THE UNITED REPUBLIC OF TANZANIA

FEASIBILITY STUDY ON THE MKOMAZI VALLEY AREA IRRIGATION DEVELOPMENT PROJECT

VOLUME II

ANNEXES

JANUARY 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

THE UNITED REPUBLIC OF TANZANIA

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IRRIGATION DEVELOPMENT PROJECT

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ANNEX A

METEOROLOGY AND HYDROLOGY

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1. GENERAL

Meteorological and hydrological investigations and studies were carried out to clarify the natural conditions in the project area and to assess the natural water resources of the project. Field investigations were made in the Mkomazi Valley area (1,900 km^2) during two periods from October 1982 to December 1983 and from May 1983 to June 1983. Data and information were collected at observation sites and from the authorities concerned (i.e. Water Office in Kilimanjaro Region, Project Preparation Division of the Ministry of Water and Energy and the Department of Meteorology of the Ministry of Transport and Communications). The collected information and the data obtained were used for studies in Japan dealing with the meteorology and hydrology. The results of these are reported in this annex.

2. METEOROLOGY

2.1 Observation Record

2.1.1 Meteorological record

There are three meteorological stations in and around the Mkomazi Valley area. These are listed below.

Name of Station	Organization	Commence-ment
1. Same meteorological station	Min. Transport. & Comm.	1962
2. Kalimawe meteo. station	Min. Water & Energy	1962
3. Buiko meteo. station	Min. Transport. & Comm.	1962

The location of the above three stations is shown in Fig. A-1. Of the above stations, data at the Kalimawe meteorological station was used the for the project studies because only the Kalimawe meteorological station is located in the Mkomazi river basin. The meteorology of the other stations is quite different from that of the Mkomazi river basin because to the effect of the South Pare Mountains.

Observations of temperature, humidity, wind velocity, evaporation, solar radiation and rainfall have been observed daily at the Kalimawe meteorological station located on the right bank of the Kalimawe dam. Collected daily data are processed monthly as shown in Tables A-1 and A-2.

2.1.2 Rainfall record

There are 12 rain gauge stations in and around the Mkomazi Valley area as listed below. Long term daily data observed continuously are, however, available at only the three stations of the Tia dam site, Gonja estate and the Kalimawe meteorological station. The observation periods of the other stations are rather short and often interrupted due to the breakage of the rain gauges.

Name of Station	Registered No.	Period of Record
Kwizu mission school	9438032	1961 - 1979
Kisiwani sisal estate	9437011	1949 -
Tia dam site	9437010	1962 -
Gonja estate	9438011	1937 -
Mtii primary school	9438050	1965 - 1973
Ndungu sisal estate	9438051	1974 -
Kalimawe meteo. station	9438040	1962 -
Ibaya	9337104	1968 - 1971
Dindera		1968 - 1971
Mbula		1968 - 1971
Mbugaya pundamilia		1968 - 1970
Kisima		1968 - 1970

The duration and kind of collected data are illustrated in Fig. A-2. Monthly rainfalls are processed based on the daily rainfall as shown in Table A-3.

In view of the particular importance of rainfall data for the irrigation development planning of the project, JICA (Japan International Cooperation Agencies) established five additional rain gauge stations in the catchment area of the Mkomazi river from November 1982 to June 1983.

- Manka secondary school (27th May '83)
- Mheza primary school (27th May '83)
- Mtii primary school (22th Nov.'82)
- Parane primary school (23th Nov.'82)
- Idaru primary school (28th May '83)

The locations of the existing rain gauge stations as well as the five new stations are shown in Fig. A-1.

2.2 Meteorology of Mkomazi Valley Area

2.2.1 Classification of seasons

The Mkomazi Valley area is located at around 4°to 4°30'S latitude and 37°55' to 38°10'E. The area is generally classified as tropical savanna. The climate in the area is affected by the north-east wind (from November to April) and by the south-east wind (from May to October). The North-east monsoon provides most of the annual rainfall. From the rainfall distribution shown in Fig. A-3 and A-4, the year can be classified into 2 seasons as follows:

(1) Rainy season from November to May:

(2) Dry season from June to October:

The rainfall in January and February is rather less than the other months and the rainy season can therefore be divided into two distinct seasons.

Taking into consideration that the rainfall in October is sometimes high, it is determined that the hydrological year begins in October and ends in September in the next year.

2.2.2 Meteorology of Mkomazi Valley area

The mean temperature recorded at the Kalimawe meteorological station ranges from 22°C to 28°C and has little seasonal variation. Both the monthly mean maximum and minimum temperature are 34.1°C and 16.2°C respectively. The annual average Class A pan evaporation observed at Kalimawe is 2,150 mm. The monthly average evaporation reaches its maximum in February; about 6.6 mm/day and its minimum in August; 5.5 mm/day. The annual average relative humidity is approximately 58 % at Kalimawe with very little seasonal variation. The main climatic features are summarized in Table A-1 and Fig. A-3.

The annual amount of rainfall in the Mkomazi river basin vaires substantially from place to place, generally there is much rainfall in the eastern slopes and highlands of the South Pare Mountains, less in the flat lowlands of the Mkomazi valley area and in the Mkomazi Game Reserve. As shown in Table A-3, the average annual rainfall at the Tia dam site station located in the highlands of the South Pare Mountains is about 1,430 mm which is about 3 times that at the Kalimawe meteorological station located in the lowlands of the Mkomazi valley. Based on the record and results of the investigations, the annual rainfall in the highest area of the South Pare Mountains can be assumed approximately at 1,500 mm in the northern part and 800 m in the southern part.

2.3 Rainfall Analysis

2.3.1 Correlation among rain gauge stations

A comparison of annual rainfalls between the Gonja estate station and other rain gauge stations was made as shown in Fig. A-5. No particular differences of the distribution pattern are observed among the stations.

2.3.2 Seasonal distribution

Monthly distribution patterns of the average rainfall at each rain gauge stations are shown in Fig. A-4. In the Mkomazi Valley area, more than 90 % of the annual rainfall occurs in the rainy season as shown

below.

Station	Altitude (mm)	Annual Rainfall (mm)	Rainy Season (%)	Dry Season (%)
Tia dam site	1,670	1,430	92	8
Gonja estate	549	870	91	9
Kalimawe meteo. station	508	470	92	8

2.3.3 Probability analysis of annual rainfall

Of the 12 stations, 6 stations with long-term observation records are selected for the probability analysis of non-exceedance. While the amount of rainfall in a hydrological year (from Oct. to Sep.) is utilized for the analysis, the annual rainfall in the calendar year is used at the Kisiwani sisal estate which has insufficient monthly records for the calculation of the annual rainfall in the hydrological year. Results of the analysis are shown in Fig. A-6 and summarized in the following table.

station	alti-tude (m)	Nos. of Data (Nos.)	Re-corded Max. (mm)	Return Period in Years 2 (mm)	5 (mm)	10 (mm)	20 (mm)	Re-corded Min. (mm)
Kwizu mission school	1,150	15	1,239	792	615	536	477	398
Kisiwani sisal estat	685	32	1,675	624	394	303	240	251
Tia dam site	1,670	20	2,664	1,397	1,095	959	857	872
Gonja estate	548	44	1,889	820	609	519	453	397
Ndungu sisal estate	533	16	1,283	653	425	333	268	340
Kalimawe meteo. station	508	20	1,007	430	284	224	182	187

Based on the above results, the annual rainfall at Kalimawe from 1979 to 1980 corresponds to once in 5 years occurence of a drought year, that from 1964 to 1965 to 10 years occurence and that from 1974 to 1975 to 20 years occurence.

2.3.4 Isohyetal analysis and basin rainfall

Taking into consideration the annual rainfall of the stations mentioned in the above section, an isohyetal map is prepared as shown in

Fig. A-1.

Based on the map, the following equations can be developed for calculation of basin rainfall.

$$RN = 0.33 \times RT + 0.52 \times RG + 0.15 \times RK \quad \ldots\ldots\ldots (2.1)$$
$$RH = 1.00 \times RT \quad \ldots\ldots\ldots (2.2)$$
$$RY = 0.40 \times RT + 0.60 \times RG \quad \ldots\ldots\ldots (2.3)$$
$$RL = 0.11 \times RT + 0.17 \times RG + 0.72 \times RK \quad \ldots\ldots\ldots (2.4)$$
$$RS = 0.15 \times RT + 0.49 \times RG + 0.36 \times RK \quad \ldots\ldots\ldots (2.5)$$

where: RN = Basin rainfall of Nakombo river
RH = Basin rainfall of Hingilili river
RY = Basin rainfall of Yongoma river
RL = Basin rainfall of Kamabaga river at Kalimawe dam
RS = Basin rainfall of Saseni river
RT = Rainfall at Tia dam site
RG = Rainfall at Gonja estate
RK = Rainfall at Kalimawe

Tia dam site, Gonja estate and Kalimawe meteorological station are applied in the above equations, since long term daily data are available for only the above three stations. The calculation is carried out daily and the results are summarized in monthly and are shown in Table A-4.

3. WATER RESOURCES

3.1 River and Basin

3.1.1 Mkomazi river

The Mkomazi river has a catchment area of about 1,490 km^2 for the Kalimawe dam at which the river length is about 70 km from north to south. It originates from the southern end of the North Pare Mountains and runs in an almost southeast direction down to the confluence with the Nakombo river, passing through the Mkomazi Game Reserve. The surface runoff of the river, however, does not always flow throughout the year. It appears occasionally at the occurrence of heavy rainfalls in the rainy season.

After joining with the Nakombo river, the Mkomazi river is called the Kambaga river and has surface runoff flowing nearly throughout the year. Passing through the Igoma gorge located 5 km downstream from the confluence with the Nakombo river, the river water spreads out and stagnates in the marshy area. Consequently, the stream of the river usually fades out during the dry season. After joining with the perennial rivers, Hingilili and Yongoma, the Kambaga river provides flow to the Kalimawe reservoir.

3.1.2 Major tributaries

There are four major tributaries (the Nakombo river, the Hingilili river, the Yongoma river and the Saseni river) which originate from the South Pare Mountains at elevations varying from 1,000 to 2,400 meters above sea level. The plentiful rainfall is distributed in the South Pare Mountains, particularly at its eastern slope from which the above tributaries receive most of their water throughout the year.

After leaving the South Pare Mountains, these tributaries spread out to the alluvial fan and then flows into the Mkomazi river. The catchment area of the above tributaries at the debouching point are shown in Fig. A-7 and listed as follows:

River	Catchment Area at Debouching Point (km^2)
Nakombo	32.5
Hingilili	55.8
Yongoma	70.5
Saseni	198.5

Although the catchment areas of these rivers have been developed over many generations for farming by the inhabitants, the forest

vegetation over 1,700 m has been preserved. Therefore, the above rivers can be employed as water source for the project, provided that the forest reservation works are not hampered.

3.2 Discharge and Water Level Record

3.2.1 Gauging station

There are two discharge measurement stations in the tributaries as shown in Fig A-8. One is at Kiruka (31.5 km^2) in the Hingilili river and the other at Gulutu (192 km^2) in the Saseni river. Observation water level records of the Kalimawe reservoir are also available and the collected data are shown in Fig. A-9.

The discharge measurement and water level recording at the above stations have been operated by the Water Office of Kilimanjaro Region in the Ministry of Water and Energy since 1963, as shown below.

Station	Water Level	Discharge	Period
Kiruka (1DB18) on Hingilili river (31.5 km^2)	Daily readings	current meter in rainy season	1963 - 1966 -
Gulutu (1DB2A) in Saseni river (192 km^2)	Daily readings Automatic recorder		1963 - 1971 1972 -
		current meter in rainy season	1963 -
Kalimawe dam	Daily reading	-	1963 -

In order to secure more reliable discharge data of the river, JICA established three additional water level gauge stations.

- Nakombo river in Kisiwani village (6th Dec. '82)
- Kambaga river at Njiro bridge (11th Jun. '83)
- Yongoma river in Ndungu village (10th Dec. '82)

The cross sections of the above stations are shown in Fig. A-10

3.2.2 Rating curve

Based on the discharge measurements mentioned above, the rating curve of each station were developed as shown in Fig. A-11 and below. The rating curve of Kisiwani, Njiro and Ndungu stations are developed based on the discharge measurements carried out during the survey period. The equation is parabola and as follows:

$$Q = A \times (H + C)^B$$

where Q = discharge (m^3/sec)
A and C = coefficient
B = 2
H = gauge reading in meter

Station			Period of Validity
Kisiwani (Installed by JICA on 6th Dec.1982)			
A = 14.26		C = -0.32	6 Dec. '82 - 15 Feb. '83
A = 10.42		C = -0.24	16 Feb. '83 -
Njiro (Installed by JICA on 11th Jun.1983)			
A = 5.29		C = -0.37	11 Jun. '83 -
Kiruka (1DB18)			
A = 12.505	B = 1.739	C = -0.28	11 Jan. '71 - 14 Dec. '79
A = 9.881	B = 5.184	C = 0	15 Dec. '79 - 1981
A = 22.07		C = -0.34	1982, 1983 -
Ndungu (Installed by JICA on 10 Dec. '82)			
A = 9.84		C = -0.40	10 Dec. '82 -
Gulutu (1DB2A)			
A = 0.0011	B = 18.331	H: lower than 1.475	
A = 0.0718	B = 7.515	H: higher than 1.475	
A = 20.50		C = -1.24	1982, 1983 -

The Gulutu station is located at a highly suitable site for discharge measurement and water level recording. The rating curve of Gulutu can be satisfactorily utilized for low range of water levels.

The Kiruka station is located at a rather good site for discharge measurement. The staff gauge of the station is installed at the curve of the Hingilili river. However, it is located at the opposite side of the access road, and it is difficult to read the staff gauge when the log bridge is submerged at flood time. Besides, at a point 30 m downstream from the staff gauge, there is a critical flow point, where the effects on the discharge can be observed during the high water level.

3.2.3 Discharge at gauging station

The daily discharge data are calculated by using the above mentioned rating curves prepared by the Project Preparation Division in the Ministry of Water and Energy in Dar es Salaam. The monthly mean discharges of the Hingilili river at Kiruka station and the Saseni river at Gulutu station are shown in Table A-5 and summarized below.

Unit: m^3/sec

River	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
Hingilili	0.96	0.68	0.84	1.02	0.77	0.56	0.41	0.38	0.36	0.34	0.76	1.42	0.71
Saseni	4.39	2.76	3.43	3.39	2.01	1.21	0.83	0.60	0.50	0.49	1.62	4.99	2.18

The relation between the discharge of both stations and the basin rainfall are examined as shown in Fig. A-12 and A-13, which show rather a close correlation.

3.3 Present Water Balance at Kalimawe Reservoir

The present water balance at the Kalimawe reservoir is simulated on the assumptions and approach mentioned hereunder, by using an electronic computer. The runoff from the catchment area of the Kalimawe dam is estimated in order to provide the basic data for water source development planning described in Annex F.

3.3.1 Present state of Kalimawe dam

The Kalimawe dam was constructed in 1963 to control occasional floods of the Mkomazi river and to supply irrigation water downstream. It has a catchment area of 1,492 km^2 and has about 5.5 x 10^6 m^3 of effective storage capacity at the crest of the spillway. The spillway of the dam has an overflow section equipped with stoplogs and a flushing sluice. An intake gate for irrigation is equipped at the left bank of the dam in order to supply irrigation water. Water taken from the intake passes through the concrete conduit under the dam body and flows into two canals at the outlet structure. The amount of water to be released from the intake is determined based on the farmers and inhabitants requests in the Kuhurio scheme. The principal features of these structures are listed below and shown in Fig. A-14. The reservoir capacity curve and reservoir surface area curve are shown in Fig. A-15.

Dam : Effective reservoir capacity
21,000,000 m^3 at full surface water level
(EL. 506.52 m)
5,500,000 m^3 at crest of spillway
(EL. 504.76 m)
Reservoir surface area
1,140 ha at EL. 506.52 m
680 ha at EL. 504.76 m

Spillway: Overflow section with stoplog
20 spans, width of one span = 3.36 m
total height of stoplog = 0.93 m
Flushing sluice with slide gate
2 lanes, width of one lane = 1.50 m
Flow capacity at water level = 507.43 m

with stoplogs = 320 m^3/sec approx.
without stoplogs = 520 m^3/sec approx.

Diversion structure:
Diameter of conduit = 0.91 m
Flow capacity = 1.2 m^3/sec approx. in maximum

Operation and maintenance works have been carried out by the Water Office in Kilimanjaro Region. The reservoir water level and the opening of the intake gate have been recorded since 1963 with some interruptions.

3.3.2 Principle of water balance formula

In a reservoir system, the relationship among inflow, outflow and storage over a certain time is generally given by the following equation.

$$\frac{dS(h)}{dt} = i - O \quad \text{.....(3.1)}$$

Where; S(h): storage in the reservoir as a function of water level
h : water level of reservoir
i : amount of inflow
O : amount of outflow

In the above equation, factors on inflow and outflow of the study are determined as follows, considering the present state of the reservoir.

(a) Inflow:
i) runoff from the catchment area, Q_i
ii) precipitation, Q_p

(b) Outflow:
iii) discharge from the spillway, Q_s
iv) discharge passing through the intake, Q_g
v) evaporation from the reservoir, Q_e

Using the above indexes, the equation (3.1) can be transferred as follows.

$$Q_i = \frac{dS(h)}{dt} + Q_s + Q_g + Q_e - Q_p$$

$$= \frac{S(ht) - S(ht-1)}{t} + Q_s + Q_g + Q_e - Q_p \quad \text{.....(3.2)}$$

Where S : storage capacity as a function of the water level
ht-1: previous reservoir water level

ht : reservoir water level at the time of measurement

t : time increment from t-1 to t

3.3.3 Water level at Kalimawe reservoir

Daily water levels of the Kalimawe reservoir have been recorded since November in 1963 with several interruptions. There are several staff gauges in and around the reservoir. Their relationships are obtained by the topographic survey during the survey period in 1982. The following table shows the elevations of specific points of the Kalimawe dam.

Unit:El.m

1.	Crest of Kalimawe dam	509.23
2.	Top of lining	506.80
3.	Design flood water level (108 ft)	507.43
4.	Full surface water level (105 ft)	506.52
5.	Top of intake tower (BM16)	507.831
6.	Zero point of staff gauge on the intake tower wall (1DB8)	
	; feet gauge	501.005
	; meter gauge	500.891
7.	Zero point of staff gauge in the approach channel of spillway (1DB13)	504.986
8.	Crest of spillway	504.76
9.	Top of spillway stoplog	505.69
10.	Bottom of flushing sluice	503.25
11.	Top of outlet structure	505.10
12.	Bottom of outlet structure	501.05
13.	Top of high level canal	503.96
14.	Bottom of high level canal	501.05

Based on the above relations, the recorded gauge heights are converted to the water levels as shown in Fig. A-9 in each 10 days mean. As shown in Fig. A-9, there is a certain correlation between the basin rainfal and the reservoir water level.

3.3.4 Computation of storage

The storage capacity and water surface area of the reservoir can be calculated according to the reservoir capacity curve and the reservoir surface area curve shown in Fig. A-15.

The variation of storage and surface area from 1963 to 1982 are computed on a 10 days mean basis.

3.3.5 Estimation of outflow

(1) Evaporation from reservoir

The evaporation from the reservoir is assumed at 70 percent of the observed evaporation of Class A-pan at the Kalimawe meteorological station. The following table shows the amounts of evaporation from the reservoir computed according to the reservoir surface based on the reservoir water level recorded.

Unit: mm/day

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
4.5	4.6	4.4	4.0	3.9	4.1	3.9	3.9	4.0	4.3	4.2	4.3	4.2

(2) Discharge from spillway

According to the operation record and information obtained from the site, the stoplogs and sluice gate installed are roughly operated to result in a certain leakage of water from the reservoir. The discharge from the spillway is estimated by following equation.

$$Q_S = C \times L \times H^{3/2}$$

Where Q_S = overflow discharge from stoplog crest (m^3/sec)
C = discharge coefficient (2.1)
L = effective width (3.36 x 20)
H = overflow depth of stoplog crest (m)

By using the recorded reservoir water level, Q_S are calculated on a 10 days mean basis. Q_S is estimated at 107 m^3/sec and 323 m^3/sec at the full surface water level (EL.506.52 m) and the high water level (EL. 507.43 m) respectively.

(3) Discharge from diversion structure

The amount of irrigation water released from the diversion structure is influenced by the reservoir water level, the opening condition of intake gate and the water level at the outlet structure.

The following equation gives the relationship between the discharge and the water level difference.

$$h = \left(\frac{n^2 \times L}{A^2 \times R^{4/3}} + \frac{f}{2 \times g \times A^2} \right) \times Q^2$$

Where h = water level difference (m)
n = roughness coefficient (0.02)

A = cross sectional area (0.65 m^2)
R = hydraulic radius (0.2275 m)
L = length (36.5 m)
f = coefficient of head loss due to intake gate
g = acceleration of gravity (9.8 m/sec^2)
Q = discharge passing through the diversion structure (m^3/sec)

3.3.6 Estimation of runoff from the catchment area

(1) Total runoff

Runoff to the reservoir can be computed based on the water balance formula given in equation (3.2) in Section 3.3.2 by the application of the outflow estimated beforehand. In the calculation, the recorded rainfall at the Kalimawe meteorological station is applied to the precipitation of the reservoir. The results of computation are shown in Table A-6. The runoff which can not be computed due to the lack of data is interpolated by the basin rainfall.

The runoff from the entire catchment area largely varies from year to year. During the past 20 years, the minimum and the maximum annual runoffs at the Kalimawe dam are estimated at 43 million m^3 and 665 million m^3 respectively. The average runoff is 166 million m^3.

(2) Runoff coefficient

The annual runoff coefficient of the Mkomazi river at the Kalimawe dam can be calculated by dividing annual runoff by amount of annual basin rainfall. The annual basin rainfall was estimated 660 mm and the catchment area is 1,492 km^2. The annual runoff coefficient is caluculated at 17 %.

3.4 Estimation of Available Water of Tributaries

3.4.1 Nakombo river

The monthly mean discharge of the Nakombo river at the gauging site is estimated based on the specific discharge of the Hingilili river and the ratio of its average rainfall to that of Hingilili river.

$$Q_1 = Q_k/A_k \times (R_1/R_k) \times A_1$$

Where: Q_1 = Discharge of the Nakombo river at gauging point
Q_k = Discharge of the Hingilili river at Kiruka gauging station
A_k = Catchment area of Hingilili river at Kiruka gauging station(31.5 km^2).
R_1 = Basin rainfall of Nakombo = 1,060 mm
R_k= Basin rainfall of Hingilili river = 1,440 mm
A_1 = Catchment area of Nakombo at debouching point = 48.5 km^2

The estimated results are shown in Table A-7 and summarized below. The annual runoff is estimated 25 million m^3.

Unit: m^3/sec

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
mean	1.09	0.77	0.94	1.54	0.88	0.65	0.46	0.43	0.41	0.39	0.86	1.61	0.80

3.4.2 Hingilili river

The catchment area of the Hingilili river is 55.8 km^2 at its debouching point from the South Pare Mountains. The catchment area at the Kiruka gauging station is approximately 31.5 km^2 calculated by using the topographic map with 1 to 50,000 in scale prepared by JICA in December 1982. The annual basin ranfall is estimated at 1,440 mm in Section 2.3.4.

The monthly mean discharge at the debouching point is estimated based on the specific discharge of the Hingilili river at Kiruka gauging station.

$$Q_l = Q_k/A_k \times A_l$$

Where Q_l = Discharge of Hingilili at debouching point
Q_k = Discharge of Hingilili at Kiruka gauging station
A_k = Catchment area at Kiruka station = 31.5 km^2
A_l = Catchment area at debouching point = 55.8 km^2

The estimated monthly mean discharges are shown in Table A-7 and summarized below. The annual runoff is estimated 39 million m^3.

Unit: m^3/sec

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	ave.
mean	1.70	1.20	1.48	1.80	1.37	1.00	0.72	0.68	0.64	0.61	1.35	2.52	1.26

3.4.3 Yongoma river

The catchment area of the Yongoma river is about 70.5 km^2 at its gauging station established by JICA. The catchment area is located between the catchment area of the Hingilili river and that of the Saseni river.

The annual basin rainfall is estimated at 1,160 mm in Section 2.3.4. It is almost the same as the average of the basin rainfalls of the Hingilili river and the Saseni river. Topography, vegetation and

other natural conditions in the area except rainfall are almost similar to those in the said two rivers.

As no discharge data for the basin is available, the discharge of the Yongoma river at the gauging station is estimated by using the mean value of the specific discharge of the Hingilili river and the Saseni river. The results are shown in Table A-7 and summarized below. The annual runoff is estimated at 37 million m^3.

Unit: m^3/sec

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	ave.
mean	1.87	1.25	1.55	1.74	1.23	0.85	0.60	0.54	0.49	0.47	1.14	2.48	1.18

3.4.4 Saseni river

The catchment area of 198.5 km^2 at the debouching point of the Saseni river is nearly equal to that of the Gulutu gauging station. Although the catchment area at the Gulutu gauging station had been estimated at 170 km^2, the acreage was checked again and confirmed to be using the new topographic map mentioned in Sub seciton 3.4.2. The monthly mean discharge of the Saseni river at the Gulutu station is shown in Table A-7 and summarized below. The annual runoff is estimated at 68 million m^3.

Unit: m^3/sec

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
Ave.	4.39	2.76	3.43	3.39	2.01	1.21	0.83	0.60	0.50	0.49	1.62	4.99	2.18

3.4.5 Runoff of Kambaga river at Njiro bridge

(1) Runoff from seasonal and occasional rivers

As mentioned before, only three rivers provide the surface runoff almost throughout the year to the Kalimawe reservoir. The total catchment area of the above rivers is only 175 km^2, which provide an average runoff of about 100 million m^3 a year. The remaining 66 million m^3 of water is provided by other small tributaries. These rivers have no perennial surface flow but only seasonal water in the rainy season. Moreover some of them have only occasional water when the catchment area receives heavy rainfall. Therefore it is quite difficult to estimate the runoff from the catchment area except for Nakombo, Hingilili and Yongoma. The balance between the total runoff at the Kalimawe dam and the total runoff from the above three rivers are calculated as the runoff from the seasonal and occasional rivers.

(2) Runoff of Kambaga river at Njiro bridge

In order to adapt to the water source development plan mentioned in ANNEX F, runoff of Kambaga river is estimated by means of following equations.

$$Q' = Q \times (A'/A) \times (R'/R) + Q_N$$

where Q' = runoff of Kambaga river at Njiro bridge
Q = runoff from seasonal and occasional rivers
A' = catchment area at Njiro bridge = 749 km^2
A = catchment area of seasonal and occasional rivers (1,317 km^2)
R' = basin rainfall at Njiro bridge (600 mm)
R = basin rainfall at Kalimawe dam (670 mm)
Q_N = discharge of Nakombo river (estimated in Section 3.3.1)

The results are shown in Table A-7. The annual runoff is estimated at 51 million m^3.

Unit: m^3/sec

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Abe.
mean	2.09	1.81	1.48	4.02	2.08	1.20	0.70	0.52	1.41	0.46	0.86	2.81	1.62

3.5 Water Quality

In order to check the water quality in the Mkomazi river, water samplings were carried out at the 8 locations shown below during the period of the field survey. Chemical tests were carried out in Japan.

(1) Kisiwani gauge site on Nakombo river
(2) Njiro bridge on Kambaga river
(3) Kiruka gauge site on Hingilili river
(4) Same-Tanga Road bridge on Hingilili river
(5) Gauge site on Yongoma river
(6) Kalimawe dam low level canal
(7) Gulutu gauge site on Saseni river
(8) Upstream of Saseni river

The electrical conductivity ranges from 20 to 248 micro mhos/cm and the Sodium Adsorption Ratio is less than 1.0. The results of the chemical analysis are shown in Table A-8. Based on the standard of United States Department of Agricurture, the water in Mkomazi Valley area is excellent for irrigation.

CLASSIFICATION OF IRRIGATION WATER (Standard of U.S.D.A.)

Class	Sodium Absorption ratio	Electrical Conductivity (micro mhos/cm)
Excellent		
C1 - S1	Less than 10	Less than 250
Good		
C1 - S2, C2 - S2, C2 - S1	Less than 18	Less than 750
Useful		
C1 - S3, C2 - S3, C2 - S3	Less than 26	Less than 2250
C3 - S2, C3 - S1		

4. FLOOD ANALYSIS

4.1 Flood Water Level Records

4.1.1 Saseni river

An automatic recorder has been in operation on the Saseni river since 1972. However no daily nor hourly rainfall have been observed in the catchment area of the Saseni river. Therefore, it is difficult to analyze the correlation of recorded flood and rainfall. It is very risky to simply adopt the recorded data for the flood control planning unless cross checking is made with the results estimated by other methods, because the rating curve is developed by the results of discharge measurement during the low water period. The recorded highest water level and discharge extrapolated from the cross section survey are shown below.

Year	Date	Gauge Height (m)	Estimated Discharge (m^3/sec)
1972	Dec. 10th	2.20	31
1973	Dec. 14th	2.38	38
1974	Dec. 28th	2.51	45
1975	Dec. 14th	2.55	49
1976	Jan. 11th	3.16	102
1977	Dec. 10th	2.52	46
1978	Dec. 13th	3.35	125
1979	Feb. 11th	2.70	60
1980	Dec. 18th	2.40	40
1981	Dec. 30th	2.82	72

4.1.2 Analysis of records of the Yongoma river

An automatic recorder installed on the Yongoma river recorded some floods during last rainy season. The hydrographs at the gauging station are drawn together with rainfall observed at Mtii primary school where an automatic raingauge was installed. Among several flood hydrographs, hydrographs resulting from a heavy consecutive rainfall are selected as shown in Table A-9. The result of analysis shows a large dispersion of the peak runoff coefficient. On the other hand, a good relation can be observed between the rainfall intensity and the time of flood concentration as shown in Fig. A-16.

4.2 Estimation of Flood Discharge

Peak flood discharge of the Nakombo, Hingilili, Yongoma, Saseni rivers and seasonal rivers is estimated by use of the Rational formula as shown below.

$$Q_p = 1/3.6 \times r_e \times A \quad \ldots\ldots\ldots \quad (4.1)$$

Where Q_p = peak flood discharge (m^3/sec)
r_e = effective rainfall intensity for the duration equal to the flood concentration (mm/hr)
A = catchment area (km^2)

The procedure of calculation is described below.

4.2.1 Flood concentration time

The flood concentration time is given by the summation of the time required for flood to flow out into the river course from the farthest point in the catchment area and the time required for flood to flow down through the river course up to the point to be considered.

Several empirical formulas have been proposed for the estimation of the flood concentration time. Almost all of them, however, are valid in the specific region where it was developed. The following equation proposed in Japan is adopted and coefficients of the equation are tentatively modified to that obtained from the flood analysis mentioned in Section 4.1.2.

$$T_p = m \times r_e^{-c} \times A^d \quad \ldots\ldots\ldots\ldots \quad (4.2)$$

Where T_p = flood concentration time (min.)
m = 242 (see Fig. A-16)
c = 0.433 (see Fig. A-16)
d = 0.22 constant
r_e = effective rainfall intensity for the duration equal to the flood concentration (mm/hr)
A = catchment area (km^2)

4.2.2 Rainfall intensity

In general, rainfall intensity can be calculated from daily rainfall data by using the following formula.

$$r_t = R_{24}/t \times (t/24)^K \quad \ldots\ldots\ldots \quad (4.3)$$

Where r_t = rainfall intensity during t hours (mm/hr)
R_{24} = rainfall during 24 hours (mm)
t = time in hours
K = coefficient (= 1/3)

4.2.3 Probable basin rainfall

(1) Basin rainfall

The average depth of rainfall for a given duration in a certain area generally tends to decrease conversely with the increase of the

area. The equation mentioned in Section 2.3.4 is utilized for calculation of a basin rainfall. The calculated annual maximum basin rainfall is shown in Table A-10 and probable basin rainfall estimated by the Third type of Pearson's formura is shown in Table A-11.

(2) Point rainfall

In order to estimate the drainage water requirement from the cultivated area, a probable point rainfall is calculated. From the daily rainfall data at the Tia dam site, Gonja estate and Kalimawe meteorological station, annual maximum rainfalls are extracted as shown in Table A-12. Probable storm rainfalls are estimated by using the extracted annual maximum rainfalls and the Third type of Pearson's formura. Results are shown in the following table.

Station	Altitude (m)	Nos. of Data (Nos)	Return Period in Years 2 (mm)	5 (mm)	10 (mm)	20 (mm)	50 (mm)	Recorded Max. (mm)
Tia dam site	1,670	21						
1 day			95	139	171	203	247	209
2 day consecutive			124	174	209	239	290	258
Gonja estate	549	12						
1 day			80	117	139	159	183	147
2 day consecutive			100	138	163	185	221	149
Kalimawe	508	22						
1 day			56	84	105	126	157	111
2 days consecutive			64	94	117	140	184	184

4.2.4 Peak runoff coefficient

Taking into consideration the annual runoff coefficient estimated in Section 3.3.6 and the peak runoff coefficient calculated in Section 4.1.2 the runoff coefficient of the Rational formula is taken at 0.2 and 0.5 for main stream of Mkomazi river and tributaries respectively. The effective rainfall intensity can be estimated as follows.

$$r_e = r \times r_t \quad \cdots\cdots\cdots \quad (4.4)$$

Where r_e = effective rainfall intensity (mm/hr)
r = peak runoff coefficient
r_t = rainfall intensity during t hours (mm/hr)

4.2.5 Peak flood discharge

The r_e-T_p relationship of each river basin is obtained by the equation (4.2) and then, the r_e - t relationship is obtained by the equation (4.3) and (4.4). The r_e - T_p relationship is shown in Table A-13.

From these two relations, the value of r_e in each return period is obtained. The results are summarized below.

River	Catchment Area (km^2)	Return Period in Years 2	5	10	20	50	100	200
Nakombo	48.5	34	53	65	77	97	110	126
Kambaga(Igoma)	749.0	64	119	171	208	270	333	395
Hingilili	55.8	54	84	104	127	163	194	225
Yongoma	70.5	59	86	108	127	157	184	205
Mkomazi(Kakimawe)	1,492.9	141	228	282	353	477	518	580
Saseni	198.5	91	144	176	203	251	288	320
Other small river	20	25	39	54	69	78	108	128
	10	14	23	31	42	46	64	75

From the above results, the relationship between the peak flood discharge and the catchment area can also be obtained as shown in Fig. A-17. The peak flood discharge of other rivers can also be obtained by using this relationshiop.

Table A-1 CLIMATE AT KALIMAWE METEO. STATION

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean of Total	Period
Mean Max. Temp. (°C)	33.5	34.1	34.0	31.7	29.3	28.5	28.3	28.9	30.4	32.2	33.2	32.3	31.4	'68-'82
Mean Min. Temp. (°C)	21.5	21.9	21.9	21.5	20.3	18.6	17.1	16.2	16.9	19.2	21.1	21.5	19.8	'68-'82
Mean Temperature (°C)	27.2	27.9	27.9	26.5	24.8	23.6	22.7	22.6	24.0	25.7	27.1	27.0	25.6	'68-'82
Min. Temperature (°C)	18.8	19.2	19.2	18.4	17.0	14.7	12.9	13.2	13.3	15.0	17.8	18.7	16.5	'71-'82
Mean Max. Humid. (%)	81	79	81	80	81	78	81	83	83	81	82	82	71	'76-'81
Mean Min. Humid. (%)	33	34	34	39	42	37	35	33	31	29	34	37	35	'76-'81
Mean Humidity (%)	57	57	58	60	62	58	58	58	56	55	58	59	58	'76-'81
Pan Evaporation (mm/day)	6.3	6.6	6.3	5.7	5.5	5.8	5.6	5.5	5.7	6.1	6.0	6.1	5.9	'64-'82
Radiation (mm/day)	16.1	16.3	16.1	15.6	13.5	14.1	13.5	13.9	15.5	16.5	16.0	16.9	15.3	'67-'82
Run of Wind (km/day)	138	134	120	138	184	197	187	145	118	121	129	143	146	'67-'82
Rainfall (mm)	63.6	46.9	80.9	72.8	25.4	4.5	2.2	5.4	8.4	17.2	53.5	96.3	477.2	'62-'82
Rainy days (days)*	7.5 (7.0)	6.0 (5.6)	8.9 (8.2)	11.4 (10.5)	8.0 (7.1)	2.3 (1.9)	1.6 (1.4)	2.5 (2.0)	2.9 (2.5)	6.0 (5.3)	9.5 (8.9)	10.8 (10.1)	77.4 (70.5)	'62-'82

*: Days having less than 0.1 mm (trace) are excluded.

Table A-2 (1/12) MONTHLY MEAN MAX. TEMPERATURE

Station: Kalimawe Met

(Unit: C°)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1968						27.3	27.0	27.8	29.4	31.1	30.0	31.6
1969	33.3	31.1	32.4	32.2	28.9	28.1	28.6	28.7	30.3	31.2	-	-
1970	32.1	32.9	33.2	29.9	28.6	-	-	-	30.7	32.8	34.3	31.2
1971	32.2	33.8	-	32.1	29.5	27.7	28.0	28.2	29.8	-	-	-
1972	-	-	-	-	-	28.2	28.3	29.4	30.6	31.8	-	-
1973	32.8	35.2	36.1	33.0	29.0	28.6	28.5	29.5	30.7	33.6	33.1	32.0
1974	33.2	34.0	33.0	32.0	30.3	28.7	27.6	29.2	30.2	32.4	33.1	34.1
1975	32.7	34.6	34.6	31.8	29.8	28.2	28.7	28.1	29.4	31.8	34.2	32.1
1976	34.1	34.2	34.0	31.1	28.8	28.4	27.7	28.8	30.5	32.3	34.5	34.5
1977	34.8	35.0	34.4	31.3	30.9	29.7	29.2	28.8	29.8	32.3	32.8	32.5
1978	33.2	34.6	32.3	30.1	28.6	28.1	27.8	29.0	31.4	33.1	32.8	28.7
1979	31.0	31.5	32.7	31.8	28.6	27.8	28.2	29.2	30.7	32.8	33.7	34.5
1980	37.0	34.7	35.6	33.7	30.0	29.2	28.9	28.5	31.1	32.6	33.4	32.1
1981	34.6	35.5	34.0	31.3	29.7	29.2	28.7	30.0	31.0	32.1	34.2	32.3
1982	34.2	36.1	35.5	31.8	28.7	29.3	28.7	29.3	30.0	30.8	32.7	31.6
1983	33.9	33.7	-	-	-	-	-	-	-	-	-	-
Average	33.5	34.1	34.0	31.7	29.3	28.5	28.3	28.9	30.4	32.2	33.2	32.3

Table A-2 (2/12) MONTHLY MEAN MIN. TEMPERATURE

Station: Kalimawe Met

(Unit: C°)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.
1968						18.1	16.7	15.6	16.3	20.0	21.0	21.8
1969	23.2	22.4	23.1	23.3	21.8	17.9	17.9	16.5	16.8	20.0	-	-
1970	22.3	23.3	22.8	21.4	20.0	-	-	-	14.8	17.1	20.7	21.3
1971	20.0	19.6	-	21.5	20.3	18.2	16.8	15.5	16.1	-	-	-
1972	-	-	-	-	-	19.0	17.5	16.2	17.5	20.1	-	-
1973	21.2	22.4	22.4	22.0	20.3	19.5	16.7	16.2	18.0	19.2	21.5	21.4
1974	21.3	21.5	21.0	21.0	20.1	18.5	17.6	16.4	16.5	17.4	21.6	21.8
1975	22.0	20.8	21.6	20.8	19.8	19.2	17.2	15.9	16.8	17.9	20.5	21.6
1976	21.3	25.4	22.1	21.7	20.4	19.4	17.0	16.3	17.1	20.2	21.7	22.5
1977	22.0	20.5	21.9	21.8	20.7	18.5	17.7	16.8	16.9	18.7	21.3	21.9
1978	21.2	21.9	21.6	20.8	19.2	17.9	16.9	15.9	17.0	19.8	20.9	20.8
1979	21.0	21.5	21.6	20.9	20.6	18.6	16.3	16.1	16.0	19.5	22.1	20.9
1980	21.0	21.5	21.4	22.1	20.8	18.6	18.0	16.6	17.2	18.9	21.1	21.4
1981	22.0	22.1	21.0	20.9	19.6	17.7	15.5	16.9	17.1	19.9	20.4	21.7
1982	21.9	21.6	22.1	21.0	20.6	19.3	18.1	16.5	18.8	19.9	20.9	21.4
1983	20.5	21.9	-	-	-	-	-	-	-	-	-	-
Average	21.5	21.9	21.9	21.5	20.3	18.6	17.1	16.2	16.9	19.2	21.1	21.5

Table A-2 (3/12) MONTHLY MEAN TEMPERATURE

Station: Kalimawe Met

(Unit: C^{o})

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1968						22.7	21.9	21.7	22.9	25.6	25.4	26.7
1969	28.3	26.8	27.8	27.8	25.4	23.0	23.3	22.6	23.6	25.6	26.3	27.4
1970	27.2	28.2	28.0*	25.7*	24.3*	23.7	22.2	22.0	22.8	24.9	27.5	26.3
1971	26.1	26.8	26.8	26.8	24.9	23.0	22.4	22.0	23.0	24.5	-	26.0
1972	26.6	26.7	27.8	27.1	24.5	23.0	22.5	22.8	24.1	26.0	26.2	27.4
1973	27.1	28.8	29.3	27.5	24.7	25.0	22.6	23.0	30.7	26.4	27.3	26.7
1974	27.3	27.7	27.0	26.7	25.2	23.6	22.6	22.8	23.4	24.9	27.4	28.0
1975	27.4	27.6	28.1	26.3	24.8	23.7	22.9	22.0	23.1	24.9	27.4	26.9
1976	27.7	29.8	28.1	26.4	24.6	23.9	22.4	22.6	23.8	26.25	28.1	28.4
1977	28.2	28.1	28.1	26.5	25.8	24.1	23.5	22.8	23.4	25.5	27.1	27.2
1978	27.2	28.3	26.9	25.4	23.9	23.0	22.3	22.5	24.2	26.5	26.7	25.5
1979	26.0	26.5	27.2	26.3	24.7	23.2	22.2	22.7	23.3	26.2	27.9	27.7
1980	27.9	27.5	28.5	27.9	25.2	23.9	23.6	22.8	24.2	26.3	27.3	26.7
1981	26.1	28.8	27.5	24.8	24.6	23.5	22.1	24.1	22.4	26.0	27.3	27.0
1982	28.1	28.9	28.8	26.4	24.7	24.3	23.4	22.9	24.4	25.4	26.8	26.5
1983	27.2	27.8	-	-	-	-	-	-	-	-	-	-
Average	27.2	27.9	27.9	26.5	24.8	23.6	22.7	22.6	24.0	25.7	27.1	27.0

Source of record: Project preparation division in Ministry of Water and Energy, Dar es Salaam

* : Revised based on daily records from Water Office, Kilimanjaro.

Table A-2 (4/12) MONTHLY MINIMUM TEMPERATURE

Station: Kalimawe Met

(Unit: ^{o}C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1971			20.0	-	15.0	14.0	11.0	12.0	12.0	-	-	-	11.0
1972	-	-	-	-	-	14.0	13.0	12.0	13.0	16.0	-	19.7	12.0
1973	19.0	19.0	20.0	19.0	16.4	14.6	12.4	13.0	13.3	14.0	18.8	17.0	12.4
1974	17.9	19.1	19.1	18.4	18.4	12.8	14.6	12.8	12.0	14.0	19.0	20.0	12.0
1975	19.1	-	18.4	17.3	16.2	15.9	12.4	12.8	12.6	14.4	15.0	-	12.4
1976	17.3	20.0	19.5	18.8	16.4	16.0	11.3	13.7	13.0	16.4	17.0	19.0	11.3
1977	19.3	17.9	19.0	19.2	17.3	15.3	14.2	13.0	14.0	15.3	18.4	18.2	13.0
1978	16.4	19.0	19.0	18.0	16.4	14.4	12.4	12.8	13.9	15.0	17.9	18.4	12.4
1979	18.8	19.3	19.9	18.0	18.6	15.0	13.0	13.3	12.8	14.4	19.9	18.2	12.8
1980	19.5	18.8	19.3	19.0	18.2	14.8	13.7	14.6	13.3	14.8	18.4	18.8	13.3
1981	19.0	20.4	17.9	18.4	15.9	14.0	12.0	14.4	14.0	15.9	15.3	18.8	12.0
1982	19.9	19.0	19.5	17.9	18.0	15.1	14.6	13.5	15.9	15.3	18.4	19.3	13.5
1983	20.4	19.3	-	-	-	-	-	-	-	-	-	-	-
Mean	18.8	19.2	19.2	18.4	17.0	14.7	12.9	13.2	13.3	15.0	17.8	18.7	12.3
ABS	16.4	17.9	17.9	17.3	15.0	12.8	11.0	12.8	12.0	14.0	15.0	17.0	11.0

Table A-2 (5/12) MONTHLY MEAN MAX. RELATIVE HUMIDITY

Station: Kalimawe Met

(Unit: %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1976	78	76	79	81	81	76	81	82	82	79	-	78
1977	77	78	79	77	78	76	76	79	80	79	80	80
1978	82	81	82	82	-	85	83	85	83	79	82	83
1979	83	83	85	82	75	73	81	84	83	81	80	82
1980	80	79	79	80	89	80	82	84	85	86	86	85
1981	84											
Average	81	79	81	80	81	78	81	83	83	81	82	82

Table A-2 (6/12) MONTHLY MEAN MIN. RELATIVE HUMIDITY

Station: Kalimawe Met

(Unit: %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1976	28	29	30	38	44	39	36	32	33	30	-	31
1977	32	31	30	38	36	34	31	34	32	33	36	38
1978	37	34	47	47	-	39	35	32	29	28	36	46
1979	41	44	38	39	46	39	36	32	29	28	30	31
1980	29	30	24	32	41	36	37	34	31	28	33	39
1981	29											
Average	33	34	34	39	42	37	35	33	31	29	34	37

Table A-2 (7/12) MONTHLY MEAN RELATIVE HUMIDITY

Station: Kalimawe Met

(Unit: %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1976	53	54	55	60	62	58	58	57	58	54	-	56
1977	55	54	55	57	58	55	54	56	56	56	58	60
1978	59	58	64	64	-	62	60	59	56	54	59	65
1979	62	64	62	61	63	56	59	58	50	55	55	52
1980	55	54	52	57	63	58	58	59	58	57	59	62
1981	57											
Average	57	57	58	60	62	58	58	58	56	55	58	59

Table A-2 (8/12) MONTHLY MEAN PAN EVAPORATION

Station: Kalimawe Met

(Unit: mm/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1964	5.8	6.3	6.0	6.1	6.2	6.1	6.1	-	5.9	-	-	6.4
1965	-	-	-	-	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-	-	-	-	-
1967	7.9	8.1	7.9	5.8	4.6	5.6	5.8	6.1	5.3	5.1	6.1	6.1
1968	6.9	6.6	4.6	5.1	4.3	4.7	5.2	5.4	5.6	6.1	4.9	6.3
1969	6.8	5.6	6.0	6.3	6.6	5.7	6.0	5.5	5.9	5.7	5.4	6.6
1970	5.4	5.8	6.0	5.4	5.3	6.1	4.8	5.1	6.2	6.7	6.9	5.5
1971	5.6	6.6	6.3	-	-	-	5.4	5.3	5.8	6.4	-	6.1
1972	6.2	5.4	6.6	6.1	4.5	5.8	5.4	5.4	5.6	5.6	4.5	5.7
1973	5.5	6.3	7.0	6.3	5.6	6.1	5.9	5.1	5.4	5.8	5.5	-
1974	-	-	-	6.6	5.7	5.0	5.6	6.0	6.0	6.7	6.4	6.8
1975	6.7	7.7	6.6	6.5	5.7	6.5	6.5	6.1	6.2	6.2	7.1	6.4
1976	7.0	7.1	7.3	5.6	5.7	6.0	5.8	5.8	5.4	5.7	6.7	6.9
1977	-	-	-	-	-	6.1	6.3	5.0	5.3	6.3	5.6	5.3
1978	5.6	6.8	4.8	4.8	5.4	5.4	5.3	5.1	6.2	6.4	5.9	5.0
1979	5.3	5.2	5.5	5.6	5.3	5.9	5.2	5.2	5.5	6.1	6.6	6.9
1980	6.9	6.1	7.0	6.0	6.2	6.6	6.0	5.6	5.9	6.9	6.1	5.9
1981	7.0	7.4	6.5	5.2	6.1	6.3	5.2	5.2	6.0	6.2	6.8	6.1
1982	6.7	7.4	6.0	4.8	4.7	5.5	5.1	5.5	4.7	5.2	-	-
1983	5.5	-	-	-	-	-	-	-	-	-	-	-
Average	6.3	6.6	6.3	5.7	5.5	5.8	5.6	5.5	5.7	6.1	6.0	6.1

Note: Class A pan

Table A-2 (9/12) MONTHLY MEAN RADIATION (G.B.R.I.)

Station: Kalimawe Met

(Unit: mm/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1967	20.8	19.3	-	-	8.4	16.2	14.4	14.2	14.3	14.0	15.6	17.5
1968	15.9	14.3	12.8	15.3	12.5	15.3	14.1	14.6	17.3	16.5	15.7	20.4
1969	17.0	16.3	17.7	17.7	15.2	14.4	14.9	15.0	16.8	17.3	16.4	23.5
1970	14.8	17.8	17.3	16.4	14.0	15.6	12.7	13.2	17.3	18.9	18.1	15.3
1971	15.4	16.3	15.4	16.0	12.8	12.5	12.2	13.4	16.2	16.4	-	14.5
1972	15.9	13.7	16.2	15.3	11.7	14.5	13.6	14.3	16.0	15.7	15.4	21.5
1973	16.2	15.7	18.0	15.8	13.2	14.1	15.0	14.7	15.6	18.0	17.3	18.2
1974	17.4	16.3	17.1	15.5	16.0	13.2	13.3	16.0	15.7	17.8	16.1	17.5
1975	15.1	17.1	17.8	15.3	19.3	13.8	14.5	14.1	15.1	16.0	16.7	17.1
1976	16.3	16.7	16.4	16.5	14.7	14.9	13.7	14.5	15.7	15.6	15.5	17.8
1977	15.4	15.3	15.9	13.9	14.1	13.6	13.9	13.0	14.5	15.7	14.6	13.4
1978	14.7	16.7	14.2	14.8	14.1	13.5	14.0	14.4	17.0	16.2	15.4	12.5
1979	14.8	14.4	16.5	14.8	11.1	13.1	11.9	12.9	14.2	16.7	15.5	16.2
1980	15.6	16.0	16.4	15.5	13.8	13.8	12.7	11.6	14.8	16.6	15.5	15.4
1981	16.6	16.3	14.4	15.6	13.2	14.0	12.5	12.8	14.6	16.3	18.3	14.3
1982	16.5	18.4	16.1	15.0	11.6	13.1	12.5	14.1	13.2	15.5	13.9	15.6
1983	14.8	15.8	-	-	-	-	-	-	-	-	-	-
Average	16.1	16.3	16.1	15.6	13.5	14.1	13.5	13.9	15.5	16.5	16.0	16.9

Table A-2 (10/12) MONTHLY MEAN WIND RUN

Station: Kalimawe Met

(Unit: km/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1967	-	-	-	-	208	222	238	216	138	124	122	137
1968	145	164	117	119	129	166	175	129	108	117	97	114
1969	148	127	129	145	240	188	195	124	109	100	95	142
1970	105	97	111	148	179	158	111	95	84	77	119	105
1971	97	97	142	216	299	311	246	203	177	192	-	219
1972	158	103	85	-	-	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	135	102	110	136	145
1974	149	153	142	138	114	134	196	144	121	110	145	145
1975	130	143	128	176	188	247	208	170	124	113	129	129
1976	136	136	125	133	197	216	190	155	98	102	113	130
1977	106	103	97	164	184	176	177	133	93	104	96	102
1978	91	113	82	98	159	178	166	127	135	163	168	139
1979	141	115	128	136	203	246	198	136	131	156	185	182
1980	164	177	145	146	208	200	225	172	137	168	166	221
1981	191	208	122	91	149	179	160	136	134	127	156	154
1982	174	148	133	85	118	142	130	101	72	54	74	82
1983	134	119	-	-	-	-	-	-	-	-	-	-
Average	138	134	120	138	184	197	187	145	118	121	129	143

Table A-2 (11/12) MONTHLY RAINY DAYS AT KALIMAWE METEO. STATION

(Unit: days)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1962	17	8	9	11	5	0	2	5	3	8	8	14	90
1963	10	7	10	13	4	5	0	0	2	4	16	13	84
1964	9	8	9	11	3	1	0	2	2	6	5	9	65
1965	9	2	4	8	6	0	1	1	4	9	10	9	63
1966	3	6	12	11	7	3	1	1	1	3	5	6	59
1967	0	2	6	19	13	1	4	3	6	11	15	7	87
1968	0	8	22	14	12	6	4	3	0	6	15	11	101
1969	5	8	13	7	4	3	1	3	0	8(7)	8(7)	1	61(59)
1970	13(11)	8	12(8)	8(7)	8(5)	0	1(0)	4(1)	3(2)	1	5	11	74(59)
1971	9	3	6	12(10)	8(6)	5(3)	2	0	0	2	3	11	61(55)
1972	7	6	10(7)	11(9)	16(14)	0	2(1)	3(2)	5(3)	13(9)	18(17)	12(9)	103(84)
1973	13(10)	8(6)	7(4)	14(12)	7	3(1)	0	1(0)	0	3	10(9)	9(8)	75(60)
1974	3	6(3)	3(2)	8(7)	5(4)	1	2	1	2(1)	3(2)	7(5)	9	50(40)
1975	6	3	7	8(7)	9	1	1	0	7(6)	3(2)	3(2)	13	61(57)
1976	5(4)	7	7(5)	14(12)	7(6)	3(2)	2	3(2)	7(5)	6(5)	6(3)	6	73(59)
1977	10	6	10	5(4)	6(4)	2	2(1)	8(7)	6(5)	9(7)	14(13)	17	95(86)
1978	12(10)	5(4)	18	17(14)	5	2	0	0	0	3	17(15)	20(15)	99(86)
1979	14	13(11)	7	13	14(13)	4	3(1)	2	4(3)	6(4)	8	10	98(90)
1980	10(8)	5	7(6)	12(10)	4(3)	0	1	7(5)	0	2(1)	10(9)	12(10)	70(58)
1981	5	3	11(10)	16(13)	6(5)	0	0	4(3)	3	5	7	19(15)	79(67)
1982	1	3	2(1)	12	14(11)	7(6)	5	1	6	15(14)	10	8	84(78)
1983	4(2)	6	4	6	13(10)	3(1)	-	-	-	-	-	-	36(29)
Average	7.5 (7.0)	6.0 (5.6)	8.9 (8.2)	11.4 (10.5)	8.0 (7.1)	2.3 (1.9)	1.6 (1.4)	2.5 (2.0)	2.9 (2.5)	6.0 (5.3)	9.5 (8.9)	10.8 (10.1)	77.4 (70.5)

Note: Days in ( ) are rainy days excluding less than 0.1 mm day (trace).

Table A-2 (12/12) RAINY DAYS AT KALIMAWE METEO. STATION
(more than 5 mm/day)

(Unit: day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1962	9	4	4	4	0	0	0	0	1	0	2	8
1963	4	4	4	3	1	1	0	0	0	1	8	9
1964	4	4	6	2	0	0	0	0	0	0	1	1
1965	2	0	3	2	1	0	0	1	0	2	3	6
1966	3	3	5	1	3	1	0	1	0	1	2	4
1967	0	0	1	8	3	0	1	1	3	2	4	3
1968	0	2	11	4	2	1	0	0	0	1	8	2
1969	1	2	7	2	0	0	0	0	0	3	3	0
1970	8	6	3	2	1	0	0	0	0	0	2	6
1971	3	1	4	3	0	1	0	0	0	0	0	4
1972	2	6	1	1	3	0	0	0	1	3	5	5
1973	4	3	1	0	3	0	0	0	0	1	2	3
1974	1	0	0	5	0	0	0	1	0	0	0	3
1975	4	0	1	1	2	0	0	0	2	1	0	5
1976	2	2	1	7	1	0	1	0	4	1	0	1
1977	4	2	3	0	0	0	0	0	1	1	6	12
1978	3	2	11	8	1	1	0	0	0	1	7	12
1979	5	6	3	2	6	1	0	0	2	2	1	1
1980	6	1	2	4	1	0	0	2	0	1	3	7
1981	1	0	5	7	1	0	0	0	0	3	1	4
1982	1	2	0	4	3	1	1	0	2	8	7	4
1983	2	3	2	2	2	1	-	-	-	-	-	-
Average	3.1	2.4	3.5	3.3	1.5	0.4	0.1	0.3	0.8	1.5	3.1	4.8

Table A-3 (1/6) MONTHLY RAINFALL

Station: Kisiwani Sisal Estate Altitude: 685 m Registered No. 9437011

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
1949	-	-	-	-	-	-	-	-	-	-	-	-	262.4
1950	-	-	-	-	-	-	-	-	-	-	-	-	597.9
1951	-	-	-	-	-	-	-	-	-	-	-	-	1,014.7
1952	-	-	-	-	-	-	-	-	-	-	-	-	386.1
1953	-	-	-	-	-	-	-	-	-	-	-	-	810.8
1954	-	-	-	-	-	-	-	-	-	-	-	-	408.9
1955	-	-	-	-	-	-	-	-	-	-	-	-	988.3
1956	-	-	-	-	-	-	-	-	-	-	-	-	684.5
1957	-	-	-	-	-	-	-	-	-	-	-	-	814.8
1958	-	-	-	-	-	-	-	-	-	-	-	-	740.4
1959	-	-	-	-	-	-	-	-	-	-	-	-	331.2
1960	-	-	-	-	-	-	-	-	-	-	-	-	453.1
1961	61.5	78.1	25.7	46.0	-	-	7.1	-	15.8	114.3	396.3	354.0	1,098.8
1962	649.1	80.7	91.9	55.9	-	-	-	1.0	16.2	66.8	253.0	391.8	1,606.4
1963	135.7	15.2	133.4	21.3	-	30.0	-	-	7.1	2.3	259.8	133.7	738.5
1964	49.8	53.3	83.3	130.6	-	-	-	2.5	12.8	6.4	59.7	233.4	631.8
1965	58.4	17.8	83.9	13.5	23.6	-	-	10.2	8.9	22.9	101.3	89.1	429.6
1966	67.3	70.0	134.0	17.9	27.5	-	6.4	2.0	0	16.5	43.3	56.0	440.9
1967	5.1	58.5	51.1	222.5	47.3	-	38.2	-	38.1	62.2	88.9	63.5	670.3
1968	0	80.1	583.0	130.9	39.4	19.1	-	-	-	55.9	65.3	82.6	1,056.3
1969	95.2	71.1	156.3	-	-	-	-	-	-	42.0	129.0	46.5	540.1
1970	146.6	114.8	194.3	92.0	5.1	-	-	-	-	-	127.0	231.2	911.0
1971	90.2	-	68.6	73.7	-	-	-	-	-	-	-	-	232.5
1972	-	-	-	-	-	-	-	-	-	26.6	107.9	116.9	251.4
1973	158.8	109.3	24.1	123.2	19.1	-	-	-	-	-	214.7	50.8	700.0
1974	49.6	-	73.6	125.7	0	31.0	16.5	10.2	0	25.5	29.3	67.1	428.5
1975	63.6	7.1	79.2	34.9	35.3	-	-	-	22.8	-	98.6	-	341.5
1976	-	-	-	-	-	-	-	-	-	-	-	-	330.2
1977	-	-	-	-	-	-	-	-	-	-	-	-	355.6
1978	-	-	-	-	-	-	-	-	-	-	-	-	1,217.9
1979	55.9	67.3	66.1	205.7	120.7	-	-	-	-	-	87.6	127.1	730.4
1980	102.9	30.5	95.3	41.9	0	0	0	0	0	0	76.1	101.6	448.3
1981	-	-	-	-	-	-	-	-	-	-	-	730.4	739.1
1982	-	-	-	-	-	-	-	-	-	59.8	204.6	63.5	327.9
1983	55.9	85.2	97.8	0	-	-	-	-	-	-	-	-	238.9
Average ('49-'81)	-	-	-	-	-	-	-	-	-	-	-	-	646.9

Table A-3 (2/6) MONTHLY RAINFALL

Station: Kwizu Mission School Altitude: 1,105 m Registered No. 9438032

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total	Total Oct-Sep
1961	23.0	72.8	34.3	46.8	29.2	32.2	31.9	2.3	37.0	125.0	263.8	-	698.3	
1962	132.8	44.4	48.2	8.5	5.3	1.0	6.2	1.0	2.3	15.8	73.7	46.0	385.2	638.5
1963	279.1	46.2	75.6	10.7	93.1	50.8	12.4	0	28.4	25.2	-	-	621.5	731.8
1964	0	2.6	164.2	180.4	11.2	0	0	10.2	4.6	87.7	4.9	156.9	622.7	398.4
1965	0	99.0	99.0	218.5	259.1	50.8	7.6	17.8	18.4	47.1	46.8	245.5	1,109.6	1019.7
1966	32.4	84.1	211.4	16.3	118.9	0	0	0	2.5	2.5	0	43.5	511.6	805.0
1967	0	131.6	107.0	219.4	155.4	7.9	34.8	32.5	73.4	90.7	140.0	98.2	1,090.9	808.0
1968	0	10.1	210.7	123.3	100.0	84.8	0	0	10.9	78.8	114.5	128.7	861.8	868.7
1969	129.5	70.6	204.3	43.8	41.7	0	0	36.8	0	162.4	264.3	69.6	1,023.0	848.7
1970	197.5	74.7	333.2	69.6	3.8	0	0	5.4	14.0	0	90.4	215.7	1,004.3	1,194.5
1971	85.9	0	32.2	87.1	44.9	0	30.2	0.9	4.2	5.4	20.1	247.9	558.8	591.5
1972	41.5	48.8	177.4	38.4	124.9	0.9	0	13.3	47.9	49.2	214.7	129.0	886.0	766.5
1973	138.0	128.0	13.0	130.6	54.4	0	0	114.9	173.2	255.7	360.4	83.5	1,451.7	1,145.0
1974	121.4	21.9	53.2	176.6	7.0	100.9	56.0	2.8	-	33.2	24.8	73.2	671.0	1,239.4
1975	53.5	23.4	240.3	73.9	44.7	0	12.8	0	79.4	39.1	61.0	72.5	700.6	659.2
1976	26.6	286.6	103.3	31.1	46.1	20.5	16.8	6.0	60.5	30.7	65.0	87.0	780.2	770.1
1979	164.5	150.7	248.7	310.5	347.5	-	-	-	-	-	-	-	1,221.9	1,404.6
Average ('61-'76)	78.8	71.6	131.7	92.2	71.2	21.9	13.0	15.2	37.1	65.5	116.3	121.2	811.0	

Station: Tia Dam Site Altitude: 1,670 m Registered No. 9437010

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total	Total Oct-Sep
1962	-	-	-	-	-	-	-	-	-	22.8	388.2	476.0	887.0	
1963	390.8	91.7	216.0	168.7	43.7	75.0	15.2	10.1	79.5	69.1	434.8	452.3	2,046.9	1,977.7
1964	170.4	182.9	260.6	262.5	54.9	5.1	5.1	48.9	10.5	154.9	109.0	390.1	1,654.9	1,957.1
1965	61.3	6.7	78.0	161.5	63.5	0.5	5.7	16.8	13.8	107.0	403.7	275.1	1,193.6	1,061.8
1966	60.4	69.3	256.2	115.6	65.0	17.8	2.6	5.8	27.8	24.4	103.5	123.6	872.0	1,406.3
1967	12.6	155.5	108.5	493.5	106.2	5.3	25.2	22.5	61.0	143.7	284.6	167.0	1,585.6	1,241.8
1968	1.3	131.9	398.7	214.7	82.2	62.7	7.3	10.7	2.0	117.3	340.5	273.7	1,643.0	1,506.8
1969	100.3	110.6	326.2	130.4	46.2	11.1	1.2	12.2	5.1	99.3	390.9	141.8	1,375.3	1,474.8
1970	242.8	173.1	198.9	145.3	16.6	0	0	5.2	15.5	9.4	153.3	213.1	1,173.2	1,429.4
1971	61.4	19.1	214.5	329.2	34.1	6.8	8.9	1.2	22.9	21.6	112.6	309.7	1,142.0	1,073.9
1972	126.8	128.3	94.3	63.6	177.4	0.4	10.2	28.1	56.1	108.7	435.6	306.8	1,536.3	1,129.1
1973	172.5	115.4	78.7	202.7	93.7	2.6	0	42.1	7.0	29.9	300.0	304.5	1,349.1	1,565.8
1974	95.5	44.1	114.7	274.1	52.7	56.7	14.0	12.8	5.4	48.2	187.7	233.2	1,139.1	1,304.4
1975	97.7	79.5	170.4	243.6	83.0	0	0.5	6.9	47.7	98.7	196.0	230.3	1,254.3	1,198.4
1976	68.9	57.2	129.7	40.8	49.1	-	1.8	0	-	41.2	173.2	144.2	706.1	872.5
1977	110.5	100.1	176.1	115.0	47.4	8.8	9.7	22.7	110.0	86.1	406.4	445.5	1,638.3	1,058.9
1978	211.6	136.1	391.0	176.5	38.0	3.4	3.1	3.3	10.3	47.1	751.1	595.7	2,367.2	1,911.3
1979	234.4	154.3	180.8	420.2	210.9	28.0	6.7	21.4	13.7	76.6	253.1	282.2	1,882.3	2,664.3
1980	190.2	47.0	109.6	142.9	76.5	0.2	1.3	45.3	27.0	14.9	562.8	309.9	1,527.6	1,251.9
1981	42.5	10.9	179.5	291.8	49.3	1.3	2.5	5.7	23.0	88.5	174.0	254.0	1,123.0	1,494.1
1982	31.6	21.8	120.8	251.8	52.8	10.7	19.0	5.8	125.0	251.8	586.9	170.8	1,648.8	1,155.8
1983	171.1	345.9	232.5	53.6	30.8	-	-	-	-	-	-	-	833.9	1,843.4
Average ('63-'81)	129.0	95.5	193.8	210.1	73.2	15.0	6.4	16.9	29.9	73.0	303.8	287.0	1,432.1	

Table A-3 (3/6) MONTHLY RAINFALL

Station: Gonja Estate — Altitude: 549 m — Registered No. 9438011

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total	Total Oct-Sep
1937	-	-	-	-	-	-	-	-	-	130.3	105.3	142.5	378.1	
1938	22.5	55.0	215.8	61.0	80.0	26.3	0	0	0	23.8	173.8	279.3	937.5	838.7
1939	67.5	0	68.3	81.5	60.8	3.8	9.3	10.5	13.8	9.8	211.5	44.5	581.3	792.4
1940	103.8	94.8	125.0	137.7	50.8	-	-	38.1	41.9	21.0	285.3	45.5	943.9	857.9
1941	16.5	25.3	95.5	60.5	56.3	64.3	26.3	0	26.3	61.8	324.8	168.8	926.4	722.8
1942	122.3	0	383.8	184.8	150.0	0	0	23.8	0	61.8	324.8	168.8	1,420.1	1,420.1
1943	12.5	25.0	81.0	136.3	14.3	9.0	11.8	20.3	0	147.5	140.5	25.8	624.0	865.6
1944	94.3	1.3	46.0	319.5	42.5	25.0	0	2.5	55.0	54.8	129.5	101.3	871.7	899.9
1945	42.5	80.0	114.5	29.8	77.0	0	0	0	1.3	0	85.8	42.5	473.4	630.7
1946	0	28.8	31.3	108.5	10.0	0	0	7.5	83.3	110.0	40.3	80.8	500.5	397.7
1947	65.0	5.3	136.5	133.5	52.8	5.0	2.5	2.5	22.5	18.8	76.3	162.0	682.7	656.7
1948	25.5	5.0	96.5	153.0	14.8	10.0	0	0	0	45.0	101.5	296.5	747.8	561.9
1949	0	0	-	-	-	-	-	-	-	-	-	-	0	443.0
1950	0	0	212.5	157.0	108.3	0	20.8	23.8	30.0	19.8	108.0	130.0	810.2	552.4
1951	63.3	76.8	84.8	320.3	98.8	12.3	2.3	1.3	1.8	265.8	76.5	466.0	1,470.0	919.5
1952	84.5	104.3	314.8	63.0	8.5	0.5	7.0	11.3	11.0	41.5	36.0	90.5	772.9	1,413.2
1953	120.0	14.5	120.5	117.8	36.3	0	2.8	11.0	18.0	41.5	90.8	195.3	768.5	608.9
1954	81.3	62.3	9.5	53.0	46.0	0.5	0	8.3	4.5	13.0	58.5	83.5	420.4	593.0
1955	44.5	407.8	207.3	37.3	14.8	27.5	1.8	7.0	0	5.3	223.5	312.3	1,289.1	903.0
1956	327.5	178.3	100.0	97.3	15.8	0	0	0	27.0	10.0	164.5	134.5	1,054.9	1,287.0
1957	164.0	26.0	136.0	237.3	104.0	23.5	0	5.0	9.3	82.3	130.3	-	917.7	1,014.1
1958	40.3	259.0	2.5	84.8	75.5	21.3	11.3	2.8	10.8	0	147.0	312.5	967.8	720.9
1959	63.8	25.5	35.0	86.5	97.0	0	0	0	0	2.5	156.5	226.0	692.8	767.3
1960	103.8	7.5	171.8	69.3	20.3	0	0	0	0	7.8	68.0	43.5	492.0	757.7
1961	28.0	116.5	14.0	98.8	0	0	8.8	0	17.8	29.0	111.6	107.4	531.9	403.2
1962	97.0	0	0	0	0	22.5	0	0	0	15.3	113.8	107.1	355.7	367.5
1963	188.6	88.9	47.5	116.9	5.8	22.9	0	0	5.1	0	216.6	355.1	1,047.4	711.9
1964	40.6	98.3	143.0	79.0	7.6	0	0	0	0	28.0	97.8	286.3	780.6	940.2
1965	91.9	6.4	107.8	8.6	21.6	0	3.6	20.8	13.0	34.3	105.8	267.5	681.3	685.8
1966	130.0	112.1	233.4	37.4	25.4	0	0	0	0	0	155.7	54.7	748.7	945.9
1967	0	200.7	73.7	410.9	73.0	0	25.4	11.4	58.1	79.3	184.9	172.3	1,289.7	1,063.6
1968	1.8	303.0	575.1	243.9	116.8	45.8	0	4.1	5.1	22.8	137.5	174.1	1,630.0	1,732.1
1969	119.9	73.2	141.4	67.9	0	0	0	10.5	8.2	31.2	209.3	80.5	742.1	755.5
1970	176.3	74.1	268.2	24.9	6.2	0	0	4.3	16.3	10.2	107.9	292.2	980.6	891.3
1971	78.7	20.3	135.7	261.5	27.1	11.2	0.5	0	0	27.4	74.5	168.3	805.2	945.3
1972	127.6	71.6	100.8	62.0	85.9	0	0.5	20.6	38.6	57.4	143.2	171.3	887.1	785.4
1973	150.0	96.4	29.5	138.1	40.3	2.0	0	11.7	1.5	8.3	102.3	313.8	893.9	841.4
1974	59.3	31.1	40.9	131.2	24.0	37.6	18.4	26.5	6.5	21.0	106.8	119.9	623.2	799.9
1975	75.0	21.8	136.5	18.6	54.2	0	2.9	2.3	23.7	14.2	62.6	97.1	508.9	582.7
1976	116.0	91.5	189.1	156.3	67.9	26.1	1.5	7.1	81.7	36.0	125.8	190.3	1,089.3	911.1
1977	180.9	61.5	84.0	19.1	19.0	1.6	0	5.6	64.8	38.0	99.3	359.0	932.8	788.6
1978	222.4	81.0	349.3	129.3	36.2	0	15.2	0	0	10.0	338.9	473.0	1,655.3	1,329.7
1979	246.8	255.4	192.6	216.2	139.6	26.9	0	40.6	18.7	41.3	99.3	251.2	1,528.6	1,958.7
1980	102.1	13.8	76.6	76.4	13.9	0	0	33.7	0	0	233.9	156.2	706.6	708.3
1981	33.9	38.4	171.6	137.4	40.8	0	0	0	11.3	25.1	163.8	313.1	935.4	823.5
1982	8.0	11.5	69.1	147.9	45.9	24.1	29.5	10.1	67.4	162.8	372.3	184.2	1,132.8	915.5
1983	183.7	206.6	59.6	51.0	82.1	-	-	-	-	-	-	-	583.0	
Average ('38-'81)	89.4	75.9	137.2	120.1	47.4	10.3	4.1	8.7	16.9	36.7	143.0	188.6	865.9	1,302.3

Table A-3 (4/6) MONTHLY RAINFALL

Station: Ndungu Sisal Estate | Altitude: 533 m | Registered No. 9438051

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total	Total Oct-Sep
1966	85.0	108.0	298.0	45.0	61.0	0	0	7.0	13.0	37.0	59.0	88.0	801.0	
1967	0	59.0	110.0	342.0	90.0	3.0	18.0	11.0	50.0	85.0	157.0	168.0	1,093.0	867.0
1968	0	190.0	422.0	100.0	45.0	28.0	6.0	0	20.0	20.0	12.0	15.0	858.0	1,221.0
1969	53.0	90.0	125.0	150.0	0	0	0	0	10.0	50.0	278.0	39.0	795.0	475.0
1970	400.0	58.0	412.0	21.0	25.0	0	0	0	0	5.0	34.0	300.0	1,255.0	1,283.0
1971	75.0	18.0	114.0	118.0	6.0	0	0	0	0	9.0	18.0	131.0	489.0	670.0
1972	141.0	77.0	25.0	118.0	85.0	0	0	5.0	28.0	87.0	118.0	151.0	835.0	637.0
1973	150.0	164.0	26.0	130.0	53.0	6.0	0	0	0	5.0	134.0	162.0	830.0	885.0
1974	51.0	46.0	14.0	163.0	35.0	0	0	20.0	0	9.0	52.0	71.0	461.0	630.0
1975	69.0	12.0	125.0	73.0	15.0	0	0	0	0	19.0	0	202.0	515.0	426.0
1976	38.0	90.0	114.0	70.0	0	28.0	0	24.0	79.0	43.0	25.0	148.0	659.0	664.0
1977	102.0	19.0	23.0	0	0	0	0	0	27.0	47.0	53.0	265.0	536.0	387.0
1978	142.0	82.0	175.0	177.0	25.0	3.0	0	0	0	0	275.0	391.0	1,270.0	969.0
1979	102.0	218.0	43.0	103.0	112.0	3.0	0	0	0	35.0	35.0	149.0	800.0	1,247.0
1980	53.0	0	17.0	73.0	0	0	0	35.0	0	0	144.0	-	322.0	397.0
1981	-	18.0	81.0	99.0	7.0	0	0	0	0	38.0	29.0	236.0	508.0	349.0
1982	13.0	0	15.1	151.5	16.0	0	0	0	62.0	110.0	243.0	152.2	762.7	560.5
1983	72.4	116.0	57.5	11.3	91.5	-	-	-	-	-	-	-	348.7	853.9
Average ('66-'81)	97.4	78.1	132.8	111.4	34.9	4.4	1.5	6.4	14.2	30.6	88.9	167.7	751.7	

Station: Kalimawe Met Station | Altitude: 508 m | Registered No. 9438040

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total	Total Oct-Sep
1962	222.5	61.3	40.1	54.6	2.2	0	1.3	6.4	15.5	6.5	37.9	178.7	627.0	
1963	89.7	57.3	59.3	55.4	14.9	9.4	0	0	5.1	13.5	181.4	277.0	763.0	514.2
1964	72.1	55.1	122.9	90.1	0.9	0.3	0	2.8	3.8	6.0	10.7	15.3	380.0	819.9
1965	29.1	1.3	93.8	27.6	20.2	0	2.3	7.9	7.9	26.3	54.0	101.9	372.3	282.1
1966	31.5	91.0	192.7	27.6	25.0	7.2	0.3	6.1	0.8	6.4	22.1	57.2	467.9	564.4
1967	0	6.1	12.9	242.4	59.2	0.5	9.4	9.7	29.7	40.2	74.9	30.2	515.2	455.6
1968	0	36.5	203.3	111.9	59.7	16.4	3.6	0.9	0	17.9	95.6	48.7	594.5	577.6
1969	19.6	45.4	74.5	52.8	8.7	2.6	0.8	9.6	0	34.7	68.5	2.8	320.0	376.2
1970	193.3	110.5	135.3	51.8	12.0	0	0	1.5	2.3	1.5	19.6	144.6	672.4	612.7
1971	42.7	9.4	53.1	30.5	8.2	14.5	2.4	0	0	2.9	1.6	99.7	265.0	326.5
1972	23.7	68.7	28.2	45.4	65.2	0	1.3	5.0	15.3	44.9	102.9	70.2	470.8	357.0
1973	84.5	29.7	10.1	49.1	53.1	3.0	0	0	0	11.3	34.1	35.7	310.6	447.5
1974	35.5	1.7	3.5	184.5	5.0	1.0	5.5	6.2	0.8	3.4	5.7	33.2	286.0	324.8
1975	47.7	5.1	30.3	16.4	28.7	0.5	1.6	0	14.9	11.5	3.4	83.0	243.1	187.5
1976	13.5	21.8	41.8	89.5	15.8	6.5	8.1	4.3	38.2	12.3	3.7	22.4	277.9	337.4
1977	72.5	58.8	32.3	4.6	10.3	2.3	1.4	12.2	16.6	23.8	111.0	158.0	503.8	249.4
1978	138.9	24.5	282.1	91.9	13.2	6.0	0	0	0	7.6	153.0	297.0	1,014.2	848.6
1979	89.4	232.4	52.2	57.7	82.6	19.7	2.0	1.9	11.9	20.9	15.7	76.0	662.4	1,007.4
1980	57.4	13.2	32.3	54.9	7.6	0	4.2	24.9	0	11.0	55.2	110.1	370.8	312.1
1981	7.7	8.8	117.1	117.5	16.3	0	0	3.9	5.4	42.1	18.8	84.2	421.8	453.0
1982	7.1	37.3	4.2	59.2	50.5	13.1	11.7	1.7	23.7	98.6	152.0	106.9	566.0	353.6
1983	41.9	95.1	19.1	25.0	28.3	6.8	-	-	-	-	-	-	216.2	573.7
Average ('62-'81)	63.6	46.9	80.9	72.8	25.4	4.5	2.2	5.2	8.4	17.2	53.5	96.3	476.9	

Table A-3 (5/6) MONTHLY RAINFALL

Station: Ntii Primary School — Altitude: 1,275.0 m — Registered No. 9438050

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
1965	-	-	-	-	-	-	-	52.1	107.7	15.2	350.8	361.1	886.9
1966	217.2	157.6	476.5	257.1	26.9	10.4	0	0	0.3	90.2	182.9	79.5	1,498.6
1967	93.3	344.3	454.1	466.1	321.2	47.5	45.7	22.9	91.5	196.4	187.8	116.1	2,386.9
1968	17.8	288.4	368.4	222.0	252.7	2.5	24.2	26.9	10.4	-	-	-	4,528.9
1969	-	-	-	-	-	-	-	-	-	-	251.0	251.5	502.5
1970	394.7	216.9	329.2	-	-	-	-	-	41.9	40.1	454.9	671.8	2,149.5
1971	250.7	70.9	225.7	0	0	0	0	0	0	0	108.7	125.8	781.6
1972	400.3	173.9	101.4	97.8	103.8	-	-	-	-	-	-	-	877.2
1973	-	-	75.4	158.7	-	-	-	-	-	-	119.0	709.4	1,062.5
1974	-	27.7	-	38.9	-	-	-	-	-	-	-	-	66.6
1982	-	-	-	-	-	-	-	-	-	-	*226.5	281.0	519.0
1983	276.5	255.5	230.0	17.5	124.5	-	-	-	-	-	-	-	904.0
Average ('66-'74)	229.0	182.8	290.1	177.2	140.9	15.0	17.3	20.4	42.0	68.4	236.4	330.7	1,193.3

Station: Ibaya — Altitude: 883 m — Registered No. 9337104

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
1968	-	131.4	362.7	202.2	66.7	31.5	10.2	12.7	0	18.3	147.5	81.8	1,065.0
1969	28.2	142.2	158.6	28.4	26.6	0	0	1.3	0	71.5	308.8	56.7	822.3
1970	262.2	84.3	353.7	73.3	-	-	-	-	14.0	8.9	85.9	211.6	1,093.9
1971	82.2	12.7	69.1	184.4	35.3	5.1	8.9	-	-	-	-	-	397.7
Average ('68-'71)	124.2	92.7	236.0	122.1	42.9	12.2	6.4	7.0	4.7	32.9	180.7	116.7	844.7

Station: Mbula — Altitude: 820 m — Registered No.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
1968	23.4	61.2	244.3	-	34.1	26.4	3.3	-	-	5.1	101.3	94.2	593.3
1969	-	50.3	72.4	56.4	6.4	25.4	0	-	-	69.8	57.2	7.6	345.5
Average ('68-'69)	23.4	55.8	158.4	56.4	20.3	25.9	1.7	-	-	37.5	79.3	50.9	469.4

Station: Dindera — Altitude: 900 m — Registered No.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
1968	0	58.4	349.0	209.2	35.5	28.7	0	-	-	7.6	61.8	61.3	811.5
1969	-	35.6	103.4	45.7	24.1	25.4	0	14.0	-	-	95.3	20.8	364.3
1970	72.4	28.9	108.5	24.9	11.7	-	-	-	1.5	0	87.4	161.1	496.4
1971	57.2	2.5	48.3	297.9	39.4	12.7	-	-	-	-	-	-	458.0
Average ('68-'71)	43.2	31.4	152.3	144.4	27.7	22.3	0	14.0	1.5	3.8	81.5	81.1	532.6

Table A-3 (6/6) MONTHLY RAINFALL

Station: Mbugaya Pundamilia Altitude: 800 m Registered No.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
1968	22.9	24.3	305.4	40.1	0	41.1	6.4	-	-	0	61.0	137.2	638.4
1969	5.1	34.8	21.6	114.3	52.1	1.8	0	-	-	-	-	33.3	263.0
1970	14.0	13.2	0	45.7	-	-	-	-	-	-	-	-	72.9
Average ('68-'70)	14.0	24.1	109.0	66.7	26.1	21.5	3.2	-	-	0	61.0	85.3	324.8

Station: Kisima Altitude: 730 m Registered No.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
1968	-	28.3	291.5	187.9	27.3	23.6	1.5	2.5	5.3	42.0	125.6	52.9	788.4
1969	37.5	38.2	89.0	12.8	13.8	7.2	3.8	21.8	39.2	64.1	183.5	45.7	556.6
1970	62.8	12.7	11.0	77.8	0	12.2	-	-	-	-	-	-	176.5
Average ('68-'70)	50.2	26.4	130.5	92.8	20.6	14.3	2.7	12.2	22.3	53.1	154.6	49.3	507.2

Station: Parane Primary School Altitude: 1,350 m Registered No.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
1982	-	-	-	-	-	-	-	-	-	-	*136.0	238.5	374.5
1983	54.0	109.5	170.0	28.0	44.5	-	-	-	-	-	-	-	406.0

* Automatic raingauge was installed on 23rd November in 1982.

Table A-4 (1/3) BASIN RAINFALL

River: Nakombo Station: Kisivani gauge site C.A.: 48.5 km^2 Unit: mm

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Total (Oct.-Sep.)
1962	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1963	240.5	85.1	104.9	124.8	19.7	38.1	5.0	3.3	29.7	24.8	283.3	375.5	1,334.7	-
1964	88.2	119.7	178.8	141.2	22.2	1.7	1.7	16.6	4.0	66.6	88.4	279.9	1,009.0	1,257.7
1965	72.4	5.7	95.9	61.9	35.2	0.2	4.1	17.5	12.5	57.1	196.3	245.2	804.0	740.3
1966	92.3	94.8	234.8	61.7	38.4	7.0	0.9	2.8	9.3	9.0	118.4	77.8	747.2	1,040.6
1967	4.1	156.6	76.1	412.9	81.9	1.8	22.9	14.8	54.8	94.7	201.3	149.2	1,271.1	1,031.3
1968	1.4	206.6	461.1	214.5	96.8	47.0	2.9	5.8	3.3	53.3	198.2	188.2	1,479.1	1,484.6
1969	98.4	81.4	192.3	86.3	16.6	4.1	0.5	10.9	5.9	54.2	248.1	89.1	887.8	936.1
1970	200.8	112.2	225.4	68.7	10.5	0.	0.	4.2	13.9	8.6	109.6	244.0	997.9	1,027.1
1971	67.6	18.3	149.3	249.1	26.6	10.2	3.6	0.4	7.6	21.8	76.1	204.7	835.3	894.9
1972	111.8	89.9	87.8	60.0	113.0	4.1	3.8	20.7	40.9	72.5	233.6	200.9	1,039.0	834.6
1973	147.6	92.7	42.8	146.1	59.8	2.3	0.	20.0	3.1	15.9	157.3	269.0	956.6	1,021.4
1974	67.7	31.0	59.6	186.4	30.6	38.4	15.0	18.9	5.3	27.3	118.3	144.3	742.8	895.1
1975	78.4	38.3	131.8	92.5	59.9	0.1	1.9	3.5	30.3	41.7	97.7	138.9	715.0	726.6
1976	85.1	69.7	147.4	108.2	53.9	14.5	2.6	4.3	48.2	34.2	123.1	149.9	841.1	812.2
1977	141.4	73.8	106.6	48.6	27.1	4.1	3.4	12.2	72.5	51.7	202.4	357.4	1,101.2	796.9
1978	206.3	90.7	353.0	139.3	33.3	2.0	8.9	1.1	3.4	21.9	447.0	487.1	1,794.0	1,449.5
1979	222.1	218.6	167.6	259.7	154.6	26.2	2.5	28.5	16.0	49.9	137.5	235.1	1,518.3	2,051.8
1980	124.5	24.7	81.6	95.1	33.6	0.1	1.1	36.2	8.9	6.6	315.6	200.0	928.0	828.3
1981	32.8	24.9	166.0	185.4	39.9	0.4	0.8	2.5	14.3	48.6	145.4	259.3	920.3	989.2
1982	15.7	18.8	76.4	168.9	48.9	18.0	23.4	7.4	79.9	182.5	410.1	168.2	1,218.2	910.7
1983	158.3	235.8	110.6	48.0	57.1	1.0	-	-	-	-	-	-	-	-
Mean ('63-'82)	105.0	82.6	157.0	145.6	50.1	11.0	5.3	11.6	23.2	47.1	195.4	223.2	1,057.0	1,038.4

River: Kambaga (Mkomazi) Station: Njiro bridge C.A.: 749 km^2 Unit: mm

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Total (Oct.-Sep.)
1962	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1963	133.4	65.3	61.4	72.3	13.8	14.3	0.5	0.3	7.3	15.6	174.1	244.9	803.2	
1964	68.1	68.4	131.5	92.9	18.5	0.4	0.2	3.6	3.2	15.3	32.8	86.2	521.1	821.4
1965	43.9	2.6	96.4	27.4	21.8	0.	2.7	11.0	9.2	30.5	75.9	143.5	464.9	349.3
1966	54.0	95.0	203.6	32.4	26.3	5.9	0.3	4.7	1.4	5.5	53.9	58.6	541.6	673.5
1967	0.4	53.4	29.1	287.0	63.6	0.5	13.4	10.5	36.9	51.9	105.4	65.6	717.7	612.8
1968	0.4	98.0	291.0	144.0	73.0	24.3	2.9	1.9	1.2	22.0	112.2	83.0	853.9	859.6
1969	44.1	53.4	96.8	58.5	7.9	2.3	0.6	9.9	2.0	35.9	109.1	24.1	444.6	492.7
1970	191.0	104.4	166.4	48.7	10.9	0	0	2.2	5.8	3.7	43.0	179.1	755.2	698.5
1971	51.2	12.1	76.1	90.3	13.1	13.5	2.2	0	0.7	8.9	21.0	121.1	410.2	485.0
1972	49.7	71.1	46.2	49.6	73.1	1.7	1.4	9.1	21.7	49.6	121.7	99.5	594.4	474.6
1973	101.5	46.9	16.4	73.3	51.5	2.8	0	3.8	9.5	11.2	57.1	104.9	470.1	567.5
1974	42.5	9.4	15.1	175.5	10.6	10.7	8.6	10.9	2.2	8.6	33.4	58.3	385.8	458.7
1975	55.2	11.0	57.9	23.7	35.9	0.4	1.9	0.7	17.8	14.7	22.2	90.5	331.9	304.8
1976	37.7	38.2	76.8	102.7	28.3	10.6	6.5	4.8	46.6	18.4	35.6	63.0	469.3	479.6
1977	97.5	60.6	48.0	11.1	13.3	2.3	1.3	11.1	30.0	28.8	117.3	210.8	632.2	392.2
1978	159.5	40.3	300.2	102.7	19.0	4.6	3.4	0.1	0.3	9.3	211.8	344.7	1,195.8	987
1979	128.6	235.1	86.9	103.4	99.0	21.5	1.7	11.0	13.5	27.1	41.2	120.7	889.8	1,266.5
1980	71.2	14.3	48.1	62.3	11.1	0.0	3.2	27.4	0.8	8.7	109.7	126.2	483.1	427.4
1981	14.5	15.4	131.0	127.1	22.7	0.0	0.1	3.1	7.2	39.8	55.4	139.7	555.8	565.7
1982	8.0	31.2	22.0	84.5	49.6	15.4	15.8	3.7	36.4	117.3	213.5	125.8	723.2	501.5
1983	77.0	127.2	34.4	31.6	40.2	5.1	-	-	-	-	-	-	-	-
Mean ('63-'82)	67.7	56.3	100.0	88.5	33.2	6.6	3.4	6.5	12.3	26.1	87.4	124.5	612.2	601.0

Table A-4 (2/3) BASIN RAINFALL

River: Hingilili Station: Debouching point C.A.: 55.8 km^2 Unit: mm

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Total (Oct.-Sep.)
1962	-	-	-	-	-	-	-	-	-	22.8	388.2	476.0	887.0	-
1963	390.8	91.7	216.0	168.7	43.7	75.0	15.2	10.1	79.5	69.1	434.8	452.3	2,046.9	1,977.7
1964	170.4	182.9	260.6	262.5	54.9	5.1	5.1	48.9	10.5	154.9	109.0	390.1	1,654.9	1,957.1
1965	61.3	6.7	78.0	161.5	63.5	0.5	5.7	16.8	13.8	107.0	403.7	275.1	1,193.6	1,061.8
1966	60.4	69.3	256.2	115.6	65.0	17.8	2.6	5.8	27.8	24.4	103.5	123.6	872.0	1,406.3
1967	12.6	155.5	108.5	493.5	106.2	5.3	25.2	22.5	61.0	143.7	284.6	167.0	1,585.6	1,241.8
1968	1.3	131.9	398.7	214.7	82.2	62.7	7.3	10.7	2.0	117.3	340.5	273.7	1,643.0	1,506.8
1969	100.3	110.6	326.2	130.4	46.2	11.1	1.2	12.2	5.1	99.3	390.9	141.8	1,375.3	1,474.8
1970	242.8	173.1	198.9	145.3	16.6	0	0	5.2	15.5	9.4	153.3	213.1	1,173.2	1,429.4
1971	61.4	19.1	214.5	329.2	34.1	6.8	8.9	1.2	22.9	21.6	112.6	309.7	1,142.0	1,073.9
1972	126.8	128.3	94.3	63.6	177.4	0.4	10.2	28.1	56.1	108.7	435.6	306.8	1,536.3	1,129.1
1973	172.5	115.4	78.7	202.7	93.7	2.6	0	42.1	7.0	29.9	300.0	304.5	1,349.1	1,565.8
1974	95.5	44.1	114.7	274.1	52.7	56.7	14.0	12.8	5.4	48.2	187.7	233.2	1,139.1	1,304.4
1975	97.7	79.5	170.4	243.6	83.0	0	0.5	6.9	47.7	98.7	196.0	230.3	1,254.3	1,198.4
1976	68.9	57.2	129.7	40.8	49.1	0	1.8	0	0	41.2	173.2	144.2	706.1	872.5
1977	110.5	100.1	176.1	115.0	47.4	8.8	9.7	22.7	110.0	86.1	406.4	445.5	1,638.3	1,058.9
1978	211.6	136.1	391.0	176.5	38.0	3.4	3.1	3.3	10.3	47.1	751.1	595.7	2,367.2	1,911.3
1979	243.4	154.3	180.8	420.2	210.9	28.0	6.7	21.4	13.7	76.6	253.1	282.2	1,891.3	2,673.3
1980	190.2	47.0	109.6	142.9	76.5	0.2	1.3	45.3	27.0	14.9	562.8	309.9	1,527.6	1,251.9
1981	42.5	10.9	179.5	291.8	49.3	1.3	2.5	5.7	23.0	88.5	174.0	254.0	1,123.0	1,494.1
1982	31.6	21.8	120.8	251.8	52.8	10.7	19.0	5.8	125.0	251.8	586.9	170.8	1,648.8	1,155.8
1983	171.1	345.9	232.5	53.6	30.8	-	-	-	-	-	-	-	-	-
Mean ('63-'82)	124.6	91.8	190.2	212.3	72.2	14.8	7.0	16.4	33.2	81.9	318.0	281.2	1,443.4	1,437.3

River: Yongoma Station: Ndungu gauge site C.A.: 70.5 km^2 Unit: mm

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Total (Oct.-Sep.)
1962	-	-	-	-	-	-	-	-	-	18.3	223.6	254.7	496.6	-
1963	269.5	90.0	114.9	137.6	21.0	43.7	6.1	4.0	34.9	27.6	303.9	394.0	1,447.2	1,218.3
1964	92.5	132.1	190.0	152.4	26.5	2.0	2.0	19.6	4.2	78.8	102.3	327.8	1,130.2	1,346.8
1965	79.7	6.5	95.9	69.8	38.7	0.2	4.4	19.2	13.3	63.4	225.0	270.5	886.6	836.6
1966	102.2	95.0	242.5	68.7	41.2	7.1	1.0	2.3	11.1	9.8	134.8	82.3	798.0	1,130.0
1967	5.0	182.6	87.6	443.9	86.3	2.1	25.3	15.8	59.3	105.1	224.8	170.2	1,408.0	1,134.8
1968	1.6	234.6	504.5	232.2	103.0	52.6	2.9	6.7	3.9	60.6	218.7	213.9	1,635.2	1,642.1
1969	112.1	88.2	215.3	92.9	18.5	4.4	0.5	11.2	7.0	58.4	281.9	105.0	995.4	1,043.3
1970	202.9	113.7	240.5	73.1	10.4	0.	0.	8.8	16.0	9.9	126.1	260.6	1,062.0	1,110.7
1971	71.8	19.8	167.2	288.6	30.0	9.4	3.9	0.5	9.2	25.1	89.7	224.9	940.1	997.0
1972	127.3	94.3	98.2	62.6	122.5	4.7	4.4	23.6	45.6	77.9	260.2	225.5	1,146.8	922.9
1973	159.0	104.0	49.2	163.9	61.7	2.2	0.	23.9	3.7	16.9	181.4	310.1	1,076.0	1,131.2
1974	73.8	36.3	70.4	188.4	35.5	45.2	16.6	21.0	6.1	31.9	139.2	165.2	829.6	1,001.7
1975	84.1	44.9	150.1	108.6	65.7	0.	1.9	4.1	33.3	48.0	116.0	150.4	807.1	829.0
1976	97.2	77.8	165.3	110.1	60.4	15.7	1.6	4.3	49.0	38.1	144.8	171.9	936.2	895.8
1977	152.7	76.9	120.8	57.5	30.4	4.5	3.9	12.4	82.9	57.2	222.1	393.6	1,214.9	896.8
1978	218.1	103.0	366.0	148.2	36.9	1.4	10.4	1.3	4.1	24.8	503.8	522.1	1,940.1	1,562.3
1979	245.4	215.0	187.9	297.8	168.1	27.3	2.7	32.9	16.7	55.4	160.8	263.6	1,673.6	2,244.5
1980	137.3	27.1	89.8	103.0	38.9	0.1	0.5	38.3	10.8	6.0	365.5	217.7	1,035.0	925.6
1981	37.3	27.4	174.8	199.2	44.2	0.5	1.0	2.3	16.0	50.5	167.9	289.5	1,010.4	1,091.9
1982	17.4	15.6	89.8	189.5	48.7	18.7	25.3	8.4	90.4	198.4	458.1	178.8	1,339.1	1,011.7
1983	178.7	262.3	128.8	52.0	61.6	-	-	-	-	-	-	-	-	-
Mean ('63-'82)	114.3	89.2	171.0	159.4	54.4	12.1	5.7	13.0	25.9	52.2	221.4	246.9	1,165.6	1,148.7

Table A-4 (3/3) BASIN RAINFALL

River: Mkomazi Station: Kalimawe dam C.A.: 1,492 km^2 Unit: mm

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Total (Oct.-Sep.)
1962	-	-	-	-	-	-	-	-	-	9.8	89.3	199.2	298.3	-
1963	139.6	66.5	74.5	78.3	16.5	18.9	1.7	1.1	13.3	17.3	215.3	309.6	952.6	708.7
1964	77.6	76.5	141.5	107.2	8.0	0.8	0.6	7.4	3.9	26.1	36.3	102.6	588.5	965.7
1965	43.3	2.8	94.4	39.1	25.2	0.1	2.9	11.1	9.4	36.5	101.3	149.1	515.2	393.3
1966	51.4	92.2	206.6	38.9	29.5	7.1	0.5	5.0	3.6	7.3	53.8	64.1	560.0	721.7
1967	1.4	55.6	33.8	298.7	66.7	0.9	13.9	11.4	38.0	58.2	116.7	69.4	764.7	645.6
1968	0.4	92.3	288.0	145.6	71.9	26.5	3.4	2.5	1.1	29.7	129.7	94.8	885.9	806.6
1969	45.5	57.3	113.6	63.9	11.3	3.1	0.7	10.0	2.0	41.2	127.9	31.3	507.8	561.6
1970	195.9	111.2	164.9	57.5	11.5	0.	0.	2.4	6.1	3.8	49.3	177.2	779.8	749.9
1971	50.9	12.3	84.9	102.6	14.3	13.1	2.8	0.1	2.5	9.1	26.2	134.5	453.3	513.8
1972	52.7	75.7	47.8	50.2	81.1	1.3	2.1	10.2	23.7	54.0	146.3	113.4	658.8	514.9
1973	105.3	50.5	20.9	81.1	55.4	2.8	0.	6.6	1.0	12.8	74.9	112.5	524.0	637.5
1974	46.1	11.4	22.1	185.3	13.5	13.3	8.6	10.4	2.3	11.3	42.9	69.9	437.2	513.3
1975	57.8	16.1	63.8	41.8	39.0	0.4	1.7	1.2	20.0	21.6	34.7	101.6	399.5	365.7
1976	37.0	37.5	76.5	95.5	28.3	9.1	6.3	4.3	41.4	19.5	43.1	64.3	462.9	493.9
1977	95.1	63.8	56.9	19.2	15.9	2.9	2.1	12.2	35.1	33.1	141.5	223.8	701.5	430.0
1978	161.1	46.4	305.5	107.6	19.8	4.7	2.9	0.4	1.1	12.4	250.4	359.8	1,272.0	1,047.8
1979	133.1	227.7	90.2	124.5	106.4	21.8	2.2	10.6	13.3	30.5	56.0	128.5	944.8	1,352.4
1980	79.6	17.0	51.9	68.2	16.3	0.	3.2	28.6	3.0	9.6	141.4	139.9	558.7	482.8
1981	16.0	14.1	133.2	140.1	24.1	0.1	0.3	3.4	8.3	44.3	60.5	141.8	586.2	630.5
1982	9.9	31.2	28.1	95.5	50.0	14.7	15.5	3.6	42.3	126.4	237.3	127.1	781.5	537.3
1983	80.2	141.6	49.5	32.6	37.7	4.9	-	-	-	-	-	-	-	-
Mean ('63-'82)	70.0	57.9	104.9	97.1	35.3	7.1	3.6	7.1	13.5	30.2	104.3	135.8	666.7	653.7

River: Saseni Station: Gulutu gauge site (1DB2A) C.A.: 192 km^2 Unit: mm

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Total (Oct.-Sep.)
1962	-	-	-	-	-	-	-	-	-	13.3	127.6	188.2	329.1	-
1963	183.3	77.9	77.0	102.2	14.8	25.9	2.3	1.5	16.3	15.2	236.7	341.6	1,094.7	830.3
1964	71.4	95.4	153.4	98.0	12.3	0.9	0.8	8.3	2.9	39.1	68.1	204.3	754.9	1,036.9
1965	64.7	4.6	98.3	38.4	27.4	0.1	3.4	15.6	11.3	42.3	131.8	209.0	646.9	575.3
1966	84.1	98.1	222.2	45.6	31.2	5.3	11.7	3.1	4.5	6.0	99.8	65.9	677.5	888.9
1967	1.9	123.9	57.0	362.6	73.0	1.0	19.6	12.5	48.3	74.9	160.3	120.3	1,055.3	871.5
1968	1.1	181.4	414.8	192.0	91.1	37.8	2.4	3.9	2.8	35.2	152.9	143.9	1,259.3	1,282.8
1969	80.9	68.8	145.0	71.8	10.1	2.6	0.5	10.4	4.8	42.3	185.9	61.7	684.8	726.9
1970	192.4	102.1	210.0	52.6	9.8	0.	0.	3.4	11.1	6.9	82.9	227.2	898.4	871.3
1971	63.1	16.2	117.8	188.5	21.3	11.7	2.4	0.2	3.4	17.7	54.0	164.8	661.1	741.6
1972	90.1	79.1	73.7	56.3	92.2	3.8	2.2	16.1	32.8	60.6	172.6	155.2	834.6	682.7
1973	129.8	75.2	29.9	115.8	52.9	2.4	0.	12.0	1.8	12.6	107.4	212.3	752.2	808.3
1974	56.2	22.5	38.5	171.8	21.5	27.3	13.1	17.1	4.3	18.7	82.5	105.7	579.2	704.6
1975	68.6	24.4	103.4	51.6	49.3	0.2	2.1	2.2	24.1	25.9	61.3	112.0	525.0	532.7
1976	72.0	61.3	127.2	114.9	46.3	15.1	3.9	5.0	53.8	28.2	89.0	122.9	739.7	698.8
1977	131.3	66.3	79.2	28.3	20.1	2.9	2.0	10.5	54.2	40.1	149.6	299.6	884.2	635.0
1978	190.7	68.9	331.4	122.9	28.2	2.7	7.9	0.5	1.5	14.7	333.8	428.0	1,531.3	1,244.1
1979	189.6	232.0	140.3	189.7	129.8	24.5	1.7	23.8	15.5	39.3	92.3	192.8	1,271.2	1,723.3
1980	99.2	18.6	67.4	78.6	21.0	0.	1.7	32.3	4.1	6.2	218.9	162.7	710.7	647.3
1981	25.8	23.6	153.2	153.4	33.3	0.2	0.4	2.3	10.9	40.7	113.1	221.8	778.6	790.8
1982	11.2	22.3	53.5	131.6	48.6	18.1	21.5	6.4	60.3	153.0	325.2	154.4	1,006.2	749.2
1983	130.8	187.4	71.0	42.0	55.0	2.4	-	-	-	-	-	-	-	-
Mean ('63-'82)	90.4	73.2	134.6	118.3	41.7	9.1	4.9	9.3	18.5	36.0	145.9	185.3	867.3	852.1

Table A-5 RECORD OF MONTHLY MEAN DISCHARGE

River: Hingilili Station: Kiruka (1DB18) C.A.: 31.5 km^2 Unit: m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.	Average Oct.-Sep.
1963	2.47	0.98	0.69	0.82	0.60	0.45	0.36	0.30	0.27	0.24	0.98	1.66	0.82	
1964	1.60	0.90	0.97	1.04	0.95	0.63	0.48	0.39	0.30	0.31	0.34	1.61	0.79	0.85
1965	0.78	0.42	0.40	0.44	0.33	0.26	0.24	0.22	0.19	0.23	0.51	1.29	0.44	0.46
1966	0.56	0.55	0.73	0.78	0.54	0.43	0.35	0.27	0.22	0.22	0.38	0.56	0.47	0.54
1967	0.23	0.37	0.28	0.78	0.61	0.42	0.34	0.26	0.26	0.28	0.97	0.83	0.47	0.39
1968	0.42	0.36	1.56	1.37	0.93	0.72	0.53	0.43	0.35	0.37	0.67	1.44	0.76	0.73
1969	0.81	0.88	2.26	1.68	0.93	0.62	0.47	0.39	0.31	0.31	0.91	1.19	0.90	0.90
1970	0.92	0.90	1.17	1.54	0.94	0.63	0.48	0.39	0.33	0.24	0.57	0.89	0.75	0.81
1971	0.36	0.35	0.44	0.80	0.64	0.42	0.35	0.30	0.25	0.23	0.27	1.23	0.47	0.47
1972	0.84	0.53	0.46	0.35	0.55	0.33	0.28	0.25	0.24	0.26	0.78	1.52	0.53	0.46
1973	0.75	0.57	0.49	0.67	0.64	0.42	0.34	0.31	0.26	0.23	0.81	1.91	0.62	0.58
1974	0.72	0.48	0.50	0.93	0.81	0.55	0.44	0.38	0.30	0.30	0.50	1.56	0.62	0.67
1975	0.99	0.69	0.93	0.94	0.86	0.65	0.35*	0.31*	0.48	0.47	0.72	1.10	0.71	0.71
1976	0.68	0.53	0.62	1.04	0.69	0.58	0.47	0.47	0.42	0.44*	0.41	0.41	0.56	0.65
1977	0.83	0.38	0.56	0.64	0.55	0.40	0.31	0.26	0.26	0.22	0.77	2.17	0.61	0.45
1978	1.81	1.30	1.76	1.91	1.15	0.79	0.77	0.86	0.74	0.64	2.35	5.10	1.60	1.19
1979	2.85	2.27	1.83	2.86	2.45	1.91	0.76*	1.16	0.99	0.87	1.00	0.81	1.65	2.10
1980	0.46	0.36	0.30	0.43	0.34	0.26	0.22	0.20	0.46*	0.15	0.73	0.87	0.40	0.48
1981	0.40	0.26	0.30	0.51	0.40	0.30	0.15	0.11	0.17	0.17	0.17	0.33	0.27	0.36
1982	0.75	0.48	0.43	0.84	0.60	0.48	0.45	0.40	0.42	0.75	1.41	1.96	0.75	0.46
Average	0.97	0.69	0.86	1.03	0.78	0.57	0.40	0.38	0.36	0.33	0.73	1.39	0.71	

*: Interpolated by discharge of Saseni river

River: Saseni Station: Gulutu (1DB2A) C.A.: 192 km^2 Unit: m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.	Average Oct.-Sep.
1963	25.4*	3.55*	1.68*	1.98	1.33	0.87	0.72	0.44	0.40	0.35	2.09	4.26	1.38	
1964	4.76	2.13	8.77	3.18	2.46	1.30	0.73	0.40	0.42	0.45	0.34	2.70	2.30	2.57
1965	2.04	0.82	1.20	1.05	0.54	0.41	0.32	0.28	0.20	0.26	0.95	6.77	1.24	0.86
1966	2.69	3.28	3.14	3.11	1.46	1.20	0.83	0.53	0.41	0.45	1.00	1.78	1.66	2.05
1967	0.55	1.60	1.18	3.18	2.84	1.17	0.75	0.53	0.58	0.63	2.63	2.49*	1.51	1.30
1968	0.77	0.56	3.62	5.44	1.89	1.33	0.75	0.46	0.29	0.24	0.99	6.42	1.90	1.74
1969	4.62	5.37	4.57	4.55	1.92	1.15	0.74	0.54	0.35	0.47	1.83	3.55	2.47	2.62
1970	3.16	5.81	7.56	6.33	2.68	1.36	0.87	0.59	0.42	0.34	2.61	4.39	3.01	2.89
1971	2.15	1.73	1.15	2.04	1.21	0.73	0.51	0.34	0.29	0.26	0.58	2.46	1.12	1.46
1972	3.30	2.02	1.90	2.13	1.87	1.24	0.77	0.52	0.52	0.21*	0.49	3.19	1.51	1.46
1973	2.48	1.71	1.34	1.89	1.50	0.85	0.58	0.37	0.30	0.28	1.74	3.19	1.35	1.24
1974	1.67	1.19	1.52	1.81	1.49	0.63	0.46	0.32	0.24	0.19	1.50	5.05	1.34	1.21
1975	2.78	1.03	1.88	1.48	1.17	0.60	0.40	0.30	0.27	0.19	0.85	3.31	1.19	1.39
1976	3.20	2.67	3.78	5.83	2.47	1.48	1.09	0.74	0.80	0.66	0.46	1.61	2.07	2.20
1977	3.64	1.71	3.73	2.39	1.36	0.86	0.59	0.56	0.44	0.49	1.58	8.23	2.13	1.50
1978	6.66	3.15	11.02	7.00	2.90	1.80	1.43	0.88	0.63	0.54	3.08	15.88	4.58	3.81
1979	8.61	11.37	5.45	5.72	5.20	3.31	2.06	1.55	1.23	0.93	1.76	2.14	4.11	5.33
1980	2.04	2.17	2.36	3.57	2.34	1.63	1.28	1.07	0.71	0.49	1.54	7.67	2.24	1.83
1981	2.95	1.86	1.35	2.65	1.62	1.14	0.83	0.70	0.66	0.75	1.03	7.24	1.90	1.96
1982	4.36	1.45	1.43	2.56	1.86	1.08	0.96	0.85	0.82	1.53	5.28	7.43	2.47	2.03
Average	4.39	2.76	3.43	3.39	2.01	1.21	0.83	0.60	0.50	0.49	1.62	4.99	2.18	

*: Interpolated by discharge of Hingilili river

Table A-6 ESTIMATED MONTHLY MEAN RUNOFF AT KALIMAWE DAM

River: Mkomazi Station: Kalimawe dam Total Catchment Area: 1,492 km^2 Unit: m^3/sec

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.	Ave Oct-Sep
1963	15.3*	4.18*	2.69*	3.09*	2.33*	1.77*	1.49*	1.17*	1.08*	0.98*	3.43*	1.60	3.26	-
1964	3.21	3.31*	1.70	4.09*	0.48	1.08	0.72	0.59	0.35	0.34	0.13	0.30	1.36	1.80
1965	3.96	0.24	1.86*	1.85*	1.31*	1.24*	0.32	0.53	0.80	0.98	0.35	4.93	1.53	1.07
1966	4.53	3.79	2.62	3.11	3.72	3.60	3.07	2.28	0.58	0.42	0.25	0.38	2.36	2.80
1967	0.25	0.65	0.83	5.74	3.16*	1.88*	1.46*	1.15*	65.8	3.63	0.76	3.63	7.41	6.83
1968	1.66	0.31	9.04	30.4	14.3	12.2	5.33	4.04	3.80	2.44	2.38	2.43	7.36	7.43
1969	13.0	32.1	22.4	70.2	62.0	26.4	11.3	3.86	3.10	2.41	2.03	4.36	21.10	20.97
1970	5.49	10.2	12.3	42.9	8.55	3.46	2.60	0.93	0.53	0.44	0.89	17.7	8.83	7.98
1971	11.30	3.19	0.38	0.87	2.33*	1.61*	0.80	0.51	0.96*	0.89*	1.20*	4.05*	2.34	3.42
1972	3.81*	0.56	2.37*	2.29*	2.53*	1.74*	0.30	1.11*	1.09*	0.93*	2.20*	4.89*	1.99	1.83
1973	5.51	2.82	1.81	1.64	1.47	0.75	0.58	0.40	0.28	0.91*	2.94*	5.51*	2.05	1.94
1974	3.33	6.73	2.62	0.89	3.66	2.70	2.29	1.05	0.68	0.40	0.32	3.57	2.10	2.53
1975	4.82	2.20	3.24*	3.05*	2.73*	2.01*	1.26*	1.11*	1.46*	1.39*	2.29*	4.25*	2.48	2.18
1976	3.47*	2.93*	3.67*	5.36*	4.57	3.33	2.79	2.59	1.89	0.48	0.56	0.77	2.70	3.21
1977	6.15	13.91	5.77	3.57	1.56	0.39	0.38	0.26	0.06	1.03*	2.78*	8.13*	3.67	2.82
1978	33.0	12.4	19.1	78.8	9.79	3.32	3.47	3.06	2.34	1.12	2.40	70.8	19.97	14.77
1979	20.4	21.9	10.6	12.12	9.40	2.29	2.39	0.47	0.58	0.54	1.56	2.67	7.08	12.87
1980	3.47	2.59	0.69	0.77	1.00	0.42	0.76	0.79	1.68*	0.87*	2.69*	3.74*	1.62	1.41
1981	7.46	1.36	0.27	4.66	4.93	2.70	1.72	0.48	0.74	0.67	0.29	2.95	2.35	2.64
1982	7.12	2.83	1.65	1.18	1.55	1.27	0.83	0.49	0.43	0.38	1.78	30.8	4.19	1.77
1983	14.1	10.4	7.62	5.65	3.65	-	-	-	-	-	-	-		
Ave (63-82)	7.71	6.41	5.28	13.8	7.07	3.71	2.19	1.34	4.41	1.06	1.56	8.87	5.29	5.27

* : Interpolated from the basin rainfall

Table A-7 (1/5) ESTIMATED MONTHLY MEAN DISCHARGE OF NAKOMBO RIVER

River: Nakombo Station: at Gauging Station C.A.: 48.5 km^2 Unit: m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.	Average Oct.-Sep.
1963	2.81	1.12	0.78	0.93	0.68	0.51	0.41	0.34	0.30	0.27	1.11	1.89	0.93	
1964	1.82	1.02	1.10	1.18	1.08	0.71	0.54	0.44	0.34	0.35	0.38	1.83	0.89	0.96
1965	0.88	0.47	0.45	0.50	0.37	0.61	0.27	0.25	0.21	0.26	0.58	1.46	0.50	0.55
1966	0.63	0.62	0.83	0.88	0.61	0.48	0.39	0.30	0.25	0.25	0.43	0.63	0.53	0.60
1967	0.26	0.42	0.31	0.88	0.69	0.47	0.38	0.29	0.29	0.31	1.10	0.94	0.53	0.44
1968	0.47	0.41	1.77	1.56	1.05	0.82	0.60	0.48	0.39	0.42	0.76	1.65	0.86	0.83
1969	0.92	1.00	2.57	1.91	1.05	0.70	0.53	0.44	0.35	0.35	1.03	1.35	1.02	1.02
1970	1.04	1.02	1.33	1.75	1.07	0.71	0.54	0.44	0.37	0.27	0.64	1.01	0.85	0.92
1971	0.41	0.39	0.50	0.91	0.72	0.47	0.39	0.34	0.28	0.26	0.30	1.40	0.53	0.53
1972	0.95	0.60	0.52	0.39	0.62	0.37	0.31	0.28	0.27	0.29	0.88	1.73	0.60	0.52
1973	0.85	0.64	0.55	0.76	0.72	0.47	0.38	0.35	0.29	0.26	0.92	2.17	0.70	0.66
1974	0.82	0.54	0.56	1.05	0.92	0.62	0.50	0.43	0.34	0.34	0.56	1.77	0.70	0.76
1975	1.12	0.78	1.05	1.07	0.97	0.74	0.39	0.35	0.54	0.53	0.82	1.25	0.80	0.81
1976	0.77	0.60	0.70	1.18	0.78	0.66	0.53	0.53	0.47	0.50	0.46	0.46	0.63	0.74
1977	0.94	0.43	0.63	0.72	0.62	0.45	0.35	0.29	0.29	0.25	0.87	2.47	0.69	0.51
1978	2.06	1.48	2.00	2.17	1.30	0.89	0.87	0.97	0.84	0.72	2.67	5.81	1.82	1.35
1979	3.24	2.58	2.08	3.25	2.79	2.17	0.86	1.32	1.12	0.99	1.13	0.92	1.87	2.38
1980	0.52	0.41	0.34	0.48	0.38	0.29	0.25	0.22	0.52	0.17	0.83	0.99	0.45	0.54
1981	0.45	0.29	0.34	0.58	0.45	0.34	0.17	0.12	0.19	0.19	0.19	0.37	0.30	0.41
1982	0.84	0.54	0.48	0.94	0.67	0.54	0.50	0.45	0.47	0.84	1.57	2.18	0.84	0.52
Average	1.09	0.77	0.94	1.15	0.88	0.65	0.46	0.43	0.41	0.39	0.86	1.61	0.80	

Table A-7 (2/5) ESTIMATED MONTHLY MEAN DISCHARGE OF HINGILILI RIVER

River: Hingilili Station: at Debouching Point C.A.: 55.8 km^2 Unit: m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.	Average Oct.-Sep.
1963	4.37	1.74	1.22	1.45	1.06	0.80	0.64	0.53	0.48	0.43	1.74	2.94	1.45	
1964	2.83	1.59	1.72	1.84	1.68	1.12	0.85	0.69	0.53	0.55	0.60	2.85	1.40	1.50
1965	1.38	0.74	0.71	0.78	0.58	0.46	0.43	0.39	0.34	0.41	0.90	2.29	0.78	0.82
1966	0.99	0.97	1.29	1.38	0.96	0.76	0.62	0.48	0.39	0.39	0.67	0.99	0.83	0.95
1967	0.41	0.65	0.50	1.38	1.08	0.74	0.60	0.46	0.46	0.50	1.72	1.47	0.83	0.69
1968	0.74	0.64	2.76	2.43	1.65	1.28	0.94	0.76	0.62	0.66	1.19	2.55	1.35	1.29
1969	1.43	1.56	4.00	2.98	1.65	1.10	0.83	0.69	0.55	0.55	1.61	2.11	1.59	1.60
1970	1.63	1.59	2.07	2.73	1.66	1.12	0.85	0.69	0.58	0.42	1.01	1.58	1.33	1.43
1971	0.64	0.62	0.78	1.42	1.13	0.74	0.62	0.53	0.44	0.41	0.48	2.18	0.83	0.83
1972	1.49	0.94	0.81	0.62	0.97	0.58	0.50	0.44	0.42	0.46	1.38	2.69	0.94	0.82
1973	1.33	1.01	0.87	1.19	1.13	0.74	0.60	0.55	0.46	0.41	1.43	3.38	1.10	1.03
1974	1.28	0.85	0.89	1.65	1.43	0.97	0.78	0.67	0.53	0.53	0.88	2.76	1.10	1.19
1975	1.75	1.22	1.65	1.67	1.52	1.15	0.62	0.55	0.85	0.83	1.28	1.95	1.26	1.26
1976	1.20	0.94	1.10	1.84	1.22	1.03	0.83	0.83	0.74	0.78	0.73	0.73	0.99	1.15
1977	1.47	0.67	0.99	1.13	0.97	0.71	0.55	0.46	0.46	0.39	1.36	3.84	1.08	0.80
1978	3.21	2.30	3.12	3.38	2.04	1.40	1.36	1.52	1.31	1.13	4.16	9.03	2.83	2.10
1979	5.05	4.02	3.24	5.07	4.34	3.38	1.35	2.05	1.75	1.54	1.77	1.43	2.92	3.71
1980	0.81	0.64	0.53	0.76	0.60	0.46	0.39	0.35	0.81	0.27	1.29	1.54	0.71	0.84
1981	0.71	0.46	0.53	0.90	0.71	0.53	0.27	0.19	0.30	0.30	0.30	0.58	0.48	0.64
1982	1.33	0.85	0.76	1.49	1.06	0.85	0.80	0.71	0.74	1.33	2.50	3.47	1.32	0.81
Average	1.70	1.20	1.48	1.80	1.37	1.00	0.72	0.68	0.64	0.61	1.35	2.52	1.26	

Table A-7 (3/5) ESTIMATED MONTHLY MEAN DISCHARGE OF YONGOMA RIVER

River: Yongoma Station: at Gauging Station C.A.: 70.5 km^2 Unit: m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.	Average Oct.-Sep.
1963	7.42	1.75	1.08	1.27	0.91	0.66	0.53	0.41	0.37	0.33	1.47	2.62	1.57	
1964	2.64	1.39	2.65	1.73	1.50	0.94	0.67	0.51	0.41	0.43	0.44	2.28	1.30	1.41
1965	1.24	0.62	0.66	0.68	0.47	0.36	0.33	0.30	0.25	0.30	0.74	2.65	0.72	0.67
1966	1.11	1.20	1.38	1.43	0.86	0.69	0.54	0.40	0.32	0.33	0.60	0.94	0.82	0.97
1967	0.36	0.70	0.52	1.44	1.19	0.68	0.51	0.39	0.39	0.43	1.55	1.37	0.79	0.67
1968	0.61	0.50	2.39	2.50	1.38	1.04	0.73	0.56	0.44	0.46	0.93	2.75	1.19	1.13
1969	1.73	1.94	3.34	2.69	1.38	0.90	0.66	0.53	0.41	0.43	1.34	1.96	1.44	1.48
1970	1.59	2.04	2.66	2.85	1.53	0.95	0.69	0.54	0.44	0.33	1.10	1.78	1.38	1.42
1971	0.79	0.70	0.70	1.26	0.93	0.60	0.48	0.40	0.33	0.30	0.41	1.81	0.70	0.78
1972	1.53	0.95	0.85	0.77	0.95	0.59	0.45	0.37	0.36	0.33	0.96	2.27	0.87	0.78
1973	1.28	0.94	0.79	1.09	0.98	0.62	0.48	0.41	0.34	0.31	1.22	2.71	0.93	0.87
1974	1.10	0.75	0.83	1.36	1.17	0.73	0.57	0.48	0.38	0.37	0.83	2.64	0.93	0.97
1975	1.60	0.96	1.38	1.32	1.17	0.83	0.46	0.40	0.59	0.56	0.96	1.82	1.00	1.05
1976	1.33	1.07	1.37	2.20	1.22	0.91	0.72	0.66	0.61	0.61	0.54	0.75	1.00	1.12
1977	1.58	0.73	1.29	1.14	0.86	0.60	0.45	0.39	0.37	0.33	1.14	3.89	1.06	0.78
1978	3.21	2.02	3.93	3.38	1.80	1.20	1.12	1.12	0.94	0.81	3.18	8.53	2.60	2.01
1979	4.72	4.56	3.02	4.22	3.67	2.73	1.22	1.57	1.33	1.14	1.43	1.29	2.58	3.30
1980	0.88	0.79	0.76	1.12	0.80	0.58	0.47	0.41	0.64	0.26	1.09	2.34	0.85	0.86
1981	0.97	0.62	0.58	1.04	0.74	0.54	0.32	0.25	0.31	0.32	0.37	1.66	0.64	0.76
1982	1.62	0.80	0.74	1.40	1.00	0.93	0.67	0.60	0.62	1.11	2.52	3.52	1.29	0.89
Average	1.87	1.25	1.55	1.74	1.23	0.85	0.60	0.54	0.49	0.47	1.14	2.48	1.18	

Table A-7 (4/5) ESTIMATED MONTHLY MEAN DISCHARGE OF SASENI RIVER

River: Saseni Station: Gulutu (1DB2A) C.A.: 192 km^2 Unit: m^3/sec

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.	Average Oct.-Sep.
1963	25.4*	3.55*	1.68*	1.98	1.33	0.87	0.72	0.44	0.40	0.35	2.09	4.26	1.38	
1964	4.76	2.13	8.77	3.18	2.46	1.30	0.73	0.40	0.42	0.45	0.34	2.70	2.30	2.57
1965	2.04	0.82	1.20	1.05	0.54	0.41	0.32	0.28	0.20	0.26	0.95	6.77	1.24	0.86
1966	2.69	3.28	3.14	3.11	1.46	1.20	0.83	0.53	0.41	0.45	1.00	1.78	1.66	2.05
1967	0.55	1.60	1.18	3.18	2.84	1.17	0.75	0.53	0.58	0.63	2.63	2.49*	1.51	1.30
1968	0.77	0.56	3.62	5.44	1.89	1.33	0.75	0.46	0.29	0.24	0.99	6.42	1.90	1.74
1969	4.62	5.37	4.57	4.55	1.92	1.15	0.74	0.54	0.35	0.47	1.83	3.55	2.47	2.62
1970	3.16	5.81	7.56	6.33	2.68	1.36	0.87	0.59	0.42	0.34	2.61	4.39	3.01	2.89
1971	2.15	1.73	1.15	2.04	1.21	0.73	0.51	0.34	0.29	0.26	0.58	2.46	1.12	1.46
1972	3.30	2.02	1.90	2.13	1.87	1.24	0.77	0.52	0.52	0.21*	0.49	3.19	1.51	1.46
1973	2.48	1.71	1.34	1.89	1.50	0.85	0.58	0.37	0.30	0.28	1.74	3.19	1.35	1.24
1974	1.67	1.19	1.52	1.81	1.49	0.63	0.46	0.32	0.24	0.19	1.50	5.05	1.34	1.21
1975	2.78	1.03	1.88	1.48	1.17	0.60	0.40	0.30	0.27	0.19	0.85	3.31	1.19	1.39
1976	3.20	2.67	3.78	5.83	2.47	1.48	1.09	0.74	0.80	0.66	0.46	1.61	2.07	2.20
1977	3.64	1.71	3.73	2.39	1.36	0.86	0.59	0.56	0.44	0.49	1.58	8.23	2.13	1.50
1978	6.66	3.15	11.02	7.00	2.90	1.80	1.43	0.88	0.63	0.54	3.08	15.88	4.58	3.81
1979	8.61	11.37	5.45	5.72	5.20	3.31	2.06	1.55	1.23	0.93	1.76	2.14	4.11	5.33
1980	2.04	2.17	2.36	3.57	2.34	1.63	1.28	1.07	0.71	0.49	1.54	7.67	2.24	1.83
1981	2.95	1.86	1.35	2.65	1.62	1.14	0.83	0.70	0.66	0.75	1.03	7.24	1.90	1.96
1982	4.36	1.45	1.43	2.56	1.86	1.08	0.96	0.85	0.82	1.53	5.28	7.43	2.47	2.03
Average	4.39	2.76	3.43	3.39	2.01	1.21	0.83	0.60	0.50	0.49	1.62	4.99	2.18	

*: Interpolated by discharge of Hingilili river

Table A-7 (5/5) ESTIMATED MONTHLY MEAN DISCHARGE OF KAMBAGA RIVER AT NJIRO BRIDGE

River: Kambaga Station: Njiro bridge C.A.: 749 km^2 Unit: m^3/sec

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.	Ave. Oct-Sep
1963	3.01	1.12	0.78	0.93	0.68	0.51	0.41	0.34	0.30	0.27	1.11	1.89	0.95	
1964	1.82	1.02	1.10	1.18	1.08	0.71	0.54	0.44	0.34	0.35	0.38	1.83	0.90	0.96
1965	1.01	0.47	0.46	0.50	0.37	0.61	0.27	0.25	0.21	0.26	0.58	1.46	0.54	0.56
1966	1.15	0.91	0.83	0.88	0.93	0.96	0.83	0.62	0.25	0.25	0.43	0.63	0.73	0.81
1967	0.26	0.42	0.31	1.47	0.75	0.47	0.38	0.29	19.04	1.00	1.10	0.94	2.20	2.06
1968	0.47	0.41	2.38	8.49	4.01	3.45	1.49	1.13	1.07	0.68	0.76	1.65	2.17	2.16
1969	3.51	9.00	6.19	20.07	17.85	7.57	3.22	1.08	0.87	0.66	1.03	1.35	6.03	6.04
1970	1.40	2.63	3.14	12.07	2.31	0.91	0.69	0.44	0.37	0.27	0.64	4.88	2.48	2.25
1971	3.15	0.82	0.50	0.91	0.71	0.47	0.39	0.34	0.28	0.26	0.30	1.40	0.80	1.11
1972	0.95	0.60	0.58	0.54	0.62	0.43	0.31	0.29	0.28	0.29	0.88	1.73	0.62	0.55
1973	1.44	0.71	0.55	0.76	0.72	0.47	0.38	0.35	0.29	0.26	0.92	2.17	0.75	0.71
1974	0.82	1.87	0.66	1.05	0.96	0.73	0.63	0.43	0.34	0.34	0.56	1.77	0.85	0.90
1975	1.22	0.78	1.05	1.07	0.97	0.74	0.39	0.35	0.54	0.53	0.82	1.25	0.81	0.82
1976	0.82	0.69	0.84	1.22	1.17	0.87	0.74	0.70	0.49	0.50	0.46	0.46	0.75	0.85
1977	1.57	3.93	1.46	0.89	0.62	0.45	0.35	0.29	0.29	0.27	0.87	2.47	1.12	0.94
1978	9.17	3.39	4.91	22.43	2.65	0.89	0.90	0.97	0.84	0.72	2.67	19.56	5.76	4.15
1979	5.38	5.69	2.74	3.25	2.79	2.17	0.86	1.32	1.12	0.99	1.13	0.92	2.36	4.02
1980	0.89	0.63	0.34	0.48	0.38	0.29	0.25	0.22	0.52	0.22	0.83	0.99	0.50	0.59
1981	2.00	0.29	0.34	1.20	1.33	0.71	0.45	0.12	0.19	0.19	0.19	0.47	0.62	0.72
1982	1.81	0.73	0.48	0.94	0.67	0.54	0.50	0.45	0.47	0.84	1.57	8.45	1.45	0.62
Average	2.09	1.81	1.48	4.02	2.08	1.20	0.70	0.52	1.41	0.46	0.86	2.81	1.62	1.62

Table A-8 WATER QUALITY ANALYSIS

River		Nakombo			Kambaga		Hingilili	
Location		River Bed		Gauge Site	Igoma		Kiruka Bridge	
Date of Sampling		28 Dec. '82		17 Jun. '83	29 Dec. '82	17 Jun. '83	28 Dec. '82	19 Jun. '83
pH		6.60	6.80	7.30	6.99	7.90	6.89	7.00
Electric micro conductivity	mhos/cm	145.5	109	128.0	180.0	248.0	20.25	37.05
Na^+	meq/ℓ	0.36	0.37	0.46	0.47	0.70	0.09	0.13
	mg/ℓ	8.20	8.50	10.5	10.90	16.20	2.10	3.0
K^+	meq/ℓ	0.01	0.01	0.02	0.03	0.05	0.005	0.008
	mg/ℓ	0.50	0.40	0.6	1.10	1.90	0.20	0.3
Ca^{2+}	meq/ℓ	0.43	0.34	0.26	0.70	0.10	0.09	0.70
	mg/ℓ	8.60	6.90	5.2	14.10	2.0	1.90	14.0
Mg^2	meq/ℓ	0.32	0.26	0.35	0.46	0.07	0.04	0.08
	mg/ℓ	3.90	3.20	4.30	5.60	0.90	0.50	1.0
Alkalinity	meq/ℓ	0.78	0.64	0.78	1.34	1.78	0.10	0.19
$C\ell^-$	meq/ℓ	0.18	0.17	0.18	0.30	0.24	0.07	0.08
	mg/ℓ	6.30	5.90	6.30	10.50	8.50	2.40	2.70
SO_4^{2-}	meq/ℓ	0.19	0.17	0.19	0.19	0.21	0.03	0.06
	mg/ℓ	9.30	8.00	9.0	9.00	10.0	1.60	2.80
SiO_2	mg/ℓ	27.60	21.90	25.5	25.30	23.0	9.70	13.8
Σ cation	meq/ℓ	1.12	0.99	1.09	1.67	0.93	0.23	0.92
Σ anion	meq/ℓ	1.15	0.97	1.15	1.82	2.23	0.20	0.32
Σ ion	meq/ℓ	2.27	1.96	2.23	3.49	3.16	0.43	1.24
Total iron	mg/ℓ	14.84	3.53		2.06		0.72	
Manganese	mg/ℓ	0	0		0		0	
Soluble solid	mg/ℓ	76.20	77.50		19.30		97.30	
SAR/1		0.59	0.68	0.83	0.62	2.40	0.35	0.21

River		Yongoma		Kalimawe	Saseni	
Location		Gauge Site		Low Level Canal	Upstream	Gulutu
Date of Sampling		29 Dec. '82	19 Jun. '83	19 Jun. '83	31 Dec. '82	19 Jun. '83
pH		7.15	7.05	7.40	6.95	7.56
Electric micro conductivity	mhos/cm	33.4	45.8	209.0	28.35	115.0
Na^+	meq/ℓ	0.12	0.14	0.91	0.10	0.30
	mg/ℓ	2.70	3.30	21.0	2.40	7.0
K^+	meq/ℓ	0.05	0.01	0.03	0.003	0.01
	mg/ℓ	0.20	0.40	1.2	0.10	0.40
Ca^{2+}	meq/ℓ	0.12	0.47	0.10	0.10	0.34
	mg/ℓ	2.50	9.5	2.0	2.00	6.8
Mg^{2+}	meq/ℓ	0.09	0.44	0.11	0.06	0.32
	mg/ℓ	1.10	5.4	1.3	0.70	3.9
Alkalinity	meq/ℓ	0.16	0.18	1.35	0.14	0.62
$C\ell^-$	meq/ℓ	0.11	0.12	0.29	0.08	0.22
	mg/ℓ	3.90	4.1	10.3	2.80	7.9
SO_4^{2-}	meq/ℓ	0.05	0.09	0.20	0.03	0.17
	mg/ℓ	2.60	4.3	9.5	1.60	8.0
SiO_2	mg/ℓ	11.40	11.50	10.5	11.10	18.8
Σ cation	meq/ℓ	0.34	1.07	1.15	0.26	0.98
Σ anion	meq/ℓ	0.32	0.39	1.84	0.25	1.01
Σ ion	meq/ℓ	0.66	1.46	2.99	0.52	1.98
Total iron	mg/ℓ	0.46			0.26	
Manganese	mg/ℓ	0			0	
Soluble solid	mg/ℓ	15.50			12.70	
SAR/1		0.37	0.21	2.80	0.35	0.52

Note: /1: SAR = Sodium Adsorption Ratio $= Na^+ / \sqrt{(Ca^{++} + Mg^{++})/2}$

Table A-9 ANALYSIS OF RECORDS OF THE YONGOMA RIVER

Date	10 Jan.'83	17 Jan.'83	15 Feb.'83
Gauge height	1.72	2.37	2.18
Water level	528.43	529.08	528.89
Peak discharge (m^3/sec)	101	140	120
Flood concentration time, T_p (min)	210	180	120
Basin rainfall within T_p (mm)	41	63	80
Rainfall intensity within T_p (mm/hr)	11	21	40
Peak runoff coefficient (%)	47	34	15
Effective rainfall intensity (mm/hr)	5	7	6

Table A-10 ANNUAL MAXIMUM BASIN RAINFALL

Unit: mm

	Nakombo	Kambaga (Igoma)	Hingilili	Yongoma	Mkomazi (Kalimawe)	Saseni
1972	60.4	25.3	180.0	72.8	24.2	35.7
1973	37.6	47.1	99.1	41.7	49.7	37.3
1974	30.7	85.2	50.5	34.1	82.2	49.5
1975	26.7	26.6	58.3	31.5	28.7	24.1
1976	40.4	27.3	48.5	46.6	28.1	38.1
1977	51.5	33.1	103.8	59.5	34.9	48.2
1978	83.8	65.8	114.8	88.6	62.0	82.9
1979	60.3	84.6	92.4	69.6	84.6	55.8
1980	63.0	44.8	127.8	72.5	48.4	59.6
1981	55.1	35.6	77.7	63.2	40.0	47.6
1982	51.4	48.5	124.0	59.3	47.0	48.4
1983	87.8	61.8	209.5	102.0	76.2	77.1

Table A-11 PROBABLE BASIN RAINFALL

Unit: mm

Return period in year	Nakombo	Kambaga (Igoma)	Hingilili	Yongoma	Mkomazi (Kalimawe)	Saseni
2	51	44	63	58	46	48
5	69	64	89	79	66	64
10	81	78	107	93	80	74
20	91	91	123	104	92	82
50	108	113	149	123	112	96
100	119	129	169	136	126	105
200	131	146	187	149	141	115

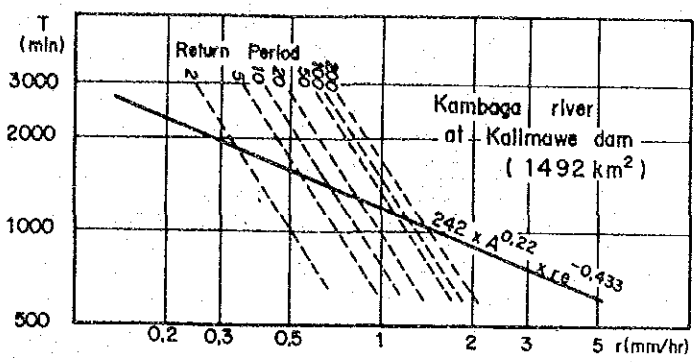
Table A-12 RECORDED ANNUAL MAXIMUM RAINFALL

Station	Year	One day (mm)	2 days' Consecutive (mm)	Station	Year	One day (mm)	2 days' Consecutive (mm)
				Kalimawe meteo. sta.	1962	49.8	75.2
Tia dam site	1963	151.9	201.4		1963	96.8	184.4
	1964	111.8	169.5		1964	44.2	46.7
	1965	90.7	132.4		1965	63.8	78.3
	1966	117.3	117.3		1966	87.1	89.6
	1967	88.6	137.7		1967	70.1	70.6
	1968	57.9	89.4		1968	53.3	54.8
	1969	89.9	139.2		1969	33.3	44.7
	1970	57.7	76.4		1970	84.6	93.7
	1971	96.3	101.0		1971	36.1	43.8
	1972	180.0	257.0		1972	31.8	37.8
	1973	99.1	104.1		1973	55.5	55.6
	1974	50.5	66.6		1974	108.0	132.0
	1975	58.3	92.0		1975	34.0	54.5
	1976	48.5	63.1		1976	35.4	36.8
	1977	103.8	117.1		1977	38.8	45.9
	1978	114.8	145.7		1978	69.0	101.2
	1979	92.4	108.9		1979	111.2	111.2
	1980	127.8	213.4		1980	57.0	57.0
	1981	77.7	112.6		1981	41.4	47.4
	1982	124.0	150.4		1982	61.0	65.3
	1983	209.5	244.4		1983	73.2	85.9
Gonja estate	1972	71.1	91.4				
	1973	61.2	81.7				
	1974	30.3	50.2				
	1975	38.9	46.8				
	1976	77.7	99.5				
	1977	97.9	97.9				
	1978	117.4	144.9				
	1979	111.3	148.5				
	1980	120.9	120.9				
	1981	82.0	118.1				
	1982	98.8	121.3				
	1983	146.7	149.4				

Table A-13 CALCULATION OF PEAK FLOOD DISCHARGE

1. Kalimawe dam

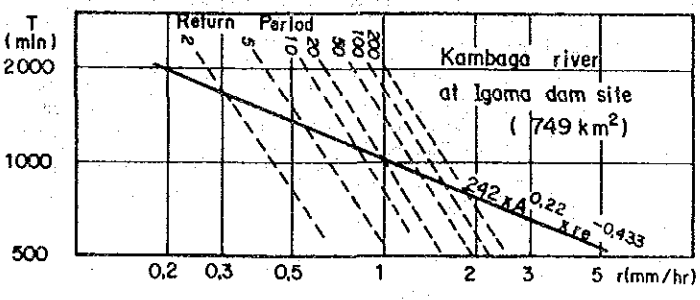
t (hr)	(mm/hr)	Return Period in Year 2	5	10	20	50	100	200
2	r_t =	10.1	14.4	17.5	20.1	24.5	27.5	30.8
5	r_t =	5.5	7.8	9.5	10.9	13.3	14.9	16.7
2	$r_e.t$ =	2.0	2.9	3.5	4.0	4.9	5.5	6.2
5	$r_e.t$ =	1.1	1.6	1.9	2.2	2.7	3.0	3.3



1,492 km²	Return Period in Year 2	5	10	20	50	100	200
r_e (mm/hr)	0.34	0.55	0.68	0.85	1.15	1.25	1.4
Tp (min)	1,900	1,600	1,400	1,300	1,150	1,100	1,050
Qp (m^3/sec)	141	228	282	353	477	518	580

2. Igoma dam site

t (hr)	(mm/hr)	Return Period in Year 2	5	10	20	50	100	200
2	r_t =	9.6	14.0	17.0	19.9	24.7	28.0	31.9
5	r_t =	5.2	7.6	9.3	10.8	13.4	15.3	17.3
2	$r_e.t$ =	1.9	2.8	3.4	4.0	4.9	5.6	6.4
5	$r_e.t$ =	1.0	1.5	1.9	2.2	2.7	3.1	3.5

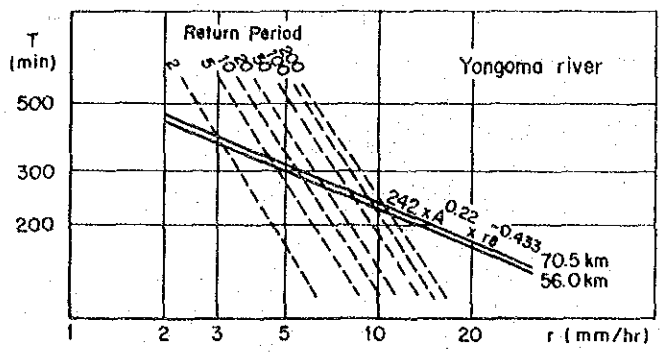


749 km²	Return Period in Year 2	5	10	20	50	100	200
r_e (mm/hr)	0.31	0.57	0.82	1.0	1.3	1.60	1.9
Tp (min)	1,650	1,300	1,150	1,050	920	850	880
Qp (m^3/sec)	64	119	171	208	270	333	395

(to be continued)

3. Yongoma river

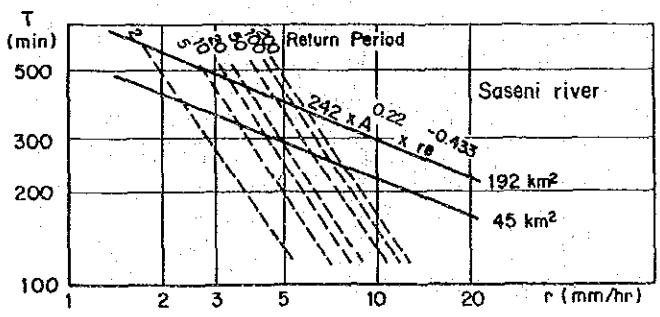
t (hr)	(mm/hr)	Return Period in Year 2	5	10	20	50	100	200
2	r_t =	12.7	17.3	20.3	22.7	26.9	29.7	32.5
5	r_t =	6.9	9.4	11.0	12.3	14.6	16.1	17.7
2	$r_e.t$ =	6.3	8.6	10.2	11.3	13.4	14.9	16.3
5	$r_e.t$ =	3.5	4.7	5.5	6.2	7.3	8.1	8.8



	Return Period in Year 2	5	10	20	50	100	200
70.5 km^2							
r_e (mm/hr)	3.0	4.4	5.5	6.5	8.0	9.4	10.5
T_p (min)	400	330	310	290	260	240	230
Q_p (m^3/sec)	59	86	108	127	157	184	205
56 km^2							
r_e (mm/hr)	3.1	4.6	5.6	6.7	8.5	9.6	11.0
T_p (min)	370	310	300	280	240	230	220
Q_p (m^3/sec)	61	90	110	131	161	188	215

4. Saseni river

t (hr)	(mm/hr)	Return Period in Year 2	5	10	20	50	100	200
2	r_t =	10.5	14.0	16.2	17.9	21.0	23.0	25.0
5	r_t =	5.7	7.6	8.8	9.7	11.4	12.5	13.6
2	$r_e.t$ =	5.3	7.0	8.1	8.9	10.5	11.5	12.5
5	$r_e.t$ =	2.8	3.8	4.4	4.8	5.7	6.3	6.8

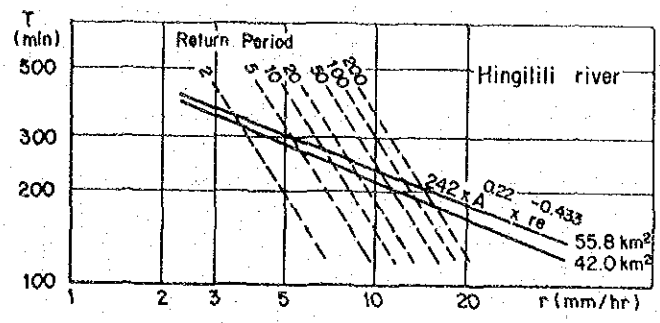


	Return Period in year 2	5	10	20	50	100	200
192 km^2							
r_e (mm/hr)	1.7	2.7	3.3	3.8	4.7	5.4	6.0
T_p (min)	620	510	470	440	400	380	360
Q_p (m^3/sec)	91	144	176	203	251	288	320
45 km^2							
r_e (mm/hr)	2.4	3.6	4.5	5.0	6.3	7.2	8.0
T_p (min)	400	330	310	290	260	250	240
Q_p (m^3/sec)	30	45	56	63	79	90	100

(to be continued)

5. Hingilili river

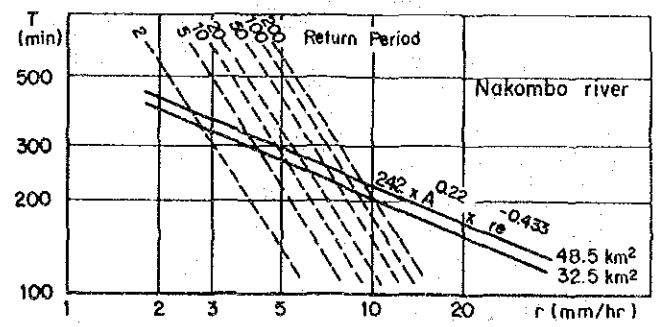
t (hr)	(mm/hr)	Return Period in Year 2	5	10	20	50	100	200
2	r_t =	13.8	19.5	23.4	26.9	32.6	36.9	40.9
5	r_t =	7.5	10.6	12.7	14.6	17.7	20.0	22.2
2	$r_e.t$ =	6.9	9.7	11.7	13.4	16.3	18.4	20.4
5	$r_e.t$ =	3.8	5.3	6.3	7.3	8.8	10.0	11.1



55.8 km²	Return Period in Year 2	5	10	20	50	100	200
r_e (mm/hr)	3.5	5.4	6.7	8.2	10.5	12.5	14.5
T_p (min)	350	300	280	260	230	220	210
Q_p (m^3/sec)	54	84	104	127	163	194	225
42.0 km²							
r_e (mm/hr)	3.6	5.6	7.2	8.8	11.5	14.0	16.0
Tp (min)	330	270	250	230	210	190	180
Qp (m^3/sec)	42	65	84	103	134	163	186

6. Nakombo river

t (hr)	(mm/hr)	Return Period in Year 2	5	10	20	50	100	200
2	r_t =	11.1	15.1	17.7	19.9	23.6	26.0	28.6
5	r_t =	6.0	8.2	9.6	10.8	12.8	14.1	15.5
2	$r_e.t$ =	5.6	7.5	8.8	10.0	11.8	13.0	14.3
5	$r_e.t$ =	3.0	4.1	4.8	5.4	6.4	7.1	7.8

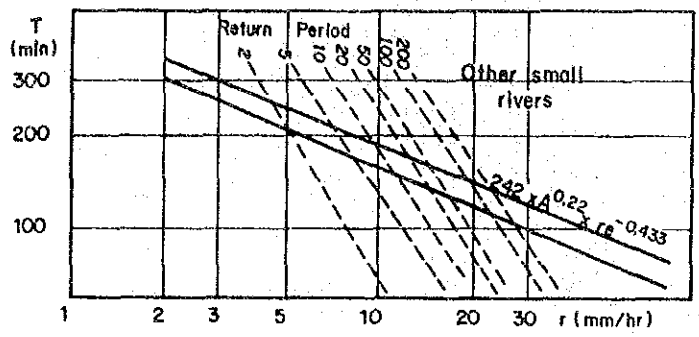


32.5 km²	Return Period in Year 2	5	10	20	50	100	200
r_e (mm/hr)	2.8	4.2	5.3	6.1	7.7	9.0	10.5
Tp (min)	350	290	270	250	260	210	200
Qp (m^3/sec)	25	38	48	55	70	81	95
48.5 km²							
r_e (mm/hr)	2.5	3.9	4.8	5.7	7.2	8.2	9.4
T_p (min)	390	330	330	280	230	240	230
Q_p (m^3/sec)	34	53	65	77	97	110	126

(to be continued)

7. Other small river

t (hr)	(mm/hr)	Return Period in Year 2	5	10	20	50	100	200
2	r_t =	14	21	26	31	34	43	49
5	r_t =	8	11	14	17	19	23	26
2	$r_e.t$ =	7	10.5	13	15.5	17	21.5	24.5
5	$r_e.t$ =	4	5.5	7	8.5	9.5	11.5	13



20 km²	Return Period in Year 2	5	10	20	50	100	200
r_e (mm/hr)	4.5	7.0	9.8	12.5	14.0	19.5	23.0
T_p (min)	260	210	190	170	160	140	130
Q_p (m^3/sec)	25	39	54	69	78	108	128
10 km²							
r_e (mm/hr)	5.0	8.4	11.0	15.0	16.5	23.0	27
T_p (min)	210	170	150	130	125	110	105
Q_p (m^3/sec)	14	23	31	42	46	64	75

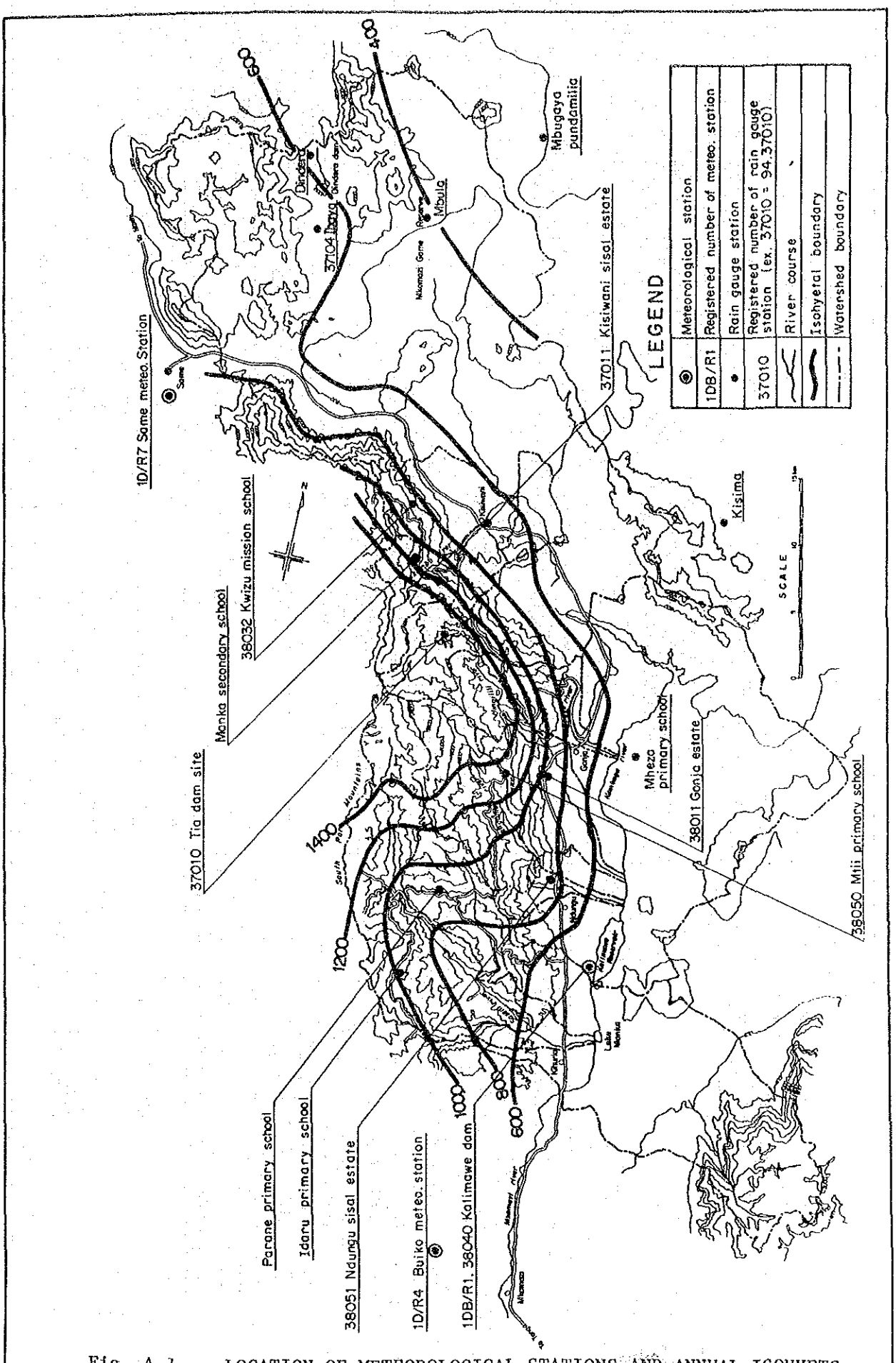


Fig. A-1 LOCATION OF METEOROLOGICAL STATIONS AND ANNUAL ISOHYETS

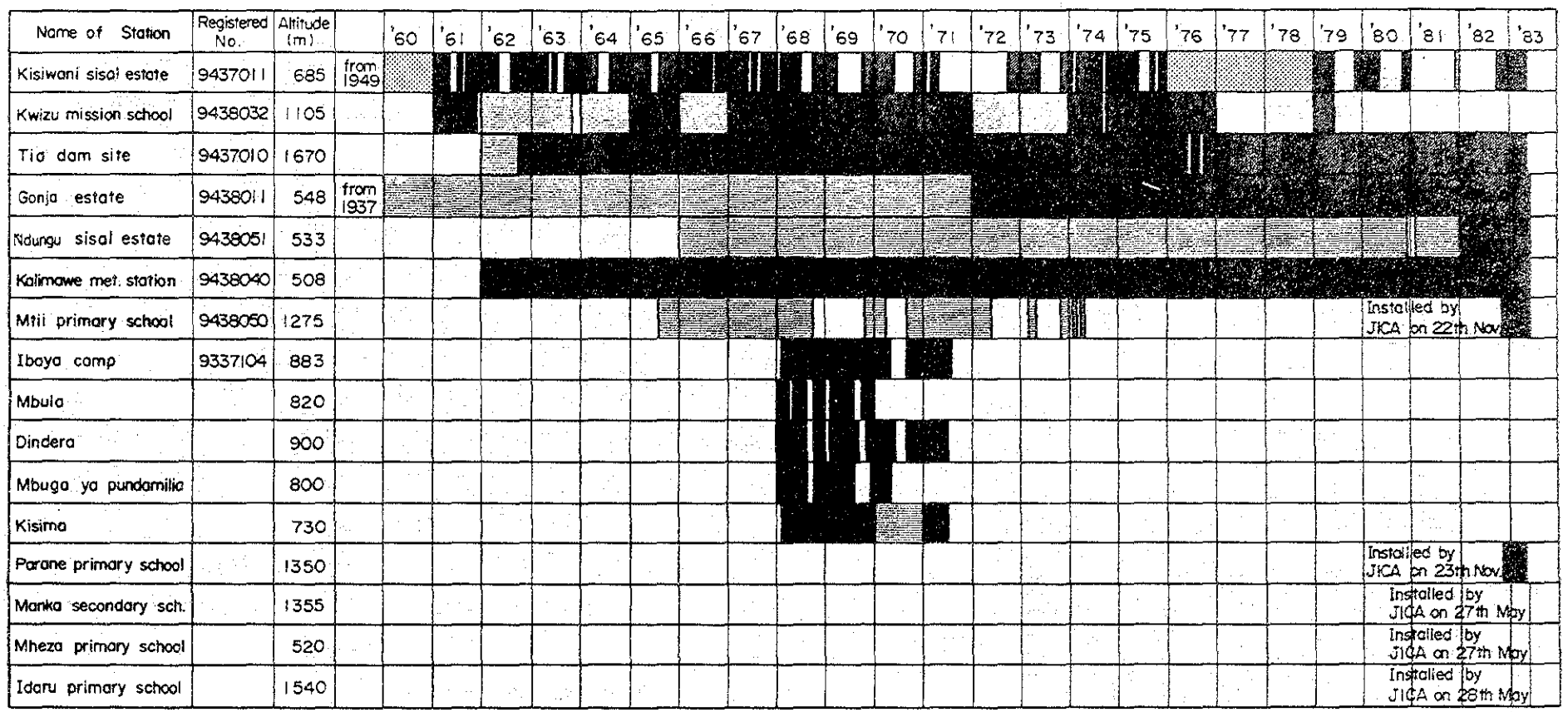


Fig. A-2 COLLECTED RAINFALL RECORDS

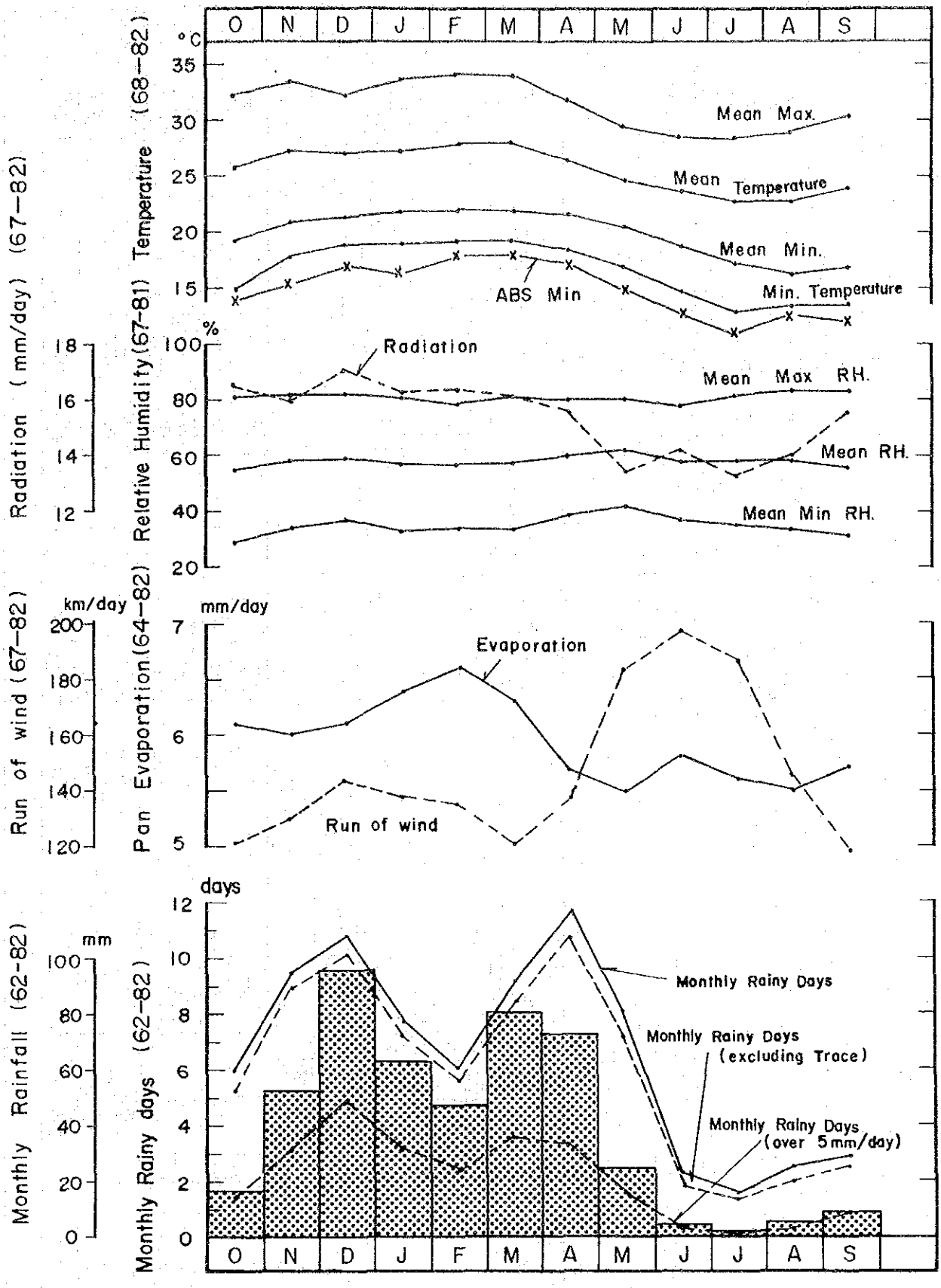


Fig. A-3 CLIMATIC FEATURES AT KALIMAWE METEOROLOGICAL STATION

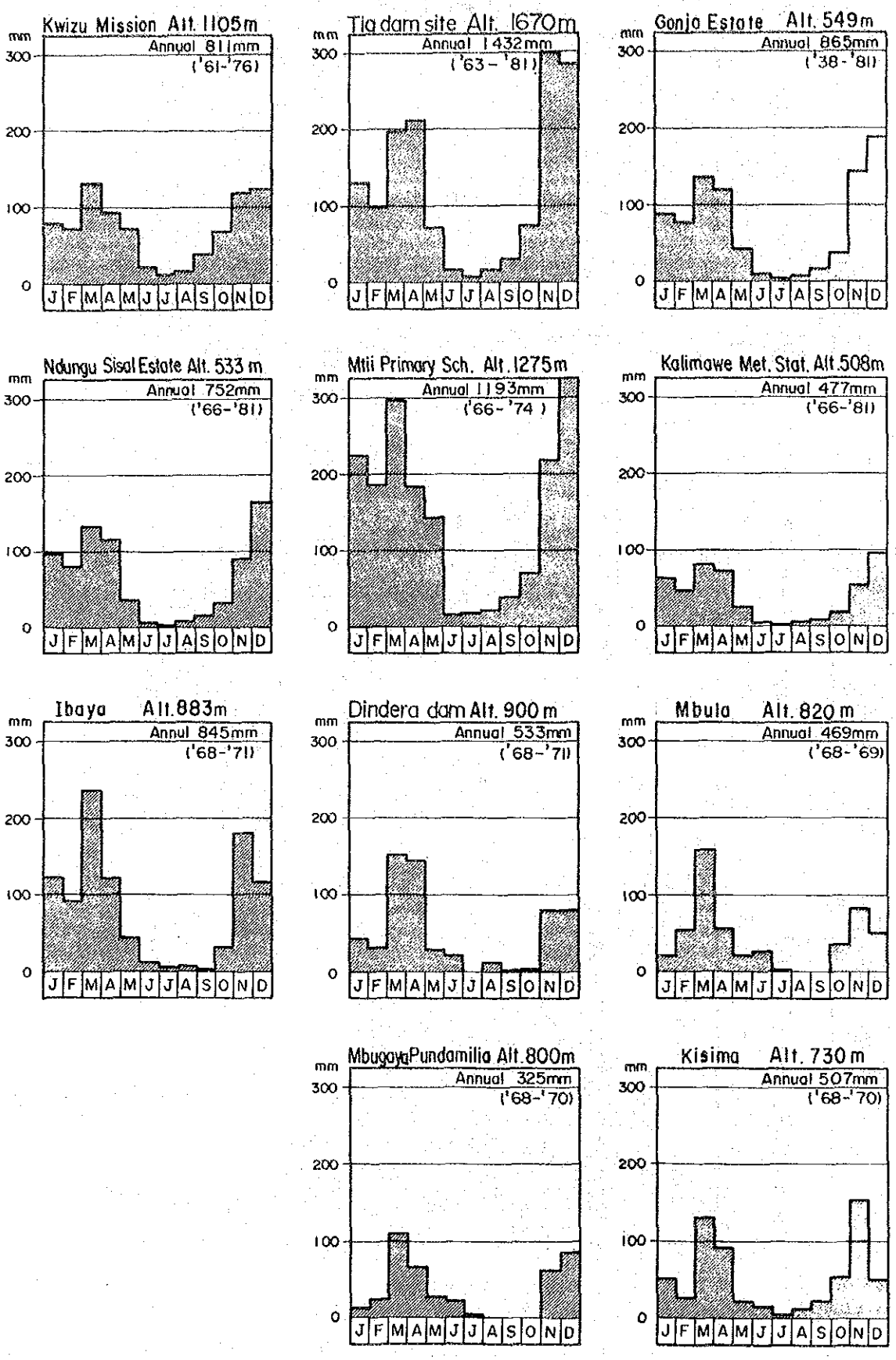


Fig. A-4 MONTHLY DISTRIBUTION OF RAINFALL

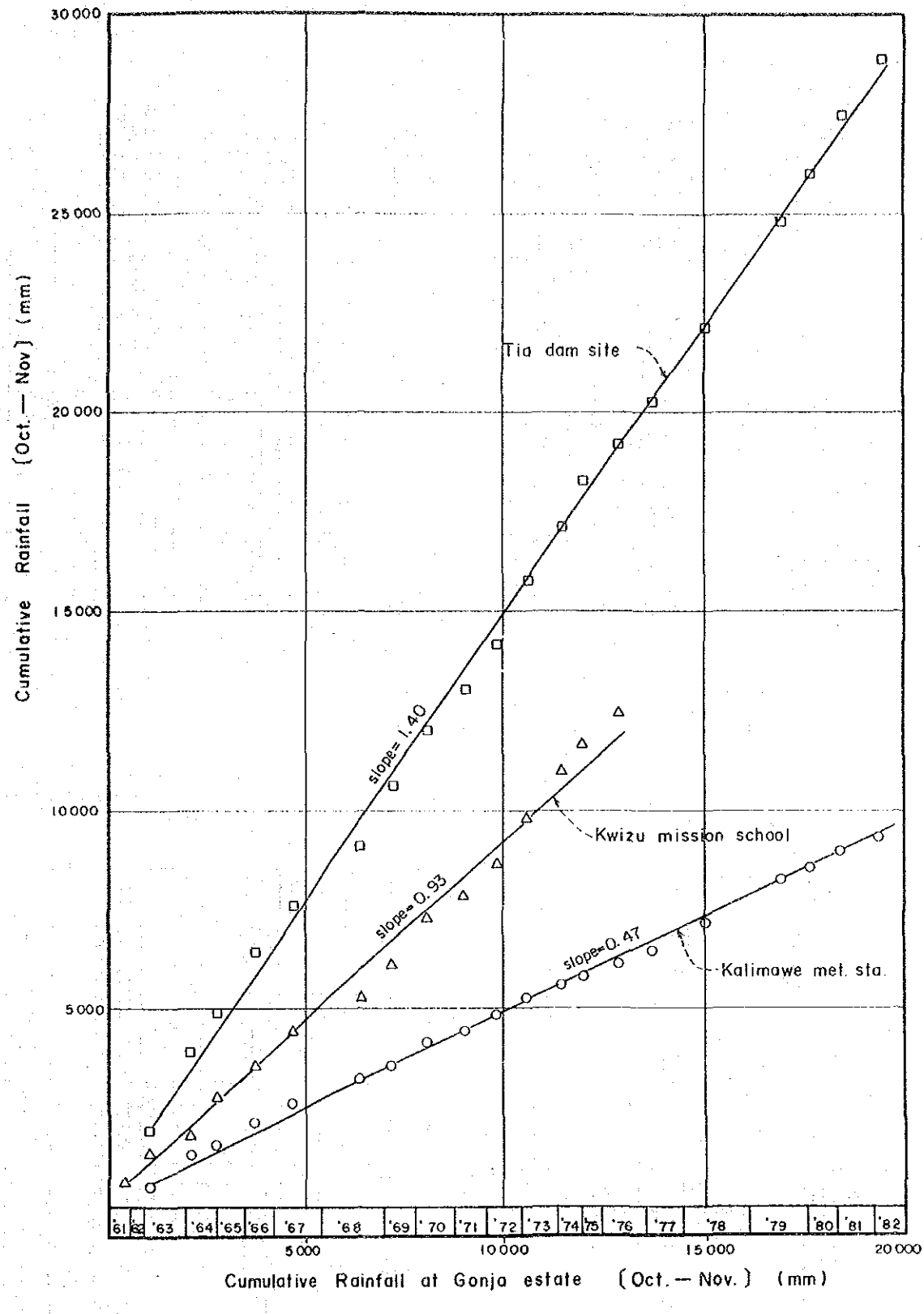


Fig. A-5 DOUBLE MASS CURVE OF RAIN GAUGE STATION S

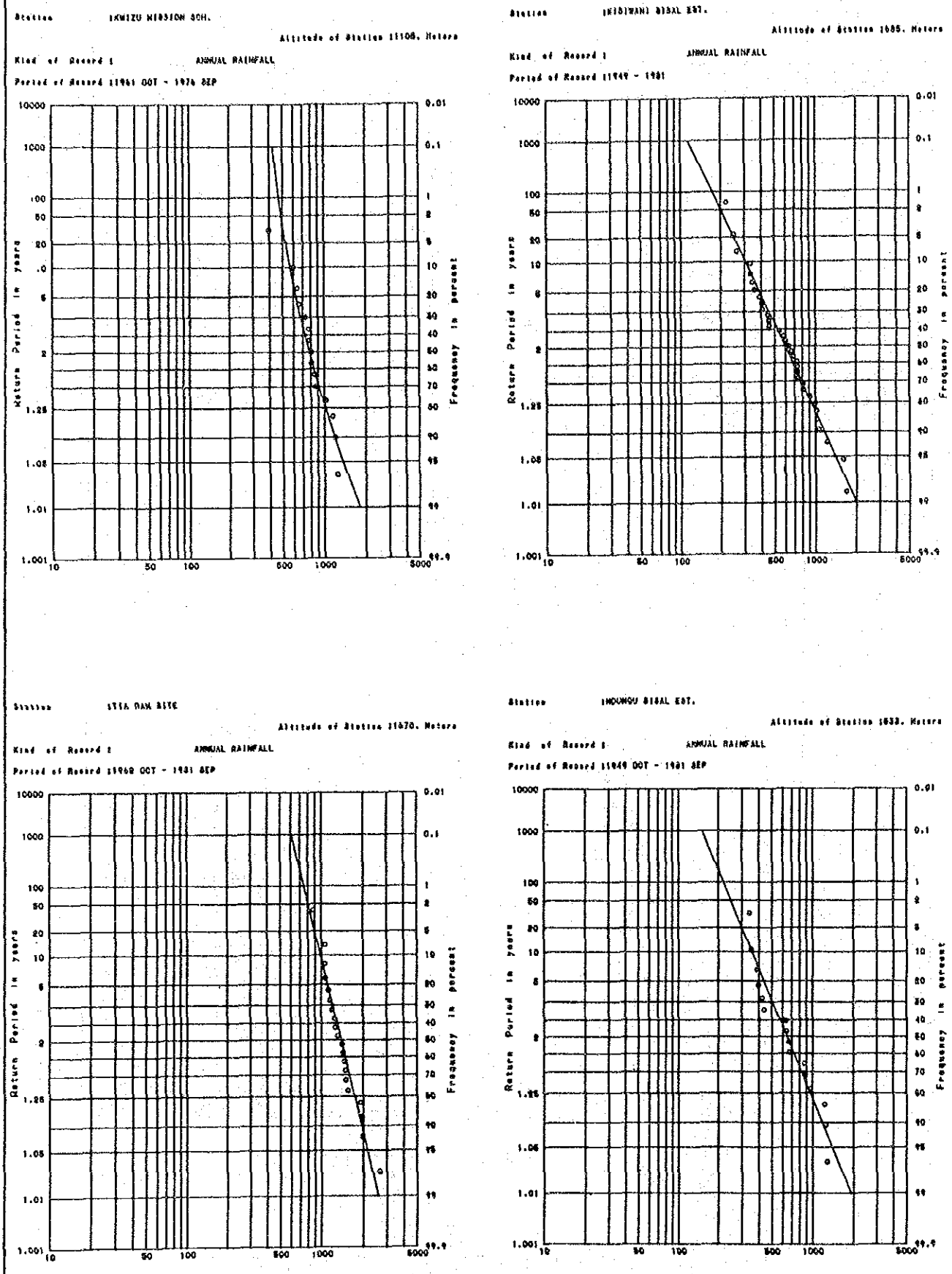
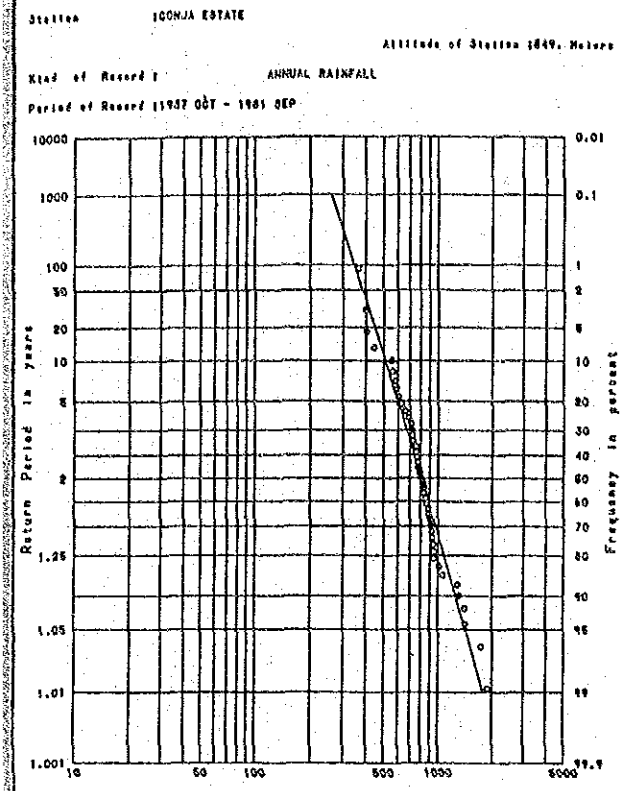


Fig. A-6 (1/2) FREQUENCY OF ANNUAL RAINFALL



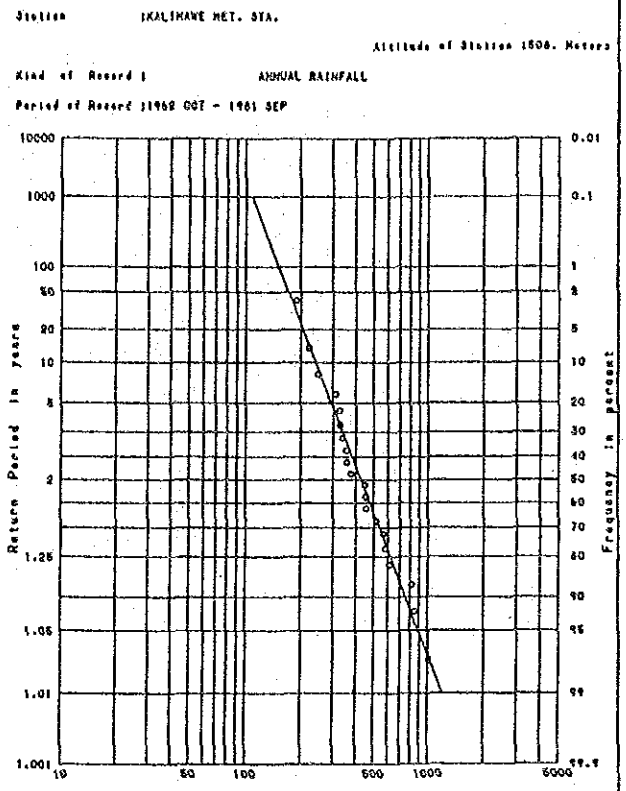


Fig. A-6 (2/2) FREQUENCY OF ANNUAL RAINFALL

CATCHMENT AREA OF EACH WATERSHED BOUNDARY

No.		C.A (Km²)	No.		C.A (Km²)	No.		C.A (Km²)
①		622.3	⑫	Hingilili r. Kiruka	31.5	㉓		291.4
②		54.1	⑬	Hingilili river	24.3	Total	C.A. at Kalimawe dam	1492.2
③	Nakombo river	32.5	⑭		9.7	㉔		30.5
④	Nakombo r. gauge site	16.0	⑮	Talanda river	6.6	㉕		52.0
⑤		240	⑯	Rika river	8.9	㉖	Saseni r. Gulutu	140.0
⑥		81.8	⑰	Kisangazi river	6.6	㉗	Saseni river	6.5
⑦		49.5	⑱		13.7	㉘		7.4
⑧		394	⑲		12.4	㉙		14.3
⑨	Bwaya river	324	⑳	Yongoma r. gauge site	70.5	㉚		15.0
			㉑		12.5	㉛		131.0
⑪		18.6	㉒		33.5	㉜		44.2
						Total	C.A. at Lasabridge	1933.1

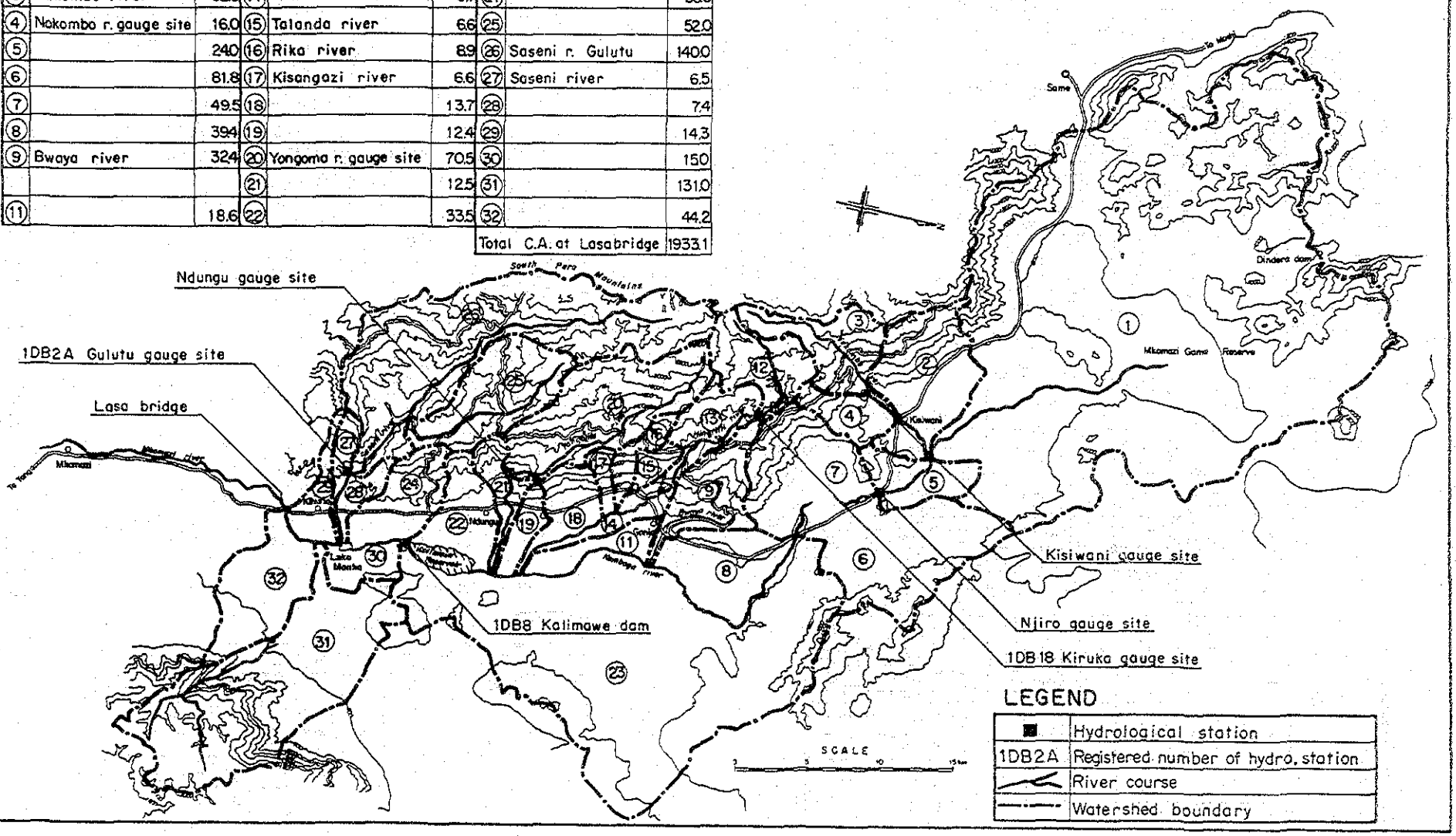


Fig. A-7 LOCATION OF GAUGING STATIONS AND WATERSHED BOUNDARY

Name of station	Registered No.	Altitude (m)	'63	'64	'65	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81	'82	'83
Kiruka on Hingilili river	1DB18	1540																					
Gulutu on Saseni river	1DB2A	550																					
Kisiwani on Nakombo r.		676																		Installed by JICA on 6th Dec.1982			
Njiro on Kombaga river		640																		Installed by JICA on 11th Jun. 1983			
Ndungu on Yongoma r.		526																		Installed by JICA on 10th Dec.1982			
Kalimawe Reservoir	1DB8	506																					

Fig. A-8 COLLECTED DISCHARGE AND WATER LEVEL RECORDS

: Daily record

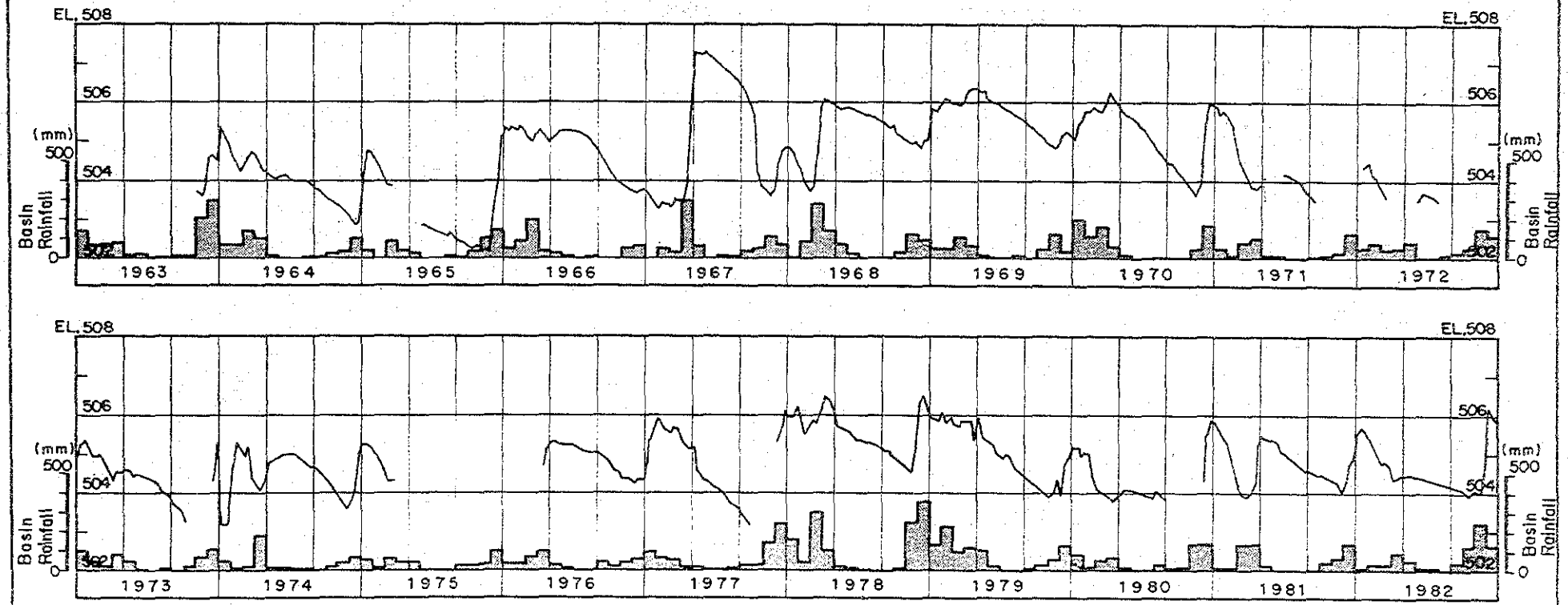


Fig. A-9 WATER LEVEL AT KALIMAWE RESERVOIR

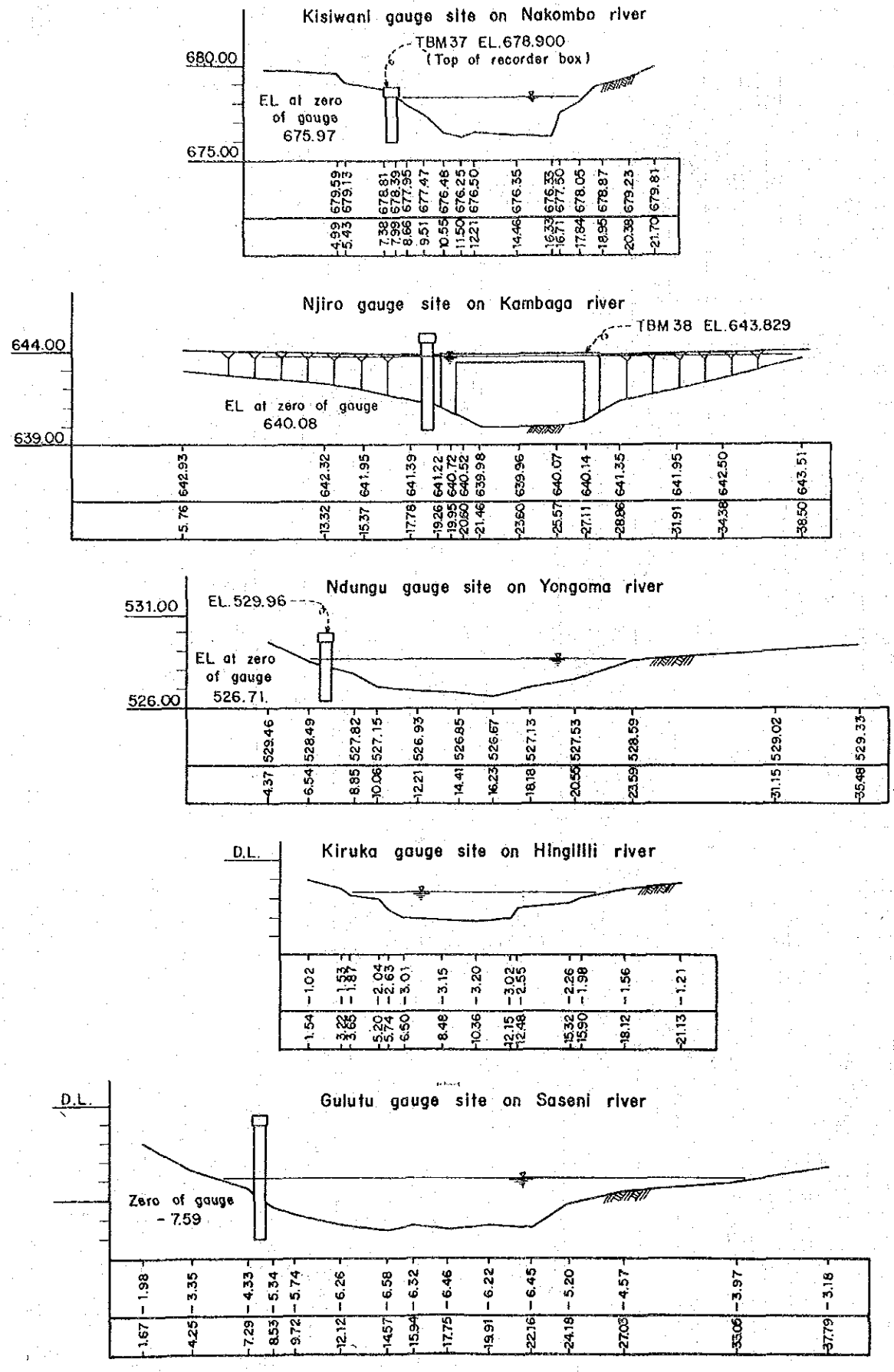
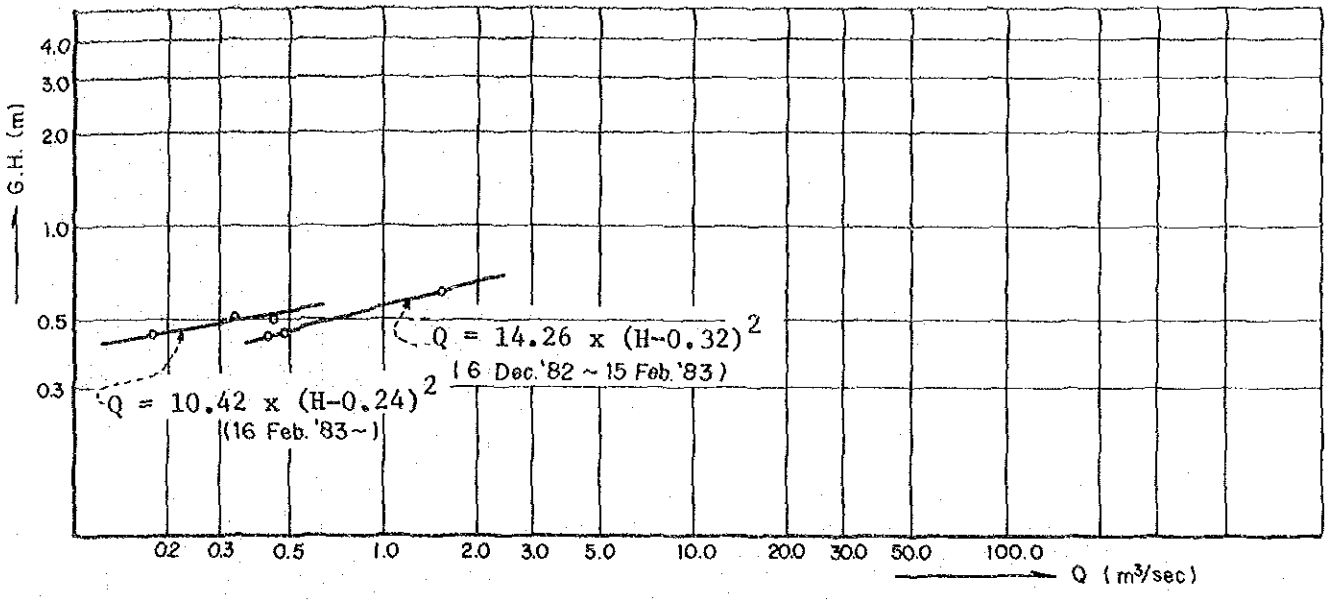
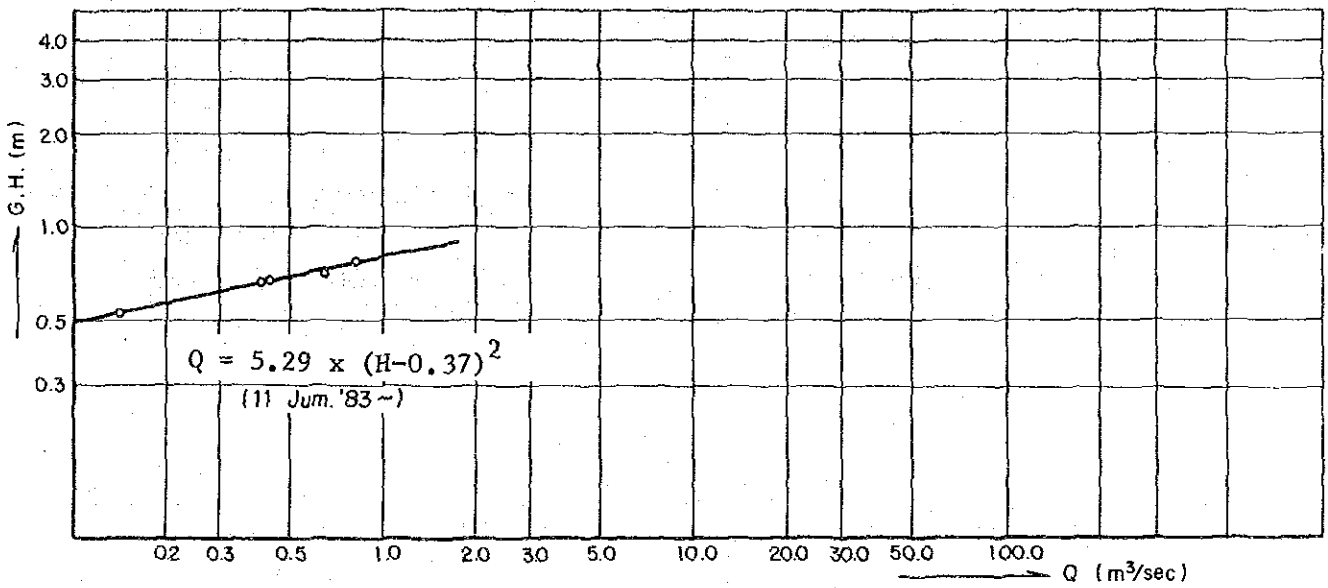


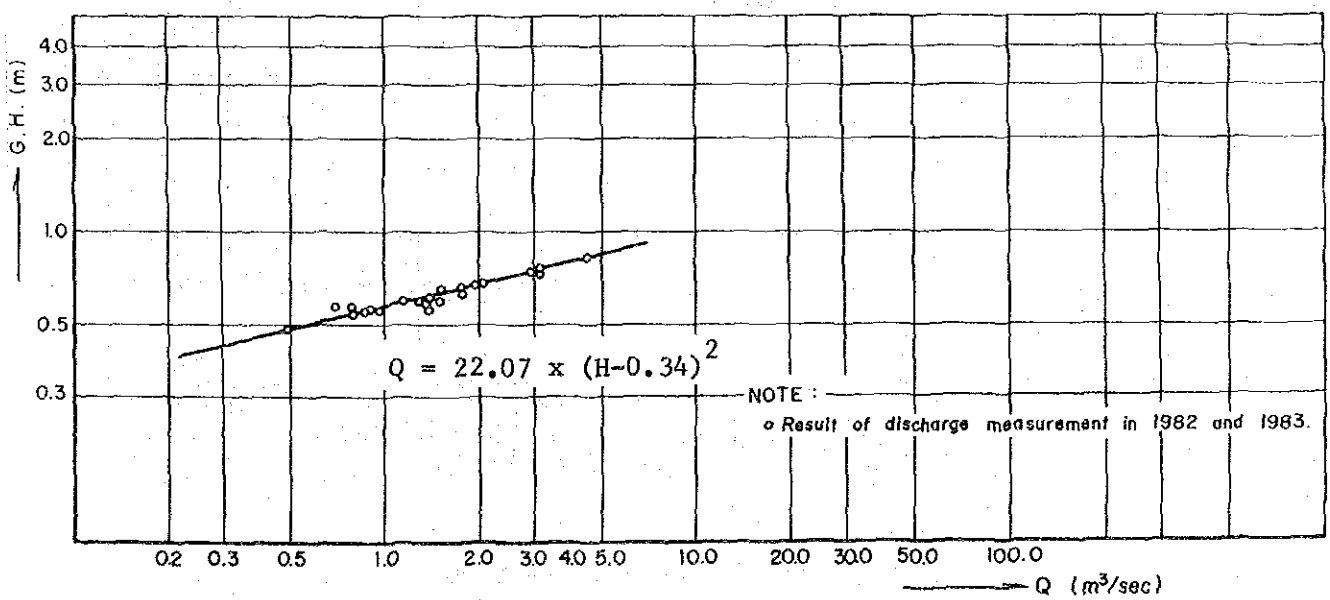
Fig. A-10 CROSS SECTIONS OF GAUGING STATIONS



RATING CURVE AT KISIWANI GAUGE SITE ON NAKOMBO RIVER

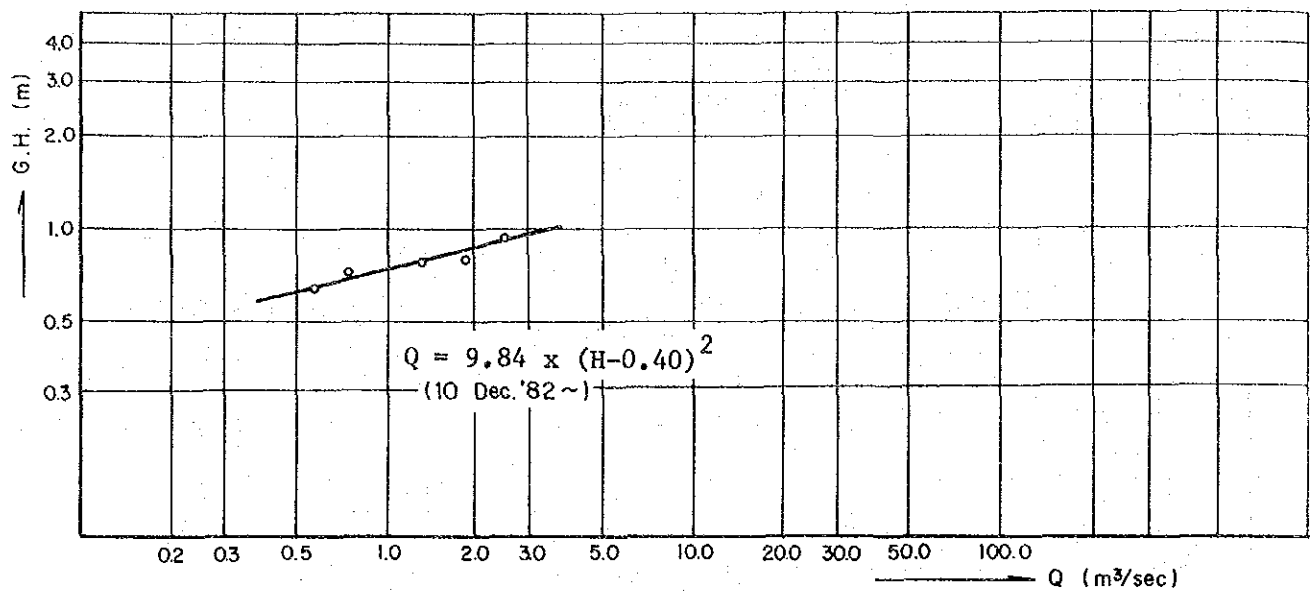


RATING CURVE AT NJIRO GAUGE SITE ON KAMBAGA RIVER

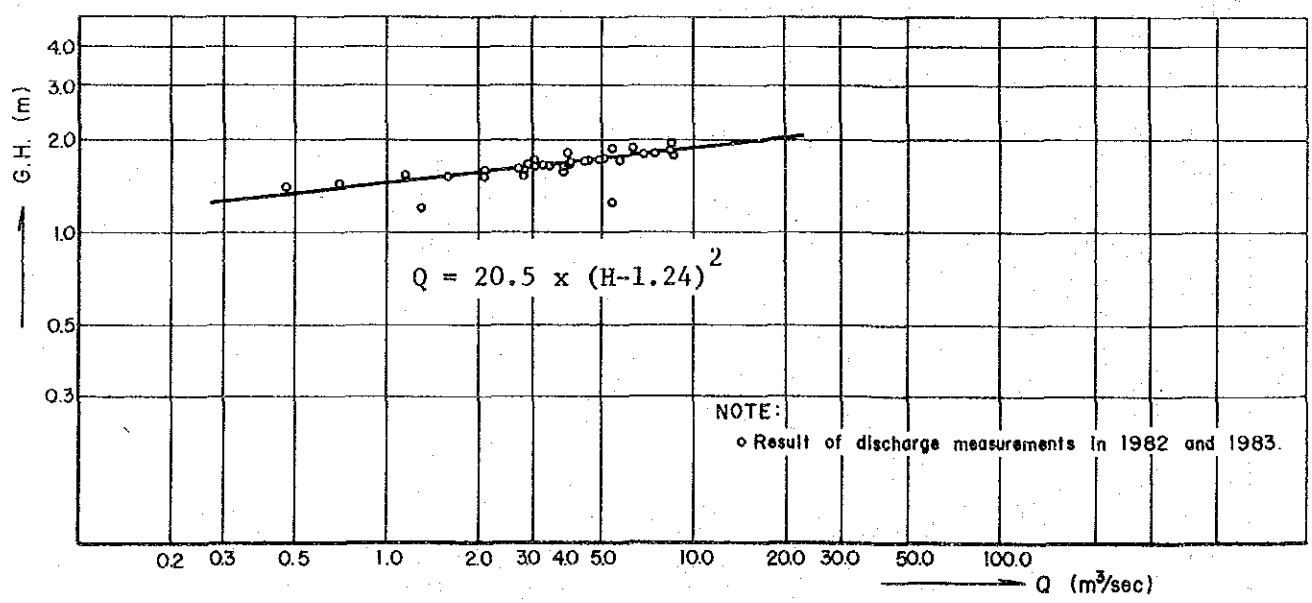


RATING CURVE AT KIRUKA ON HINGILILI RIVER

Fig. A-11 (1/2) RATING CURVE OF GAUGING STATIONS

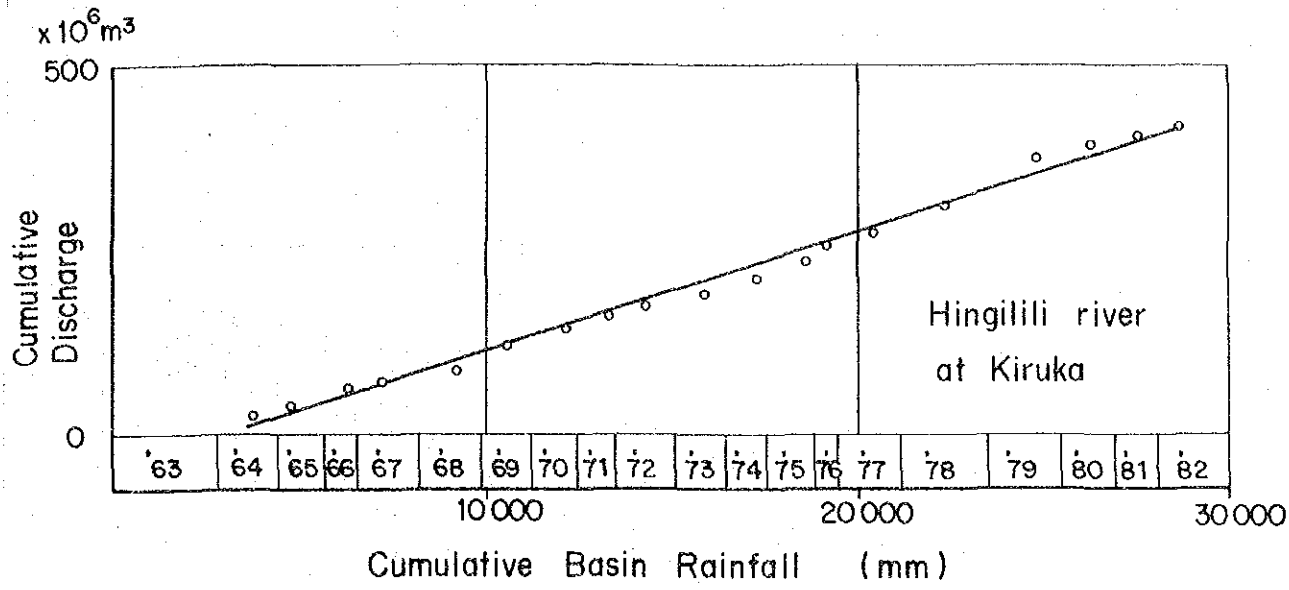


RATING CURVE AT NDUNGU GAUGE SITE ON YONGOMA RIVER



RATING CURVE AT GULUTU ON SASENI RIVER

Fig. A-11 (2/2) RATING CURVE OF GAUGING STATIONS



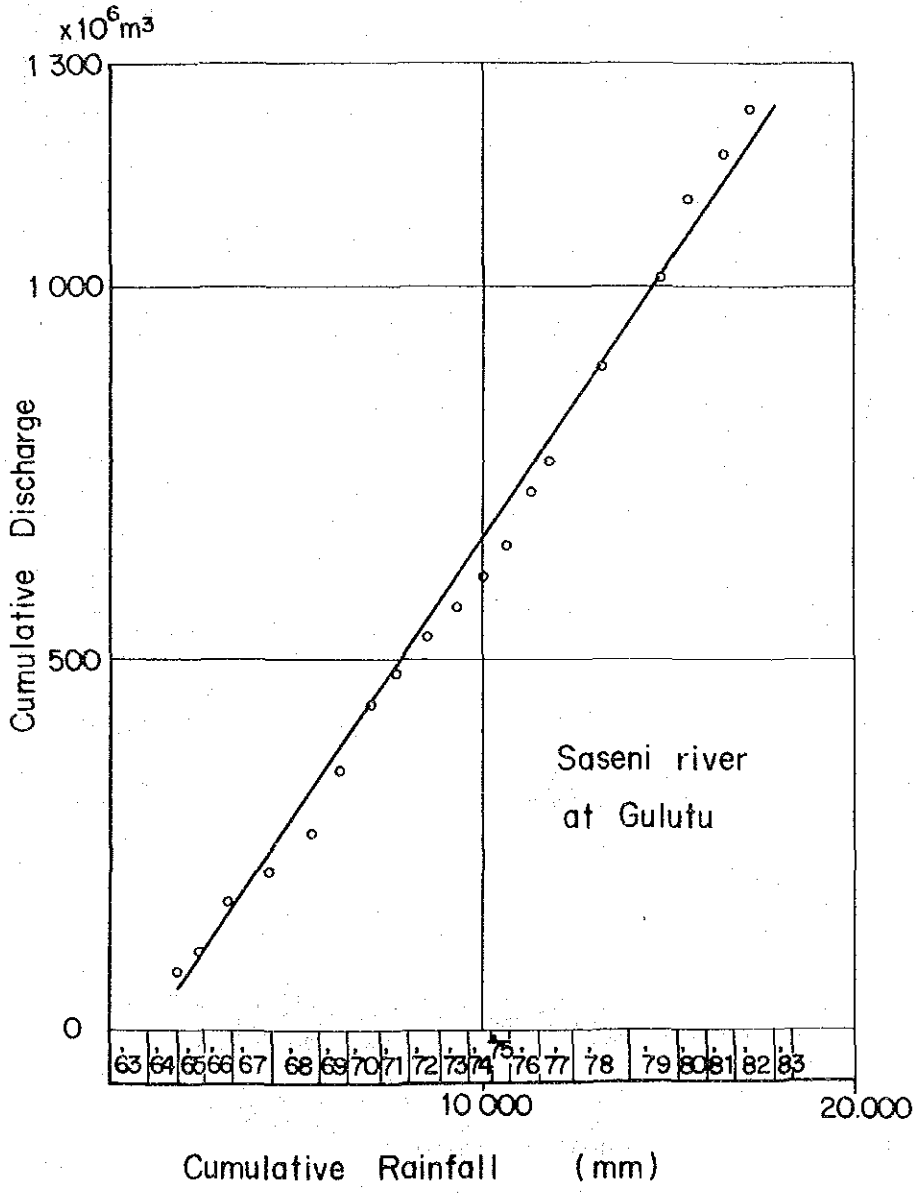
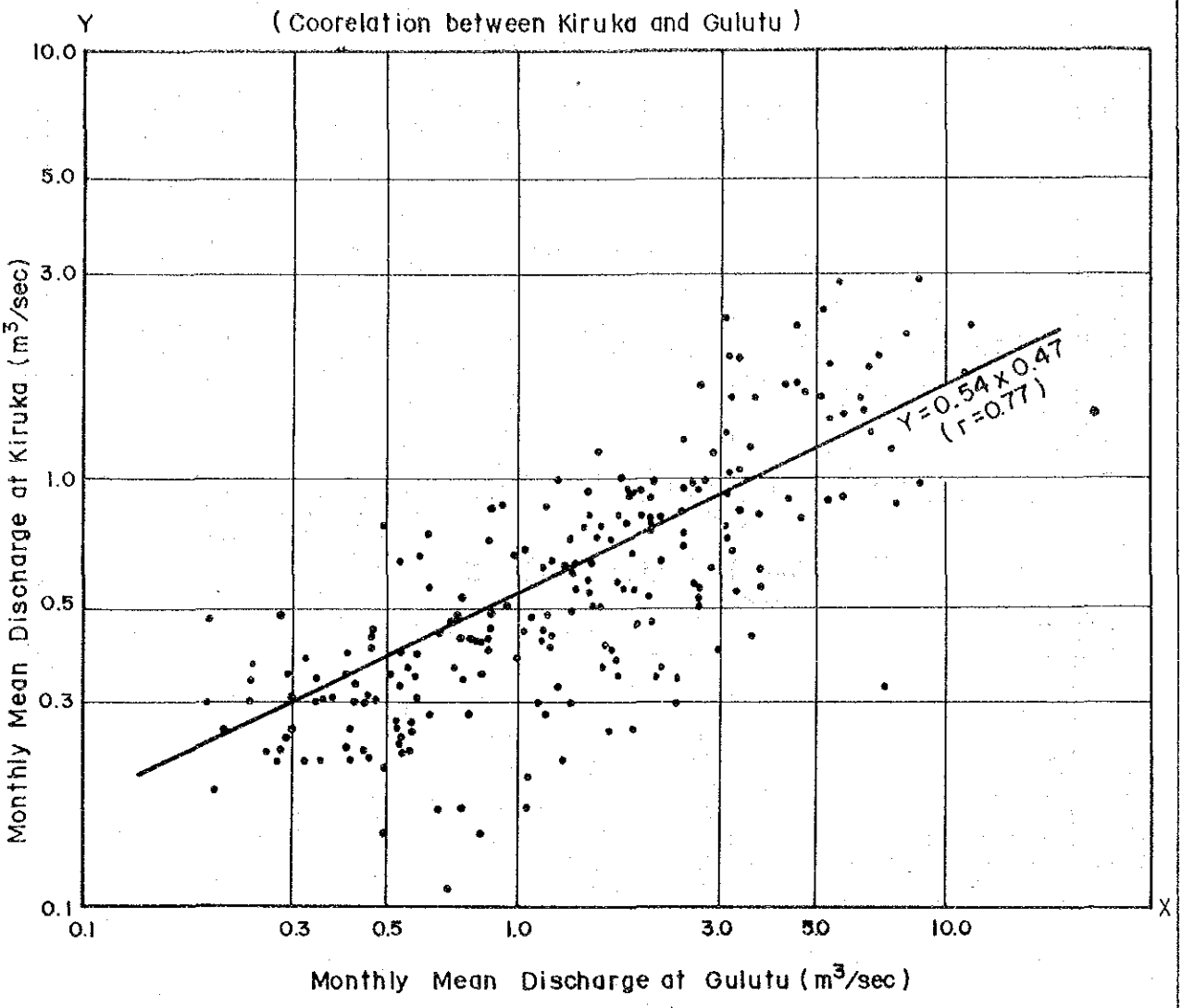


Fig. A-12 DOUBLE MASS CURVE OF BASIN RAINFALL AND DISCHARGE



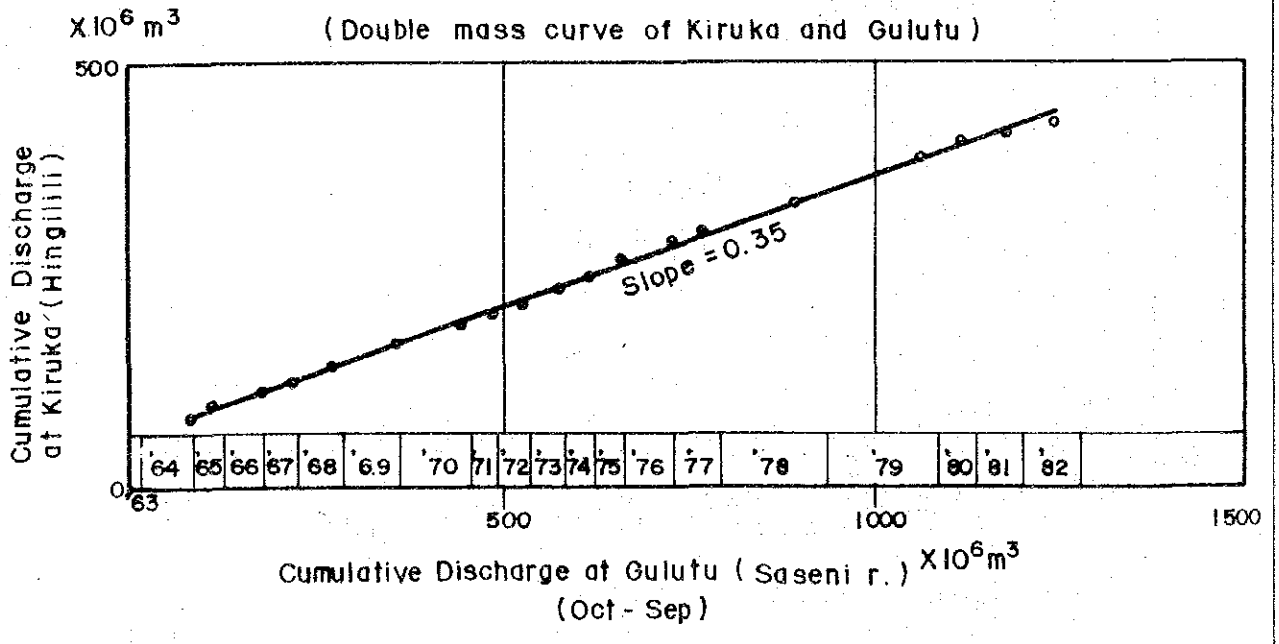
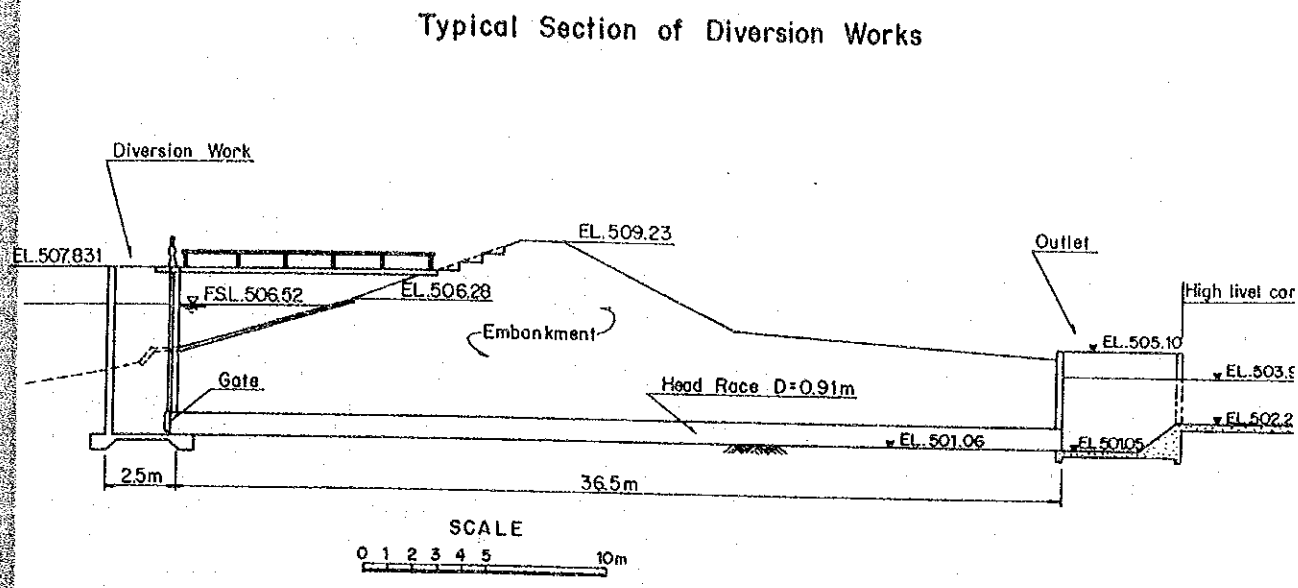


Fig. A-13 RELATION BETWEEN DISCHARGES AT KIRUKA AND GULUTU GAUGING STATION



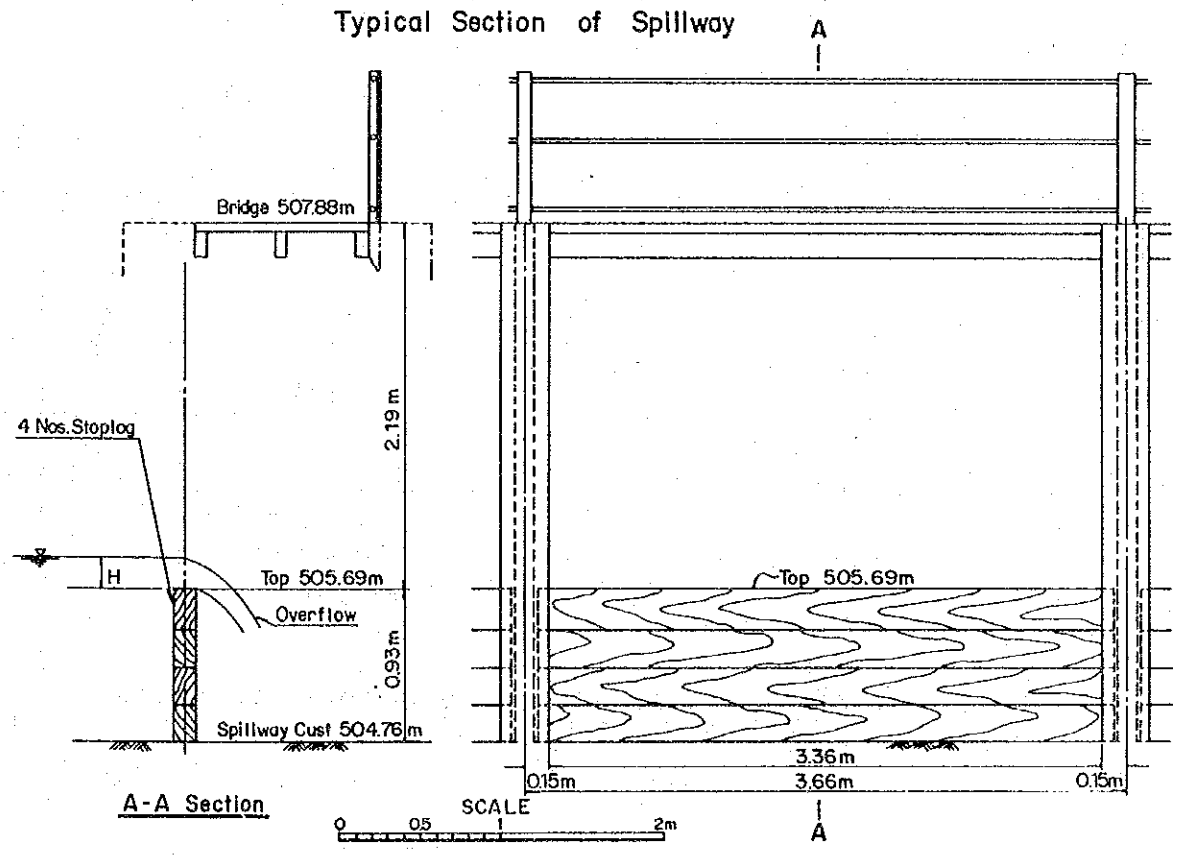


Fig. A-14 PRINCIPAL FEATURES OF KALIMAWE DAM

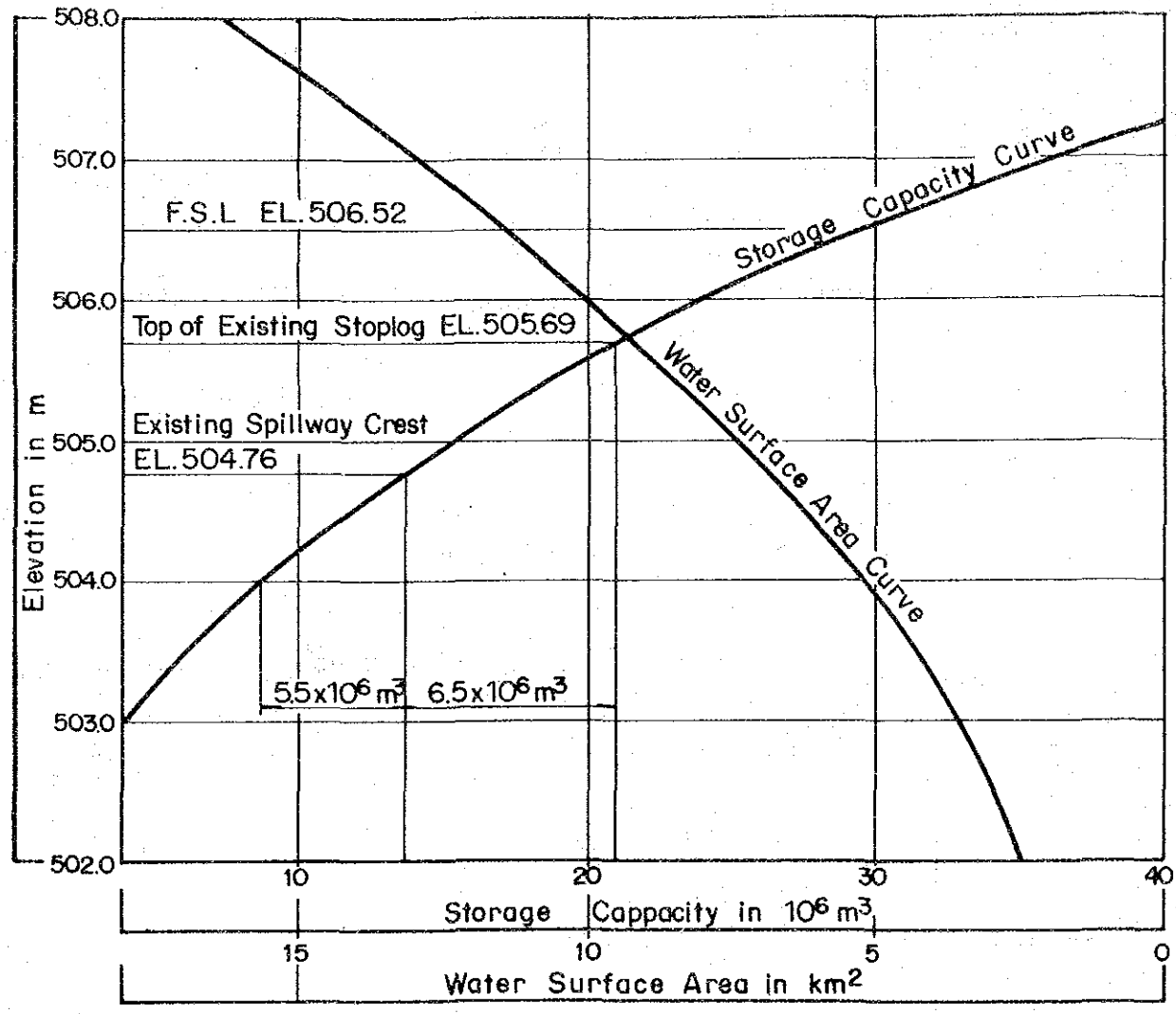


Fig. A-15 RESERVOIR CAPACITY CURVE AND RESERVOIR SURFACE AREA CURVE OF KALIMAWE DAM

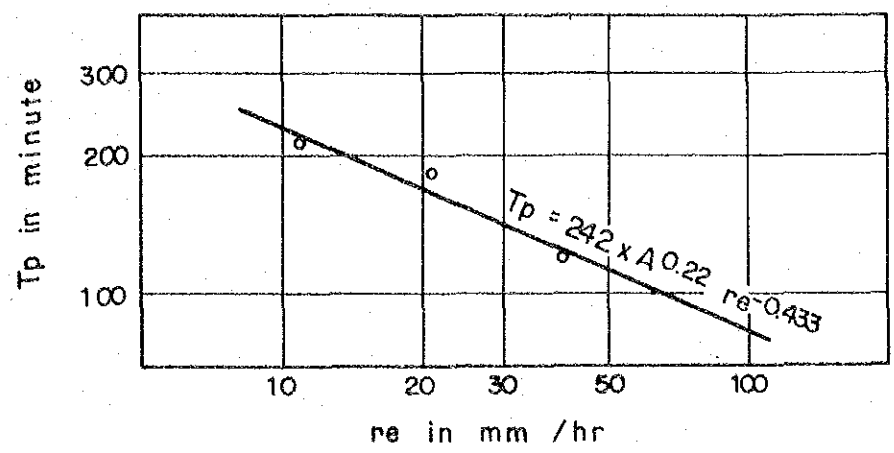


Fig. A-16 RELATION BETWEEN RAINFALL INTENSITY AND TIME OF CONCENTRATION

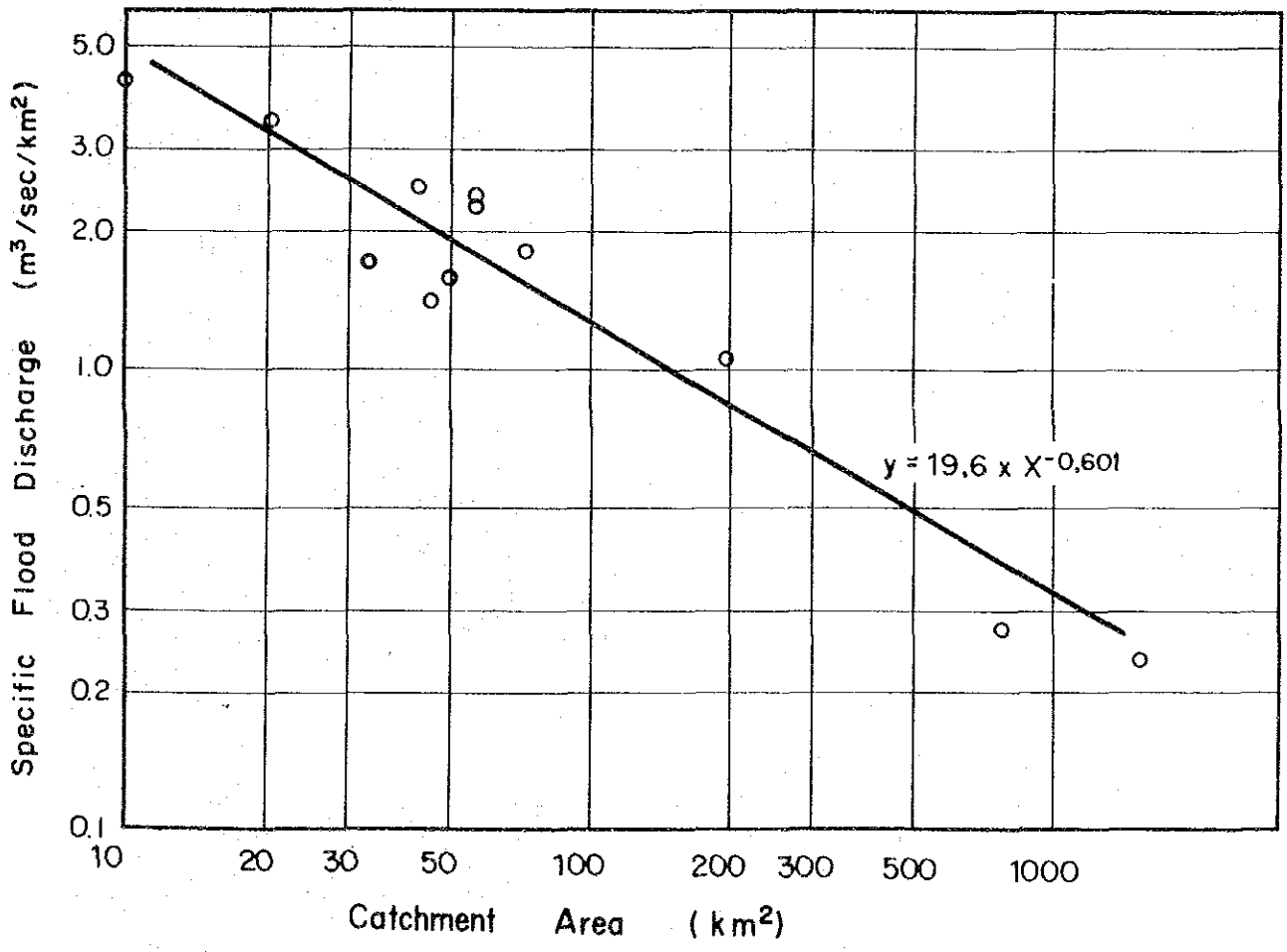


Fig. A-17 RELATION BETWEEN PEAK FLOOD DISCHARGE AND CATCHMENT AREA

ANNEX B

GEOLOGY, HYDROGEOLOGY AND SOIL MECHANICS

ANNEX B

GEOLOGY AND HYDROGEOLOGY AND SOIL MECHANICS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. GENERAL GEOLOGY IN THE PROJECT AREA

1.1 Physiography

The project area is located at the eastern border of the South Pare Mountains. The physiographic feature of the project area is an extensive plain, a part of the so-called Umba Steppes, in which many residual hills (monadnocks) are scattered.

The topography in the project area is classified into the following five topographic units by the feature of land forms and geological constitutions.

a) Residual hills,
b) Higher terraces,
c) Lower terraces,
d) Alluvial fans, and
e) Flood plains.

Higher and lower terraces form the tablelands with gentle slopes, while alluvial fans and flood plains have a flat or quite gentle topography, though meso-relief is observed to a certain extent.

(1) Residual hills

Residual hills (monadnocks) emerge in the steppes with various scale mounds. Gentle slopes covered by reddish brown soils, are developed at the foot of these residual hills.

(2) Higher terraces

This unit lies at the foots of the South Pare Mountains, mainly in the Kihurio village area and the southern foots of Tossa Mountains. The land of this unit is characterized by dissected and undulated relief. Surface materials of this land are of thin (less than 50 cm) gravels and sand isolated from the gneissose basement, gravels and sand cemented by gypsite, reddish brown soils or exposures of basement rocks.

(3) Lower terraces

These lands are the predominant land unit developed in the Umba Steppes. Their reliefs are gently sloping and slightly undulating. Surface soils on these lands are residual reddish brown soils of 1 to more than 4 meters in thickness. Gully erosion or rill erosion is excessive on these lands. The vegetation consists mainly of open thornbush with grass and scattered trees. There are some sisal estates in operation. Diluvial deposits overlain by the reddish brown soils are gravelly sand cemented by gypsite or the Mkomazi Lake Beds which are composed of gypsiferous sand and silt containing layers of crystalline gypsum and gypsite.

(4) Alluvial fans

Alluvial fans are developed at the foots of the South Pare Mountains along the Nakombo, Hingilili, Yongoma and Saseni rivers which run from the South Pare Mountains. Their reliefs are very flat and gently sloping. The soils of these lands are generally fine sandy loam to loam sand throughout the profile. Reddish brown ferruginous mottlings or gypsum patches are found in clays in subsoil layers. These lands are largely cultivated with maize and partly with paddy under the traditional irrigation practices from the rivers mentioned above.

(5) Flood plains

Flood plains extend mainly along the Kisiwani, Kambaga and Mkomazi rivers. Their reliefs are very flat and the rivers are meandering. The lands are partly cultivated with paddy or maize under rainfed conditions. The greater parts of these lands are not used for agriculture because of seasonal flooding and/or highly water-logging due to the lack of an effective drainage system.

In the flood plains, the Kisiwani, Kambaga and Mkomazi rivers run with narrow channels. These channels are narrowed by the existing gneissose basement rocks and sediments of diluvial terraces.

Soils of the flood plains consist mainly of dark gray, ill-drained clayey soils with somewhat gypsite concretions.

The schematic profile of the geology in the Mkomazi valley is shown in Fig. B-1.

Fig. B-2 show the geological maps of the project area. The typical columnar sections of the geology are shown in Fig. B-3

1.2 Geology

The South Pare Mountains and residual hills in the Umba Steppes are composed geologically of metamorphic rocks which belong to the Usangaran System of the Pre-Cambrian age. They consist of banded gneisses with metamorphosed basic and ultrabasic intrusives.

Most of the gneisses show pronounced foliations. Generally, these rocks have a simple structure with the foliations of gneisses dipping NE or ENE at low angles (around 20°) and the liniations plunge gently in the same directions.

The South Pare Mountains are the fault blocks which have been uplifted about 900 meters in relation to the plains. The NW trending faults cut the South Pare block, but the nature and age of these faults are unknown.

Superficial deposits of the Umba Steppes are primarily the diluvial and alluvial deposits rather deeply underlain by the Mkomazi Lake Beds (Tanzania Geological Survey, 1962).

2. HYDROGEOLOGY

2.1 Field Studies for Groundwater Development

To examine the development potential of the groundwater in the project area, the study was made through the following;

a) collection of information on groundwater use and regional geology

b) aerialphotographic interpretation

c) geological reconnaissance

- geological field survey
- geoelectric sounding
- exploration of test pits

Based on the results of these studies, the mode of groundwater occurrences in the project area is largely determined as hereunder.

2.2 Groundwater Use Information

No traditionally dug wells exist in the project area. Major villages are supplied with drinking water from the neighboring rivers running from the South Pare Mountains by a pipe-line system which has been constructed by the District Water Office. Other small villages located at the foots of mountains and in the steppes take drinking water from rivers, the Kalimawe reservoir or canals.

A few temporary dug pits for obtaining water in the dry season are found at the sandy river beds of the Kambaga river near the Gonja village.

Three deep bore holes have been drilled in the Mkomazi valley area. One having a depth of 321 m and 75 mm in diameter is located at the Mkomazi Game Control Center. The yield of this bore hole is quite low at 5 m^3/hour. The water quality shows low salinity. The other two bore holes located at the sisal estate in Kisiwani are now disused. According to the information obtained on these bore holes, one having a 59 m depth and 150 mm diameter has a high salinity and is not suitable for drinking.

2.3 Mode of Occurrence of Groundwater

According to the geomorphological and geological constitutions studied in the preceding sections, two patential aquifers are expected in the project area; one of them is the sediments in alluvial fans, and the other one is the Mkomazi Lake Beds, which is overlain by the reddish brown soils in the lower terraces.

Groundwater in the alluvial fans is observed in the discharge zone of Kihurio alluvial fan and in the case of test pit excavating, in the intake area of Ndungu alluvial fan. The ground water table in these tests pits lies in the clayey subsoils. The permeability test, which was carried out in test pit of Kihurio, resulted in a permeability coefficient of 5.3×10^{3} cm/sec (Fig. B-4).

The result of the calculation for shallow well capacity is as follows.

The Farchheimer's used is as follows.

$$Q = \frac{\pi (H^2 - h_o^2)}{2.3 \cdot \log (R/a)} \cdot \left(\frac{y + 0.5a}{h_o}\right)^{0.5} \cdot \left(\frac{2h_o - y}{h_o}\right)^{0.25}$$

Where Q expressed in cm^3/sec, and all other quantities are in cm.

The variable factors for wells are assumed as follows. The depth of the groundwater table in the dry season is 2 m, and the distance from the ground surface to the impermeable zone is 8 m. Thus, H = 6 m, ho = 5.0 m and y (proposed drawdown) is 1.0 m. Diameter of well (2a) is 1.0 m and cone of influence in silty layers is estimated 10 m.

Detail of calculation is as follows.

$$Q = \frac{3.14 \times 5.3 \times 10^{-3} \ (600^2 - 500^2)}{2.3 \cdot \log (1000/500)} \cdot \left(\frac{100 + 0.5 \times 50}{500}\right)^{0.5} \cdot \left(\frac{2 \times 500 - 100}{500}\right)^{0.25}$$

$$= 354.58 \ (cm^3/sec)$$

$$= 1{,}276 \ (\ell/hour)$$

Thus, it is expected that at least 1.3 m^3/hour per one shallow dug well is available in the alluvial fans. The yield of this aquifer is, however, very low.

Mkomazi Lake Beds for the objective development will be a potential aquifer, but attention shall be paid to the water quality because of their gypsiferous faces. In the lower terraces, the gravelly sand beds cemented by gypsite are also overlain by the reddish brown soils. These beds, however, do not retain any groundwater.

The strata which constitute the mountains, residual hills, higher terraces and flood plains are considered impermeable layers, because of their lithological and hydrological conditions such as hard rocks, lack of superficial sediments, ill-drained fine materials, poor percolating from the grounds etc.

The hydrogeological constitution so far studied, suggests that the development potential of the groundwater for irrigation in the project area is rather low.

2.4 Geoelectric Sounding

Geoelectric soundings were carried out at total 22 points by means of the Wenner's four electrodes arrangement so as to examine the subsurface geological structures in Kisiwani, Gonja, Ndungu, Kihurio areas and Kalimawe dam site.

The depths of specific layers, which are characterized by the different resistivity are interpreted from the apparent resistivity (ρ)-depth(a) curves using the Sundberg's standard curves and Hummer's auxiliary curves. The results are illustrated in Fig. B-5, and the apparent resistivity (ρ)-depth(a) curves at each sounding points are shown in Fig. B-6

According to the above study, it is considered that the first stratum in the Kisiwani section is of alluvial clayey sediment, and the second and third stratum are of diluvial Mkomazi Lake Beds and/or reddish brown soils in the lower terraces, and gneissose basement, respectively. In this profile, the first and second stratum are laid with basin-like structures over the impermeable gneissose basement (the third stratum). The first stratum is considered impermeable because of its poorly drained clayey facies. The second stratum exposed in excavating site for pond near No. 4 sounding point is a consolidated gypsite. Taking this evidence into consideration, the second layer is also impermeable. The information on the groundwater of unused bore holes in Kisiwani sisal estate, suggests that the fissure water in the third stratum is a saline water.

In the Gonja, Ndungu and Kihurio sections, it is considered that the first stratum is of alluvial sediments in the alluvial fans, the second stratum reddish brown soils on the lower terraces, the third stratum Mkomazi Lake Beds including gypsite beds and the fourth stratum gneissose basement. No groundwater has so far found in the second and third stratum lying over the impermeable gneissose basement (the fourth stratum) on the higher parts of these profiles. Salt crusts which have been formed by capillarity and evaporation from the groundwater are often observed at the sounding points on low-lying lands in these sections. This field evidence indicates a salt accumulation in the first and/or second stratum in the low-lying lands.

3. GEOLOGY OF DAM SITES AND PROPOSED INTAKE WEIR SITES

(1) Kalimawe dam

Kalimawe dam has been constructed on the Mkomazi river narrowed by the residual hill of gneiss and the of reddish brown soil terraces The geology of left bank of dam site is composed of gneiss. The gneiss is weakly weathered and its foliation strikes N50°W and dips 15°NE. Reddish brown soils, mainly sandy loam in texture, with more than 3 meters thick are exposed at the right bank of dam site (Fig. B-7).

Drilling works for geological investigation were performed at three points in the dam site. The results are illustrated in Fig. B-8 and Fig. B-9.

In the dam site, the gneiss is overlain by the Mkomazi Lake Beds and reddish brown soils. The Mkomazi Lake Beds consist of sand interbedded with silt layers and grade upward into gypsite or gypsiferous silt beds. Mkomazi Lake Beds and overlying reddish brown soils range in total thickness from 20 to 48 meters in the dam site.

As the results of these surveys, it was found out that the embankment and spillway of Kalimawe dam might be constructed on the reddish brown soils. This soils are sandy-loamy in texture and compact under dry and wet conditions. Phenomena which indicate leakage through this layer are not observed at the dam site.

(2) Igoma dam site proposed

Igoma dam site was originally planned on the gorge of Kambaga river near Njiro. Detailed field investigation of the geology, however, shows that the gorge was formed by big rock fall existing on the slope of South Pare Mountains. Dam construction on this site is unfeasible because of the difficulty of grouting works and large excavating in a rock fall blocks.

The present dam site was shifted toward upstream from the former dam site. These are no critical conditions of geology for dam construciton.

Geological reconnaissance and drilling work at three points were performed at the dam site. The results are illustrated in Fig. B-10 and Fig. B-11.

Geology of the dam site is composed of gneissose basement, Mkomazi Lake Beds, reddish brown soils and alluvial sediments in ascending orders. The gneiss exposed at the left bank of dam site is weakly weathered, its foliation strikes N30° and dips 25°E, and intruded by aplite dikes. Debris having 1 meter or more thick covers the gneiss on the slopes. Depth of the gneissose basement ranges from 7.0 to 7.5 meters under the terrace between Kambaga river and Same - Tanga road, and increase in depth towards the South Pare Mountains. The overlying Mkomazi Lake Beds are mostly composed of gypsum and gypsiferous clay. These beds and the reddish brown soils of sandy loam in texture are both compact. Their N-values vary from 40 to 50 or more. These field

evidence suggests that the construction of earth dam on the reddish brown soils and/or Mkomazi Lake Beds will be possible.

(3) Nakombo intake weir site

In the proposed weir site, the alluvial terrace gravels interbedded with sandy clay layer are exposed. They are more than 1.8 meters thick and overlain by a loose sand bed 1.2 meters thick. These gravel beds are considered to be buried under the present river bed gravels and estimated to be 10 meters or more thick.

On the basis of this geologic conditions, the floating type weir is recommended.

(4) Hingilili intake weir site

Gneissose rocks are exposed at the left bank of the proposed weir site. The right bank consists of boulder beds of the alluvial cove. These boulder beds are considered to be buried under the present river bed gravels and are estimated to be 5 meters thick. On the basis of this geology, the fixed type weir is recommended.

(5) Yongoma intake weir site

Gneissose rocks are exposed at the left bank of proposed weir site. Right bank is composed of boulder beds of the alluvial cone. Ground water with ferruginous contents discharges into the river from this boulder beds.

Drilling work at one point was performed in the right bank of weir site. The result is illustrated in Fig. B-12.

Geological profile at the weir site shows that the boulder beds of alluvial cone are buried under the thin river bed gravels and the total thickness of these beds around 7 meters.

On the basis of this geologic profile, either a floating or fixed type weir is recommended.

(6) Saseni intake weir site

Gneissose rocks are exposed at the slopes of both banks. Terrace deposits of fine sand crop out at the both banks.

Geological profile illustrated from the results of drilling works at two points shows that the older river bed gravels are buried under the terrace deposits. They overlie in having 4 to 4.5 meters thick on the hard gneissose rocks (Fig. B-13).

On the basis of this geologic profile, a fixed type weir is recommended.

(7) Proposed dam sites in the South Pare Mountains

A geological reconnaissance for the proposed dam sites of Saseni, Yongoma and Hingilili rivers in the South Pare Mountains was carried out.

Based on the field data obtained, the dam types, depth of cut off and borrow areas were discussed. This discussion, however, is based on the preliminary field surveys. More detailed field data for the geology and soil mechanics in each dam to be proposed will be examined in the forth coming stage survey.

(a) Saseni dam site

Slopes at the left bank of dam site have steep gradients, and are composed of gneissose rocks. Surface soils on the slope are thin and stony. On the river beds, the hard gneiss crops out about 50 meters upstream of the dam axis, and their foliation strikes N75oW and dips 10oN. Stony colluvial soils of 1 to 2 meters in thickness cover the slopes at right bank of dam site.

In this proposed dam site, the rock fill type dam is recommended because of insufficiency of earth for earth fill dam construction. The depth of the cut off on the dam center is approximately estimated at 6 meters.

(b) Yongoma dam site

Hard gneissose rocks are exposed on the river beds at both dam sites proposed, and their foliations strike $N40^{o}W$ to $N60^{o}W$ and dip 25^{o} to $30^{o}N$. Colluvial soils and detritus cover the slopes of both banks and the weathered gneiss crops out at the upper parts of slope at right bank.

Earthfill dams are recommended for these proposed dam sites. Borrow sites are found at the terraces and hills about 2 kilometers upstream of the dam sites. Depth of the cut off on the dam center is approximately estimated at 6 meters.

(c) Hingilili dam sites

Gneissose rocks are not exposed and the debris of big boulders developed at both dam sites to be proposed. Its thickness is estimated 7 m or more. Depth of the cut off on the dam center should be planned around 10 meters.

Earth fill type dams are recommended for these proposed dam sites. Borrow sites are found at the hills about 500 meters upstream of the dam sites. Residual soil on surface of the hills, however, is thin, being 1.5 meters on average. This field evidence suggests that the excavation works should cover a wide scope.

4. SOIL MECHANICS AND FOUNDATION CONDITION

4.1 General

4.1.1 Objectives

Related to the feasibility study, investigations were carried out into the mechanical properties of the soil and the foundation conditions. The objectives were as follows.

(a) to make clear the characteristics of soil properties in the area by means of reconnaissance throughout the project area;

(b) to clarify the foundation conditions of the proposed main canal and major structures;

(c) to clarify the soil mechanical characteristics of the embankment materials; and

(d) to identify the proposed borrow areas of the earth materials for embankments and the quarry sites for concrete aggregates.

4.1.2 Method and content of investigation

The investigations were divided into a field investigation and home office work including laboratory testing.

(1) Field investigation

The field invetigation is divided into a field test, soil sampling and reconnaissance for construction materials, such as earth, sand and gravel. The field test consists of the cone-penetration and the permeability tests for the proposed main canals and sites of the major structure. The following shows the number of sites tested.

schemes	cone-penetration test	field permeability test
Kisiwani	4	2
Gonja	4	1
Ndungu	3	2
Kihurio	4	2
Igoma	1	2
Total	16	9

The locations of these sites and the results of test are shown in Fig. B-14, and Table B-1, respectively. The samples, taken from the

following sites by auger boring and/or test pitting were mainly analyzed at the sites for grain size distribution, in order to grasp the general charateristics of the soils from the viewpoint of soil mechanics.

scheme	test pitting	soil sampling
Kisiwani	6	3
Gonja	5	3
Ndungu	6	2
Kihurio	7	4
Igoma	2	1
Total	26	13

The boring logs obtained through test-pitting are shown in Fig. B-15 for each site, and the grain size accumulation curves obtained by the gradation analysis on the samples are shown in Fig. B-16.

(2) Home office work

The home office work consists of the laboratory test on the embankment materials, and the analysis of the data obtained from the field investigation and the laboratory test. The laboratory test was carried out for the representative soil samples obtained from the field, with regard to the following items;

- Gradation
- Specific gravity
- Consistency
- Compaction
- Permeability
- Consolidation
- Shearing

These results are shown in Table B-2.

4.2 Physical Condition of Soils

4.2.1 General description

Most of the land of the five development schemes is classified into the lower terraces the alluvial fans and the flood plains, from the topographical and geological point of view. The mechanical condition of the soils in these areas can be clarified from the result of the gradation analysis and observation of the profiles at the test pits.

The following table shows indices for the soil mechanics analyzed from the grain size accumulation curves.