5.2 Water Balance

The irrigation area by the surface water is assessed by means of the water balance between the available water and the series of irrigation water requirements in the available discharge period. The dependable irrigation level for the scheme is taken to be 80 % in both the dry and rainy seasons.

(1) Rau river system

For irrigation schemes are planned to take water from the Njoro and the Rau rivers: two on the Njoro and the other two on the Rau rivers in consideration of topography and the existing water use. The prospective land use plan shows that all the land extending along the Rau river is suitable and used for paddy cultivation.

As shown in ANNEX 1, the estimated Rau and Njoro riverflows are quantified for 15 years from 1965 to 1979. For making the water balance study, the irrigation water requirements for each crop are estimated by use of water consumption and effective rainfall at Miwaleni substation as shown in Table IV-20. In the study, the existing fields that have water rights, such as the sugarcane fields and perennial crops, are taken into account. The balance of the demand and the supply is separately examined for the Njoro and the Rau rivers as shown in Table IV-21.

The result indicates that the Rau river and the Njoro river can ensure irrigation for 2,300 ha and 950 ha in the rainy and dry seasons, respectively.

(2) Miwaleni springs

The available water of the Miwaleni springs for the Lower Moshi area is estimated under the following considerations:

The present cultivated area of NAFCO Kahe scheme will not be expanded more than the originally planned area of 3,400 ha, but as the village irrigation plans are drawn up by use of the NAFCO lead canal, the water supply to their areas has to be ensured.

The diversion water requirement for the NAFCO Kahe area is calculated as shown in Table IV-22 based on the Report on the Engineering Aspects and Technical Soundness of the Proposed Kahe irrigation Scheme by FAO. The available water for the Project is assessed to be the surplus flow based on the balance of the recorded monchtly miniumum for 5 year from 1966 to 1970 as shown in ANNEX I and the water requirement for the NAFCO Kahe area as shown in Table IV-23. The water requirements are estimated based on the effective rainfall with 80 % dependability at Miwaleni substation as shown in Table IV-13.

The water balance study shown in Table IV-24 shows that the area of 2,000 ha can be irrigated in the rainy season and of 750 ha in the dry season.

(3) Himo river system

The Himo river discharge is estimated for 12 years from 1968 to 1979 as shown in ANNEX I. The irrigation water requirements for the same period are estimated based on the effective rainfall at the Himo sisal estate as shown in Table IV-25. According to the results of the water balance study, the irrigation area of 1,000 ha and 480 ha in the respective rainy and dry seasons can be ensured.

The results of the water balance for each water sources system are summarized in Table IV-26.

(4) Groundwater systems

As for the groundwater scheme, development potential is studied by dividing the groundwater zone into four parts as in ANNEX II. Out of the acquifers underlying the Project area, the Miwaleni and the Himo groundwater zones are provisionally selected in view of productivity of acquifers and water quality. The Arusha Chini zone, in which the Chekereni and Mabogini areas are located, is doubtful in respect to productivity and water quality. Therefore, the north groundwater scheme is proposed in the Miwaleni zone and the east groundwater scheme in the Himo zone.

The groundwater potential estimated in the said ANNEX is an effective indication of the amount of available water for irrigation, but it cannot fully be utilized. Taking into account the efficiency of extraction from wells to be installed and the influence on the existing outflows of springs and wells, the utilized amount of groundwater has to be estimated.

According to the proposed cropping pattern for the groundwater scheme, the irrigation water requirements are estimated as shown in Table V-13, showing a maximum requirement of 0.91 ℓ/s/ha. Production of a well in the north groundwater scheme is expected to be 60 ℓ/s, and in the east groundwater scheme to be 30 ℓ/s as mentioned in ANNEX II. Thus the irrigation area of a well is to be 60 ha and 30 ha for the north and east groundwater schemes, respectively. The total scheme area of the groundwater is determined by the available groundwater to be able to extracted from acquifers and the extent of the irrigable land.

In the north groundwater scheme, 14 numbers of well are proposed, which command an area of 840 ha. In the east groundwater scheme, 6 numbers of well commanding an area of 180 ha are proposed due to the limited amount of the available water.

Consequently, with assessment of monthly water balance between the irrigation water requirement and the available irrigation water, the irrigable area with the dependability of 80 % is determined. Based on this, the Project is formulated. The irrigation areas for each scheme are as shown in Table IV-27 and summarized below.

		Command Area (ha)	Irrigation Area	
			Rainy Season (ha)	Dry Season (ha)
1.	Surface Water System			
(i)	Rau River System	2,300	2,300	950
(ii)	Miwaleni Springs	2,000	2,000	750
(iii)	Himo River System	1,000	1,000	480
	Sub-total	5,300	5,300	2,180
2.	Groundwater System	1,020	1,020	856
	Total	6,320	6,320	3,036

Based on the diversion water requirements of the above mentioned proposed schemes, the total amount of water extractions from the rivers, the springs and the groundwater flows is estimated. Besides the above, the water use of the present cultivation area of Kahe NAFCO scheme of 1,400 ha extracted from the Miwaleni springs, and the groundwater use by TPC are estimated. These are shown in Table IV-28. The results are summarized below.

	Annual extraction of Water ($10^6 m^3$)
1. Lower-Moshi Area (Average year)	
(1) from Rau river system	37.9
(2) from Miwaleni Spring	24.8
(3) from Mue river	11.2
(4) from groundwater	14.2
Total	88.1
2. Other Scheme	
(1) Kahe NAFCO from Miwaleni Springs	32.6
(2) TPC from groundwater	20.4

6. Drainage Water Requirement

6.1 General

The schemes in the Project consist of paddy fields and upland fields. The drainage characteristics differ on these fields. Drainage water requirements on paddy field and that on upland field are separately estimated hereunder.

Surface drains for upland field are provided so as to remove the excess runoff from 5-year, 1-hour storm rainfall, while drains for paddy field is contemplated on assumption that 5-year, 24-hour storm rainfall is to be drained from paddy fields within 48 hours.

6.2 Design rainfall

Design rainfall is determined scheme by scheme based on daily maximum rainfall-altitude relations as shown in Figure I-12 (Annex 1).

For upland field, one hour rainfall intensity is converted from the daily rainfall using the following formula (refer to section 2.4.2 in Annex I).

$$r_1 = R_{24} \left(\frac{1}{24}\right)^{1/3} = 0.347 \cdot R_{24}$$

Where; r_1 = one hour rainfall intensity (mm/hr)

R_{24} = daily rainfall (mm/day)

The design rainfall thus obtained are summarized below.

Design Rainfall for the Lower-Moshi Project
(5-year recurrence interval)

Name of Scheme	Average Elevation (El. m)	Design Rainfall 24-hour (mm/day)	Design Rainfall 1-hour (mm/hr)
Upper Mabogini	752	94	33
Mabogini	743	90	31
Rau Ya Kati	733	84	29
Chekereni	720	78	27
Makuyuni	781	108	37
Ghona & Kileo	724	80	28
Miwaleni	722	79	27
North Groundwater	755	96	33
East Groundwater	715	76	26

6.3 Drainage Water Requirement for Paddy Field

6.3.1 Rainfall pattern

Recurrence interval of daily storm rainfall in a short period (more than 50 mm/day) is analyzed in order to determine necessary hours to drain excess water caused by design storm rainfall. Daily rainfall data recorded at Moshi meteorological station (recent 30 years) are used. For each year, an interval (number of days) of the storm rainfall more than 50 mm after the daily maximum rainfall is counted and summarized as follows.

Recurrence Interval (days)	Frequency (nos.)	Probability (%)
1 day	1	3.3
2 days	6	20.0
3 - 5 days	2	6.7
more than 6 days	21	70.0
Total	30	100.0

As shown on this result, probability of occurrence of 2-day consecutive rainfall (50 mm/day or above) is as low as 3.3%.

Hence, the design condition of drainage for paddy field is determined such that 5-year, 24-hour storm rainfall can be drained from paddy field within 48 hours.

6.3.2 Calculation of drainage requirement

Design drainage requirement is calculated using the following equation.

$$Q = q \times A$$

$$q = \frac{R24 \text{ mm/hr} \times 10^{-3} \times 10^{4} \text{ m}^2}{3{,}600 \text{ sec} \times 48 \text{ hr}}$$

$$= 5.787 \times 10^{-5} \times R24 \ (m^3/sec/ha)$$

$$\doteq 5.8 \times 10^{-2} \times R_{24} \ (lit/sec/ha)$$

where; Q = design drainage requirement
q = unit drainage requirement per ha
A = drainage area (ha)
R_{24} = design rainfall (mm/day)

Results of calculation are as follows.

Name of Scheme	Design Rainfall (mm/day)	Unit Drainage Requirement (lit/sec/ha)
Upper Mabogini	94	4.89
Mobogini	90	4.68
Rau Ya Kati	84	4.37
Chekereni	78	4.06
Ghona & Kileo	80	4.63
Miwaleni	79	4.58

6.4 Drainage Water Requirement for Upland Field and Outside Basin

Drainage requirements for upland field and from outside basins of each scheme are estimated by using the McMath formula[1/] as shown below.

$$Q = 2.3 \cdot C \cdot i \cdot S^{1/5} \cdot A^{4/5}$$

where; Q = flood discharge (lit/sec),

C = coefficient representing the basin characteristics (= 0.3),

i = rate of rainfall for the time of concentration and frequency (mm/hr),

S = fall of main channel between the farthest contributing point and the point of concentration, and

A = area of drainage basin (ha).

Equation applicable to each scheme is shown as follows.

Drainage Requirements

Name of Scheme	Design Rainfall (mm/hr)	Applied Equation	Drainage Requirement[2/] (m^3/sec)
Makuyuni	37	$25.53\ S^{1/5}\ A^{4/5}$	2.8
Ghona & Kileo	26	$19.32\ S^{1/5}\ A^{4/5}$	2.0
Miwaleni	27	$18.63\ S^{1/5}\ A^{4/5}$	10.2
North Groundwater	33	$22.77\ S^{1/5}\ A^{4/5}$	2.4
East Groundwater	26	$17.94\ S^{1/5}\ A^{4/5}$	0.5

1/: "Drainage Manual," U.S. Department of the Interior, Bureau of Reclamation, first edition, 1978.

2/: at the end point of major drain for each scheme.

The calculations are conducted for each point on drainage canals using the above equation in the table. Results are shown in Annex VII in the form of a diagram.

Table IV-1 (1)

EXISTING IRRIGATION SYSTEM (1)

No.	Name of Canal or Scheme	Water Source	Location of Scheme	Irrigated Area Rainy Season (ha)	Irrigated Area Dry Season (ha)	Water Right	Crops Grown	Intake Structure	Remarks
A.	Rau River System								
A-1	Kaloreni	Kaloreni Spring	Moshi Mabogini	80	-	Customary	Paddy	Natural Intake	
A-2	Mabogini Paddy	Njoro River	Mabogini	140	-	Customary	Paddy	Natural Intake	8 Nos. of intakes from Njoro R.
A-3	Uru Chini	"	Mabogini New land Mutakuga	600 50 70	85 -	Water Right Q = 10 cusec	Maize, Beans	Natural Intake	At intake, 12 cusec of water right
A-4	Sugar Farm	"	Rau Ya Kati	80	80	Water Right Q = 2 cusec	Sugar Cane	Turnout on Uru Chini Canal	
A-5	Dishon	"	Mabogini	30	-	Customary	Paddy	Natural Material Weir	
A-6	Suidi	"	Mabogini	40	-	"	Paddy	Natural Material Weir	
A-7	Odaro	"	Rau Ya Kati	180	-	"	Paddy Maize	Concrete Weir	
A-8	Rauya	Rau River	MSaranga/ Mandaka	150	150	"	Upland Crops Banana	Natural Intake	
A-9	Mandaka Spring	Mandaka Spring	"	150	-	"	Paddy	Natural Material Weir	
A-10	Mandaka Paddy	Rau River	MSaranga/ Mandaka	100	-	"	Paddy	Natural Intake	
A-11	Kondo	"	Rau Ya Kati	120	10	"	Upland Crops Banana, Coffee	Intake Gate	
A-12	Machua	Rau River	Yam Maka Kisangesangeni	120 30	10	Customary	Upland Crops	Natural Material Weir	
A-13	Kati	"	Kisangesangeni	30	5	"	Upland Crops Paddy	"	
A-14	Sakafu	"	"	20	0	"	"	"	
A-15	Chekereni	"	Chekereni	210	85	Water Right Q = 5 cusec	"	Intake Gate	
A-16	Gynja (Kahe Sisal estate)	"	Oria	40	20	Water Right Q = 3.75 cusec	Upland Crops	Intake Gate	Intake gate broken
A-17	Ismaili Muldadi	"	"	20	-	Customary	Upland Crops	Intake Weir	
A-18	Lengesi	"	"	5	-	"	"	-	
A-19	Leleshwa	"	"	5	-	"	"	-	
A-20		"	Mangaria	30	-	"	"	Natural Intake	
		Total		2,300	435				
B.	Mivaleni Springs System								
B-1	Kahe KAFCO	Mivaleni Springs	Kahe	1,400		Water Right Q = 108 cusec	Upland Crops	Concrete Weir	
C.	Mue River System								
C-1	Mabungo	Mue River	Uchira	70	-	Customary	Upland Crops	Natural Intake	Non-perenial
C-2	Kiboani	"	Ghona Kitereni	100 150	-	"	Upland Crops	Natural Intake	Non-perenial weir broken
C-3	Koshianga	"	Kitereni	80	-	"	"	"	Non-perenial weir broken flooding
		Total		430	0				

- Continued

Table IV-1 (2) EXISTING IRRIGATION SYSTEM (2)

No.	Name of Canal or Scheme	Water Source	Location of Scheme	Irrigated Area Rainy Season (ha)	Irrigated Area Dry Season (ha)	Water Right	Crops Grown	Intake Structure	Remarks
D.	Soko Spring System								
D-1	Soko (I)	Soko River	Kitereni Mangaria	10 30	-	Customary	Paddy	Natural Intake	
D-2	Soko (II)	"	Mangaria	30	-	"	"	Intake Weir	
		Total		70	0				
D'	Bore hole								
D'-1	Mivaleni Bore Hole No.2	Ground water	Uchira	20	-		Upland Crops	Deep Well	
D'-2	" No.3	"	Uchira	10	10		"	Deep well	
		Total		30	10				
E.	Himo River System								
E-1	Mananga (Himo sisal estate)	Himo River	Himo Lotima	200 150	- 5	Water Right Q = 3 cusec	Upland Crops	Natural Intake	Out of 3 cusec, 2 cusec for Makuyuni
E-2	Ushirika	"	Lotima Makuyuni	150 10	10	Water Right Q = 5 cusec	"	"	Out of 5 cusec, 1 cusec for Makuyuni
E-3	Himo Tanneries	"	Himo	30	5	Water Right Q = Appr. 0.1 cusec	"	Intake Weir	
E-4	Himo Pofo	"	Kilima Pofo	150	-	Customary	"	Natural Intake	
E-5	Masaga	"	Lotima, Makuyuni	300 10	40	"	"	Intake Weir	
E-6	Marangu Siding	"	Makuyuni	150	35	"	"	"	
E-7	Ghona	"	Ghona Kiomu	200 30	10	"	"	"	
E-8	Others	"	Kiomu Kwacha-Kindo	70 40	- -			Natural Intake "	
		Total		1,390	105				
F.	Kileo Spring System								
F-1	Kileo	Kileo Spring	Kileo	290	25	Customary		Natural Intake	

Table IV-2 (1)

WATER RIGHTS

NO.	NAME OF SCHEME	WATER SOURCE	PURPOSE OF WATER SUPPLY	LOCATION OF SCHEME	IRRIGABLE AREA (ha)	WATER HIGHT					
						Holder	Amount (Cusec)	Granted Date	No.	STRUCTURE	CROP
Rau River System											
1.	Uru Chini	Njoro River	Irrigation	Mabogini	880	Village	10.0	-	-	Intake Gate	Maize Beans
2.	Rau River Sugar Estate	Njoro River	Irrigation	Rau Ya Kati	115	Private	2.0	'56 July	No. 189	Intake on Uru Chini Canal	
3.	Chekereni	Rau River	Irrigation	Chekereni	80	Village	5.0	'73 Feb.	No. 4019	Intake Gate	Parry Banana Maize
4.	Kahe Sisal Estate	Rau River	Irrigation & Domestic Use	Oria	8	Kahe Sisal Estate	3.75	'61 Dec.	No. 574	Intake Gate	Sisal
5.	Kahe Railway Station	Rau River	Domestic Use	Oria	-	Railway Station	10,000 G.P.D.	'55 Jan.	No. 10	Pump	-
Miwaleni Springs											
1.	Kahe NAFCO	Miwaleni Spring	Irrigation	Kahe	1,400	NAFCO	108	'73 Jan.	No. 2411	Intake Weir	Maize Beans

- Continued

Table IV-2 (2)

WATER RIGHTS

NO.	NAME OF SCHEME	WATER SOURCE	PURPOSE OF WATER SUPPLY	LOCATION OF SCHEME	IRRIGABLE AREA (ha)	WATER HIGHT				
						Holder	Amount (Cusec)	Granted Date	No.	STRUCTURE / CROP
Himo River System										
1.	Himo Sisal Estate	Himo River	Irrigation & Domestic Use	Himo, Lotima, Makuyuni	-	Himo Sisal Estate	18.0 15 cusecs for hydropower to be returned 1 cusec for sisal factory 2 cusecs for irrigation in Makyuni	'41 Sep.	No. 692	
2.	Himo Sisal Estate	Himo River	Irrigation & Domestic Use	Himo, Lotima Makuyuni	-	Himo Sisal Estate	5.0 2 cusecs for sisal factory 3 cusecs for irrigation in Makuyuni	'39 Aug.	No. 1128	
3.	Himo Tannery	Himo River	Tanning	Himo	-	Himo Tanners & Planters	35,000 G.P.D.	'77 Aug. (provisional re-grant)	No. 2466/ 2467	
4.	Kiracha	Himo River	Domestic, Livestock, Fishfarm, Irrigation	Himo, Lotima	186	Kiracha Farm	1.0 abstraction of water from the canal which is register under water right No. 692	'76 Dec.	No. 4443	
5.	Makuyuni	Himo River	Irrigation	Lotima, Makuyuni	-	K.D.C.	2.0 water right of 2.0 cusecs to Makuyuni, which has been registered under water right No. 692, is confirmed.	'68 Dec.	No. 2483	

Note: This is prepared based on data supplied by the Ministry of Water Development and Power in Moshi

Table IV-3 (1) POTENTIAL EVAPOTRANSPIRATION

at Miwaleni Sub-station
Altitude = 770 m

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1. Data												
(1) Mean Temp., T mean (°C)	25.7	26.1	26.3	25.2	23.3	21.8	21.4	21.8	23.1	25.3	25.9	25.5
(2) Mean Relative Humidity, RH mean (%)	59	59	62	68	73	70	68	66	62	57	57	59
(3) Wind Speed, V (m/sec)	1.62	1.62	1.58	1.30	1.21	1.05	1.01	1.17	1.31	1.35	1.77	1.90
(4) Sunshine Hour, n (hr/day)	8.0	8.0	7.7	6.8	6.1	5.3	5.5	6.3	7.6	8.7	8.6	8.7
(5) Absolute Sunshine Hour, N (hr/day)	12.2	12.2	12.1	12.0	11.9	11.9	11.9	11.9	12.0	12.1	12.2	12.3
(6) Extra Terrestrial Radiation, Ra (mm/day)	15.4	15.8	15.7	15.0	14.0	13.3	13.6	14.4	15.2	15.5	15.4	15.2
2. Calculation												
(1) Vapour Pressure, (ea-ed)												
(i) ea at T mean (m bar)	33.0	33.8	34.2	32.1	28.6	26.1	25.5	26.1	28.3	32.3	33.4	32.7
(ii) ed = ea x RH mean/100 (m bar)	19.5	19.9	21.2	21.8	20.9	18.3	17.3	17.2	17.5	18.4	19.0	19.3
(iii) (ea-ed) (m bar)	13.5	13.9	13.0	10.3	7.7	7.8	8.2	8.9	10.8	13.9	14.4	13.4
(2) Wind Function, f(u)												
(i) Wind Speed, U (Km/day)	140	140	137	112	105	91	87	101	113	117	153	164
(ii) f(u) = 0.27 (1+U/100)	0.65	0.65	0.64	0.57	0.55	0.52	0.50	0.54	0.58	0.59	0.68	0.71
(3) Weighting Factor (W)												
(i) W at T mean	0.76	0.77	0.77	0.76	0.74	0.72	0.72	0.72	0.73	0.76	0.77	0.76
(ii) (1-W)	0.24	0.23	0.23	0.24	0.26	0.28	0.28	0.28	0.27	0.24	0.23	0.24
(4) Net Radiation, (Rn)												
(i) n/N	0.66	0.66	0.64	0.57	0.51	0.45	0.46	0.53	0.63	0.72	0.70	0.71
(ii) (0.25+0.5·n/N)	0.58	0.58	0.57	0.54	0.51	0.48	0.48	0.52	0.57	0.61	0.60	0.61
(iii) Rs = (0.25+0.5·n/N)·Ra (mm/day)	8.9	9.2	8.9	8.1	7.1	6.4	6.5	7.5	8.7	9.5	9.2	9.3
(iv) Rns = 0.75·Rs (mm/day)	6.7	6.9	6.7	6.1	5.3	4.8	4.9	5.6	6.5	7.1	6.9	7.0
(v) Rnl = f(T mean)·f(ed)·f(n/N)	1.6	1.6	1.5	1.3	1.2	1.1	1.2	1.3	1.6	1.9	1.9	1.7
f(T mean)	15.8	15.9	16.0	15.7	15.3	15.0	14.9	15.0	15.2	15.7	15.9	15.8
f(ed)	0.14	0.14	0.13	0.13	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.14
f(n/N)	0.74	0.74	0.72	0.62	0.56	0.51	0.52	0.58	0.71	0.80	0.78	0.79
(vi) Rn = Rns-Rnl (mm/day)	5.1	5.3	5.2	4.8	4.1	3.7	3.7	4.3	4.9	5.2	5.0	5.3
(5) Adjustment Factor, (C)	1.02	1.02	1.04	1.06	1.06	1.06	1.06	1.04	1.04	1.02	1.02	1.02
(6) Potential Evapotranspiration (mm/day) (ea-ed)·f(u)·(1-W) + W·Rn ·C	6.1	6.3	6.1	5.4	4.4	4.0	4.0	4.6	5.5	6.0	6.2	6.4

- Continued

Table IV-3 (2) POTENTIAL EVAPOTRANSPIRATION

at Moshi Meteorological Station
Altitude = 813 m

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1. Data												
(1) Mean Temp., T mean (°C)	24.8	25.2	25.2	24.1	22.7	21.3	21.0	21.1	22.3	23.9	24.5	24.9
(2) Mean Relative Humidity, RH mean (%)	67	67	70	78	79	76	74	72	69	66	68	68
(3) Wind Speed, V (m/sec)	1.62	1.62	1.62	1.32	0.81	0.75	0.75	0.93	1.49	1.80	1.86	1.43
(4) Sunshine Hour, n (hr/day)	8.9	8.1	7.2	6.3	5.5	4.3	5.3	5.8	7.0	8.4	7.9	8.9
(5) Absolute Sunshine Hour, N (hr/day)	12.2	12.2	12.1	12.0	11.9	11.9	11.9	11.9	12.0	12.1	12.2	12.3
(6) Extra Terrestrial Radiation, Ra (mm/day)	15.4	15.8	15.7	15.0	14.0	13.3	13.6	14.4	15.2	15.5	15.4	15.2
2. Calculation												
(1) Vapour Pressure, (ea-ed)												
(i) ea at T mean (m bar)	31.3	32.1	32.1	30.0	27.6	25.4	24.9	25.1	26.9	29.6	30.8	31.5
(ii) ed = ea x RH mean/100 (m bar)	21.0	21.5	22.5	23.4	21.8	19.3	18.4	18.1	18.6	19.5	20.9	21.4
(iii) (ea-ed) (m bar)	10.3	10.6	9.6	6.6	5.8	6.1	6.5	7.0	8.3	10.1	9.9	10.1
(2) Wind Function, f(u)												
(i) Wind Speed, U (Km/day)	140	140	140	97	70	65	65	80	129	156	161	124
(ii) f(u) = 0.27 (1+U/100)	0.65	0.65	0.65	0.53	0.46	0.45	0.45	0.49	0.62	0.69	0.70	0.60
(3) Weighting Factor (W)												
(i) W at T mean	0.76	0.76	0.76	0.75	0.74	0.72	0.72	0.72	0.73	0.75	0.76	0.76
(ii) (1-W)	0.24	0.24	0.24	0.25	0.26	0.28	0.28	0.28	0.27	0.25	0.24	0.24
(4) Net Radiation (Rn)												
(i) n/N	0.73	0.66	0.60	0.53	0.46	0.36	0.45	0.49	0.58	0.69	0.65	0.72
(ii) (0.25+0.5·n/N)	0.62	0.58	0.55	0.52	0.48	0.43	0.48	0.50	0.54	0.60	0.58	0.61
(iii) Rs = (0.25+0.5·n/N)·Ra (mm/day)	9.5	9.2	8.6	7.8	6.7	5.7	6.5	7.2	8.2	9.3	8.9	9.3
(iv) Rns = 0.75·Rs (mm/day)	7.1	6.9	6.5	5.9	5.0	4.3	4.9	5.4	6.2	7.0	6.7	7.0
(v) Rnl = f(T mean)·f(ed)·f(n/N)	1.7	1.5	1.4	1.1	1.0	0.9	1.1	1.2	1.4	1.7	1.6	1.6
f(T mean)	15.6	15.7	15.7	15.4	15.1	14.9	14.8	14.8	15.1	15.4	15.5	15.6
f(ed)	0.14	0.13	0.13	0.12	0.13	0.14	0.15	0.15	0.15	0.14	0.14	0.13
f(n/N)	0.80	0.74	0.69	0.58	0.52	0.43	0.51	0.54	0.62	0.77	0.73	0.80
(vi) Rn = Rns-Rnl (mm/day)	5.4	5.4	5.1	4.8	4.0	3.4	3.8	4.2	4.8	5.3	5.1	5.4
(5) Adjustment Factor (C)	1.02	1.02	1.04	1.06	1.06	1.06	1.06	1.04	1.04	1.02	1.02	1.02
(6) Potential Evapotranspiration (mm/day) (ea-ed)·f(u)·(1-W) + W·Rn ·C	5.8	5.9	5.6	4.7	3.9	3.4	3.8	4.1	5.1	5.8	5.7	5.7

- Continued

Table IV-3 (3) POTENTIAL EVAPOTRANSPIRATION

at TPC Langasani
Altitude 701 m

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1. Data												
(1) Mean Temp., T mean (°C)	24.9	25.2	25.4	24.6	23.1	21.2	20.4	20.9	22.2	23.9	24.6	24.9
(2) Mean Relative Humidity, RH mean (%)	68	67	69	74	75	72	71	69	67	65	67	68
(3) Wind Speed, V (m/sec)	1.62	1.62	1.58	1.30	1.21	1.05	1.01	1.17	1.31	1.35	1.77	1.90
(4) Sunshine Hour, n (hr/day)	8.3	8.6	8.3	7.0	6.2	5.2	5.6	6.4	7.9	8.6	8.6	8.5
(5) Absolute Sunshine Hour, N (hr/day)	12.2	12.2	12.1	12.0	11.9	11.9	11.9	11.9	12.0	12.1	12.2	12.3
(6) Extra Terrestrial Radiation, Ra (mm/day)	15.4	15.8	15.7	15.0	14.0	13.3	13.6	14.4	15.2	15.5	15.4	15.2
2. Calculation												
(1) Vapour Pressure, (ea-ed)												
(i) ea at T mean (m bar)	31.5	32.1	32.5	30.9	28.3	25.2	24.0	24.8	26.7	29.6	30.9	31.5
(ii) ed = ea x RH mean/100 (m bar)	21.4	21.5	22.4	22.9	21.2	18.1	17.0	17.1	17.9	19.2	20.7	21.4
(iii) (ea-ed) (m bar)	10.1	10.6	10.1	8.0	7.1	7.1	7.0	7.7	8.8	10.4	10.2	10.1
(2) Wind Function, f(u)												
(i) Wind Speed, U (Km/day)	140	140	137	112	105	91	87	101	113	117	153	164
(ii) f(u) = 0.27 (1+U/100)	0.65	0.65	0.64	0.57	0.55	0.52	0.50	0.54	0.58	0.59	0.68	0.71
(3) Weighting Factor (W)												
(i) W at T mean	0.76	0.76	0.76	0.76	0.74	0.72	0.71	0.71	0.74	0.75	0.76	0.76
(ii) (1-W)	0.24	0.24	0.24	0.24	0.26	0.28	0.29	0.29	0.26	0.25	0.24	0.24
(4) Net Radiation (Rn)												
(i) n/N	0.68	0.70	0.69	0.58	0.52	0.44	0.47	0.54	0.66	0.71	0.70	0.69
(ii) (0.25+0.5·n/N)	0.59	0.60	0.60	0.54	0.51	0.47	0.49	0.52	0.58	0.61	0.60	0.60
(iii) Rs = (0.25+0.5·n/N)·Ra (mm/day)	9.1	9.5	9.4	8.1	7.1	6.3	6.7	7.5	8.8	9.5	9.2	9.1
(iv) Rns = 0.75·Rs (mm/day)	6.8	7.1	7.1	6.1	5.3	4.7	5.0	5.6	6.6	7.1	6.9	6.8
(v) Rnl = f(T mean)·f(ed)·f(n/N)	1.5	1.6	1.6	1.4	1.7	1.1	1.2	1.3	1.7	1.7	1.7	1.7
f(T mean)	15.6	15.7	15.8	15.6	15.2	14.8	14.7	14.8	15.0	15.4	15.6	15.6
f(ed)	0.13	0.13	0.13	0.13	0.13	0.15	0.16	0.15	0.15	0.14	0.14	0.14
f(n/N)	0.76	0.78	0.77	0.67	0.57	0.50	0.53	0.59	0.74	0.79	0.78	0.77
(vi) Rn = Rns-Rnl (mm/day)	5.3	5.5	5.5	4.7	4.2	3.6	3.8	4.3	4.9	5.4	5.2	5.1
(5) Adjustment Factor (C)	1.02	1.02	1.04	1.06	1.06	1.06	1.06	1.04	1.04	1.02	1.02	1.02
(6) Potential Evapotranspiration (mm/day) (ea-ed)·f(u)·(1-W) + W·Rn ·C	5.7	5.9	6.0	4.9	4.4	3.8	3.9	4.4	5.2	5.7	5.7	5.7

Table IV-4 (1)

AVERAGE CROP COEFFICIENT

1. Paddy

Rainy season paddy	Apr.		May		Jun.		July	
Dry season paddy	Oct.		Nov.		Dec.		Jan.	
1st half	1.05	1.10	1.15	1.22	1.27	1.25	1.15	-
2nd half	-	1.05	1.10	1.15	1.22	1.27	1.25	1.15
Average	1.05	1.08	1.13	1.19	1.25	1.26	1.20	1.15

2. Maize

Rainy season maize	Feb.		Mar.		Apr.		May		Jun.		July	
Dry season maize	Aug.		Sep.		Oct.		Nov.		Dec.		Jan.	
1st half	0.33	0.37	0.49	0.70	0.95	1.08	1.13	1.11	1.00	0.82	0.48	-
2nd half	-	0.33	0.37	0.49	0.70	0.95	1.08	1.13	1.11	1.00	0.82	0.48
Average	0.33	0.35	0.43	0.60	0.83	1.02	1.11	1.12	1.06	0.91	0.65	0.48

3. Cotton

	Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.	
1st half	0.33	0.35	0.39	0.46	0.58	0.70	0.85	0.98	1.08	1.13	1.15	1.14	1.12	-
2nd half	-	0.33	0.35	0.39	0.46	0.58	0.70	0.85	0.98	1.08	1.13	1.15	1.14	1.12
Average	0.33	0.34	0.37	0.43	0.52	0.64	0.78	0.92	1.03	1.11	1.14	1.15	1.13	1.12

- Continued

Table IV-4 (2)

AVERAGE CROP COEFFICIENT

4. Vegetables

Rainy season vegetables	Feb.		Mar.		Apr.		May		Jun.	
Dry season vegetables	Aug.		Sep.		Oct.		Nov.		Dec.	
Tomato, 1st half	0.30	0.39	0.56	0.83	1.05	1.15	1.11	0.93	0.62	-
2nd half	-	0.30	0.39	0.56	0.83	1.05	1.15	1.11	0.93	0.62
Average	0.30	0.35	0.48	0.70	0.94	1.10	1.13	1.02	0.78	0.62
Cabbage, 1st half	0.34	0.37	0.45	0.62	0.81	0.96	1.04	1.00	0.85	-
2nd half	-	0.34	0.37	0.45	0.62	0.81	0.96	1.04	1.00	0.85
Average	0.34	0.36	0.41	0.54	0.72	0.89	1.00	1.02	0.93	0.85
Onion, 1st half	0.33	0.50	0.88	1.01	1.03	1.02	0.96	0.88	0.78	-
2nd half	-	0.33	0.50	0.88	1.01	1.03	1.02	0.96	0.88	0.78
Average	0.33	0.42	0.69	0.95	1.02	1.03	0.99	0.92	0.83	0.78
Average	0.32	0.38	0.53	0.73	0.89	1.01	1.04	0.99	0.85	0.75

5. Soybeans

Rainy season soybeans	Mar.		Apr.		May		Jun.		Jul.	
Dry season soybeans	Aug.		Sep.		Oct.		Nov.		Dec.	
1st half	0.30	0.44	0.69	0.93	1.06	1.09	1.02	0.82	0.45	-
2nd half	-	0.30	0.44	0.69	0.93	1.06	1.09	1.02	0.82	0.45
Average	0.30	0.37	0.57	0.81	1.00	1.08	1.06	0.92	0.64	0.45

- Continued

Table IV-4 (3)

AVERAGE CROP COEFFICIENT

6. Pulses

	Aug.		Sep.		Oct.		Nov.		Dec.	
1st half	0.30	0.38	0.57	0.87	1.06	1.13	1.09	0.80	0.30	-
2nd half	-	0.30	0.38	0.57	0.87	1.06	1.13	1.09	0.80	0.30
Average	0.30	0.34	0.48	0.72	0.97	1.10	1.11	0.95	0.55	0.30

7. Banana

Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.
1.05	1.20	1.20	1.20	1.15	1.15	1.10	0.70	0.75	0.70	0.75	0.85

Table IV-4(1)

Table IV-5 (1)

CONSUMPTION OF WATER FOR EACH CROP

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
PETo	6.1	6.3	6.1	5.4	4.4	4.0	4.0	4.6	5.5	6.0	6.2	6.4

1. Paddy

	Dry season paddy				Rainy season paddy								Dry season paddy					
Kc	1.20	1.15			1.05	1.08	1.13	1.19	1.25	1.26	1.20	1.15	1.05	1.08	1.13	1.19	1.25	1.26
Cu	117	105			85	87	80	79	75	76	77	69	101	97	105	111	128	121

2. Maize

	Dry season maize						Rainy season maize								Dry season maize									
Kc	0.65	0.48	0.33	0.35	0.43	0.60	0.83	1.02	1.11	1.12	1.06	0.91	0.65	0.48	0.33	0.35	0.43	0.60	0.83	1.02	1.11	1.12	1.06	0.91
Cu	63	44	29	31	42	55	67	83	78	74	64	55	42	29	24	24	35	50	80	92	103	104	109	87

3. Cotton

Kc	0.33	0.34	0.37	0.43	0.52	0.64	0.78	0.92	1.03	1.11	1.14	1.15	1.13	1.12		
Cu	32	31	30	35	37	42	47	55	66	67	84	79	93	92		

4. Vegetables

	Rainy season vegetables										Dry season vegetables									
Kc	0.32	0.38	0.53	0.73	0.89	1.01	1.04	0.99	0.85	0.75	0.32	0.38	0.53	0.73	0.89	1.01	1.04	0.99	0.85	0.75
Cu	28	37	48	59	72	71	69	59	51	48	24	28	44	60	85	91	97	92	87	72

- Continued

Table IV-5 (2)

CONSUMPTION OF WATER FOR EACH CROP

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
PETo	6.1	6.3	6.1	5.4	4.4	4.0	4.0	4.6	5.5	6.0	6.2	6.4

5. Soybeans

	Rainy season soybeans										Dry season soybeans									
Kc	0.30	0.37	0.57	0.81	1.00	1.08	1.06	0.92	0.64	0.45	0.30	0.37	0.57	0.81	1.00	1.08	1.06	0.92	0.64	0.45
Cu	29	34	46	66	70	71	64	55	41	27	22	27	47	67	96	97	99	86	66	43

6. Pulses

	Rainy season pulses										Dry season pulses									
Kc	0.30	0.34	0.48	0.72	0.97	1.10	1.11	0.95	0.55	0.30	0.30	0.34	0.48	0.72	0.97	1.10	1.11	0.15	0.55	0.30
Cu	29	31	39	58	68	73	67	57	55	18	22	23	40	59	93	99	103	88	56	29

7. Banana

Kc	1.05	1.20	1.20	1.20	1.15	1.15	1.10	0.70	0.75	0.70	0.75	0.85
Cu*	199	212	227	194	157	138	136	100	124	130	140	169

Note: PETo: Potential Evapotranspiration at Miwaleni estimated by modified Penman method (mm/day)
Kc : Crop Coefficient
Cu : Consumption of water by crop (mm/half month)
Cu*: " (mm/month)

Talbe IV-6 PUDDLING WATER REQUIREMENTS

PHASE	PERIOD (day)	PUDDLING AREA	PUDDLING WATER (mm)	PLANTED AREA
First Month	10	1/6	30	
	20	1/6	30	1/6
Second	30	1/6	30	2/6
Month	40	1/6	30	3/6
	50	1/6	30	4/6
Third	60	1/6	30	5/6
Month	65	-	-	6/6
Total			180 mm	

Table IV-7 NURSERY WATER REQUIREMENTS

PHASE	PERIOD (day)	PUDDLING WATER (mm)	WATER DEMAND			TOTAL	
			Crop Index	Consumptive Use (mm)	Percolation (mm)	Total (mm)	Weighted Average (5%) (mm)
First	5	30	0	-	-	30	
Half	10	30	1/6	6	2	38	
Month	15	30	2/6	12	3	45	6
Second	20	30	3/6	18	5	53	
Half	25	30	4/6	23	7	60	
Month	30	30	5/6	29	8	67	9
Third	35	-	5/6	29	8	37	
Half	40	-	4/6	23	7	30	
Month	45	-	3/6	18	5	23	5
Forth	50	-	2/6	12	3	15	
Half	55	-	1/6	6	2	8	
Month	60	-	-	-	-	-	1
Total		180		176	50	406	21

Table IV-8 (1) EFFECTIVE RAINFALL: MOSHI STATION

Unit: mm/month

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Jan	117	0	26	10	0	65	17	6	0	0
Feb	6	6	0	103	62	0	28	12	72	39
Mar	108	12	10	139	70	39	82	16	111	14
Apr	106	104	77	110	144	47	138	91	148	41
May	71	28	29	38	60	45	96	168	129	94
Jun	33	0	4	42	0	0	24	10	73	30
Jul	0	60	7	16	0	0	6	36	9	6
Aug	0	0	12	0	0	0	0	34	17	32
Sept	0	37	0	8	15	0	0	30	10	0
Oct	27	78	8	0	29	28	0	126	27	36
Nov	8	162	66	126	9	42	6	42	44	51
Dec	0	133	47	73	15	8	34	0	58	0
Total	476	620	286	665	404	274	431	571	698	343

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Jan	80	37	6	38	31	24	0	0	18	48
Feb	24	0	41	26	0	12	24	22	42	35
Mar	132	53	78	0	34	42	120	53	126	93
Apr	150	115	126	86	186	120	66	150	146	123
May	84	88	129	33	22	51	79	88	95	126
Jun	0	35	0	4	63	0	30	4	12	40
Jul	0	19	20	0	0	21	0	0	0	66
Aug	22	0	4	0	0	0	0	8	0	0
Sept	0	0	29	0	0	63	5	7	0	13
Oct	0	0	46	0	0	0	0	66	0	0
Nov	0	11	123	37	24	10	10	58	63	18
Dec	31	96	10	34	8	0	36	0	27	21
Total	523	454	612	258	368	343	370	456	529	583

- Continued

Table IV-8 (2) EFFECTIVE RAINFALL: MIWALENI STATION

Unit: mm/month

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Jan	114	0	26	10	0	65	17	6	0	0
Feb	6	6	0	99	61	0	27	12	69	39
Mar	105	12	10	133	69	39	80	15	107	14
Apr	103	99	77	106	140	47	135	88	141	41
May	69	27	29	37	59	45	94	160	124	91
Jun	32	0	4	40	0	0	23	10	70	30
Jul	0	58	7	15	0	0	6	35	9	6
Aug	0	0	12	0	0	0	0	33	16	32
Sept	0	36	0	8	15	0	0	29	10	0
Oct	26	75	8	0	28	28	0	122	26	36
Nov	8	156	66	121	9	42	6	41	42	50
Dec	0	128	47	70	15	8	33	0	56	0
Total	(463)	(597)	(286)	(639)	(396)	(274)	(421)	(551)	(670)	(339)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Jan	78	36	9	110	0	10	8	34	63	54
Feb	23	0	73	11	0	24	12	53	20	49
Mar	128	52	95	0	28	30	61	6	174	72
Apr	146	111	83	100	170	96	89	124	141	107
May	81	86	168	41	32	32	106	60	50	71
Jun	0	34	0	14	44	0	23	6	7	19
Jul	0	19	0	0	11	8	0	0	0	41
Aug	21	0	0	0	0	0	0	21	0	0
Sept	0	0	52	0	0	56	5	0	0	7
Oct	0	0	89	0	0	0	0	37	0	0
Nov	0	11	62	33	11	35	8	27	34	44
Dec	30	94	37	37	16	0	10	111	47	17
Total	(507)	(443)	668	346	312	291	322	479	536	481

Note: Figures for 1960 to 1971 are estimated based on correlation of effective rainfall between Miwaleni and Moshi stations for 1972 to 1979.

- Continued

Table IV-8 (3) EFFECTIVE RAINFALL: KAKE NAFCO

Unit: mm/month

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Jan	87	0	16	8	0	39	12	0	0	8
Feb	4	5	0	81	44	0	20	28	62	44
Mar	80	9	7	110	50	24	59	0	183	52
Apr	79	81	51	87	101	29	101	153	147	0
May	53	22	18	30	43	27	69	149	128	25
Jun	24	0	0	33	0	0	17	0	13	4
Jul	0	47	4	13	0	0	4	31	0	0
Aug	0	0	7	0	0	0	0	15	0	13
Sept	0	29	0	6	11	0	0	19	10	0
Oct	20	61	5	0	21	17	0	32	11	19
Nov	6	127	41	100	6	26	4	0	50	36
Dec	0	104	29	58	11	5	25	17	78	0
Total	(353)	(485)	(178)	(526)	(287)	(167)	(311)	444	682	201

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Jan	54	60	6	64	0	28	12	24	36	10
Feb	8	0	59	21	0	0	9	49	56	8
Mar	100	21	34	0	19	8	70	7	161	58
Apr	70	120	95	70	123	29	117	144	86	87
May	8	67	122	12	30	31	72	36	34	92
Jun	0	54	0	13	23	0	6	0	0	34
Jul	0	0	0	0	0	6	0	0	0	0
Aug	0	0	0	0	0	0	9	9	0	0
Sept	11	0	25	0	0	36	24	8	0	0
Oct	0	0	25	13	0	0	0	28	0	0
Nov	0	0	74	20	0	7	6	7	15	11
Dec	55	27	15	0	19	42	0	69	59	7
Total	306	349	455	213	214	187	325	381	447	307

Note: Figures for 1960 to 1971 are estimated based on correlation of rainfall between Kake NAFCO and Arusha Chini Stations for 1967 to 1979.

- Continued

Table IV-8 (4) EFFECTIVE RAINFALL: HIMO SISAL ESTATE

Unit: mm/month

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Jan	36	0	103	89	0	28	0	0	0	0
Feb	18	66	21	43	7	30	74	52	0	113
Mar	93	90	16	112	101	23	113	22	118	28
Apr	118	115	63	70	118	55	113	118	118	53
May	51	43	57	79	38	44	22	99	71	0
Jun	0	0	9	34	0	0	36	0	0	0
Jul	0	47	4	8	0	0	0	24	0	0
Aug	0	0	0	0	0	0	5	61	45	27
Sept	0	31	0	0	0	5	0	61	0	0
Oct	21	90	34	0	12	83	0	0	0	22
Nov	9	118	66	115	44	96	8	118	69	28
Dec	0	116	84	48	93	53	34	52	9	0
Total	(346)	(676)	(462)	(590)	(413)	(417)	(405)	(607)	(430)	(271)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Jan	47	80	70	92	0	6	66	68	(63)	22
Feb	26	0	80	29	0	8	120	60	(20)	113
Mar	118	42	123	0	6	20	102	114	(174)	78
Apr	118	92	55	67	136	35	158	140	(141)	93
May	49	110	122	68	68	0	78	59	(50)	80
Jun	0	71	28	27	37	26	18	18	(7)	14
Jul	0	8	19	0	44	18	6	0	(0)	7
Aug	0	17	24	0	0	50	0	42	(0)	38
Sept	8	0	36	0	0	10	17	0	(0)	9
Oct	0	27	32	0	18	17	27	37	(0)	0
Nov	66	24	144	35	0	30	104	102	(34)	0
Dec	85	83	61	0	0	36	31	70	(47)	126
Total	(517)	554	794	318	309	256	727	710	(536)	580

Table IV-9 PROBABLE EFFECTIVE RAINFALL

Unit: mm/month

DEPENDABILITY/1	MIWALENI STATION			HIMO SISAL ESTATE		
	95%	90%	80%	95%	90%	80%
Jan	0	0	0	0	0	0
Feb	0	0	6	0	0	8
Mar	0	10	14	6	16	22
Apr	47	77	88	53	55	63
May	29	32	41	0	22	43
Jun	0	0	0	0	0	0
Jul	0	0	0	0	0	0
Aug	0	0	0	0	0	0
Sept	0	0	0	0	0	0
Oct	0	0	0	0	0	0
Nov	0	8	9	0	8	24
Dec	0	0	8	0	0	9

DEPENDABILITY/1	KAHE NAFCO			MOSHI		
	95%	90%	80%	95%	90%	80%
Jan	0	0	6	0	0	0
Feb	0	0	0	0	0	6
Mar	0	7	8	10	12	16
Apr	29	29	70	47	66	86
May	12	18	25	28	29	38
Jun	0	0	0	0	0	0
Jul	0	0	0	0	0	0
Aug	0	0	0	0	0	0
Sept	0	0	0	0	0	0
Oct	0	0	0	0	0	0
Nov	0	0	4	6	8	10
Dec	0	0	5	0	0	0

Note: /1: Dependability is estimated from figures in Table V-8.

95% : 19 years out of 20 years
90% : 18 years out of 20 years
80% : 16 years out of 20 years

Table IV-10 (1)

IRRIGATION WATER REQUIREMENTS OF EACH CROP

Rainfall: Miwaleni Station

(1)	Paddy		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
					Wet Season Paddy						Dry Season Paddy			
1.	CU	(mm/M)	222	-		172	159	151	146	-		198	216	249
2.	P	(mm/M)	62			30	31	30	31			62	60	62
3.	ER_{80}	(mm/M)	0	6	14	88	41	0	0	0	0	0	9	8
4.	NWD	(mm/M)	284	-	0	114	149	181	177	-	0	260	267	303
5.	CI		1/2		1/20	1/2	1	1	1/2		1/20	1/2	1	1
6.	NW	(mm)			15	6					15	6		
7.	PW	(mm)			30	150					30	150		
8.	NR	(mm/M)	142		45	213	149	181	89		45	286	267	303
9.	GR	(mm/M)	232		74	348	243	296	145		74	467	436	495
		(ℓ/s/ha)	0.87		0.28	1.34	0.91	1.14	0.54		0.28	1.74	1.68	1.85

Note:
- CU: Consumption of water
- P: Percolation
- ER_{80}: Effective rainfall with 80% dependability at Miwaleni station
- NWD: Net water deficit, (CU + P - ER_{80})
- CI: Crop index
- NW: Nursery water
- PW: Puddling water
- NR: Net requirement, (NWD x CI + NW + PW)
- GR: Gross requirement, using overall irrigation efficiency of 0.61

- Continued

Table IV-10 (2) IRRIGATION WATER REQUIREMENTS OF EACH CROP

Rainfall: Miwaleni Station

(2)	Pulses		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
					Wet Season Pulses					Dry Season Pulses				
1.	CU	(mm/M)	-	-	60	97	141	124	53	45	99	192	191	85
2.	ER80	(mm/M)	0	6	14	88	41	0	0	0	0	0	9	8
3.	NWD	(mm/M)			46	9	100	124	53	45	99	192	182	77
4.	CI				1/2	1	1	1	1/2	1/2	1	1	1	1/2
5.	PI	(mm)			60					60				
6.	NR	(mm/M)			83	9	100	124	27	83	99	192	182	39
7.	GR	(mm/M)			166	18	200	248	54	166	198	384	364	78
		(ℓ/s/ha)			0.62	0.07	0.75	0.96	0.20	0.62	0.76	1.43	1.40	0.29

Note: Abbreviations for all calculations of upland crops are as follows:

CU: Consumption of water
ER80: Effective rainfall with 80% dependability at Miwaleni station
NWD: Net water deficit, (CU - ER80)
CI: Crop index
PI: Pre-irrigation
NR: Net requirement, (NWD x CI + PI)
GR: Gross requirement, using overall irrigation efficiency of 0.50

- Continued

Table IV-10 (3)

IRRIGATION WATER REQUIREMENTS OF EACH CROP

Rainfall: Miwaleni Station

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
(3)	Maize					Wet Season Maize						Dry Season Maize		
1.	CU	(mm/M)	107	60	97	150	152	119	71	48	85	172	207	196
2.	ER_{80}	(mm/M)	0	6	14	88	41	0	0	0	0	0	9	8
3.	NWD	(mm/M)	107	54	83	62	111	119	71	48	85	172	198	188
4.	CI		1/2	1/2	1	1	1	1	1/2	1/2	1	1	1	1
5.	PI	(mm)		60						60				
6.	NR	(mm/M)	54	87	83	62	111	119	36	84	85	172	198	188
7.	GR	(mm/M)	108	174	166	124	222	238	72	168	170	344	396	376
		(ℓ/s/ha)	0.40	0.72	0.62	0.48	0.83	0.92	0.27	0.63	0.66	1.28	1.53	1.40

(4)	Cotton							Cotton						
1.	CU	(mm/M)	-	-	63	65	79	102	133	163	185	-	-	-
2.	ER_{80}	(mm/M)	0	6	14	88	41	0	0	0	0	0	9	8
3.	NWD	(mm/M)			49	0	38	102	133	163	185			
4.	CI				1/2	1	1	1	1	1	1/2			
5.	PI	(mm)			60									
6.	NR	(mm/M)			85	0	38	102	133	163	93			
7.	GR	(mm/M)			170	0	76	204	266	326	186			
		(ℓ/s/ha)			0.63	0	0.28	0.79	0.99	1.22	0.72			

- Continued

Table IV-10 (4) IRRIGATION WATER REQUIREMENTS OF EACH CROP

Rainfall: Miwaleni Station

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
(5)	Vegetables			Wet Season Vegetables						Dry Season Vegetables				
1.	CU	(mm/M)		28	85	131	140	110	48	52	104	176	189	159
2.	ER_{80}	(mm/M)	0	6	14	88	41	0	0	0	0	0	9	8
3.	NWD	(mm/M)		22	71	43	99	110	48	52	104	176	180	151
4.	CI			1/4	3/4	1	1	3/4	1/4	1/2	1	1	1	1/2
5.	PI	(mm)		30	30					60				
6.	NR	(mm/M)		36	83	43	99	83	12	86	104	176	189	80
7.	GR	(mm/M)		72	166	86	198	166	24	172	208	352	378	160
		(ℓ/s/ha)		0.60	0.64	0.33	0.74	0.64	0.19	0.64	0.80	1.31	1.46	0.60
(6)	Soybeans				Wet Season Soybean					Dry Season Soybean				
1.	CU	(mm/M)	-	-	63	112	141	119	68	49	114	193	185	109
2.	ER_{80}	(mm/M)			14	88	41	0	0	0	0	0	9	8
3.	NWD	(mm/M)			49	24	100	119	68	49	114	193	176	101
4.	CI				0.5	1	1	1	0.5	0.5	1	1	1	0.5
5.	PI	(mm)			60	-	-	-	-	60	-	-	-	-
6.	NR	(mm/M)			85	24	100	119	34	85	114	193	176	51
7.	GR	(mm/M)			170	48	200	238	68	170	228	386	352	102
		(ℓ/s/ha)			0.63	0.19	0.75	0.92	0.25	0.63	0.88	1.44	1.36	0.38

- Continued

Table IV-10 (5)

IRRIGATION WATER REQUIREMENTS OF EACH CROP

Rainfall: Miwaleni Station

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
(7)	Banana								Banana					
1.	CU	(mm/M)	198	211	227	194	156	138	136	100	124	130	140	168
2.	ER_{80}	(mm/M)	0	6	14	88	41	0	0	0	0	0	9	8
3.	NR	(mm/M)	198	205	213	106	115	138	136	100	124	130	131	160
4.	GR	(mm/M)	396	410	426	212	230	276	272	200	248	260	262	320
		(ℓ/s/ha)	1.43	1.96	1.54	0.82	0.83	1.06	0.98	0.72	0.96	0.94	1.01	1.16

- Continued

Table IV-10 (6)

IRRIGATION WATER REQUIREMENTS OF EACH CROP

Rainfall: Kahe NAFCO

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
(1)	Paddy					Wet Season Paddy						Dry Season Paddy		
1.	CU	(mm/M)	222			172	159	151	146			198	216	249
2.	P	(mm/M)	62			30	31	30	31			62	60	62
3.	ER_{80}	(mm/M)	6	0	8	70	25	0	0	0	0	0	4	5
4.	NWD	(mm/M)	278		0	132	165	181	177		0	260	272	306
5.	CI		1/2		1/20	1/2	1	1	1/2		1/20	1/2	1	1
6.	NW	(mm)			15	6					15	6		
7.	PW	(mm)			30	150					30	150		
8.	NR	(mm/M)	139		45	222	165	181	89		45	286	272	306
9.	GR	(mm/M)	227		74	363	270	296	145		74	467	444	500
		(ℓ/s/ha)	0.85		0.28	1.40	1.01	1.14	0.54		0.29	1.74	1.71	1.87

(2)	Banana		Banana											
1.	CU	(mm/M)	198	211	227	194	156	138	136	100	124	130	140	168
2.	ER_{80}	(mm/M)	6	0	8	70	25	0	0	0	0	0	4	5
3.	NR	(mm/M)	192	211	219	124	131	138	136	100	124	130	136	163
4.	GR	(mm/M)	384	422	438	248	262	276	272	200	248	260	272	326
		(ℓ/s/ha)	1.43	1.74	1.64	0.96	0.98	1.06	1.02	0.75	0.96	0.97	1.05	1.22

Note: ER_{80}: Effective rainfall with 80% dependability at Kahe NAFCO.
Other abbreviations, refer to Table IV-10(1).

- Continued

Table IV-10 (7)

IRRIGATION WATER REQUIREMENTS OF EACH CROP

Rainfall: Himo Sisal Estate

(1)	Paddy		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
			Wet Season Paddy								Dry Season Paddy			
1.	CU	(mm/M)	222			172	159	151	146			198	216	249
2.	P	(mm/M)	62			30	31	30	31			62	60	62
3.	ER_{80}	(mm/M)	0	8	22	63	43	0	0	0	0	0	24	9
4.	NWD	(mm/M)	160		0	139	147	181	177		0	260	252	302
5.	CI		1/2		1/20	1/2	1	1	1/2		1/20	1/2	1	1
6.	NW	(mm)			15	6					15	6		
7.	PW	(mm)			30	150					30	150		
8.	NR	(mm/M)	80		45	226	147	181	89		45	286	252	302
9.	GR	(mm/M)	131		74	369	240	296	145		74	467	412	493
		(ℓ/s/ha)	0.49		0.28	1.42	0.90	1.14	0.54		0.29	1.74	1.59	1.84

Note: ER_{80}: Effective rainfall with 80% dependability at Himo Sisal Estate

- Continued

Table IV-10 (8)

IRRIGATION WATER REQUIREMENTS OF EACH CROP

Rainfall: Himo Sisal Estate

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
(2)	Pulses				Wet Season Pulses					Dry Season Pulses				
1.	CU	(mm/M)			60	97	141	124	53	45	99	192	191	85
2.	ER_{80}	(mm/M)	0	8	22	63	43	0	0	0	0	0	24	9
3.	NWD	(mm/M)			38	34	98	124	53	45	99	192	167	76
4.	CI				1/2	1	1	1	1/2	1/2	1	1	1	1/2
5.	PI	(mm)			60					60				
6.	NR	(mm/M)			79	34	98	124	27	83	99	192	167	38
7.	GR	(mm/M)			158	68	196	248	54	166	198	384	134	76
		(ℓ/s/ha)			0.59	0.26	0.73	0.96	0.20	0.62	0.76	1.43	0.52	0.28

(3)	Maize			Wet Season Maize						Dry Season Maize				
1.	CU	(mm/M)	107	60	97	150	152	119	71	48	85	172	207	196
2.	ER_{80}	(mm/M)	0	8	22	63	43	0	0	0	0	0	24	9
3.	NWD	(mm/M)	107	52	75	87	109	119	71	48	85	172	183	187
4.	CI		1/2	1/2	1	1	1	1	1/2	1/2	1	1	1	1
5.	PI	(mm)		60						60				
6.	NR	(mm/M)	54	86	75	87	109	119	36	84	85	172	183	187
7.	GR	(mm/M)	108	172	150	174	218	238	72	168	170	344	266	374
		(ℓ/s/ha)	0.40	0.71	0.56	0.67	0.81	0.92	0.27	0.63	0.66	1.28	1.03	1.40

- Continued

Table IV-10 (9) IRRIGATION WATER REQUIREMENTS OF EACH CROP

Rainfall: Himo Sisal Estate

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
(4)	Cotton				Cotton									
1.	CU	(mm/M)			63	65	79	102	133	163	185	-	-	-
2.	ER_{80}	(mm/M)	0	8	22	63	43	0	0	0	0	0	24	9
3.	NWD	(mm/M)			41	2	36	102	133	163	185	-	-	-
4.	CI				1/2	1	1	1	1	1	1/2			
5.	PI	(mm)			60									
6.	NR	(mm/M)			81	2	36	102	133	163	93			
7.	GR	(mm/M)			162	4	72	204	266	226	186			
		(ℓ/s/ha)			0.60	0.02	0.27	0.79	0.99	0.84	0.72			

					Wet Season Vegetables						Dry Season Vegetables					
(5)	Vegetables															
1.	CU	(mm/M)		28	85	131	140	110	48	52	104	176	189	159		
2.	ER_{80}	(mm/M)	0	8	22	63	43	0	0	0	0	0	24	9		
3.	NWD	(mm/M)		20	63	68	97	110	48	52	104	176	165	150		
4.	CI			1/4	3/4	1	1	3/4	1/4	1/2	1	1	1	1/2		
5.	PI	(mm)		30	30					60						
6.	NR	(mm/M)		35	77	68	97	83	12	86	104	176	165	75		
7.	GR	(mm/M)		70	154	136	194	166	24	172	208	352	330	150		
		(ℓ/s/ha)		0.58	0.57	0.52	0.72	0.64	0.18	0.64	0.80	1.31	1.27	0.56		

- Continued

Table IV-10 (10)

IRRIGATION WATER REQUIREMENTS OF EACH CROP

Rainfall: Himo Sisal Estate

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
(6)	Soybeans				Wet Season Soybean					Dry Season Soybean				
1.	CU	(mm/M)			63	112	141	119	68	49	114	193	185	109
2.	ER_{80}	(mm/M)	0	0	22	63	43	0	0	0	0	0	24	9
3.	NWD	(mm/M)			41	49	98	119	68	49	114	193	161	100
4.	CI				0.5	1	1	1	0.5	0.5	1	1	1	0.5
5.	PI	(mm)			60					60				
6.	NR	(mm/M)			81	49	98	119	34	85	114	193	161	50
7.	GR	(mm/M)			162	98	196	238	68	170	228	386	322	100
		(ℓ/s/ha)			0.60	0.38	0.73	0.92	0.25	0.63	0.88	1.44	1.24	0.37
(7)	Banana				Banana									
1.	CU	(mm/M)	198	211	227	194	156	138	136	100	124	130	140	168
2.	ER_{80}	(mm/M)	0	8	22	63	43	0	0	0	0	0	24	9
3.	NR	(mm/M)	198	203	205	131	113	138	136	100	124	130	116	159
4.	GR	(mm/M)	396	406	410	262	226	276	272	200	248	260	232	318
		(ℓ/s/ha)	1.48	1.68	1.53	1.01	0.84	1.06	1.02	0.75	0.96	0.97	0.90	1.19

Table IV-11 DIVERSION WATER REQUIREMENTS - RAU RIVER SYSTEM

	UPPER MABOGINI SCHEME				MOBOGINI SCHEME							
	Paddy				Paddy			Sugar Cone		Banana		
		DR				DR						
	UVR	WS	DS	Total	UVR	WS	DS	UVR[1]	DR	UVR	DR	Total (m^3/sec)
Cropping Area (ha)	-	150	50	-	-	750	250	-	70	-	30	-
F	-	-		-	-	-		1.0	0.07	1.96	0.06	0.13
M	0.28	0.04		0.04	0.28	0.21		1.0	0.07	1.54	0.05	0.33
A	1.34	0.20		0.20	1.34	1.01		0.7	0.05	0.82	0.02	1.08
M	0.91	0.14		0.14	0.91	0.68		0.7	0.05	0.83	0.02	0.75
J	1.14	0.17		0.17	1.14	0.86		0.7	0.05	1.06	0.03	0.94
J	0.54	0.08		0.08	0.54	0.41		0.7	0.05	0.98	0.03	0.49
A	-		-	-	-		-	0.7	0.05	0.72	0.02	0.07
S	0.28		0.01	0.01	0.28		0.07	0.7	0.05	0.96	0.03	0.15
O	1.74		0.09	0.09	1.74		0.44	0.7	0.05	0.94	0.03	0.52
N	1.68		0.08	0.08	1.68		0.42	1.0	0.07	1.01	0.03	0.52
D	1.85		0.09	0.09	1.85		0.46	1.0	0.07	1.16	0.03	0.56
J	0.87		0.04	0.04	0.87		0.22	1.0	0.07	1.43	0.04	0.33

	RAU YA KATI SCHEME						CHEKERENI SCHEME						
	Paddy			Banana			Paddy			Banana		Pilot Farm	
		DR						DR					
	UVR	WS	DS	UVR	DR	Total	UVR	WS	DS	UVR	DR	DR[2]	Total (m^3/sec)
Cropping Area (ha)	-	400	130	-	50	-	-	700	220	-	70	80	
F	-	-		1.96	0.10	0.10	-	-		1.74	0.12	0.01	0.13
M	0.28	0.11		1.54	0.08	0.19	0.28	0.20		1.64	0.11	0.02	0.33
A	1.34	0.54		0.82	0.04	0.58	1.40	0.98		0.96	0.07	0.06	1.11
M	0.91	0.36		0.83	0.04	0.40	1.01	0.71		0.98	0.07	0.08	0.86
J	1.14	0.46		1.06	0.05	0.51	1.14	0.80		1.06	0.07	0.08	0.95
J	0.54	0.22		0.98	0.05	0.27	0.54	0.38		1.02	0.07	0.04	0.49
A	-		-	0.72	0.04	0.04	-		-	0.75	0.05	0.02	0.07
S	0.28		0.04	0.96	0.05	0.09	0.29		0.06	0.96	0.07	0.03	0.17
O	1.74		0.23	0.94	0.05	0.28	1.74		0.38	0.97	0.07	0.08	0.53
N	1.68		0.22	1.01	0.05	0.27	1.71		0.38	1.05	0.07	0.10	0.55
D	1.85		0.24	1.16	0.06	0.30	1.87		0.41	1.22	0.09	0.10	0.60
J	0.87		0.11	1.43	0.07	0.18	0.85		0.19	1.43	0.10	0.05	0.34

Note: UVR: Unit water requirement (l/sec/ha)
DR: Diversion water requirement (m^3/sec)
WS: Wet season
DS: Dry season

1/ Refer to Table-6 "Continuous Monthly Discharge for 4,000 Acres of Sugar Cone", SURVEY AND PLAN FOR IRRIGATION DEVELOPMENT IN THE PANGANI AND WAMI RIVER BASINS, IRRIGATION AND POWER DEVELOPMENT, FAO, 1968

2/ Refer to THE IMPLEMENTATION DESIGN REPORT ON THE KILIMANJARO AGRICULTURAL DEVELOPMENT PROJECT IN THE UNITED REPUBLIC OF TANZANIA, JICA, 1980

Table IV-12 DIVERSION REQUIREMENTS - HIMO RIVER SYSTEM

MAKUYUNI SCHEME

	Oil Seeds			Pulses		Maize		Cotton		Vegetable			Banana		
	UWR	DR WS	DR DS	UWR	DR WS	UWR	DR WS	UWR	DR WS	UWR	DR WS	DR DS	UWR	DR	Total (ℓ/sec)
Cropping Area (ha)	-	150	130	-	100	-	120	-	100	-	10	10	-	10	-
F	-			-	-	0.78	85	-		0.58	6		1.68	17	108
M	0.60	90		0.59	59	0.56	67	0.60	60	0.57	6		1.53	15	297
A	0.38	57		0.26	26	0.67	80	0.02	2	0.52	5		1.01	10	180
M	0.73	110		0.73	73	0.81	97	0.27	27	0.72	7		0.84	8	322
J	0.92	138		0.96	96	0.92	110	0.79	79	0.64	6		1.06	11	440
J	0.25	38		0.20	20	0.27	32	0.99	99	0.18	2		1.02	10	201
A	0.63		82					0.84	84	0.64		6	0.75	8	180
S	0.88		114					0.72	72	0.80		8	0.96	10	204
O	1.44		187							1.31		13	0.97	10	210
N	1.24		161							1.27		13	0.90	9	183
D	0.37		48							0.56		6	1.19	12	66
J	-									-		-	1.48	15	15

GHONA & KILEO SCHEME

	Paddy		Oil Seeds			Pulses		Maize		Cotton		Vegetable			Banana		
	UWR	DR WS	UWR	DR WS	DR DS	UWR	DR WS	UWR	DR WS	UWR	DR	UWR	DR WS	DR DS	UWR	DR	Total (ℓ/sec)
Cropping Area (ha)	-	150	-	100	120	-	70	-	80	-	70	-	20	20	-	10	
F	-		-			-		0.73	57	-		0.58	12		1.68	17	86
M	0.28	42	0.60	60		0.59	41	0.56	45	0.60	42	0.57	11		1.53	15	256
A	1.42	213	0.38	38		0.26	18	0.67	54	0.02	1	0.52	10		1.01	10	344
M	0.90	135	0.73	73		0.73	51	0.81	65	0.27	19	0.72	14		0.84	8	365
J	1.14	171	0.92	92		0.96	67	0.92	74	0.79	55	0.64	13		1.06	11	483
J	0.54	81	0.25	25		0.20	14	0.27	22	0.99	69	0.18	4		1.02	10	225
A			0.63		76					0.84	59	0.64		13	0.75	8	156
S			0.88		106					0.72	50	0.80		16	0.96	10	182
O			1.44		173							1.31		16	0.97	10	199
N			1.24		149							1.27		25	0.90	9	183
D			0.37		44							0.56		11	1.19	12	67
J			-									-			1.48	15	15

Note: UWR: Unit water requirement (ℓ/sec/ha)
DR: Diversion water requirement (ℓ/sec)
WS: Wet season crop
DS: Dry season crop

Table IV-13 DIVERSION WATER REQUIREMENTS - MIVALENI PUMP LIFT SCHEME AND GROUNDWATER SCHEME

MIVALENI SCHEME

	Paddy			Oil Seeds		Pulses		Maize		Cotton		Vegetable			Total
		DR			DR		DR		DR		DR		DR		
	UVR	WS	DS	UVR	WS	UVR	WS	UVR	WS	UVR	WS	UVR	WS	DS	(m^3/sec)
Cropping Area (ha)	-	900	470	-	320	-	220	-	280	-	220		60	60	
F	-			-		-		0.72	0.20	-	-	0.60	0.04		0.24
M	0.28	0.25		0.63	0.20	0.62	0.14	0.62	0.17	0.63	0.14	0.64	0.04		0.94
A	1.34	1.21		0.19	0.06	0.07	0.02	0.48	0.13	0	0	0.33	0.02		1.44
M	0.91	0.82		0.75	0.24	0.75	0.17	0.83	0.23	0.28	0.06	0.74	0.04		1.56
J	1.14	1.03		0.92	0.29	0.96	0.21	0.92	0.26	0.79	0.17	0.64	0.04		2.00
J	0.54	0.49		0.25	0.08	0.20	0.04	0.27	0.08	0.99	0.22	0.19	0.01		0.92
A	-									1.22	0.27	0.64		0.04	0.31
S	0.28		0.13							0.72	0.16	0.80		0.05	0.34
O	1.74		0.82									1.31		0.08	0.90
N	1.68		0.79									1.46		0.09	0.88
D	1.85		0.87									0.60		0.04	0.91
J	0.87		0.41									-			0.41

NORTH GROUND WATER SCHEME (14 NOS.)

	Oil Seeds			Pulses		Maize		Cotton		Vegetable			Total
		DR			DR		DR		DR		DR		
	UVR	WS	DS	UVR	WS	UVR	WS	UVR	WS	UVR	WS	DS	(ℓ/sec)
Cropping Area (ha)	-	18	35	-	12	-	15	-	12	-	3	3	
F	-	-		-	-	0.72	10.8	-	-	0.60	1.8		12.6
M	0.63	11.3		0.62	7.4	0.62	9.3	0.63	7.6	0.64	1.9		37.5
A	0.19	3.4		0.07	0.8	0.48	7.2	0	0	0.33	1.0		12.4
M	0.75	13.5		0.75	9.0	0.83	12.5	0.28	3.4	0.74	2.2		40.6
J	0.92	16.6		0.96	11.5	0.92	13.8	0.79	9.5	0.64	1.9		53.3
J	0.25	4.5		0.20	2.4	0.27	4.1	0.99	11.9	0.19	0.6		23.5
A	0.63		22.1					1.22	14.6	0.64		1.9	38.6
S	0.88		30.8					0.72	8.6	0.80		2.4	41.8
O	1.44		50.4							1.31		3.9	54.3
N	1.36		47.6							1.46		4.4	52.0
D	0.38		13.3							0.60		1.8	15.1
J	-		-							-		-	-

EAST GROUND WATER SCHEME (6 NOS.)

	Oil Seeds			Pulses		Maize		Cotton		Vegetable			Total
		DR			DR		DR		DR		DR		
	UVR	WS	DS	UVR	WS	UVR	WS	UVR		UVR	WS	DS	(ℓ/sec)
Cropping Area (ha)	-	8	18	-	6	-	8	-	6	-	2	2	
F	-	-		-	-	0.72	5.8	-	-	0.60	1.2		7.0
M	0.63	5.0		0.62	3.7	0.62	5.0	0.63	3.8	0.64	1.3		18.8
A	0.19	1.5		0.07	0.4	0.48	3.8	0	0	0.33	0.7		6.4
M	0.75	6.0		0.75	4.5	0.83	6.6	0.28	1.7	0.74	1.5		20.3
J	0.92	7.4		0.96	5.8	0.92	7.4	0.79	4.7	0.64	1.3		26.6
J	0.25	2.0		0.20	1.2	0.27	2.2	0.99	5.9	0.19	0.4		11.7
A	0.63		11.3					1.22	7.3	0.64		1.3	19.9
S	0.88		15.8					0.72	4.3	0.80		1.6	21.7
O	1.44		25.9							1.31		2.6	28.5
N	1.36		24.5							1.46		2.9	27.4
D	0.38		6.8							0.60		1.2	8.0
J	-		-							-		-	-

Note: UVR: Unit water requirement (ℓ/sec/ha)
DR: Diversion water requirement (m^3/sec or ℓ/sec)
WS: Wet season
DS: Dry season

Table IV-14

RESULT OF CYLINDER INTAKE RATE TEST

NO.	AREA	SOIL			INFILTRATION CURVE		BASIC INTAKE RATE			MEASURING DATE
		Pit No.	Top Soil (0-30cm)	Sub-soil (below 30cm)	A	B	A	B	Average	
1.	Mabogini	LM-84	C.	C.	$536T^{-0.53}$	$356T^{-0.46}$	25.3	26.8	26.1	18,23 Feb.'80
2.	Mandaka	LM-79	C.	C.	$246T^{-0.43}$	$184T^{-0.41}$	22.6	19.3	21.0	19 Feb. '80
3.	Chekereni	LM-64	C.	C.	$734T^{-0.64}$	$262T^{-0.54}$	16.3	11.6	14.0	19 Feb. '80
4.	Upper Miwaleni	-	C.	C.	$240T^{-0.26}$	$335T^{-0.40}$	64.6	37.4	51.0	22 Feb. '80
5.	Miwaleni	-	C.	C.	$380T^{-0.56}$	$192T^{-0.43}$	14.6	17.6	16.1	22 Feb. '80
6.	Lower Miwaleni	-	C.	C.	$277T^{-0.58}$	$153T^{-0.59}$	9.3	4.8	7.1	22 Feb. '80
7.	Kitereni	LM-36	C.	C.	$324T^{-0.50}$	$208T^{-0.38}$	18.7	26.4	22.6	21 Feb. '80
8.	Soko	LM-29	C.	C.	$210T^{-0.76}$	$99T^{-0.77}$	2.0	0.9	1.5	21 Feb. '80
9.	Makuyuni	LM-02	C.L.	C.L.	$445T^{-0.35}$	$347T^{-0.41}$	68.5	36.3	52.4	20,23 Feb.'80
10.	Kileo	LM-13	L.	L.	$257T^{-0.66}$	$141T^{-0.58}$	5.0	4.7	4.9	20 Feb. '80

Note: C.: Clay
C.L.: Clay loam
L.: Loam

Table IV-14

Table IV-15 IRRIGATION WATER REQUIREMENTS OF SURFACE AND SPRINKLER SYSTEMS

	Oil Seeds		Pulses		Maize		Cotton		Vegetables		Total
	UWR	DR	UWR	DR	UWR	DR	UWR	DR	UWR	DR	
A. Surface System											
Rainy season											
Cropping area (ha)	18		12		15		12		3		60
F	-		-		0.72	11	-	0	0.60	2	13
M	0.63	11	0.62	7	0.62	9	0.63	8	0.64	2	37
A	0.19	3	0.07	1	0.48	7	0	0	0.33	1	12
M	0.75	14	0.75	9	0.83	12	0.28	3	0.74	2	40
J	0.92	17	0.96	12	0.92	14	0.79	9	0.64	2	54
J	0.25	5	0.20	2	0.27	4	0.99	12	0.19	1	24
Dry Season											
Cropping area (ha)	35						12		3		50
A	0.63	22					1.22	15	0.64	2	39
S	0.88	31					0.72	9	0.80	2	42
O	1.44	50					-		1.31	4	54
N	1.36	48					-		1.46	4	52
D	0.38	13					-		0.60	2	15
J	-						-		-		
B. Sprinkler System											
Rainy season											
Cropping area (ha)	20		14		18		14		4		70
F	-	-	-	-	0.54	10	-		0.45	2	12
M	0.47	9	0.46	6	0.46	8	0.47	7	0.48	2	32
A	0.14	3	0.05	1	0.36	6	0	0	0.25	1	11
M	0.56	11	0.55	8	0.62	11	0.21	3	0.55	2	35
J	0.69	14	0.72	10	0.69	12	0.59	8	0.48	2	46
J	0.19	4	0.15	2	0.20	4	0.74	10	0.14	1	21
Dry Season											
Cropping area (ha)	47						14		4		65
A	0.47	22					0.91	10	0.48	2	
S	0.66	31					0.53	6	0.60	2	
O	1.07	50					-		0.98	4	54
N	1.01	47					-		1.09	4	
D	0.28	13					-		0.45	2	
J	-	-					-		-	-	

Note: UWR: Unit water requirement (ℓ/sec/ha)
DR : Diversion water requirement (ℓ/sec)

Table IV-16(1) COMPARISON ON IRRIGATION OPERATION - SPRINKLER METHOD

1.	Supply of irrigation water at peak demand period	:	60 ℓ/s for 24 hrs
2.	Net application depth, D (Beans; 39 mm, Soybeans; 42 mm)	:	40 mm
3.	Irrigation efficiency	:	0.67
	Application efficiency, Ea	:	0.70
	Conveyance efficiency, Ec	:	0.95
4.	Sprinkler set (middle pressure type)		
	Nozzle size	:	5.0/5.5 mm
	Pressure	:	3.0 kg/cm^2
	Spacing	:	20m x 20m
	Discharge, qo	:	3.6 m^3/hr (1 ℓ/s)
	Sprinkling intensity	:	10 mm/hr
5.	Sprinkling hour per operation (D + qo + Ea)	:	5.7 hr
6.	Irrigated area by one sprinkler set per operation	:	0.04 ha
7.	Operating number of sprinkler set for the discharge of 60 ℓ/s	:	60 Nos.
8.	Attached number of sprinkler on one lateral	:	5 Nos.
9.	Working number of lateral pipes	:	12 Nos.
10.	System capacity		
	Lateral pipe	:	1 ℓ/s to 5 ℓ/s
	Tertiary pipe	:	5 ℓ/s to 30 ℓ/s
	Secondary pipe	:	30 ℓ/s to 60 ℓ/s
	Lead pipe	:	60 ℓ/s

Table IV-16(2) COMPARISON ON IRRIGATION OPERATION -- FURROW METHOD

1.	Supply of irrigation water at peak demand period	:	60 ℓ/s for 24 hrs
2.	Net application depth, D (Beans; 39 mm, Soybeans; 42 mm)	:	40 mm
3.	Irrigation efficiency	:	0.54
	Application efficiency, Ea	:	0.60
	Conveyance efficiency, Ec	:	0.90
4.	Field layout		
	Farm size	:	0.5 ha
5.	Irrigation practice		
	Equivalent furrow intake rate, Ir	:	25 mm/hr
	Irrigation interval at peak demand period	:	5 days
	Time needed for refilling soil profile (D + Ir + Ea x 1.25)	:	3.3 hr
	Irrigation operation hr per day at peak demand period	:	18 hr
	Irrigation area per day (0.5ha x 5 times)	:	2.5 ha
	Irrigation rotation block (2.5ha x 5 days)	:	12.5 ha
	Unit field discharge (1.33 ℓ/s/ha[1]/ x 24/18 x 12.5 ha)	:	22 ℓ/s
6.	System capacity		
	Canal capacity - Tertiary canal	:	22 ℓ/s
	- Secondary canal	:	22 ℓ/s to 44 ℓ/s
	-- Lead canal	:	44 ℓ/s
	Regulating pond storage (60 ℓ/s x 6 hr x 3,600 sec)	:	1,300 m^3

1/ Unit requirement for soybeans

Table IV-17 GENERAL FEATURES OF SPRINKLER SYSTEM

1. Pump

Discharge	:	60 ℓ/s
Type	:	Submersible type
Rated head	:	70 m
Pump diameter	:	ϕ200 mm
Motor output	:	80

2. Pipelines and sprinkler

	Diameter (mm)	Length (m)	Material
Lead pipeline	ϕ250	50	P.V.C.
Secondary pipeline	ϕ200, ϕ250	880	P.V.C.
Tertiary pipeline	ϕ125, ϕ150	3,400	P.V.C.
Lateral, 30 Nos.	ϕ50, ϕ65	3,300	Aluminium

Sprinkler set : 150 Nos.

3. Drain

Type	:	Trapezoidal section
Length	:	5,100 m

4. Road

Width	:	4.0 m
Length	:	5,300 m

Table IV-18 COST ESTIMATE OF SURFACE AND SPRINKLER SYSTEMS

A.	Surface Irrigation System (60 ha)	
1.	Pump station	
	Pump house	3,000
	Pump equipment	25,000
2.	Irrigation system	
	Lead & secondary canal	5,000
	Tertiary canal	60,000
	Regulating pond	31,000
3.	Drainage canal	24,000
4.	Farm road	22,000
5.	Land levelling	27,000
	Total	197,000 (≒ 3,290 $/ha)
B.	Sprinkler Irrigation System (70 ha)	
1.	Pump station	
	Pump house	3,000
	Pump equipment	42,000
2.	Irrigation system	
	Lead and secondary pipeline	34,000
	Tertiary pipeline	103,000
	Lateral pipe	22,000
	Sprinkler set	15,000
3.	Drainage canal	27,000
4.	Farm road	25,000
	Total	271,000 (≒ 3,870 $/ha)

Table IV-19 MAXIMUM LENGTH OF FURROW IRRIGATION RUN

IRRIGATION SLOPE (%)	MAXIMUM LENGTH OF FURROW IRRIGATION RUN /1 Deep Root Crops /2 (m)	Medium Root Crops /3 (m)
(1) High intake rate area		
0.5	170	130
0.75	140	100
1.0	120	90
1.5	90	75
(2) Medium intake rate area		
0.5	220	150
0.75	170	120
1.0	140	110
1.5	120	85
(3) Low intake rate area		
0.5	250	180
0.75	190	150
1.0	170	130
1.5	140	100

Note: /1: Referring to the maximum lengths of irrigation run for furrows or Corrugations, Instructions and Criteria for Preparation of Irrigation Guide, prepared by U.S.A.D.

/2: Applied for such crops as cotton and maize with net application depths of 80 mm to 90 mm.

/3: Applied for such crops as pulses, soybeans and tomatoes with net application depths of 40 mm to 50 mm.

Table IV-20(1) WATER REQUIREMENTS FOR EACH YEAR - RAU RIVER SYSTEM-(1)

1. Paddy - Rainy Season -

Month		M	A	M	J	J
Consumptive use	(mm)	-	172	159	151	146
Percolation rate	(1 mm/day)	-	30	31	30	31
Nursery water	(mm)	15	6	-	-	-
Puddling water	(mm)	30	150	-	-	-
Ratio of irrigation area		1/20	1/2	1	1	1/2
Year		1965				
Effective rainfall	(mm)	39	47	45	0	0
Net deficit	(mm)	-	155	145	181	177
Net requirement	(mm)	45	234	145	181	89
Gross requirement	(mm)	74	382	237	296	145
"	(l/sec/ha)	0.28	1.47	0.88	1.14	0.54
Year		1966				
Effective rainfall	(mm)	80	135	94	23	6
Net deficit	(mm)	-	67	96	158	171
Net requirement	(mm)	45	190	96	158	86
Gross requirement	(mm)	74	310	157	258	140
"	(l/sec/ha)	0.28	1.20	0.59	1.00	0.52
Year		1967				
Effective rainfall	(mm)	15	88	160	10	35
Net deficit	(mm)	-	114	30	171	142
Net requirement	(mm)	45	213	30	171	71
Gross requirement	(mm)	74	348	49	279	116
"	(l/sec/ha)	0.28	1.34	0.18	1.08	0.43
Year		1968				
Effective rainfall	(mm)	107	141	124	70	9
Net deficit	(mm)	-	61	66	111	168
Net requirement	(mm)	45	187	66	111	84
Gross requirement	(mm)	74	306	108	181	137
"	(l/sec/ha)	0.28	1.18	0.40	0.70	0.51
Year		1969				
Effective rainfall	(mm)	14	41	91	30	6
Net deficit	(mm)	-	161	99	151	171
Net requirement	(mm)	45	237	99	151	86
Gross requirement	(mm)	74	387	161	247	141
"	(l/sec/ha)	0.28	1.49	0.60	0.95	0.53
Year		1970				
Effective rainfall	(mm)	128	146	81	0	0
Net deficit	(mm)	-	56	109	181	177
Net requirement	(mm)	45	184	109	181	89
Gross requirement	(mm)	74	301	178	296	145
"	(l/sec/ha)	0.28	1.16	0.66	1.14	0.54
Year		1971				
Effective rainfall	(mm)	52	111	86	34	19
Net deficit	(mm)	-	91	104	147	158
Net requirement	(mm)	45	202	104	147	76
Gross requirement	(mm)	74	330	170	240	124
"	(l/sec/ha)	0.28	1.27	0.63	0.93	0.46
Year		1972				
Effective rainfall	(mm)	95	83	168	0	0
Net deficit	(mm)	-	119	22	181	177
Net requirement	(mm)	45	216	22	181	89
Gross requirement	(mm)	74	353	36	296	145
"	(l/sec/ha)	0.28	1.36	0.33	1.14	0.54

	M	A	M	J	J
	-	172	159	151	146
	-	30	31	30	31
	15	6	-	-	-
	30	150	-	-	-
	1/20	1/2	1	1	1/2
1973					
	0	100	41	14	0
	-	102	149	170	177
	45	207	149	170	89
	74	338	243	278	145
	0.28	1.30	0.91	1.07	0.54
1974					
	28	170	32	44	11
	-	32	158	137	166
	45	172	158	137	83
	74	281	258	224	136
	0.28	1.08	0.96	0.86	0.51
1975					
	30	96	32	0	8
	-	106	158	181	169
	45	209	158	181	85
	74	342	258	296	139
	0.28	1.32	0.96	1.14	0.52
1976					
	61	89	106	23	0
	-		84	158	177
	45	213	84	158	89
	74	348	137	258	145
	0.28	1.34	0.51	0.96	0.54
1977					
	6	124	60	6	0
	-		130	175	177
	45	195	130	175	89
	74	319	212	286	145
	0.28	1.23	0.79	1.10	0.54
1978					
	174	141	50	7	0
	-		140	174	177
	45	187	140	174	89
	74	306	229	284	145
	0.28	1.18	0.85	1.10	0.54
1979					
	72	107	71	19	41
	-		119	162	136
	45	204	119	162	68
	74	333	194	265	111
	0.28	1.28	0.72	1.02	0.41

- Continued

Table IV-20(2) WATER REQUIREMENTS FOR EACH YEAR - RAU RIVER SYSTEM-(2)

2. Paddy - Dry Season -

Month		S	O	N	D	J	S	O	N	D	J
Consumptive use	(mm)	-	198	216	249	222	-	198	216	249	222
Percolation rate	(2 mm/day)	-	62	60	62	62	-	62	60	62	62
Nursery water	(mm)	15	6	-	-	-	15	6	-	-	-
Puddling water	(mm)	30	150	-	-	-	30	150	-	-	-
Ratio of irrigation area		1/20	1/2	1	1	1/2	1/20	1/2	1	1	1/2
Year		1965					1973				
Effective rainfall	(mm)	0	28	42	8	65	0	0	33	37	110
Net deficit	(mm)	-	232	234	303	219	-	260	243	274	174
Net requirement	(mm)	45	272	234	303	110	45	286	243	274	87
Gross requirement	(mm)	74	444	382	495	180	74	467	397	448	142
"	(l/sec/ha)	0.29	1.66	1.47	1.85	0.67	0.29	1.74	1.53	1.67	0.53
Year		1966					1974				
Effective rainfall	(mm)	0	0	6	33	17	0	0	11	16	0
Net deficit	(mm)	-	260	270	278	267	-	260	265	295	284
Net requirement	(mm)	45	286	270	278	134	45	286	265	295	142
Gross requirement	(mm)	74	467	441	454	219	74	467	433	482	232
"	(l/sec/ha)	0.29	1.73	1.70	1.70	0.82	0.29	1.14	1.67	1.80	0.87
Year		1967					1975				
Effective rainfall	(mm)	29	122	41	0	6	56	0	35	0	10
Net deficit	(mm)	-	138	235	311	278	-	260	241	311	274
Net requirement	(mm)	45	225	235	311	139	45	286	241	311	137
Gross requirement	(mm)	74	368	384	508	227	74	467	394	508	224
"	(l/sec/ha)	0.29	1.37	1.48	1.90	0.85	0.29	1.74	1.52	1.90	0.84
Year		1968					1976				
Effective rainfall	(mm)	10	26	42	56	0	5	0	8	10	8
Net deficit	(mm)	-	234	234	255	284	-	260	268	301	276
Net requirement	(mm)	45	273	234	255	142	45	286	268	301	138
Gross requirement	(mm)	74	446	382	417	232	74	467	438	492	225
"	(l/sec/ha)	0.29	1.67	1.47	1.56	0.87	0.29	1.74	1.69	1.84	0.84
Year		1969					1977				
Effective rainfall	(mm)	0	36	50	0	0	0	37	27	111	34
Net deficit	(mm)	-	224	226	311	284	-	223	249	200	250
Net requirement	(mm)	45	268	226	311	142	45	268	249	200	125
Gross requirement	(mm)	74	438	369	508	232	74	438	407	327	204
"	(l/sec/ha)	0.29	1.64	1.42	1.90	0.87	0.29	1.64	1.57	1.22	0.76
Year		1970					1978				
Effective rainfall	(mm)	0	0	0	30	78	0	0	34	47	63
Net deficit	(mm)	-	260	276	281	206	-	260	242	264	221
Net requirement	(mm)	45	286	276	281	108	45	286	242	264	111
Gross requirement	(mm)	74	467	451	459	176	74	467	395	431	181
"	(l/sec/ha)	0.29	1.74	1.76	1.71	0.66	0.29	1.74	1.52	1.61	0.68
Year		1971					1979				
Effective rainfall	(mm)	0	0	11	94	36	7	0	44	37	54
Net deficit	(mm)	-	260	265	217	248	-	260	232	294	230
Net requirement	(mm)	45	286	265	217	124	45	286	232	294	115
Gross requirement	(mm)	74	467	433	355	203	74	467	379	480	188
"	(l/sec/ha)	0.29	1.74	1.67	1.33	0.76	0.29	1.74	1.46	1.79	0.70
Year		1972									
Effective rainfall	(mm)	52	89	62	37	9					
Net deficit	(mm)	-	171	214	274	275					
Net requirement	(mm)	45	242	214	274	138					
Gross requirement	(mm)	74	395	350	448	225					
"	(l/sec/ha)	0.29	1.47	1.35	1.67	0.84					

- Continued

Table IV-20(3) WATER REQUIREMENTS FOR EACH YEAR - RAU RIVER SYSTEM-(3)

3. Banana - Rainy Season -

Month		F	M	A	M	J	J	F	M	A	M	J	J
Consumptive use	(mm)	211	227	194	156	138	136	211	227	194	156	138	136
Ratio of irrigation area		1	1	1	1	1	1	1	1	1	1	1	1
Pre-irrigation	(mm)	-	-	-	-	-	-	-	-	-	-	-	-
Year		1965						1973					
Effective rainfall	(mm)	0	39	47	45	0	0	11	0	100	41	14	0
Net deficit	(mm)	211	188	147	111	138	136	200	227	94	115	124	136
Net requirement	(mm)	211	188	147	111	138	136	200	227	94	115	124	136
Gross requirement	(mm)	422	376	294	222	276	272	400	454	188	230	248	272
"	(l/sec/ha)	1.74	1.40	1.13	0.83	1.06	1.02	1.65	1.70	0.73	0.86	0.96	1.02
Year		1966						1974					
Effective rainfall	(mm)	27	80	135	94	23	6	0	28	170	32	44	11
Net deficit	(mm)	184	147	59	62	115	130	211	199	24	124	94	125
Net requirement	(mm)	184	147	59	62	115	130	211	199	24	124	94	125
Gross requirement	(mm)	368	294	118	124	230	260	422	398	48	248	188	250
"	(l/sec/ha)	1.52	1.10	0.46	0.46	0.89	0.97	1.74	1.49	0.19	0.93	0.73	0.93
Year		1967						1975					
Effective rainfall	(mm)	12	15	88	156	10	35	24	30	96	32	0	8
Net deficit	(mm)	199	212	106	0	128	101	187	197	98	124	138	128
Net requirement	(mm)	199	212	106	0	128	101	187	197	98	124	138	128
Gross requirement	(mm)	398	424	212	0	256	202	374	394	196	248	276	256
"	(l/sec/ha)	1.65	1.58	0.82	0	0.99	0.75	1.55	1.47	0.76	0.93	1.06	0.96
Year		1968						1976					
Effective rainfall	(mm)	69	107	141	124	70	9	12	61	89	106	23	0
Net deficit	(mm)	142	20	53	32	68	127	199	166	105	50	115	136
Net requirement	(mm)	142	20	53	32	68	127	199	166	105	50	115	136
Gross requirement	(mm)	284	40	106	64	136	254	398	332	210	100	230	272
"	(l/sec/ha)	1.17	0.15	0.41	0.24	0.52	0.95	1.65	0.78	0.81	0.37	0.89	1.02
Year		1969						1977					
Effective rainfall	(mm)	39	14	41	91	30	6	53	6	124	60	6	0
Net deficit	(mm)	172	213	153	65	108	130	158	221	70	96	132	136
Net requirement	(mm)	172	213	153	65	108	130	158	221	70	96	132	136
Gross requirement	(mm)	344	426	306	130	216	260	316	442	140	192	264	272
"	(l/sec/ha)	1.42	1.59	1.18	0.49	0.83	0.97	1.31	1.65	0.54	0.72	1.02	1.02
Year		1970						1978					
Effective rainfall	(mm)	23	128	146	81	0	0	20	174	141	50	7	0
Net deficit	(mm)	188	99	48	75	138	136	191	53	53	106	131	136
Net requirement	(mm)	188	99	48	75	138	136	191	53	53	106	131	136
Gross requirement	(mm)	376	198	96	150	276	272	382	106	106	212	262	272
"	(l/sec/ha)	1.55	0.74	0.37	0.56	1.06	1.02	1.58	0.40	0.41	0.79	1.01	1.02
Year		1971						1979					
Effective rainfall	(mm)	0	52	111	86	34	19	49	72	107	71	19	41
Net deficit	(mm)	211	175	83	70	104	117	162	155	87	85	119	95
Net requirement	(mm)	211	175	83	70	104	117	162	155	87	85	119	95
Gross requirement	(mm)	422	350	166	140	208	234	324	310	174	170	238	190
"	(l/sec/ha)	1.74	1.31	0.64	0.52	0.80	0.87	1.34	1.16	0.67	0.63	0.92	0.71
Year		1972											
Effective rainfall	(mm)	73	95	83	156	0	0						
Net deficit	(mm)	138	132	111	0	138	136						
Net requirement	(mm)	138	132	111	0	138	136						
Gross requirement	(mm)	276	264	222	0	276	272						
"	(l/sec/ha)	1.14	0.99	0.86	0	1.06	1.02						

- Continued

Table IV-20(4) WATER REQUIREMENTS FOR EACH YEAR - RAU RIVER SYSTEM-(4)

4. Banana - Dry Season -

	Month	F	M	A	M	J	J	F	M	A	M	J	J
Consumptive use	(mm)	100	124	130	140	168	198	100	124	130	140	168	198
Ratio of irrigation area		1	1	1	1	1	1	1	1	1	1	1	1
Pre-irrigation	(mm)	-	-	-	-	-	-	-	-	-	-	-	-
Year		1965						1973					
Effective rainfall	(mm)	0	0	28	42	8	65	0	0	0	33	37	110
Net deficit	(mm)	100	124	102	98	160	133	100	124	130	107	131	88
Net requirement	(mm)	100	124	102	98	160	133	100	124	130	107	131	88
Gross requirement	(mm)	200	248	204	196	320	266	200	248	260	214	262	176
"	(l/sec/ha)	0.75	0.96	0.76	0.76	1.19	0.99	0.75	0.96	0.97	0.83	0.98	0.66
Year		1966						1974					
Effective rainfall	(mm)	0	0	0	6	33	17	0	0	0	11	16	0
Net deficit	(mm)	100	124	130	134	135	181	100	124	130	129	152	198
Net requirement	(mm)	100	124	130	134	135	181	100	124	130	129	152	198
Gross requirement	(mm)	200	248	260	268	270	362	200	248	260	258	304	396
"	(l/sec/ha)	0.75	0.96	0.97	1.03	1.01	1.35	0.75	0.96	0.97	1.00	1.14	1.48
Year		1967						1975					
Effective rainfall	(mm)	33	29	122	41	0	6	0	56	0	35	0	10
Net deficit	(mm)	67	95	8	99	168	192	100	68	130	105	168	188
Net requirement	(mm)	67	95	8	99	168	192	100	68	130	105	168	188
Gross requirement	(mm)	134	190	16	198	336	384	200	136	260	210	336	376
"	(l/sec/ha)	0.50	0.73	0.06	0.76	1.25	1.43	0.75	0.52	0.97	0.81	1.25	1.40
Year		1968						1976					
Effective rainfall	(mm)	16	10	26	42	56	0	0	5	0	8	10	8
Net deficit	(mm)	84	114	104	98	112	198	100	119	130	132	158	190
Net requirement	(mm)	84	114	104	98	112	198	100	119	130	132	158	190
Gross requirement	(mm)	168	228	208	196	224	396	200	238	260	264	316	380
"	(l/sec/ha)	0.63	0.88	0.78	0.76	0.84	1.48	0.75	0.92	0.97	1.02	1.18	1.42
Year		1969						1977					
Effective rainfall	(mm)	32	0	36	50	0	0	21	0	37	27	111	34
Net deficit	(mm)	68	124	94	90	168	198	79	124	93	113	57	164
Net requirement	(mm)	68	124	94	90	168	198	79	124	93	113	57	164
Gross requirement	(mm)	136	248	188	180	336	396	158	248	186	226	114	328
"	(l/sec/ha)	0.51	0.96	0.70	0.70	1.25	1.48	0.59	0.96	0.69	0.87	0.43	1.22
Year		1970						1978					
Effective rainfall	(mm)	21	0	0	0	30	78	0	0	0	34	47	63
Net deficit	(mm)	79	124	130	140	138	120	100	124	130	106	121	135
Net requirement	(mm)	79	124	130	140	138	120	100	124	130	106	121	135
Gross requirement	(mm)	158	248	260	280	276	240	200	248	260	212	242	270
"	(l/sec/ha)	0.59	0.96	0.97	1.08	1.03	0.90	0.75	0.96	0.97	0.82	0.90	1.01
Year		1971						1979					
Effective rainfall	(mm)	0	0	0	11	94	36	0	7	0	44	17	54
Net deficit	(mm)	100	124	130	129	74	162	100	115	130	96	151	144
Net requirement	(mm)	100	124	130	129	74	162	100	115	130	96	151	144
Gross requirement	(mm)	200	248	260	258	148	324	200	230	260	192	302	288
"	(l/sec/ha)	0.75	0.96	0.97	1.00	0.55	1.21	0.75	0.89	0.97	0.74	1.13	1.08
Year		1972											
Effective rainfall	(mm)	0	52	89	62	31	9						
Net deficit	(mm)	100	72	41	78	131	189						
Net requirement	(mm)	100	72	41	78	131	189						
Gross requirement	(mm)	200	144	82	156	262	378						
"	(l/sec/ha)	0.75	0.56	0.31	0.60	0.98	1.41						

Table IV-21(1) WATER BALANCE OF RAU RIVER SYSTEM

Unit: m^3/sec

	J	F	M	A	M	J	J	A	S	O	N	D
1965												
DIS (1)	2.06	1.84	1.74	2.06	1.74	1.70	1.69	1.69	1.69	1.60	1.57	1.53
DR (1)	-	0.12	0.36	1.41	0.87	1.11	0.52	0.07	0.17	0.57	0.54	0.66
BAL (1)	-	1.72	1.38	0.65	0.87	0.59	1.17	1.62	1.52	1.03	1.03	0.87
DIS (2)	1.56	0.23	0.38	3.32	2.08	0.85	0.23	0.22	0.16	0.22	1.32	0.69
DR (2)	-	0.18	0.47	1.79	1.13	1.44	0.74	0.10	0.23	0.74	0.69	0.87
BAL (2)	-	1.77	1.29	2.18	1.82	0	0.66	1.74	1.45	0.51	0.63	0.69
1966												
DIS (1)	1.46	1.39	1.42	1.49	1.42	1.47	1.66	1.77	1.84	1.73	1.57	1.49
DR (1)	0.36	0.12	0.36	1.14	0.60	0.98	0.55	0.07	0.17	0.60	0.61	0.61
BAL (1)	1.10	1.27	1.06	0.35	0.82	0.49	1.11	1.70	1.67	1.13	0.96	0.88
DIS (2)	0.15	0.13	4.54	4.53	3.37	2.46	1.18	0.40	0.18	0.16	0.15	0.13
DR (2)	0.47	0.16	0.44	1.43	0.78	1.27	0.71	0.10	0.23	0.78	0.80	0.80
BAL (2)	0.78	1.24	5.16	3.45	3.41	1.68	1.58	2.00	1.62	0.51	0.31	0.21
1967												
DIS (1)	1.30	1.09	0.99	1.13	1.33	1.32	1.47	1.72	1.96	2.19	2.15	2.06
DR (1)	0.37	0.12	0.37	1.28	0.21	1.05	0.46	0.07	0.16	0.46	0.54	0.68
BAL (1)	0.93	0.97	0.62	-0.15	1.12	0.27	1.01	1.65	1.80	1.73	1.61	1.38
DIS (2)	0.10	1.52	0.22	1.22	4.25	3.26	2.34	1.38	4.09	2.26	2.15	0.91
DR (2)	0.49	0.18	0.49	1.62	0.28	1.37	0.59	0.07	0.21	0.57	0.69	0.89
BAL (2)	0.54	2.31	0.35	-0.55	5.09	2.16	2.76	2.96	5.68	3.42	3.07	1.40
1968												
DIS (1)	1.92	1.76	1.79	2.00	1.95	2.36	2.62	2.76	2.64	2.49	2.40	2.57
DR (1)	0.38	0.11	0.33	1.08	0.42	0.70	0.54	0.07	0.16	0.58	0.54	0.56
BAL (1)	1.54	1.65	1.46	0.92	1.53	1.66	2.08	2.69	2.48	1.91	1.86	2.01
DIS (2)	0.19	0.73	2.16	5.20	3.78	3.12	1.90	1.46	0.54	0.30	0.84	2.44
DR (2)	0.50	0.13	0.34	1.40	0.54	0.90	0.70	0.08	0.22	0.74	0.69	0.73
BAL (2)	1.23	2.25	3.28	4.72	4.77	3.88	3.28	4.07	2.80	1.47	2.01	3.72

Note: DIS (1): Discharge of Njoro river
DR (1): Diversion requirement of Upper Mobogini and Mabogini schemes
BAL (1): Water balance of Njoro river
DIS (2): Discharge of Rau river
DR (2): Diversion requirement of Rau Ya Kati and Checkerani schemes
BAL (2): Water balance of Rau river system

- Continued

Table IV-21(2) WATER BALANCE OF RAU RIVER SYSTEM

Unit: m^3/sec

	J	F	M	A	M	J	J	A	S	O	N	D
1969												
DIS (1)	2.19	2.06	1.97	1.80	1.96	1.76	1.70	1.72	1.64	1.67	1.60	1.50
DR (1)	0.38	0.11	0.37	1.43	0.61	0.93	0.56	0.07	0.17	0.56	0.52	0.68
BAL (1)	1.81	1.95	1.60	0.37	1.35	0.83	1.14	1.65	1.47	1.11	1.08	0.82
DIS (2)	0.44	1.13	1.24	0.78	2.98	1.95	1.00	1.63	0.67	1.22	0.69	0.45
DR (2)	0.50	0.15	0.49	1.82	0.79	1.21	0.72	0.07	0.23	0.72	0.67	0.89
BAL (2)	1.75	2.93	2.35	-0.67	3.54	1.57	1.42	3.21	1.91	1.61	1.10	0.38
1970												
DIS (1)	1.43	1.40	1.52	1.66	1.56	1.82	1.96	1.97	1.79	1.63	1.34	1.19
DR (1)	0.30	0.12	0.34	1.11	0.66	1.11	0.57	0.07	0.17	0.60	0.63	0.62
BAL (1)	0.13	1.28	1.18	0.55	0.90	0.71	1.39	1.90	1.62	1.03	0.71	0.57
DIS (2)	1.51	1.07	1.58	5.03	3.32	1.43	0.65	0.24	0.21	0.19	0.16	0.13
DR (2)	0.37	0.17	0.40	1.37	0.86	1.44	0.74	0.08	0.23	0.79	0.82	0.79
BAL (2)	1.27	2.18	2.36	4.21	3.36	0.70	1.30	2.06	1.60	0.43	0.05	-0.09
1971												
DIS (1)	1.43	1.32	1.43	1.77	1.63	1.96	2.47	2.47	2.25	2.27	1.37	1.72
DR (1)	0.33	0.12	0.36	1.21	0.63	0.91	0.49	0.07	0.17	0.60	0.60	0.49
BAL (1)	1.10	1.20	1.07	0.56	1.00	1.05	1.98	2.40	2.08	1.67	0.77	1.23
DIS (2)	0.13	0.46	0.71	4.72	4.76	2.60	1.75	0.82	0.22	0.16	0.13	0.42
DR (2)	0.45	0.18	0.46	1.52	0.83	1.18	0.63	0.10	0.23	0.79	0.78	0.62
BAL (2)	0.78	1.48	1.32	3.76	4.93	2.47	3.10	3.12	2.07	1.04	0.12	1.03
1972												
DIS (1)	1.74	1.73	1.74	1.74	1.77	2.09	2.17	2.10	1.94	1.50	1.66	1.49
DR (1)	0.36	0.10	0.35	1.30	0.17	1.11	0.57	0.07	0.16	0.50	0.49	0.60
BAL (1)	1.38	1.63	1.39	0.44	1.60	0.98	1.60	2.03	1.78	1.10	1.17	0.89
DIS (2)	0.23	1.34	2.14	2.85	3.91	2.34	1.04	0.56	1.08	2.55	5.36	2.16
DR (2)	0.49	0.12	0.43	1.64	0.22	1.44	0.74	0.10	0.19	0.63	0.63	0.72
BAL (2)	1.12	2.85	3.10	1.65	5.29	1.88	1.90	2.49	2.67	3.02	5.90	2.33
1973												
DIS (1)	1.43	1.42	1.43	1.39	1.67	1.44	1.39	1.37	1.33	0.89	1.16	1.26
DR (1)	0.25	0.12	0.37	1.24	0.90	1.04	0.57	0.03	0.17	0.60	0.56	0.60
BAL (1)	1.18	1.30	1.06	0.15	0.77	0.40	0.82	1.34	1.16	0.29	0.60	0.66
DIS (2)	3.20	2.70	1.52	1.72	3.87	1.70	0.96	0.34	0.23	0.22	0.20	0.21
DR (2)	0.30	0.18	0.50	1.56	1.17	1.35	0.74	0.10	0.23	0.79	0.72	0.78
BAL (2)	4.08	3.82	2.08	0.31	3.47	0.75	1.04	1.58	1.16	-0.28	0.08	0.09

- Continued

Table IV-21(3) WATER BALANCE OF RAU RIVER SYSTEM

Unit: m^3/sec

	J	F	M	A	M	J	J	A	S	O	N	D
1974												
DIS (1)	1.16	1.13	0.93	1.43	1.29	1.26	1.29	1.29	1.33	1.33	1.30	1.27
DR (1)	0.38	0.12	0.37	1.03	0.94	0.85	0.54	0.07	0.17	0.60	0.60	0.64
BAL (1)	0.78	1.01	0.56	0.40	0.35	0.41	0.75	1.22	1.16	0.73	0.70	0.63
DIS (2)	0.14	0.12	0.17	5.89	4.12	2.44	2.06	0.67	0.19	0.16	0.14	0.20
DR (2)	0.50	0.18	0.48	1.27	1.23	1.10	0.70	0.10	0.23	0.79	0.78	0.83
BAL (2)	0.42	0.95	0.25	5.02	3.24	1.75	2.11	1.79	1.12	0.10	0.06	0
1975												
DIS (1)	1.17	1.07	1.09	1.49	1.39	1.26	1.12	1.17	1.27	1.29	1.14	1.16
DR (1)	0.37	0.12	0.37	1.26	0.94	1.11	0.55	0.07	0.15	0.60	0.55	0.68
BAL (1)	0.80	0.95	0.72	0.23	0.45	0.15	0.57	1.10	1.12	0.69	0.59	0.48
DIS (2)	0.21	0.10	6.02	7.04	3.75	2.02	1.58	0.89	1.25	0.27	0.17	0.15
DR (2)	0.48	0.17	0.48	1.59	1.23	1.44	0.71	0.10	0.19	0.79	0.71	0.89
BAL (2)	0.53	0.88	6.26	5.68	2.97	0.73	1.44	1.89	2.18	0.17	0.05	-0.26
1976												
DIS (1)	0.97	0.96	0.87	1.10	1.09	0.93	0.90	0.89	0.94	0.93	0.90	0.89
DR (1)	0.37	0.12	0.35	1.28	0.52	0.94	0.57	0.07	0.17	0.60	0.61	0.66
BAL (1)	0.60	0.84	0.52	-0.18	0.57	-0.01	0.33	0.82	0.77	0.33	0.29	0.23
DIS (2)	0.13	2.02	0.87	1.36	2.68	2.47	1.14	0.54	0.19	0.13	0.13	0.17
DR (2)	0.49	0.18	0.41	1.62	0.68	1.23	0.74	0.10	0.23	0.79	0.79	0.86
BAL (2)	0.24	2.68	0.98	-0.44	2.57	1.23	0.73	1.26	0.73	-0.33	-0.37	-0.46
1977												
DIS (1)	0.87	0.90	0.92	1.23	1.19	1.17	1.43	1.67	1.66	1.54	1.49	1.29
DR (1)	0.34	0.11	0.37	1.17	0.78	1.07	0.57	0.07	0.17	0.56	0.57	0.45
BAL (1)	0.53	0.79	0.55	0.06	0.41	0.10	0.86	1.60	1.49	0.98	0.92	0.84
DIS (2)	0.21	0.45	1.87	5.94	4.24	1.67	0.68	1.26	0.42	1.42	2.68	1.33
DR (2)	0.44	0.14	0.49	1.47	1.02	1.39	0.74	0.08	0.23	0.72	0.74	0.67
BAL (2)	0.30	1.10	1.93	4.53	3.63	0.38	0.80	2.78	1.68	0.70	2.86	1.50
1978												
DIS (1)	1.17	1.19	1.13	1.22	1.14	1.24	1.39	1.40	1.52	1.62	1.53	1.63
DR (1)	0.30	0.12	0.33	1.12	0.84	1.07	0.57	0.07	0.17	0.60	0.55	0.58
BAL (1)	0.87	1.07	0.80	0.10	0.30	0.17	0.82	1.33	1.35	1.02	0.98	1.05
DIS (2)	1.61	1.01	2.63	3.60	3.69	3.16	1.95	0.92	0.33	0.22	1.44	3.88
DR (2)	0.39	0.17	0.37	1.40	1.10	1.39	0.74	0.10	0.23	0.79	0.71	0.75
BAL (2)	2.09	1.91	3.06	2.30	2.89	1.94	2.03	2.15	1.45	0.45	1.71	4.18

- Continued

Table IV-21(4) WATER BALANCE OF RAU RIVER SYSTEM

Unit: m^3/sec

1979	J	F	M	A	M	J	J	A	S	O	N	D
DIS (1)	1.52	1.32	1.44	1.82	1.79	-	-	-	-	-	-	-
DR (1)	0.31	0.11	0.36	1.22	0.72	1.00	0.44	0.07	0.17	0.60	0.53	0.64
BAL (1)	1.21	1.21	1.08	0.60	1.07	-	-	-	-	-	-	-
DIS (2)	1.79	2.69	1.74	5.41	4.29	4.07	1.57	1.15	0.99	0.54	0.28	0.23
DR (2)	0.40	0.14	0.44	1.54	0.94	1.27	0.56	0.10	0.22	0.79	0.69	0.85
BAL (2)	2.60	3.76	2.38	4.47	4.42	-	-	-	-	-	-	-

Table IV-22 DIVERSION REQUIREMENTS FOR KAHE NAFCO SCHEME

	EVAPO-TRANSPIRATION (110% mean) (mm)	EFFECTIVE RAINFALL (90% exceedence) (mm)	WATER DEFICIT (mm)	UNIT[2/] WATER REQUIREMENT (l/s/ha)	DIVERSION[3/] REQUIREMENT FOR 2,000 HA (m^3/s)
Jan	160	0	160	0.95	1.90
Feb	147	0	147	0.96	1.92
Mar	147	8	139	0.82	1.64
Apr	124	41	83	0.51	1.02
May	102	10	92	0.55	1.10
Jun	94	0	94	0.58	1.16
Jul	91	0	91	0.54	1.08
Aug	107	0	107	0.63	1.26
Sep	124	0	124	0.76	1.52
Oct	147	0	147	0.87	1.74
Nov	147	0	147	0.90	1.80
Dec	152	0	152	0.90	1.80

Note: 1/: Referring to Appendix C, Hydrological Aspects, A Report on The Engineering Aspects and Technical Soundness of the Proposed Kahe Irrigation Scheme, FAO

2/: Based on overall irrigation efficiency of 0.63, which is referred to Chapter IV, Irrigation and Power Development, Survey and Plan for Irrigation Development in the Pangani and Wani River Basins.

3/: Including drawn-up extension areas of about 600 ha in Oriya village in addition to the present cultivated area of 1,400 ha in NAFCO field.

Table IV-23 AVAILABLE WATER OF MIWALENI SPRINGS FLOW FOR MIWALENI PUMP LIFT SCHEME

MONTH	MIWALENI SPRING FLOW [1/] (m^3/s)	DIVERSION WATER REQUIREMENT FOR NAFCO AREA		AVAILABLE WATER FOR MIWALENI PUMP LIFT SCHEME (m^3/s)
		24 hrs Supply (m^3/s)	16 hrs Supply (m^3/s)	
Jan	3.57	1.90	2.85	0.72
Feb	3.54	1.92	2.88	0.66
Mar	3.59	1.64	2.46	1.13
Apr	3.72	1.02	1.53	2.19
May	3.97	1.10	1.65	2.32
Jun	3.83	1.16	1.74	2.09
Jul	3.59	1.08	1.62	1.97
Aug	3.54	1.26	1.89	1.65
Sep	3.51	1.52	2.28	1.23
Oct	3.59	1.74	2.61	0.98
Nov	3.60	1.80	2.70	0.90
Dec	3.61	1.80	2.70	0.91

Note: 1/: Using recorded minimum flow during 5 years from 1966 to 1970

Table IV-24 WATER BALANCE OF MIWALENI PUMP LIFT SCHEME

MONTH	AVAILABLE[1/] WATER FOR MIWALENI PUMP LIFT SCHEME (m^3/sec)	DIVERSION[2/] REQUIREMENT OF MIWALENI PUMP LIFT SCHEME (m^3/sec)	WATER BALANCE (m^3/sec)
Jan	0.72	0.41	0.31
Feb	0.66	0.24	0.42
Mar	1.13	0.94	0.19
Apr	2.19	1.44	0.75
May	2.32	1.56	0.76
Jun	2.09	2.00	0.09
Jul	1.97	0.92	1.05
Aug	1.65	0.31	1.34
Sep	1.23	0.34	0.89
Oct	0.98	0.90	0.08
Nov	0.90	0.88	0.02
Dec	0.91	0.91	0

Note: 1/: Refer to Table IV-23

2/: Refer to Table IV-13

Table IV-25(1) WATER REQUIREMENTS OF EACH YEAR - HIMO RIVER SYSTEM-(1)

1. Paddy - Rainy Season -

	Month	M	A	M	J	J	M	A	M	J	J
Consumptive use	(mm)	-	172	159	151	146	-	172	159	151	146
Percolation rate	(1 mm/day)	-	30	31	30	31	-	30	31	30	31
Nursery water	(mm)	15	6	-	-	-	15	6	-	-	-
Puddling water	(mm)	30	150	-	-	-	30	150	-	-	-
Ratio of irrigation area		1/20	1/2	1	1	1/2	1/20	1/2	1	1	1/2
Year		1968					1974				
Effective rainfall	(mm)	118	118	78	0	0	6	136	68	37	44
Net deficit	(mm)	-	84	119	181	177	-	66	122	144	133
Net requirement	(mm)	45	198	119	181	89	45	189	122	144	67
Gross requirement	(mm)	74	324	194	296	145	74	309	199	235	109
"	(l/sec/ha)	0.28	1.24	0.72	1.14	0.54	0.28	1.19	0.74	0.91	0.41
Year		1969					1975				
Effective rainfall	(mm)	28	53	0	0	0	20	35	0	26	18
Net deficit	(mm)	-	149	190	181	177	-	167	190	155	159
Net requirement	(mm)	45	231	190	181	89	45	240	190	155	80
Gross requirement	(mm)	74	377	310	296	145	74	392	310	253	131
"	(l/sec/ha)	0.28	1.45	1.16	1.14	0.54	0.28	1.51	1.16	0.98	0.49
Year		1970					1976				
Effective rainfall	(mm)	118	118	49	0	0	102	158	78	18	6
Net deficit	(mm)	-	84	141	181	177	-	44	112	163	171
Net requirement	(mm)	45	198	141	181	89	45	178	112	163	86
Gross requirement	(mm)	74	324	230	296	145	74	291	183	266	141
"	(l/sec/ha)	0.28	1.25	0.86	1.14	0.54	0.28	1.12	0.68	1.03	0.53
Year		1971					1977				
Effective rainfall	(mm)	42	92	110	71	8	114	140	59	18	0
Net deficit	(mm)	-	110	80	110	169	-	62	131	163	177
Net requirement	(mm)	45	211	80	110	85	45	187	131	163	89
Gross requirement	(mm)	74	345	131	180	139	74	306	214	266	145
"	(l/sec/ha)	0.28	1.33	0.49	0.69	0.52	0.28	1.18	0.80	1.03	0.54
Year		1972					1978				
Effective rainfall	(mm)	123	55	122	28	19	174	141	50	7	0
Net deficit	(mm)	-	147	68	153	158	-	61	140	174	177
Net requirement	(mm)	45	230	68	153	79	45	187	140	174	89
Gross requirement	(mm)	74	376	111	250	120	74	306	229	284	145
"	(l/sec/ha)	0.28	1.45	0.41	0.96	0.48	0.28	1.18	0.85	1.10	0.54
Year		1973					1979				
Effective rainfall	(mm)	0	67	68	27	0	78	93	80	14	7
Net deficit	(mm)	-	135	122	154	177	-	109	110	167	170
Net requirement	(mm)	45	224	122	154	89	45	211	110	167	85
Gross requirement	(mm)	74	366	199	252	145	74	345	180	273	139
"	(l/sec/ha)	0.28	1.41	0.74	0.97	0.54	0.28	1.33	0.67	1.05	0.52

- Continued

Table IV-25(2) WATER REQUIREMENTS OF EACH YEAR - HIMO RIVER SYSTEM-(2)

2. Soybeans - Rainy Season -

Month		M	A	M	J	J	M	A	M	J	J
Consumptive use	(mm)	63	112	141	119	68	63	112	141	119	68
Ratio of irrigation area		1/2	1	1	1	1/2	1/2	1	1	1	1/2
Pre-irrigation	(mm)	60	-	-	-	-	60	-	-	-	-
Year		1968					1974				
Effective rainfall	(mm)	60	97	71	0	0	6	97	68	37	44
Net deficit	(mm)	3	15	70	119	68	57	15	73	82	24
Net requirement	(mm)	62	15	70	119	34	89	15	73	82	12
Gross requirement	(mm)	124	30	140	238	68	178	30	146	164	24
"	(l/sec/ha)	0.46	0.12	0.52	0.92	0.25	0.66	0.12	0.55	0.63	0.09
Year		1969					1975				
Effective rainfall	(mm)	28	53	0	0	0	20	35	0	26	18
Net deficit	(mm)	35	59	141	119	68	43	77	141	93	50
Net requirement	(mm)	78	59	141	119	34	82	77	141	93	25
Gross requirement	(mm)	156	118	282	238	68	164	154	282	186	50
"	(l/sec/ha)	0.58	0.46	1.05	0.92	0.25	0.61	0.59	1.05	0.72	0.19
Year		1970					1976				
Effective rainfall	(mm)	60	97	49	0	0	60	97	78	18	6
Net deficit	(mm)	3	15	92	119	68	3	15	63	101	62
Net requirement	(mm)	62	15	92	119	34	62	15	63	101	31
Gross requirement	(mm)	124	30	184	238	68	124	30	126	202	62
"	(l/sec/ha)	0.46	0.12	0.69	0.92	0.25	0.46	0.12	0.47	0.78	0.23
Year		1971					1977				
Effective rainfall	(mm)	42	92	110	71	8	60	97	59	18	0
Net deficit	(mm)	21	20	31	48	60	3	15	82	101	68
Net requirement	(mm)	71	20	31	48	30	62	15	63	101	34
Gross requirement	(mm)	142	40	62	96	60	124	30	126	202	68
"	(l/sec/ha)	0.53	0.15	0.23	0.37	0.22	0.46	0.12	0.47	0.78	0.25
Year		1972					1978				
Effective rainfall	(mm)	60	55	122	28	19	60	97	50	7	0
Net deficit	(mm)	3	57	19	91	50	3	15	91	112	68
Net requirement	(mm)	62	57	19	91	25	62	15	91	112	34
Gross requirement	(mm)	124	114	38	182	50	124	30	182	224	68
"	(l/sec/ha)	0.46	0.44	0.14	0.70	0.19	0.46	0.12	0.68	0.86	0.25
Year		1973					1979				
Effective rainfall	(mm)	0	67	68	27	0	60	93	80	14	7
Net deficit	(mm)	63	45	73	92	68	3	19	61	105	61
Net requirement	(mm)	92	45	73	92	34	62	19	61	105	31
Gross requirement	(mm)	184	90	146	184	68	124	38	122	210	32
"	(l/sec/ha)	0.69	0.35	0.55	0.71	0.25	0.46	0.15	0.46	0.81	0.12

- Continued

Table IV-25(3) WATER REQUIREMENTS OF EACH YEAR - HIMO RIVER SYSTEM(3)

3. Soybeans - Dry Season -

Month		A	S	O	N	D	A	S	O	N	D
Consumptive use	(mm)	49	114	193	185	109	49	114	193	185	109
Ratio of irrigation area		1/2	1	1	1	1/2	1/2	1	1	1	1/2
Pre-irrigation	(mm)	60	-	-	-	-	60	-	-	-	-
Year		1968					1974				
Effective rainfall	(mm)	45	0	0	69	9	0	0	18	0	0
Net deficit	(mm)	4	114	193	185	100	49	114	175	185	109
Net requirement	(mm)	62	114	193	185	50	85	114	175	185	55
Gross requirement	(mm)	124	228	386	370	100	170	228	350	370	110
"	(l/sec/ha)	0.46	0.88	1.44	1.43	0.37	0.63	0.88	1.31	1.43	0.41
Year		1969					1975				
Effective rainfall	(mm)	27	0	22	28	0	45	10	17	30	36
Net deficit	(mm)	22	114	171	157	109	4	104	176	155	73
Net requirement	(mm)	71	114	171	157	55	62	104	176	155	37
Gross requirement	(mm)	142	228	342	314	110	124	208	352	310	74
"	(l/sec/ha)	0.53	0.88	1.28	1.21	0.41	0.46	0.80	1.31	1.20	0.28
Year		1970					1976				
Effective rainfall	(mm)	0	8	0	66	85	0	17	27	104	31
Net deficit	(mm)	49	106	193	119	24	49	97	166	81	78
Net requirement	(mm)	85	106	193	119	12	85	97	166	81	39
Gross requirement	(mm)	170	212	386	238	24	170	194	332	162	78
"	(l/sec/ha)	0.63	0.82	1.44	0.92	0.09	0.63	0.75	1.24	0.62	0.29
Year		1971					1977				
Effective rainfall	(mm)	17	0	27	24	83	42	0	37	102	70
Net deficit	(mm)	32	114	166	161	26	7	114	156	83	39
Net requirement	(mm)	76	114	166	161	13	64	114	156	83	20
Gross requirement	(mm)	152	228	332	322	26	128	228	312	166	40
"	(l/sec/ha)	0.57	0.88	1.24	1.24	0.10	0.48	0.88	1.16	0.64	0.15
Year		1972					1978				
Effective rainfall	(mm)	24	36	32	144	61	0	0	0	34	47
Net deficit	(mm)	25	78	161	41	48	49	114	193	151	62
Net requirement	(mm)	73	78	161	41	24	85	114	193	151	31
Gross requirement	(mm)	146	156	322	82	48	170	228	386	302	62
"	(l/sec/ha)	0.55	0.60	1.20	0.32	0.18	0.63	0.88	1.44	1.17	0.23
Year		1973					1979				
Effective rainfall	(mm)	0	0	0	35	0	38	9	0	0	85
Net deficit	(mm)	49	114	193	150	109	11	105	193	185	24
Net requirement	(mm)	85	114	193	150	55	66	105	193	185	12
Gross requirement	(mm)	170	228	386	300	110	132	210	386	370	24
"	(l/sec/ha)	0.63	0.88	1.44	1.16	0.41	0.49	0.81	1.44	1.42	0.09

- Continued

Table IV-25(4) WATER REQUIREMENTS OF EACH YEAR - HIMO RIVER SYSTEM-(4)

4. Pulses - Rainy Season -

Month		M	A	M	J	J
Consumptive use	(mm)	60	97	141	124	53
Ratio of irrigation area		1/2	1	1	1	1/2
Pre-irrigation	(mm)	60	-	-	-	-
Year		1968				
Effective rainfall	(mm)	60	97	71	0	0
Net deficit	(mm)	0	0	70	124	53
Net requirement	(mm)	60	0	70	124	27
Gross requirement	(mm)	120	0	140	248	54
"	(l/sec/ha)	0.45	0	0.52	0.96	0.20
Year		1969				
Effective rainfall	(mm)	28	53	0	0	0
Net deficit	(mm)	32	44	141	124	53
Net requirement	(mm)	76	44	141	124	27
Gross requirement	(mm)	152	88	282	248	54
"	(l/sec/ha)	0.57	0.34	1.05	0.96	0.20
Year		1970				
Effective rainfall	(mm)	60	97	49	0	0
Net deficit	(mm)	0	0	92	124	53
Net requirement	(mm)	60	0	92	124	27
Gross requirement	(mm)	120	0	184	248	54
"	(l/sec/ha)	0.45	0	0.69	0.96	0.20
Year		1971				
Effective rainfall	(mm)	42	92	110	71	8
Net deficit	(mm)	18	5	31	53	45
Net requirement	(mm)	69	5	31	53	23
Gross requirement	(mm)	138	10	62	106	46
"	(l/sec/ha)	0.52	0.04	0.23	0.41	0.17
Year		1972				
Effective rainfall	(mm)	60	55	122	28	19
Net deficit	(mm)	0	42	19	96	34
Net requirement	(mm)	60	42	19	96	17
Gross requirement	(mm)	120	84	38	192	34
"	(l/sec/ha)	0.45	0.32	0.14	0.74	0.13
Year		1973				
Effective rainfall	(mm)	0	67	68	27	0
Net deficit	(mm)	60	30	73	97	53
Net requirement	(mm)	90	30	73	97	27
Gross requirement	(mm)	180	60	146	194	54
"	(l/sec/ha)	0.67	0.23	0.55	0.75	0.20

Month		M	A	M	J	J
Consumptive use	(mm)	60	97	141	124	53
Ratio of irrigation area		1/2	1	1	1	1/2
Pre-irrigation	(mm)	60	-	-	-	-
Year		1974				
Effective rainfall	(mm)	6	97	68	37	44
Net deficit	(mm)	54	0	73	87	9
Net requirement	(mm)	87	0	73	87	5
Gross requirement	(mm)	174	0	146	174	10
"	(l/sec/ha)	0.65	0	0.55	0.67	0.04
Year		1975				
Effective rainfall	(mm)	20	35	0	26	18
Net deficit	(mm)	40	62	141	98	35
Net requirement	(mm)	80	62	141	98	18
Gross requirement	(mm)	160	124	282	196	36
"	(l/sec/ha)	0.60	0.48	1.05	0.76	0.13
Year		1976				
Effective rainfall	(mm)	60	97	78	18	6
Net deficit	(mm)	0	0	63	106	47
Net requirement	(mm)	60	0	63	106	24
Gross requirement	(mm)	120	0	126	212	48
"	(l/sec/ha)	0.45	0	0.47	0.82	0.18
Year		1977				
Effective rainfall	(mm)	60	97	59	18	0
Net deficit	(mm)	0	0	82	106	53
Net requirement	(mm)	60	0	82	106	27
Gross requirement	(mm)	120	0	164	212	54
"	(l/sec/ha)	0.45	0	0.61	0.82	0.20
Year		1978				
Effective rainfall	(mm)	60	97	50	7	0
Net deficit	(mm)	0	0	91	117	53
Net requirement	(mm)	60	0	91	117	27
Gross requirement	(mm)	120	0	182	234	54
"	(l/sec/ha)	0.45	0	0.68	0.90	0.20
Year		1979				
Effective rainfall	(mm)	60	93	80	14	7
Net deficit	(mm)	0	4	61	110	46
Net requirement	(mm)	60	4	61	110	23
Gross requirement	(mm)	120	8	122	220	46
"	(l/sec/ha)	0.45	0.03	0.46	0.85	0.17

- Continued

Table IV-25(5) WATER REQUIREMENTS OF EACH YEAR - HIMO RIVER SYSTEM (5)

5. Maize - Rainy Season -

	Month	F	M	A	M	J	J	F	M	A	M	J	J
Consumptive use	(mm)	60	97	150	152	119	71	60	97	150	152	119	71
Ratio of irrigation area		1/2	1	1	1	1	1/2	1/2	1	1	1	1	1/2
Pre-irrigation	(mm)	60	-	-	-	-	-	60	-	-	-	-	-
Year		1968						1974					
Effective rainfall	(mm)	0	97	118	71	0	0	0	6	136	68	37	44
Net deficit	(mm)	60	0	32	81	119	71	60	91	14	84	82	27
Net requirement	(mm)	90	0	32	81	119	36	90	91	14	84	82	14
Gross requirement	(mm)	180	0	64	162	238	72	180	182	28	168	164	28
"	(l/sec/ha)	0.74	0	0.26	0.60	0.92	0.27	0.74	0.68	0.11	0.63	0.63	0.10
Year		1969						1975					
Effective rainfall	(mm)	60	28	53	0	0	0	8	20	35	0	26	18
Net deficit	(mm)	0	69	97	152	119	71	52	77	115	152	93	53
Net requirement	(mm)	60	69	97	152	119	36	86	77	115	152	93	27
Gross requirement	(mm)	120	138	194	304	238	72	172	154	230	304	186	54
"	(l/sec/ha)	0.50	0.52	0.75	1.14	0.92	0.27	0.71	0.57	0.89	1.14	0.72	0.20
Year		1970						1976					
Effective rainfall	(mm)	26	97	118	49	0	0	60	97	150	78	18	6
Net deficit	(mm)	34	0	32	103	119	71	0	0	0	74	101	65
Net requirement	(mm)	77	0	32	103	119	36	60	0	0	74	101	33
Gross requirement	(mm)	154	0	64	206	238	72	120	0	0	148	202	66
"	(l/sec/ha)	0.64	0	0.25	0.77	0.92	0.27	0.50	0	0	0.55	0.78	0.25
Year		1971						1977					
Effective rainfall	(mm)	0	42	92	110	71	8	60	97	140	59	18	0
Net deficit	(mm)	60	55	58	42	48	63	0	0	10	93	101	71
Net requirement	(mm)	90	55	58	42	48	32	60	0	10	93	101	36
Gross requirement	(mm)	180	110	116	84	96	64	120	0	20	186	202	72
"	(l/sec/ha)	0.74	0.41	0.45	0.31	0.37	0.24	0.50	0	0.08	0.69	0.78	0.27
Year		1972						1978					
Effective rainfall	(mm)	60	97	55	122	28	19	20	97	141	50	7	0
Net deficit	(mm)	0	0	95	30	91	52	40	0	9	102	112	71
Net requirement	(mm)	60	0	95	30	91	26	80	0	9	102	112	36
Gross requirement	(mm)	120	0	190	60	182	52	160	0	18	204	224	72
"	(l/sec/ha)	0.50	0	0.73	0.22	0.70	0.19	0.66	0	0.07	0.76	0.86	0.27
Year		1973						1979					
Effective rainfall	(mm)	29	0	67	68	27	0	60	78	93	80	14	7
Net deficit	(mm)	31	97	83	84	92	71	0	19	57	72	105	64
Net requirement	(mm)	76	97	83	84	92	36	60	19	57	72	105	32
Gross requirement	(mm)	152	194	166	168	184	72	120	38	114	144	210	64
"	(l/sec/ha)	0.63	0.72	0.64	0.63	0.71	0.27	0.50	0.14	0.44	0.54	0.81	0.24

-- Continued

Table IV-25(6) WATER REQUIREMENTS OF EACH YEAR - HIMO RIVER SYSTEM-(6)

6. Cotton

Month		M	A	M	J	J	A	S	M	A	M	J	J	A	S
Consumptive use	(mm)	63	65	79	102	133	163	185	63	65	79	102	133	163	185
Ratio of irrigation area		1/2	1	1	1	1	1	1/2	1/2	1	1	1	1	1	1/2
Pre-irrigation	(mm)	60	-	-	-	-	-	-	60	-	-	-	-	-	-
Year		1968							1974						
Effective rainfall	(mm)	63	65	71	0	0	45	0	6	65	68	37	44	0	0
Net deficit	(mm)	0	0	8	102	133	188	185	57	0	11	65	89	163	185
Net requirement	(mm)	60	0	8	102	133	118	93	89	0	11	65	89	163	93
Gross requirement	(mm)	120	0	16	204	266	236	186	178	0	22	130	178	326	186
"	(l/sec/ha)	0.45	0	0.06	0.79	0.99	0.88	0.72	0.66	0	0.08	0.50	0.66	1.22	0.72
Year		1969							1975						
Effective rainfall	(mm)	28	53	0	0	0	27	0	20	35	0	26	18	50	10
Net deficit	(mm)	35	12	79	102	133	136	185	43	30	79	76	115	113	175
Net requirement	(mm)	78	12	79	102	133	136	93	82	30	79	76	115	113	88
Gross requirement	(mm)	156	24	158	204	266	272	186	164	60	158	152	130	226	176
"	(l/sec/ha)	0.58	0.09	0.59	0.79	0.99	1.02	0.72	0.61	0.23	0.59	0.59	0.49	0.84	0.68
Year		1970							1976						
Effective rainfall	(mm)	63	65	49	0	0	0	8	63	65	78	18	6	0	17
Net deficit	(mm)	0	0	30	102	133	163	177	0	0	1	84	127	163	168
Net requirement	(mm)	60	0	30	102	133	163	89	60	0	1	84	127	163	84
Gross requirement	(mm)	120	0	60	204	266	326	178	120	0	2	168	254	326	168
"	(l/sec/ha)	0.45	0	0.22	0.79	0.99	1.22	0.69	0.45	0	0.01	0.65	0.95	1.22	0.65
Year		1971							1977						
Effective rainfall	(mm)	42	65	79	71	8	17	0	63	65	59	18	0	42	0
Net deficit	(mm)	21	0	0	31	125	146	185	0	0	20	84	133	121	185
Net requirement	(mm)	71	0	0	31	125	146	93	60	0	20	84	133	121	93
Gross requirement	(mm)	142	0	0	62	250	292	186	120	0	40	168	266	242	186
"	(l/sec/ha)	0.53	0	0	0.24	0.93	1.09	0.72	0.45	0	0.15	0.65	0.99	0.90	0.72
Year		1972							1978						
Effective rainfall	(mm)	63	55	79	28	19	24	36	63	65	50	7	0	0	0
Net deficit	(mm)	0	10	0	74	114	139	146	0	0	29	95	133	163	185
Net requirement	(mm)	60	10	0	74	114	139	75	60	0	29	95	133	163	93
Gross requirement	(mm)	120	20	0	148	228	278	150	120	0	58	190	266	326	186
"	(l/sec/ha)	0.45	0.08	0	0.57	0.85	1.04	0.58	0.45	0	0.22	0.73	0.99	1.22	0.72
Year		1973							1979						
Effective rainfall	(mm)	0	65	68	27	0	0	0	63	65	79	14	7	38	9
Net deficit	(mm)	63	0	11	75	133	163	185	0	0	0	88	126	125	176
Net requirement	(mm)	92	0	11	75	133	163	93	60	0	0	88	126	125	88
Gross requirement	(mm)	184	0	22	150	266	326	186	130	0	0	176	252	250	176
"	(l/sec/ha)	0.69	0	0.08	0.58	0.99	1.22	0.72	0.49	0	0	0.68	0.94	0.93	0.68

- Continued

Table IV-25(7) WATER REQUIREMENTS OF EACH YEAR - HIMO RIVER SYSTEM-(7)

7. Vegetable - Rainy Season -

Month		F	M	A	M	J	J	F	M	A	M	J	J
Consumptive use	(mm)	28	85	131	140	110	48	28	85	131	140	110	48
Ratio of irrigation area		1/4	3/4	1	1	3/4	3/4	1/4	3/4	1	1	3/4	1/4
Pre-irrigation	(mm)	60	-	-	-	-	-	60	-	-	-	-	-
Year		1968						1974					
Effective rainfall	(mm)	0	85	118	71	0	0	0	6	131	68	37	44
Net deficit	(mm)	28	0	13	69	110	48	28	79	0	72	73	4
Net requirement	(mm)	67	0	13	69	83	12	67	59	0	72	55	1
Gross requirement	(mm)	134	0	26	138	166	24	134	118	0	144	110	2
"	(l/sec/ha)	0.55	0	0.10	0.52	0.64	0.09	0.55	0.44	0	0.54	0.42	0.01
Year		1969						1975					
Effective rainfall	(mm)	28	28	53	0	0	0	8	20	35	0	26	18
Net deficit	(mm)	0	57	78	140	110	48	20	65	96	140	84	30
Net requirement	(mm)	60	43	78	140	83	12	5	49	96	140	63	8
Gross requirement	(mm)	120	86	156	280	166	24	10	98	192	280	126	16
"	(l/sec/ha)	0.50	0.32	0.60	1.05	0.64	0.09	0.04	0.37	0.74	1.05	0.49	0.06
Year		1970						1976					
Effective rainfall	(mm)	26	85	118	49	0	0	28	85	131	78	18	6
Net deficit	(mm)	2	0	13	91	110	48	0	0	0	62	92	42
Net requirement	(mm)	61	0	13	91	83	12	60	0	0	62	69	11
Gross requirement	(mm)	122	0	26	182	166	24	120	0	0	124	138	22
"	(l/sec/ha)	0.50	0	0.10	0.68	0.64	0.09	0.50	0	0	0.46	0.53	0.08
Year		1971						1977					
Effective rainfall	(mm)	0	42	92	110	71	8	28	85	131	59	18	0
Net deficit	(mm)	28	43	39	30	39	40	0	0	0	81	92	48
Net requirement	(mm)	67	32	39	30	29	10	60	0	0	81	69	12
Gross requirement	(mm)	134	64	78	60	58	20	120	0	0	162	138	24
"	(l/sec/ha)	0.55	0.24	0.30	0.22	0.22	0.07	0.50	0	0	0.60	0.53	0.09
Year		1972						1978					
Effective rainfall	(mm)	28	85	55	122	28	19	20	85	131	50	7	0
Net deficit	(mm)	0	0	76	18	82	29	8	0	0	90	103	48
Net requirement	(mm)	60	0	76	18	62	7	62	0	0	90	77	12
Gross requirement	(mm)	120	0	152	36	124	14	124	0	0	180	154	24
"	(l/sec/ha)	0.50	0	0.59	0.13	0.48	0.05	0.51	0	0	0.67	0.59	0.09
Year		1973						1979					
Effective rainfall	(mm)	28	0	67	68	27	0	28	78	93	80	14	7
Net deficit	(mm)	0	85	64	72	83	48	0	7	38	60	96	41
Net requirement	(mm)	60	64	64	72	62	12	60	5	38	60	72	10
Gross requirement	(mm)	120	128	128	144	124	24	120	10	76	120	144	20
"	(l/sec/ha)	0.50	0.48	0.49	0.54	0.48	0.09	0.50	0.04	0.29	0.45	0.56	0.07

- Continued

Table IV-25(8) WATER REQUIREMENTS OF EACH YEAR - HIMO RIVER SYSTEM-(8)

8. Vegetable - Dry Season -

Month		A	S	O	N	D
Consumptive use	(mm)	52	104	176	189	159
Ratio of irrigation area		1/2	1	1	1	1/2
Pre-irrigation	(mm)	60	-	-	-	-
Year		1968				
Effective rainfall	(mm)	45	0	0	69	9
Net deficit	(mm)	7	104	176	120	150
Net requirement	(mm)	64	104	176	120	75
Gross requirement	(mm)	128	208	352	240	150
"	(l/sec/ha)	0.48	0.80	1.31	0.93	0.56
Year		1969				
Effective rainfall	(mm)	27	0	22	28	0
Net deficit	(mm)	25	104	154	161	159
Net requirement	(mm)	73	104	154	161	80
Gross requirement	(mm)	146	208	308	322	160
"	(l/sec/ha)	0.55	0.80	1.15	1.24	0.60
Year		1970				
Effective rainfall	(mm)	0	8	0	66	85
Net deficit	(mm)	52	96	176	123	74
Net requirement	(mm)	86	96	176	123	37
Gross requirement	(mm)	172	192	352	246	74
"	(l/sec/ha)	0.64	0.74	1.31	0.95	0.28
Year		1971				
Effective rainfall	(mm)	17	0	27	24	83
Net deficit	(mm)	35	104	149	165	76
Net requirement	(mm)	78	104	149	165	38
Gross requirement	(mm)	156	208	298	330	76
"	(l/sec/ha)	0.58	0.80	1.11	1.27	0.28
Year		1972				
Effective rainfall	(mm)	24	36	32	144	61
Net deficit	(mm)	28	68	144	45	98
Net requirement	(mm)	74	68	144	45	49
Gross requirement	(mm)	148	136	288	90	98
"	(l/sec/ha)	0.55	0.52	1.08	0.35	0.37
Year		1973				
Effective rainfall	(mm)	0	0	0	35	0
Net deficit	(mm)	52	104	176	154	159
Net requirement	(mm)	86	104	176	154	80
Gross requirement	(mm)	172	208	352	308	160
"	(l/sec/ha)	0.64	0.80	1.31	1.19	0.60

		A	S	O	N	D
		52	104	176	189	159
		1/2	1	1	1	1/2
		60	-	-	-	-
Year		1974				
Effective rainfall	(mm)	0	0	18	0	0
Net deficit	(mm)	52	104	158	189	159
Net requirement	(mm)	86	104	158	189	80
Gross requirement	(mm)	172	208	316	378	160
"	(l/sec/ha)	0.64	0.80	1.18	1.46	0.60
Year		1975				
Effective rainfall	(mm)	50	10	17	30	36
Net deficit	(mm)	2	94	159	159	123
Net requirement	(mm)	61	94	159	159	62
Gross requirement	(mm)	122	188	318	318	124
"	(l/sec/ha)	0.46	0.73	1.19	1.23	0.46
Year		1976				
Effective rainfall	(mm)	0	17	27	104	31
Net deficit	(mm)	52	87	149	85	128
Net requirement	(mm)	86	87	149	85	64
Gross requirement	(mm)	172	174	298	170	128
"	(l/sec/ha)	0.64	0.67	1.11	0.66	0.48
Year		1977				
Effective rainfall	(mm)	42	0	37	102	70
Net deficit	(mm)	10	104	139	87	89
Net requirement	(mm)	65	104	139	87	45
Gross requirement	(mm)	130	208	278	174	90
"	(l/sec/ha)	0.49	0.80	1.04	0.67	0.34
Year		1978				
Effective rainfall	(mm)	0	0	0	34	47
Net deficit	(mm)	52	104	176	155	122
Net requirement	(mm)	86	104	176	155	56
Gross requirement	(mm)	172	208	352	310	112
"	(l/sec/ha)	0.64	0.80	1.31	1.20	0.42
Year		1979				
Effective rainfall	(mm)	38	9	0	0	126
Net deficit	(mm)	14	95	176	189	33
Net requirement	(mm)	67	95	176	189	17
Gross requirement	(mm)	134	190	352	378	34
"	(l/sec/ha)	0.50	0.73	1.31	1.46	0.13

- Continued

Table IV-25(9) WATER REQUIREMENTS OF EACH YEAR - HIMO RIVER SYSTEM-(9)

9. Banana - Rainy Season -

	Month	P	N	A	M	J	J	P	N	A	M	J	J
Consumptive use	(mm)	211	227	194	156	138	136	211	227	194	156	138	136
Ratio of irrigation area		1	1	1	1	1	1	1	1	1	1	1	1
Pre-irrigation	(mm)	-	-	-	-	-	-	-	-	-	-	-	-
Year		1968						1974					
Effective rainfall	(mm)	0	118	118	71	0	0	0	6	136	68	37	44
Net deficit	(mm)	211	109	76	85	138	136	211	221	58	88	101	92
Net requirement	(mm)	211	109	76	85	138	136	211	221	58	88	101	92
Gross requirement	(mm)	422	218	152	170	276	272	422	442	116	176	202	184
"	(l/sec/ha)	1.74	0.81	0.59	0.63	1.06	1.02	1.74	1.65	0.45	0.66	0.78	0.69
Year		1969						1975					
Effective rainfall	(mm)	113	28	53	0	0	0	8	20	35	0	26	18
Net deficit	(mm)	98	199	141	156	138	136	203	207	159	156	112	118
Net requirement	(mm)	98	199	141	156	138	136	203	207	159	156	112	118
Gross requirement	(mm)	196	398	282	312	276	272	406	414	318	312	224	236
"	(l/sec/ha)	0.81	1.49	1.09	1.16	1.06	1.02	1.68	1.55	1.23	1.16	0.86	0.88
Year		1970						1976					
Effective rainfall	(mm)	26	118	118	49	0	0	120	102	158	78	18	6
Net deficit	(mm)	185	109	76	107	138	136	91	125	36	78	120	130
Net requirement	(mm)	185	109	76	107	138	136	91	125	36	78	120	130
Gross requirement	(mm)	170	218	152	214	276	272	182	250	72	156	240	260
"	(l/sec/ha)	0.70	0.81	0.59	0.80	1.06	1.02	0.75	0.93	0.28	0.58	0.93	0.97
Year		1971						1977					
Effective rainfall	(mm)	0	42	92	110	78	8	60	114	140	59	18	0
Net deficit	(mm)	211	185	102	46	67	128	151	113	54	97	120	136
Net requirement	(mm)	211	185	102	46	67	128	151	113	54	97	120	136
Gross requirement	(mm)	422	370	204	92	134	256	302	226	108	194	240	272
"	(l/sec/ha)	1.74	1.38	0.79	0.34	0.52	0.96	1.25	0.84	0.42	0.72	0.93	1.02
Year		1972						1978					
Effective rainfall	(mm)	80	123	55	122	28	19	20	174	141	50	7	0
Net deficit	(mm)	131	104	139	34	110	117	191	53	53	106	131	136
Net requirement	(mm)	131	104	139	34	110	117	191	53	53	106	131	136
Gross requirement	(mm)	262	208	278	68	220	234	382	106	106	212	262	272
"	(l/sec/ha)	1.08	0.78	1.07	0.25	0.85	0.87	1.58	0.40	0.41	0.79	1.01	1.02
Year		1973						1979					
Effective rainfall	(mm)	29	0	67	68	27	0	113	78	93	80	14	7
Net deficit	(mm)	182	227	127	88	111	136	98	149	101	76	124	129
Net requirement	(mm)	182	227	127	88	111	136	98	149	101	76	124	129
Gross requirement	(mm)	364	454	254	176	222	272	196	298	202	152	248	258
"	(l/sec/ha)	1.50	1.70	0.98	0.66	0.86	1.02	0.81	1.11	0.78	0.57	0.96	0.96

- Continued

Table IV-25(10) WATER REQUIREMENTS OF EACH YEAR - HIMO RIVER SYSTEM-(10)

10. Banana - Dry Season -

	Month	A	S	O	N	D	J
Consumptive use	(mm)	100	124	130	140	168	198
Ratio of irrigation area		1	1	1	1	1	1
Pre-irrigation	(mm)	-	-	-	-	-	-
Year		1968					
Effective rainfall	(mm)	45	0	0	69	9	0
Net deficit	(mm)	55	124	130	71	159	198
Net requirement	(mm)	55	124	130	71	159	198
Gross requirement	(mm)	110	248	260	142	318	396
"	(l/sec/ha)	0.41	0.96	0.97	0.55	1.19	1.48
Year		1969					
Effective rainfall	(mm)	27	0	22	28	0	47
Net deficit	(mm)	73	124	108	112	168	151
Net requirement	(mm)	73	124	108	112	168	151
Gross requirement	(mm)	146	248	216	224	336	302
"	(l/sec/ha)	0.55	0.96	0.81	0.86	1.25	1.13
Year		1970					
Effective rainfall	(mm)	0	8	0	66	85	80
Net deficit	(mm)	100	116	130	74	83	118
Net requirement	(mm)	100	116	130	74	83	118
Gross requirement	(mm)	200	232	260	148	166	236
"	(l/sec/ha)	0.75	0.90	0.97	0.57	0.62	0.88
Year		1971					
Effective rainfall	(mm)	17	0	27	24	83	70
Net deficit	(mm)	83	124	103	116	85	128
Net requirement	(mm)	83	124	103	116	85	128
Gross requirement	(mm)	166	248	206	232	170	256
"	(l/sec/ha)	0.62	0.96	0.77	0.90	0.63	0.96
Year		1972					
Effective rainfall	(mm)	24	36	32	140	61	92
Net deficit	(mm)	76	88	98	0	107	106
Net requirement	(mm)	76	88	98	0	107	106
Gross requirement	(mm)	152	176	196	0	214	212
"	(l/sec/ha)	0.57	0.68	0.73	0	0.80	0.79
Year		1973					
Effective rainfall	(mm)	0	0	0	35	0	0
Net deficit	(mm)	100	124	130	105	168	198
Net requirement	(mm)	100	124	130	105	168	198
Gross requirement	(mm)	200	248	260	210	336	396
"	(l/sec/ha)	0.75	0.96	0.97	0.81	1.25	1.48

A	S	O	N	D	J
100	124	130	140	168	198
1	1	1	1	1	1
-	-	-	-	-	-
1974					
0	0	18	0	0	6
100	124	112	140	168	192
100	124	112	140	168	192
200	248	224	280	336	384
0.75	0.96	0.84	1.08	1.25	1.43
1975					
50	10	17	30	36	66
50	114	113	110	132	132
50	114	113	110	132	132
100	228	226	220	264	264
0.37	0.88	0.84	0.85	0.99	0.99
1976					
0	17	27	104	31	68
100	107	103	36	137	130
100	107	103	36	137	130
200	214	206	72	274	260
0.75	0.83	0.77	0.28	1.02	0.97
1977					
42	0	37	102	70	63
58	124	93	38	98	135
58	124	93	38	98	135
116	248	186	76	196	270
0.43	0.96	0.69	0.29	0.73	1.01
1978					
0	0	0	34	47	22
100	124	130	106	121	176
100	124	130	106	121	176
200	248	260	212	242	352
0.75	0.96	0.97	0.82	0.90	1.31
1979					
38	9	0	0	126	
62	115	130	140	42	
62	115	130	140	42	
124	230	260	280	84	
0.46	0.89	0.97	1.08	0.31	

Table IV-26(1) WATER BALANCE OF HINO RIVER SYSTEM (1)

Unit: m^3/sec

	J	F	M	A	M	J	J	A	S	O	N	D
1968												
DIS	0.41	0.42	0.97	2.46	3.56	5.46	2.32	1.66	0.98	0.65	1.06	2.46
DR	0.03	0.20	0.33	0.28	0.49	0.93	0.42	0.30	0.39	0.44	0.41	0.13
BAL	0.38	0.22	0.64	2.64	3.07	4.53	1.90	1.36	0.59	0.21	0.65	2.33
1969												
DIS	0.84	2.56	2.59	1.56	1.53	1.07	1.27	1.06	0.76	1.28	1.28	0.94
DR	0.02	0.14	0.53	0.61	1.00	0.93	0.42	0.33	0.39	0.41	0.37	0.15
BAL	0.82	2.42	2.06	0.95	0.53	0.14	0.85	0.73	0.37	0.87	0.91	0.79
1970												
DIS	0.85	1.20	3.15	7.43	4.77	3.65	2.82	1.57	1.13	0.73	0.59	0.47
DR	0.02	0.16	0.33	0.28	0.66	0.93	0.42	0.41	0.38	0.44	0.28	0.04
BAL	0.83	1.04	2.82	7.15	4.21	2.72	2.40	1.16	0.75	0.29	0.31	0.43
1971												
DIS	0.94	0.88	0.45	7.69	5.58	3.67	2.36	1.83	1.07	0.57	0.48	0.46
DR	0.02	0.20	0.47	0.37	0.25	0.39	0.39	0.36	0.39	0.38	0.38	0.05
BAL	0.94	0.68	-0.02	7.32	5.33	3.28	1.97	1.47	0.68	0.19	0.10	0.41
1972												
DIS	0.52	0.75	0.77	1.68	2.51	3.28	2.05	1.38	1.37	1.38	2.05	1.51
DR	0.02	0.14	0.33	0.59	0.18	0.72	0.34	0.35	0.28	0.35	0.10	0.09
BAL	0.50	0.61	0.44	1.09	2.33	2.56	1.71	1.03	1.09	1.03	1.95	1.42
1973												
DIS	2.00	1.28	1.12	1.44	1.84	1.36	0.96	0.76	0.44	0.39	0.35	0.33
DR	0.03	0.18	0.63	0.51	0.52	0.73	0.42	0.41	0.39	0.44	0.36	0.15
BAL	1.97	1.10	0.49	0.93	1.32	0.63	0.54	0.35	0.05	-0.05	-0.01	0.18
1974												
DIS	0.29	0.26	0.24	4.78	3.57	3.43	3.92	1.94	1.10	0.51	0.58	0.35
DR	0.03	0.20	0.61	0.23	0.52	0.66	0.23	0.41	0.39	0.40	0.44	0.15
BAL	0.26	0.06	-0.37	4.55	3.05	2.77	3.69	1.53	0.71	0.11	0.14	0.20

Note: DIS: Discharge
DR: Diversion requirement of Makuyuni and Ghona & Kileo schemes
BAL: Balance

- Continued

Table IV-26(2) WATER BALANCE OF HIMO RIVER SYSTEM (2)

Unit: m^3/sec

	J	F	M	A	M	J	J	A	S	O	N	D
1975												
DIS	0.42	0.36	0.95	2.19	1.73	1.19	1.94	1.22	2.07	1.08	0.43	0.38
DR	0.02	0.18	0.56	0.73	1.00	0.74	0.28	0.29	0.36	0.40	0.37	0.11
BAL	0.40	0.18	0.39	1.46	0.73	0.45	1.66	0.93	1.71	0.68	0.06	0.27
1976												
DIS	0.56	0.64	1.48	2.82	2.04	1.76	1.10	0.59	0.81	0.73	0.35	0.29
DR	0.02	0.14	0.33	0.21	0.44	0.79	0.40	0.41	0.34	0.38	0.19	0.11
BAL	0.54	0.50	1.15	2.61	1.60	0.97	0.70	0.18	0.47	0.35	0.16	0.18
1977												
DIS	0.29	0.30	0.65	4.40	2.61	1.35	1.18	0.88	0.52	0.43	1.01	1.03
DR	0.02	0.15	0.33	0.24	0.55	0.79	0.42	0.30	0.39	0.34	0.19	0.07
BAL	0.27	0.15	0.32	4.16	2.06	0.56	0.76	0.58	0.13	0.09	0.82	0.96
1978												
DIS	0.99	0.71	1.34	3.10	2.54	2.30	1.64	0.80	0.40	0.38	0.36	0.61
DR	0.03	0.19	0.32	0.23	0.66	0.88	0.42	0.41	0.39	0.44	0.36	0.10
BAL	0.96	0.52	1.02	2.87	1.88	1.42	1.22	0.39	0.01	-0.06	0	0.51
1979												
DIS	0.45	2.83	2.20	4.70	3.96	3.43	2.26	1.76	1.81	1.46	0.88	0.61
DR	0.01	0.14	0.36	0.37	0.42	0.83	0.37	0.30	0.36	0.44	0.44	0.05
BAL	0.44	2.69	1.84	4.33	3.54	2.60	1.89	1.46	1.45	1.02	0.44	0.56

Table IV-27

SUMMARY OF IRRIGATION AREA

Unit: ha

	SCHEME AREA	RAINY SEASON Paddy	DRY SEASON Paddy	PERENNIAL CROPS	OTHERS
1. Rau River System					
(1) Njoro River	1,000	900	300	30	70
(i) Upper Mabogini Scheme	150	150	50	-	-
(ii) Mabogini Scheme	850	750	250	30	70 (sugar field)
(2) Rau River	1,300	1,100	350	120	80
(iii) Rau ya Kati	450	400	130	50	-
(iv) Chekereni	850	700	220	70	80 (pilot farm)
Total	2,300	2,000	650	150	150

2. Miwaleni Pump Lift Scheme	SCHEME AREA	RAINY SEASON						DRY SEASON		
		Paddy	Oil Seeds	Pulses	Maize	Cotton	Vegetables	Paddy	Cotton	Vegetables
	2,000	900	320	220	280	220	60	470	220	60

3. Himo River System	SCHEME AREA	RAINY SEASON						DRY SEASON			PERENNIAL CROPS
		Paddy	Seeds	Pulses	Maize	Cotton	Vegetables	Oil Seeds	Cotton	Veteta-bles	
(i) Makuyuni Scheme	500	-	150	100	120	100	20	130	100	20	10
(ii) Ghona & Kileo Scheme	500	150	100	70	80	70	20	120	70	20	10
Total	1,000	150	250	170	200	170	40	250	170	40	20

4. Groundwater Scheme	SCHEME AREA	RAINY SEASON					DRY SEASON		
		Oil Seeds	Pulses	Maize	Cotton	Vegetables	Oil Seeds	Cotton	Vegetables
(i) North Groundwater Scheme (14 Nos. of well)	840	252	168	210	168	42	490	160	42
(ii) East Groundwater Scheme (6 Nos. of well)	180	48	36	48	36	12	108	36	12
Total	1,020	300	204	258	204	54	598	204	54

Table IV-28

TOTAL WATER CONSUMPTION BY PROJECT

Unit: 10^6 m^3

1. Lower-Moshi Area

Year	Rau River System		Miwaleni Springs		Himo River		Ground water		Total		
	Rainy season	Dry season	Rainy season	Dry season	Rainy season	Dry season	Rainy season	Dry season	Rainy season	Dry season	Annual
1968	19.0	14.1	12.0	8.9	6.9	4.4	4.3	8.8	42.2	36.2	78.4
1969	24.3	14.6	17.6	9.2	9.5	4.3	7.8	8.3	59.2	36.4	95.6
1970	23.6	14.7	15.5	9.3	7.3	4.1	6.0	7.9	52.4	36.0	88.4
1971	22.7	14.1	14.0	9.0	5.4	4.2	5.1	7.9	47.2	35.2	82.4
1972	21.7	13.4	13.8	8.5	6.1	3.1	5.3	5.8	46.9	30.8	77.7
1973	25.9	13.8	17.9	9.0	8.0	4.7	7.6	8.7	59.4	36.2	95.6
1974	23.4	15.4	15.6	9.7	6.6	4.8	6.3	9.0	51.9	38.9	90.8
1975	26.4	15.0	18.7	9.5	9.2	4.1	8.1	7.9	62.4	36.5	98.9
1976	23.1	15.4	14.9	9.8	6.1	3.7	5.8	7.3	49.9	36.2	86.1
1977	24.7	13.2	16.8	8.3	6.5	3.5	6.9	6.7	54.9	31.7	86.6
1978	24.4	14.1	16.2	9.1	7.2	4.6	6.4	8.5	54.2	36.3	90.5
1979	23.2	14.4	14.9	9.3	6.5	4.1	5.6	8.3	50.2	36.1	86.3
Average	23.5	14.4	15.7	9.1	7.1	4.1	6.3	7.9	52.6	35.5	88.1
80% dependable supply	25.9	15.4	17.9	9.7	9.2	4.7	7.8	8.8	59.4	36.5	95.6

2. Other Schemes

(1)	Kahe NAFCO (1,400 ha, from Miwaleni Springs)	14.4	18.2	32.6
(2)	Existing deep wells including TPC (from groundwater extraction)			20.4

Fig. IV - 1

EXISTING IRRIGATION SYSTEMS

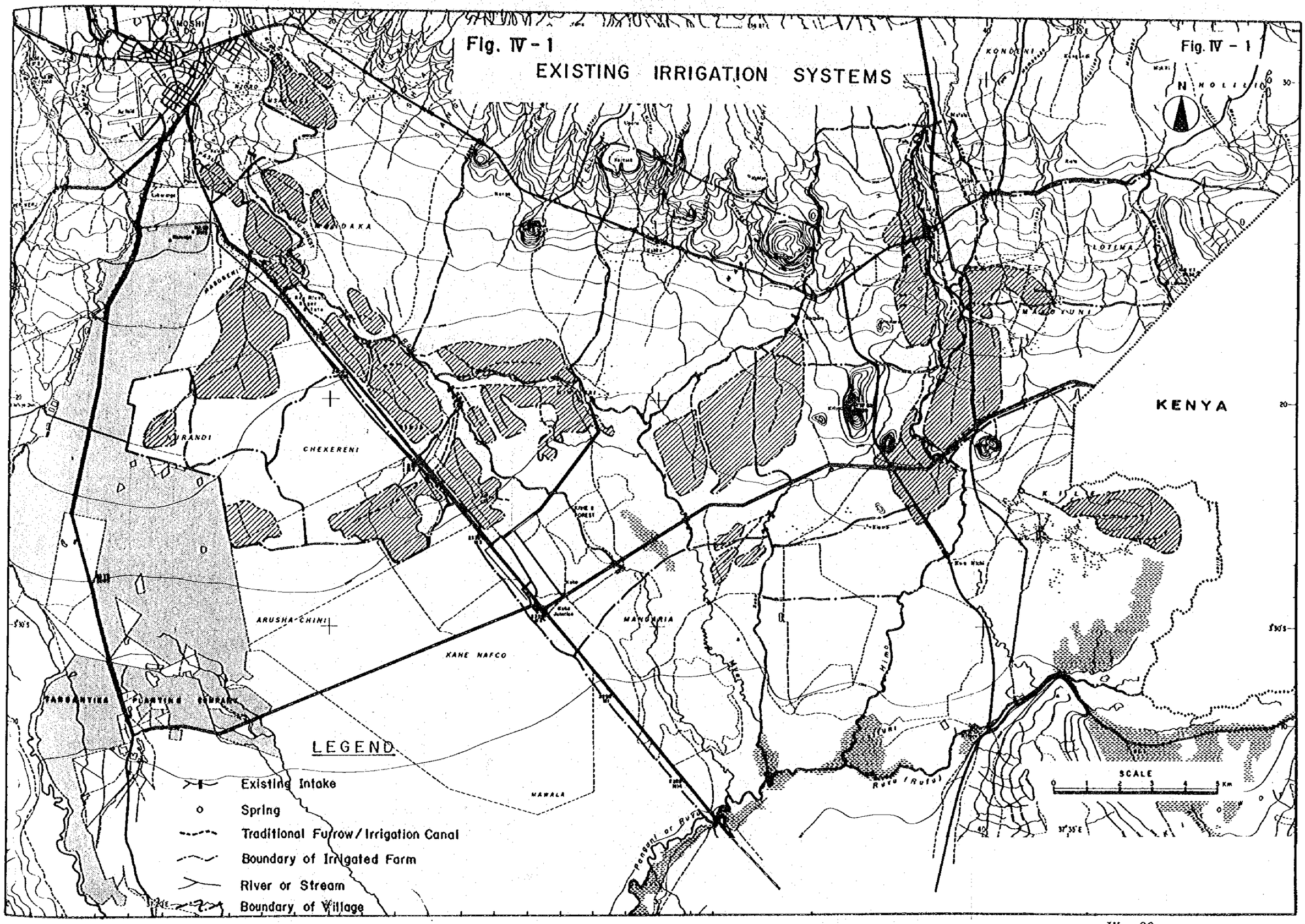


Fig. IV - 2 (1)

CROP COEFFICIENT CURVE

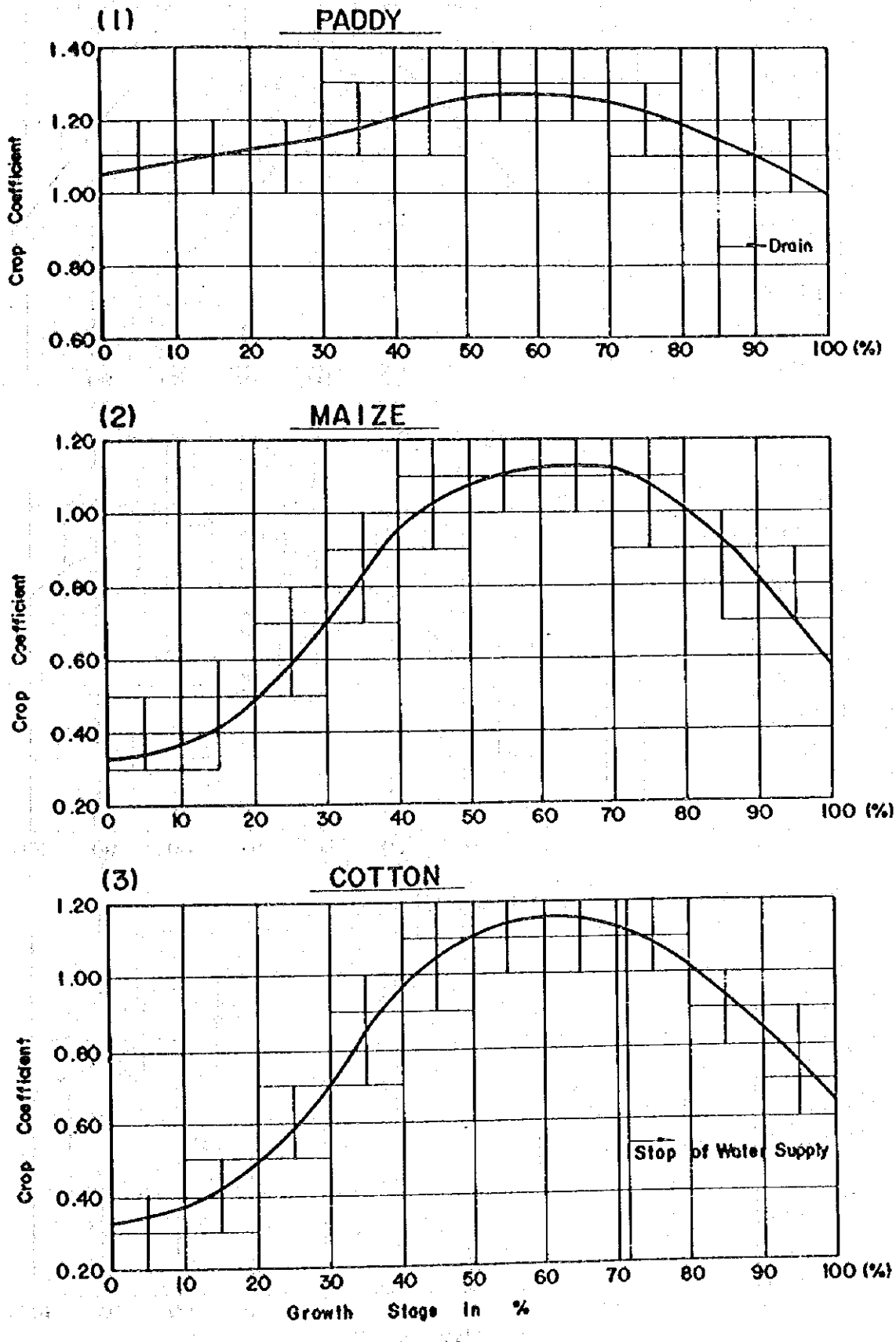


Fig. Ⅳ - 2 (2)

CROP COEFFICIENT CURVE

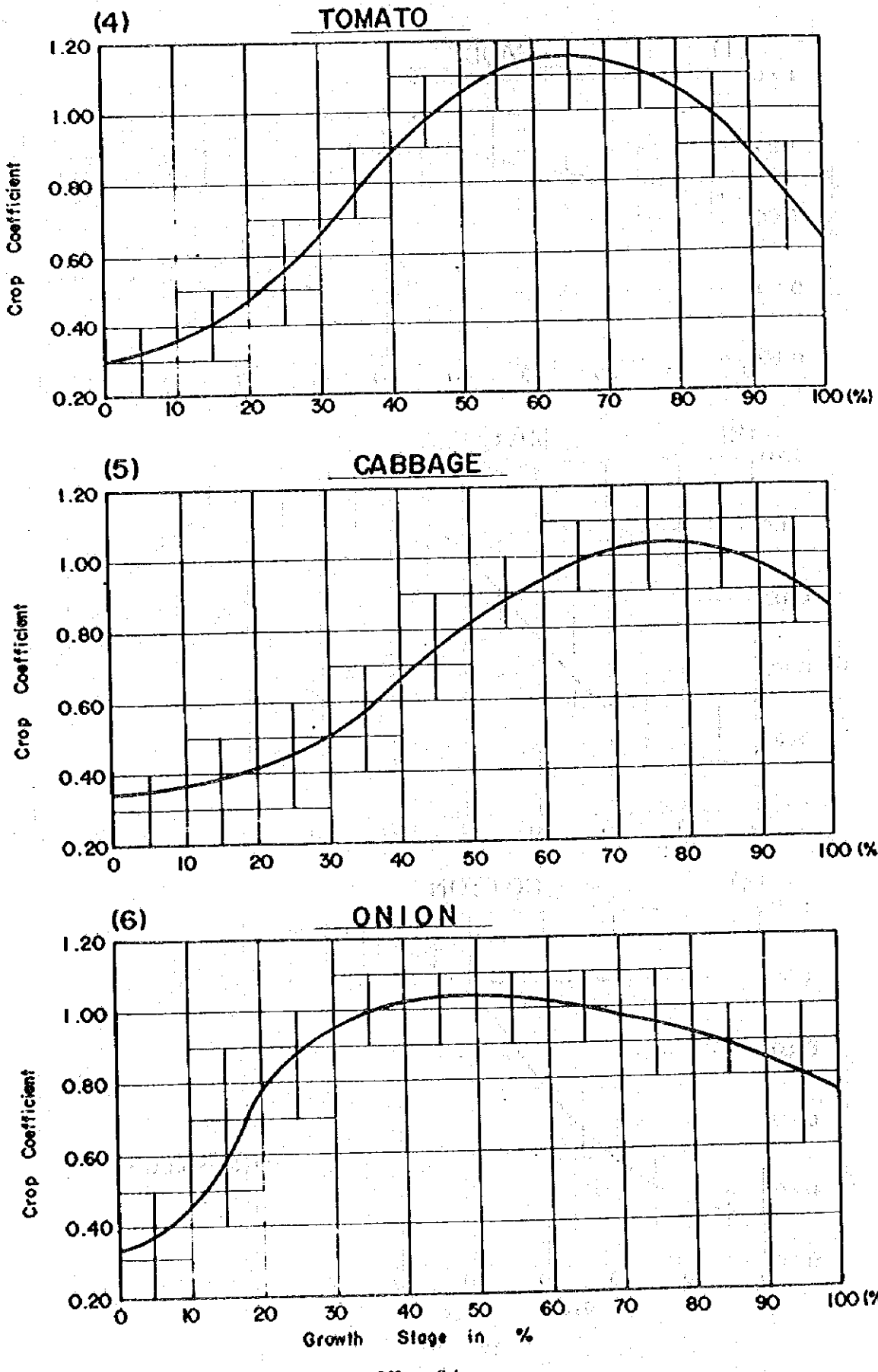
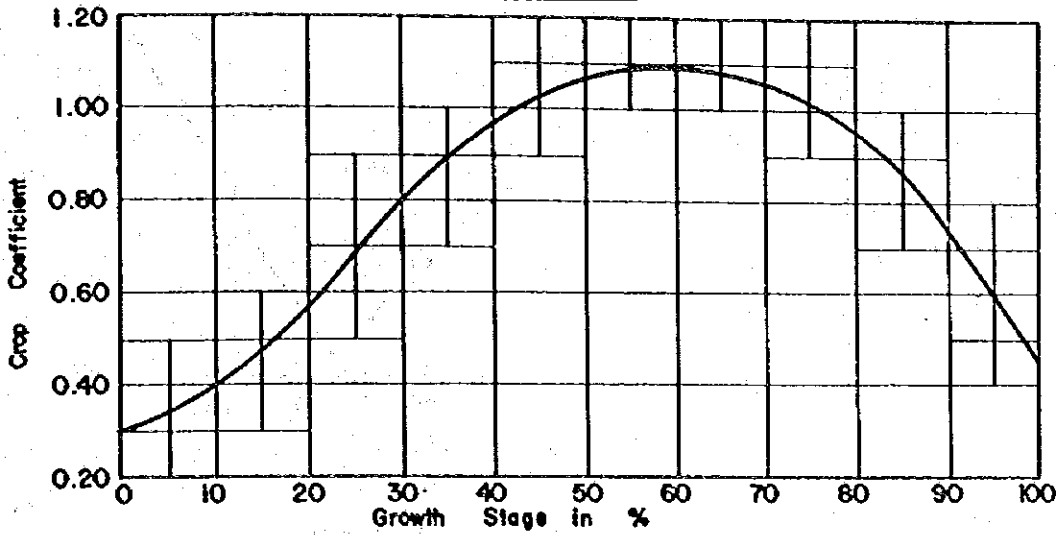


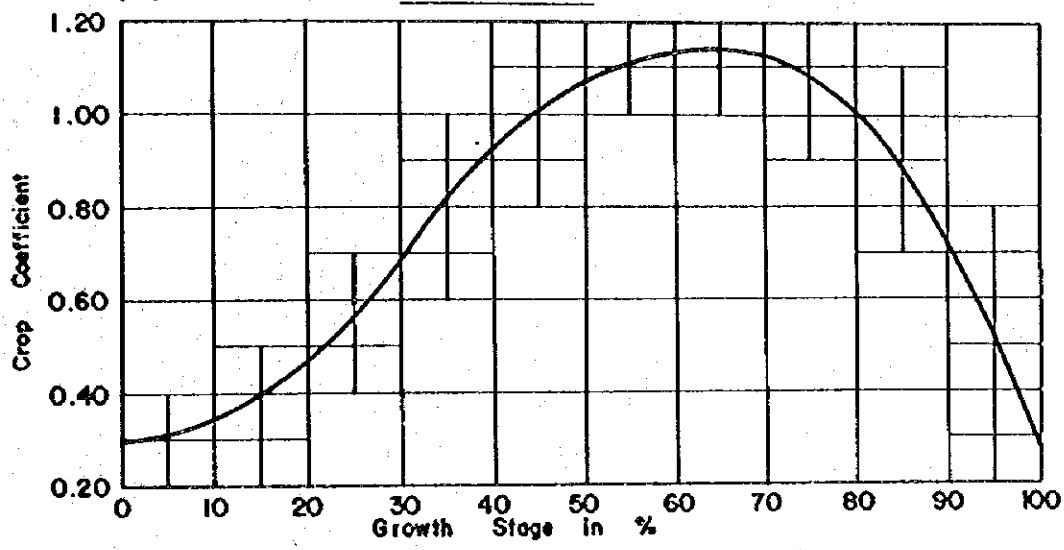
Fig. IV - 2 (3)

CROP COEFFICIENT CURVE

(7) SOYBEANS



(8) PULSES



(9) BANANA

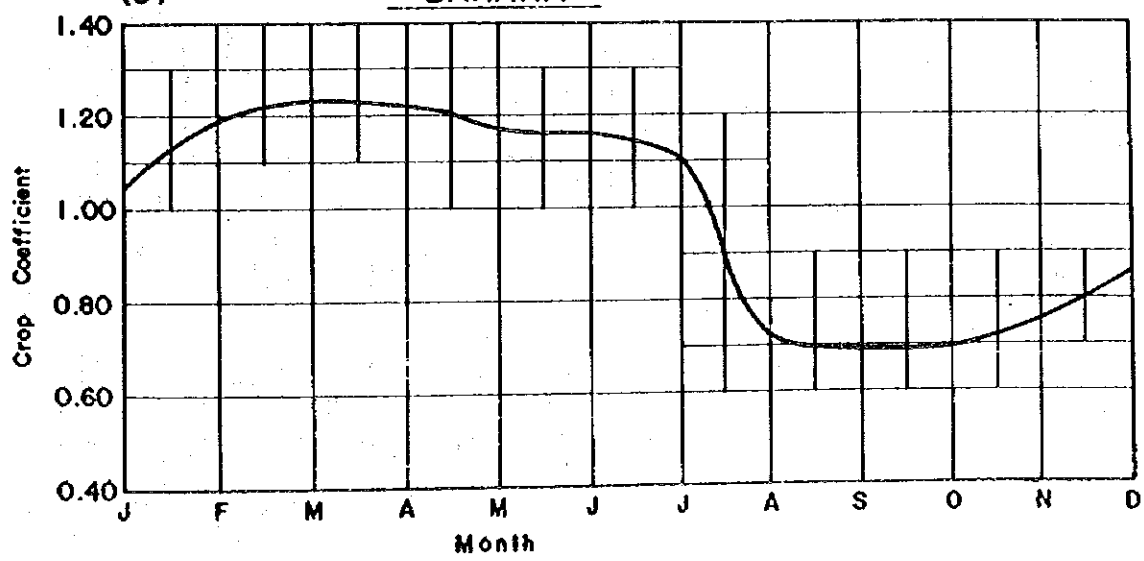
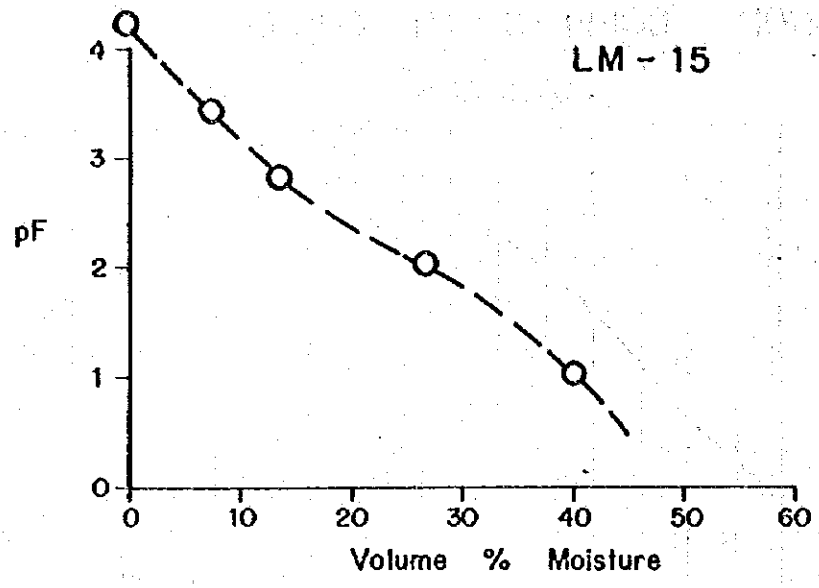
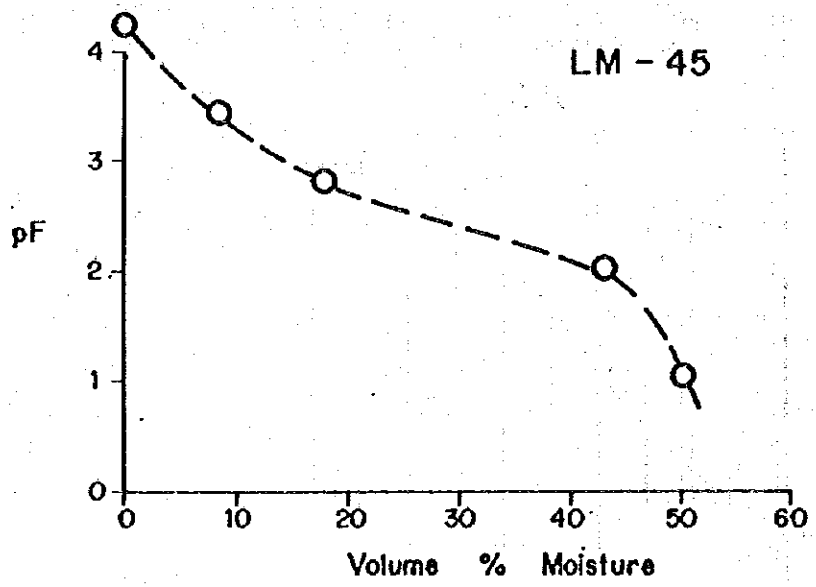
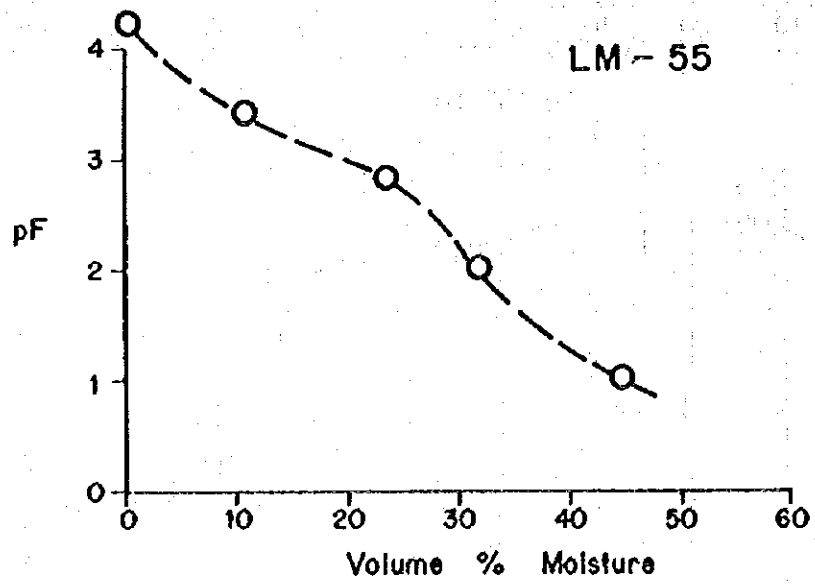


Fig. Ⅳ - 3 pF - CURVE







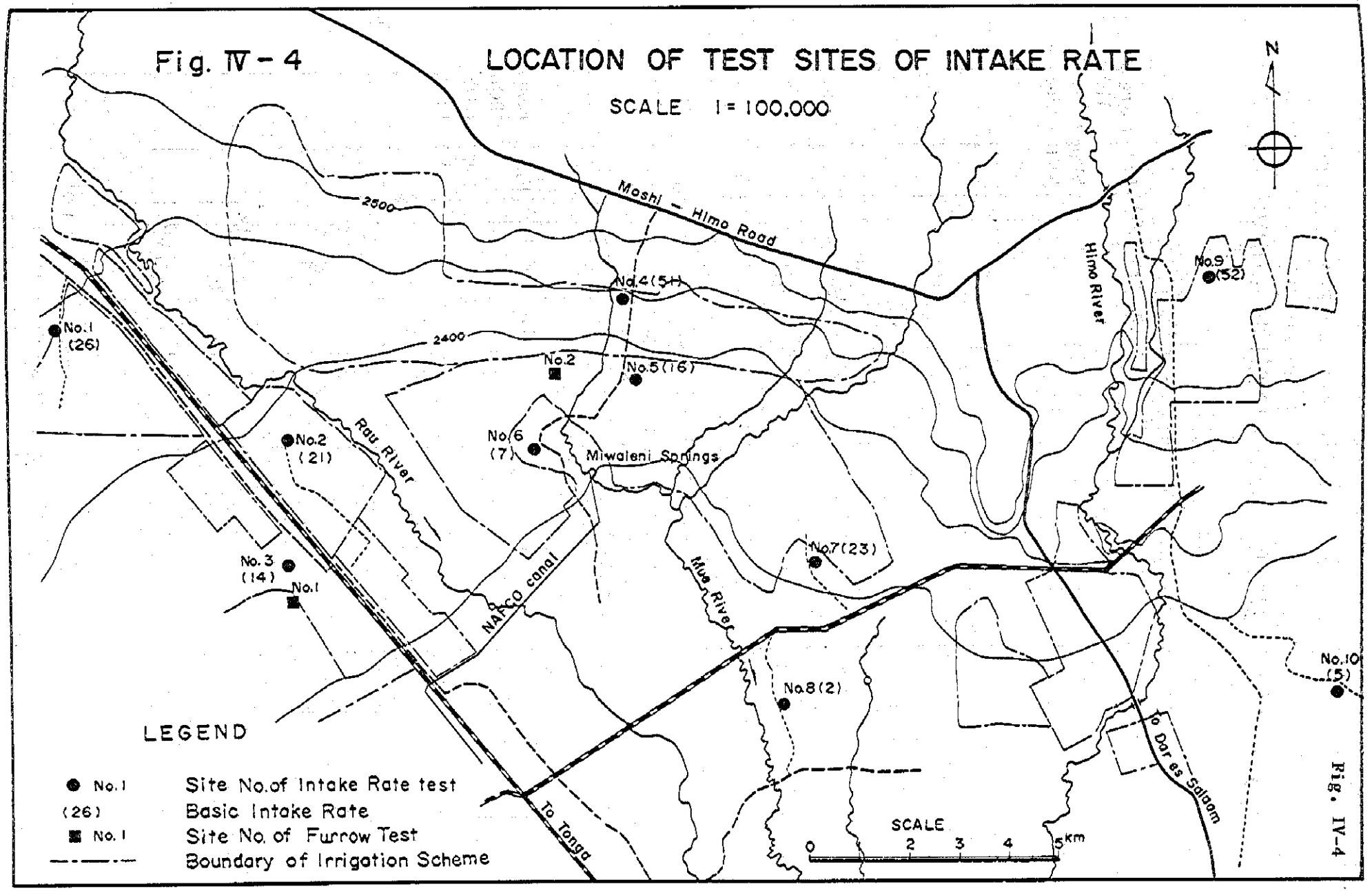
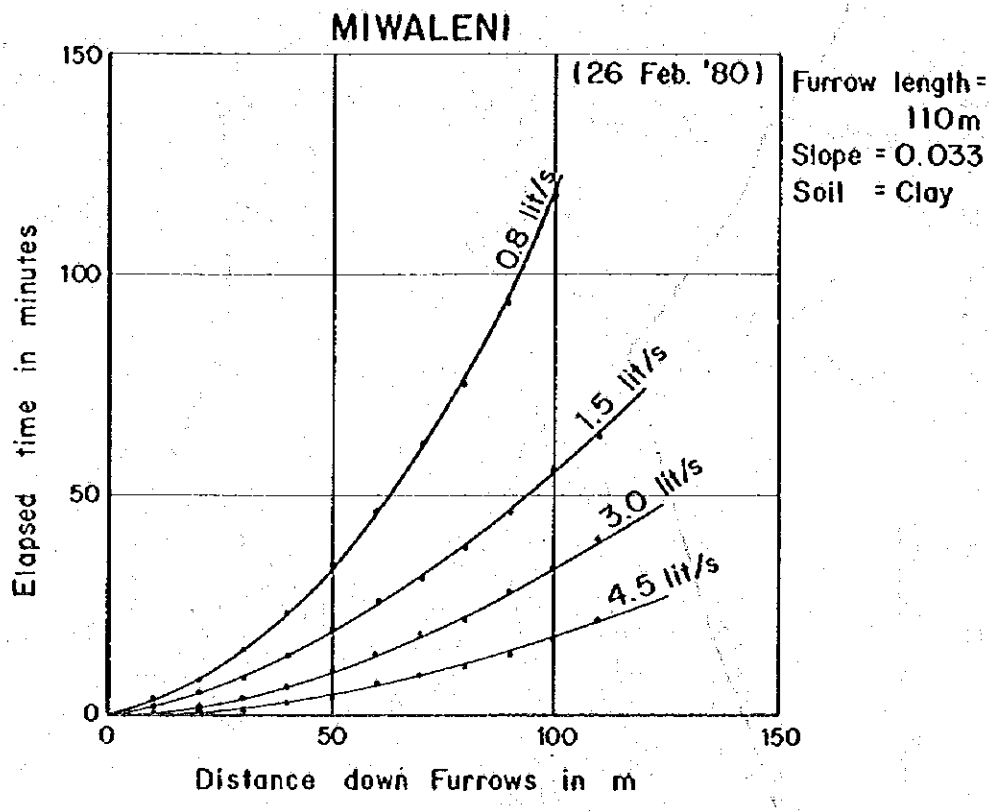


Fig. IV - 4
LOCATION OF TEST SITES OF INTAKE RATE
SCALE 1 = 100,000
N
Moshi – Himo Road
2500
2400
No.4 (51)
No.1 (26)
No.2
No.5 (16)
No.9 (52)
Himo River
No.2 (21)
Rau River
No.6 (7)
Miwaleni Springs
No.3 (14)
No.1
NAFCO canal
Mue River
No.7 (23)
No.8 (2)
No.10 (5)
To Dar es Salaam
To Tanga
LEGEND
No.1 Site No. of Intake Rate test
(26) Basic Intake Rate
No.1 Site No. of Furrow Test
Boundary of Irrigation Scheme
SCALE
0 2 3 4 5km

Fig. IV-4

Fig. IV-5 RATE-OF-ADVANCE CURVE



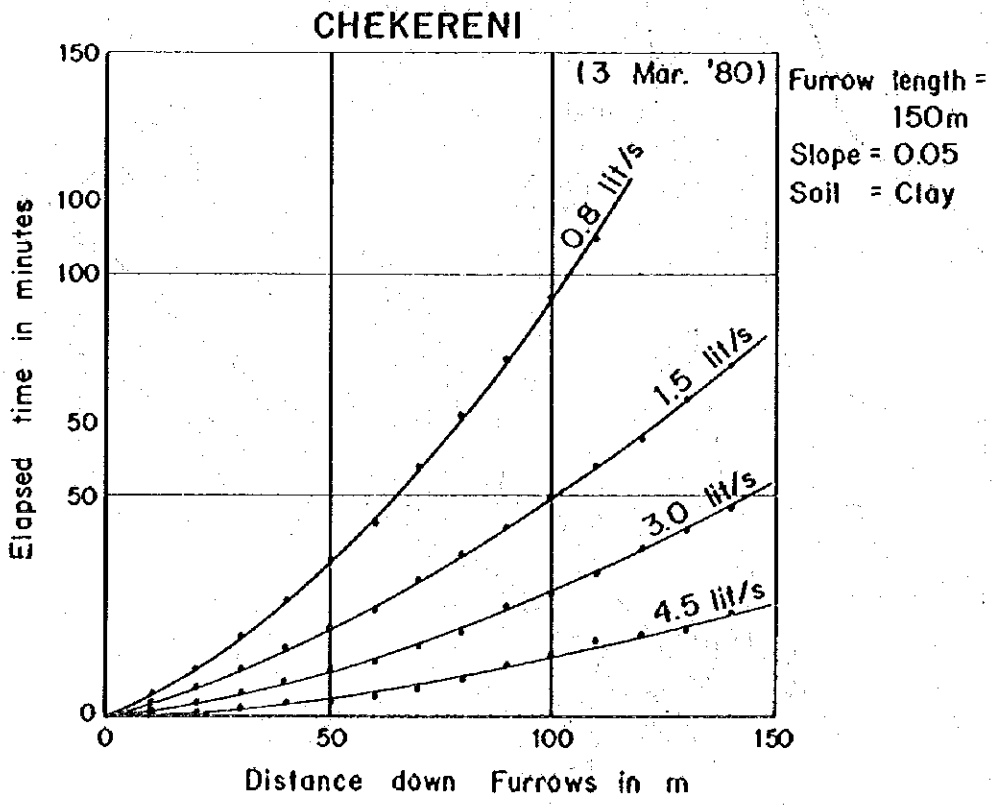
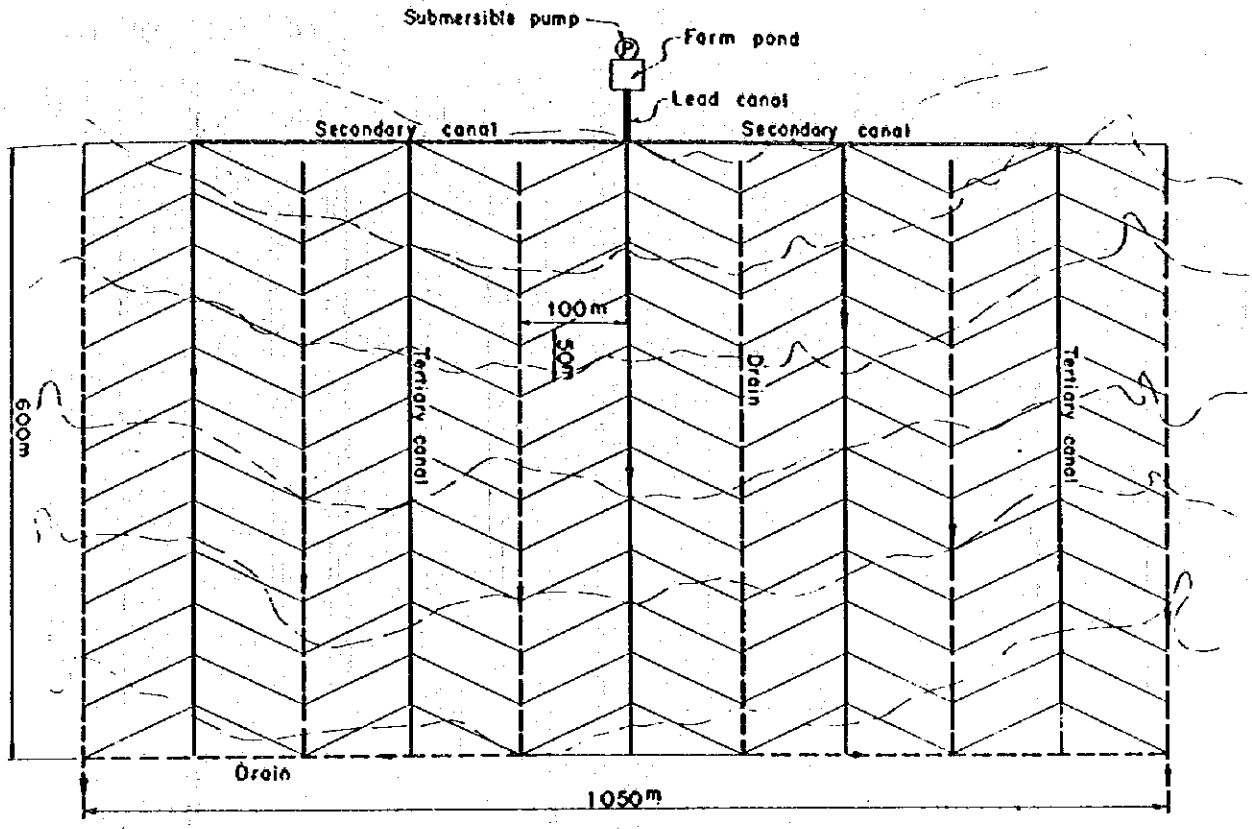
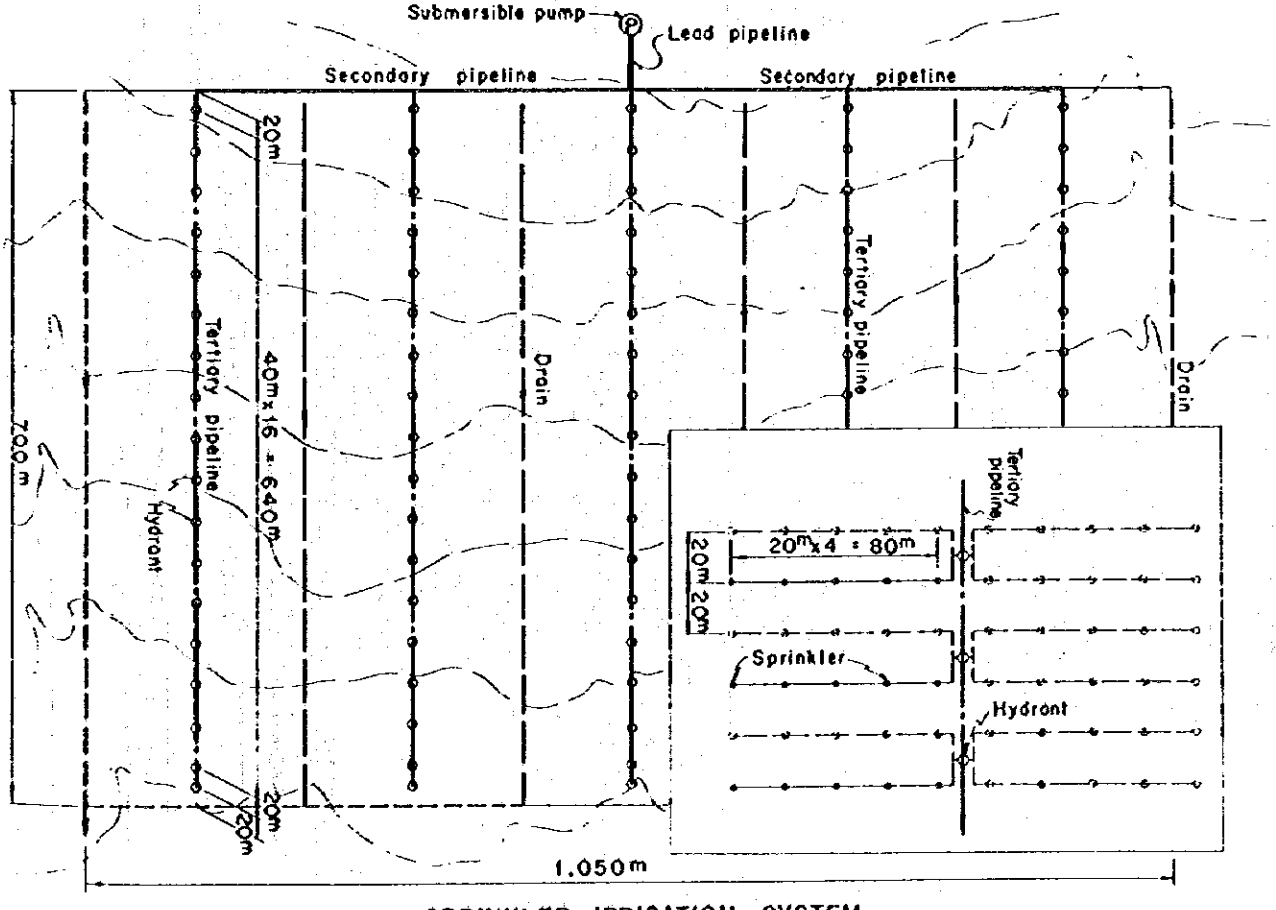


Fig N-6 TYPICAL LAYOUT OF SURFACE AND SPRINKLER IRRIGATION SYSTEMS



SURFACE IRRIGATION SYSTEM



SPRINKLER IRRIGATION SYSTEM

Fig. IV-7 TYPICAL FIELD LAYOUT FOR UPLAND FIELD

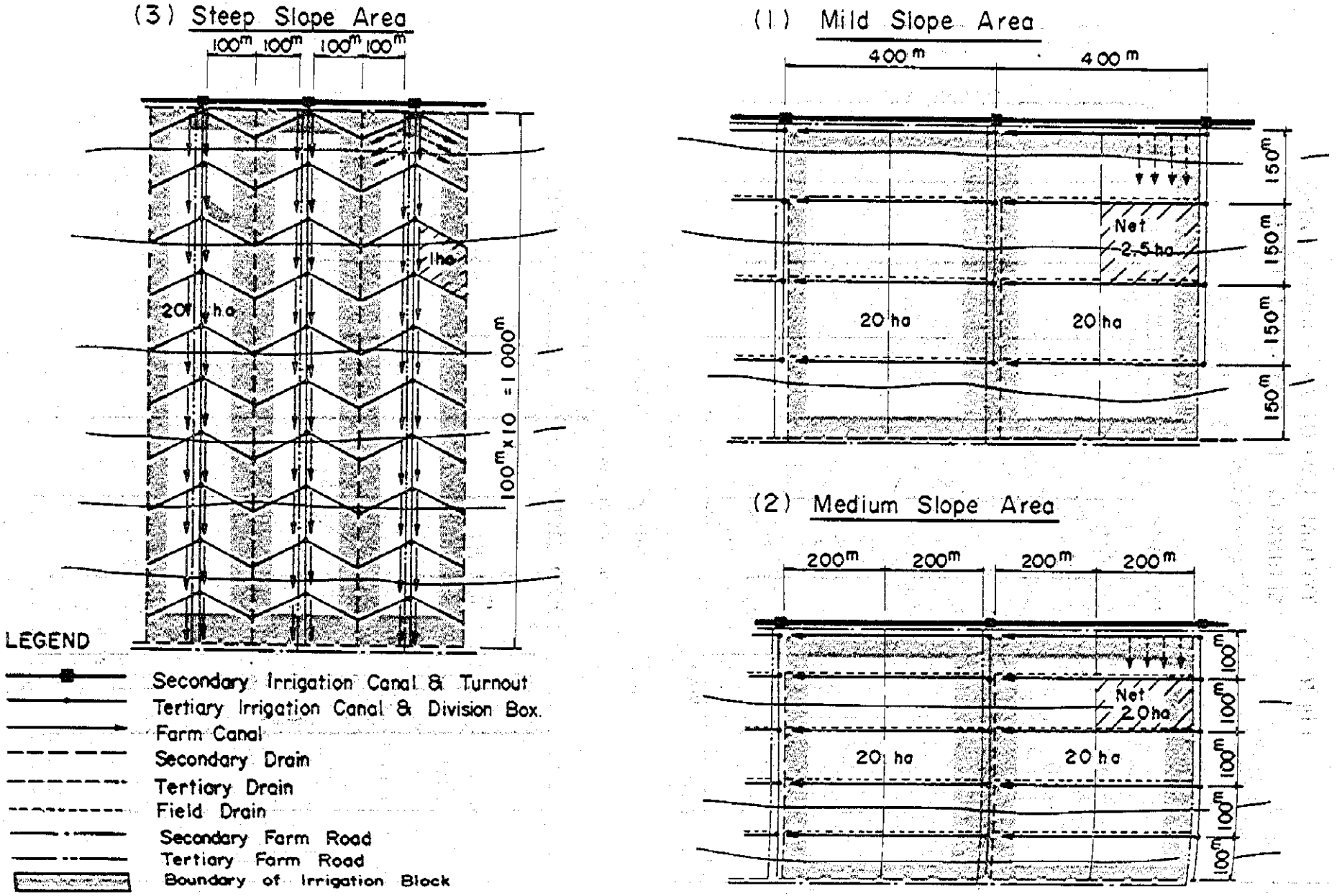
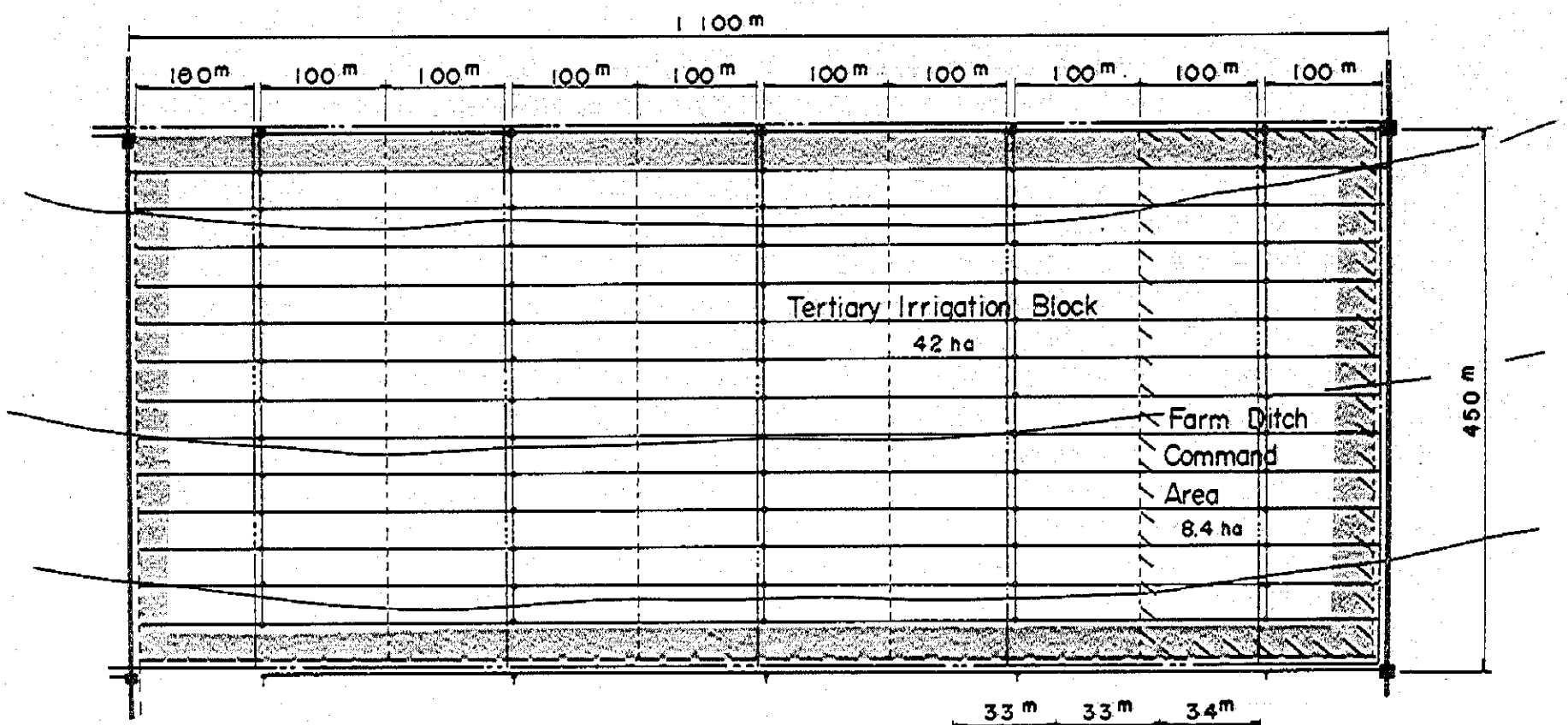
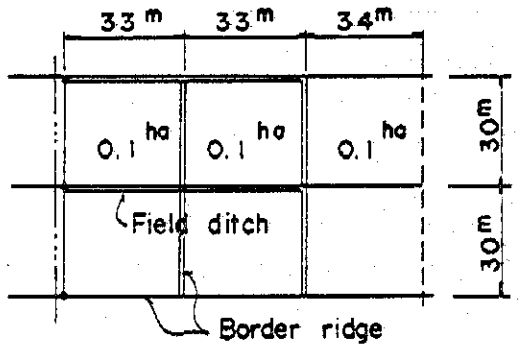


Fig. IV-8 TYPICAL FIELD LAYOUT FOR PADDY FIELD



LEGEND

- Secondary Irrigation Canal & Turnout
- Tertiary Irrigation Canal & Division Box
- Farm Ditch & Farm Outlet
- Tertiary Drain
- Farm Drain
- Secondary Farm Road
- Tertiary Farm Road
- Field Road



ANNEX V

AGRICULTURE

FEASIBILITY REPORT

ON

THE LOWER-MOSHI AGRICULTURAL DEVELOPMENT PROJECT

ANNEX V. AGRICULTURE

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ANNEX V

AGRICULTURE

1. General

The agricultural field investigation and studies were carried out in and around the Lower-Moshi area to clarify the present agricultural conditions and to assess the potential land productivity in the Project area. For this purpose, data and information were collected concerning land holdings, the land tenure system, land use, cropping patterns, crop yields and production, farming practices, farm inputs, etc. in and around the Lower-Moshi area.

The data and information were obtained mainly from the Kilimanjaro Regional Development offices and Moshi District Development offices concerned, and further from the National Milling Cooperation (NMC), General Agricultural Production and Exports Corp. (GAPEX), Tanzanian Cotton Authority (TCA), Tanzanian Authority of Coffer (TAC), Lyamungu Agricultural Research Center, etc. in Moshi. Besides, the field interview with farmers and village officials was made to obtain more practical information particularly on crop yields, farming practices and labour requirement.

Taking into account the physical nature of the land and the present agricultural conditions and also the socio-economic background of agriculture and the government policy for further agricultural development, the most applicable and profitable agricultural plan was formulated making reference to the land suitability classification and the study results on irrigation/drainage engineerings. In this context, the following studies are made thoroughly:

(1) Selection of suitable crops and their varieties based on their marketability, profitability, degree of domestic requirement, familiality of farmers, and plant characteristics to be capable to the soil and climatic conditions in the Project area.

(2) Formulation of the most suitable cropping pattern and proposed land use on the basis of the climatic conditions, irrigation cum drainage conditions to be anticipated in the future with the Project, the development plan formulated by the regional and district agricultural offices, the labour force available in an average farm household as well as in the whole Lower-Moshi area, and the plant physiological characteristics of crops studied by the Miwaleni Agricultural Experimental sub-station under the Lyamungu Agricultural Research Center.

(3) Estimation of the prospective unit yield and production, farm input requirements based on the present crop production in and around the Lower-Moshi area, results of crop experiments, and soil and future irrigation/drainage conditions.

(4) Improvement of the present farming practices, taking into consideration the available labour force, prospective field conditions to be improved in the future with the project, characteristics of crop varieties to be introduced, the prevailing pests and diseases in and around the Lower-Moshi area.

2. Present Conditions of Agriculture

2.1 Land Use

Recently, agricultural in the Lower-Moshi area has been almost completely developed by spontaneous transmigrants and the arable land has been reclaimed close to its possible maximum for the agricultural production.

At present, the land survey programme has not yet started in the Lower-Moshi area, and no reliable estimation on its area is available. Thus, the present condition of land use is approximated by the use of base maps (1:5,000 and 1:50,000) with the information collected from the field investigation and the aerial photo-interpretation (1:25,000 of contact prints, shot in August, 1979). In this context, the following land categories are preliminarily for estimating the extent area to assess the land potential for the future development and to assist land reclamation planning.

The land categories herein defined are:

A. Agricultural Land

a. Upland field:

1) Irrigable land; The land is managed by the traditional furrow system and irrigated in certain extent. Various kinds of crop are grown under irrigated conditions. The intensity of the present land use is 100% to 125%.

2) Rainfed land; The land has no irrigation facilities. Maize and some millet, beans, etc. are grown under rainfed conditions. The intensity of land use is less than 90%.

b. Paddy field: The land has irrigation facilities and paddy rice is grown under irrigated conditions. Some beans and vegetables are also grown as

	secondary crops after harvesting paddy rice. The intensity of land use is estimated at about 100 to 125%.
c. Estate farm:	The land includes the saisal and sugar estates which are managed by private farmers or companies. The large scale saisal estate has been already closed and the land transferred to the Government though saisal is still grown in certain acreages.
d. Grassland:	The land is densely covered with the wild grasses and most land is now used for the livestock grazing. For land reclamation in the future, it is required to clear acacia thorn-bushes to a certain extent.
B. Village yard	The land includes some extent of gardens for banana and other home-consumable crops.
C. Non-agricultural Land	
a. Swampy land;	The land, which is seasonal marsh, is covered with swampy grasses, such as reeds, cattail, etc. The flood water stands more than 120 consecutive days from April to August.
b. Brush land;	The land is rather densely covered with secondary forest and shrub which are mainly composed of acacia thorn-trees.
c. Wild palm land;	The land lies waste from any economic activities due to soils which are strongly affected by salinity and alkalinity. The land has also brackish groundwater at shallow depth in the surface.
d. Forest;	The land is the forest reserve and gallery forest along the river banks.

According to the land classification made in the above, the present conditions of the land use and/or extent of natural vegetation

are approximated as shown in Present Land Use Map attached to this report. The extent area in each land category is estimated as shown in Table V-1.

2.2 General Conditions of Agricultural Setting

Generally speaking, the agricultural setting in the Lower-Moshi area is characterized by small individually, owned farms and by cereal crop and stock production, in contrast with the coffee and banana plantation in the Highland area (so-called Upper-Moshi area).

In this agricultural setting, there are two types of land holding tenure. One is the "Kihamba", an almost freehold type of tenure. This tenure is, however, limited to only a small percentage of farmers, who have settled in the area since long ago. In case of this Kihamba tenure, the land holdings are rather sizable (more than 15 ha.) and these lands are traditionally cultivated by the tenant or contract systems. The land fee is generally paid by the crop production, but no common standardized sharing exists.

Almost all of the farm land in the Lower-Moshi area is being held by "Shamba", excluding the Kihamba type of land tenure. In the Shamba type of tenure, farmers are given out certain acreages of the arable land with the cultivation permission from the local authority, for example, the village committee. According to the statistical data provided by the village offices, the unit size of the land holding per farm family in the Shamba varies from 0.8 to 2.5 ha and is estimated at about 1.2 ha (3 acs.) on average as shown in Table V-2.

In this Lower-Moshi area, another type of agricultural is also found in almost half of the agricultural land. It is based upon traditional cultivation right and farmers are the seasonal migrants mainly from the Highland area. Generally, they hold the farm land less than 1 ha and grow maize and millet once a year mainly for their home consumption. The numbers of such households is estimated at more than 9,300 in total. Their distribution in each village is shown in Table V-2.

As seen in the land use map, the agricultural setting in the area is broadly classified into three zones; namely (1) Upland crop cultivation, (2) Paddy rice cultivation and (3) Live stock grazing.

(1) Upland crop cultivation is the most predominant agriculture in the area. It traditionally prevails in all of the villages except Kochakindo and some parts of Mangaria, Kisangesangeni, Kiomu, Makuyuni and Kileo where the soils are strongly affected by salinity and alkalinity. In this setting, farmers grow maize, beans and cotton as the major staples and other various crops, such as finger-millet, sorghum, sunflower, groundnut, sesame, sweet-potato, cassava, onion, cabbage, tobacco, etc. are also grown for supplemental home consumption and cash sources.

Until recently, so-called traditional furrows (irrigation facilities) have been exploited by the farmers themselves and about 4,240 ha of upland field or 24% of the total net cultivated area are irrigated supplementally in the rainy season. Although some of the above facilities have been improved by the local government, dry season cropping is still limited to only 200 ha or 3% of the irrigated rainy season cropping.

Generally, a mixed standing system of various kind of crops is traditionally prevalent in this area, and the cultivation of most crops is concentrated in the rainy season from March to July for the shorter-term crops and from March to November for cotton.

(2) Paddy rice cultivation has been recently introduced by the farmers in Mabogini, Mandaka, Rau ya Kati and Chekereni villages, in the lowlying area. Irrigation water comes from Njoro and other small springs. In other villages, such as Kisangesangeni, Mangaria, Kitereni and Kileo, some farmers also develop paddy field, but to a small extent, at present, due mainly to the shortage water for irrigation. Because of little research on paddy rice cultivation and also on the traditional cropping practices in the area, the yield and production of this paddy rice are still at subsistence levels.

(3) Live stock grazing is the most important agricultural element other than the cereal crop production in the Lower-Moshi area.

At present, there are in total about 25,490 cattle, 9,750 sheep and 26,820 goats in the Lower-Moshi area. Of them, almost all of the cattle, which mainly consist of Zobu, are concentrated in Kahe and Kileo wards and their grazing is rather extensively practiced by cattle farmers, using the wild grasses reserved in about 9,070 ha.

Generally, sheep and goat populations are even distributed over the whole Lower-Moshi area and their grazing is mainly for home consumption and cash earning by full use of the by-products from cereal crop cultivation.

The milk production from the above live stock is, at present, very limited to only local consumption. Poultry is also raised on subsistence basis in the area. The population of cattle, sheep and goats is summarized in Table V-3.

2.3 Present Cropping Pattern and Farming Practices

2.3.1 Cropping pattern

Owing to relatively mild climate for crop growth, excluding the uneven distribution of rainfall each year, various kind of crops have been introduced in the Lower-Moshi area. Of them, maize is the most predominant crop not only as a staple food product, but also as a cash source. At present, the cultivated area of maize is estimated at about 15,175 ha of which some 12,805 ha is rainfed, 2,265 ha are supplemented by irrigation in the rainy season, and 105 ha are under fully irrigated in the dry season.

Under the national maize campaign, such high yielding varieties as UCA (Ukiliguru Composit A.) and ICW (Ilonga Composit White) and Hibrids (serial No. 622 and 632) have been increasingly introduced in the irrigated area where the land is fed by traditional furrows. In this extension of high-yielding varieties, the seeds and farm-inputs are supplied by the Government with a subsidized price through the farmers' credit programme. In the rainfed area, however, farmers mainly grow the local varieties of maize mostly without the farm-inputs.

Maize cultivation in the area is generally started in early March and harvested in mid-May in the case of the local varieties, and from mid-June to July in the case of high-yielding varieties. For the dry season cropping of maize, the high yielding varieties are generally applied and grown during the months from October to February.

Beans are the second most important food crops in the upland field, followed by such minor crops as millet, sorghum, pigeon pea, sunflower, sesame, sweet-potato, cassava, ground-nut, tobacco, and such vegetables as onion, cabbages, okura, eggplant, etc. Due to the small size of holdings and the short rainy season (practically 3 months from mid-March to mid-May), a mixed stand of the above crops with maize is a common production practice, particularly in the rainfed area.

Banana and plantains also form an important part of the diet, consumed either raw and/or in the local beer. They are normally planted close to living quarters and/or in a small part of the Shamba where irrigation water is available.

Paddy rice, which is also a staple crop, is a rather new introduction in this area. Up to now, about 750 ha of paddy field is developed by the farmers themselves mostly in the lowlying area along the Njoro and Rau rivers and to a small extent in the Kileo and Soko areas. Because of the traditional farming practices still in use and also the shortage of irrigation water to a certain extent, production of paddy rice is at a low subsistence level.

For paddy cultivation, high yielding varieties are not introduced yet. The local varieties, prevalent in this area, are the oriva-sativa kind having more than 140 days growing period. The Main crop season is from January to May and no secondary cropping of paddy is practiced, at present.

Cotton is the main cash source in most of the irrigated land, particularly in Ujamaa village. Cotton is grown in the rainy season during the months from mid-May to mid-November with the supplemental irrigation. For the same season described in the preceding paragraph, cotton is also grown sometimes in mixed stands with maize, beans, sweet-potato, etc.

In the cotton cultivation, technical guidance and demonstration are rather intensively made by the field extension workers under direct management of the Tanzania Cotton Authority (TCA). The Authority also financially assists cotton growers to use farm-inputs through the credit programme. Cotton seeds are provided directly to the growers free of charge.

2.3.2 Farming practices

The soil preparation for both paddy field and upland field is mostly made by the use of farm tractors (60 ps) with disc ploughs (3-bottom) which are owned and managed by the District Agricultural Development office, Moshi. The charges for this soil preparation are Shs 400/ha in cases where the soils are hard and consolidated, and Shs 350/ha in cases having soft soil conditions. Harrowing practices in soil preparation are very rare at present. Tractor charges for harrowing are Shs 100 - 80/ha.

Use of animals for the soil preparation and other farming practices is very limited in this area. The farming practices other than the soil preparation are done manually. During the growing period of each crop, attention is paid by the farmers only to weed control.

Fertilizers and chemicals are used only for maize (high yielding varieties), cotton and vegetables. Although these inputs have been rarely used in past years, in the last two to three seasons application has been increasing due to the farmers' credit programme established by the Tanzania Cotton Authority and Tanzanian Rural Development Bank. Use of seeds of high yielding variety and chemical inputs is being demonstrated by agricultural extension workers, but proper practices are still limited to effective propagation, at present.

Irrigation operation is performed by farmers' individually, while maintenance of facilities is made as communal work in general.

2.3.3 Farm inputs and labour requirements

As stated in the former section, farm inputs such as seeds of high yielding varieties of maize and cotton, and fertilizers and chemicals are only used under the farmers' credit programme. Application of these farm inputs specified in the programme is summarized in Table V - 4. According to information obtained through field interview with the farmers, the actual dosage of fertilizers and chemicals is generally small. The fact is that the farmers use these inputs over wider areas than that specified in the credit or use a part for other crops, particularly for vegetables.

In the cultivation of vegetables, farmers Purchase the inputs commercially through farmers' corporation.

For crop production other than the above, farmers do not use any fertilizers and chemicals and seeds which are obtained from the farmer's own production are generally used. An average dosage of the farm inputs is also summarized in Table V-4.

The labour requirements for each crop are estimated as shown in Table V-5. All the works for farming except harvesting of cotton are operated by family labour which is sufficient. In case of cotton harvesting, some seasonal labourers are employed to supplement a shortage in the family labour force. The labour wages are Shs 8.85/day.

2.4 Crop Yield and Production

At present, no statistical data on crop yield and production are available in the Lower-Moshi area. For understanding the present production conditions, an estimation of production and unit yield were made on the major crops, making reference to the data provided by the TCA, NMC, GAPEX, NAFCO in Kahe and information collected from the village offices and local farmers and the field data obtained by field investigation. By comparing the referenced and field data, the present conditions of crop yield and production in each village are approximated in the following Tables from V-6 to V-9.

As seen in Table V-10 , about 17,470 ha of the land or 85 % of the total farm land is under cultivation with such crops as maize, cotton, beans, etc. The remaining part (about 15 % or 3,000 ha) is left fallow under a shifting cultivation schedule. Out of the total net cultivation area, maize growing occupies about 15,000 ha or 86 % of the total cultivation area in the rainy season, of which about 2,260 ha is tilled under irrigated conditions. The cultivation area by crops is summarized below:

Cultivated Area by Crops

(Unit: ha)

Major Crops	Rainy Season Cropping		Dry Season Cropping	Total
	Irrigated	Rainfed	Irrigated	
Maize	2,265	12,805	105	15,175
Cotton	640	-	-	640
Beans	-	775	120	895
Paddy	655	-	-	655
Vegetables	180	-	20	200
Other crops	-	590	-	590
Banana	-	-	495	495
Total	3,740	14,170	740	18,650

Unit yield of each crop is as follows:

Unit Yield of Major Crops (Unit: tons/ha)

Major Crops	Rainy Season Cropping		Dry Season Cropping
	Irrigated	Rainfed	Irrigated
Maize	1.76	0.92	1.76
Cotton	0.40	-	-
Beans	0.89	0.43	0.89
Paddy	1.40	-	-
Vegetables 1/	5.13	-	5.13
Other crops 2/	-	0.46	-

Note: 1/: Figures are shown based on average yield of dry onions.
2/: Figure is shown based on average yield of finger-millet.

As seen in the preceding Table, the effect of irrigation combined with improved farming practices clearly indicates that the unit yield under irrigated conditions is almost two times higher than that under the rainfed conditions. According to local opinion, however, after damage from a drought and/or after water from seasonal flooding stands for a certain amount of time, the unit yield of each crop sharply decreases to about 50% - 80% of the yield in normal years. In this Lower-Moshi area, the drought and/or seasonal flooding not only directly affects crop yield, but they also decrease the cropping acreages to a certain extent even in the irrigable area because of the small discharge capacity of rivers in a drought season.

Based on the cropping acreages and average unit yield in each crop presented above, the total production of major crops is estimated and summarized in the following Table.

Production of Major Crops

(Unit: tons)

Major Crops	Rainy Season Cropping		Dry Season Cropping	Total
	Irrigated	Rainfed	Irrigated	
Maize	3,870	11,480	180	15,530
Cotton	260	-	-	260
Beans	-	340	110	450
Paddy	920	-	-	920
Vegetables 1/	920	-	100	1,020
Other crops 2/	-	280	-	280

Note: 1/: The production is converted to dry onion basis.
2/: The production is converted to finger-millet basis.

3. Agricultural Development Plan

3.1 Basic Concept for Development

The agricultural development in the Lower-Moshi area was studied, taking into account the following objectives:

(1) Removal of the present agricultural constraints.

(2) Increasing the production of staple food crops as well as oil crops by means of crop intensification and diversification with provision of modernized irrigation, so as to contribute to the government policy for self-sufficiency in food and also to regional economy.

(3) Increasing the living standard of farmers by increasing their farm products.

The present constraints or hazards to agricultural production particularly focus on a shortage of irrigation water even in the rainy season due to uneven rainfall and rain water distribution. Seasonal flooding and/or the standing of deep water is caused by lack and/or small capacity of the existing culverts crossing the roads and by irrigation canals and railways particularly in the mid- and lower reaches of Rau and Mue rivers. A lack of all year link-roads and a farm road network also discourages farm operation and the marketing of farm-inputs and outputs.

The poor drainage conditions and shortage of irrigation water as well as poor infrastructure could be rectified by providing modernized technical irrigation and drainage facilities and their related facilities. The present low land-productivity could also improved through introduction of improved irrigation farming with proper fertilizer application and land consolidation.

The specific objective of the agricultural sector in the National Five Year Development Plan is the attainment of self-sufficiency in food grains and increase of oil seed production. Under the Development Plan, the Government of Tanzania has the strategy to increase the production of food crops (especially rice) through development of improved irrigation farming.

In the Kilimanjaro Region, at present, production of maize and wheat has surpassed self-sufficiency requirements; however, other food production is still short such requirements and heavy pressure is being applied by the growth of population to increase these agricultural productions. In the case of rice, although some 1,450 tons are marketed in the region, more than 4,000 tons of foreign rice is also imported to supply rural consumption. In addition, a large amount of food grain such as finger-millet, pulses, etc. and oil seeds are purchased from other regions. In the near future, it is considered that the population pressure on agricultural production will increase particularly for the Moshi Township which is expanding through industrialization and urban development (1976).

In the Lower-Moshi area, crop production at present shows a very small surplus, particularly for the food crops. Hence, the farmers' livelihood is at a subsistence level, even though reproduces about 230 tons of seed cotton, 60 tons of oil-seeds, and certain quantities of vegetables and has animal production from cattle grazing.

A countermeasure to the above situation is to increase unit yield of crops by intensification of land use pattern and introduction of modern farming practices. Efficient water utilization is the key to the successful intensification of land use and improvement of the traditional farming practices.

Under the circumstances stated above, the main concept of agricultural development in the Lower-Moshi area is as follows:

- to increase paddy production as much as possible by expansion of paddy acreage and introducing of double cropping with year-round irrigation and drainage facilities.

- to increase and stabilize yield and production of upland crops particularly of rainy season cropping through proper supplementation of irrigation, improvement of drainage, and introduction of improved farming practices.

- to increase oil seeds and vegetable production by means of crop intensification or diversification under year-round irrigated conditions.

With the above concept, the proposed agricultural development in the Lower-Moshi area is studied as presented hereinunder.

3.2 Proposed Land Use

As discussed in ANNEX III and IV, the potential arable land which is economically suitable for agricultural development is estimated as about 24,700 ha gross or about 60% of the whole Lower-Moshi area. According to the soil and topographic conditions, out of the 24,700 ha, about 15,300 ha of land is suitable for paddy cultivation, while 24,500 ha of land is suitable for irrigated upland crop cultivation.

The low availability of irrigation water is the most limiting factor on this development plan. Thus, out of the gross potentially arable land, the total irrigable land proposed for the project is estimated as about 7,200 ha, of which about 2,580 ha (or 2,190 ha net) of land can be irrigated year-round. In the total irrigable area, paddy field will be developed for about 3,520 ha (or 3,050 ha net), and remaining 3,680 ha (or 3,270 ha net) will be used for upland field, based on the soil and topographic conditions and the economic viability of water use. New reclamation in this irrigation development will be made for only about 590 ha of grass and brush land in the Kisangesangeni and Kiomu village areas.

Based on the project demarcation stated above, the forecast land use in the whole Lower-Moshi area is as shown in the following Table V-11. Without the project, no drastic change in land use could be anticipated from the present situation mainly due to the physical constraints which would remain over the whole area. The forecast land use acreage both with and without the project are summarized as below.

Forecast Land Use

(Lower-Moshi Area)

Specific Land Categories	Acreage With Project	Acreage Without Project	Increment
Upland field			
(1) Irrigable land advanced by technical irrigation	3,685	-	+3,685
(2) Irrigable land by traditional furrow	3,315	3,690	-375
(3) Rainfed land	10,230	16,070	-5,840
Paddy field			
(4) Irrigable land advanced by technical irrigation	3,520	-	+3,520
(5) Irrigable land with traditional furrow	340	740	-400
(Sub-total)	(21,090)	(20,500)	(+590)
Estates	1,180	1,180	0
Grazing reserves	8,910	9,070	-160
Village yards	890	890	-
Non-agricultural lands	9,850	10,280	-430
Total	41,920	41,920	± 0

Note: Figures are shown in gross acreage (ha).

In comparison with the forecast land use both with and without the project, the increment of the improved land attributed to the Project is about 7,200 ha, corresponding to about 35% of the total farm land without the Project.