% of Family without Social Infra. **	0.6	3.1	1.2	2.9	6.6	3.3	5.4	4.3	1.5	2.5	1.7	13.7
Avrage Farm Size (ha)	6.4	9.8	9.1	5.3	20.7	6.0	24.4	18.0	11.6	29.6	8.2	41.7
Coffee Area/ Total Area ***	0.80	0.70	0.41	0.44	0.31	0.52	0.19	0.38	0.49	0.24	0.72	0.03

Source : Quindio Estadistico 1984-1987
* : Planeacion Departamental del Quindio para 1990
** : Censas 1985
*** : Comite Departamental de Cafeteros

ANNEX B :

METEOROLOGY AND HYDROLOGY

ANNEX B : METEOROLOGY AND HYDROLOGY

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ANNEX B : METEOROLOGY AND HYDROLOGY

B.1 INTRODUCTION

B.1.1 The Objective of The Study

The objective of the study is to learn the meteorological and hydrological conditions prevailing in the study areas of the Quindio Basin Integrated Agricultural Development Project for formulation of the development plan, and carry out the analysis for the design of basic dimensions of facilities.

B.1.2 Summary of Meteorology

The meteorological conditions in the study areas can be summarized as follows:

Table B.1.1 Summary of Meteorological Conditions

Study Area	Altitude (m)	Annual Rainfall (mm)	Temperature Mean (C)	Max. (C)	Min. (C)	Relative Humidity (%)
Circasia	1,600-1,900	2,800	15	16	14	72
Salento	1,600-2,100	2,300	18	22	14	72
Quindio Right	1,000-1,200	2,000	22	31	13	80
Quindio Left	1,000-1,200	2,100	22	28	17	77
Pijao	1,600-2,200	2,200	18	23	15	75
Genova	1,400-2,200	1,600	18	23	15	75

B.1.3 Summary of Hydrology

For each study area, the annual rainfall, the effective rainfall the maximum 24 hour rainfall, the continuous drought days, the drought river discharge, the mean river discharge, the flood discharge, etc. were analyzed and each value was estimated for 2,5,10 and 20 year return period. The results are shown in Table B.1.2.

Table B.1.2 Summary of the Result of the Hydrological Analyses (1)

Return Period	1/2	1/5	1/10	1/20
Circasia Area				
Annual Rainfall (mm)	2,855	2,466	2,283	2,145
Effective Rainfall (mm)	1,234	1,204	1,185	1,168
Number of Rain days (days)	248	228	218	211
Continuous Droughty Days (days)	13	18	22	25
Maximum 24 hour Rain (mm/day)	85	100	109	117
(The Roble River at the Bridge, Catchment Area 50.40 km2)				
Droughty Discharge (m3/s)	0.452	0.300	0.243	0.215
Mean Discharge (m3/s)	1.885	1.552	1.320	1.204
Flood Discharge (m3/s)	153.2	189.4	212.0	232.5
Salento Area				
Annual Rainfall (mm)	2,218	1,896	1,746	1,632
Effective Rainfall (mm)	1,149	1,102	1,074	1,046
Number of Rain Days (days)	136	105	92	82
Continuous Drought Days (days)	20	25	28	30
Maximum 24 hour Rain (mm/day)	92	122	141	159
(The Dos Quebrados River at the Bridge, Catchment Area 7.44 km2)				
Droughty Discharge (m3/s)	0.067	0.044	0.036	0.032
Mean Discharge (m3/s)	0.278	0.229	0.195	0.178
Flood Discharge (m3/s)	36.2	52.3	63.1	73.8

Table B.1.2 Summary of the Result of the Hydrological Analyses (2)

Return Period	1/2	1/5	1/10	1/20
Quindio River Right Margin Area				
Annual Rainfall (mm)	2,052	1,708	1,551	1,434
Effective Rainfall (mm)	1,186	1,118	1,076	1,039
Number of Rain Days (days)	155	135	125	118
Continuous Droughty Days (days)	19	24	27	30
Maximum 24 hour Rain (mm/day)	82	100	111	121
(The El Cantaro River at the junction with the La Jaramilla River, Catchment Area 13.63 km2)				
Droughty Discharge (m3/s)	0.122	0.081	0.066	0.058
Mean Discharge (m3/s)	0.510	0.420	0.357	0.325
Flood Discharge (m3/s)	50.8	65.8	75.4	84.4
(The Cristales River at the junction with the La Vieja River, Catchment Area 91.95 km2)				
Droughty Discharge (m3/s)	0.826	0.547	0.443	0.392
Mean Discharge (m3/s)	3.439	2.833	2.409	2.198
Flood Discharge (m3/s)	69.7	81.2	87.8	93.5
(from the result of the Master Plan)				
Quindio River Left Margin Area				
Annual Rainfall (mm)	2,104	1,806	1,666	1,561
Effective Rainfall (mm)	996	858	793	744
Number of Rain days (days)	192	170	160	152
Continuous Droughty Days (days)	16	22	27	31
Maximum 24 hour Rain (mm/day)	81	91	97	102
(La Picota River at the junction with the Quindio River, Catchment Area 27.66 km2)				
Droughty Discharge (m3/s)	0.248	0.165	0.133	0.118
Mean Discharge (m3/s)	1.039	0.852	0.725	0.661
Flood Discharge (m3/s)	88.6	103.1	112.1	119.7
(The small stream at the junction with the Quindio River, Catchment Area 0.73 km2)				
Droughty Discharge (m3/s)	0.007	0.005	0.004	0.003
Mean Discharge (m3/s)	0.027	0.022	0.019	0.017
Flood Discharge (m3/s)	4.7	5.5	5.9	6.3

Table B.1.2 Summary of the Result of the Hydrological Analyses (3)

Return Period	1/2	1/5	1/10	1/20
Pijao Area				
Annual Rainfall (mm)	2,234	1,926	1,779	1,667
Effective Rainfall (mm)	1,092	957	893	844
Number of Rain Days (days)	191	169	159	150
Continuous Drought Days (days)	21	28	33	38
Maximum 24 hour Rain (mm/day)	82	100	111	121
(The Lejos River at the Bridge, Catchment Area 17.77 km2)				
Droughty Discharge (m3/s)	0.160	0.106	0.086	0.076
Mean Discharge (m3/s)	0.665	0.547	0.466	0.425
Flood Discharge (m3/s)	62.4	81.5	91.4	94.5
Genova Area				
Annual Rainfall (mm)	1,618	1,321	1,118	1,089
Effective Rainfall (mm)	834	711	655	611
Number of Rain Days (days)	124	100	90	82
Continuous Droughty Days (days)	26	36	43	50
Maximum 24 hour Rain (mm/day)	67	87	100	112
(The Tamborales River at the Bridge, Catchment Area 9.24 km2)				
Droughty Discharge (m3/s)	0.083	0.055	0.045	0.039
Mean Discharge (m3/s)	0.346	0.285	0.242	0.221
Flood Discharge (m3/s)	28.5	40.1	48.0	55.7

B.2 Available Data

Following 17 meteorological stations were selected from 50 meteorological stations which exist in quindio for the study, considering there location and the accuracy of the data.

Circasia : Villadora(14),Bremen(7),La Ilusion(31),Amazonas(41)
Salento : Salento(49),Cocora(2)
Quindio Right : El Eden(47),La Milanda(35),La Argentina(25)
Tebaida(6),La Bella(22)
Quindio Left : El Provenir(33),Paraguaycito(23)
Pijao : Cordoba(19),La Esperanza(34),Pijao(48)
Genova : Gibraltar(17),Villa Horizaba(42)

From the result of detailed study, following stations were selected for the analyses of the study area.

Table B.2.2 Meteorological Stations

Study Area	Rainfall	Temperature	Related Humidity
Circasia	Amazonas	Bremen	Bremen
Salento	Salento	Salento	Bremen
Quindio Right	El Eden	El Eden	El Eden
Quindio Left	Paraguaycito	Paraguaycito	Paraguaycito
Pijao	Pijao	Gibraltar	Gibraltar
Genova	Gibraltar	Gibraltar	Gibraltar

There are nine(9) hydrological stations in the Quindio, and following stations were selected for the anaryses, considering locations:

Alambrado : La Vieja River (Catchment Area 1,624km2)
Qebrada Cristales : Cristales River(Catchment Area 28km2)
Rio Quindio Parte Abajo : Quindio River (Catchment Area 387km2)
Rio Verde : Verde River (Catchment Area 84km2)

Table B.2.1 Meteorological Stations in the Quindío (1)

Station	Location LAT.	LONG.	ALT.	Type	Record 1950	1960	1970	1980
1. La Española	04° 34'	75° 51'	975	M				
2.Cocora	04° 38'	75° 31'	2500	M				
3.Uni.Quindío	04° 33'	75° 40'	1551	M				
4.Laboratorio	04° 33'	75° 40'	1585	M				
5.La Avenida	04° 33'	75° 40'	1550	M				
6.Tebaida	04° 27'	75° 47'	1200	M				
7.Bremen	04° 39'	75° 37'	2000	M				
8.Gobernación	04° 32'	75° 41'	1551	P				
9.Filandia	04° 40'	75° 39'	1800	P				
10.San Rafael	04° 31'	75° 38'	1600	P				
11.La Picota	04° 39'	75° 28'	2780	P				
12.El Tunel	04° 27'	75° 35'	2600	P				
13.Buenos Aires	04° 32'	75° 35'	2480	P				
14.Villadora	04° 38'	75° 37'	1900	P				
15.La Albania	04° 28'	75° 42'	1340	P				
16.Planadas	04° 29'	75° 37'	2350	P				
17.Gibraltar	04° 13'	75° 47'	1650	P				
18.Navarco	04° 29'	75° 34'	2800	P				
19.Córdoba	04° 23'	75° 42'	1490	P				
20.Barragán	04° 20'	75° 47'	1180	P				
21.El Sena	04° 32'	75° 40'	1550	M				
22.La Bella	04° 31'	75° 40'	1450	M				
23.Paraguaycito	04° 23'	75° 44'	1250	M				
24.El Bremen	04° 40'	75° 37'	2040	P				
25.La Argentina	04° 26'	75° 46'	1200	P				

Note : The location of the stations is approximate.
P=Rainfall Station M=Meteorological Station
LAT.=Latitude LONG.=Longitude ALT.=Altitude

Table B.2.1 Meteorological Stations in the Quindío (2)

Station	Location LAT.	LONG.	ALT.	Type	Record 1950	1960	1970	1980
26.Vivero	04° 37'	75° 46'	1400	P				
27.Maracay	04° 36'	75° 46'	1450	M				
28.Yolanda	04° 37'	75° 47'	1320	P				
29.El Rocio	04° 34'	75° 46'	1250	P				
30.El Agrado	04° 28'	75° 49'	1350	P				
31.La Ilusión	04° 36'	75° 39'	1500	P				
32.Tucuman	04° 32'	75° 44'	1250	P				
33.El Porvenir	04° 19'	75° 45'	1540	P				
34.La Esperanza	04° 21'	75° 45'	1400	P				
35.La Miranda	04° 26'	75° 50'	1220	P				
36.Monaco	04° 24'	75° 40'	1300	P				
37.Quebradanegra	04° 31'	75° 38'	1500	P				
38.El Paraiso	04° 30'	75° 42'	1400	P				
39.Sorrento	04° 32'	75° 51'	1290	P				
40.La Pradera	04° 28'	75° 43'	1350	P				
41.Amazonas	04° 38'	75° 39'	1750	P				
42.Villa Horizaba	04° 12'	75° 44'	1540	P				
43.Pueblo Tapao	04° 34'	75° 47'	1250	P				
44.Pisamal	04° 26'	75° 48'	1050	M				
45.Sevilla	04° 16'	75° 55'	1540	M				
46.Alcalá	04° 40'	75° 48'	1320	M				
47.El Edén	04° 27'	75° 46'	1204	M				
48.Pijao	04° 20'	75° 42'	1625	P				
49.Salento	04° 38'	75° 34'	1895	P				
50.El Alambrado	04° 24'	75° 52'	1100	P				

Note : The location of the stations is approximate.
P=Rainfall Station M=Meteorological Station
LAT.=Latitude LONG.=Longitude ALT.=Altitude

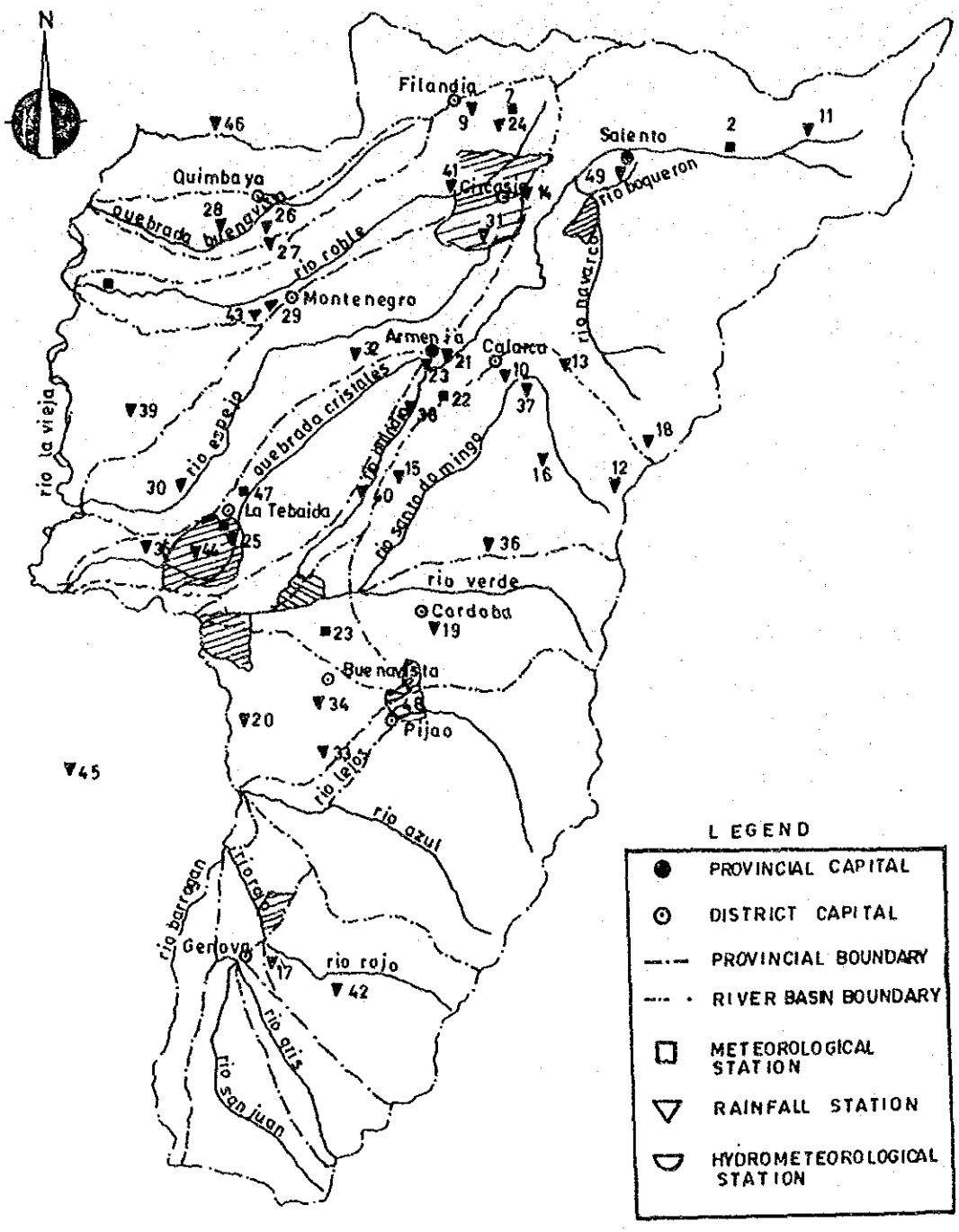


Fig. B.2.1 Hydrometeorological Stations in the Quindío

The river discharge has been observed since 1974 at the Alambrado Bridge over the La Vieja river, and since 1986 at the Cristales, Quindio and Verde rivers.

B.3 Meteorology

B.3.1 Rainfall

The average annual rainfall from approximately 1,600 mm to 2,600 mm are observed in the study area and generally, two dry periods (January-February and June-August) and wet periods (April-May and October-November) are shown in the annual rainfall pattern. The rainfalls in the study areas are Summarized below:

Table B.3.1 Summary of Rainfall in the Study Area (mm)

Area	Circasia	Salento	Quindio Right	Quindio Left	Pijao	Genova
Station	Amazonas	Salento	El Eden	Paraguay-cito	Pijao	Gibraltar
Altitude(m)	1,750	1,895	1,204	1,250	1,625	1,650
Jan.	246	143	120	135	179	105
Feb.	210	196	138	124	179	115
Mar.	276	180	176	198	182	156
Apr.	282	277	235	280	259	172
May	269	201	212	224	190	166
Jun.	140	113	135	97	94	99
Jul.	111	67	96	67	77	55
Aug.	138	72	114	99	91	78
Sep.	207	141	169	161	133	130
Oct.	393	338	241	299	307	248
Nov.	348	310	284	283	304	180
Dec.	188	239	150	170	226	121
Annual	2,807	2,276	2,083	2,137	2,220	1,625

B.3.2 Temperature

Mean temperature do not vary considerably throughout the year. The mean maximum and minimum temperatures have a tendency to vary daily depending on the influence of the isolation and rainfall. The difference between the mean maximum and mean minimum temperatures is comparatively large in low altitude areas, and becomes smaller the altitude increases. Temperature in the study areas area summarized below:

Table B.3.2 Summary of Temperature in the Study Area (C)

Area	Circasia			Salento			Quindio Right		
Station	Bremen			Salento			El Eden		
Altitude(m)	2,000			1,895			1,204		
	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.
Jan.	17.0	15.5	13.7	22.5	17.6	13.4	31.2	22.2	12.7
Feb.	16.5	15.2	13.8	22.7	18.2	13.9	31.3	22.2	13.0
Mar.	16.9	15.9	14.9	22.9	18.4	13.7	31.6	22.3	13.0
Apr.	16.3	15.5	14.7	22.3	17.2	14.8	30.8	21.8	13.2
May	13.6	15.1	12.9	22.6	19.5	14.7	30.3	21.9	14.0
Jun.	15.8	14.9	14.4	22.7	19.3	14.2	30.1	21.9	13.3
Jul.	17.1	15.9	14.8	23.2	18.3	13.9	31.2	22.2	12.6
Aug.	16.9	15.8	14.6	22.6	18.2	14.4	31.7	22.3	12.4
Sep.	16.5	15.4	14.6	22.5	17.8	14.3	31.0	21.9	13.5
Oct.	15.7	14.8	14.1	21.7	17.5	14.4	30.5	21.3	12.6
Nov.	15.7	15.0	14.3	21.7	17.5	14.3	29.8	21.2	13.3
Dec.	16.3	15.0	14.2	21.8	17.5	13.4	30.8	21.7	13.1
Annual	16.2	15.3	14.3	22.4	18.1	14.1	30.9	21.9	13.1

Area	Quindio Left			Pijao,Genova		
Station	Paraguaycito			Gibraltar		
Altitude(m)	1,250			1,650		
	Max.	Mean	Min.	Max.	Mean	Min.
Jan.	28.4	21.6	16.5	23.9	19.0	14.3
Feb.	28.5	21.9	16.9	23.4	19.2	14.6
Mar.	28.7	21.9	17.2	23.3	18.7	14.1
Apr.	28.0	21.7	17.4	22.5	18.6	15.5
May	27.5	21.5	17.4	22.5	18.4	15.0
Jun.	27.7	21.6	17.2	22.6	18.5	15.0
Jul.	28.6	22.0	16.7	22.2	18.5	15.1
Aug.	28.5	22.0	16.7	22.1	18.6	15.1
Sep.	28.0	21.5	16.7	21.5	17.6	14.6
Oct.	27.2	20.9	16.8	21.5	17.8	14.7
Nov.	27.2	21.0	16.9	22.5	18.1	14.6
Dec.	27.7	21.3	16.8	22.3	18.3	14.0
Annual	28.0	21.6	16.9	22.5	18.4	14.7

B.3.3 Relative Humidity

The relative humidity in the Quindio is generally high, with an annual average of approximately 70%-80%, and variation in the relative humidity is not much depending on the location. Seasonal variation in the relative humidity has a tendency to vary by more or less than 5% between the dry and wet periods, but is not much. The relative humidity in the study areas are summarized below:

Table B.3.3 Summary of Relative Humidity in the Study Area (%)

Area	Circasia, Salento	Quindio Right	Quindio Left	Pijao, Genova
Station	Bremen	El Eden	Paraguaycito	Gibraltar
Altitude(m)	2,000	1,204	1,250	1,650
Jan.	71.4	78.0	75.9	73.0
Feb.	69.8	79.0	74.8	72.0
Mar.	74.6	78.0	75.8	72.5
Apr.	72.3	82.0	79.1	77.0
May	71.5	82.0	80.7	76.0
Jun.	71.5	81.0	78.9	76.5
Jul.	76.2	78.0	74.0	73.5
Aug.	74.8	78.0	74.1	74.5
Sep.	70.3	79.0	76.8	75.5
Oct.	69.1	82.0	80.2	78.5
Nov.	68.6	82.0	80.3	77.0
Dec.	71.5	81.0	78.4	75.0
Annual	71.8	80.0	77.4	75.0

B.3.4 Evaporation

An approximate evaporation of 300-400 mm/year is stated in the data of Paraguaycito station. However, this value is too low to be applied with no consideration. Based on the rough estimates from the data of river discharge and rainfall, evaporation in this area is estimated to be approximately 1,000 mm/year. Therefore, it will be necessary to rectify the data or verify the methods of observation. The comparison of the evaporation data with the potential evapotranspiration calculated by CENICAFE(Garcia-Lopez Method) is as shown below;

Table B.3.4 Evaporation Data and Potential Evapotranspiration in Paraguaycito (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
EVP	36	42	42	29	31	29	40	39	39	34	28	31	420
ETP	120	104	118	104	101	108	115	115	107	103	97	107	1,299

Note EVP : Evaporation
ETP : Potential Evapotranspiration

B.3.5 Duration of Bright Sunshine

The duration of bright sunshine in Quindio is approximately 1,500-2,000 hours/year. The seasonal pattern of the dry period and the wet period at some stations are clear from the data. The duration of bright sunshine in the morning is shorter than that in the afternoon. Considering the location of the Quindio, this phenomenon may show a tendency of more cloudy in the morning than in the afternoon, in general. The monthly durations of bright sunshine at stations near the study areas are as shown below:

Table B.3.5 Duration of Bright Sunshine (hours)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
I	160	127	123	107	112	135	171	160	140	96	92	122	1,545
II	197	164	150	134	133	148	183	170	144	149	138	162	1,862

Note I : Cocora (Altitude 2,500m) II : Paraguaycito (1,250m)

B.3.6 Wind Speed

From the data of wind speed over the Paraguaycito Station, the wind speed in the Quindio may be estimated as 0.86 m/s (N.W.) in the daytime and 0.33 m/s (S.W.) in the nighttime. The maximum wind speed may be considered to be from approximately 15 to 20 m/s. However, due to a lack of the wind data, it is difficult to find out wind characteristics over all areas of the study area.

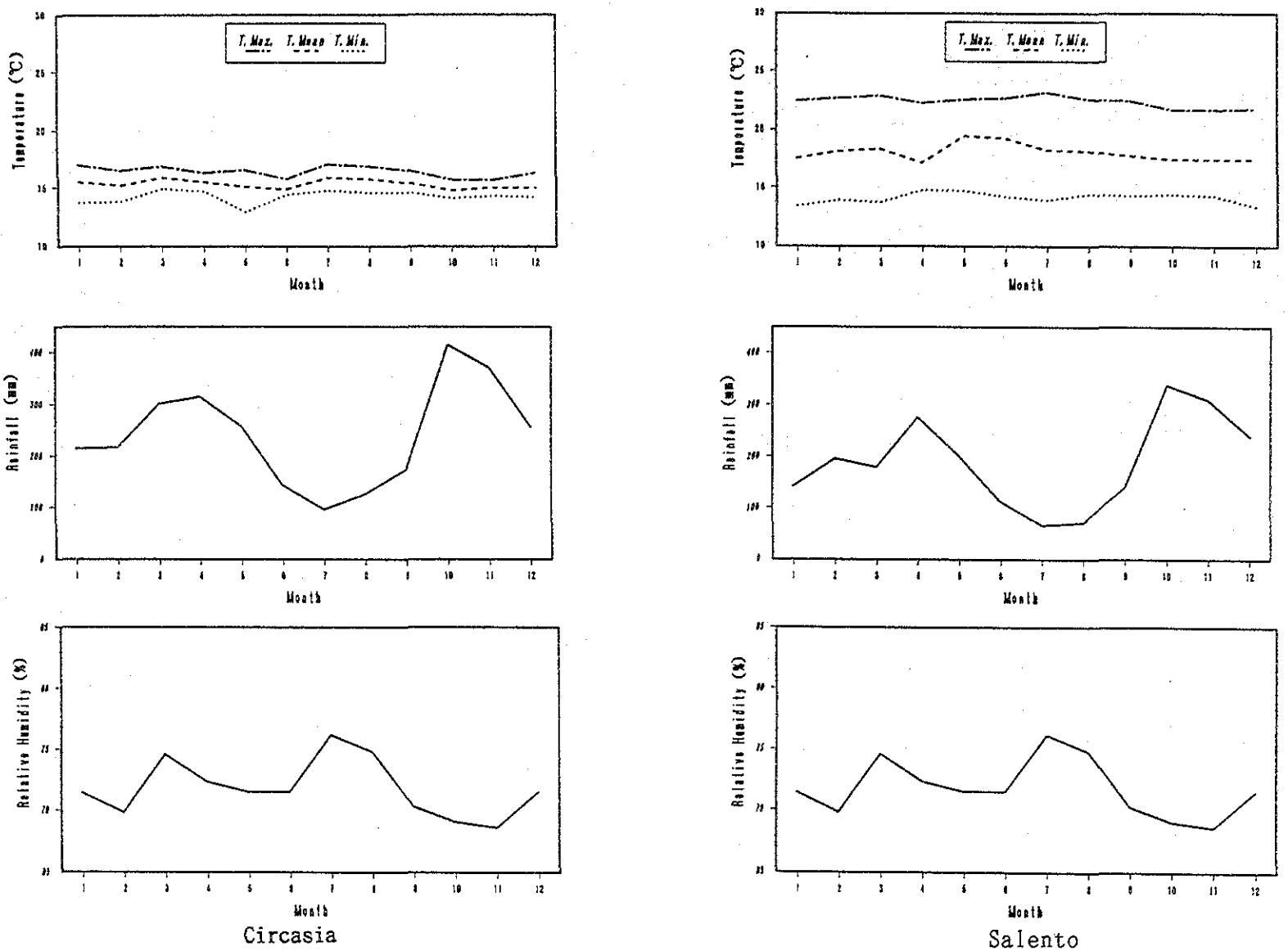


Fig. B.3.1 Meteorological Condition in the Study Area (1)

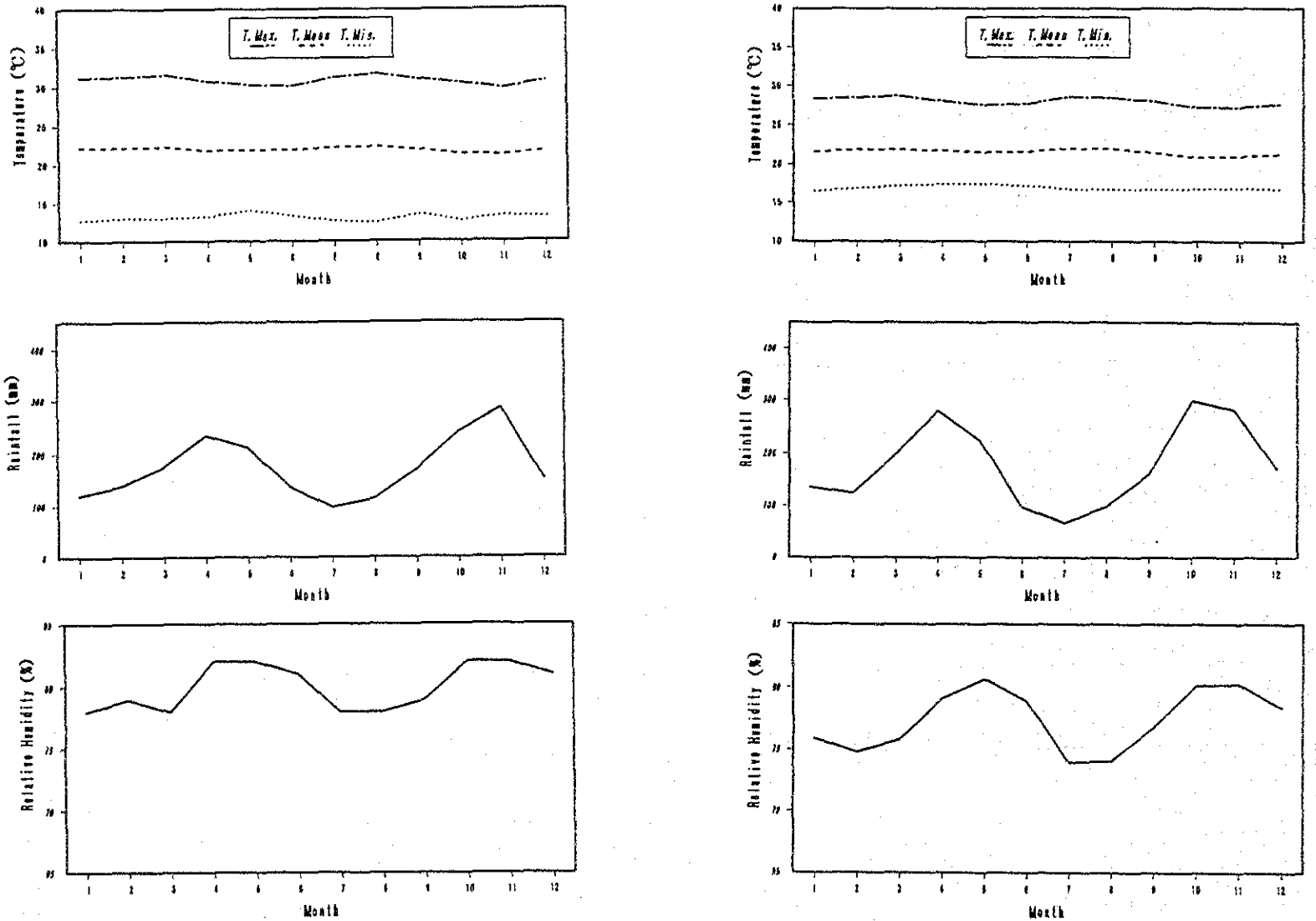


Fig. B.3.1 Meteorological Condition in the Study Area (2)

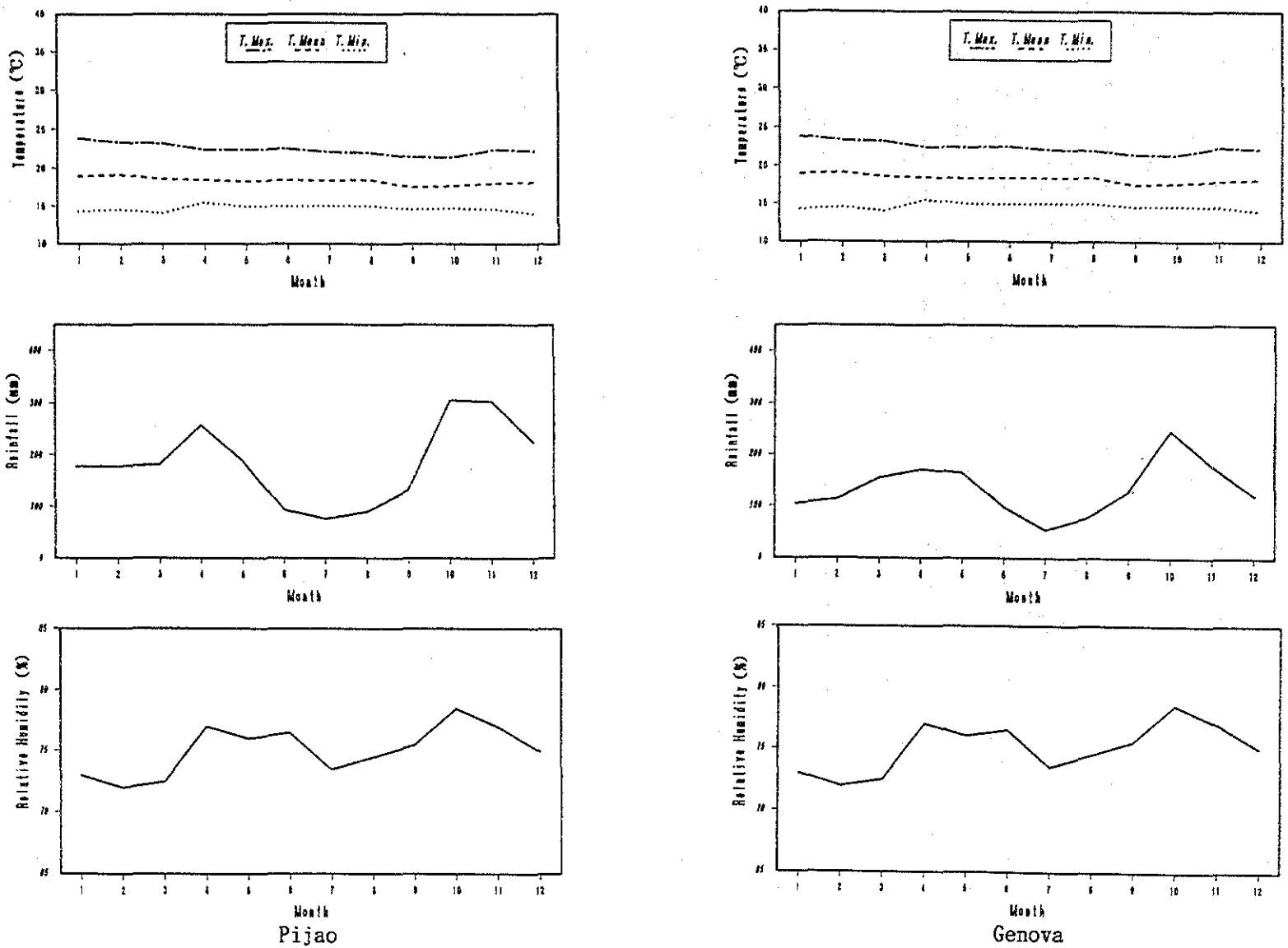


Fig. B.3.1 Meteorological Condition in the Study Area (3)

B.4 Hydrology

B.4.1 Rainfall

(1) The Annual Rainfall Pattern and Effective Rainfall in the Drought Year

The annual rainfall at the selected stations were analyzed probabilistically by the Hazen Plot Method as shown in Fig.B.4.1 and Table B.4.1. Based on the probability of the annual rainfall, the drought design rainfall was estimated as shown in in Table B.4.1. The drought design effective rainfall pattern were estimated by the method of U.S.Bureau of Reclamation as shown in Table B.4.2 and Fig.B.4.2.

(2) Number of Rain Days and Continuous Drought Days

The numbers of rain days and the continuous drought days were also analyzed by the Hazen Plot Method as shown in Fig.B.4.3, Fig.B.4.4, and Table B.4.3, Table B.4.4.

(3) Maximum 24-hour Rainfall and Rainfall Intensity

The maximum 24-hour rainfall at the selected stations were analyzed by the Hazen Plot Method as shown in Fig.B.4.5 and Table B.4.5. Due to a the lack of hourly rain fall data, rainfall intensity for each study area were estimated using the following formula;

$$i = R24/24*(24/t)^n$$

where i : Rainfall Intensity (mm/hour)
R24: 24-hour Rainfall (mm)
t : Duration Time (hour)
n : Coefficient (from 1/2 to 2/3)

Table B.4.1 Probability of Annual Rainfall (1) Bremen Station

Probability of Annual Rainfall (station BREMEN)

Year	Annual Rainfall	No.	Data(year)	Ratio	Probability
1970	2902	1	2176(1977)	0.752	2.94
1971	3643	2	2308(1987)	0.797	8.82
1972	2495	3	2314(1978)	0.799	14.71
1973	2792	4	2495(1972)	0.862	20.59
1974	3322	5	2501(1983)	0.864	26.47
1975	3890	6	2600(1986)	0.898	32.35
1976	2939	7	2739(1985)	0.946	38.24
1977	2176	8	2746(1979)	0.949	44.12
1978	2314	9	2792(1973)	0.965	50.00
1979	2746	10	2902(1970)	1.002	55.88
1980	----	11	2934(1982)	1.014	61.76
1981	3304	12	2939(1976)	1.015	67.65
1982	2934	13	3304(1981)	1.141	73.53
1983	2501	14	3322(1974)	1.148	79.41
1984	3602	15	3602(1984)	1.244	85.29
1985	2739	16	3643(1971)	1.259	91.18
1986	2600	17	3890(1975)	1.344	97.06
1987	2308				

Total Xs= 49205.7 days Average Xo= 2894.5 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	Rainfall [days]
5%	20	0.741	2144.5
10%	10	0.789	2283.5
20%	5	0.852	2465.6
25%	4	0.877	2537.8
33%	3	0.913	2643.5
50%	2	0.986	2854.6

Rainfall Pattern for Design Year at BREMEN

Month	17 Years Average	Return Period 1/2	1/5	1/10	1/20
1	215	212(106)	183(104)	170(103)	159(103)
2	217	214(106)	185(104)	171(103)	161(103)
3	301	297(108)	257(108)	238(106)	223(106)
4	315	311(108)	269(108)	249(107)	234(106)
5	259	256(108)	221(106)	205(106)	192(105)
6	144	142(99)	123(93)	114(90)	107(87)
7	96	95(80)	82(72)	76(68)	71(64)
8	126	124(93)	107(87)	99(83)	93(79)
9	175	173(103)	149(101)	138(98)	130(95)
10	415	410(108)	354(108)	328(108)	308(108)
11	371	366(108)	316(108)	293(108)	275(108)
12	257	254(107)	219(106)	203(106)	191(105)
Annual	2894	2855(1234)	2466(1204)	2283(1185)	2145(1168)

( ) : Effective Rainfall [mm]

Table B.4.1 Probability of Annual Rainfall (2) Salento Station

Probability of Annual Rainfall (station SALENTO)

Year	Annual Rainfall	No.	Data(year)	Ratio	Probability
1974	----	1	1769(1978)	0.786	6.25
1975	2913	2	1780(1982)	0.791	18.75
1976	2246	3	1945(1977)	0.864	31.25
1977	1945	4	2246(1976)	0.998	43.75
1978	1769	5	2286(1985)	1.016	56.25
1979	----	6	2463(1984)	1.095	68.75
1980	----	7	2601(1981)	1.156	81.25
1981	2601	8	2913(1975)	1.294	93.75
1982	1780				
1983	----				
1984	2463				
1985	2286				
1986	----				

Total Xs= 18002.7 days Average Xo= 2250.3 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	Rainfall [days]
5%	20	0.725	1631.8
10%	10	0.776	1745.6
20%	5	0.842	1895.6
25%	4	0.869	1955.2
33%	3	0.908	2042.8
50%	2	0.986	2218.5

Rainfall Pattern for Design Year at SALENTO

Month	8 Years Average	Return Period 1/2	1/5	1/10	1/20
1	141	139(98)	119(91)	109(88)	102(85)
2	194	191(105)	163(103)	150(102)	141(99)
3	178	175(103)	150(101)	138(98)	129(95)
4	274	270(108)	231(105)	213(106)	199(105)
5	199	196(105)	168(103)	154(1..)	144(100)
6	111	110(88)	94(80)	86(75)	81(71)
7	66	65(59)	56(51)	51(48)	48(45)
8	71	70(63)	60(55)	55(51)	51(48)
9	139	137(98)	117(91)	108(87)	101(84)
10	335	330(108)	282(108)	260(108)	243(106)
11	307	302(108)	258(108)	238(106)	222(106)
12	236	233(106)	199(105)	183(104)	171(103)
Annual	2250	2218(1149)	1896(1102)	1746(1074)	1632(1046)

( ) : Effective Rainfall [mm]

Table B.4.1 Probability of Annual Rainfall (3) El Eden Station

Probability of Annual Rainfall (station EL EDEN)

Year	Annual Rainfall	No.	Data(year)	Ratio	Probability
1960	-----	1	1529(1976)	0.729	2.63
1961	2017	2	1590(1986)	0.758	7.89
1962	1829	3	1602(1977)	0.764	13.16
1963	2048	4	1655(1980)	0.789	18.42
1964	2552	5	1797(1968)	0.857	23.68
1965	2025	6	1829(1962)	0.872	28.95
1966	2038	7	1872(1978)	0.892	34.21
1967	1996	8	1934(1969)	0.922	39.47
1968	1797	9	1996(1967)	0.952	44.74
1969	1934	10	2017(1961)	0.961	50.00
1970	2341	11	2025(1965)	0.966	55.26
1971	3314	12	2038(1966)	0.971	60.53
1972	-----	13	2048(1963)	0.976	65.79
1973	-----	14	2110(1979)	1.006	71.05
1974	3000	15	2341(1970)	1.116	76.32
1975	2603	16	2552(1964)	1.217	81.58
1976	1529	17	2603(1975)	1.241	86.84
1977	1602	18	3000(1974)	1.430	92.11
1978	1872	19	3314(1971)	1.580	97.37
1979	2110				
1980	1655				
1981	-----				
1982	-----				
1983	-----				
1984	-----				
1985	-----				
1986	1590				
1987	-----				
1988	-----				
1989	-----				

Total Xs= 39851.7 days Average Xo= 2097.5 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	Rainfall [days]
5%	20	0.684	1433.9
10%	10	0.740	[illegible]
20%	5	0.814	1707.7
25%	4	0.844	1770.6
33%	3	0.888	1863.5
50%	2	0.978	2051.7

Rainfall Pattern for Design Year at EL EDEN

Month	19 Years Average	Return Period			
		1/2	1/5	1/10	1/20
1	120	117(91)	98(82)	89(76)	82(72)
2	139	136(97)	113(89)	103(85)	95(80)
3	177	173(103)	144(100)	131(95)	121(92)
4	256	251(107)	209(106)	190(105)	175(103)
5	213	208(106)	173(103)	157(103)	146(100)
6	135	132(96)	110(88)	100(83)	92(79)
7	97	94(80)	79(70)	71(64)	66(60)
8	114	112(89)	93(79)	84(73)	78(69)
9	169	166(103)	138(98)	125(93)	116(90)
10	242	236(106)	197(105)	179(103)	165(103)
11	285	279(108)	232(105)	211(106)	195(105)
12	151	147(101)	123(93)	111(89)	103(85)
Annual	2097	2052(1186)	1708(1118)	1551(1076)	1434(1039)

( ) : Effective Rainfall [mm]

Table B.4.1 Probability of Annual Rainfall (4) Paraguaycito Station

Probability of Annual Rainfall (station PARAGUAYCITO)

Year	Annual Rainfall	No.	Data(year)	Ratio	Probability
1964	1716	1	1678(1977)	0.785	2.08
1965	1831	2	1704(1980)	0.797	6.25
1966	2069	3	1710(1987)	0.800	10.42
1967	2404	4	1712(1983)	0.801	14.58
1968	2054	5	1716(1964)	0.803	18.75
1969	1786	6	1786(1969)	0.836	22.92
1970	2217	7	1823(1976)	0.853	27.08
1971	3064	8	1831(1965)	0.857	31.25
1972	2036	9	1911(1985)	0.895	35.42
1973	2447	10	2005(1982)	0.938	39.58
1974	2758	11	2036(1972)	0.953	43.75
1975	2668	12	2054(1968)	0.962	47.92
1976	1823	13	2069(1966)	0.968	52.08
1977	1678	14	2075(1978)	0.971	56.25
1978	2075	15	2139(1979)	1.001	60.42
1979	2139	16	2217(1970)	1.038	64.58
1980	1704	17	2277(1986)	1.066	68.75
1981	2485	18	2404(1967)	1.125	72.92
1982	2005	19	2447(1973)	1.145	77.08
1983	1712	20	2485(1981)	1.163	81.25
1984	2707	21	2668(1975)	1.249	85.42
1985	1911	22	2707(1984)	1.267	89.58
1986	2277	23	2758(1974)	1.291	93.75
198[illegible]	1710	24	3064(1971)	1.434	97.92

Total Xs= 51276.1 days Average Xo= 2136.5 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	Rainfall [days]
5%	20	0.730	1560.7
10%	10	0.780	1666.5
20%	5	0.845	1805.6
25%	4	0.871	1860.9
33%	3	0.909	1941.9
50%	2	0.985	2104.2

Rainfall Pattern for Design Year at PARAGUAYCITO

Month	24 Years Average	Return Period 1/2	1/5	1/10	1/20
1	135	133(96)	114(90)	106(86)	99(83)
2	124	123(93)	105(86)	97(82)	91(78)
3	198	195(105)	167(103)	154(102)	144(100)
4	280	276(108)	236(106)	218(106)	204(106)
5	224	221(106)	189(105)	175(103)	164(103)
6	97	96(81)	82(72)	76(68)	71(64)
7	67	66(60)	56(52)	52(48)	49(45)
8	99	98(82)	84(73)	77(69)	72(65)
9	160	158(103)	136(97)	125(93)	117(91)
10	299	294(108)	252(107)	233(106)	218(106)
11	283	278(108)	239(106)	220(106)	207(106)
12	170	168(103)	144(100)	133(96)	124(93)
Annual	2137	2104(1152)	1806(1096)	1666(1064)	1561(1039)

( ) : Effective Rainfall

[mm]

Table B.4.1 Probability of Annual Rainfall (5) Pijao Station

Probability of Annual Rainfall (station PIJAO)

Year	Annual Rainfall	No.	Data(year)	Ratio	Probability
1974	----	1	1609(1983)	0.709	6.25
1975	2672	2	1944(1978)	0.856	18.75
1976	2177	3	2177(1976)	0.959	31.25
1977	----	4	2251(1985)	0.991	43.75
1978	1944	5	2360(1981)	1.039	56.25
1979	----	6	2532(1984)	1.115	68.75
1980	----	7	2619(1982)	1.153	81.25
1981	2360	8	2672(1975)	1.177	93.75
1982	2619				
1983	1609				
1984	2532				
1985	2251				
1986	----				

Total Xs= 18163.9 days Average Xo= 2270.5 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	Rainfall [days]
5%	20	0.734	1666.5
10%	10	0.783	1778.8
20%	5	0.848	1926.4
25%	4	0.874	1985.1
33%	3	0.912	2071.0
50%	2	0.988	2243.1

Rainfall Pattern for Design Year at PIJAO

Month	8 Years Average	Return Period 1/2	1/5	1/10	1/20
1	183	181(104)	155(102)	143(100)	134(97)
2	183	180(104)	155(102)	143(100)	134(97)
3	186	184(104)	158(103)	146(100)	137(97)
4	264	261(108)	224(105)	207(106)	194(105)
5	194	192(105)	165(103)	152(102)	143(99)
6	97	95(81)	82(72)	76(67)	71(64)
7	79	78(69)	67(61)	62(57)	58(53)
8	93	92(78)	79(70)	73(65)	68(62)
9	136	134(97)	115(90)	106(86)	100(83)
10	314	310(108)	266(108)	246(106)	230(105)
11	311	308(108)	264(108)	244(106)	228(105)
12	231	228(105)	196(105)	181(104)	169(103)
Annual	2270	2243(1170)	1926(1130)	1779(1099)	1666(1071)

( ) : Effective Rainfall [mm]

Table B.4.1 Probability of Annual Rainfall (6) Gibraltar Station

Probability of Annual Rainfall (station GIBRALTAR)

Year	Annual Rainfall	No.	Data(year)	Ratio	Probability
1971	----	1	973(1977)	0.586	3.33
1972	1664	2	1227(1978)	0.739	10.00
1973	1525	3	1336(1976)	0.805	16.67
1974	1610	4	1461(1989)	0.880	23.33
1975	2103	5	1507(1980)	0.908	30.00
1976	1336	6	1525(1973)	0.919	36.67
1977	973	7	1580(1982)	0.952	43.33
1978	1227	8	1610(1974)	0.970	50.00
1979	----	9	1627(1988)	0.980	56.67
1980	1507	10	1664(1972)	1.003	63.33
1981	2360	11	1718(1986)	1.035	70.00
1982	1580	12	1839(1987)	1.108	76.67
1983	----	13	2103(1975)	1.267	83.33
1984	2365	14	2360(1981)	1.422	90.00
1985	----	15	2365(1984)	1.425	96.67
1986	1718				
1987	1839				
1988	1627				
1989	1461				

Total Xs= 24896.3 days Average Xo= 1659.8 days

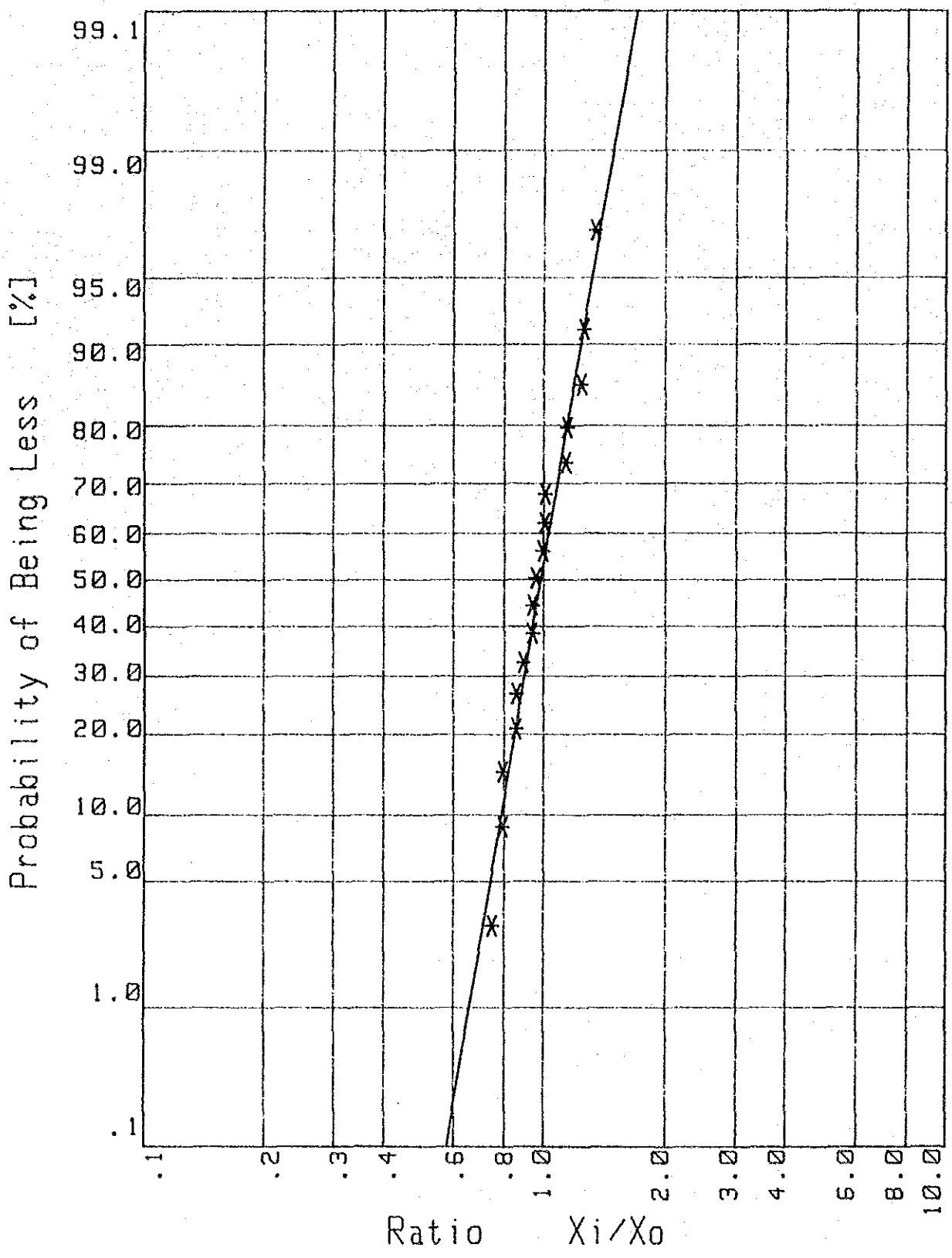
Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	Rainfall [days]
5%	20	0.656	1088.7
10%	10	0.716	1187.7
20%	5	0.796	1321.0
25%	4	0.828	1374.9
33%	3	0.877	1454.9
50%	2	0.975	1618.4

Rainfall Pattern for Design Year at GIBRALTAR

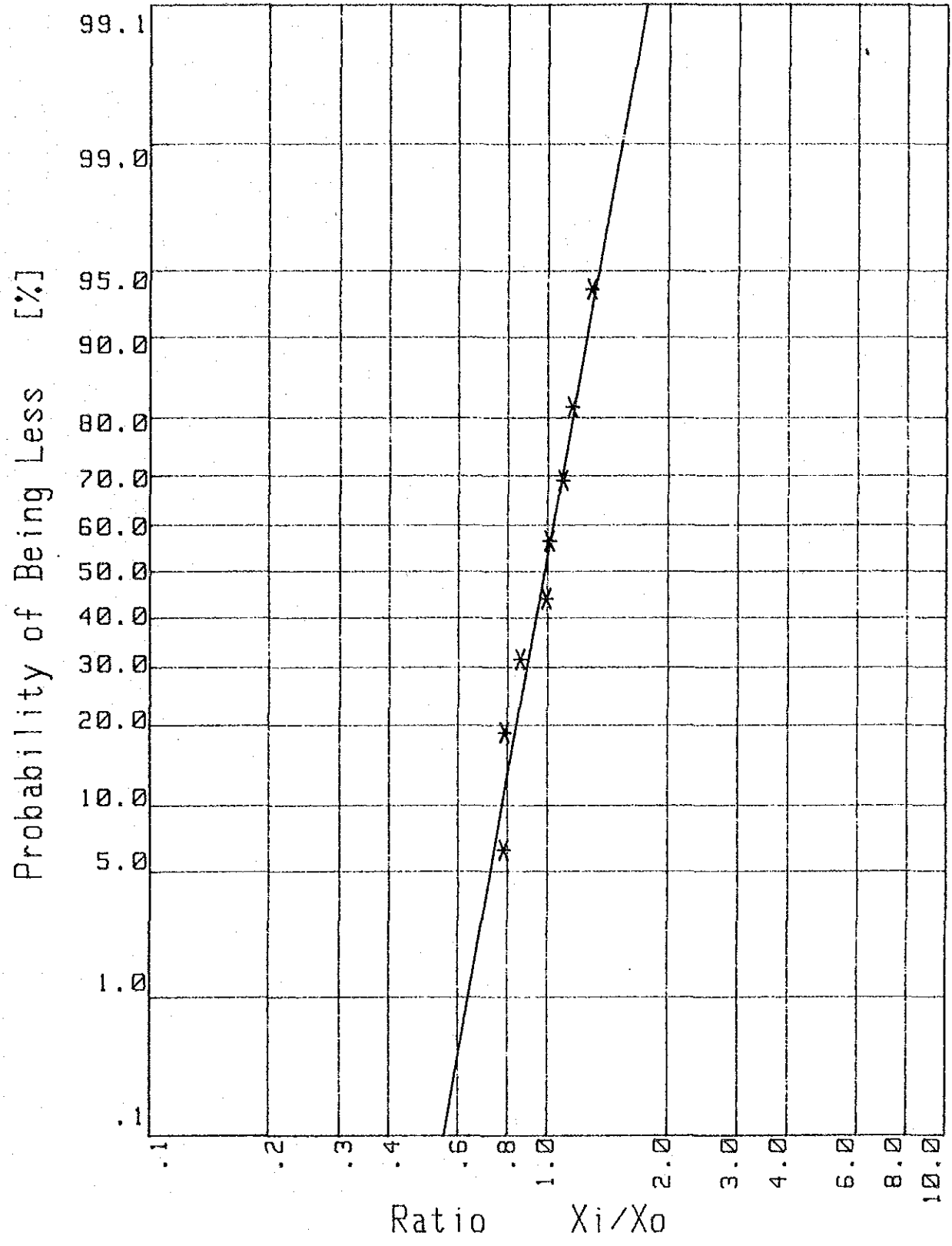
Month	15 Years Average	Return Period 1/2	1/5	1/10	1/20
1	107	104(86)	85(74)	76(68)	70(63)
2	117	114(90)	93(79)	84(73)	77(68)
3	159	155(102)	127(94)	114(90)	104(86)
4	176	172(103)	140(99)	126(94)	116(90)
5	170	166(103)	135(97)	122(92)	111(89)
6	101	99(82)	80(71)	72(65)	66(60)
7	56	54(50)	44(42)	40(37)	37(34)
8	80	78(69)	64(58)	57(53)	53(49)
9	133	129(95)	106(86)	95(80)	87(75)
10	253	247(106)	201(106)	181(104)	166(103)
11	184	179(103)	146(100)	132(96)	121(92)
12	124	121(92)	99(83)	89(76)	81(71)
Annual	1660	1618(1083)	1321(988)	1188(928)	1089(881)

( ) : Effective Rainfall [mm]



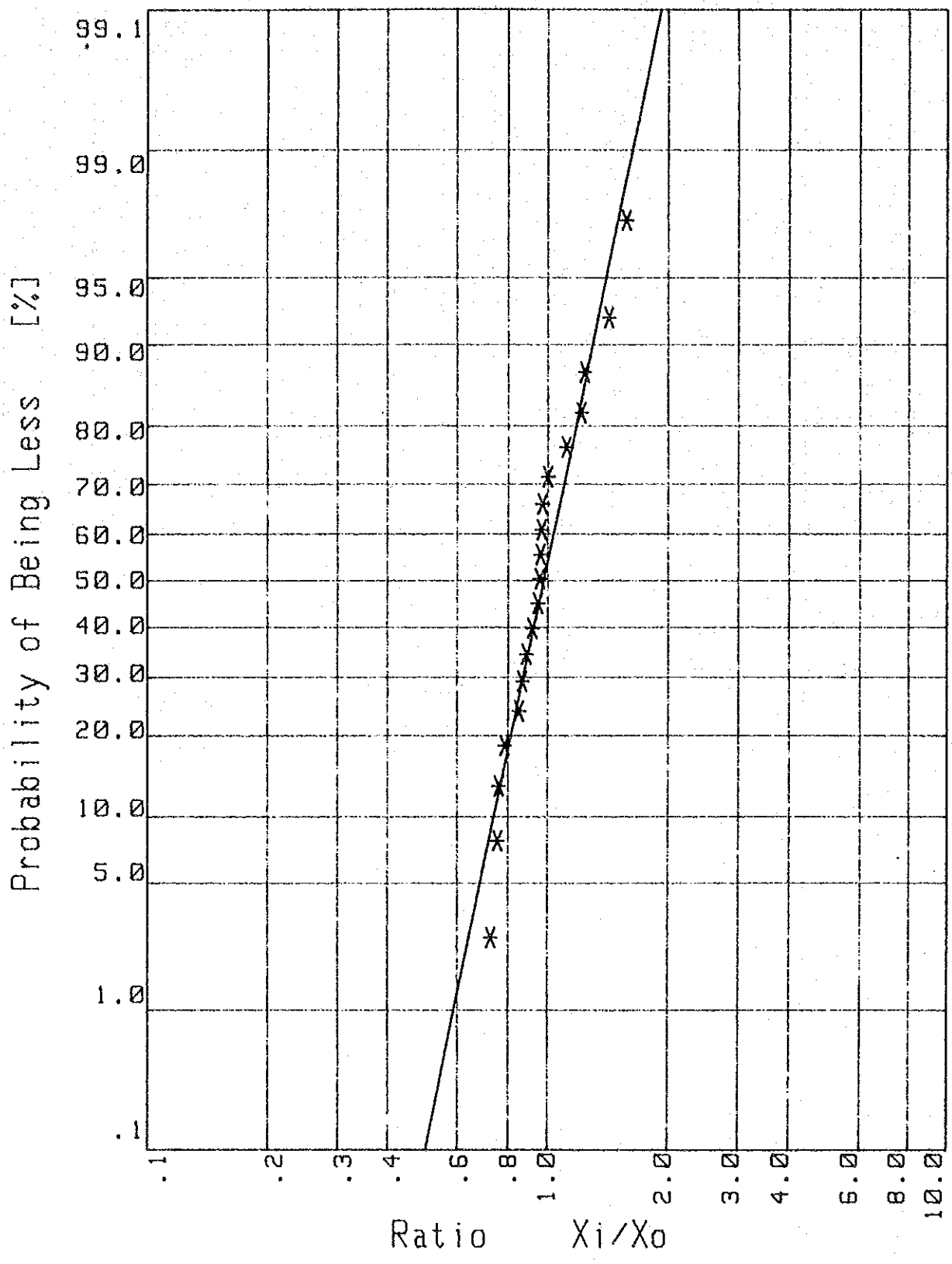
Probability of Annual Rainfall
(Station BREMEN)

Fig. B.4.1 Probability of Annual Rainfall (1) Bremen Station



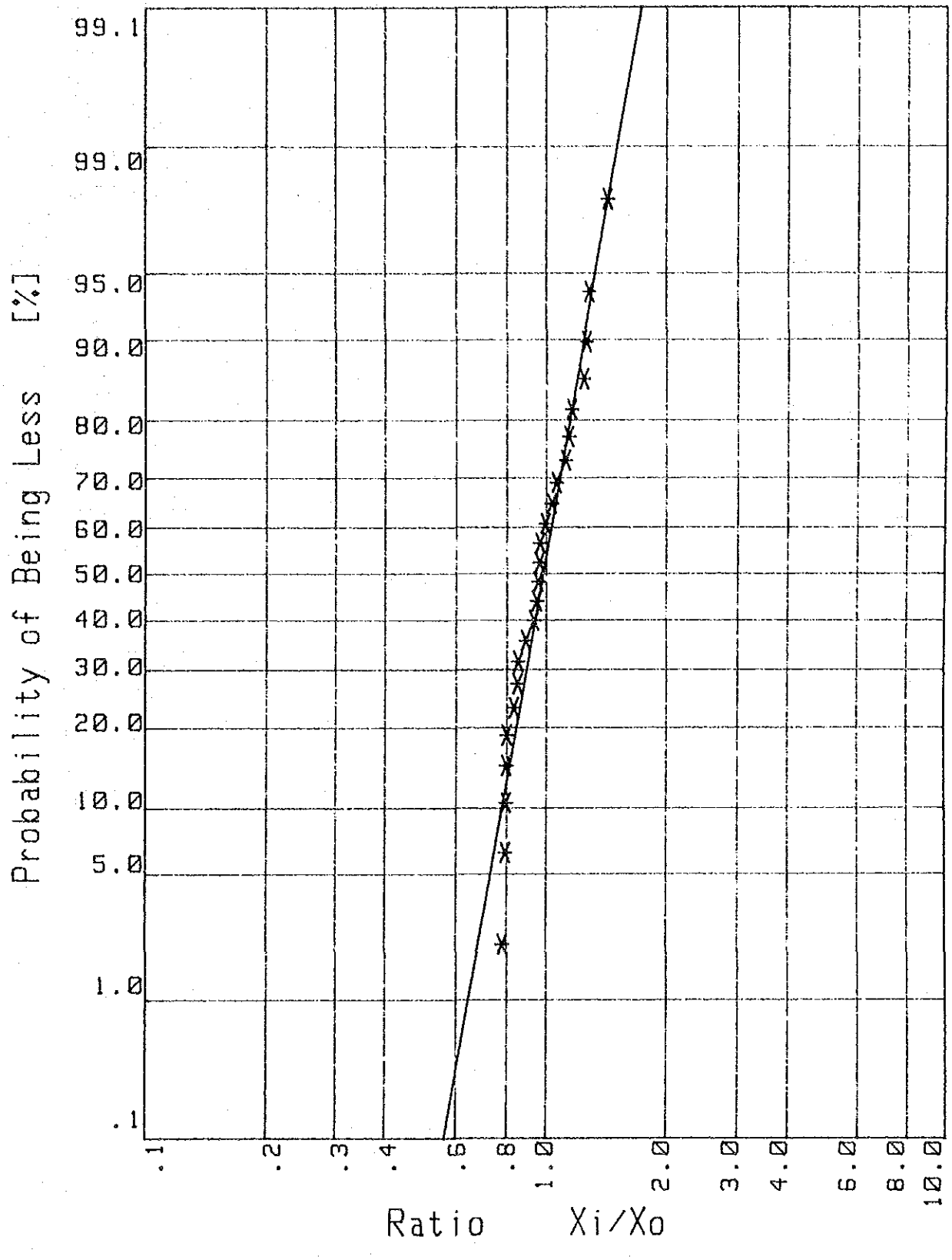
Probability of Annual Rainfall
(Station SALENTO)

Fig. B.4.1 Probability of Annual Rainfall (2) Salento Station



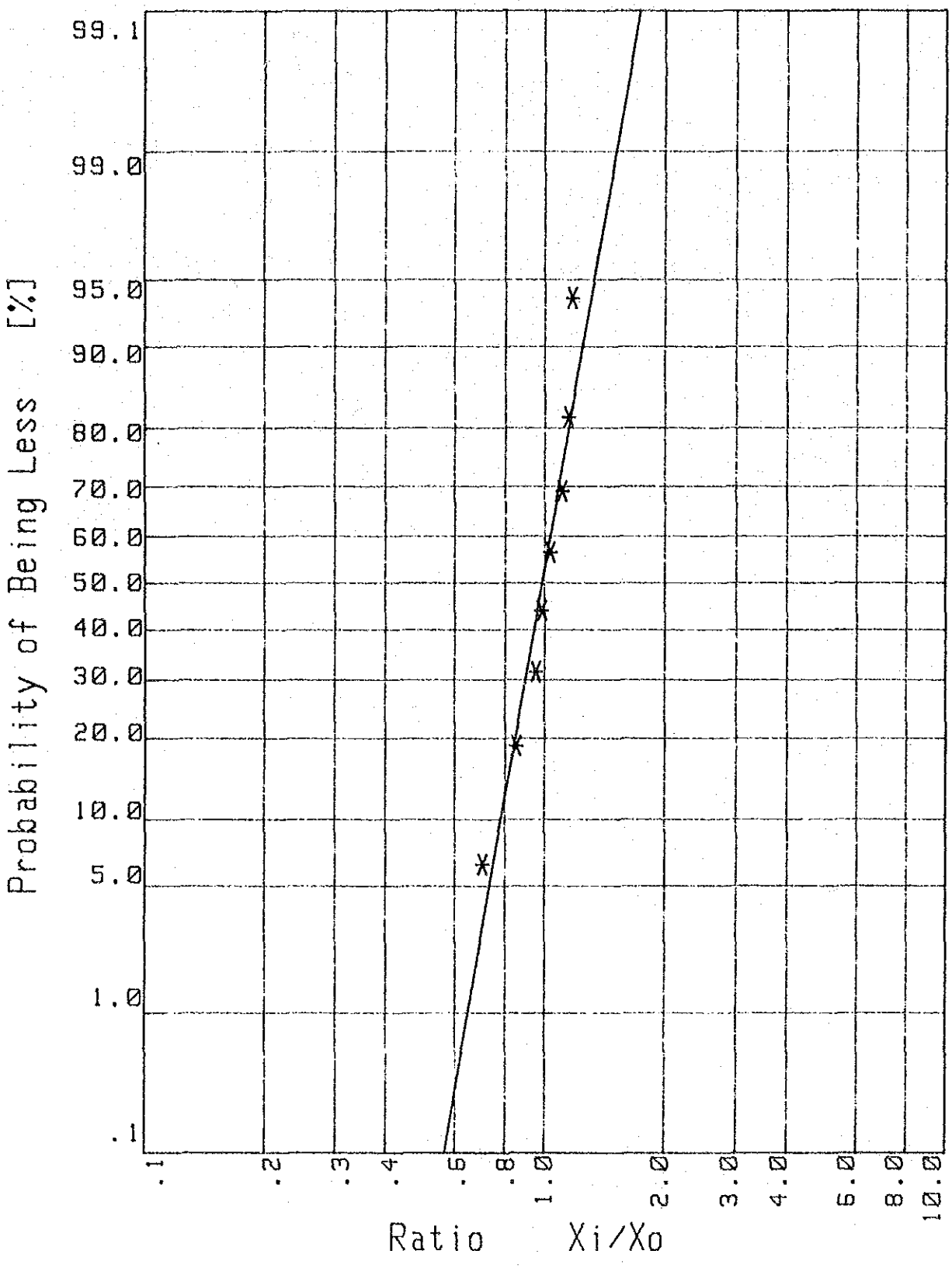
Probability of Annual Rainfall
(Station EL EDEN)

Fig. B.4.1 Probability of Annual Rainfall (3) El Eden Station



Probability of Annual Rainfall
(Station PARAGUAYCITO)

Fig. B.4.1 Probability of Annual Rainfall (4) Paraguaycito Station



Probability of Annual Rainfall
(Station PIJAO)

Fig. B.4.1 Probability of Annual Rainfall (5) Pijao Station

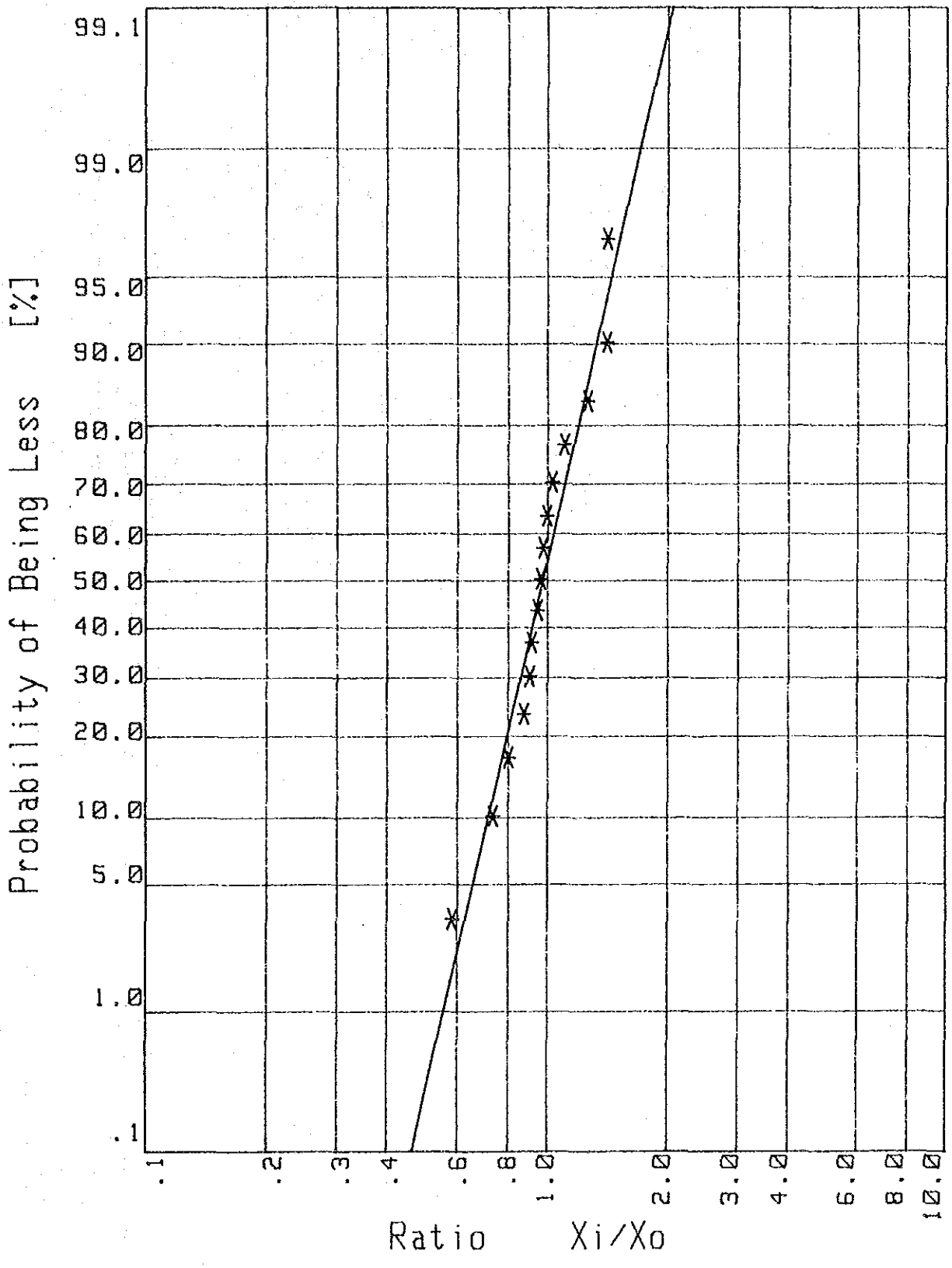


Fig. B.4.1 Probability of Annual Rainfall (6) Gibraltar Station

Table B.4.2 Relationship between Rainfall and Effective Rainfall

Rainfall		Effective Rainfall		
inches	mm	inches	mm	%
1	25.4	0.95	24.13	95
2	50.8	1.85	46.99	93
3	76.2	2.67	67.82	89
4	101.6	3.32	84.33	83
5	127.0	3.79	96.87	74
6	152.4	4.02	102.11	67
7	177.8	4.07	103.38	58
8	203.2	4.12	104.65	52
9	228.6	4.17	105.92	46
10	254.0	4.22	107.19	42

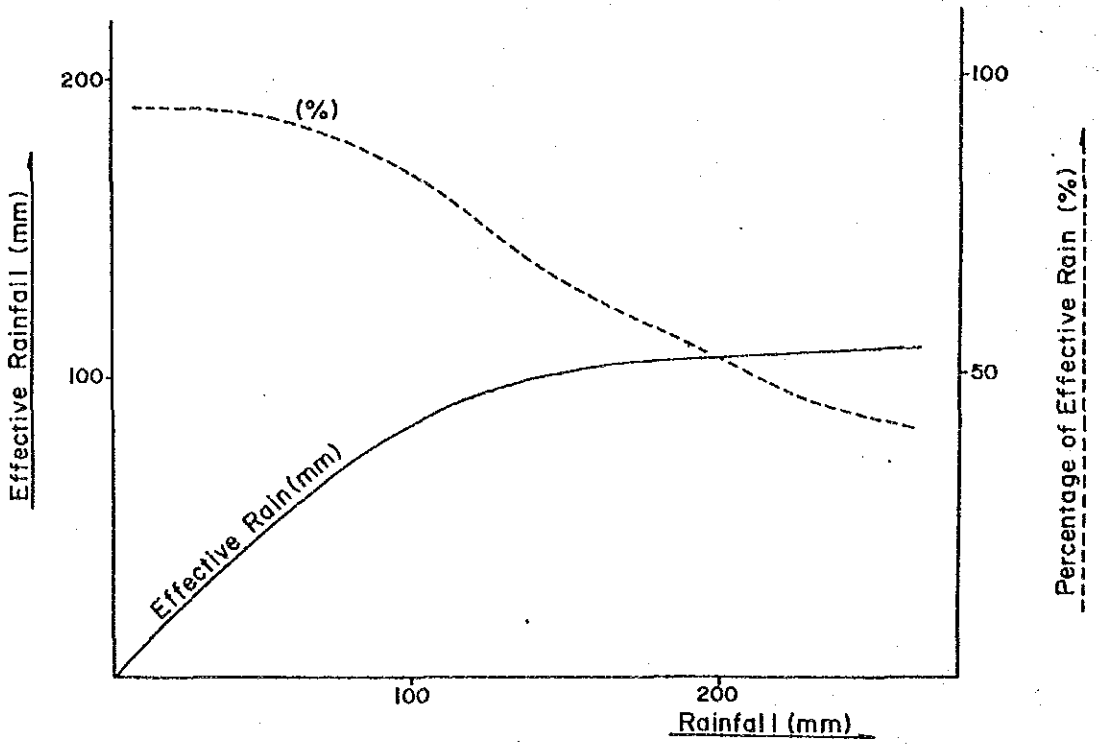


Fig. B.4.2 Relationship between Rainfall and Effective Rainfall

Table B.4.3 Probability of Number of Rain Day (1) Bremen Station

Probability of Rainy Days (station BREMEN)

Year	No. of Rainy Day	No.	Data(year)	Ratio	Probability
1970	262	1	219(1976)	0.878	2.94
1971	289	2	222(1978)	0.890	8.82
1972	234	3	226(1986)	0.906	14.71
1973	275	4	226(1987)	0.906	20.59
1974	277	5	231(1977)	0.926	26.47
1975	282	6	232(1985)	0.930	32.35
1976	219	7	234(1972)	0.938	38.24
1977	231	8	237(1979)	0.950	44.12
1978	222	9	240(1982)	0.962	50.00
1979	237	10	245(1983)	0.983	55.88
1980	-----	11	259(1981)	1.039	61.76
1981	259	12	262(1970)	1.051	67.65
1982	240	13	275(1973)	1.103	73.53
1983	245	14	277(1974)	1.111	79.41
1984	283	15	282(1975)	1.131	85.29
1985	232	16	283(1984)	1.135	91.18
1986	226	17	289(1971)	1.159	97.06
1987	226				

Total Xs= 4239.0 days Average Xo= 249.4 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	No. of Rainy Day [days]
5%	20	0.844	210.5
10%	10	0.875	218.3
20%	5	0.915	228.1
25%	4	0.930	232.0
33%	3	0.952	237.5
50%	2	0.996	248.3

Table B.4.3 Probability of Number of Rain Day (2) Salento Station

Probability of Rainy Days (station SALENTO)

Year	No. of Rainy Day	No.	Data(year)	Ratio	Probability
1975	221	1	82(1979)	0.577	4.55
1976	169	2	89(1980)	0.626	13.64
1977	153	3	107(1982)	0.753	22.73
1978	159	4	120(1985)	0.844	31.82
1979	82	5	134(1983)	0.942	40.91
1980	89	6	153(1977)	1.076	50.00
1981	155	7	155(1981)	1.090	59.09
1982	107	8	159(1978)	1.118	68.18
1983	134	9	169(1976)	1.189	77.27
1984	175	10	175(1984)	1.231	86.36
1985	120	11	221(1975)	1.554	95.45
1986	----				

Total Xs= 1564.0 days Average Xo= 142.2 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	No. of Rainy Day [days]
5%	20	0.577	82.0
10%	10	0.645	91.7
20%	5	0.740	105.2
25%	4	0.779	110.7
33%	3	0.838	119.1
50%	2	0.961	136.6

Table B.4.3 Probability of Number of Rain Day (3) El Eden Station

Probability of Rainy Days (station EL EDEN)

Year	No. of Rainy Day	No.	Data(year)	Ratio	Probability
1949	-----	1	121(1961)	0.769	2.17
1950	193	2	122(1987)	0.775	6.52
1951	----	3	125(1959)	0.794	10.87
1952	175	4	128(1958)	0.813	15.22
1953	160	5	133(1957)	0.845	19.57
1954	173	6	135(1977)	0.857	23.91
1955	-----	7	139(1976)	0.883	28.26
1956	189	8	140(1969)	0.889	32.61
1957	133	9	141(1980)	0.896	36.96
1958	128	10	144(1968)	0.915	41.30
1959	125	11	151(1979)	0.959	45.65
1960	-----	12	154(1970)	0.978	50.00
1961	121	13	160(1953)	1.016	54.35
1962	171	14	168(1964)	1.067	58.70
1963	174	15	171(1962)	1.086	63.04
1964	168	16	173(1954)	1.099	67.39
1965	-----	17	174(1963)	1.105	71.74
1966	----	18	175(1952)	1.112	76.09
1967	----	19	189(1956)	1.200	80.43
1968	144	20	190(1974)	1.207	84.78
1969	140	21	192(1971)	1.220	89.13
1970	154	22	193(1950)	1.226	93.48
1971	192	23	203(1975)	1.289	97.83
1972	----				
1973	----				
1974	190				
1975	203				
1976	139				
1977	135				
1978	----				
1979	151				
1980	141				
1981	----				
1982	----				
1983	----				
1984	----				
1985	----				
1986	----				
1987	122				
1988	----				

Total Xs= 3621.0 days Average Xo= 157.4 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	No. of Rainy Day [days]
5%	20	0.750	118.0
10%	10	0.796	125.4
20%	5	0.858	135.0
25%	4	0.882	138.8
33%	3	0.917	144.4
50%	2	0.987	155.4

Table B.4.3 Probability of Number of Rain Day (4) Paraguaycito Station

Probability of Rainy Days (station PARAGUAYCITO)

Year	No. of Rainy Day	No.	Data(year)	Ratio	Probability
1964	211	1	152(1968)	0.783	2.08
1965	169	2	159(1987)	0.819	6.25
1966	169	3	166(1977)	0.855	10.42
1967	177	4	169(1966)	0.871	14.58
1968	152	5	169(1965)	0.871	18.75
1969	180	6	176(1985)	0.907	22.92
1970	221	7	177(1976)	0.912	27.08
1971	251	8	177(1967)	0.912	31.25
1972	185	9	179(1983)	0.922	35.42
1973	221	10	180(1969)	0.928	39.58
1974	225	11	181(1980)	0.933	43.75
1975	245	12	185(1972)	0.953	47.92
1976	177	13	187(1979)	0.964	52.08
1977	166	14	188(1986)	0.969	56.25
1978	194	15	193(1982)	0.995	60.42
1979	187	16	194(1978)	1.000	64.58
1980	181	17	206(1981)	1.062	68.75
1981	206	18	211(1964)	1.087	72.92
1982	193	19	221(1973)	1.139	77.08
1983	179	20	221(1970)	1.139	81.25
1984	245	21	225(1974)	1.160	85.42
1985	176	22	245(1984)	1.263	89.58
1986	188	23	245(1975)	1.263	93.75
1987	159	24	251(1971)	1.294	97.92

Total Xs= 4657.0 days Average Xo= 194.0 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	No. of Rainy Day [days]
5%	20	0.782	151.8
10%	10	0.824	159.9
20%	5	0.878	170.3
25%	4	0.899	174.4
33%	3	0.930	180.4
50%	2	0.991	192.2

Table B.4.3 Probability of Number of Rain Day (5) Pijao Station

Probability of Rainy Days (station PIJAO)

Year	No. of Rainy Day	No.	Data(year)	Ratio	Probability
1975	222	1	153(1985)	0.794	6.25
1976	182	2	166(1983)	0.861	18.75
1977	-----	3	180(1978)	0.934	31.25
1978	180	4	182(1976)	0.944	43.75
1979	-----	5	203(1981)	1.053	56.25
1980	-----	6	208(1982)	1.079	68.75
1981	203	7	222(1975)	1.152	81.25
1982	208	8	228(1984)	1.183	93.75
1983	166				
1984	228				
1985	153				
1986	-----				

Total Xs= 1542.0 days Average Xo= 192.8 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	No. of Rainy Day [days]
5%	20	0.781	150.4
10%	10	0.823	158.6
20%	5	0.877	169.1
25%	4	0.899	173.2
33%	3	0.930	179.2
50%	2	0.991	191.1

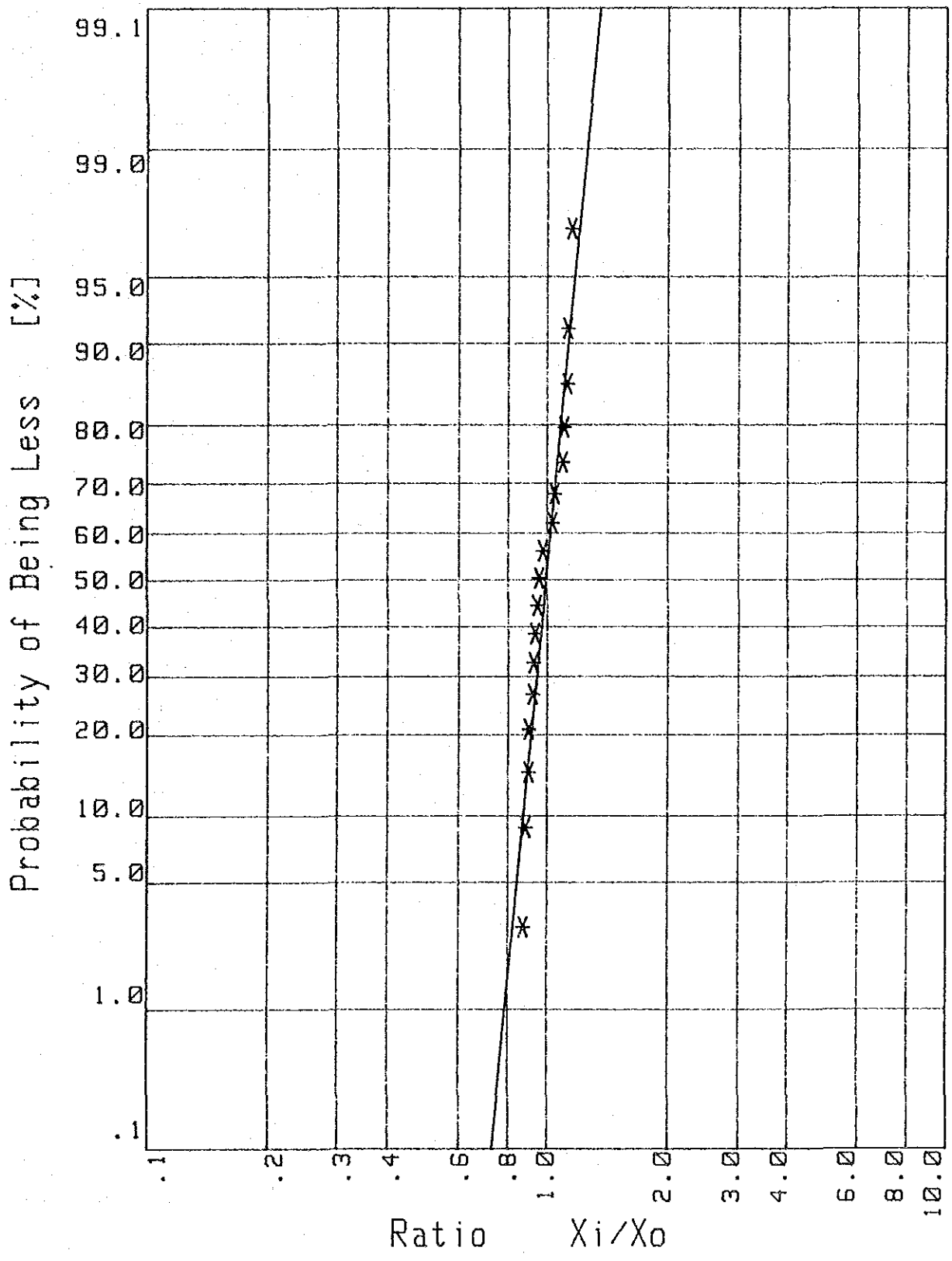
Table B.4.3 Probability of Number of Rain Day (6) Gibraltar Station

Probability of Rainy Days (station GIBRALTAL)

Year	No. of Rainy Day	No.	Data(year)	Ratio	Probability
1971	-----	1	71(1977)	0.560	3.33
1972	156	2	91(1976)	0.718	10.00
1973	142	3	91(1980)	0.718	16.67
1974	121	4	113(1978)	0.891	23.33
1975	152	5	118(1982)	0.931	30.00
1976	91	6	121(1974)	0.954	36.67
1977	71	7	132(1984)	1.041	43.33
1978	113	8	132(1987)	1.041	50.00
1979	-----	9	136(1981)	1.073	56.67
1980	91	10	142(1973)	1.120	63.33
1981	136	11	146(1989)	1.151	70.00
1982	118	12	149(1986)	1.175	76.67
1983	-----	13	152(1988)	1.199	83.33
1984	132	14	152(1975)	1.199	90.00
1985	-----	15	156(1972)	1.230	96.67
1986	149				
1987	132				
1988	152				
1989	146				
Total	Xs= 1902.0 days		Average	Xo= 126.8 days	

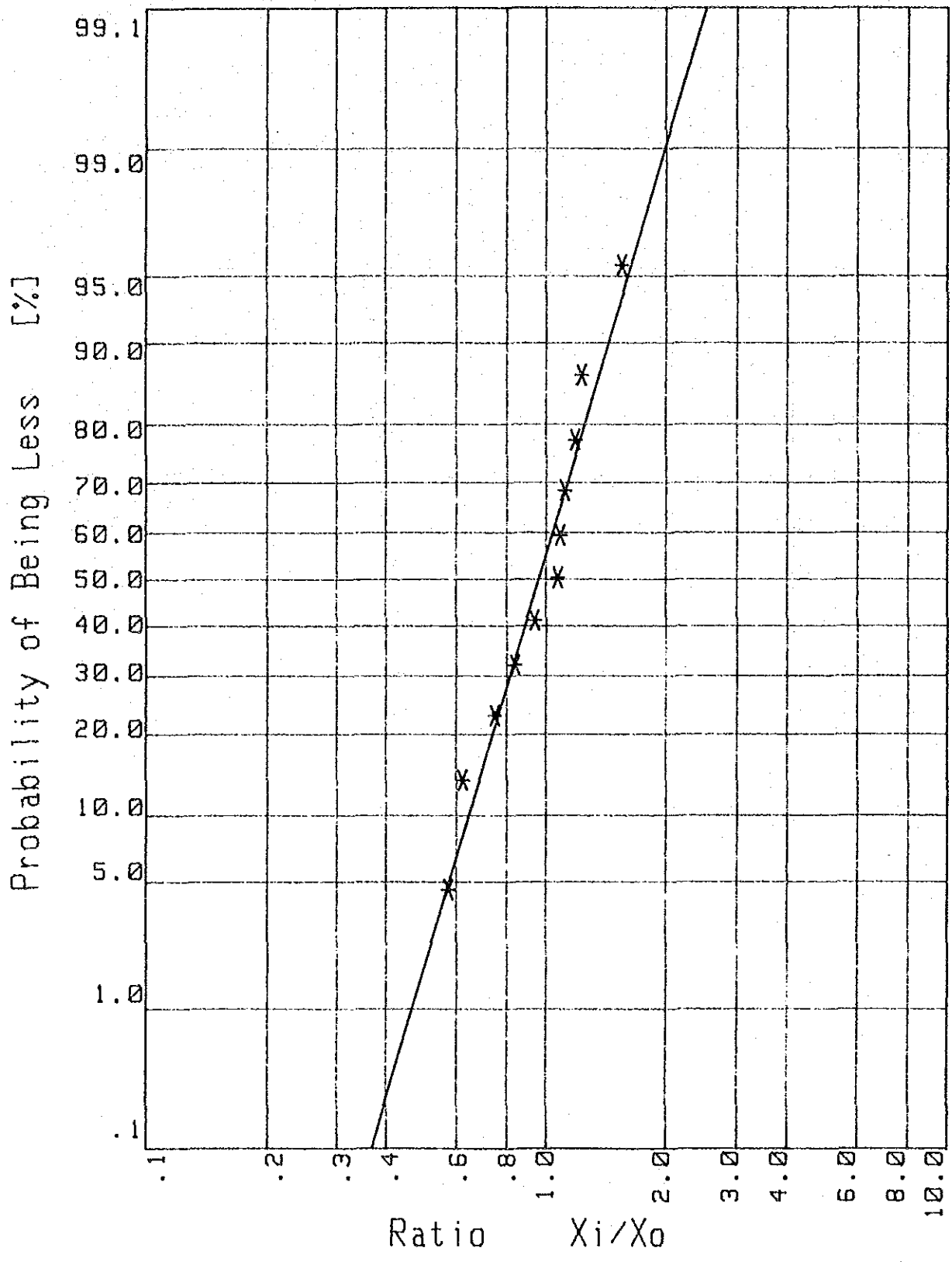
Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	No. of Rainy Day [days]
5%	20	0.648	82.1
10%	10	0.709	89.9
20%	5	0.792	100.4
25%	4	0.825	104.7
33%	3	0.875	111.0
50%	2	0.977	123.9



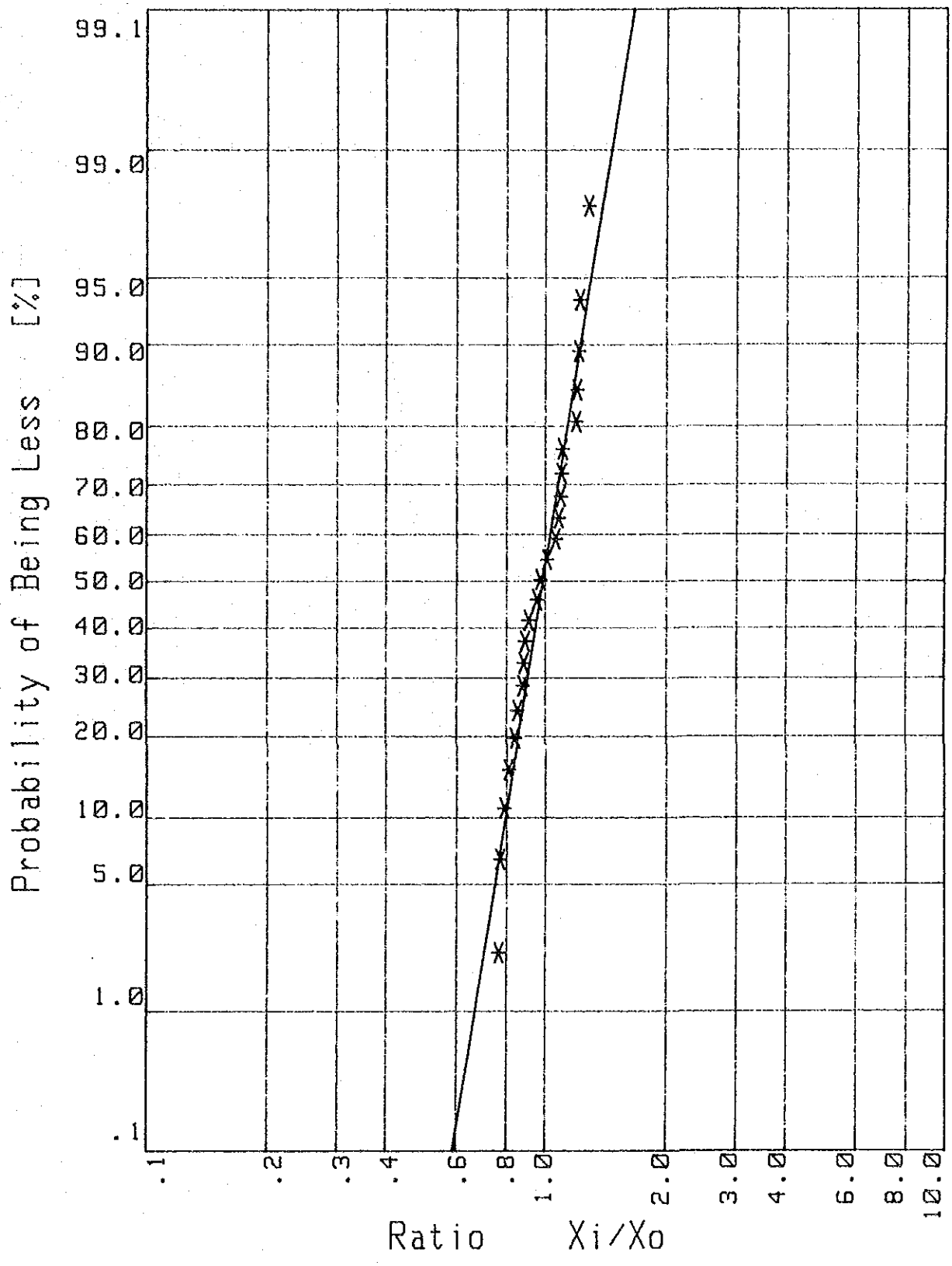
Probability of Noumber of Rainy Days
(Station BREMEN)

Fig. B.4.3 Probability of Number of Rain Day (1) Bremen Station



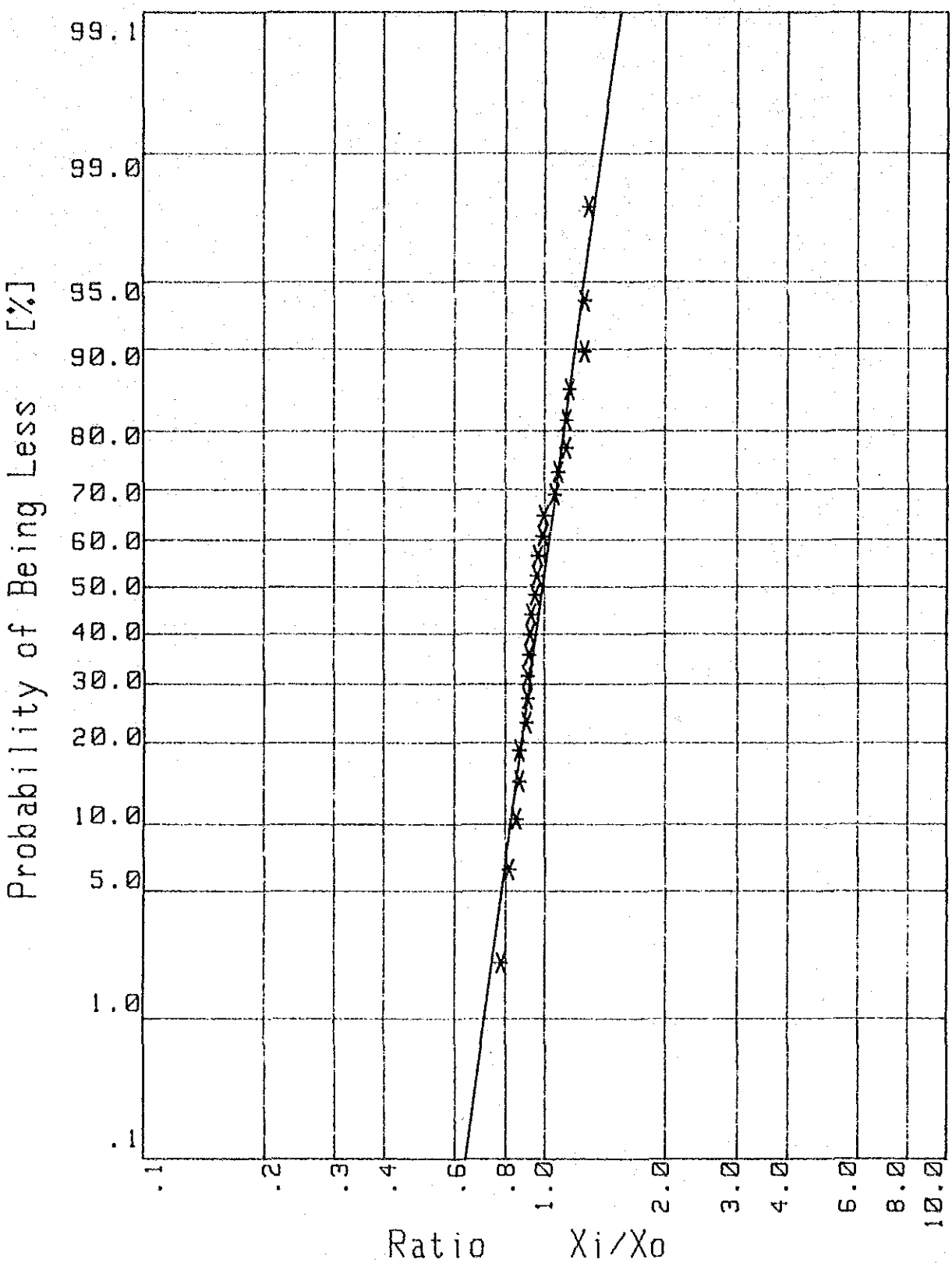
Probability of Noumber of Rainy Days
(Station SALENTO)

Fig. B.4.3 Probability of Number of Rain Day (2) Salento Station



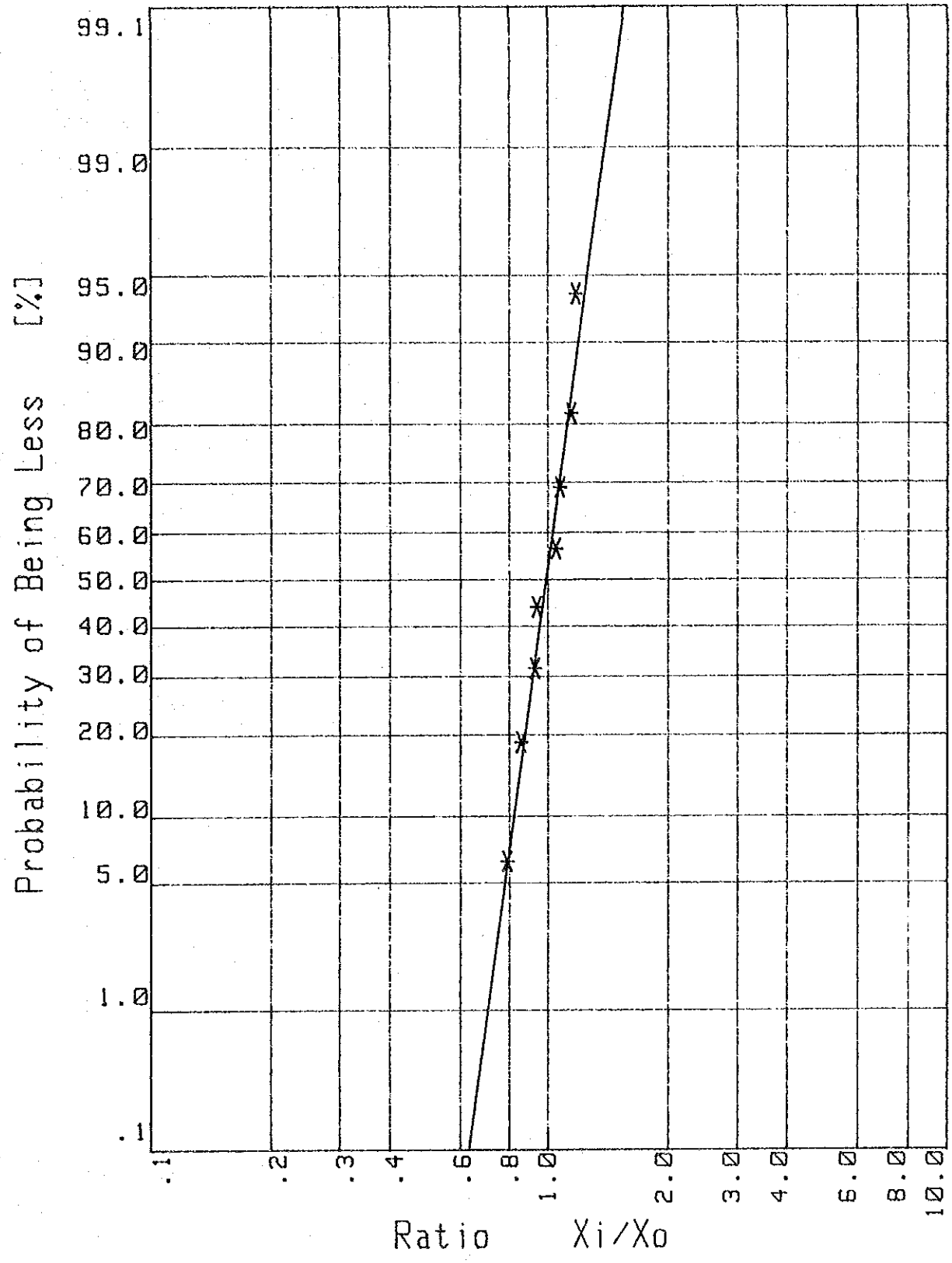
Probability of Noumber of Rainy Days
(Station EL EDEN)

Fig. B.4.3 Probability of Number of Rain Day (3) El Eden Station



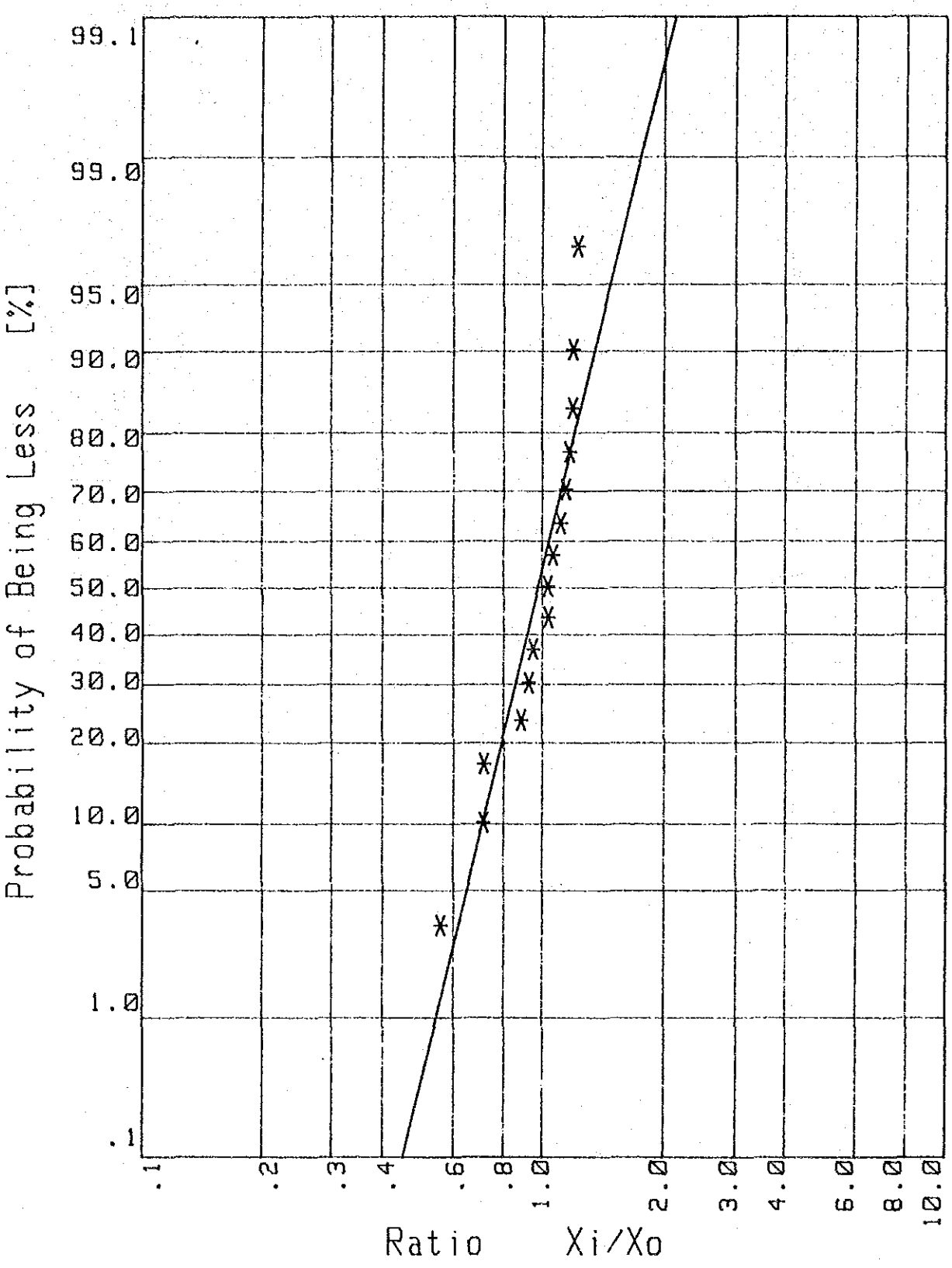
Probability of Noumber of Rainy Days
(Station PARAGUAYCITO)

Fig. B.4.3 Probability of Number of Rain Day (4) Paraguaycito Station



Probability of Noumber of Rainy Days
(Station PIJAO)

Fig. B.4.3 Probability of Number of Rain Day (5) Pijao Station



Probability of Noumber of Rainy Days
(Station GIBRALTAL)

Fig. B.4.3 Probability of Number of Rain Day (6) Gibraltar Station

Table B.4.4 Probability of Continuous Drought Days (1) Bremen Station

Probability of Continuous Drought Days (station BREMEN)

Year	Maximum [days]	No.	Data(year) [days]	Ratio Xi/Xo	Probability [%]
1970	8	1	28(1982)	2.017	2.94
1971	10	2	26(1976)	1.873	8.82
1972	15	3	17(1985)	1.225	14.71
1973	13	4	17(1986)	1.225	20.59
1974	7	5	16(1978)	1.153	26.47
1975	11	6	15(1972)	1.081	32.35
1976	26	7	14(1979)	1.008	38.24
1977	13	8	13(1973)	0.936	44.12
1978	16	9	13(1977)	0.936	50.00
1979	14	10	13(1981)	0.936	55.88
1980	----	11	11(1975)	0.792	61.76
1981	13	12	11(1983)	0.792	67.65
1982	28	13	11(1987)	0.792	73.53
1983	11	14	10(1971)	0.720	79.41
1984	6	15	8(1970)	0.576	85.29
1985	17	16	7(1974)	0.504	91.18
1986	17	17	6(1984)	0.432	97.06
1987	11				

Total Xs= 236.0 days Average Xo= 13.9 days

·Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	Maximum [days]
5%	20	1.829	25.4
10%	10	1.575	21.9
20%	5	1.311	18.2
25%	4	1.224	17.0
33%	3	1.110	15.4
50%	2	0.924	12.8

Table B.4.4 Probability of Continuous Drought Days (2) Salento Station

Probability of Continuous Drought Days (station SALENTO)

Year	Maximum [days]	No.	Data(year) [days]	Ratio Xi/Xo	Probability [%]
1975	13	1	27(1983)	1.293	5.56
1976	25	2	25(1976)	1.197	16.67
1977	21	3	24(1978)	1.149	27.78
1978	24	4	23(1980)	1.101	38.89
1979	16	5	21(1977)	1.005	50.00
1980	23	6	20(1981)	0.957	61.11
1981	20	7	19(1984)	0.910	72.22
1982	----	8	16(1979)	0.766	83.33
1983	27	9	13(1975)	0.622	94.44
1984	19				
1985	----				
1986	----				

Total Xs= 188.0 days Average Xo= 20.9 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	Maximum [days]
5%	20	1.455	30.4
10%	10	1.334	27.9
20%	5	1.199	25.0
25%	4	1.152	24.1
33%	3	1.088	22.7
50%	2	0.978	20.4

Table B.4.4 Probability of Continuous Drought Days (3) El Eden Station

Probability of Continuous Drought Days (station EL EDEN)

Year	Maximum [days]	No.	Data(year) [days]	Ratio Xi/Xo	Probability [%]
1949	----	1	32(1969)	1.669	2.17
1950	12	2	27(1964)	1.408	6.52
1951	----	3	26(1976)	1.356	10.87
1952	19	4	24(1971)	1.252	15.22
1953	18	5	22(1958)	1.147	19.57
1954	15	6	22(1961)	1.147	23.91
1955	----	7	21(1977)	1.095	28.26
1956	12	8	20(1970)	1.043	32.61
1957	15	9	20(1987)	1.043	36.96
1958	22	10	19(1962)	0.991	41.30
1959	19	11	19(1963)	0.991	45.65
1960	----	12	19(1959)	0.991	50.00
1961	22	13	19(1968)	0.991	54.35
1962	19	14	19(1979)	0.991	58.70
1963	19	15	19(1980)	0.991	63.04
1964	27	16	19(1952)	0.991	67.39
1965	----	17	18(1953)	0.939	71.74
1966	----	18	15(1957)	0.782	76.09
1967	----	19	15(1954)	0.782	80.43
1968	19	20	13(1974)	0.678	84.78
1969	32	21	12(1956)	0.626	89.13
1970	20	22	12(1950)	0.626	93.48
1971	24	23	9(1975)	0.469	97.83
1972	----				
1973	----				
1974	13				
1975	9				
1976	26				
1977	21				
1978	----				
1979	19				
1980	19				
1981	----				
1982	----				
1983	----				
1984	----				
1985	----				
1986	----				
1987	20				
1988	----				

Total Xs= 441.0 days Average Xo= 19.2 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	Maximum [days]
5%	20	1.573	30.2
10%	10	1.412	27.1
20%	5	1.238	23.7
25%	4	1.178	22.6
33%	3	1.099	21.1
50%	2	0.963	18.5

Table B.4.4 Probability of Continuous Drought Days (4) Paraguaycito Station

Probability of Continuous Drought Days (station PARAGUAYCITO)

Year	Maximum [days]	No.	Data(year) [days]	Ratio Xi/Xo	Probability [%]
1964	14	1	38(1982)	2.246	2.08
1965	12	2	31(1976)	1.833	6.25
1966	22	3	29(1986)	1.714	10.42
1967	13	4	22(1969)	1.300	14.58
1968	17	5	22(1966)	1.300	18.75
1969	22	6	19(1985)	1.123	22.92
1970	10	7	18(1977)	1.064	27.08
1971	9	8	17(1968)	1.005	31.25
1972	13	9	17(1978)	1.005	35.42
1973	16	10	17(1981)	1.005	39.58
1974	13	11	17(1987)	1.005	43.75
1975	8	12	16(1983)	0.946	47.92
1976	31	13	16(1973)	0.946	52.08
1977	18	14	14(1964)	0.828	56.25
1978	17	15	14(1979)	0.828	60.42
1979	14	16	14(1980)	0.828	64.58
1980	14	17	13(1974)	0.768	68.75
1981	17	18	13(1972)	0.768	72.92
1982	38	19	13(1967)	0.768	77.08
1983	16	20	12(1965)	0.709	81.25
1984	7	21	10(1970)	0.591	85.42
1985	19	22	9(1971)	0.532	89.58
1986	29	23	8(1975)	0.473	93.75
1987	17	24	7(1984)	0.414	97.92

Total Xs= 406.0 days Average Xo= 16.9 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	Maximum [days]
5%	20	1.816	30.7
10%	10	1.565	26.5
20%	5	1.305	22.1
25%	4	1.219	20.6
33%	3	1.107	18.7
50%	2	0.923	15.6

Table B.4.4 Probability of Continuous Drought Days (5) Pijao Station

Probability of Continuous Drought Days (station PIJAO)

Year	Maximum [days]	No.	Data(year) [days]	Ratio Xi/Xo	Probability [%]
1975	15	1	37(1976)	1.682	6.25
1976	37	2	31(1982)	1.409	18.75
1977	----	3	23(1985)	1.045	31.25
1978	18	4	22(1983)	1.000	43.75
1979	----	5	18(1978)	0.818	56.25
1980	----	6	16(1981)	0.727	68.75
1981	16	7	15(1975)	0.682	81.25
1982	31	8	14(1984)	0.636	93.75
1983	22				
1984	14				
1985	23				
1986	----				

Total Xs= 176.0 days Average Xo= 22.0 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	Maximum [days]
5%	20	1.723	37.9
10%	10	1.510	33.2
20%	5	1.286	28.3
25%	4	1.210	26.6
33%	3	1.111	24.4
50%	2	0.946	20.8

Table B.4.4 Probability of Continuous Drought Days (6) Gibraltar Station

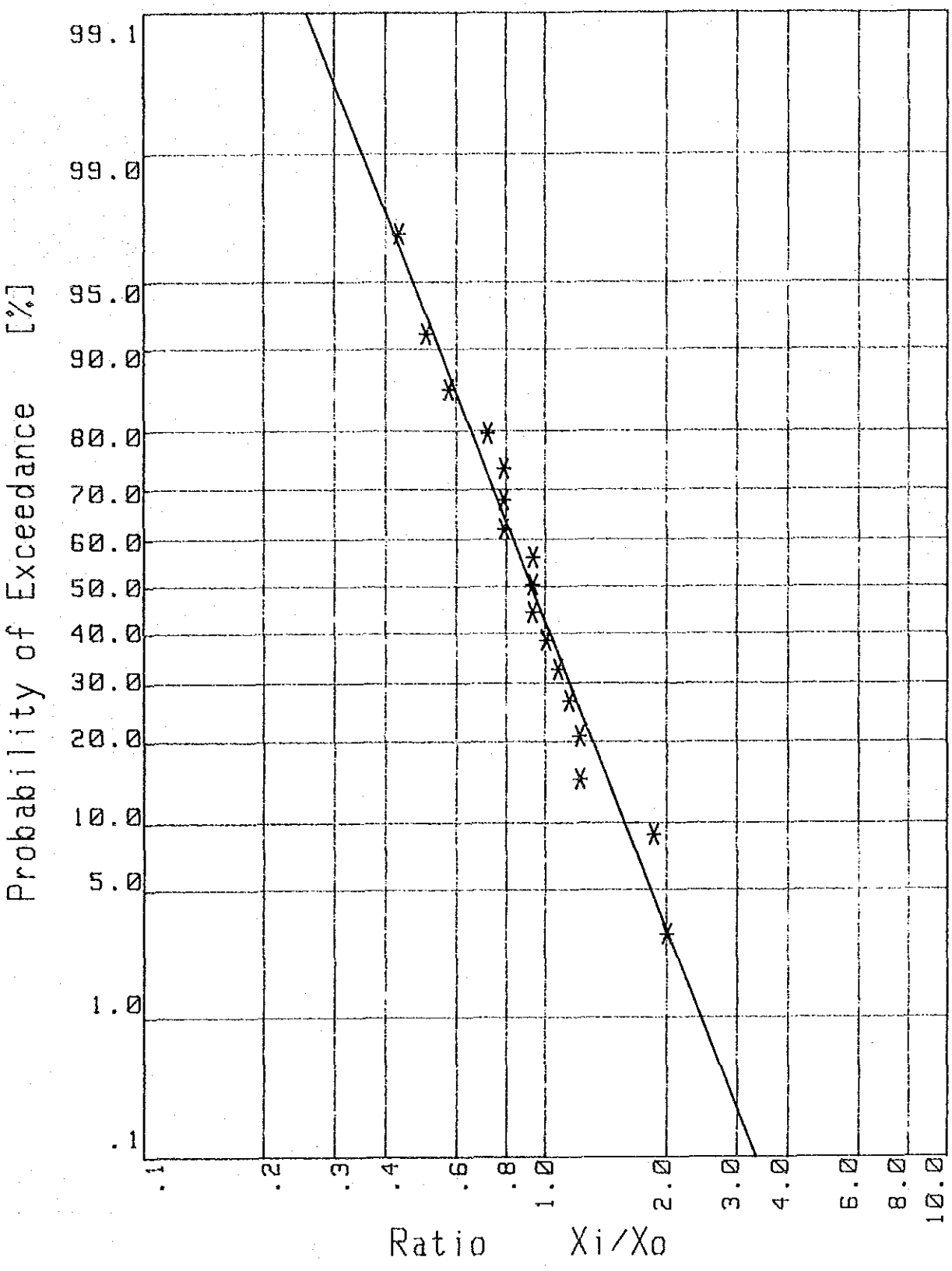
Probability of Continuous Drought Days (station GIBRALTAL)

Year	Maximum [days]	No.	Data(year) [days]	Ratio Xi/Xo	Probability [%]
1971	----	1	37(1978)	1.562	3.85
1972	25	2	28(1988)	1.182	11.54
1973	20	3	27(1977)	1.140	19.23
1974	14	4	26(1986)	1.097	26.92
1975	21	5	26(1989)	1.097	34.62
1976	----	6	25(1980)	1.055	42.31
1977	27	7	25(1972)	1.055	50.00
1978	37	8	21(1987)	0.886	57.69
1979	----	9	21(1981)	0.886	65.38
1980	25	10	21(1975)	0.886	73.08
1981	21	11	20(1973)	0.844	80.77
1982	----	12	17(1984)	0.718	88.46
1983	----	13	14(1974)	0.591	96.15
1984	17				
1985	----				
1986	26				
1987	21				
1988	28				
1989	26				

Total Xs= 308.0 days Average Xo= 23.7 days

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	Maximum [days]
5%	20	1.474	34.9
10%	10	1.345	31.9
20%	5	1.204	28.5
25%	4	1.154	27.3
33%	3	1.088	25.8
50%	2	0.973	23.1



Probability of Continuous Drought Days
(Station BREMEN)

Fig. B.4.4 Probability of Continuous Drought Days (1) Bremen Station

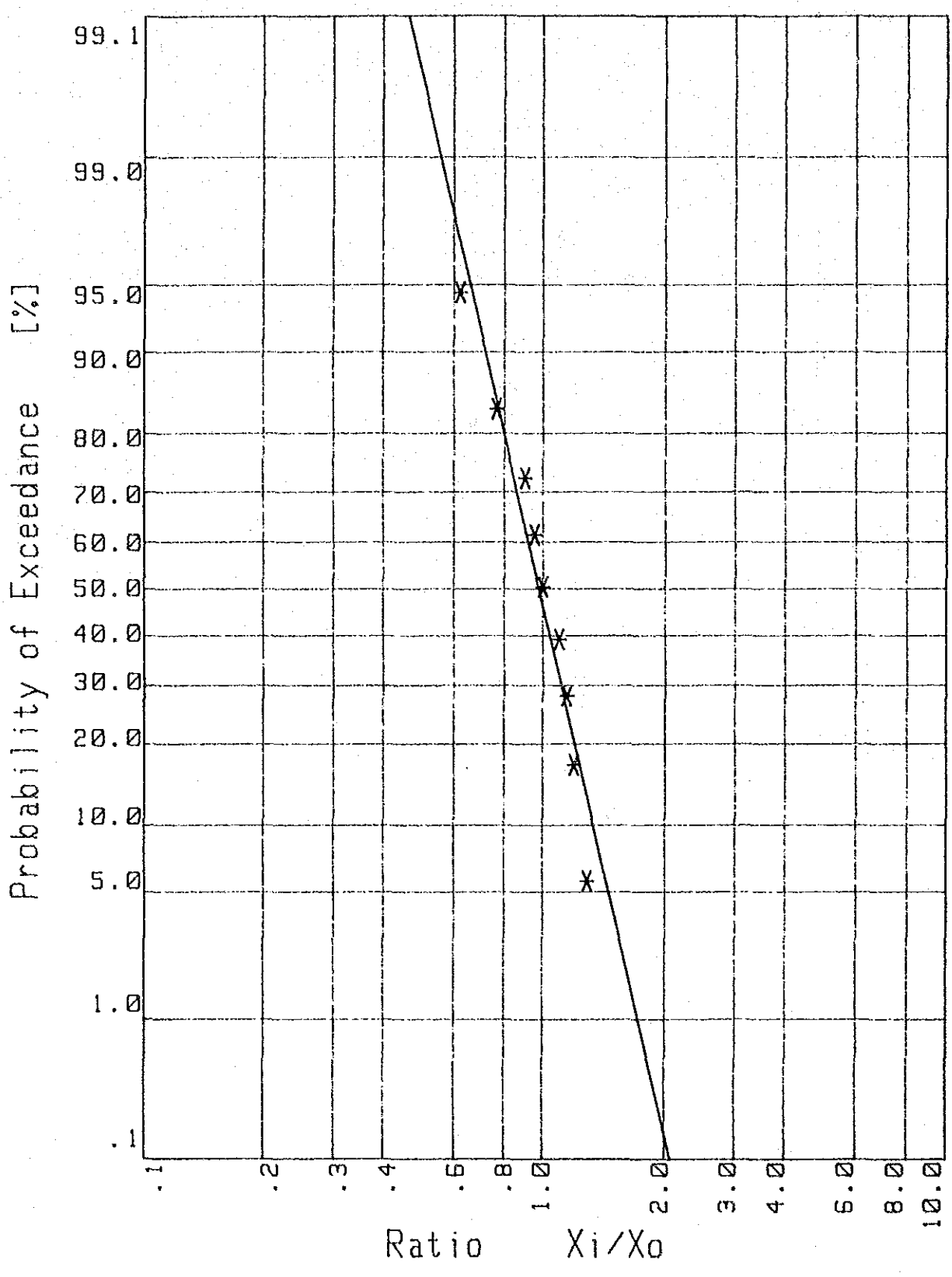
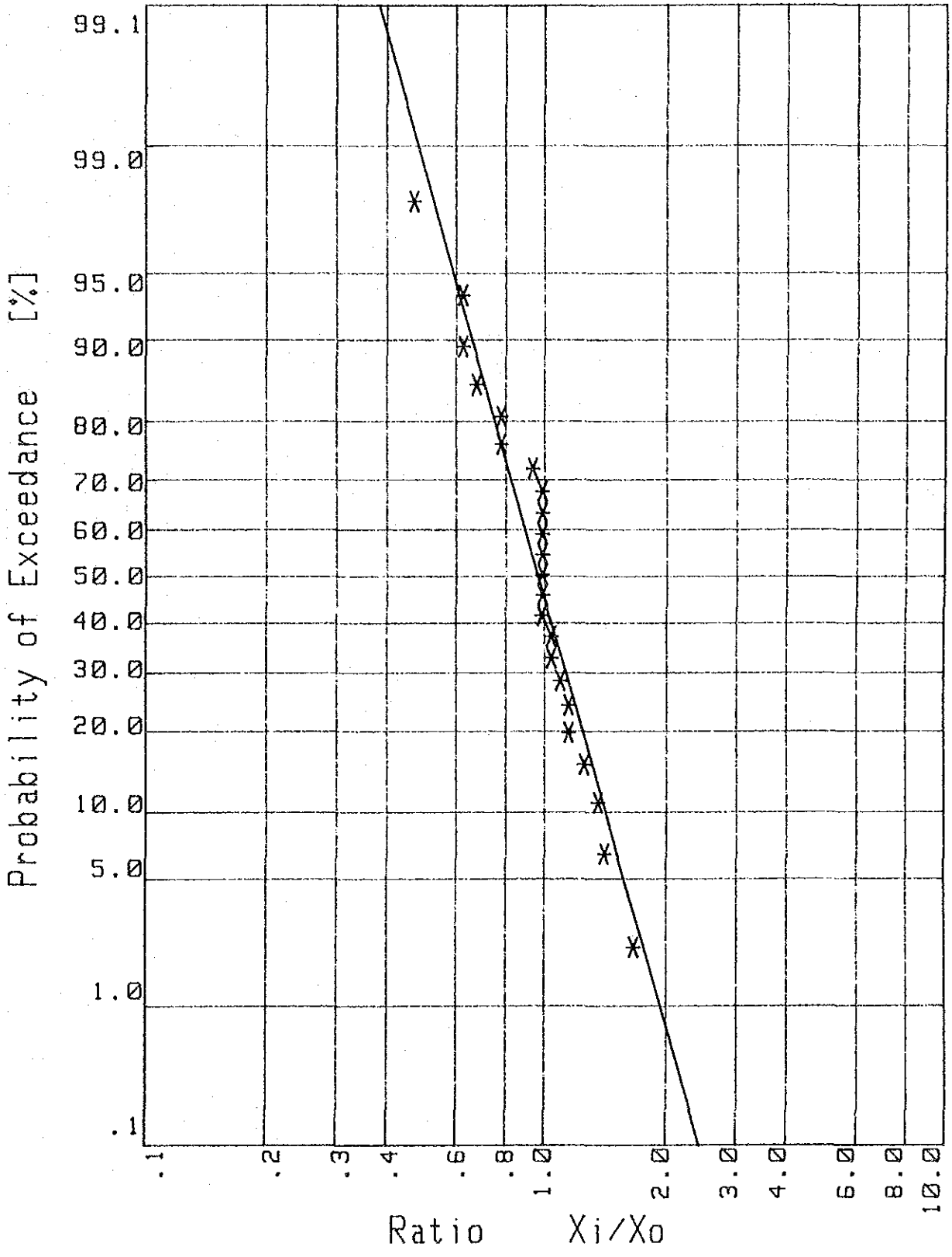
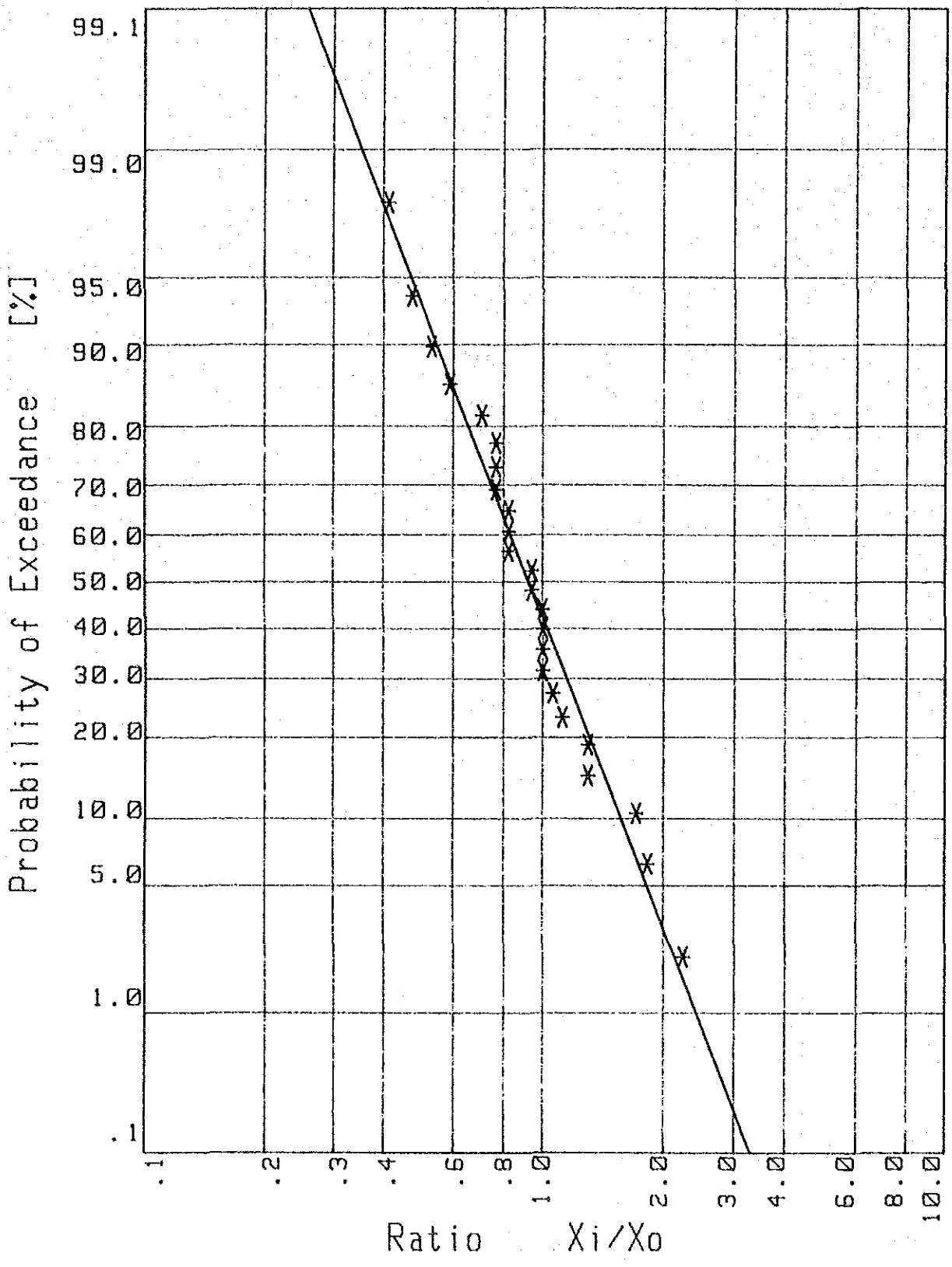


Fig. B.4.4 Probability of Continuous Drought Days (2) Salento Station



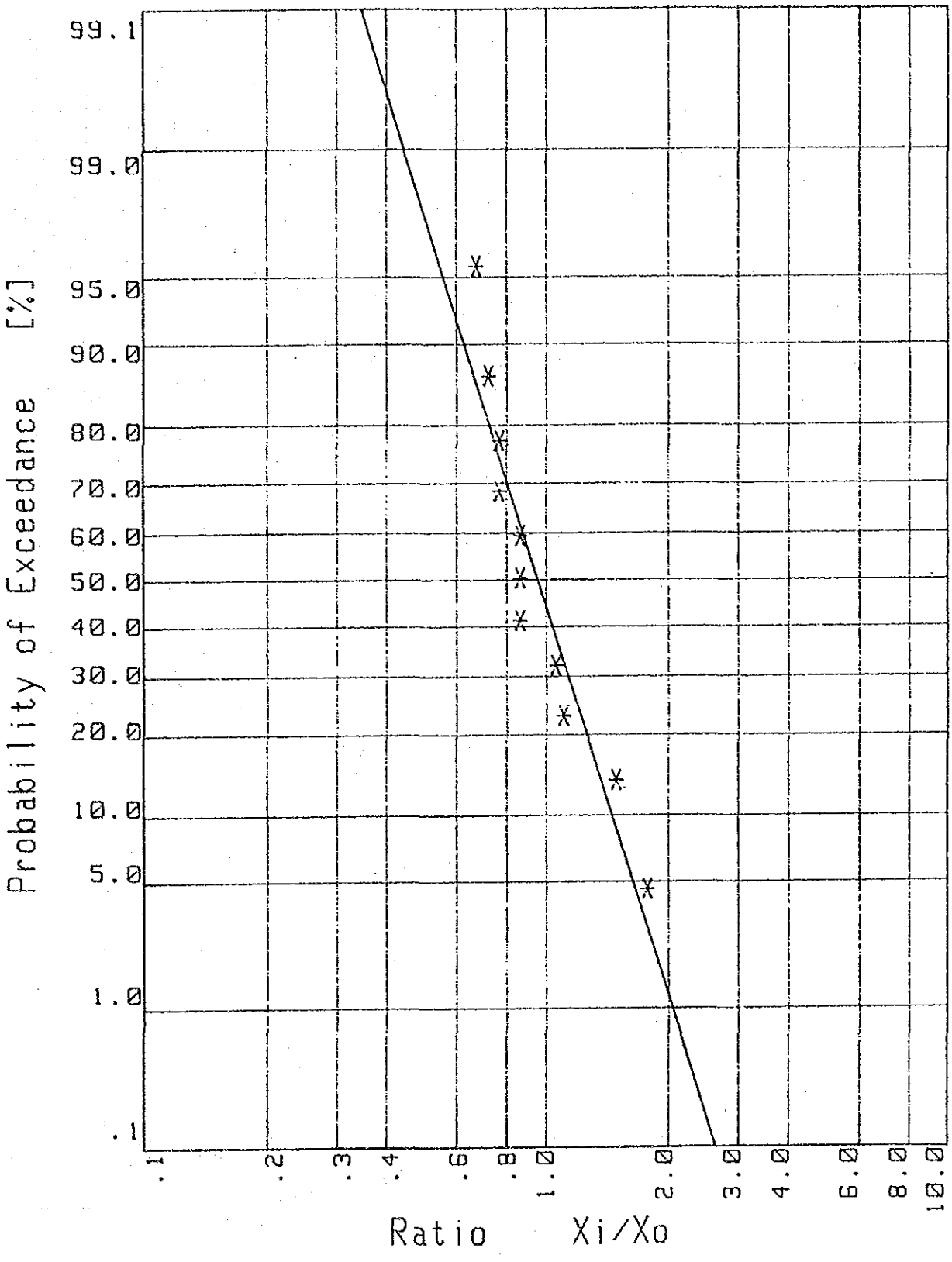
Probability of Continuous Drought Days
(Station EL EDEN)

Fig. B.4.4 Probability of Continuous Drought Days (3) El Eden Station



Probability of Continuous Drought Days
(Station PARAGUAYCITO)

Fig. B.4.4 Probability of Continuous Drought Days (4) Paraguaycito Station



Probability of Continuous Drought Days
(Station PIJAO)

Fig. B.4.4 Probability of Continuous Drought Days (5) Pijao Station

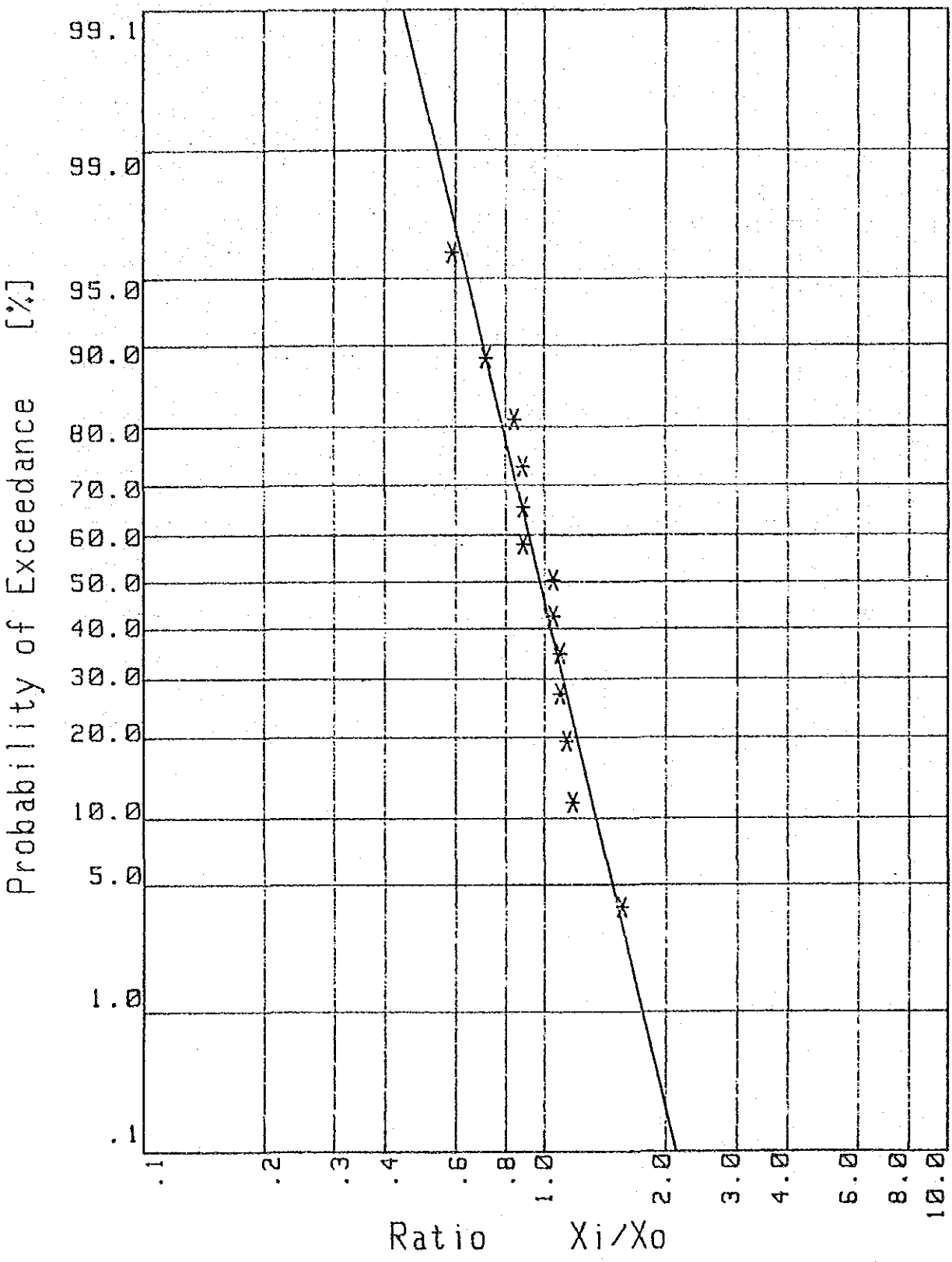


Fig. B.4.4 Probability of Continuous Drought Days (6) Gibraltar Station

Table B.4.5 Probability of Maximum 24-hour Rainfall (1) Bremen Station

Probability of Maximum 24-hour Rainfall (station BREMEN)

Year	24 Max. Rainfall [mm]	No.	Data(year) [mm]	Ratio Xi/Xo	Probability [%]
1970	68	1	123(1972)	1.422	2.94
1971	74	2	111(1985)	1.276	8.82
1972	123	3	109(1973)	1.261	14.71
1973	109	4	100(1981)	1.155	20.59
1974	76	5	95(1976)	1.102	26.47
1975	88	6	94(1987)	1.083	32.35
1976	95	7	91(1982)	1.052	38.24
1977	65	8	88(1975)	1.010	44.12
1978	80	9	80(1978)	0.924	50.00
1979	72	10	79(1984)	0.915	55.88
1980	----	11	78(1986)	0.904	61.76
1981	100	12	76(1974)	0.880	67.65
1982	91	13	74(1971)	0.855	73.53
1983	69	14	72(1979)	0.837	79.41
1984	79	15	69(1983)	0.795	85.29
1985	111	16	68(1970)	0.779	91.18
1986	78	17	65(1977)	0.751	97.06
1987	94				

Total Xs= 1472.1 mm Average Xo= 86.6 mm

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	24 Max. Rainfall [mm]
5%	20	1.348	116.7
10%	10	1.258	108.9
20%	5	1.156	100.1
25%	4	1.119	96.9
33%	3	1.070	92.7
50%	2	0.983	85.1

Table B.4.5 Probability of Maximum 24-hour Rainfall (2) Salento Station

Probability of Maximum 24-hour Rainfall (station SALENTO)

Year	24 Max. Rainfall [mm]	No.	Data(year) [mm]	Ratio Xi/Xo	Probability [%]
1975	66	1	144(1977)	1.496	4.17
1976	82	2	135(1979)	1.403	12.50
1977	144	3	135(1981)	1.403	20.83
1978	50	4	103(1982)	1.070	29.17
1979	135	5	100(1985)	1.039	37.50
1980	63	6	100(1986)	1.039	45.83
1981	135	7	94(1983)	0.977	54.17
1982	103	8	83(1984)	0.862	62.50
1983	94	9	82(1976)	0.852	70.83
1984	83	10	66(1975)	0.686	79.17
1985	100	11	63(1980)	0.655	87.50
1986	100	12	50(1978)	0.519	95.83
Total	Xs=	1155.0 mm	Average	Xo=	96.3 mm

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	24 Max. Rainfall [mm]
5%	20	1.656	159.4
10%	10	1.467	141.2
20%	5	1.265	121.8
25%	4	1.197	115.2
33%	3	1.106	106.5
50%	2	0.954	91.8

Table B.4.5 Probability of Maximum 24-hour Rainfall (3) El Eden Station

Probability of Maximum 24-hour Rainfall (station EL EDEN)

Year	24 Max. Rainfall [mm]	No.	Data(year) [mm]	Ratio Xi/Xo	Probability [%]
1949	----	1	138(1968)	1.645	2.17
1950	93	2	120(1959)	1.431	6.52
1951	----	3	109(1974)	1.300	10.87
1952	50	4	97(1980)	1.159	15.22
1953	96	5	96(1953)	1.145	19.57
1954	79	6	95(1961)	1.133	23.91
1955	----	7	93(1969)	1.109	28.26
1956	81	8	93(1950)	1.103	32.61
1957	71	9	90(1964)	1.073	36.96
1958	65	10	87(1979)	1.037	41.30
1959	120	11	87(1977)	1.037	45.65
1960	----	12	81(1956)	0.967	50.00
1961	95	13	80(1970)	0.954	54.35
1962	59	14	79(1954)	0.940	58.70
1963	73	15	73(1963)	0.870	63.04
1964	90	16	73(1987)	0.870	67.39
1965	----	17	71(1957)	0.850	71.74
1966	----	18	70(1975)	0.835	76.09
1967	----	19	65(1958)	0.775	80.43
1968	138	20	63(1971)	0.751	84.78
1969	93	21	60(1976)	0.715	89.13
1970	80	22	59(1962)	0.704	93.48
1971	63	23	50(1952)	0.596	97.83
1972	----				
1973	----				
1974	109				
1975	70				
1976	60				
1977	87				
1978	----				
1979	87				
1980	97				
1981	----				
1982	----				
1983	----				
1984	----				
1985	----				
1986	----				
1987	73				
1988	----				

Total Xs= 1928.9 mm Average Xo= 83.9 mm

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	24 Max. Rainfall [mm]
5%	20	1.448	121.4
10%	10	1.327	111.3
20%	5	1.192	100.0
25%	4	1.145	96.1
33%	3	1.082	90.8
50%	2	0.973	81.6

Table B.4.5 Probability of Maximum 24-hour Rainfall (4) Paraguaycito Station

Probability of Maximum 24-hour Rainfall (station PARAGUAYCITO)

Year	24 Max. Rainfall [mm]	No.	Data(year) [mm]	Ratio Xi/Xo	Probability [%]
1964	84	1	109(1975)	1.326	2.08
1965	75	2	102(1967)	1.239	6.25
1966	85	3	97(1978)	1.183	10.42
1967	102	4	96(1973)	1.166	14.58
1968	81	5	96(1974)	1.166	18.75
1969	68	6	94(1970)	1.149	22.92
1970	94	7	85(1966)	1.033	27.08
1971	80	8	84(1964)	1.028	31.25
1972	81	9	83(1981)	1.017	35.42
1973	96	10	81(1968)	0.992	39.58
1974	96	11	81(1972)	0.984	43.75
1975	109	12	81(1979)	0.983	47.92
1976	68	13	80(1971)	0.973	52.08
1977	72	14	79(1984)	0.958	56.25
1978	97	15	78(1986)	0.955	60.42
1979	81	16	78(1982)	0.945	64.58
1980	76	17	76(1980)	0.927	68.75
1981	83	18	75(1965)	0.918	72.92
1982	78	19	72(1977)	0.876	77.08
1983	70	20	70(1987)	0.860	81.25
1984	79	21	70(1983)	0.854	85.42
1985	67	22	68(1969)	0.827	89.59
1986	78	23	68(1976)	0.826	93.75
1987	70	24	67(1985)	0.814	97.92

Total Xs= 1967.6 mm Average Xo= 82.0 mm

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	24 Max. Rainfall [mm]
5%	20	1.246	102.1
10%	10	1.185	97.1
20%	5	1.114	91.3
25%	4	1.089	89.3
33%	3	1.054	86.4
50%	2	0.991	81.3

Table B.4.5 Probability of Maximum 24-hour Rainfall (5) Pijao Station

Probability of Maximum 24-hour Rainfall (station PIJAO)

Year	24 Max. Rainfall [mm]	No.	Data(year) [mm]	Ratio Xi/Xo	Probability [%]
1975	80	1	113(1976)	1.345	4.55
1976	113	2	108(1985)	1.286	13.64
1977	----	3	104(1981)	1.238	22.73
1978	82	4	96(1980)	1.143	31.82
1979	71	5	83(1982)	0.988	40.91
1980	96	6	82(1978)	0.976	50.00
1981	104	7	80(1975)	0.952	59.09
1982	83	8	71(1979)	0.845	68.18
1983	55	9	69(1984)	0.821	77.27
1984	69	10	63(1986)	0.750	86.36
1985	108	11	55(1983)	0.655	95.45
1986	63				

Total Xs= 924.0 mm Average Xo= 84.0 mm

Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	24 Max. Rainfall [mm]
5%	20	1.443	121.2
10%	10	1.324	111.3
20%	5	1.193	100.2
25%	4	1.146	96.3
33%	3	1.084	91.1
50%	2	0.976	82.0

Table B.4.5 Probability of Maximum 24-hour Rainfall (6) Gibraltar Station

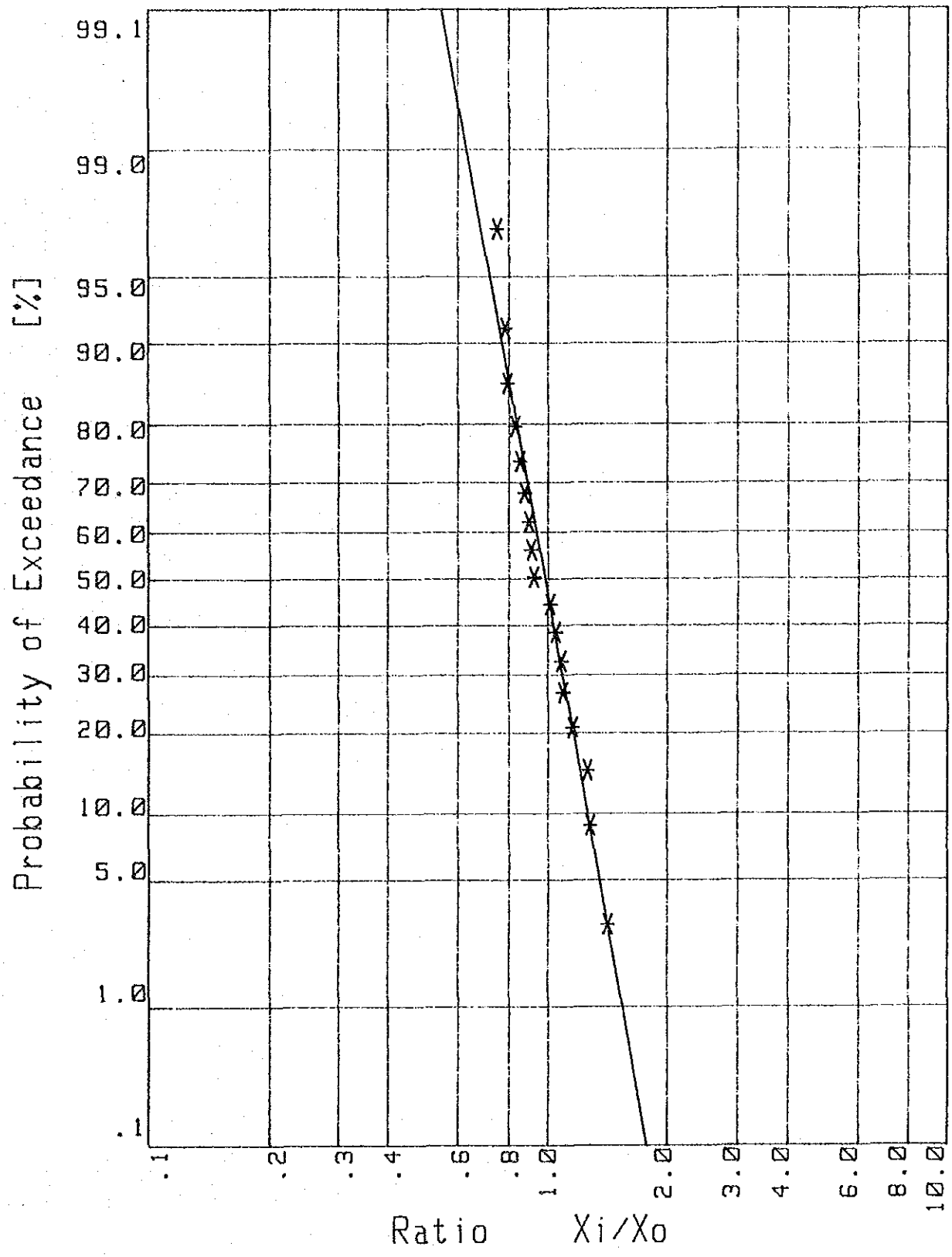
Probability of Maximum 24-hour Rainfall (station GIBRALTAR)

Year	24 Max. Rainfall [mm]	No.	Data(year) [mm]	Ratio Xi/Xo	Probability [%]
1971	----	1	130(1981)	1.850	3.13
1972	59	2	100(1982)	1.426	9.38
1973	67	3	85(1984)	1.210	15.63
1974	49	4	82(1986)	1.170	21.88
1975	52	5	80(1980)	1.138	28.13
1976	51	6	80(1983)	1.138	34.38
1977	50	7	70(1989)	0.996	40.63
1978	40	8	67(1973)	0.953	46.88
1979	----	9	66(1988)	0.939	53.13
1980	80	10	63(1987)	0.899	59.38
1981	130	11	59(1972)	0.835	65.63
1982	100	12	52(1975)	0.740	71.88
1983	80	13	51(1976)	0.726	78.13
1984	85	14	50(1977)	0.712	84.38
1985	----	15	49(1974)	0.697	90.63
1986	82	16	40(1978)	0.569	96.88
1987	63				
1988	66				
1989	70				

Total Xs= 1124.3 mm Average Xo= 70.3 mm

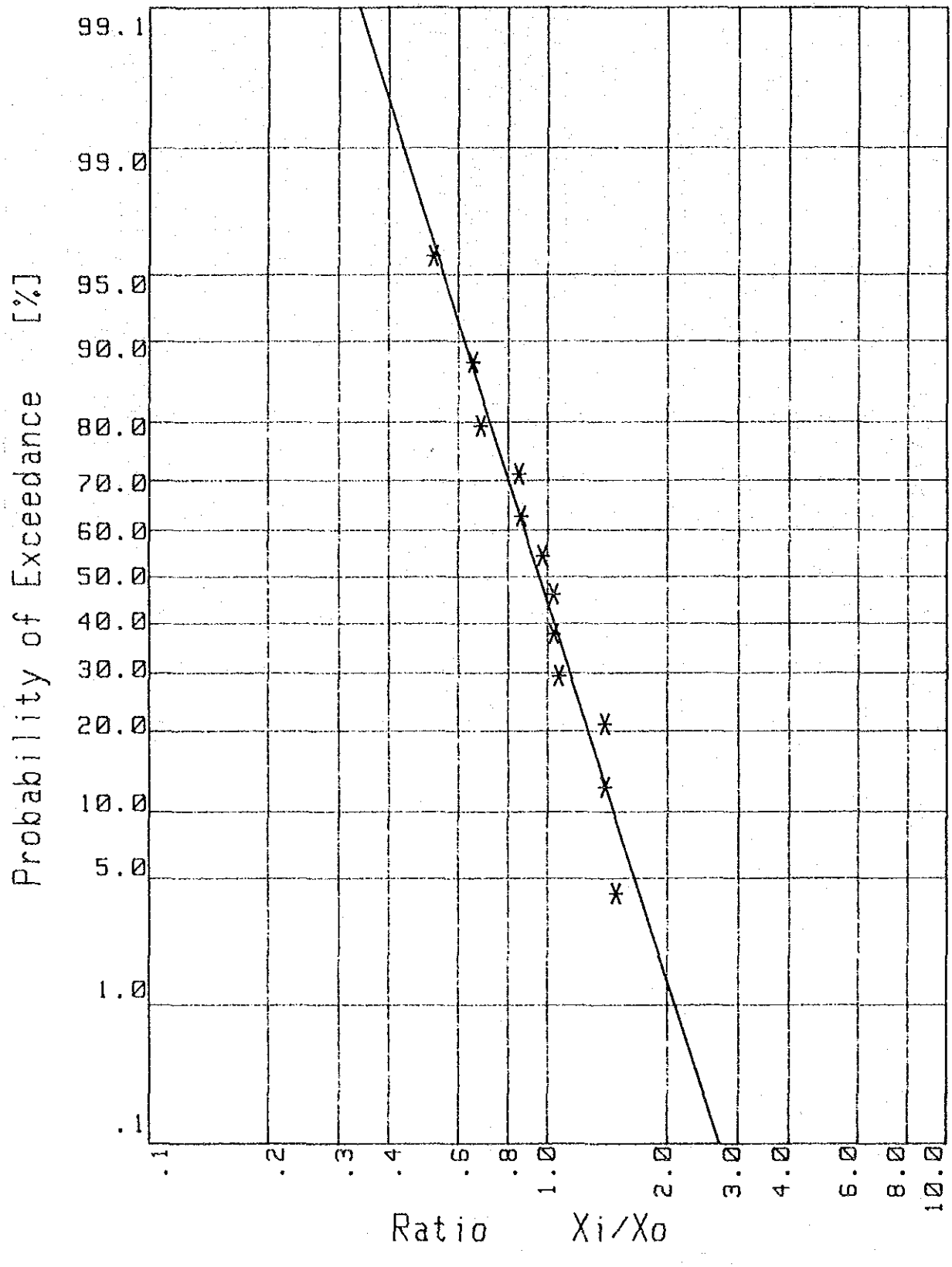
Hazen Plot

Probability	Return Period [year]	Ratio Xi/Xo	24 Max. Rainfall [mm]
5%	20	1.588	111.6
10%	10	1.421	99.9
20%	5	1.240	87.2
25%	4	1.178	82.8
33%	3	1.096	77.0
50%	2	0.957	67.2



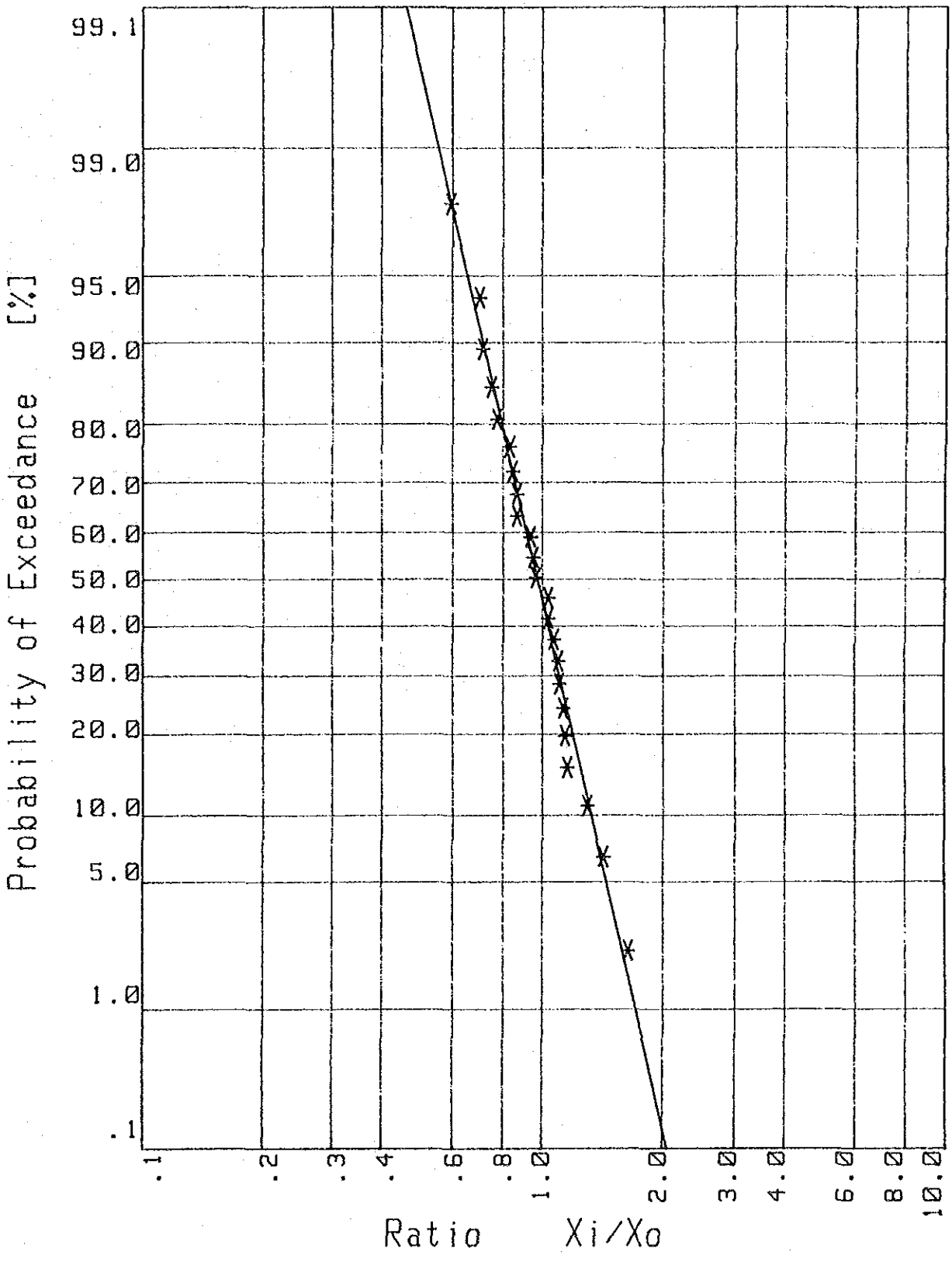
Probability of Maximum 24-hour Rainfall
(Station BREMEN)

Fig. B.4.5 Probability of Maximum 24-hour Rainfall (1) Bremen Station



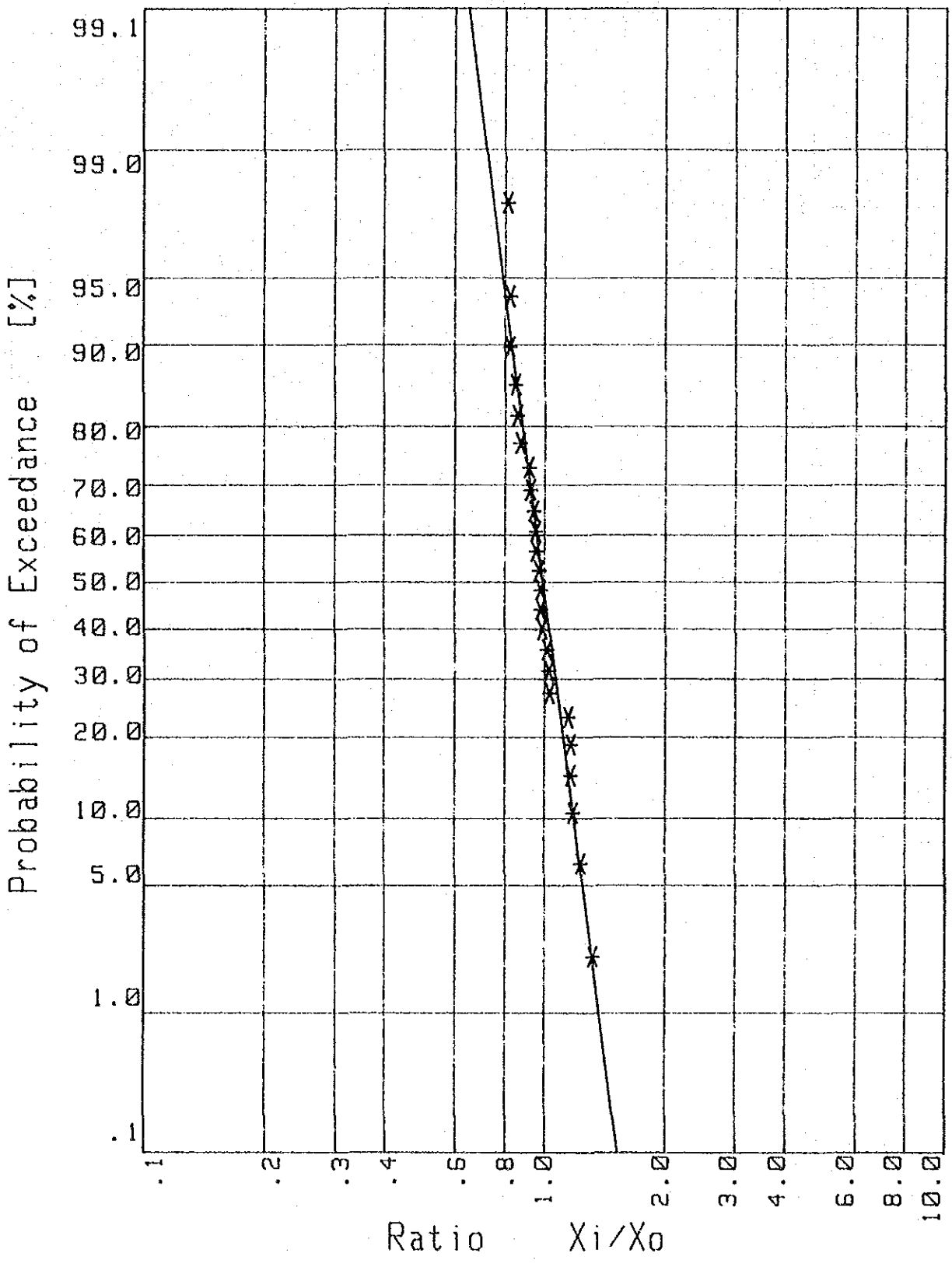
Probability of Maximum 24-hour Rainfall
(Station SALENTO)

Fig. B.4.5 Probability of Maximum 24-hour Rainfall (2) Salento Station



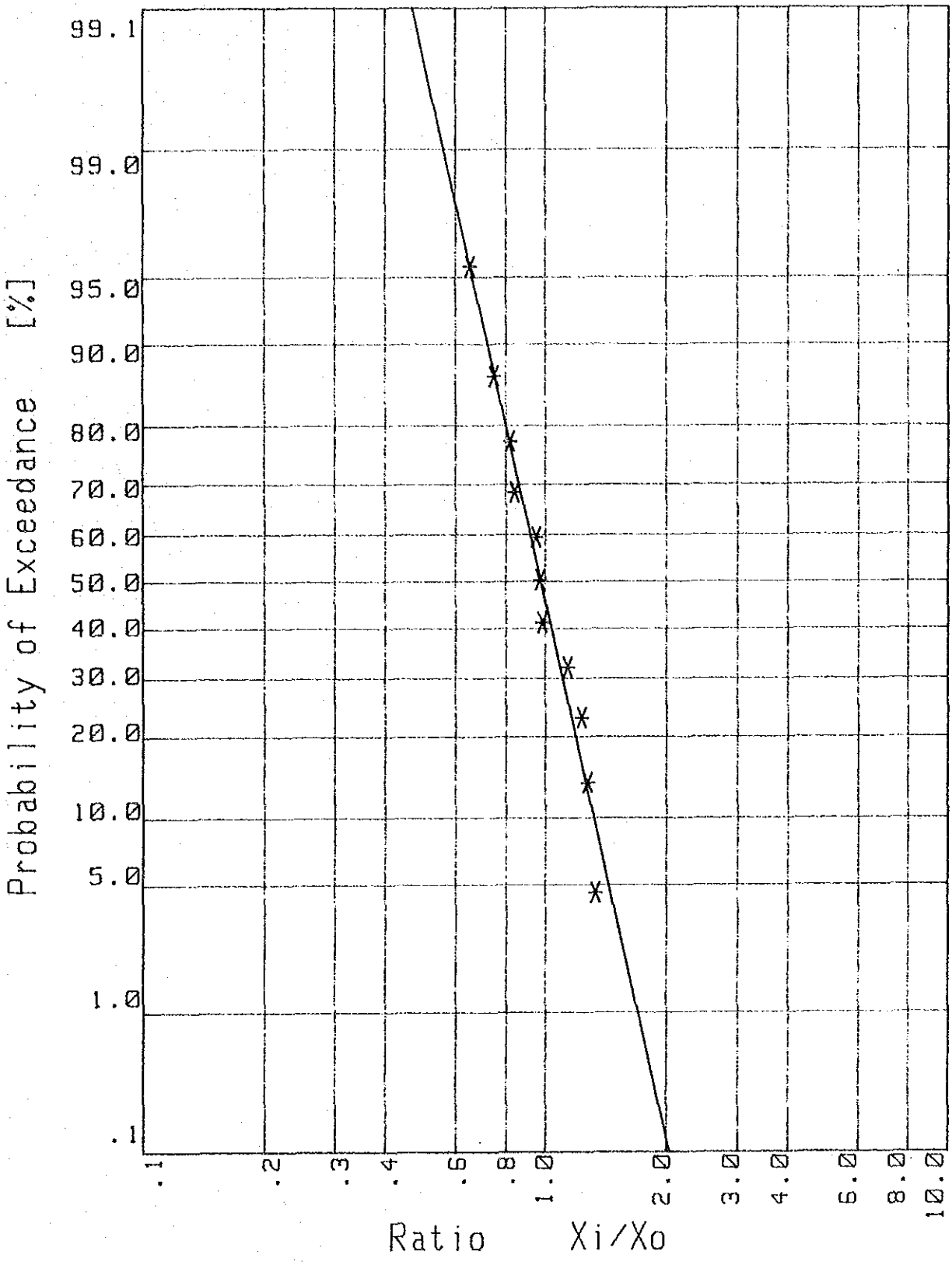
Probability of Maximum 24-hour Rainfall
(Station EL EDEN)

Fig. B.4.5 Probability of Maximum 24-hour Rainfall (3) El Eden Station



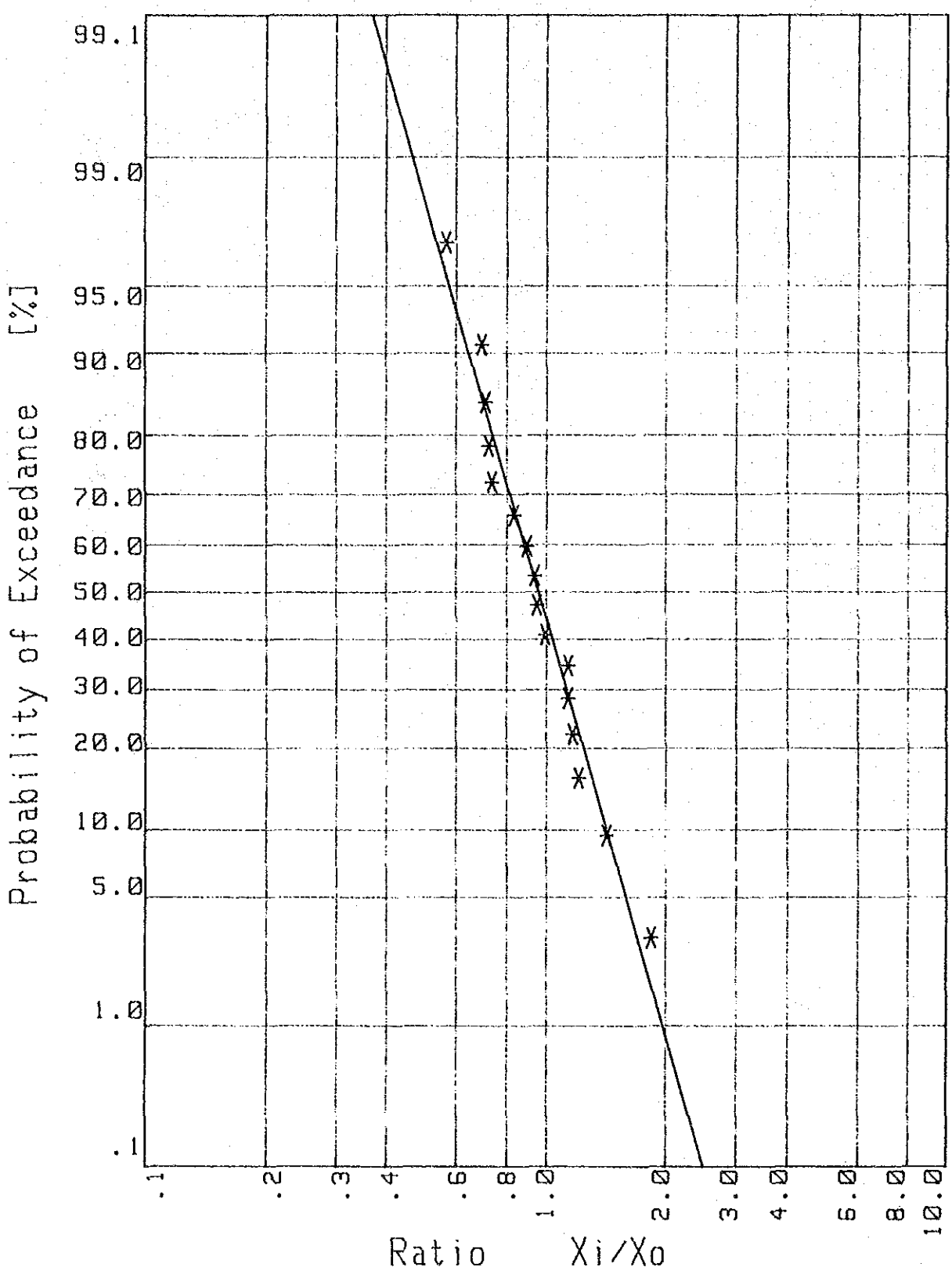
Probability of Maximum 24-hour Rainfall
(Station PARAGUAYCITO)

Fig. B.4.5 Probability of Maximum 24-hour Rainfall (4) Paraguaycito Station



Probability of Maximum 24-hour Rainfall
(Station PIJAO)

Fig. B.4.5 Probability of Maximum 24-hour Rainfall (5) Pijao Station



Probability of Maximum 24-hour Rainfall
(Station GIBRALTAR)

Fig. B.4.5 Probability of Maximum 24-hour Rainfall (6) Gibraltar Station