where, r24 : maximum daily rainfall (mm)
n : 1/3 to 2/3, usually = 2/3
T : arrival time of flood (hr)

Velocity of flood (W) and the arrival time od flood (T) area calculated by Rziha's formula expressed below;

$$W = 72 \times (H/L)^{0.6}$$

$$T = L/W$$

where, H : altitude difference (Km)
L : river length (Km)

When a river has different slopes in some sections, the foregoing formula becomes as follows;

$$Wi = 72 \times (Hi/Li)^{0.6} \ (Km/hr)$$

$$T = \Sigma \ (Li/Wi)$$

Project name	Lower Rokan Kiri	Lubuk & Upper Sosa	Lower Sosa	Mahato
Mountain peak	EL.1,037 m	EL.1,803 m	EL.2,199 m	EL. 210 m
H1	877	1,653	2,049	45
H2	70	55	65	-
H3	50	-	45	-
L1	35 Km	22 Km	25 Km	40 Km
L2	49	36	16	-
L3	48	-	60	-
W1	7.88 Km/h	15.24 Km/h	16.05 Km/h	1.22 Km/h
W2	1.41	1.47	2.65	-
W3	1.17	-	0.96	-
T1	4.44 hr	1.44 hr	1.56 hr	32.79 hr
T2	34.75	24.49	6.04	-
T3	41.03	-	62.50	-
ΣT	80.22	25.93	70.10	32.79

Therefore, the peak flood discharge of every location and probable rainfall is calculated as shown Table 5.4.

Table 4.1 Water Balance Calculation for Rokan Kiri River Basin (Year 1984)

UNIT : m3/s

PERIOD	1 RIVER DISCHARGE 2,020Km2	2 SEI KIJAN IRRIGATION 433 ha	3 RIVER DISCHARGE (1-2)	4 INFLOW 1 108Km2	5 RETURN FLOW	6 RIVER DISCHARGE (3+4+5)	7 SEI PALIS IRRI. 358 ha	8 INFLOW 2 858Km2	9 RETURN FLOW	10 RIVER DISCHARGE (6-7+8+9)	11 KOTAINTAN IRRIGATION 188 ha	12 UJUNG BATU DOMESTIC WATER	13 LOWER ROKAN KIRI IRRIGATION 19,300ha	14 RIVER DISCHARGE (10-11-12-13)	15 RETURN FLOW	16 INFLOW 3 1,001ha	17 RIVER DISCHARGE (14+15+16)
JAN. 1-10	64.84	0.08	64.76	3.47	0.02	68.25	0.08	27.54	0.02	95.73	0.12	0.04	24.32	71.26	3.04	32.13	106.43
11-20	58.98	0.03	58.95	3.15	0.01	62.11	0.00	25.05	0.00	87.17	0.00	0.04	5.40	81.72	0.68	29.23	111.63
21-31	74.94	0.00	74.94	4.01	0.00	78.95	0.02	31.83	0.00	110.77	0.02	0.04	0.00	110.70	0.00	37.14	147.84
FEB. 1-10	114.13	0.02	114.11	6.10	0.00	120.22	0.02	48.48	0.00	168.68	0.03	0.04	10.04	158.58	1.25	56.56	216.39
11-20	92.11	0.02	92.09	4.92	0.00	97.02	0.00	39.12	0.00	136.15	0.00	0.04	9.84	126.26	1.23	45.65	173.14
21-29	86.86	0.00	86.86	4.64	0.00	91.50	0.23	36.89	0.06	128.23	0.00	0.04	0.77	127.42	0.10	43.04	170.56
MAR. 1-10	96.76	0.00	96.76	5.17	0.00	101.93	0.14	41.10	0.03	142.93	0.34	0.04	4.44	138.11	0.55	47.95	186.61
11-20	83.63	0.47	83.16	4.47	0.12	87.75	0.16	35.52	0.04	123.15	0.20	0.04	2.70	120.20	0.34	41.44	161.98
21-31	67.87	0.55	67.32	3.63	0.14	71.09	0.10	28.83	0.03	99.84	0.24	0.04	0.00	99.56	0.00	33.63	133.19
APR. 1-10	81.41	0.47	80.93	4.35	0.12	85.40	0.09	34.58	0.02	119.91	0.15	0.04	0.00	119.72	0.00	40.34	160.06
11-20	98.98	0.31	98.67	5.29	0.08	104.04	0.16	42.04	0.04	145.96	0.14	0.04	19.30	126.48	2.41	49.05	177.94
21-30	72.72	0.50	72.22	3.89	0.12	76.23	0.14	30.89	0.04	107.02	0.24	0.04	27.60	79.14	3.45	36.04	118.62
MAY 1-10	75.55	0.70	74.85	4.04	0.18	79.06	0.06	32.09	0.02	111.10	0.21	0.04	34.16	76.69	4.27	37.44	118.40
11-20	96.35	0.28	96.07	5.15	0.07	101.29	0.19	40.93	0.05	142.08	0.09	0.04	19.49	122.45	2.44	47.75	172.64
21-31	73.73	0.53	73.20	3.94	0.13	77.27	0.13	31.32	0.03	108.49	0.28	0.04	33.58	74.59	4.20	36.54	115.32
JUN. 1-10	79.39	0.51	78.88	4.24	0.13	83.25	0.06	33.72	0.02	116.92	0.20	0.04	29.72	86.96	3.72	39.34	130.02
11-20	64.24	0.45	63.79	3.43	0.11	67.34	0.09	27.28	0.02	94.55	0.09	0.04	19.49	74.92	2.44	31.83	109.19
21-30	40.80	0.28	40.53	2.18	0.07	42.78	0.06	17.33	0.02	60.06	0.14	0.04	21.04	38.84	2.63	20.22	61.69
JUL. 1-10	41.61	0.23	41.38	2.22	0.06	43.66	0.01	17.67	0.00	61.33	0.09	0.04	20.27	40.93	2.53	20.62	64.08
11-20	45.05	0.22	44.83	2.41	0.05	47.29	0.03	19.13	0.01	66.41	0.02	0.04	17.56	48.78	2.28	22.32	73.30
21-31	34.34	0.07	34.27	1.84	0.02	36.12	0.02	14.59	0.01	50.69	0.04	0.04	10.81	39.80	1.35	17.02	58.17
AUG. 1-10	37.57	0.08	37.49	2.01	0.02	39.52	0.00	15.96	0.00	55.48	0.03	0.04	11.00	44.41	1.38	18.62	64.40
11-20	29.48	0.15	29.34	1.58	0.04	30.96	0.00	12.53	0.00	43.49	0.00	0.04	16.79	26.65	2.10	14.81	43.37
21-31	26.26	0.00	26.26	1.40	0.00	27.66	0.19	11.15	0.05	38.68	0.00	0.04	5.02	33.62	0.83	13.01	47.28
SEP. 1-10	29.49	0.00	29.49	1.58	0.00	31.07	0.21	12.53	0.05	43.44	0.28	0.04	2.70	40.42	0.34	14.61	55.37
11-20	52.72	0.71	52.01	2.82	0.18	55.00	0.15	22.39	0.04	77.29	0.31	0.04	3.47	73.46	0.43	26.13	100.02
21-30	45.05	0.52	44.53	2.41	0.13	47.07	0.22	19.13	0.06	66.04	0.22	0.04	0.00	65.77	0.00	22.32	88.09
OCT. 1-10	30.50	0.89	29.61	1.63	0.22	31.46	0.10	12.96	0.03	44.34	0.33	0.04	0.00	43.97	0.00	15.12	59.09
11-20	44.04	0.35	43.69	2.35	0.09	46.13	0.18	18.70	0.05	64.69	0.15	0.04	21.42	43.08	2.68	21.82	67.58
21-31	56.16	0.57	55.58	3.00	0.14	58.73	0.15	23.85	0.04	82.47	0.27	0.04	31.27	50.89	3.91	27.83	82.62
NOV. 1-10	103.22	0.75	102.47	5.52	0.19	108.18	0.05	43.84	0.01	151.98	0.23	0.04	36.48	115.24	4.56	51.15	170.95
11-20	151.50	0.23	151.27	8.10	0.06	159.42	0.18	64.35	0.04	223.65	0.08	0.04	17.37	206.17	2.17	75.08	283.41
21-30	94.94	0.43	94.51	5.08	0.11	99.69	0.05	40.33	0.01	139.98	0.24	0.04	29.14	110.56	3.64	47.05	161.25
DEC. 1-10	67.47	0.29	67.18	3.81	0.07	70.86	0.06	28.66	0.02	99.47	0.08	0.04	18.91	80.44	2.36	33.43	116.24
11-20	62.22	0.45	61.77	3.33	0.11	65.21	0.09	26.43	0.02	91.56	0.09	0.04	21.04	70.39	2.63	30.83	103.85
21-31	37.98	0.28	37.69	2.03	0.07	39.80	0.00	16.13	0.00	55.93	0.14	0.04	22.39	33.36	2.80	18.82	54.97

Table 4.2 Water Balance Calculation for Lubuk River Sub-basin(1) (Year 1984)

UNIT : m3/s

PERIOD	1 RIVER DISCHARGE 543 Km2	2 IRRIGATION FOR NORTH SUMATRA 2,600 ha	3 RETURN FLOW FROM NORTH S.	4 INFLOW 1 122 Km2	5 INFLOW 2 504 Km2	6 RETURN FLOW FROM UPPER SOSA	7 RIVER DISCHARGE (1-2+3+4+5+6)	8 DALUDALU DOMESTIC WATER	9 INFLOW 3 179 Km2	10 RIVER DISCHARGE (7-8+9)	11 LOWER SOSA IRRIGATION 11,800ha	12 RIVER DISCHARGE (10-11)	13 INFLOW 4 82 Km2	14 RETURN FLOW FROM L. SOSA	15 RIVER DISCHARGE (12+13+14)
JAN. 1-10	24.38	1.69	0.42	5.48	22.63	0.65	51.87	0.02	8.04	59.89	7.32	52.57	3.68	1.83	58.09
11-20	36.65	0.73	0.18	8.24	34.02	0.28	78.64	0.02	12.08	90.71	0.00	90.71	5.54	0.00	96.24
21-31	43.33	0.00	0.00	9.74	40.22	0.00	93.29	0.02	14.28	107.55	1.53	106.02	6.54	0.38	112.94
FEB. 1-10	31.71	0.42	0.10	7.12	29.43	0.16	68.12	0.02	10.45	78.55	1.77	76.78	4.79	0.44	82.01
11-20	20.74	0.39	0.10	4.66	19.25	0.15	44.51	0.02	6.84	51.33	0.00	51.33	3.13	0.00	54.46
21-29	17.00	0.00	0.00	3.82	15.78	0.00	36.59	0.02	5.60	42.17	0.00	42.17	2.57	0.00	44.74
MAR. 1-10	23.02	0.00	0.00	5.17	21.37	0.00	49.57	0.02	7.59	57.14	21.12	36.01	3.48	5.28	44.77
11-20	14.93	2.83	0.71	3.36	13.86	1.10	31.12	0.02	4.92	36.02	12.86	23.16	2.26	3.22	28.63
21-31	26.23	3.33	0.83	5.89	24.34	1.29	55.25	0.02	8.65	63.88	15.10	48.77	3.96	3.78	56.51
APR. 1-10	26.82	2.83	0.71	6.03	24.90	1.10	56.72	0.02	8.84	65.54	9.56	55.98	4.05	2.39	62.42
11-20	30.79	1.87	0.47	6.92	28.58	0.72	65.80	0.02	10.15	75.73	8.61	67.12	4.65	2.15	73.92
21-30	27.96	2.99	0.75	6.28	25.96	1.16	59.12	0.02	9.22	68.32	15.22	53.09	4.22	3.81	61.12
MAY 1-10	20.47	4.21	1.05	4.60	19.00	1.63	42.54	0.02	6.75	49.27	13.22	36.05	3.09	3.30	42.45
11-20	19.66	1.69	0.42	4.42	18.24	0.65	41.70	0.02	6.48	48.16	5.90	42.26	2.97	1.48	46.71
21-31	11.35	3.20	0.80	2.55	10.53	1.24	23.27	0.02	3.74	26.99	17.58	9.41	1.71	4.40	15.52
JUN. 1-10	11.29	3.04	0.76	2.54	10.48	1.18	23.21	0.02	3.72	26.91	12.39	14.52	1.71	3.10	19.33
11-20	11.62	2.68	0.67	2.61	10.79	1.04	24.04	0.02	3.83	27.85	5.90	21.95	1.75	1.48	25.18
21-30	8.15	1.66	0.42	1.83	7.56	0.64	16.33	0.02	2.69	19.60	8.85	10.75	1.23	2.21	14.19
JUL. 1-10	9.67	1.38	0.34	2.17	8.97	0.53	20.31	0.02	3.19	23.47	5.90	17.57	1.46	1.48	20.51
11-20	16.78	1.30	0.33	3.77	15.57	0.50	35.65	0.02	5.53	41.16	1.18	39.98	2.53	0.30	42.81
21-31	9.99	0.44	0.11	2.24	9.27	0.17	21.35	0.02	3.29	24.62	2.48	22.14	1.51	0.62	24.27
AUG. 1-10	13.68	0.47	0.12	3.07	12.70	0.18	29.29	0.02	4.51	33.78	2.12	31.66	2.07	0.53	34.25
11-20	6.90	0.88	0.22	1.55	6.40	0.34	14.53	0.02	2.27	16.78	0.00	16.78	1.04	0.00	17.82
21-31	5.81	0.00	0.00	1.31	5.39	0.00	12.51	0.02	1.92	14.40	0.00	14.40	0.88	0.00	15.28
SEP. 1-10	8.04	0.00	0.00	1.81	7.46	0.00	17.30	0.02	2.65	19.93	17.46	2.47	1.21	4.37	8.05
11-20	13.14	4.29	1.07	2.95	12.20	1.66	26.73	0.02	4.33	31.04	19.47	11.57	1.98	4.87	18.42
21-30	20.09	3.09	0.77	4.51	18.65	1.20	42.13	0.02	6.62	48.73	14.04	34.69	3.03	3.51	41.23
OCT. 1-10	9.94	5.36	1.34	2.23	9.22	2.07	19.45	0.02	3.28	22.70	20.77	1.93	1.50	5.19	8.63
11-20	17.00	2.11	0.53	3.82	15.78	0.81	35.82	0.02	5.60	41.41	9.56	31.85	2.57	2.39	36.81
21-31	15.31	3.43	0.86	3.44	14.21	1.33	31.72	0.02	5.05	36.75	17.11	19.64	2.31	4.28	26.23
NOV. 1-10	13.74	4.50	1.12	3.09	12.75	1.74	27.94	0.02	4.53	32.45	14.40	18.05	2.07	3.60	23.73
11-20	15.31	1.40	0.35	3.44	14.21	0.54	32.46	0.02	5.05	37.48	4.72	32.76	2.31	1.18	36.26
21-30	11.02	2.57	0.64	2.48	10.23	0.99	22.80	0.02	3.63	26.41	15.10	11.30	1.66	3.78	16.75
DEC. 1-10	21.01	1.74	0.44	4.72	19.50	0.67	44.61	0.02	6.93	51.51	4.72	46.79	3.17	1.18	51.15
11-20	9.77	2.68	0.67	2.20	9.07	1.04	20.07	0.02	3.22	23.27	5.90	17.37	1.48	1.48	20.32
21-31	6.73	1.69	0.42	1.51	6.25	0.65	13.88	0.02	2.22	16.08	8.85	7.23	1.02	2.21	10.46

Table 4.3 Water Balance Calculation for Lubuk River Sub-basin(2) (Year 1984)

UNIT : m3/s

PERIOD	1 RIVER DISCHARGE 818km2	2 IRRIGATION FOR LUBUK & U. SOSA 6,175 ha	3 RIVER DISCHARGE (1-2)	4 RETURN FLOW FROM BT.LUBUK	5 INFLOW 1 65 Km2	6 RIVER DISCHARGE (3+4+5)	7 IRRIGATION FOR SMALL IRRI.PRO. 938 ha	8 RIVER DISCHARGE (6-7)	9 RETURN FLOW FROM S.I.P.	10 INFLOW 2 159 Km2	11 RIVER DISCHARGE (8+9+10)	12 PASIR PAN. DOMESTIC WATER	13 RIVER DISCHARGE (11-12)	14 INFLOW 3 913Km2	15 KOTATENGAH DOMESTIC WATER	16 RIVER DISCHARGE (13+14-15)
JAN. 1-10	36.64	4.01	32.62	0.35	2.92	35.89	0.61	35.28	0.15	7.14	42.58	0.12	42.46	40.99	0.02	83.43
11-20	55.08	1.73	53.35	0.15	4.39	57.89	0.26	57.63	0.07	10.73	68.42	0.12	68.30	61.63	0.02	129.91
21-31	65.12	0.00	65.12	0.00	5.19	70.30	0.00	70.30	0.00	12.69	82.99	0.12	82.87	72.86	0.02	155.71
FEB. 1-10	47.65	0.99	46.67	0.09	3.80	50.55	0.15	50.40	0.04	9.29	59.72	0.12	59.60	53.32	0.02	112.90
11-20	31.17	0.93	30.24	0.08	2.48	32.81	0.14	32.67	0.04	6.07	38.78	0.12	38.66	34.88	0.02	73.51
21-29	25.54	0.00	25.54	0.00	2.03	27.58	0.00	27.58	0.00	4.98	32.55	0.12	32.43	28.58	0.02	60.99
MAR. 1-10	34.60	0.00	34.60	0.00	2.76	37.36	0.00	37.35	0.00	6.74	44.10	0.12	43.98	38.71	0.02	82.67
11-20	22.44	6.73	15.71	0.59	1.79	18.08	1.02	17.06	0.26	4.37	21.69	0.12	21.57	25.11	0.02	46.66
21-31	39.41	7.90	31.51	0.69	3.14	35.34	1.20	34.14	0.30	7.68	42.12	0.12	42.00	44.10	0.02	86.08
APR. 1-10	40.31	6.73	33.58	0.59	3.21	37.38	1.02	36.36	0.26	7.85	44.47	0.12	44.35	45.19	0.02	89.43
11-20	46.27	4.45	41.82	0.39	3.69	45.89	0.68	45.22	0.17	9.02	54.40	0.12	54.28	51.77	0.02	106.03
21-30	42.02	7.10	34.92	0.62	3.35	38.89	1.08	37.81	0.27	8.19	46.27	0.12	46.15	47.02	0.02	93.15
MAY 1-10	30.76	10.00	20.76	0.87	2.45	24.08	1.52	22.56	0.38	5.99	28.94	0.12	28.82	34.42	0.02	63.22
11-20	29.54	4.01	25.53	0.35	2.35	28.23	0.61	27.62	0.15	5.76	33.53	0.12	33.41	33.05	0.02	66.44
21-31	17.05	7.60	9.46	0.66	1.36	11.48	1.15	10.33	0.29	3.32	13.94	0.12	13.82	19.08	0.02	32.88
JUN. 1-10	16.97	7.22	9.75	0.63	1.35	11.73	1.10	10.63	0.27	3.31	14.21	0.12	14.09	18.99	0.02	33.06
11-20	17.46	6.36	11.10	0.55	1.39	13.05	0.97	12.08	0.24	3.40	15.73	0.12	15.61	19.54	0.02	35.12
21-30	12.24	3.95	8.29	0.34	0.98	9.61	0.60	9.01	0.15	2.39	11.54	0.12	11.42	13.70	0.02	25.10
JUL. 1-10	14.52	3.27	11.25	0.29	1.16	12.69	0.50	12.20	0.12	2.83	15.15	0.12	15.03	16.25	0.02	31.26
11-20	25.21	3.09	22.13	0.27	2.01	24.40	0.47	23.94	0.12	4.91	28.97	0.12	28.85	28.21	0.02	57.04
21-31	15.01	1.05	13.96	0.09	1.20	15.25	0.16	15.09	0.04	2.93	18.06	0.12	17.94	16.80	0.02	34.72
AUG. 1-10	20.56	1.11	19.45	0.10	1.64	21.19	0.17	21.02	0.04	4.01	25.07	0.12	24.95	23.01	0.02	47.93
11-20	10.36	2.10	8.26	0.18	0.83	9.27	0.32	8.95	0.08	2.02	11.05	0.12	10.93	11.60	0.02	22.51
21-31	8.73	0.00	8.73	0.00	0.70	9.43	0.00	9.43	0.00	1.70	11.13	0.12	11.01	9.77	0.02	20.76
SEP. 1-10	12.08	0.00	12.08	0.00	0.96	13.04	0.00	13.04	0.00	2.35	15.39	0.12	15.27	13.51	0.02	28.76
11-20	19.75	10.19	9.56	0.89	1.57	12.02	1.55	10.47	0.39	3.85	14.71	0.12	14.59	22.09	0.02	36.66
21-30	30.19	7.35	22.84	0.64	2.41	25.89	1.12	24.77	0.28	5.88	30.94	0.12	30.82	33.78	0.02	64.58
OCT. 1-10	14.93	12.72	2.21	1.11	1.19	4.51	1.93	2.58	0.48	2.91	5.97	0.12	5.85	16.71	0.02	22.54
11-20	25.54	5.00	20.54	0.44	2.03	23.01	0.76	22.25	0.19	4.98	27.42	0.12	27.30	28.58	0.02	55.85
21-31	23.01	8.15	14.86	0.71	1.83	17.40	1.24	16.17	0.31	4.48	20.96	0.12	20.84	25.75	0.02	46.57
NOV. 1-10	20.64	10.68	9.96	0.93	1.64	12.54	1.62	10.92	0.41	4.02	15.34	0.12	15.22	23.10	0.02	38.30
11-20	23.01	3.33	19.68	0.29	1.83	21.80	0.51	21.29	0.13	4.48	25.90	0.12	25.78	25.75	0.02	51.51
21-30	16.56	6.11	10.45	0.53	1.32	12.30	0.92	11.38	0.23	3.23	14.84	0.12	14.72	18.53	0.02	33.23
DEC. 1-10	31.58	4.14	27.44	0.36	2.52	30.32	0.63	29.69	0.16	6.15	36.00	0.12	35.88	35.33	0.02	71.19
11-20	14.69	6.36	8.33	0.55	1.17	10.05	0.97	9.09	0.24	2.86	12.19	0.12	12.07	16.43	0.02	28.48
21-31	10.12	4.01	6.10	0.35	0.81	7.26	0.61	6.65	0.15	1.97	8.78	0.12	8.66	11.32	0.02	19.96

Table 4.4 Water Balance Calculation for Kumu River Basin (Year 1984)

UNIT : m3/s

PERIOD	1 RIVER DISCHARGE 540 Km2	2 BT.KUMU IRRIGATION 7,300 ha	3 RIVER DISCHARGE (1-2)	4 INFLOW 1 140 Km2	5 RETURN FLOW FROM BT.KUMU IRRIGATION	6 MEDAN MAHATO 324 Km2	7 RIVER DISCHARGE (3+4+5-6)	8 INFLOW 2 212 Km2	9 RETURN FLOW FROM M. MAHATO	10 INFLOW FROM MAHATO RIVER	11 INFLOW 3 246 Km2	12 INFLOW 4 1,802Km2	13 INFLOW 5 108 Km2	14 RIVER DISCHARGE
JAN. 1-10	12.74	6.42	6.32	3.30	1.61	0.41	10.82	5.00	0.10	19.44	5.78	37.81	2.55	81.51
11-20	28.30	7.52	20.78	7.34	1.88	0.09	29.90	11.11	0.02	51.66	12.84	83.94	5.66	195.14
21-31	31.91	8.18	23.73	8.27	2.05	0.00	34.05	12.53	0.00	59.34	14.48	94.68	6.38	221.46
FEB. 1-10	23.49	6.42	17.07	6.09	1.61	0.17	24.60	9.22	0.04	41.92	10.66	69.69	4.70	160.82
11-20	11.45	4.45	7.00	2.97	1.11	0.17	10.91	4.49	0.04	19.56	5.19	33.96	2.29	76.46
21-29	26.14	4.05	22.09	6.78	1.01	0.01	29.86	10.26	0.00	48.46	11.86	77.54	5.23	183.21
MAR. 1-10	29.86	2.58	27.28	7.74	0.65	0.07	35.59	11.72	0.02	54.74	13.55	88.59	5.97	210.19
11-20	26.14	4.31	21.83	6.78	1.08	0.05	29.63	10.26	0.01	48.12	11.86	77.54	5.23	182.65
21-31	41.26	4.77	36.49	10.70	1.19	0.00	48.37	16.20	0.00	76.71	18.72	122.39	8.25	290.64
APR. 1-10	12.58	3.97	8.61	3.26	0.99	0.00	12.87	4.94	0.00	23.39	5.71	37.33	2.52	86.75
11-20	17.93	3.26	14.67	4.65	0.82	0.32	19.81	7.04	0.08	29.96	8.13	53.19	3.59	121.79
21-30	40.82	3.66	37.16	10.58	0.92	0.46	48.20	16.03	0.12	71.08	18.52	121.11	8.16	283.22
MAY 1-10	35.05	4.03	31.02	9.09	1.01	0.57	40.54	13.76	0.14	59.19	15.90	103.97	7.01	240.50
11-20	23.27	4.56	18.71	6.03	1.14	0.33	25.56	9.14	0.08	39.86	10.56	69.05	4.65	158.90
21-31	18.90	4.25	14.65	4.90	1.06	0.56	20.05	7.42	0.14	29.27	8.58	56.07	3.78	125.30
JUN. 1-10	34.51	4.57	29.94	8.95	1.14	0.50	39.53	13.55	0.12	58.96	15.66	102.37	6.90	237.08
11-20	27.27	4.50	22.77	7.07	1.13	0.33	30.64	10.71	0.08	47.29	12.37	80.90	5.45	187.45
21-30	10.31	3.52	6.79	2.67	0.88	0.35	9.99	4.05	0.09	15.50	4.68	30.60	2.06	66.97
JUL. 1-10	11.34	2.57	8.77	2.94	0.64	0.34	12.01	4.45	0.09	17.54	5.15	33.64	2.27	75.14
11-20	12.91	0.97	11.94	3.35	0.24	0.29	15.23	5.07	0.07	20.92	5.86	38.29	2.58	88.02
21-31	10.42	0.38	10.04	2.70	0.10	0.18	12.66	4.09	0.05	17.49	4.73	30.92	2.08	72.01
AUG. 1-10	23.11	0.38	22.73	5.99	0.10	0.18	28.63	9.07	0.05	41.05	10.49	68.57	4.62	162.48
11-20	9.29	0.43	8.86	2.41	0.11	0.28	11.09	3.65	0.07	14.33	4.21	27.55	1.86	62.77
21-31	17.17	0.24	16.93	4.45	0.06	0.08	21.36	6.74	0.02	31.05	7.79	50.94	3.43	121.34
SEP. 1-10	6.16	0.00	6.16	1.60	0.00	0.05	7.71	2.42	0.01	10.97	2.79	18.26	1.23	43.39
11-20	9.99	0.00	9.99	2.59	0.00	0.06	12.52	3.92	0.01	17.97	4.53	29.64	2.00	70.59
21-30	8.80	0.00	8.80	2.28	0.00	0.00	11.08	3.46	0.00	16.37	3.99	26.11	1.76	62.77
OCT. 1-10	4.48	4.02	0.46	1.16	1.01	0.00	2.63	1.76	0.00	8.33	2.03	13.30	0.90	28.95
11-20	13.34	7.96	5.38	3.46	1.99	0.36	10.47	5.24	0.09	21.05	6.05	39.57	2.67	85.13
21-31	21.11	7.37	13.74	5.47	1.84	0.52	20.54	8.29	0.13	33.79	9.58	62.64	4.22	139.19
NOV. 1-10	19.93	9.34	10.59	5.17	2.34	0.61	17.47	7.82	0.15	30.67	9.04	59.11	3.99	128.26
11-20	10.80	8.91	1.89	2.80	2.23	0.29	6.63	4.24	0.07	17.04	4.90	32.04	2.16	67.08
21-30	13.66	5.40	8.26	3.54	1.35	0.49	12.66	5.36	0.12	20.30	6.20	40.53	2.73	87.92
DEC. 1-10	30.67	4.02	26.65	7.95	1.01	0.32	35.29	12.04	0.08	53.72	13.92	90.99	6.13	212.18
11-20	17.82	3.21	14.61	4.62	0.80	0.35	19.68	7.00	0.09	29.45	8.09	52.87	3.56	120.73
21-31	16.04	5.04	11.00	4.16	1.26	0.38	16.04	6.30	0.09	25.90	7.28	47.58	3.21	106.40

Table 5.1 Daily Maximum Rainfall at 8 Stations

(Unit mm)

Year	Pasir Pan'yan	Ujung Batu	Bangko Jaya	Dalu Dalu	Lubuk Ben'bara	Kota Lama	Jamback	Sontang
1979	-	-	-	-	-	-	69.0	-
1980	76.5	85.1	-	-	-	-	96.3	-
1981	107.9	78.6	-	120.7	-	-	78.7	-
1982	71.8	100.2	95.5	137.1	-	-	82.0	-
1983	127.8	101.7	63.0	101.6*	91.2*	189.6*	112.6	88.1
1984	69.7	68.0	86.5	113.8	99.0	171.7	98.5	85.3
1985	115.0	58.3	100.0	92.2	108.7	147.0*	80.7	74.9
1986	108.0	140.6	84.5	104.6	91.0	68.7*	78.5	52.4
1987	98.0	73.9	121.2	153.5	156.0	96.0	84.0	84.6
1988	125.6*	49.0	65.5	120.8	95.0	80.0	68.2	65.0
1989	107.3	167.8	94.7	112.5	170.0	80.0	83.5*	60.0
1990	102.5	130.5	53.8	62.5	100.0*	73.3*	-	50.0*

Remarks:* including lack of observation

Table 5.2 Probable Rainfall by Iwai's Method

(Unit mm)

Return period	Pasir Pan'yan	Ujung Batu	Bangko Jaya	Dalu Dalu	Lubuk Ben'hara	Kota Lama	Jamback	Sontang
1,000	191.9	298.4	172.2	232.3	400.3	509.4	152.0	120.4
500	183.4	274.3	164.3	220.6	347.7	447.3	144.4	116.7
200	171.9	243.4	153.6	204.9	287.4	372.9	134.5	111.5
100	162.9	220.6	145.2	192.8	248.0	321.8	127.1	107.2
50	153.7	198.1	136.4	180.3	213.5	274.9	119.7	102.6
20	140.8	168.8	124.2	163.2	174.7	218.9	110.0	95.8
10	130.2	146.6	114.0	149.3	149.9	180.6	102.5	89.9
5	118.5	123.4	102.6	134.1	128.5	145.0	94.6	82.9
2	98.8	89.3	83.2	109.2	104.3	100.3	82.7	69.8

Table 5.3 Probable Rainfall by Gumbel Method

(Unit mm)

Return period	Pasir Pan'yan	Ujung Batu	Bangko Jaya	Dalu Dalu	Lubuk Ben'hara	Kota Lama	Jamback	Sontang
1,000	227.6	327.5	222.7	270.5	320.3	435.3	166.8	171.5
500	213.9	302.4	207.9	253.3	298.0	400.6	157.9	160.6
200	195.7	269.2	188.1	230.7	268.5	354.5	146.2	146.1
100	182.0	244.1	173.2	213.4	246.2	319.7	137.3	135.1
50	168.2	218.8	158.2	196.2	223.7	284.7	128.3	124.0
20	149.8	185.1	138.2	173.1	193.8	238.0	116.4	109.3
10	135.5	159.1	122.8	155.3	170.6	201.9	107.2	97.9
5	120.7	132.0	106.6	136.8	146.5	164.4	97.5	86.1
2	98.3	91.0	82.3	108.7	110.1	107.4	83.0	68.2

Table 5.4 Flood Discharge Calculation by Rational Formula

PROJECT NAME	CATCHMENT AREA	ARRIVAL TIME	PROBABLE YEAR	RAINFALL	RAINFALL INTENSITY	RUNOFF COEFFICIEN	SPECIFIC PEAK DISCHARGE	PEAK DISCHARGE
	A (Km2)	T (hr)		r24 (mm)	rt (mm/hr)	f	q (m3/s/Km2)	Q=q*A (m3/s)
LOWER ROKAN KIRI	3,312	80.22	1,000	400.3	7.46	0.6	1.24	4,117
	3,312	80.22	500	347.7	6.48	0.6	1.08	3,576
	3,312	80.22	200	287.4	5.35	0.6	0.89	2,956
	3,312	80.22	100	248.0	4.62	0.6	0.77	2,551
	3,312	80.22	50	213.5	3.98	0.6	0.66	2,196
	3,312	80.22	20	174.7	3.25	0.6	0.54	1,797
	3,312	80.22	10	149.9	2.79	0.6	0.47	1,542
	3,312	80.22	5	128.5	2.39	0.6	0.40	1,322
	3,312	80.22	2	104.3	1.94	0.6	0.32	1,073
LUBUK & UPPER SOSA	816	25.93	1,000	227.6	9.01	0.6	1.50	1,225
	816	25.93	500	213.9	8.46	0.6	1.41	1,151
	816	25.93	200	195.7	7.74	0.6	1.29	1,053
	816	25.93	100	182.0	7.20	0.6	1.20	980
	816	25.93	50	168.2	6.66	0.6	1.11	905
	816	25.93	20	149.8	5.93	0.6	0.99	806
	816	25.93	10	135.5	5.36	0.6	0.89	729
	816	25.93	5	120.7	4.78	0.6	0.80	650
	816	25.93	2	98.3	3.89	0.6	0.65	529
LOWER SOSA	1,348	70.1	1,000	270.5	5.51	0.6	0.92	1,239
	1,348	70.1	500	253.3	5.16	0.6	0.86	1,160
	1,348	70.1	200	230.7	4.70	0.6	0.78	1,057
	1,348	70.1	100	213.4	4.35	0.6	0.73	977
	1,348	70.1	50	196.2	4.00	0.6	0.67	899
	1,348	70.1	20	173.1	3.53	0.6	0.59	793
	1,348	70.1	10	155.3	3.17	0.6	0.53	711
	1,348	70.1	5	136.8	2.79	0.6	0.46	627
	1,348	70.1	2	108.7	2.22	0.6	0.37	498
MAHATO	348	32.79	1,000	270.5	9.15	0.6	1.53	531
	348	32.79	500	253.3	8.57	0.6	1.43	497
	348	32.79	200	230.7	7.81	0.6	1.30	453
	348	32.79	100	213.4	7.22	0.6	1.20	419
	348	32.79	50	196.2	6.64	0.6	1.11	385
	348	32.79	20	173.1	5.86	0.6	0.98	340
	348	32.79	10	155.3	5.25	0.6	0.88	305
	348	32.79	5	136.8	4.63	0.6	0.77	268
	348	32.79	2	108.7	3.68	0.6	0.61	213

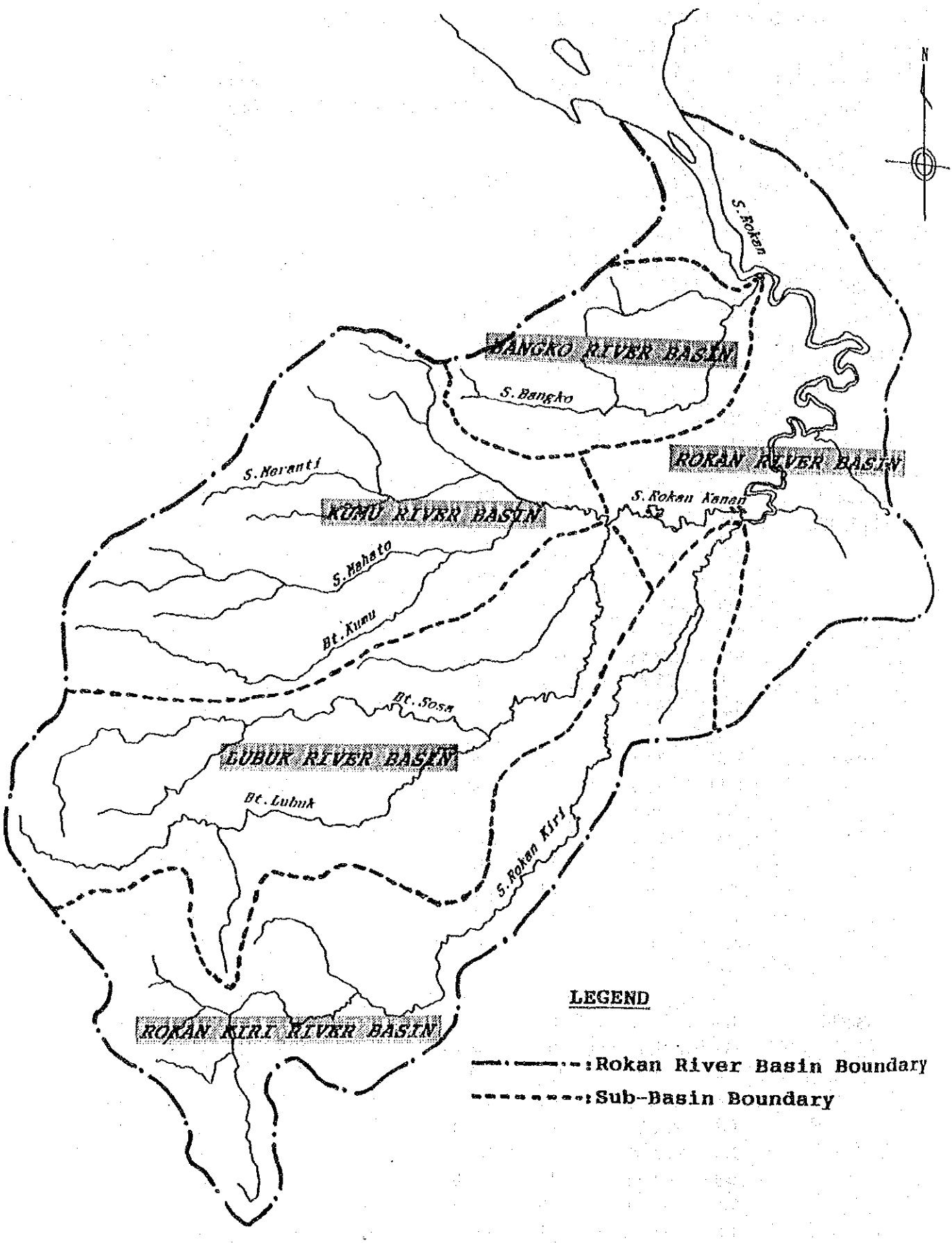


Fig.1.1 Rokan River Sub-basins

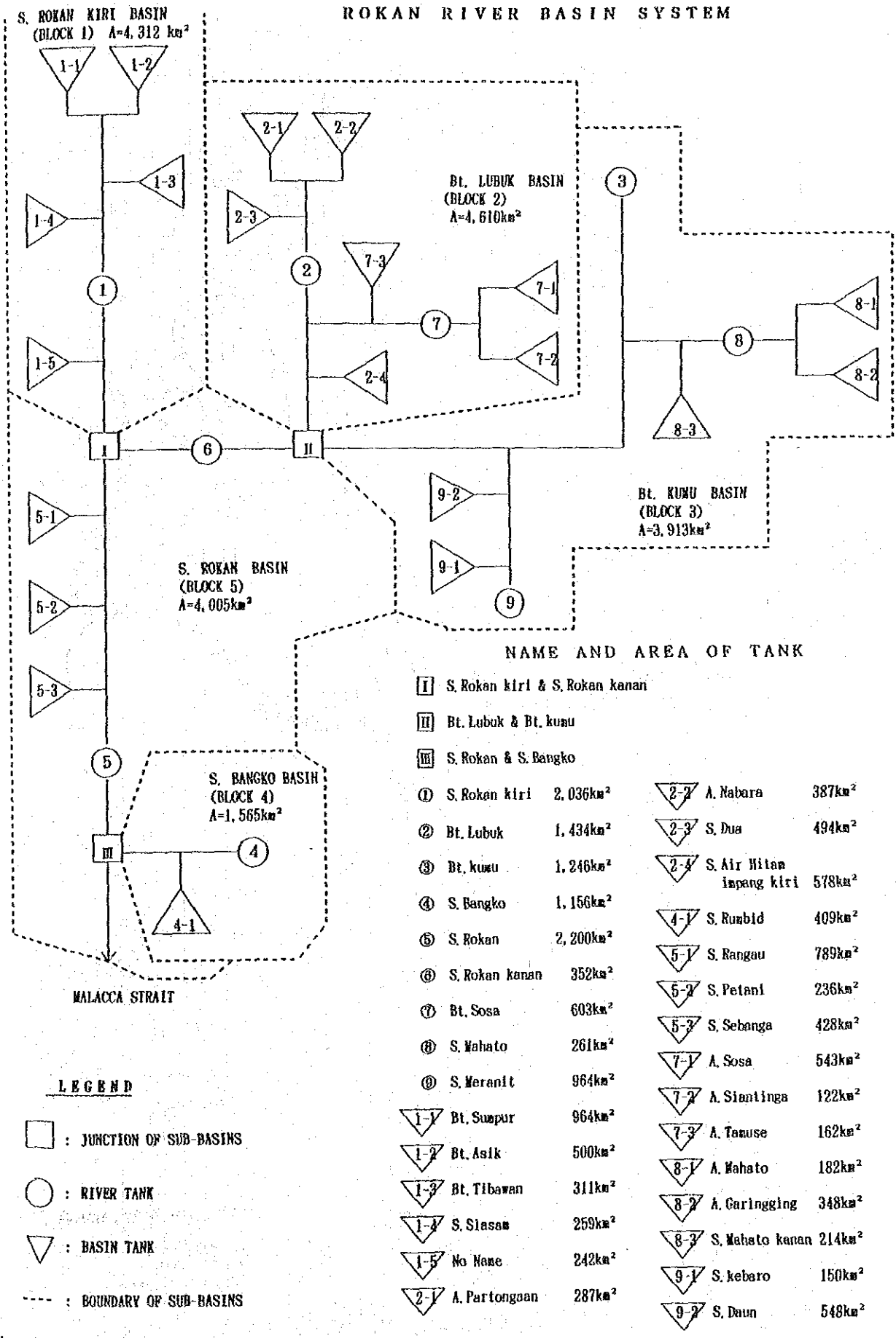


Fig.1.2 Configuration of Rokan River System

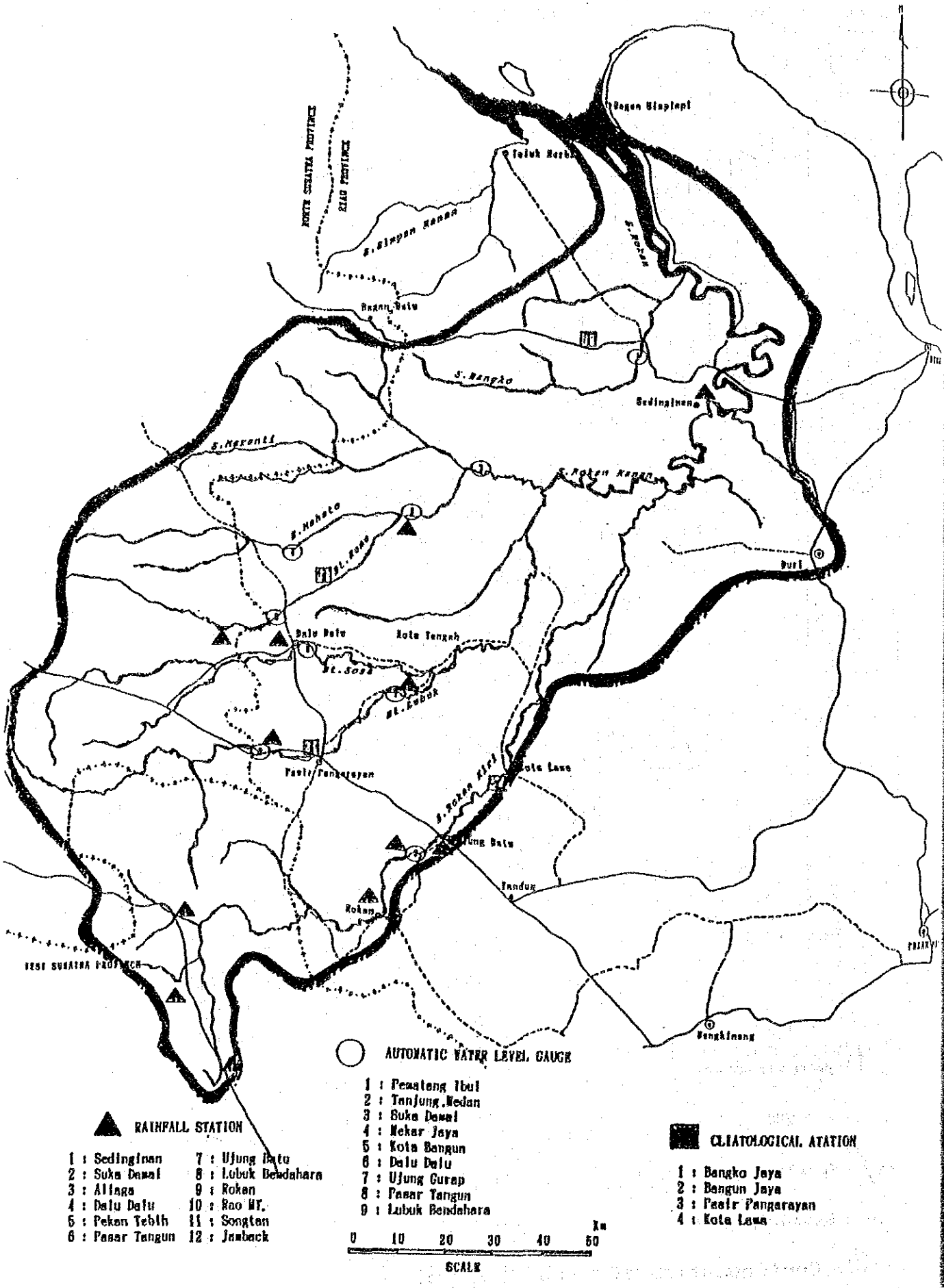


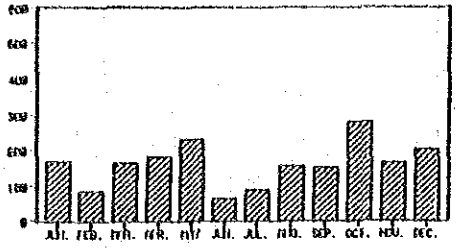
Fig.1.3 Location of Existing Meteorological Stations

Fig.1.4 **Observation Duration of Available Meteo-hydrological Data**

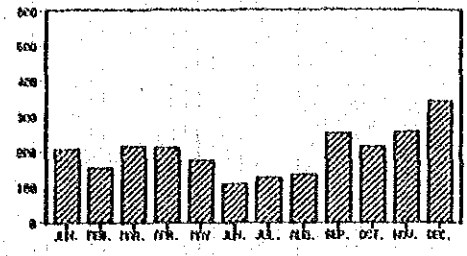
NAME OF STATION	NAME OF RIVER	INSTALLATION YEAR	CATCHMENT AREA (km2)	YEAR 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990	REMARKS
1. Climateorological Station					
1-1 Bangko Jaya	-	1981	-		
1-2 Bangun Jaya	-	1990	-		
1-3 Ps. Pangarayan	-	1979	-		
1-4 Kota Lama	-	1983	-		
2. Rainfall Station					
2-1 Bangko Jaya	-	1981	-		
2-2 Bangun Jaya	-	1990	-		
2-3 Ps. Pangarayan	-	-	-		From 1970
2-4 Kota Lama	-	1983	-		
2-5 Sedinginan	-	1985	-		
2-6 Suka Damai	-	1990	-		
2-7 Aliaga	-	1990	-		
2-8 Dalu-Dalu	-	1980	-		
2-9 Pekan Tebih	-	1990	-		
2-10 Pasar Tangun	-	1990	-		
2-11 Ujung Batu	-	1979	-		
2-12 Lubuk Bendahara	-	1983	-		
2-13 Rokan	-	1990	-		
2-14 JAMBAK	(WEST SUMATERA)	-	-		
2-15 SONTANG	(WEST SUMATERA)	-	-		
2-16 RAO MT	(WEST SUMATERA)	-	-		
3. Automatic Water Level Recorder					
3-1 Pematang Ibul	S. Bangko	1983	942		
3-2 Tanjung Medan	Bt. Kumu	1981	5.795		
3-3 Suka Damai	Bt. Kumu	1985	1,882		
3-4 Mukar Jaya	S. Mahato	1990	712		
3-5 Kota Bangun	Bt. Kumu	1982	520		
3-6 Dalu-Dalu	Bt. Sosa	1982	1,154		
3-7 Ujung Gurap	Bt. Lubuk	1982	1,335		
3-8 Pasar Tangun	Bt. Lubuk	1974	838		
3-9 Lubuk Bendahara	S.Rokan Kiri	1975	3,076		

REMARKS : The catchment areas for the automatic water level recorders are measured topographic maps of 1/250,000.

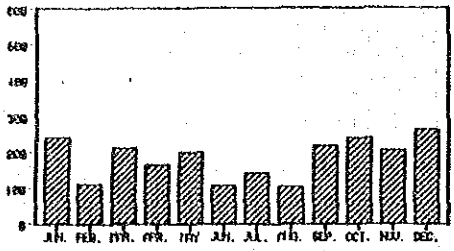
Unit : mm



Sedinginan



Pasir Pangarayan



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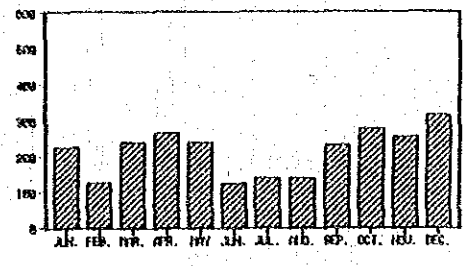
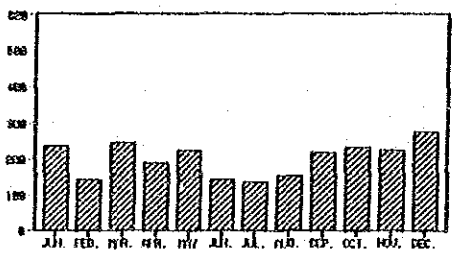
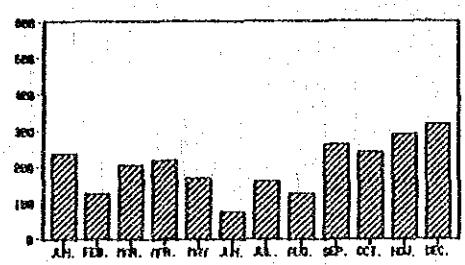


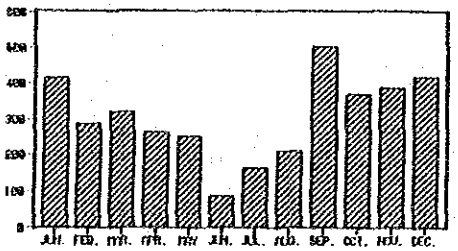
Dalu Dalu



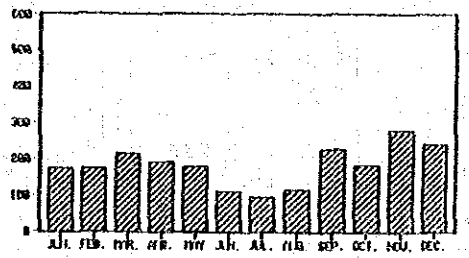
Ujung Batu



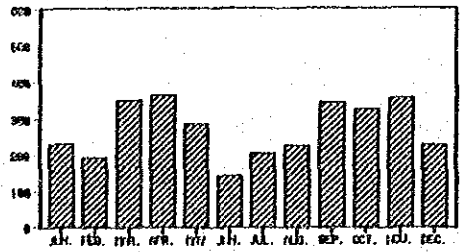
Lubuk Bendahara



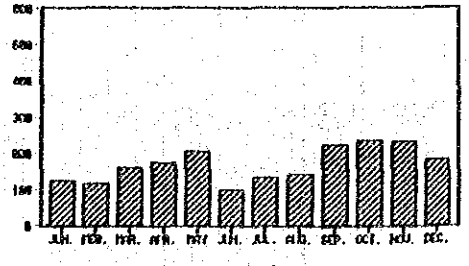
Rao MT



Sontang



Jamback



Dumai

Fig.2.1 Mean Monthly Rainfall

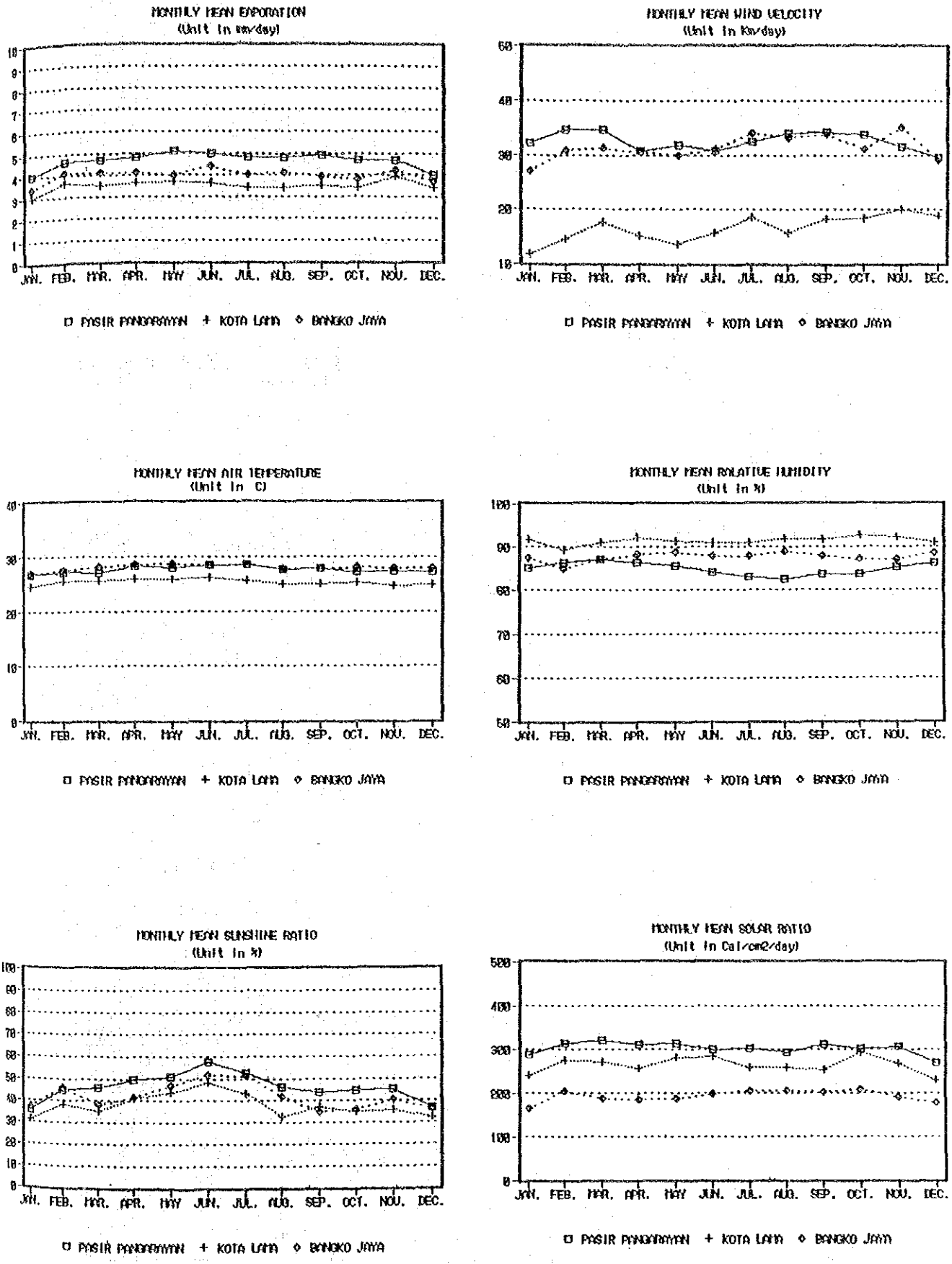
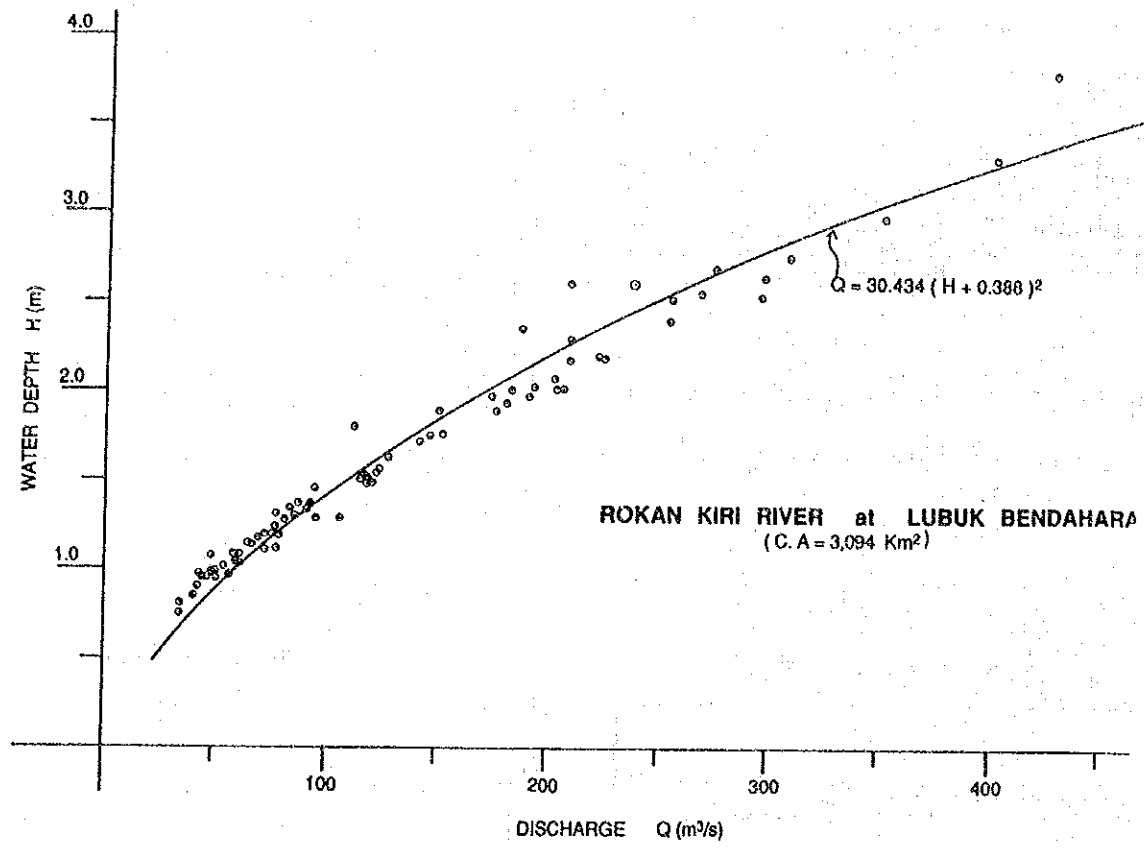


Fig.2.2 Monthly Meteological Data



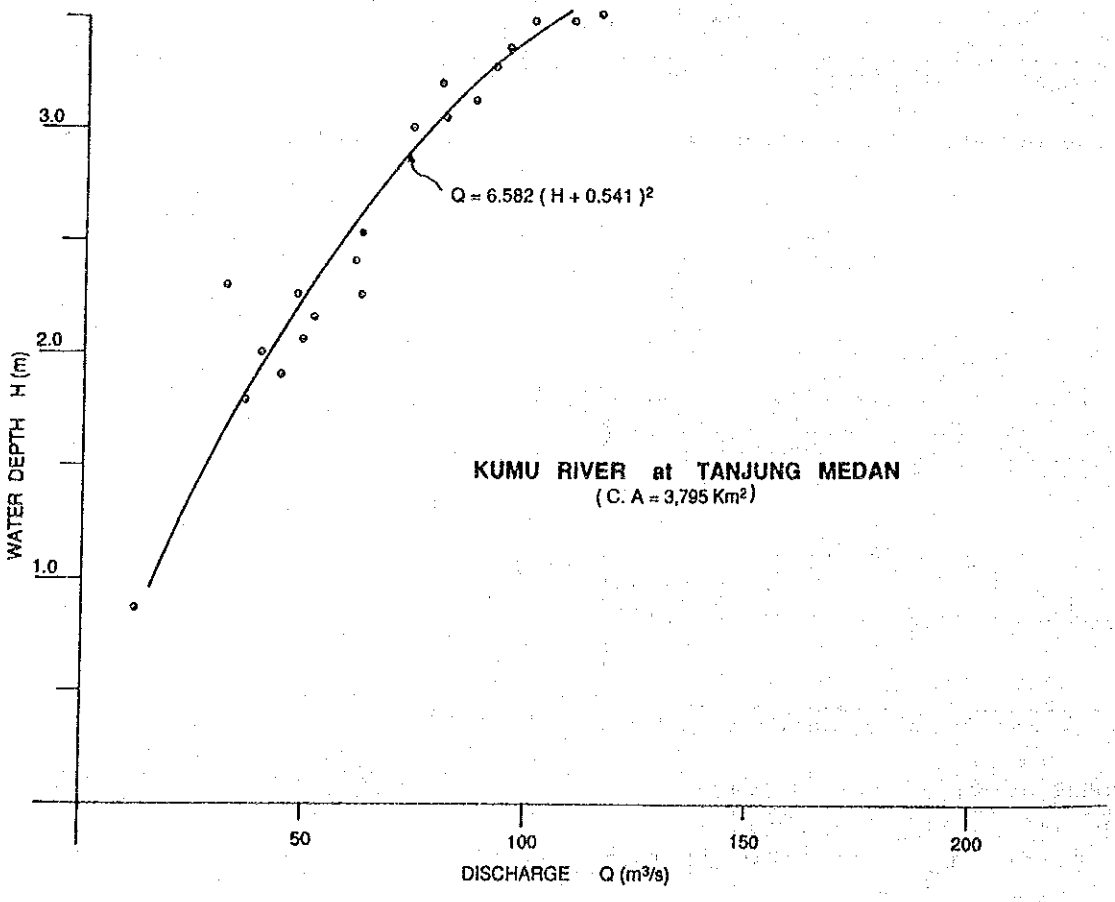
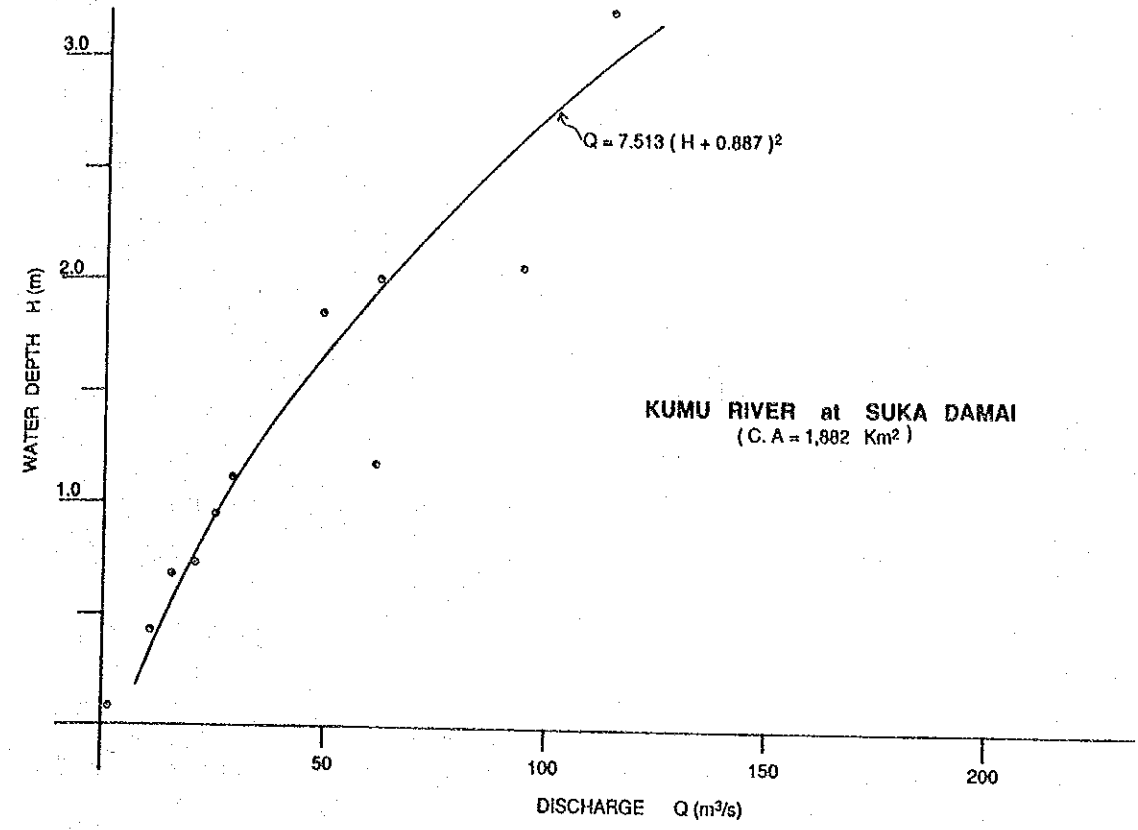


Fig.3.1(1) Rating Curves at AWLR Stations



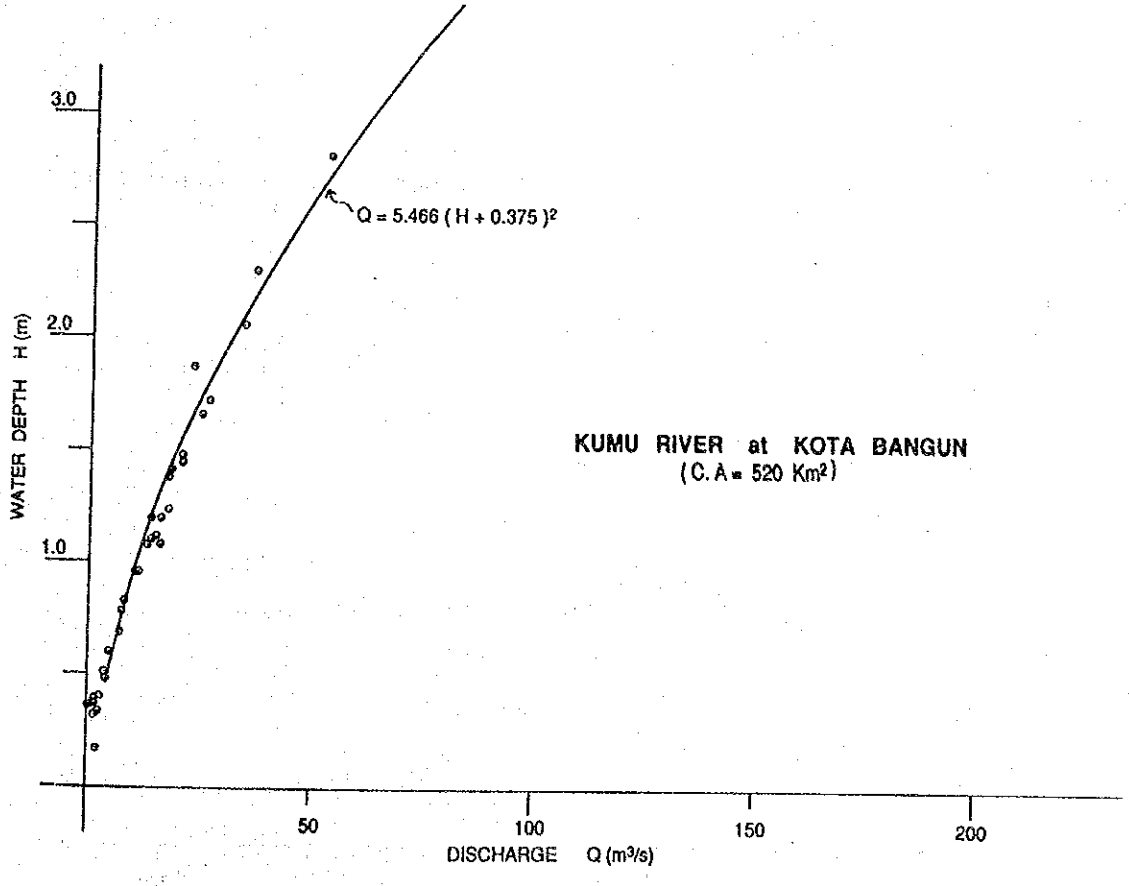
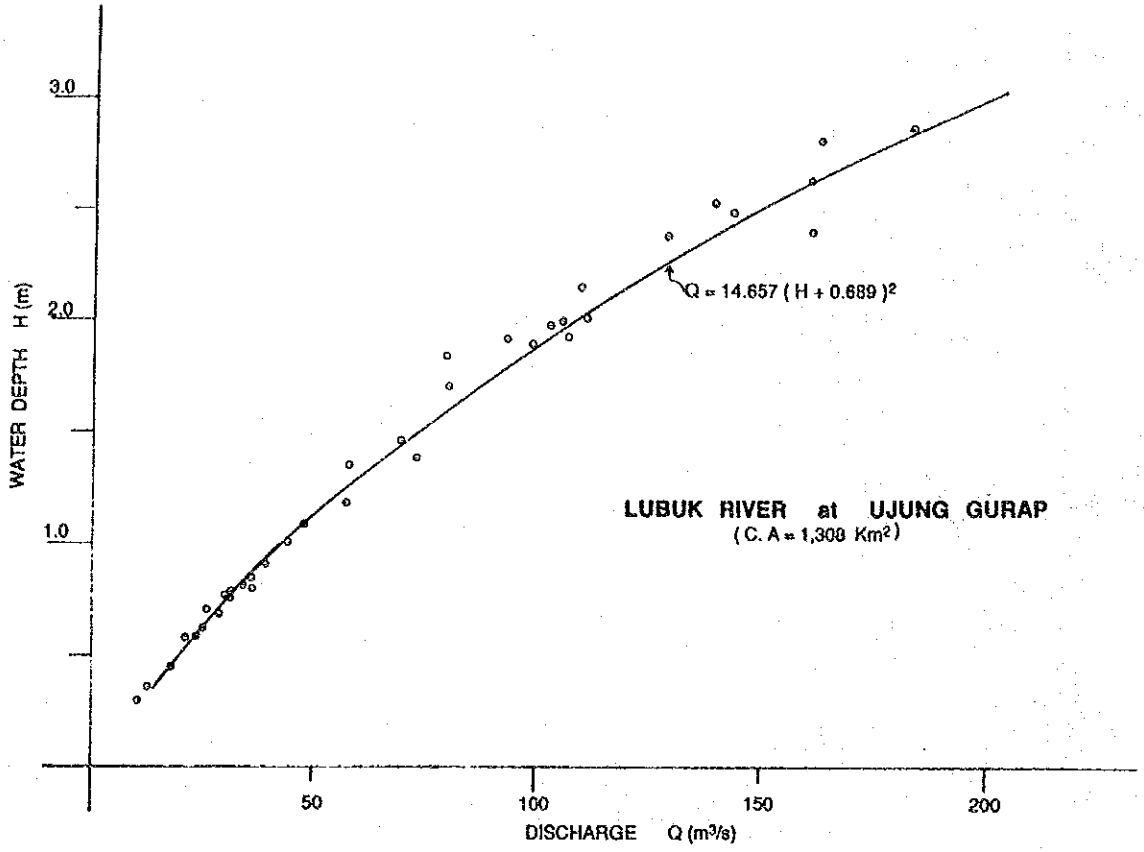


Fig.3.1(2) Rating Curves at AWLR Stations



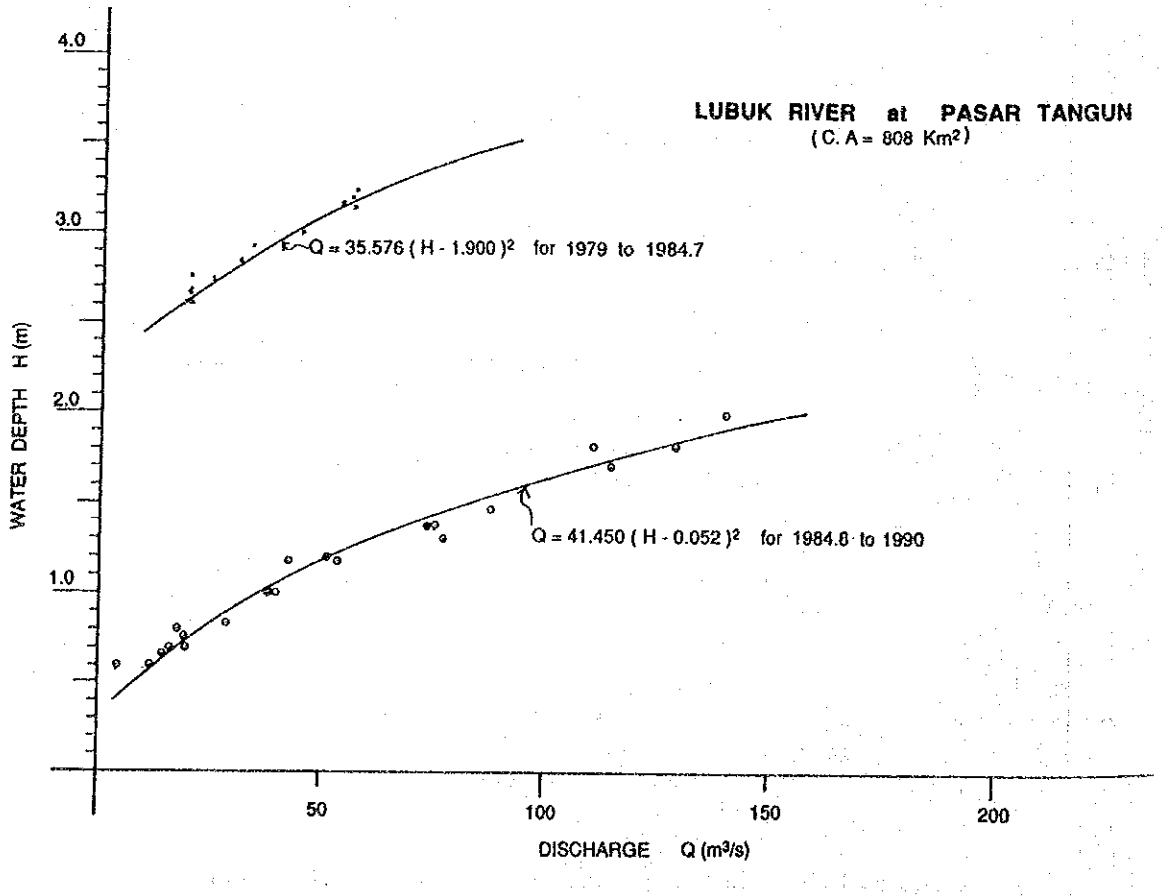
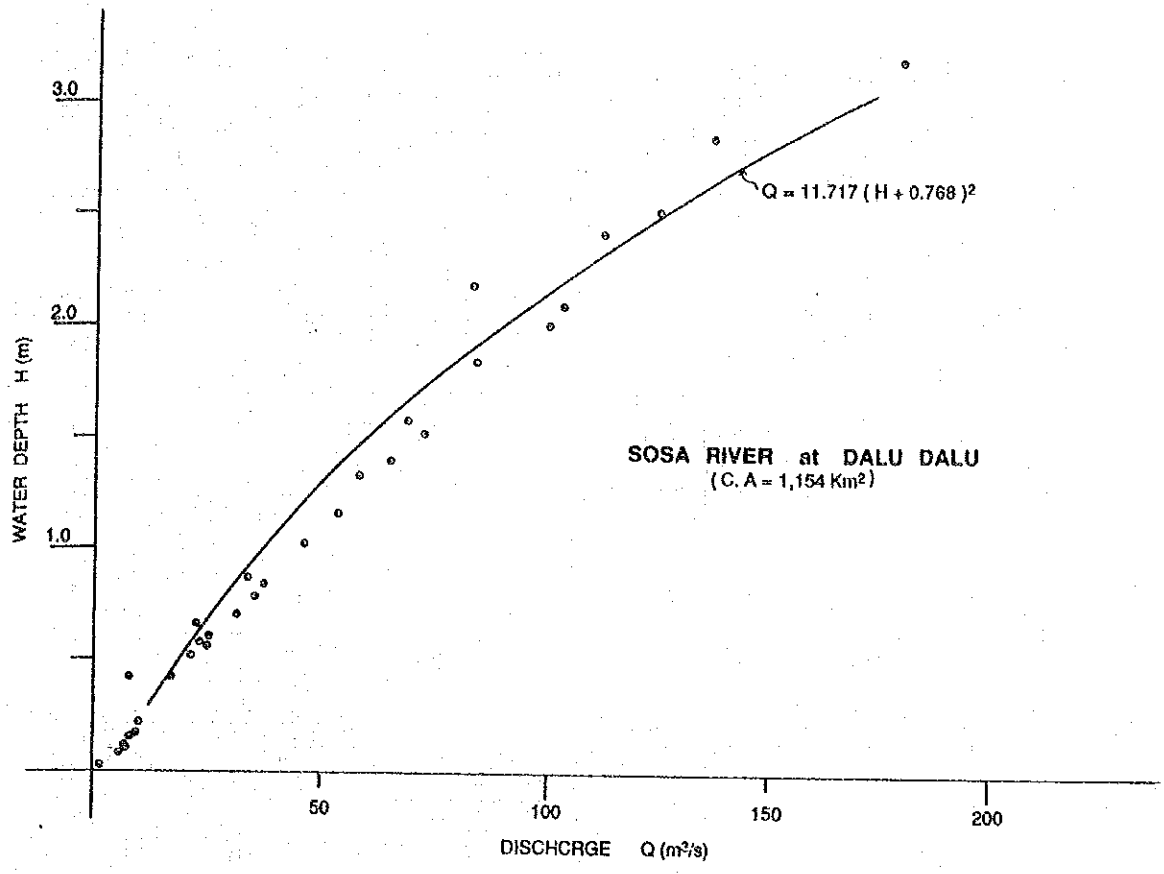


Fig.3.1(3) Rating Curves at AWLR Stations



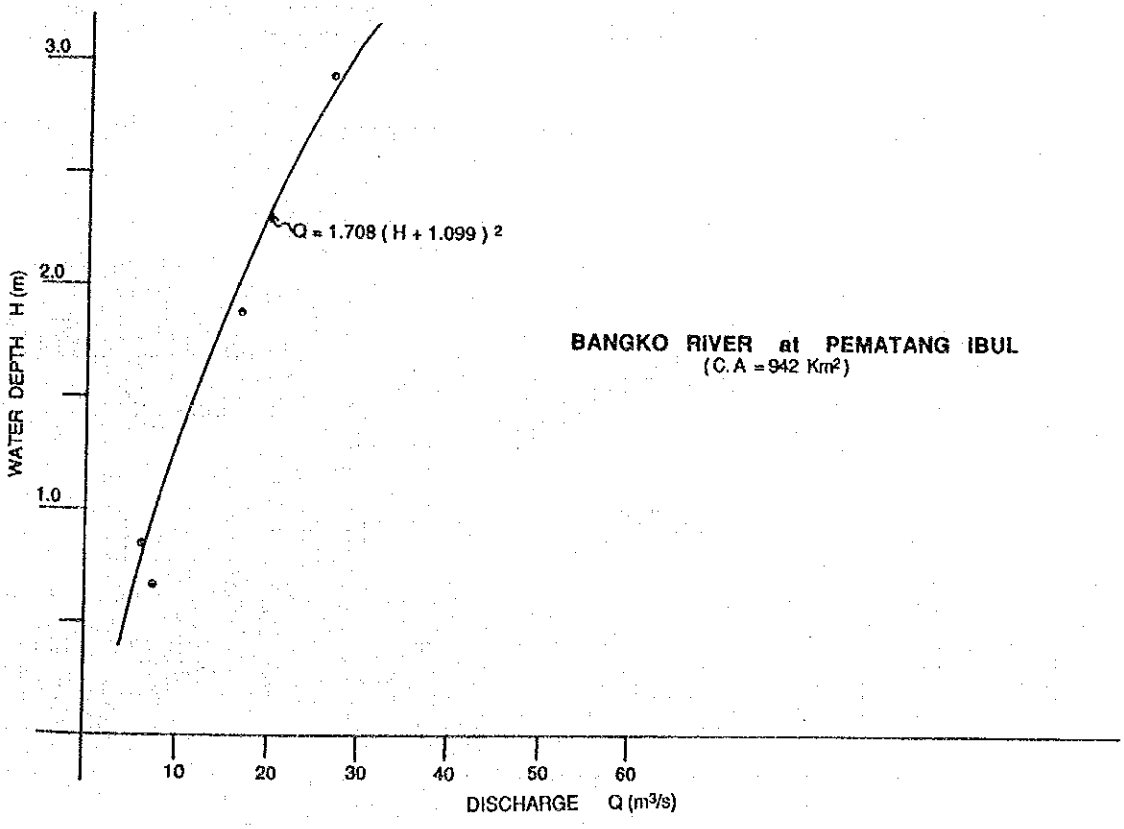


Fig.3.1(4) Rating Curves at AWLR Stations

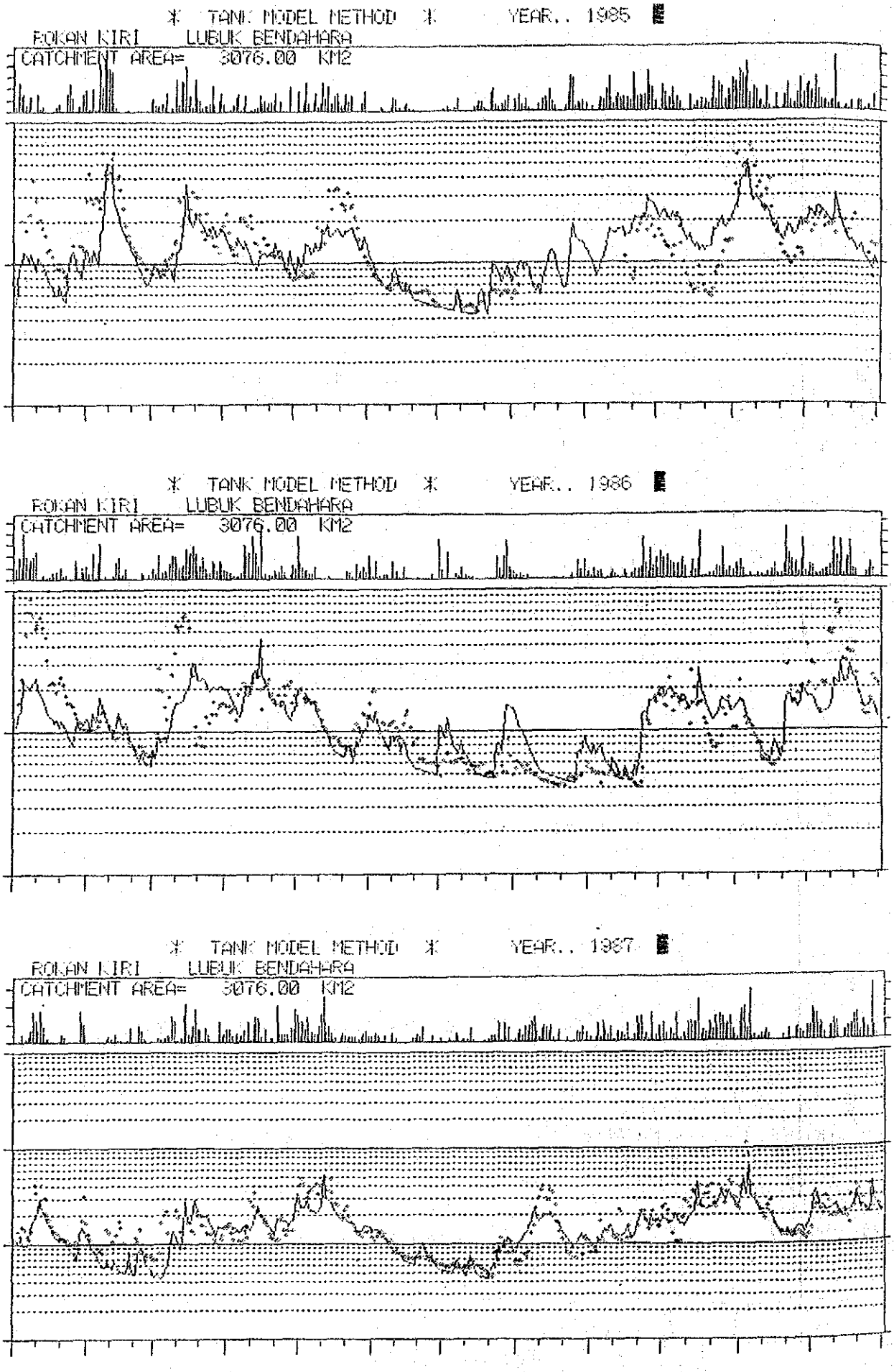


Fig.3.2 Comparison of Simulation and Record for Rokan Kiri River Discharge(1985-1987)

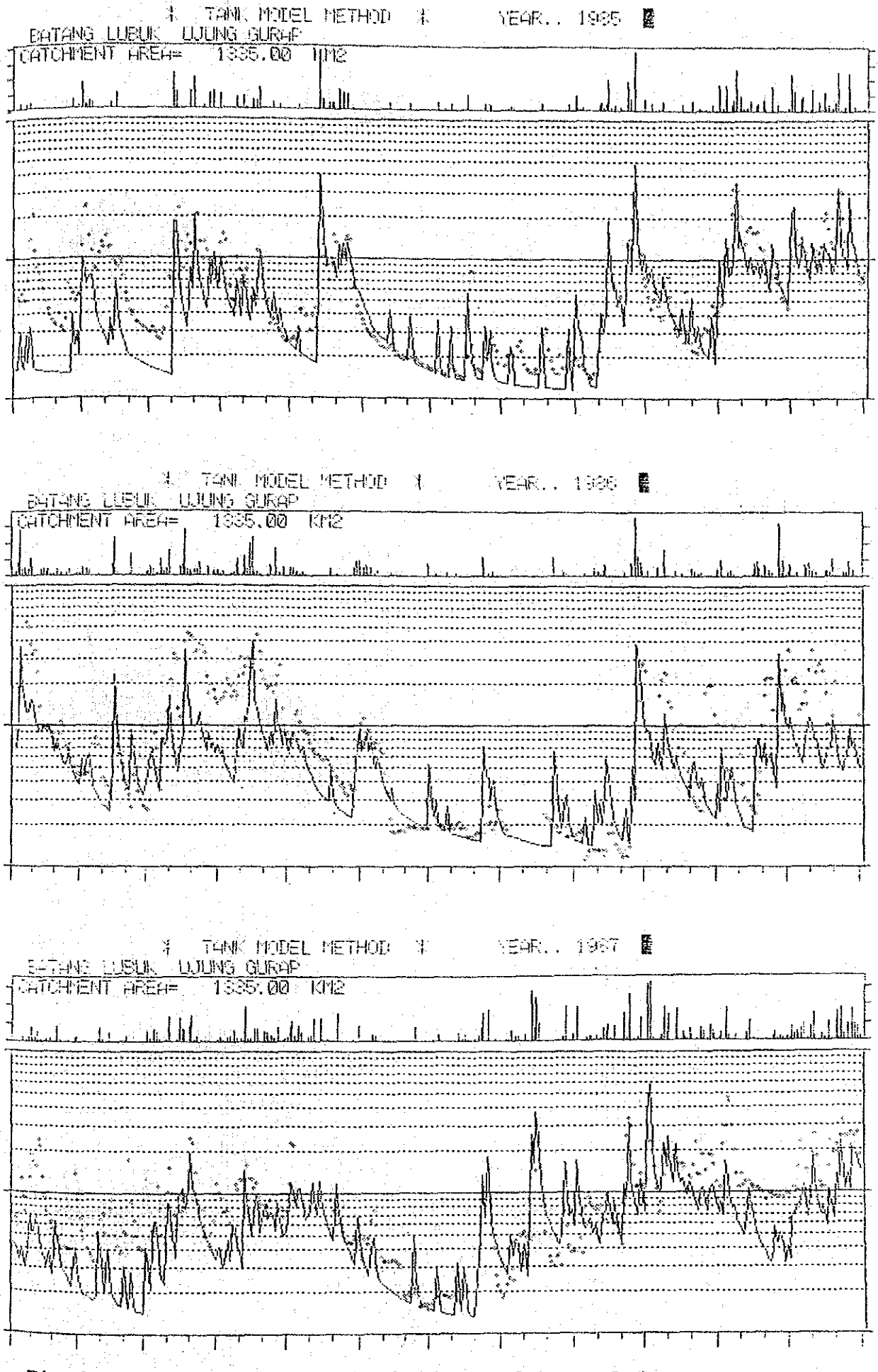


Fig.3.3 Comparison of Simulation and Record for Lubuk River Discharge(1985-1987)

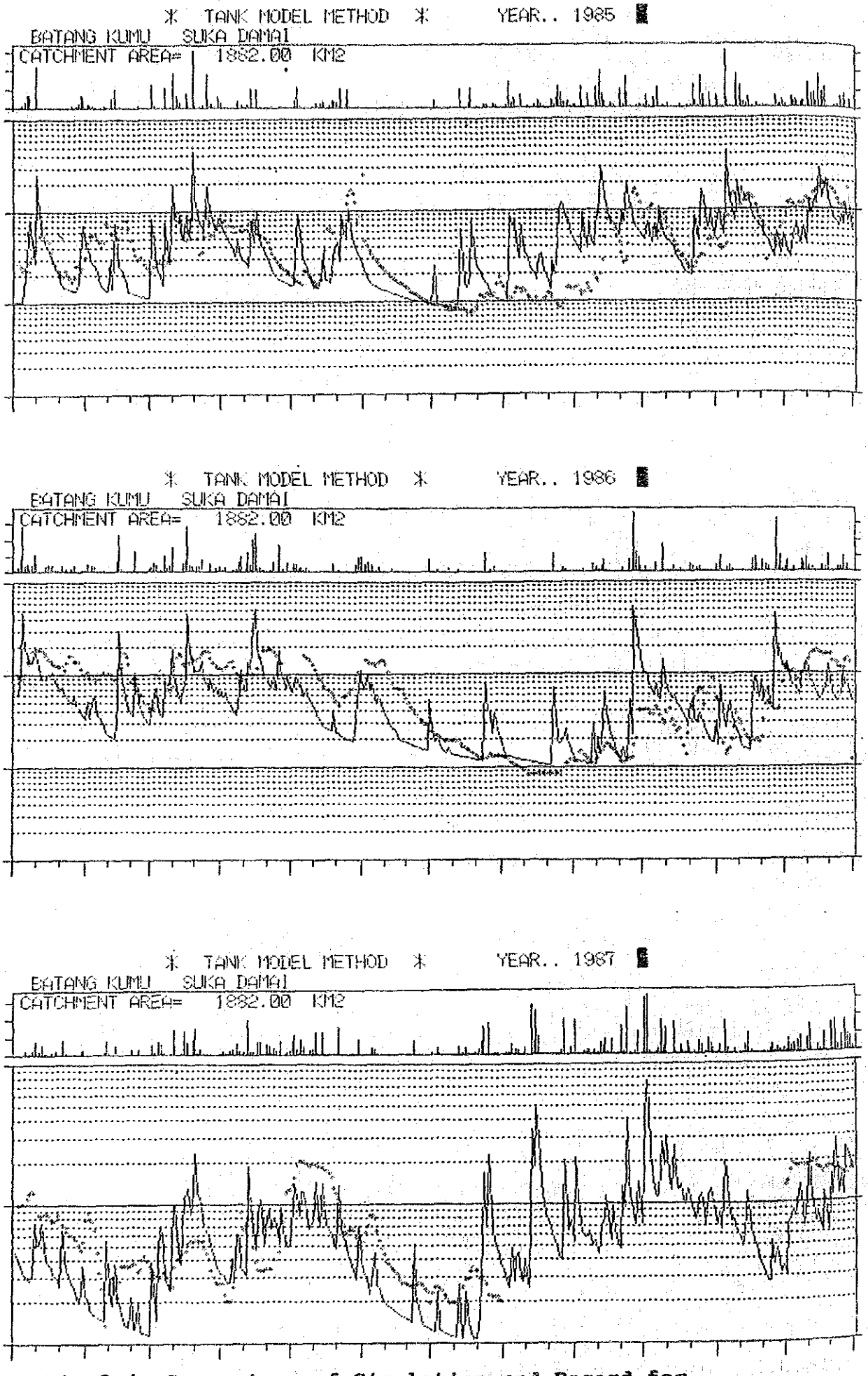


Fig.3.4 Comparison of Simulation and Record for Kumu River Discharge(1985-1987)

ANNEX C

SOIL AND LAND USE

ANNEX C SOIL AND LAND USE

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ANNEX C SOIL AND LAND USE

1. SOIL

1.1 General

The Study Area is the basin of Rokan River located in Riau Province in Sumatra Island. The total area of the Study Area is approximately 22,100 km2. The total area of the Rokan River Basin in Riau Province ,here in after referred to as the Objective Area, is 16,059 km2.

The major activities of Phase I were to collect data and information, to analyze existing data and to conduct reconnaissance field survey for confirmation of the accuracy of the existing data in the field survey. In the home office work, the general condition of the Sungai Rokan basin was recognized based on the analysis of collected data and information during the field survey. Also, a general soil distribution map of the Study Area was prepared and land suitability for agricultural development in each classification was identified to select the high priority areas for the irrigation development plan.

The soil data and information relating to the Study Area were mainly collected from the Center for Soil and Agroclimate Research in Bogor, the National Coordination Agency for Surveys and Mapping in Chibinon and the Department of Transmigration.

1.2 Data Collection

Necessary major data and information related to soil and present land use were collected from the following offices.

- -Center for Soil and Agroclimate Research, Bogor
- -The National Coordination Agency for Surveys and Mapping, Cibinong
- -Department Transmigrasi R.I. Kantor Wilayah Propinsi Daerah Tingkat I, Pekanbaru
- -Dinas Perkebunan Propinsi Daerah Tingkat I Riau, Pekanbaru

1.3 Soil Surveys

1.3.1 Soil Trench Survey

Soil trench survey was conducted at the 19 selected sites as shown in Table 1.1. The following items were observed in the field and soil samples were collected for laboratory analysis.

- Topography

- Land Use & Vegetation
- Soil Layer & Depth
- Soil Texture
- Soil Color
- Mottle
- Structure
- Ground water level where clarified
- Others

Within these soil trench survey, the results of soil profile observation were shown in Table 1.2.

1.3.2 Chemical and physical analysis in laboratory

38 soil samples were collected during the soil trench survey. These samples were sent to the Center for Soil and Agroclimate Research in Bogor for chemical and physical analysis. The items analyzed are shown below;

-Mechanical Analysis (Soil Texture)
-pH (1:5 H2O,KCL)
-Electric Conductivity (1:5 H2O)
-Cation Exchange Capacity
-Exchangeable Base(Ca, Mg, Na, K, Al)
-Total Carbon
-Total Nitrogen
-Organic Matter
-Available Phosphate
-Soluble Cations

Additionally, chemical and physical analysis of soil samples were reported in the existing documents. The soil analytical data which was difficult to collect area such as that for forest and swamp was derived from existing data.

1.4 Soil Characteristics in the Study Area

According to the report of the Regional Physical Planning Program for Transmigration, the Rokan river basin is physiographically divided into 3 regions, i.e. 1)Eastern Coastal Swamplands, 2)Eastern Plains and Hills and 3)Barisan Mountains.

The Eastern Coastal Swampland lies on the coastal, swamp and alluvial plain of the Sungai Rokan and its tributaries. Topographically this area is very flat with less than 2 % slope and less than 2 meter A.S.L.

The Eastern Plains and Hills are the flat area (less than 2% slope) adjacent to Eastern Coastal Swampland and monotonous rolling sedimentary plains and hills adjacent to the Barisan Mountains with slope between 2 to 15%. But hilly area has more than 15% in area.

The Barisan Mountains lie on the south and south-east part of the Eastern Plain and Hills. The altitude of this area is more than 200m and is characterized abrupt changes of topographical condition.

The soil was classified into 6 groups from the view point of land system and soil-forming precesses as follows.

Table 1.3 Soil Group and Topography

Topographical Region	Soil Group
The Eastern Coastal Swampland	Alluvial Plain Soil Peat Swamp Soil
The Eastern Plains and Hills	Old Marine Terrace Soil Undulating Plain Soil Rolling to Hilly Plain Soil
The Barisan Mountains	Barisan Soil

Those soil groups were derided more detail as follows;

Table 1.4 Soil Classification

Soil Group	Soil
Alluvial Plain Soil	(1) Tidal Swamp Soil (2) Riverine Alluvial Soil (3) Mender Valley Alluvial Soil (4) Alluvial Valley Soil (5) Fan Alluvial Soil
Peat Soil	(6) Shallow Peat Swamp Soil (7) Peat Swamp Soil (8) Deep Peat Swamp Soil
Old Marine Terrace Soil	(9) Marine Terrace Soil
Undulating Plain Soil	(10) Undulating Plain Soil
Hillocky Plain Soil	(11) Hillocky Plain Soil
Barisan Soil	(12) Barisan Soil

The results of chemical and physical analysis of these classified soils are reported in the study reports for transmigration. Typical analysis data of these soils are shown in Table 1.6 to 1.13. The results of sampling soils collected

in the field work also shown in Table 1.5.

The main characteristics of theses soils are summarized as follows;

Tidal Swamp Soil (TSS)

Tidal Swamp Soil consists of the alluvial soil developed on the coastal plain and the mouth of Sungai Rokan. Topography of this soils is very flat and the soils show high electric conductivity based on the daily flooding by tides. The soils are strongly affected by parents materials and the development of soil profiles is very weak. The texture of soil is expected to be fine with very poor in drainage condition. The soil pH is generally, however, acid but strongly acid sometimes occurs in small pockets. The dominant soils were classified as Hydroaquents by Soil Taxonomy (USDA) Classification.

Riverine Alluvial Soil (RAS)

Riverine Alluvial soil consists of alluvial soil at the mouth of Sungai Rokan and back area of coastline Tidal Swamp Soil. Topography of this soils is very flat. A shallow peat layer is expected locally. The development of soil profiles is weak and texture is fine with very poor in drainage condition. Rice cultivation by tidal irrigation is carried out locally. The dominant soils were classified as Tropaquepts and Fluvaquents by Soil Taxonomy (USDA) Classification.

Mender Belt Alluvial Soil (MBS)

Mender Belt Alluvial Soil consists of alluvial soil widely distributed in the basin of the middle reaches of Sungai Rokan such as Sungai Rokan Kiri and Sungai Rokan Kanan. The development of soil profile is weak. Soil texture is relatively fine but medium to coarse materials occur locally due to newly sedimentation by flooding. Drainage condition of these soils are relatively poor. The dominant soils were classified as Trophluvents by Soil Taxonomy (USDA) Classification.

Alluvial Valley Soil (AVS)

Alluvial Valley Soil lies on the narrow river valley at the middle and upstream reaches of the Sungai Rokan. The texture of soil is moderately fine to coarse with relatively poor in drainage condition. The dominant soils were classified as Tropaquents and Fluvaquents by Soil Taxonomy (USDA) Classification.

Fan Alluvial Soil (FAS)

Fan Alluvial Soil lies in small pockets in the Panti Rao

valley area in West Sumatra Province. These soils are developed on the fan. The soil textures are variable but coarse materials are dominant. The dominant soils were classified as Dystropepts by Soil Taxonomy (USDA) Classification.

Shallow Peat Swamp Soil (SPS)

Shallow Pear Swamp Soil lies on the basin of Sungai Bangko and Sungai Gankung and small pockets of tributaries of Sungai Rokan. These soils are a mixture of alluvial soil and peat soils with very poor in drainage condition. The peat layer is anticipated, however, to be relatively shallow. The textures of soils are fine. The dominant soils were classified as Tropohemists by Soil Taxonomy (USDA) Classification.

Peat Swamp Soil (PSS)

Peat Swamp Soil lies on back swamp of the middle stream of Sungai Rokan and coastal line. This soil consists of accumulation of organic debris containing a high proportion of woody materials. The contents of organic materials are more than 60 %. Chemically the peat is extremely acid is due to the incomplete decomposition of organic materials and has high organic exchangeable capacity. Drainage condition is very poor. The depth of peat layer is anticipated at than 2 or 3 meters (Reported in the Regional Physical Programme for Transmigration by BAKOSRTANAL). The dominant soils were classified as Tropsaprists or Tropohemists by Soil Taxonomy (USDA) Classification.

Deep Peat Swamp Soil (DPS)

Deep Peat Swamp Soil widely distributes on the back swamp and area sandwiched between of Peat Swamp soil. The characteristics of this soils are similar to Peat Swamp Soil, however the depth of the peat layer is deeper the Peat Swamp Soil, sometime more the 6 meters. The area of this soil in the study are covered by forest with very poor in drainage condition. The dominant soils were classified as Tropohemists or Tropfibrists by Soil Taxonomy (USDA) Classification.

Marine Terrace Soil (MTS)

Marine Terrace Soils are widely deposited in the basin of the middle reaches of Sungai Rokan. The Parent Materials are weathered tuff. The textures of this soil are fine. The surface soils contain organic with colored brackish brawn. The sub-surface soils, generally lower than 1 or 2 meters, are whitish colored materials which weathered tufaceous materials. The texture of this soil is fine with relatively poor in drainage condition. The lands of this soils are the main area for planning of transmigration. The

dominant soils were classified as Tropaquepts by Soil Taxonomy (USDA) Classification.

Undulating Plain Soil (UPS)

Undulating Plain Soil widely lies on the southern parts of Marine Terrace Soils in the area of Ujung Batu, Pasir Pangarayan and Daludalu and the northern parts of Batang Kumu. Theses soils, originally known as Red-yellow Podosoliks are dominant soil in theses areas. The parent materials are weathered tufaceous sedimentary rocks. However these soils are strongly weathered and the soil layers are well developed. The clay mineralogy is kaolinitic, which characteristically results in a low cation exchange capacity and high contents of soluble Aluminum. Base saturation is low and may be saturated by aluminum. The soil texture of these soils is fine with good in drainage condition. Many oil palm plantations are have been established in this land. The dominant soils were classified as Tropudults by Soil Taxonomy (USDA) Classification.

Hillocky Plain Soil (HPS)

The characteristics of Hilly Plain Soil are similar to Undulating Plain Soil, however, the weathering is stronger than that of the latter. Therefore soil color of sub-surface layer is redder as the results of reaching. The drainage condition is good. Theses soils lies on the hoothills of Barisan Mountains and the slope is steep with 15 to 25 %. The dominant soils were classified as Paleudlts by Soil Taxonomy (USDA) Classification.

Barisan Soil (BS)

Barisan Soils lies on the Barisan Mountains. The slope is very steep with more than 25 % inclination. The soils are variable in texture, parent materials and development of the soil layer. These soils are loosely soil which developed from sandstone sediments, siltstone and mudstones and the another soil which are developed on the volcanic materials such as andesite and baserocks. The dominant soils were classified as Tropudults or Dystropepts by Soil Taxonomy (USDA) Classification.

The main characteristics of those soils are summarized in Table 1.14. Soil distribution map is also attached in Fig. 1.1.

Peat swamp soil occupies 27% (6,235 km2) of the Study Area. And Undulating Plain Soil, Barisan Soil and Alluvial Plain Soil are covered 20.4%, 20.2% and 13.5%, respectively. In the area of alluvial soil covered 2,979 km2, Riverine Alluvial Soil widely spreaded along the Rokan River occupied more than 50% of Alluvial soil. In the peat soil. Deep Peat Swamp Soil occupied more than 60% of peat soil. of peat. Deep Peat Swamp Soil which has

more than 3m depth of peat layer is almost two third of the total Peat Swamp Soil.

1.5 Land Suitability

The most important factor for the formulation of future land use plan is the determination of the productivities of the land. Land suitability is identified by the limiting factors for its productivity and suggests the possibility of the utilization for each soil classification. The study of the Regional Physical Planning Programme for Transmigration shows land suitability for each land systems. In this Study, the land suitability for classified soils was studied based on the present information and data.

The main factors in land suitability are shown as follows;

1) Topography (Slope)
2) Soil (Texture, Soil depth)
3) Drainage

In the view point of land use plan, following items are considered for land suitability;

1) Home yards
2) Inland fisheries
3) Crop production
   - Wetland rice
   - Upland crops
   - Estate
4) Others (agroforestry, pasture etc.)

The slope of the Study Area is shown in Table 1.16. The area with less than 2 % slope covers approximate 50 % of the Study Area. This area includes most of the land of Alluvial Soil Peat Soil and Marine Terrace Soil. The area with slope ranging between 8 to 15 % covers approximate 20 % and includes most of Undulating Plain Soil.

Table 1.16 Slope Unit

Slope (%)	Area (km2)	Ratio (%)
0 - 2	10,960	49.6
2 - 8	260	1.2
8 - 15	4,400	19.9
15 - 25	1,980	9.0
25 - 40	350	1.6
40 - 60	1,720	7.8
> 60	2,430	11.0
Total	22,100	100.0

In the mountainous area in the Study Are, sandy soils are recognized in many places but the soils of other area have variable texture ranging from loamy to clayey texture. On the other hand, Peat Swamp Soil and Deep Peat Swamp Soil have deep and incompletely decomposed organic layer at the surface. In the study results of BAKOSURTANAL, these peat soils are classified as unsuitable area for crop production. It is, however, considered that theses peat soils may have the development potential for agriculture. For the development of these area, the team recognizes that there are many factors such as reclamation of surface soil, drainage control and countermeasure for expected acidity by drying etc, to solve for the development.

The area includes the land of Alluvial Plain Soil, Peat Soil and Old Marine Terrace Soil is subject to seasonal and occasional flooding and low ground water level. The area covers approximate 50 % of the Study Area and the possibility of damage from such drainage condition should be considered..

Based on the above, land suitability of each soil classification shows in Table 1.17 to 1.20. And the possible cultivation area for each crops in the view point of land suitability summarized as follows;

Table 1.21 Possible Cultivation Area in the Study Area

Crops	Area(ha)
Dryland Arable	415,300
Wetland Arable	415,300
Tidal Development	168,200
Pasture/Livestock	707,500
Agroforest	451,300
Estate	
Rubber	875,700
Oil palm	875,700
Coconut	520,300

2. LAND USE

2.1 General

Present land use condition in the Study Area has been studied by the Department of the Transmigration as the base information for the transmigration planning from the 1970's. National Coordination Agency for Survey and Mapping, moreover carried out the survey of land use condition for the reconnaissance study of the land resources in Sumatra by the analysis of Landsat Image and air photography and ground truth, etc. in the 1980's.

In this Study, the team identified modernized land use condition based on the present data and information mentioned above and the analytical results of Landsat Image obtained in 1989, and field reconnaissance survey.

2.2 Present land Use

The land use in the Study Area was basically classified into 7 categories including (1)Forest, (2)Bush and Grassland, (3)Shifting Cultivation, (4) Upland Permanent Crops, (5) Wetland, (6)Tree Crops/Estate and (7)Settlement. Each category may be classified more detail as shown in Table 2.1.

About 60 % of the Study are occupied by forest and 20 % by bush and grassland. Under these circumstances, approximate 80 % of the study area is not used for cultivation land. 20 % of the study area is utilized for crop production. Plantation occupied more than 60% in the crop production area and wetland rice and permanent crop occupied only 3 % each in the Study Area.

In the forest area, the tidal forest distributes into near coastal area and the peat swamp forest widely spreads into the back area of the coastal line and around the downstream of the Sungai Rokan. Peat swamp forest covers about 50 % of total forest area. On the other hand, logged primary forest which products timber mainly distributes in the west part of Batang Kumu and natural forest including lowland forest, heath forest and riparian forest of meander belt distribute into the meander belts of rivers and Barisan mountainous area.

Bush and grassland are widely present in the Study Area but relatively concentrated near the village area. Many bush and grassland are remained after divested cultivated land and cleared forest.

In cultivated area, upland permanent crops distribute around Dillydally and Pasir Pangarayan. Wetland rice is widely cultivated into the narrow alluvial plain of the rivers around Pasir Pangarayan and Kotatengah and around Batang Supur as isolated spots. Tidal cultivation for rice distributes around the mouth of the Sungai Rokan.

Shifting cultivation are mainly carried out by local farmers and transmigrant farmers. Its distribution is scattered in the Study Area but relatively concentrated near village area. But cultivating area will be abandoned after some years cultivation and shift to bush and grassland such as the alang-alang area. Therefore, to identified detailed area and distribution is difficult because of such a wayward cultivation by farmers.

Oil palm cultivation is carried out under large scale commercial plantation. Rubber and coconut cultivation are carried out under small scale plantation by private farmer and small companies.

Recent trends of land use are the rapid decrease of forest area and the rapid increase of the large scale plantation . Particularly the cultivated area of the oil palm plantation is increasing. As shown in Table 2.5, the area of oil palm plantation is now about 70,000 ha and will be increased.

2.3 Forest Condition

The Government of Indonesia went completed all legal formalities related to forest development for the programmed utilization and protection the forest resources unmanaged clearing, and soil erosion. On the legales named Consensus Forest Land Use Plan in 1982, the Ministry of Agriculture in Indonesia classified forest area into 5 classes based on slope, soil and rainfall intensity as shown below. These classifications of forest are submitted by the Department of Forest of each province, and determined under the agreement by the Governor.

Table 2.2 Standard of Forest Classification

Category / Items	1	2	3	4	5
Slope					
Slope %	0-8	0-15	16-25	26-45	> 45
Points	10	40	60	80	100
Soil *1)					
Erodibility	None	Low	Medium	High	Very High
Points	15	30	45	60	75
Rainfall Intensity *2)					
Intensity	<13.6	13.6-20.7	20.8-27.7	27.8-34.8	>34.8
Points	10	20	30	40	50

*1) Soil: 1. Alluvial, Grey, Planosol, Blue-grey Hydromorphic, Groundwater Laterite
2. Latosol
3. Brown Forest Soil, Non-calcic Brown, Mediterranean
4. Andosol, Laterite, Grumsol, Podosol, Podosolic
5. Regosol, Lithosol, Organosol, Renzina

*2) Rainfall Intensity = mean annual rainfall (mm) / annual rain days
(a rain day is one in which rainfall is 1.0 mm or more)

Based on these land conditions, forests are classified as follows;

1) Conversion Forest
2) Fixed Production Forest

3) Limited Production Forest
4) Conservation Forest

Conversion forest mat be converted to plantation, agricultural land, home yards, etc. Fixed production forest is classified as timber production area. Limited production forest is protected in view of conservation of water resources and prevention of soil erosion. Production of wood is limited to only for certain designated species with designated diameter. Conservation forest is reserved in consideration of land slope, soil condition, rainfall, etc. for conservation of water resources and preventing of soil erosion. Additionally the protected forest is protectedd for flora and fauna, education, sports and recreation as conservation forest.

The characteristics of these classified forests are summarized as follows;

Table 2.3 Forest Use Category

Forest Function	Site Index	Purpose	Permitted Exploitation
Conversion F.	< 125	Conversion to Agriculture etc.	Clearing-felling
Fixed Production F.	<125	Timber Production	Selective to Clearing-felling
Limited Production F.	125-174	Timber Production	Selective felling
Conservation F.	>=175	Watershed Protection	None
Protected F.	n.d.	Genetic Conservation	None

The distribution of forests are shown in Fig.3.1 and the area of forests in the Study Area shown in below;

Table 2.4 The Area of Forest in the Study Area

Forests	Area(km2)			Total
	Riau	W.Sumatra	N.Sumatra	
Protected F.	80	27	430	537
Conservation F.	418	1,503	0	418
Limited Production F.	4,268	328	3,232	7,827
Fixed Production F.	3,498	0	0	3,490
Conversion F.	3,782	0	0	3,782
Others	4,014	490	32	4,536
Total	16,059	2,347	3,694	22,100

In West Sumatra and North Sumatra Provinces, most of the Study Area except the area of transmigration and crop production purposes is occupied by Protected Forest, Conservation Forest and Limited Production Forest. In the Riau Province, Fixed Production Forest and Conversion Forest occupy approximately 45 % of the Study Area, while only 30 % of the study area is occupied by Protected, Conservation and limited Production Forests.

2.4 Estate Development

Recently the estate development is being carried out extensively in the study Area. The reason for this development is that non-cultivated land such as forest and grassland remained, and that the land suitable for estate development has also remained because the development in the Study Area is relatively inferior to the surrounding area. The condition of the present and planning estate development are shown in Table 2.5 and Fig.2.3.

According to this information, 446,000 ha will be developed in the near future, and ten estate developments covering approximately 77,000 ha already started to be plant. Moreover, an additional 14 estates are planned to be develop.

3. LAND USE PLAN

3.1 Land Resources

From the results of study of land suitability of soil, the suitable area for agricultural development covers 386,800 ha (24.1%) of the Objective Area. This area includes Riverine Alluvial Soil, Meander Belt Alluvial Soil and Marine Terrace Soil. The suitable area for agricultural development lies on the alluvial area downstream from the confluence of the Sungai Rokan Kiri and Sungai Rokan Kanan and the flat area between Sungai Rokan Kiri, Bt. Lubuk and Bt. Kumu. These areas,however, are

poorly drained. Therefore the drainage improvement condition such as establishment of drainage canal should be considered.

The suitable area for pasture and estate crops is covers 591,100 ha (36.8%) of the Objective Area. This area may possibly be adapted for upland crop cultivation. However, the area may suffer damage by soil erosion due to slope and soil minerals and deficiency of plant nutrition. Therefore necessary maintenance such as prevention of soil erosion and application of fertilizer should be considered.

3.2 Factors for the Present Land Use Condition

Agricultural production activities have been carried out by local farmers and transmigrants in the Objective Area. These existing activities are very important factors for planning of the future land use plan from the view point of potentialities of agricultural technology and human resources.

3.2.1 Increase of Farmer's Population

Under the present condition, farmer population in the objective area is approximately 400,000, and there exists 50,600 ha for wetland cultivation and 38,900 ha for permanent upland crop cultivation. Additionally 84,000 ha are under for shifting cultivation. According to the future forecast for 2020, this farmer population will rapidly increase to 1,500,000 (2,800,000 total population) in the Objective Area.

3.2.2 Estate Development Plan

At present, a total 76,000 ha have been developed as the plantation in the Study Area and its periphery. Theses plantations will be extended to 174,200 ha. Moreover approximately 261,830 ha of plantation are a waiting the permission for development from the government. Most of these plantation is for oil palm. In this situation, rapid extension of plantation development is expected.

The existing plantation located at the area of Marine Terrace Soil and Undulating Plain Soil where soil condition is good. But some of area planned for future plantation is located in the area of peat soils where soil condition is relatively poor.

3.3 Protection of Forest Resources

3.3.1 Protection of Forest Resources

As mentioned in chapter 2.1, the Government of Indonesia

classified forest for the protection of forest resources and prevention of soil erosion and fixed the development policy. The present forest area covers 966,800 ha in the Objective Area but 1,136,600 ha are designated as forest category. Out of these designated forest areas, 466,000 ha (29% of designated forest area) are Protected Forest, Conservation Forest and Limited Production Forest, which are strongly limited for development.

In Riau Province, the provincial government has the law which secure about 60% of the total area as forest area. On the basis of this government policy, the team considered that natural forest in the Objective Area will be protected to the utmost.

In protected Forest, Conservation Forest and Limited Production Forest, 44,100 ha of glass land, 9,600 ha of shifting cultivation and 10,000 ha of plantation are including. Particularly those areas either non-utilized or under shifting cultivation should be examined for appropriate utilization method (see Table 2.6).

3.3.2 Protection against Soil Erosion

The prevention of soil erosion has strong relation to the protection of forest. Most of the mountainous area in the Objective Area is designated as protected forest area because soil is relatively sandy and resistance to erosion is not strong due to clear-felling (see Table 2.7). From the view points mentioned above, the development of forest should be carefully considered.

3.4 Development Possibility of Swamp Area

The peat area in the Objective Area covers 622,600 ha (38%). The area which is in less than 1 meter in peat depth is recognized as the potential area for development. Shallow Peat Soil and a part of Peat Swamp Soil in the Objective Area is within this potential area which is anticipated at approximately 100,000 ha. Survey of the depth of peat layer, however, has not been carried out satisfactorily. Accordingly the development of the area with peat soil should be carried out with careful attention to the depth of peat layer.

3.5 Potential Area for Agricultural Development

Five high potential agricultural development areas have been selected by the Government of Indonesia. The team was requested to reconfirm the development potential of these areas.

These potential areas are:

1) Mahato Area

2) Lower Sosa Area
3) Upper Sosa Area
4) Batang Lubuk Area
5) Rokan Kiri Area

In addition to these potential areas selected by the Government of Indonesia, the team also suggests another high potential area named Lower Rokan Kiri area. These five potential areas were subsequently examined.

Mahato Area is located in flat area and soils are also suitable. But this area is in the Limited Production Forest.

Upper Sosa Area is located in undulating plain. Soil is classified as Reddish yellow Podosols which has low content of plant nutrients and is susceptible to soil erosion. According to the present information reported by the transmigration office, the suitable area for irrigation development in this area is only 35 %.

Batang Kumu Area is similar topographically and only 18 % of the total area will be suitable for irrigation development according to present information.

In the Rokan Kiri Area, many on-going plantations have already been settled and there is,therefore, a difficulty to create irrigation development area.

Lower Sosa and Lower Rokan kiri areas are located in the area of Marine Terrace Soil which is suitable for irrigation development. However, there is a plantation which for which permission by the government for development has been granted in Lower Sosa Area.

3.6 Future Land Use Pattern

According to information on soil condition, present land use condition, the protection of forest resources and development condition of plantation, the following constrain for the formulation of a future land use plan should be considered carefully.

1) The area for present agricultural production activities should be secure, and increase of productivity should be targeted.

2) Present plantations which are already permitted by the government should be secure.

3) Wayward shifting cultivation should be controlled.

4) Protected Forest, Conservation Forest and Limited Production Forest should be protected from the view points of protection of forest resources and prevention

of soil erosion.

5) Existing natural forest should be protected to the extent.

6) The area of wild grassland such as Alang-alang and bush should be converted to potential area for agricultural development.

7) The development priority order is (1)food crops, (2)plantation (3)other crops including pasture and agroforest.

8) The development of peat area should be considered carefully, and necessary survey carried out.

Under consideration of these circumstances, the future land use plan in the Objective Area is suggested as follows;

1) The suitable area for food crop production is 222,500 ha.

2) In the suitable area for food crop production, the river mouth area of Sungai Rokan is the area for tidal development.

3) The suitable area for plantation and pasture is 167,400 ha.

4) Forest protection area is 446,000 ha, of which 6,800 ha which is in grassland and under shifting cultivation which should be replanted immediately.

5) Approximately 53,000 ha which is grassland and under shifting cultivation in the Limited Production Forest is also recommended for replanting for timber production.

The general map of future land use plan is shown in Fig.3.1.

4. RESULTS AND RECOMMENDATION

The Objective Area is an important agricultural area in Riau Province and many agriculture and plantation development programs are expected.

here are many potential areas which are not utilized as they are under the condition of grassland at present. Forest resources are very important and their proper development is also necessary. However the harmonized development of land and forest resources is very important for their effective and permanent utilization .

In view of all above, the team recommends the following:

1) The improvement of present land productivity can be highly expected through effective land. Soil maintenance which matches soil characteristics should be taught to farmers after the necessary research of soil productivities.

2) The area shown as suitable land for agricultural development includes the area of low ground water level. Therefore necessary facilities in this regard should be considered for the planning of agricultural development projects.

3) There are soils which have low resistance to erosion particularly in the mountainous area. Therefore maintenance is necessary for the prevention of soil erosion and the protection of surface soil.

4) For production of timber in forest areas, prevention of soil erosion and the productivity of natural forest should be emphasized. In this regards, and the seed production and replantation should be considered.

5) For the development of peat swamp area, survey such as peat depth, characteristics of soil, the expected change of soil characteristics through development is considered necessary in development planning.

6) In order to formulation a concrete land use plan information exchange between relating agencies such as the provincial government, Department of Transmigration, Department of Forest, Department of Agriculture and other concerned agencies should be carried out.

Table 1.1 Location of Soil Survey

Sample No.	Location	Survey
1	4km west from Ujung Batu to Pasir Pangarayan	Profile, Sample
2	6km east from Pasir Pangarayan to Ujung Batu, then 9.5km north small road	Test, Sample
3	5.3km south-west from Pasir Pangarayan, Near DPU Dam Site	Profile, Sample
4	5.0km from Pasir Pangarayan to Dalududalu	Profile, Sample
5	5km west from Dalududalu to Kotatengah	Test, Sample
6	22.5km west from Daludalu to Koratengah	Profile, Sample
7	Near Kotatengah (Near river bed of Sungai Rokan Kanan)	Test, Sample
8	3.9km north-east from Ferry site at Sungai Rokan Kanan	Profile, Sample
9	26.1km west from Pasir Pangarayan to Ujungbatu Sosa	Test, Sample
10	3.2km from West Sumatra border to Dalududalu	Profile, Sample
11	In the Protected forest in Seligi	Test
12	31.7km west from Sungai Rokan Bridge to YYYY	Test, Sample
13	47.2km west from Sungai Rokan Bridge to YYYY	Test, Sample
15	5.4km east from Sungai Rokan Bridge	Profile, Sample
17	3.5km north-east from kotatengan	Test
18	7.5km west from junction of ferry site at Sungai Rokan Kanan (Oilpalm Plantation)	Test
19	SKP F Kotatengan Transmigration Area	Profile
20	19km north from Kotalama	Test

Profile: Soil Profile Observation
Test: Soil Observation by Auger
Sample: Soil sampling point for laboratory analysis

Table 1.2(1) SOIL PROFILE DESCRIPTION

1. Profile No. :1

2. Soil Classification
   a.FAO :Orthic Acrisols
   b.USDA :Typic Tropudults

3. Location :4km from Ujung Batu to PKB-PPN road

4. Land Form :Undulating

5. Maximum Slope :5 - 8 %

6. Present Land Use :Forest

7. Drainage Condition :Good

8. Profile Description :

Depth	Description
0 - 21	Dark brown(7.5YR 3/4); sandy clay loam with weak subangular blocky structure; very friable; many roots of fine to medium size; clear smooth horizon boundary
21 - 35	Brown(7.5YR 4/4); sandy clay loam with moderate subangular blocky structure; friable; common roots of fine to small size; clear smooth horizon boundary
35 -100	Dull orange(7.5YR 7/5); sandy clay loam with weak subangular blocky structure; very friable; few roots of fine size; gradual smooth boundary
100 -135	Dull orange(7.5YR 7/5); sandy clay loam with moderate subangular blocky structure; friable; few foots of fine size; clear smooth boundary
135 -200	Grayish brown(7.5YR 5/2) and orange(2.5YR 6/6); sandy loam with weak subangular blocky structure; friable; many stones

Table 1.2(2) SOIL PROFILE DESCRIPTION

1. Profile No. :3

2. Soil Classification
   a.FAO :Ferric Acrisol
   b.USDA :Paleudults

3. Location :5.3km from PPN to south-west (Near DPU Irrigation Dam Site)

4. Land Form :Rolling

5. Maximum Slope :16 - 25%

6. Present Land Use :Bush, Rubber tree forest

7. Drainage Condition :good

8. Profile Description :

Depth	Description
0 - 10	Black(7.5YR 2/1); clay with fine weak crumb structure; very friable; many roots of various size; clear wave horizon boundary
10 - 45	Dull brown(7.5YR 3/6); clay with weak crumb structure; common roots of large to fine size; gradual smooth horizon boundary
45 -110	Bright reddish brown(5YR 5/8);clay with angular blocky structure; few roots of large size; few amounts and fine size of distinct mottles with light yellow orange(2.5YR 5/8); firm; few roots of large size; diffuse smooth horizon boundary
110 -145	Bright reddish brown(5YR 5/8); clay with moderate platy structure; few roots of medium size; common amounts and medium size of distinct mottles with reddish brown(2.5YR 4/8); firm; diffuse smooth horizon boundary
145 -200	Bright reddish brown(5YR 5/8); clay with coarse andmedium to coarse and strong platy structure; few roots of medium size; common amounts and medium size of distinct mottles with reddish brown(2.5YR 4/8) mottles; firm; graduate smooth horizon boundary
200 -250	Bright reddish brown(5YR 5/8); clay with fine, medium to strong platy structure; common amounts and medium size of distinct mottles with brownish black(7.5YR 2/2) and few amounts and fine size of faint mottles with reddish brown(2.5YR 4/8)

Table 1.2(3) SOIL PROFILE DESCRIPTION

1. Profile No. :4

2. Soil Classification
   a.FAO :Orhtic Acrisola
   b.USDA :Typic Tropudults

3. Location :5.0km from PPN(PPN-Daludalu road)

4. Land Form :Rolling

5. Maximum Slope :8 - 15 %

6. Present Land Use :Bush (Aran aran)

7. Drainage Condition :Good

8. Profile Description

Depth	Description
0 - 23	Dark brown(7.5YR 3/3); clay with moderate crumb structure; many roots of coarse size; firm; clear smooth horizon boundary
23 - 74	Brown(7.5YR 4/4); clay with moderate subangular blocky structure; few amounts and fine size of district mottles with reddish brown(2.5YR 5/6); few roots of fine size; firm; gradual horizon boundary
74 -100	Brown(7.5YR 4/6); clay with weak subangular blocky structure; many amounts and medium size of district mottles with bright reddish brown(7.5YR 5/6) and dull orange(7.5YR 7/4); few roots of medium size; firm

Table 1.2(4) SOIL PROFILE DESCRIPTION

1. Profile No. :6

2. Soil Classification
   a.FAO :Humic Gleysols
   b.USDA :Histic Tropaquepts

3. Location :22.5km from Daludalu (Daludalu - Kototenga road)

4. Land Form :Flat

5. Maximum Slope :less than 2 %

6. Present Land Use :Destroyed forest

7. Drainage Condition :poor

8. Ground Water :Approx. 1.5m

9. Profile Description

Depth	Description
0 - 44	Black(10YR 1.7/1); silty loam with moderate crumb structure; friable; common roots of medium and small size; clear smooth horizon boundary
44 - 70	Reddish black(2.5YR 2/1); loam with moderate crumb structure; friable; few roots of small size; clear smooth horizon boundary
70 -120	Dull yellow orange(10YR 7/2); clay loam with moderate subangular blocky structure; very friable

Table 1.2(5) SOIL PROFILE DESCRIPTION

1. Profile No. :8

2. Soil Classification
   a. FAO :Eutric Fluvisols
   b. USDA :Aquic Tropofluvents

3. Location :3.9km from Ferry-boat point (Kototenga - PPN road)

4. Land Form :Flat

5. Maximum Slope :less than 2%

6. Present Land Use :Glassland

7. Drainage Condition :Poor

8. Ground Water :80 cm

9. Profile Description :

Depth	Description
0 - 8	Dark brown(7.5YR 3/3); clay with moderate subangular bocky structure; firm; many roots of medium and small size; gradual smooth horizon boundary
8 - 21	Dull brown(7.5YR 5/4); clay with moderate subangular blocky structure; few amounts and fine size of district mottles with bright reddish brown(5YR 5/8); friable; common roots of medium size; gradual smooth horizon boundary
21 - 80	Dull brown(7.5YR 6/3); clay loam with weak subangular blocky structure; common amounts and small size of district mottles with bright brown(5YR 5/8); friable; few roots of small size

Table 1.2(6) SOIL PROFILE DESCRIPTION

1. Profile No. :10

2. Soil Classification
   a.FAO :Dystric Cambisols
   b.USDA :Dystropepts

3. Location :3.2km from State border(Ujung Batu, Sosa - Daludalu road)

4. Land Form :Rolling

5. Maximum Slope :15%

6. Present Land Use :Bush(Aran aran)

7. Drainage Condition :Good

8. Profile Description :

Depth	Description
0 - 15	Dark brown(7.5YR 3/4); loam with moderate angular blocky structure; firm; many roots of medium and small size; clear smooth horizon boundary
15 - 50	Dull brown(7.5YR 5/4);clay loam with moderate subangular blocky structure; common amounts and fine size of faint mottles with bright reddish brown(2.5YR 5/6); friable; common roots of fine size; clear wavy horizon boundary
50 -110	Dull brown(7.5YR 5/4); clay loam with moderate subangular blocky structure; many round and sub-rounds stones which occur various thickness; common amounts and fine size of faint mottles with bright reddish brown(2.5YR 5/6); friable; clear wavy horizon boundary brown
110 -200	Dull brown(7.5YR 6/3);clay with moderate subangular blocky structure;common round and sub-round small stones; many amounts and fine size of faints and clear mottles with brown (7.5YR 4/6), bright reddish brown(5YR 5/6) respectively; friable

Table 1.2(7) SOIL PROFILE DESCRIPTIOM

1. Profile No. :15

2. Soil Classification
   a.FAO :Dystric Fluvisols
   b.USDA :Typic Fluvaquents

3. Location :Near Ujungtanjung(5.4km east from Bridge)

4. Land Form :Flat

5. Maximum Slope :less than 2 %

6. Present Land Use :Forest

7. Drainage Condition :Poor

8. Ground Water :45cm

9. Profile Description :

Depth	Description
0 - 7	Olive gray(10YR 6/2);clay loam with strong subangular blocky structure; mant amounts and medium size of mottles with light gray(10YR 7/1) and bright brown(5YR 5/8); many roots of small size; friable; clear smooth horizon boundary
7 -29	Light gray(10YR 7/2); silty loam with medium subangular blocky structure; many amounts and medium size of faints mottles with bright yellowish brown(10YR 6/6);few roots of small size; gradual smooth horizon boundary
29 -45	Olive gray(10YR 6/2); silty loam with moderate subangular blocky structure; common amounts and medium size of faints mottles with olive gray(10YR 6/2); friable

Table 1.2(8) SOIL PROFILE DESCRIPTION

1. Profile No. :18

2. Soil Classification
   a.FAO :Dystric Cambisols
   b.USDA :Typic Dystropepts

3. Location :Kota Lama Transmigration Area SKP F

4. Land Form :Flat

5. Maximum Slope :less than 2 %

6. Present Land Use :Glassland (Open Space)

7. Drainage Condition :Moderately good

8. Profile Description :

Depth	Description
0 -14	Dull yellowish brown(10YR 4/3); loam with weak subangular blocky structure; common roots of small size; firm; clear smooth boundary horizon
14 -60	Yellowish brown(10YR 5/8); sandy loam with weak subangular blocky structure; very firm; few roots of small size; gradual wavy horizon boundary
60 -95	Yellowish brown(10YR 5/8); silty clay loam with weak subangular blocky structure; firm
less than 95	(by auger)sandy clay; according to the information from farmer, after 1.5 - 2.0 meter ~~d~~th white sandy layer occurs

Table 1.5 Chemical and Physical Properties of Sampling Soils

Soil Sample		Soil Texture				H2O Ext.		KCL Ext.					CEC	Exch. Cations					Sat.	KCL Ext.	
No. *1	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Classification	pH	EC (μS/cm)	pH	Total C (%)	Total N (%)	C/N Ratio	P2O5 Bray (ppm)	(me/100g)	Ca	Mg	K	Na	Total	%	Al	H
														(me/100g)						(me/100g)	
1-1	0-21	61	16	23	Sandy Clay Loam	4.7	40	4.0	2.68	0.18	14.9	1.5	9.96	1.02	0.31	0.16	0.03	1.52	15.3	1.74	0.13
1-2	21-35	52	20	28	Sandy Clay Loam	4.6	20	4.0	1.06	0.09	11.8	0.0	6.62	0.21	0.10	0.05	0.00	0.36	5.4	1.92	0.16
1-3	35-100	51	20	29	Sandy Clay Loam	4.4	20	4.0	0.35	0.04	8.8	0.0	5.72	0.25	0.10	0.03	0.00	0.38	6.6	1.88	0.11
1-4	100-135	48	19	33	Sandy Clay Loam	4.5	10	4.0	0.29	0.03	9.7	0.0	5.34	0.26	0.10	0.05	0.03	0.44	8.2	1.71	0.15
1-5	135-200	62	19	19	Sandy Loam	4.5	10	4.1	0.20	0.02	10.0	51.9	3.79	0.25	0.10	0.03	0.00	0.38	10.0	1.18	0.10
2-1	0-10	4	30	66	Clay	4.4	60	3.7	2.34	0.27	8.7	0.2	47.93	10.52	3.00	0.46	0.11	14.09	29.4	10.71	0.81
2-2	10-30	4	26	70	Clay	4.5	40	3.6	1.97	0.22	9.0	0.0	47.55	6.58	1.75	0.29	0.05	8.67	18.2	14.80	0.96
3-1	0-10	4	28	68	Clay	5.0	180	4.4	15.91	1.09	14.6	30.5	87.28	21.48	13.47	5.13	0.09	40.17	46.0	0.42	0.10
3-2	10-45	2	31	67	Clay	4.5	50	3.5	4.47	0.42	10.6	0.0	51.79	2.56	2.24	1.88	0.05	6.73	13.0	17.09	0.95
3-3	45-110	1	29	70	Clay	4.4	30	3.6	0.46	0.07	6.6	0.0	53.60	0.27	0.22	0.40	0.02	0.91	1.7	29.38	1.70
3-4	110-145	1	32	67	Clay	4.3	30	3.6	0.43	0.07	6.1	0.0	53.00	0.27	0.26	0.36	0.05	0.94	1.8	28.60	1.65
3-5	145-200	1	34	65	Clay	4.3	30	3.5	0.36	0.06	6.0	0.0	50.11	0.27	0.32	0.39	0.02	1	2.0	28.39	1.66
3-6	200-250	1	35	64	Clay	4.4	20	3.5	0.22	0.04	5.5	1.3	48.73	0.42	0.30	0.41	0.02	1.15	2.4	27.35	1.59
4-1	0-23	10	34	56	Clay	4.7	30	3.9	2.86	0.29	9.9	1.6	30.50	8.66	3.04	0.46	0.02	10.18	33.3	2.81	0.51
4-2	23-74	5	33	62	Clay	4.5	30	3.7	1.09	0.12	9.1	0.0	30.17	2.62	0.73	0.22	0.03	3.6	11.9	10.64	1.10
4-3	74-100	3	23	74	Clay	5.0	10	3.7	0.82	0.09	8.9	0.0	40.81	4.81	1.37	0.33	0.26	6.77	16.6	14.98	1.14
5-1	0-10	44	32	24	Clay	4.3	30	3.7	2.40	0.16	15.0	1.7	13.81	0.26	0.37	0.16	0.02	0.81	5.9	5.25	0.37
5-2	10-30	32	33	35	Clay Loam	4.4	20	3.7	0.52	0.07	7.4	1.8	14.64	0.26	0.10	0.13	0.03	0.52	3.6	7.52	0.34
6-1	0-44	28	51	21	Silty Loam	3.8	20	4.1	9.26	0.38	24.4	0.6	24.73	0.28	0.11	0.14	0.00	0.53	2.1	3.04	0.22
6-2	44-70	36	55	19	Clay	3.4	300	3.8	12.67	0.60	21.1	6.0	36.57	0.28	0.18	0.20	0.05	0.71	1.9	6.22	0.59
6-3	70-120	24	44	32	Clay Loam	4.0	80	4.1	0.82	0.07	11.7	0.0	7.67	0.26	0.12	0.13	0.18	0.69	9.0	1.91	0.22
7-1	0-10	59	3	38	Sandy Loam	4.3	30	3.9	2.10	0.13	16.2	36.2	9.53	0.46	0.10	0.13	0.03	0.72	7.6	3.30	0.34
7-2	10-30	48	28	24	Sandy Clay Loam	4.1	30	3.9	0.24	0.03	8.0	3.8	7.23	0.25	0.12	0.11	0.05	0.53	7.3	3.70	0.30
8-1	0-8	18	38	44	Clay	4.4	20	3.8	3.83	0.26	14.7	1.8	24.50	0.78	0.42	0.16	0.05	1.41	5.8	6.53	0.56
8-2	8-21	13	34	53	Clay	4.5	10	3.8	0.87	0.09	9.7	0.0	14.65	0.26	0.10	0.08	0.13	0.57	3.9	5.98	0.55
8-3	21-80	13	47	40	Sandy Loam	4.4	10	3.8	0.52	0.07	7.4	0.0	13.87	0.36	0.10	0.05	0.02	0.53	3.8	6.18	0.55
9-1	0-10	10	53	37	Silty Clay Loam	5.1	50	4.5	3.41	0.36	9.5	7.2	29.84	12.33	2.20	1.09	0.05	15.67	52.5	0.15	0.04
9-2	10-30	13	64	23	Silty Clay Loam	5.2	20	4.1	1.12	0.15	7.5	0.0	19.69	7.33	0.52	0.13	0.05	8.03	40.8	1.88	0.17
10-1	0-15	50	32	18	Clay	5.4	30	4.7	2.44	0.20	12.2	1.2	13.41	5.48	1.93	0.35	0.03	7.79	58.1	0.14	0.02
10-2	15-50	37	30	33	Clay Loam	4.6	20	3.9	0.54	0.08	6.8	2.0	14.21	0.41	0.33	0.16	0.23	1.13	8.0	7.13	0.50
10-3	50-110	40	22	38	Clay Loam	4.7	100	3.9	0.39	0.05	7.8	2.4	16.52	0.41	0.35	0.19	0.05	1	6.1	8.67	0.59
10-4	110-200	18	21	61	Clay	4.9	10	3.7	0.32	0.04	8.0	0.0	32.62	0.43	0.43	0.33	0.05	1.24	3.8	17.08	1.01
12-1	0-10	-	-	-	-	4.7	120	4.2	37.46	1.81	20.7	0.9	109.11	9.56	3.45	0.93	0.76	14.7	13.5	2.54	0.45
13-1	0-10	72	7	21	Sandy Clay Loam	4.6	30	4.0	1.91	0.12	15.9	4.5	6.00	0.51	0.30	0.14	0.13	1.08	18.0	1.79	0.19
13-2	10-30	69	6	25	Sandy Clay Loam	4.6	20	4.1	0.71	0.07	10.1	1.9	4.43	0.35	0.18	0.08	0.02	0.61	13.8	1.50	0.19
15-1	0-7	22	53	25	Clay Loam	4.6	20	3.7	2.71	0.24	11.3	3.0	18.33	3.45	1.11	0.11	0.23	4.9	26.7	3.91	0.29
15-2	7-29	8	72	20	Silty Loam	4.9	10	3.7	0.67	0.08	8.4	3.0	13.99	2.32	0.91	0.11	0.15	3.49	24.9	5.01	0.31
15-3	29-45	9	77	14	Silty Loam	5.2	10	3.9	0.33	0.04	8.3	3.5	7.15	1.37	0.81	0.08	0.00	2.26	31.6	0.00	2.30

Extraction Rate: Soil 1 + Solution 5

*1 : See Table 1-1 for the identification of Soil No.

Table 1.6 Typical Soil Analysis Data
(Tidal Swamp Soil)

	Unit	Depth(cm)		
		1	2	3
		0-30	30-60	60-120
Texture				
Sand	%	1	1	1
Silt	%	58	69	68
Clay	%	42	30	32
Classification		SiC	SiC	SiC
pH				
H2O		6.2	7	5.4
CaCl2		6	6.8	4.9
EC	μS/cm	2,250	4,000	4,000
Organic Material				
Total N	%	3.91	2.09	2.13
Tptal C	%	0.25	0.18	0.25
C/N Ratio		15.6	11.6	8.5
CEC	me/100g	35.5	31.6	29.7
Exchangeable Cation				
Ca	me/100g	5.3	5	4.3
Mg	me/100g	19.7	18.3	16.8
Na	me/100g	5.2	6	5.5
K	me/100g	1.4	1.6	1.5
Al	me/100g	-	-	-

Source:SURVEY DAN PEMETAAN TANAH, DAERAH SUNGAI ROKAN
PROYEK PEMBUKAAN PESSAWAHAN PASANG SURUT(P4S)

Table 1.7 Typical Soil Analysis Data
(Riverine Alluvial Soil)

	Unit	Depth(cm)		
		1	2	3
		0-20	20-40	40-100
Texture				
Sand	%	1	1	1
Silt	%	58	51	84
Clay	%	41	49	15
Classification		SiC	C	SiL
pH				
H2O		5.5	6.1	6.7
CaCl2		5	5.7	6.2
EC	μS/cm	130	135	190
Organic Material				
Total N	%	0.37	1.01	0.32
Tptal C	%	0.08	0.1	0.05
C/N Ratio		4.6	10.1	6.4
CEC	me/100g	18.7	24.8	8.5
Exchangeable Cation				
Ca	me/100g	3.2	3.7	1.3
Mg	me/100g	11.9	17.2	6.1
Na	me/100g	0.3	0.3	0.1
K	me/100g	0.3	0.5	0.2
Al	me/100g	-	-	-

Source:SURVEY DAN PEMETAAN TANAH, DAERAH SUNGAI ROKAN
PROYEK PEMBUKAAN PESSAWAHAN PASANG SURUT(P4S)

Table 1.8 Typical Soil Analysis Data
(Mender Belt Alluvial Soil)

	Unit	Depth(cm)			
		1	2	3	4
		0-10	10-60	60-130	130 -
Texture					
Sand	%	75	68	38	32
Silt	%	16	19	42	46
Clay	%	9	13	20	22
Classification		LS	SL	CL	SiCL
pH					
H2O		4.4	4.5	4.4	4.2
KCL		3.4	3.8	3.8	3.8
EC	μS/cm	-	-	-	-
Organic Material					
Total N	%	1.43	1.11	0.76	0.24
Tptal C	%	0.09	0.11	0.08	0.06
C/N Ratio		15.9	10.1	9.5	4.0
CEC	me/100g	7.4	4.7	4.5	3.8
Exchangeable Cation					
Ca	me/100g	2.1	1.9	2.0	0.2
Mg	me/100g	0.1	0.1	0.1	0.1
Na	me/100g	0.2	0.4	0.2	0.1
K	me/100g	0.1	0.1	0.2	0.1
Al	me/100g	-	-	-	-

Source:RENCANA KERANGKA SATUAN KAWASAN PENGAMBANGAN PAKET II, PHASE II FINAL REPORT

Table 1.9 Typical Soil Analysis Data
(Alluvial Valley Soil)

	Unit	Depth(cm)			
		1	2	3	4
		0-21	21-55	55-95	95-120
Texture					
Sand	%	22	25	21	11
Silt	%	43	38	38	42
Clay	%	35	37	35	41
Classification		LiC	LiC	LiC	LiC
pH					
H2O		4.7	4.6	4.7	4.7
KCL		3.9	-	-	3.6
EC	μS/cm	-	-	-	-
Organic Material					
Total N	%	4.6	2.0	3.2	1.3
Tptal C	%	0.35	0.18	-	-
C/N Ratio		13.1	11.1	-	-
CEC	me/100g	38.6	34.3	36.2	34.7
Exchangeable Cation					
Ca	me/100g	8.5	2.9	6.2	2.3
Mg	me/100g	2.6	1.3	2.0	0.9
Na	me/100g	0.1	0.1	0.2	0.3
K	me/100g	1.2	0.4	0.6	0.6
Al	me/100g	1.3	11.4	11.3	20.1

Source:PEMTAAN TANAH SEMI DETAIL,
DAERAH PASIR PANGARAYAN II(WPP XII/CD)

Table 1.10 Typical Soil Analysis Data
(Peat Swamp Soil)

	Unit	Depth(cm)			
		1	2	3	4
		0-50	50-100	100-120	120-200
Texture					
Sand	%	N.D.	N.D.	N.D.	1
Silt	%	N.D.	N.D.	N.D.	44
Clay	%	N.D.	N.D.	N.D.	56
Classification		-	-	-	C
pH					
H2O		4.0	4.0	4.2	5.6
CaCl2		3.2	3.2	3.4	4.9
EC	μS/cm	140	155	1,700	1,600
Organic Material					
Total N	%	52.1	60.2	53.4	2.4
Tptal C	%	1.91	1.63	1.81	0.18
C/N Ratio		27.3	36.9	29.5	13.3
CEC	me/100g	75.1	82.4	77.6	27
Exchangeable Cation					
Ca	me/100g	0.8	1.1	1.0	2.6
Mg	me/100g	1.7	1.8	2.3	13.7
Na	me/100g	3.5	4.1	4.7	18.4
K	me/100g	0.7	0.9	1.2	1.2
Al	me/100g	-	-	-	-

N.D.: Not Deternibable for high Organic Contnts

Source: SURVEY DAN PEMETAAN TANAH, DAERAH SUNGAI ROKAN
PROYEK PEMBUKAAN PESSAWAHAN PASANG SURUT(P4S)

Table 1.11 Typical Soil Analysis Data
(Deep Peat Swamp Soil)

	Unit	Depth(cm)		
		1	2	3
		0-10	10-400	
Texture				
Sand	%	N.D.	N.D.	
Silt	%	N.D.	N.D.	
Clay	%	N.D.	N.D.	
Classification		-	-	
pH				
H2O		4.4	4.0	
CaCl2		3.8	3.0	
EC	μS/cm	350	110	
Organic Material				
Total N	%	57.3	61.1	
Tptal C	%	2.21	2.09	
C/N Ratio		25.9	29.2	
CEC	me/100g	92.5	105.9	
Exchangeable Cation				
Ca	me/100g	6.6	1.2	
Mg	me/100g	4.6	1.2	
Na	me/100g	0.4	0.7	
K	me/100g	1.4	0.3	
Al	me/100g	-	-	

N.D.: Not Deternibable for high Organic Contnts

Source: SURVEY DAN PEMETAAN TANAH, DAERAH SUNGAI ROKAN PROYEK PEMBUKAAN PESSAWAHAN PASANG SURUT(P4S)

Table 1.12 Typical Soil Analysis Data
(Marine Terrace Soil)

	Unit	Depth						
		1	2	3	4	5	6	7
		0-15	15-30	30-45	45-60	60-75	75-90	90-105
Texture								
Sand	%	20	35	38	50	52	48	57
Silt	%	39	25	23	12	13	14	10
Clay	%	41	40	39	38	35	38	33
Classification		LiC	LiC	LiC	LiC	LiC	LiC	SC
pH								
H2O		5.2	5.3	5.1	5.2	5.0	5.1	5.1
KCL		4.3	4.4	4.2	4.1	4.1	4.2	4.2
EC	μS/cm	-	-	-	-	-	-	-
Organic Material								
Total N	%	6.5	4.9	2.1	0.83	0.42	0.32	0.15
Tptal C	%	0.35	0.27	0.15	0.06	0.03	0.02	0.02
C/N Ratio		18.6	18.1	14.0	13.8	14.0	16.0	7.5
CEC	me/100g	27.5	20.4	16.8	12.7	9.9	10.4	8.9
Exchangeable Cation								
Ca	me/100g	1.45	0.77	0.54	0.61	0.51	0.48	0.39
Mg	me/100g	1.16	0.81	0.61	0.57	0.51	0.52	0.43
Na	me/100g	0.09	0.10	0.09	0.07	0.08	0.07	0.06
K	me/100g	0.49	0.39	0.32	0.28	0.31	0.27	0.25
Al	me/100g	-	-	-	-	-	-	-

Source: PHASE II SCREENING
KOTATENGAH WPP XIII-SKP A

Table 1.13 Typical Soil Analysis Data
(Undulating Plain Soil)

	Unit	Depth(cm)				
		1	2	3	4	5
		0-13	13-28	28-50	50-75	75-100
Texture						
Sand	%	5	7	4	5	3
Silt	%	32	40	30	29	27
Clay	%	63	53	66	66	70
Classification		C	C	C	C	C
pH						
H2O		5.0	4.9	4.7	4.9	4.8
KCL		3.8	-	-	-	3.7
EC	μS/cm	-	-	-	-	-
Organic Material						
Total N	%	5.39	0.36	0.52	0.77	0.44
Tptal C	%	0.24	0.05	-	-	-
C/N Ratio		22.5	7.2	-	-	-
CEC	me/100g	-	-	-	-	-
Exchangeable Cation						
Ca	me/100g	10.7	4.3	7.4	2.4	1.3
Mg	me/100g	3.8	1.7	2.4	0.7	0.2
Na	me/100g	0.1	0.1	0.1	0.1	0.1
K	me/100g	0.7	0.5	0.4	0.2	0.1
Al	me/100g	6.1	11.5	11.1	26.1	25.7

Source:PEMTAAN TANAH SEMI DETAIL,
DAERAH PASIR PANGARAYAN II(WPP XII/CD)

Table 1.14 Main Characteristics of Soil Classifications

Soil Classification	Dominant Slope (%)	Organic Contents	Soil Layer Development	Dominant Soil Classification (Soil Taxonomy)
Tidal Swamp S	< 2	±	±	Hydroaquents
Riverine Alluvial S	< 2	±	±	Tropaquepts Fluvaquents
Mender Belt Alluvial S	< 2	±	±	Tropfluvents
Alluvial Valley S	< 2	±	+	Tropaquepts Fluvaquents Eutropepts
Fan Alluvial S	< 15	±	+	Dystropepts
Shallow Peat Swamp S	< 2	++	+	Fluvaquents Tropaquepts Tropohemists
Peat Swamp S	< 2	+++	−	Troposaprists Tropohemists
Deep Peat Swamp S	< 2	+++	−	Tropohemists Tropofibrists
Marine Terrace S	< 2	+	+	Tropaquepts
Undulating Plain S	10-15	±	++	Tropudults
Hillocky Plain S	15-25	±	++	Paleudults
Barison Soil	> 40	±	+ or ±	Tropudults Dystropepts

Organic Contents (±: Low、 +: Medium、 ++: High、 +++: Very High)

Soil Layer Development (−:Non、 ±: Weak、 +: Medium、 ++: Strong)

Table 1.15 Soil Classification in the Study Area

Soil Classification	Area(ha)	Ratio(%)
Alluvial Plain Soil	297,900	13.5
Tidal Swamp Soil	41,000	1.9
Riverine Alluvial Soil	168,200	7.6
Mender Belt Allivial Soil	59,900	2.7
Alluvial Valley Soil	20,200	0.9
Fan Alluvial Soil	8,600	0.4
Peat Soil	623,500	28.2
Shallow Peat Swamp Soil	40,200	1.8
Peat Swamp Soil	374,300	16.9
Deep Peat Swamp Soil	209,000	9.5
Old Marine Terrace Soil		
Marine Terrace Soil	187,200	8.5
Undulating Plain Soil		
Undulating Plain Soil	451,800	20.4
Hillocky Plain Soil		
Hillocky Plain Soil	202,700	9.2
Barison Soil	446,900	20.2
Barison Soil(1)	126,900	5.7
Barison Soil(1)	320,000	14.5
	2,210,000	100.0

Table 1.17 Land Suitability of Alluvial Plain Soils

Land Utilization Type	Suitability				
	TSS	RAS	MVS	AVS	FAS
1.Houselot	N	N/S	N/S	N/S	N/S
2.Crops					
Dryland Arable	N	S	S	N/S	$
Wetland Arable	N	S	S	N/S	$
Pasture/Livestock	N	N	S	N	S
Tidal Irrigation	N	S	N	N	N
Agroforestry	N	N	N	N	$
3. Fish Culture(Brsckish)	$	N	N	N	N
4. Estate and Industrial Crops					
Rubber	N	S	S	N/S	S
Oilpalm	N	S	S	N/S	S
Coconut	N	$	S	N	S
Tea	N	N	N	N	N
Coffee(Robusta)	N	N	N	N	S
Cocoa	N	N	N	N	S/N
Clove	N	N	N	N	N/S
Peper	N	N	N	N	N
Sugar Cane	N	S	N	N	S
Tobacco	N	N	N	N	N
Pineapple	N	S	N	N	N
Cashew	N	N	N	N/S	S/N
Banana	N	S	N	N	S/N
Cotton	N	N	N	N	N
Sago	N	S	S	N/S	N/S

TSS: Tidal Swamp Soil
RAS: Riverine Alluvial Soil
MBS: Mender Belt Allivial So
AVS: Alluvial Valley Soil
FAS: Fan Alluvial Soil

N: Not Suitable
S: Suitable
$: Suitable for tree crop estate only
N/S: Unsuitable area which has a small suitable gacet
S/N: Suitable area which has a small unsuitable gacet

Table 1.18 Land Suitability of Peat Soils

Land Utilization Type	Suitability		
	SPS	PSS	DPS
1.Houselot	N	N	N
2.Crops			
Dryland Arable	N	N	N
Wetland Arable	N	N	N
Pasture/Livestock	N	N	N
Tidal Irrigation	N	N	N
Agroforestry	N	N	N
3.Fish Culture(Brackish)	N	N	N
4. Estate and Industrial Crops			
Rubber	N	N	N
Oilpalm	N	N	N
Coconut	N	N	N
Tea	N	N	N
Coffee(Robusta)	N	N	N
Cocoa	N	N	N
Clove	N	N	N
Peper	N	N	N
Sugar Cane	N	N	N
Tobacco	N	N	N
Pineapple	N	N	N
Cashew	N	N	N
Banana	N	N	N
Cotton	N	N	N
Sago	N	N	N

SPS: Shallow Peat Swamp SoilN: Not Suitable
PSS: Peat Swamp Soil
DPS: Deep Peat Swamp Soil

Table 1.19 Land Suitability of Old Marine, Undulating Plain and Hillocky Plain Soils

Land Utilization Type	Suitability		
	MTS	UPS	HPS
1.Houselot	N	S	N/S
2.Crops			
Dryland Arable	S	$	N
Wetland Arable	S	$	N
Pasture/Livestock	S	S	$
Tidal Irrigation	N	N	N
Agroforestry	$	S	$
3.Fish Culture(Brackish)	N	N	N
4. Estate and Industrial Crops			
Rubber	S	S	$
Oilpalm	S	S	$
Coconut	$	S	$
Tea	N	N	N
Coffee(Robusta)	N	S	$
Cocoa	N	S	$
Clove	N	S	$
Peper	N	S	$
Sugar Cane	S	S	$
Tobacco	N	$	N
Pineapple	N	S	$
Cashew	N	S	$
Banana	N	S	$
Cotton	N	N	N
Sago	S	N	N

MTS: Marine Terrace Soil
UPS: Undulating Plain Soil
HPS: Hillocky Plain Soil

N: Not Suitable
S: Suitable
$: Suitable for tree crop estate only

Table 1.20 Land Suitability of Barisan Soil

Land Utilization Type	Suitability
1.Houselot	N
2.Crops	
Dryland Arable	N
Wetland Arable	N
Pasture/Livestock	N
Tidal Irrigation	N
Agroforestry	N
3.Fish Culture(Brackish)	N
4. Estate and Industrial Crops	
Rubber	N
Oilpalm	N
Coconut	N
Tea	N
Coffee(Robusta)	N
Cocoa	N
Clove	N
Peper	N
Sugar Cane	N
Tobacco	N
Pineapple	N
Cashew	N
Banana	N
Cotton	N
Sago	N

N: Not Suitable

Table 2.1 Present Land Use in The Study Area

	Categoly	Area(ha)	Ratio(%)
Forest		1,318,200	59.6
1	Natural Forest	386,500	17.5
2	Peat Swamp Forest	647,100	29.3
3	Tidal Forest	26,700	1.2
4	Logged Primary Forest	257,900	11.7
Bush & Grassland		417,800	18.9
5	Bush	240,000	10.9
6	Bush + Alang-alang	58,600	2.7
7	Alang-alang	68,000	3.1
8	Savannah	35,000	1.6
9	Savannah + Bush	1,500	0.1
10	Others	14,700	0.7
Shifting Cultivation		94,700	4.3
11	Shifting Cultivation	94,700	4.3
Upland Permanent Cultivation		60,800	2.8
12	Upland Crop	50,800	2.3
13	Upland Crop + Tree Crops	10,000	0.5
Wetland		76,000	3.4
14	Wetland Rice	55,500	2.5
15	Tidal Wetland Rice	20,500	0.9
Tree Crops/Estate		238,400	10.8
16	Rubber Tree Crops	33,000	1.5
17	Coconut Tree Crops	23,600	1.1
18	Oilpalm Tree Crops	170,000	7.7
19	Other Tree Crops	11,800	0.5
Settlement		4,100	0.2
20	Settlement	4,100	0.2
	Total	2,210,000	100.0

Table 2.5 Existing and Planning Estate in the Study Area

	Name of Estate	Proposed Development Area	Currently Developed Area			
			Oil Palm	Rubber	Cocoa	Total
1	PT.PELANGI INTER PERTIWI	22,030	-	-	-	0
2	PT.KILAU KEMUNING NUSANTARA	22,900	-	-	-	0
3	PT. BHASKARA MUKTI PERMATA	27,900	-	-	-	0
4	PT. IVO MAS TUNGGAL	19,500	19,364	-	-	19,364
5	PT. Perkebunan IV	30,000	15,827	-	-	15,827
6	PT. GUNUNG MAS RAYA	12,000	2,940	-	-	2,940
7	PT. LAHANTANI SAKTI	15,000	-	-	-	0
8	PT. TUNGGAL MITRA PLANTATIONS	17,700	1,500	-	-	1,500
9	PT. ARTA DEBANG	6,000	-	-	-	0
10	PT. DARMALI JAYA LESTARI	6,000	-	-	-	0
11	PT. HUTAHAEAN	5,000	-	200	-	200
12	PT. ADEI CRUMB RUBBER	13,500	-	1,000	-	1,000
13	PT. KARIMUN AROMATIK COY.	18,000	-	-	-	0
14	PT. SUMBERJAYA INDAH NUSA COY.	7,500	-	-	-	0
15	PT. PERDANA INTI SAWIT	17,500	-	-	-	0
16	PT. ROKAN ADIRAYA PLANTATION	18,000	-	-	-	0
17	PT. ROKAN ERASUBUR PLANTATION	18,000	-	-	-	0
18	PT. ROKAN ADIMARMUR PLANTATION	12,000	-	-	-	0
19	PT. EKA DURA INDONESIA	25,000	5,341	-	-	5,341
20	PT. KUMU KAMPAR SMIATI	6,000	-	-	-	0
21	PT. ELUAN MAHKOTA	65,000	-	-	-	0
22	PT. PERKEBUNAN V	43,000	18,863	5,609	-	24,472
23	PT. SAWIT ASAHAN INDAH	7,500	5,961	-	-	5,961
24	PT. BUDI DATA	1,000	-	-	40	40
		436,030	69,796	6,809	40	76,645

Souece:Dinas Perkebunan Propinsi Daerah Tingkat I Riau,1991

Table 2.6 Relationship between Land Use and Forest in the Objective Area

Unit : ha

Categoly	Objective Area	Forest Classification						Non-Forest Area
		Protected Forest	Conserva-tion	Limited Production	Fixed Production	Conver-sion		
Forest	966,800	12,200	33,700	348,500	243,400	102,300		226,700
1 Natural Forest	172,800	7,100	11,200	77,300	11,600	8,200		57,400
2 Peat Swamp Forest	646,900	800	0	216,000	231,200	63,100		135,800
3 Tidal Forest	26,700	4,300	0	0	600	21,200		600
4 Logged Primary Forest	120,400	0	22,500	55,200	0	9,800		32,900
Bush & Grassland	294,800	800	3,000	40,300	53,300	109,900		88,400
5 Bush	203,900	800	3,000	24,800	46,200	65,400		63,700
6 Bush + Alang-alang	36,200	0	0	6,400	1,800	11,200		16,800
7 Alang-alang	38,300	0	0	6,800	3,400	27,800		300
8 Savannah	1,600	0	0	0	0	0		1,600
9 Savannah + Bush	100	0	0	0	0	0		100
10 Others	14,700	0	0	2,300	1,900	4,600		5,900
Shifting Cultivation	84,200	3,000	0	6,600	1,000	50,800		22,800
11 Shifting Cultivation	84,200	3,000	0	6,600	1,000	50,800		22,800
Upland Permanent Cultivation	38,900	0	1,700	5,800	4,600	10,100		16,700
12 Upland Crop	28,900	0	1,700	5,500	0	10,100		11,600
13 Upland Crop + Tree Crops	10,000	0	0	300	4,600	0		5,100
Wetland	50,600	0	0	400	3,100	29,900		17,200
14 Wetland Rice	30,100	0	0	400	3,100	19,100		7,500
15 Tidal Wetland Rice	20,500	0	0	0	0	10,800		9,700
Tree Crops/Estate	166,500	0	300	9,700	27,200	34,200		95,100
16 Rubber Tree Crops	33,000	0	300	4,700	5,640	5,600		16,760
17 Coconut Tree Crops	23,600	0	0	0	2,500	6,500		14,600
18 Oilpalm Tree Crops	98,100	0	0	5,000	12,200	17,600		63,300
19 Other Tree Crops	11,800	0	0	0	6,860	4,500		440
Settlement	4,100	0	0	0	0	1,700		2,400
20 Settlement	4,100	0	0	0	0	1,700		2,400
Total	1,605,900	16,000	38,700	411,300	332,600	338,000		469,300

Table 2.7 Relationship between Soil and Forest in the Objective Area

Unit : ha

Soil Classfication	Objective Area	Forest Classification					Non-Forest Area
		Protected Forest	Conserva-tion	Limited Production	Fixed Production	Conver-sion	
Alluvial Plain Soil	271,600	3,800	1,500	22,600	40,500	133,000	70,200
Tidal Swamp Soil	41,000	3,800	0	700	0	36,200	300
Riverine Alluvial Soil	160,100	0	0	15,600	29,000	57,000	58,500
Mender Belt Allivial So	57,600	0	0	0	11,500	37,000	9,100
Alluvial Valley Soil	12,100	0	1,500	6,300	0	2,800	1,500
Fan Alluvial Soil	800	0	0	0	0	0	800
Peat Soil	622,600	1,000	0	173,400	227,400	50,900	169,900
Shallow Peat Swamp Soil	39,300	0	0	12,300	18,500	6,600	1,900
Peat Swamp Soil	209,000	0	0	67,400	37,000	17,000	87,600
Deep Peat Swamp Soil	374,300	1,000	0	93,700	171,900	27,300	80,400
Old Marine Terrace Soil							0
Marine Terrace Soil	169,100	0	600	84,600	6,000	20,300	57,600
Undulating Plain Soil							0
Undulating Plain Soil	363,600	4,400	2,000	39,000	58,700	105,100	154,400
Hillocky Plain Soil							0
Hillocky Plain Soil	69,700	0	13,000	21,800	0	27,800	7,100
Barison Soil	109,300	6,800	21,600	69,900	0	900	10,100
	1,605,900	16,000	38,700	411,300	332,600	338,000	469,300

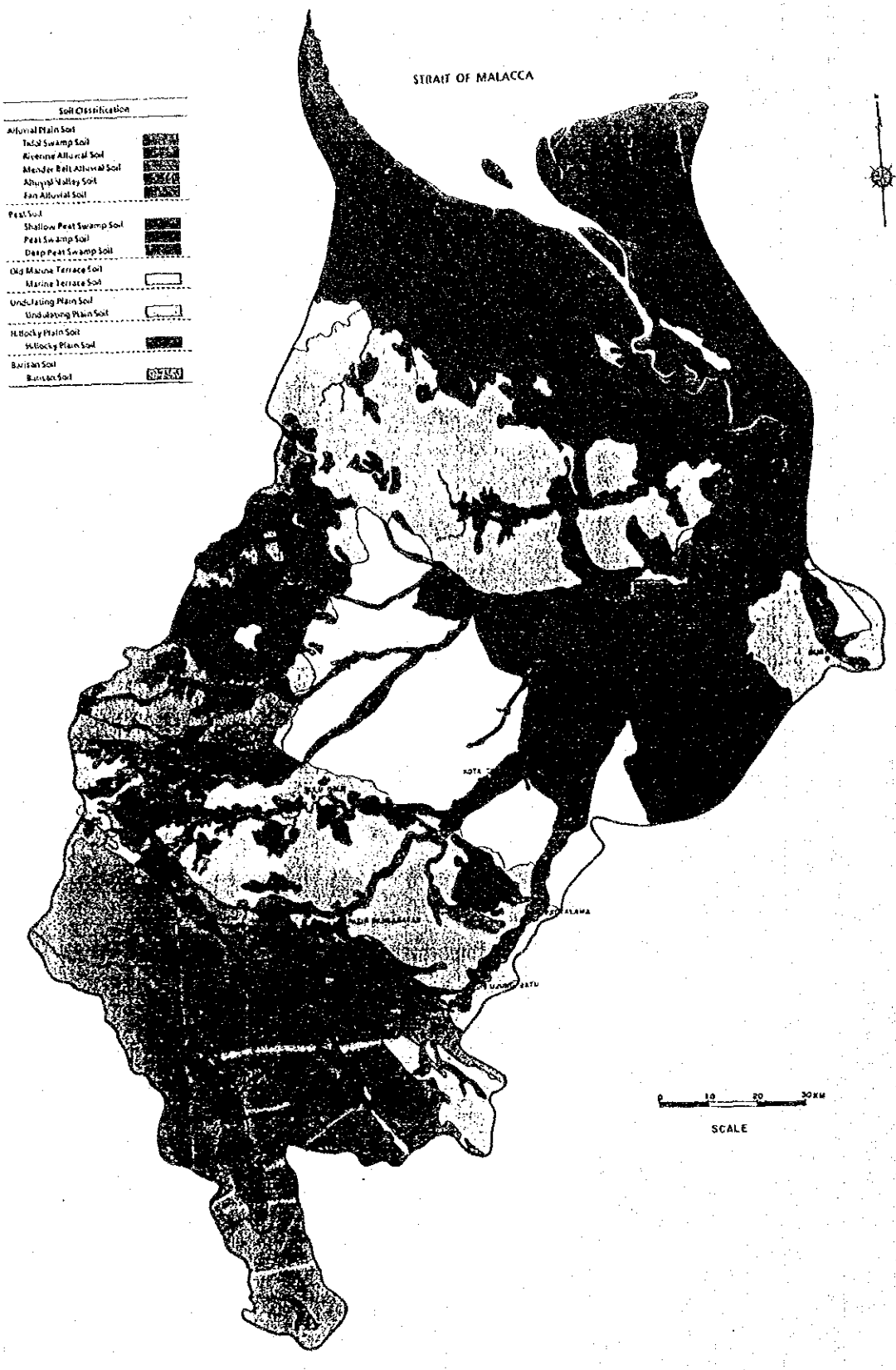

Fig. 1.1 Soil Distribution Map

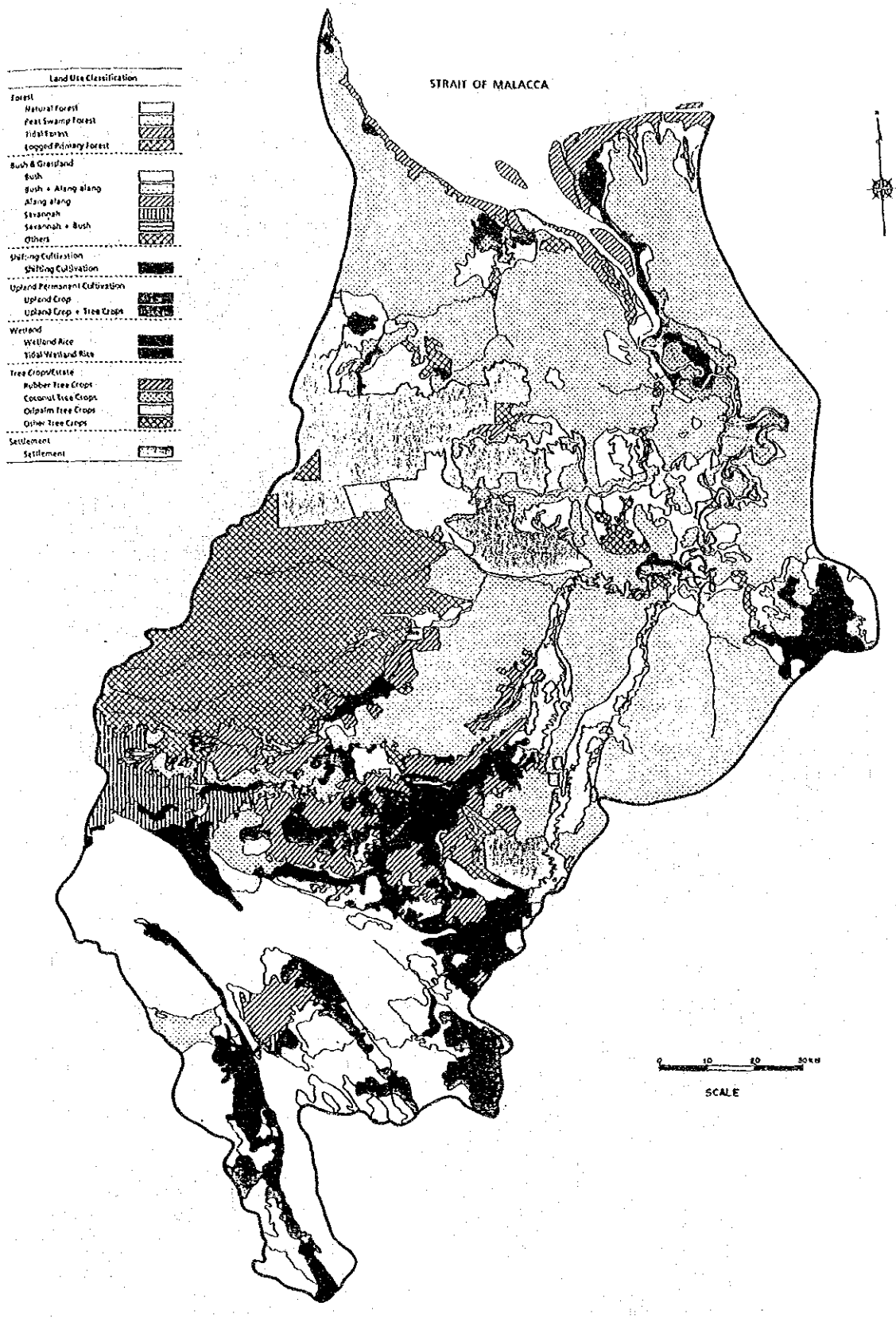

Fig. 2.1 Present Land Use Map

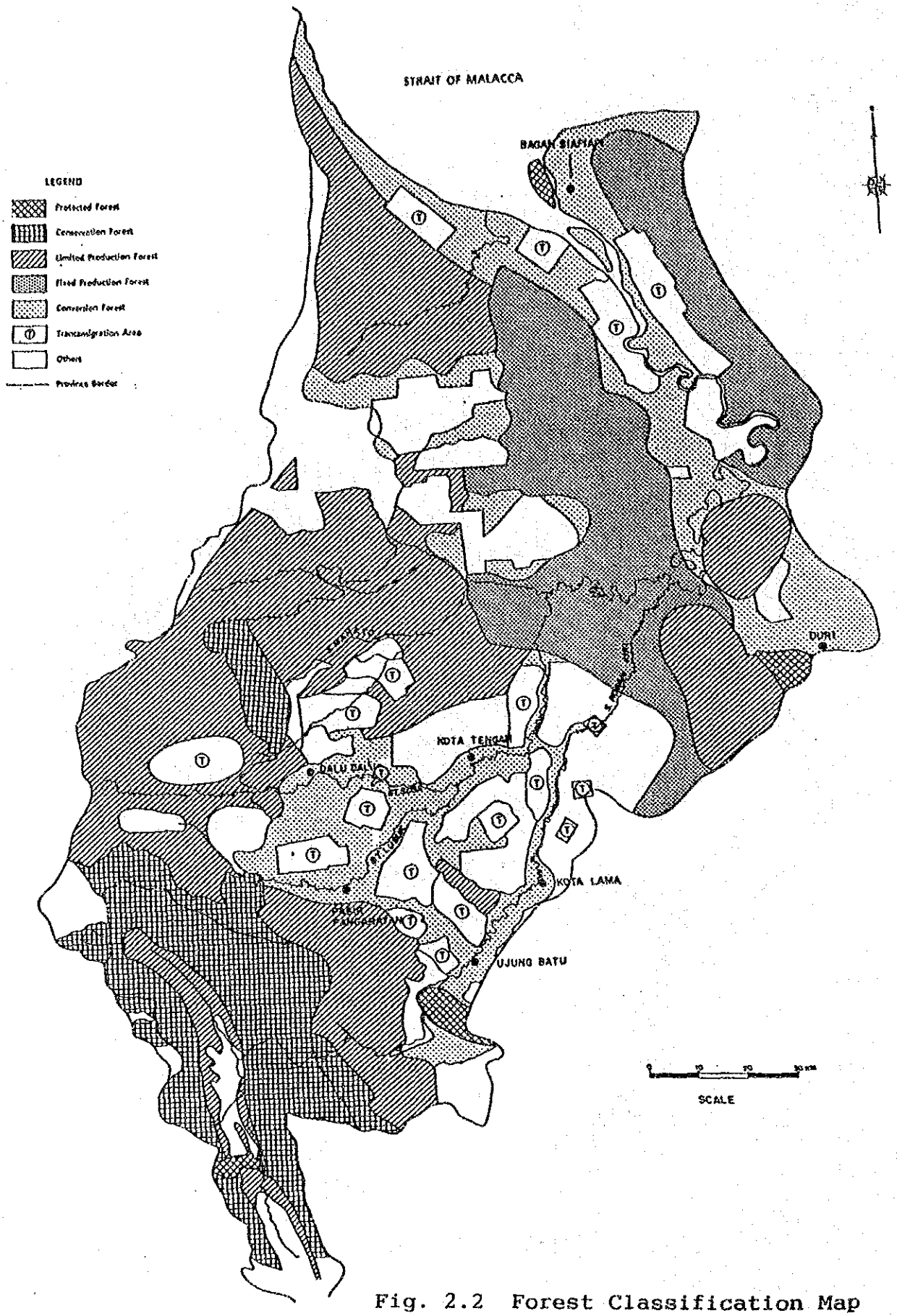

Fig. 2.2 Forest Classification Map