JAPAN INTERNATIONAL
COOPERATION AGENCY

MINISTRY OF AGRICULTURE
AND COOPERATIVES,
THE UNITED REPUBLIC OF
TANZANIA

# THE FEASIBLITY STUDY
# ON
# LOWER MOSHI INTEGRATED AGRICULTURE
# AND
# RURAL DEVELOPMENT PROJECT
# IN
# THE UNITED REPUBLIC OF TANZANIA

Volume-II

## ANNEXES (1/2)



JULY 1998

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PASCO [illegible]IONAL INC.

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# THE FEASIBLITY STUDY ON LOWER MOSHI INTEGRATED AGRICULTURE AND RURAL DEVELOPMENT PROJECT IN THE UNITED REPUBLIC OF TANZANIA

Volume-II

## ANNEXES (1/2)

JULY 1998

NIPPON KOEI CO., LTD.
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## LIST OF REPORTS

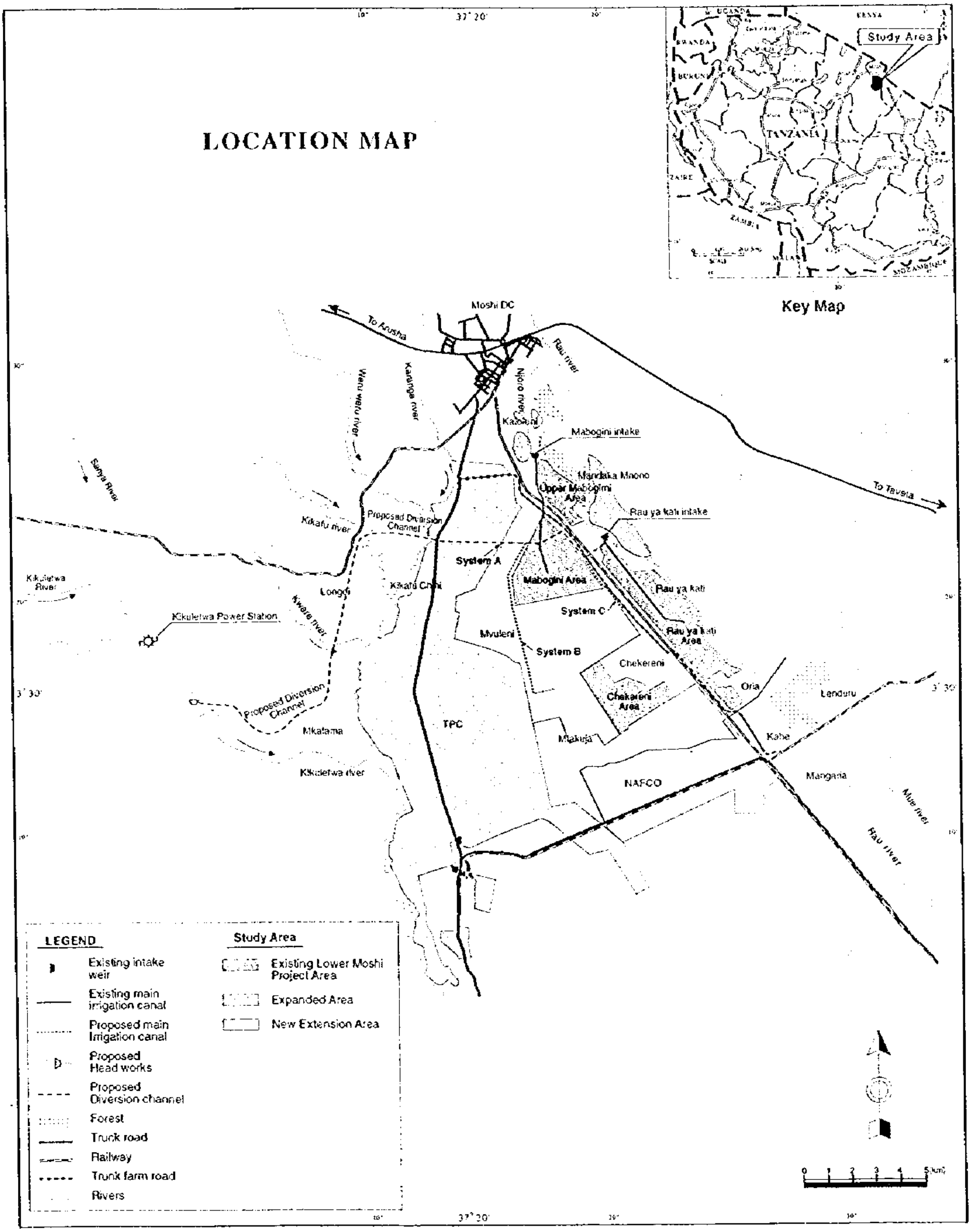


## CURRENCY EQUIVALENT

(as of December 1997)

One U.S.Doller (US$1) =Six Hundreds Twenty Tanzanian Shilling (Tsh.620)
=One Hundred Twenty Five Japanese Yen (¥ 125)

# LOCATION MAP



# *ANNEX-A*

# *METEOROLOGY AND HYDROLOGY*

# ANNEX - A

## METEOROLOGY AND HYDROLOGY

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# ANNEX - A

# METEOROLOGY AND HYDROLOGY

## 1 INTRODUCTION

This Annex presents the studies for the meteorology and hydrology, which provides necessary basic data for agriculture and irrigation and drainage plan as well as the engineering design for the Project.

Chapter 2 outlines the meteorological characteristics in the Study area, such as rainfall, temperature, relative humidity, and so on.

Chapter 3shows hydrological analysis for the Kikuletwa River and Rau and Njoro rivers, which will be the water source for the Project. It mentions the estimated available discharge as well as the probable flood discharges for the rivers.

Chapter 4 presents the result of the water quality tests, mentioning also methodology, and the adopted standards for the assessment of the water. The tests were carried out in order to assess the suitability for the irrigation and domestic water use for the Project.

Chapter 5 outlines the existing and newly applied water rights on the rivers, describing the total granted discharge by each river system.

# 2 METEOROLOGY

## 2.1 Data Collection

Since meteo-hydrological data in and around the Study Area had been collected at the time of the Feasibility Study of the Lower Moshi Agricultural Development Project in 1979 and 1980, the data compilation in the Study was only to supplement those previously collected data. Rainfall and meteorological data were collected from following meteorological stations:

| Station | Climate data available | Rainfall data available |
|---|---|---|
| Chekereni | 1981 - 1996 | 1981 - 1996 |
| TPC Langasani | 1970 - 1996 | 1971 - 1996 |
| Moshi | 1970 - 1996 | 1971 - 1997 |
| Lyamungu | 1970 - 1996 | 1935 - 1997 |
| Himo Sisal Estate | - | 1938 - 1996 |

## 2.2 Meteorology in the Study Area

The climate records at Chekereni located in the Study Area are summarised below:

| Description | Unit | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | | | | | | | | | | | | | |
| Max | ℃ | 31 | 32 | 34 | 31 | 28 | 27 | 27 | 28 | 28 | 32 | 33 | 33 |
| Mean | ℃ | 23 | 23 | 25 | 24 | 22 | 21 | 20 | 20 | 20 | 24 | 25 | 25 |
| Min. | ℃ | 17 | 18 | 20 | 20 | 19 | 17 | 16 | 16 | 16 | 18 | 20 | 19 |
| Relative Humidity | % | 62 | 61 | 69 | 74 | 77 | 74 | 72 | 72 | 63 | 66 | 65 | 67 |
| Evaporation | mm/day | 7 | 8 | 7 | 4 | 3 | 3 | 3 | 4 | 5 | 7 | 7 | 6 |

*Source Chekereni, KADP (1981 - 1996)*

The mean temperature varies from 20 °C to 25 °C throughout the year. Because of the altitude over 700 m, the daily minimum temperature falls below 26 °C even in the hottest season. The daily variation of temperature is over 14 °C in January. The monthly average of relative humidity varies from 63 to 77 %. Due to the effect of rainfall, the relative humidity increases from March and reaches the maximum in May, then decreases gradually after the rainy season, it. Pan evaporation varies widely throughout the year from 3 mm/day in May to 8 mm in February. Monthly summary data obtained from other meteorological stations are shown in Table A.2.1.

## 2.3 Rainfall

### 2.3.1 Annual Rainfall Characteristics

The period from March to May is generally a rainy season and a large amount of rainfall occurs during the period from April to May. The dry season appears from June to October followed by a light rainy season from November to February. The annual rainfall in the Kilimanjaro region varies according to altitude as shown below.

(Unit : mm)

| Station | Elevation | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chekereni | 725 | 40 | 38 | 68 | 161 | 100 | 18 | 10 | 10 | 6 | 21 | 30 | 60 | 560 |
| TPC Langasani | 701 | 39 | 24 | 90 | 192 | 74 | 5 | 8 | 10 | 12 | 29 | 49 | 36 | 566 |
| Moshi | 813 | 40 | 41 | 106 | 307 | 169 | 27 | 17 | 17 | 13 | 32 | 58 | 52 | 880 |
| Lyamungu | 1268 | 47 | 60 | 103 | 500 | 436 | 110 | 59 | 36 | 31 | 40 | 89 | 79 | 1591 |
| Himo Sisal Estate | 810 | 45 | 53 | 103 | 187 | 108 | 20 | 12 | 15 | 10 | 26 | 99 | 71 | 744 |

*Source : Chekereni, KADP (1981 - 1995)*

The monthly rainfall data at each station are shown in Tables A.2.2 to A.2.8. The recorded maximum and minimum annual rainfalls at the Chekereni station are 792 mm in 1982 and 401 mm in 1987.

### 2.3.2 Rainfall Intensity

The recorded maximum one-day rainfall is 137 mm in April 1989. The probable daily maximum rainfall at the representative rainfall stations is calculated by using the Gumbel method. The results are summarised below.

(Unit : mm/day)

| Station | No. of Data | Elevation (m) | Return Period (years) | | | |
|---|---|---|---|---|---|---|
| | | | 2 | 5 | 10 | 20 |
| Chekereni | 15 | 725 | 83 | 142 | 181 | 218 |
| TPC Langasani | 15 | 735 | 63 | 92 | 111 | 130 |
| Moshi | 51 | 813 | 100 | 151 | 185 | 217 |
| Lyamungu | 59 | 1268 | 112 | 152 | 179 | 204 |
| Himo Sisal Estate | 28 | 810 | 71 | 105 | 128 | 150 |

The annual maximum daily rainfall at each station is given in Table A.2.9. The variation of daily rainfall by altitude is graphed in Figures A.2.1 and A.2.2.

# 3 HYDROLOGY

## 3.1 Data Collection

The Regional Water Office (Maji Office) has been observing water levels at established gauging stations. Besides, the Office also has been carrying out spot discharge measurements in order to generate rating curves, by which water level at each station are converted to streamflow discharge data. During the field survey period, the JICA Study Team collected water level data as well as spot discharge data of gauging stations from the Regional Water Office in Kilimanjaro, Moshi, because no discharge data generation have been carried out by use of water levels and rating curves since 1980. A list of gauging stations with their observation period is shown in Table A.3.1. The locations of the respective stations are shown in Figure A.3.1.

| River System | River | Station | Catchment area ($km^2$) | Daily discharge data available | Daily water level data available |
|---|---|---|---|---|---|
| Kikuletwa | Kikuletwa | IDD1 | 3,840 | 1955 - 1975 | 1976 to date |
| | | IDD54 | 2,220 | 1967 - 1975 | 1976 to date |
| | Karanga | IDD3 | 211 | 1953 - 1959 | None |
| | Weruweru | IDD5A | 141 | 1958 - 1963 | None |
| | Kikafu | IDD8 | 198 | 1954 - 1963 | None |
| Ruvu | Ruvu | IDC2A | 1,810 | 1961 - 1976 | 1977 to date |
| | | IDC1 | 2,510 | 1957 - 1965 | None |
| | Rau | IDC5 | 121 | 1951 - 1959* | None |
| | Njoro | IDC35 | 15 | 1965 - 1982 | 1983 to 1986 |

Note : * Spot discharge data only

The Study Area is located in the Pangani river basin which consists of two major rivers, the Kikuletwa river and Ruvu river. Both rivers flow into the Nyumba Ya Mungu dam reservoir. Outflow from the dam discharges into the Pangani river which flows southwardly and finally discharges into the Indian Ocean.

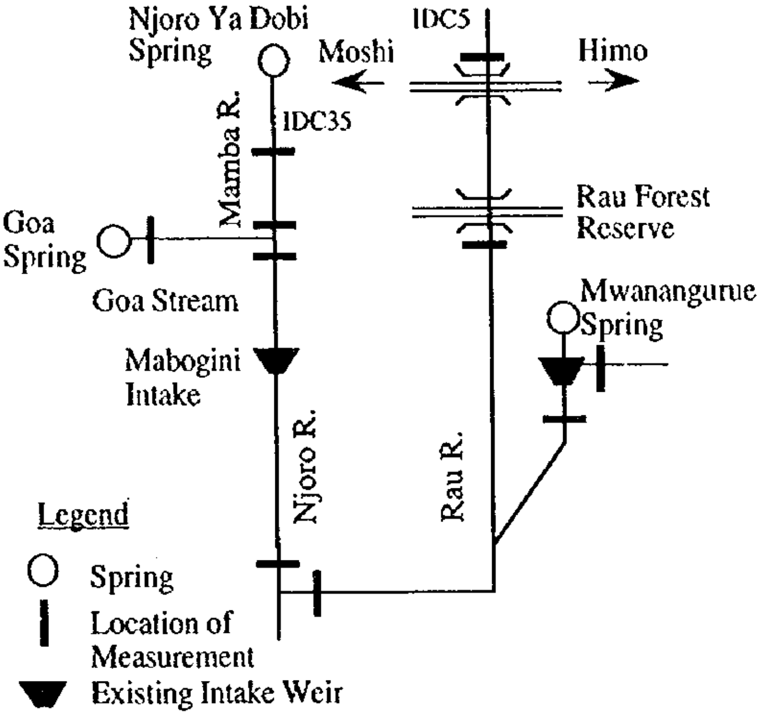
## 3.2 Check Discharge Measurement

Check measurements of discharge of the Rau river system and the Kikuletwa system were conducted during the field survey period in December 1997 in cooperation with the Regional Water Office, Kilimanjaro. The main purpose of the measurement was to verify the rating curves at IDD1 and IDD54 on the Kikuletwa River, and to confirm the hydrological characteristics of the Rau and Njoro rivers, which were clarified for the period of the detailed design of the Lower Moshi Agricultural Development Project in 1982.

### 3.2.1 Rau and Njoro Rivers

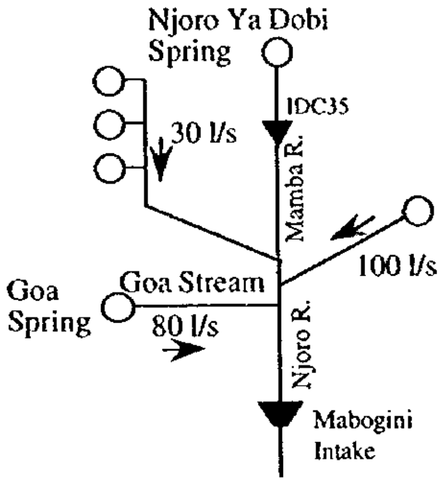
Discharge measurements on the Rau and Njoro rivers were carried out in December 1997 as shown below.

Results of measurement are shown in Figure A.3.2.




The Mwanangurue Spring discharges a constant flow throughout a year. Its discharge were measured at some 300 l/s. It is also observed that most water from the spring are abstracted to the Mandaka Mnono area in an irrigation period.

The relation between the discharge at IDC5 and that at the confluence with the Njoro river was generated based on the hydrological study on the detailed design of the Lower Moshi Agricultural Development Project. Figure A.3.3 graphs the relation with results of the spot measurement, that is appropriate correlation between two locations.




The relation between the discharge at IDC35 and that at the Mabogini Intake site was clarified at the detailed design stage of the Lower Moshi Agricultural Development Project, in which the ratio of the discharge at the Mabogini intake site to the discharge at IDC35 were expressed by a hyperbolic equation. Figure A.3.4 shows the relation with the spot discharge result and it is confirmed that the relation generated are considered to be appropriate. On the other hands, there exists several springs including the Goa spring in the Kaloleni area and their water are utilised for farmers' traditional irrigation. The result of the discharge measurement from the springs are shown in the left.

### 3.2.2 Kikuletwa River

Check discharge measurements for the Kikuletwa river were carried out in May, June and December 1997. The result of measurement were as follows:

| Station | Date | Water level (m) | Discharge ($m^3/s$) |
|---|---|---|---|
| IDD54 | May 29,1997 | 1.28 | 18.1 |
| | June 5, 1997 | 1.27 | 17.5 |
| | December 3, 1997 | 1.52 | 20.7 |
| | December 17, 1997 | 1.56 | 23.4 |
| IDD1 | June 12, 1997 | 1.50 | 35.1 |
| | December 4, 1997 | 4.68 | 42.0 |

The rating curve of IDD54 and IDD1 with results of the spot discharge measurement are shown in Figure A.3.5 and Figure A.3.6, respectively. The rating curve at IDD54 was prepared by the Regional Water Office and it was revised by the JICA Study Team based on spot discharge measurement data since 1981. The measurement result shows that the rating curve has been generated correctly. Meanwhile, the Rating curve at IDD1 was prepared by the Regional Water Office based on previous spot discharge measurement records. It is found that, the data in IDD1 show continuous water level records and their quality is appropriate because the generated rating curve is considered accurate.

## 3.3 Available Discharge

### 3.3.1 Kikuletwa River System

(1) General

The Kikuletwa river originates from the Mt. Meru in the Arusha region and flows down southwestwardly. It dries up from near the regional border with the Kilimanjaro region. The flow of the river is fed mainly by water originating from springs in the Kilimanjaro region. It joins the Sanya river just downstream of the TANESCO power station, and then flowing westwardly it forms a deep valley before joining the Kikafu river at the TPC pumping station. The Kikafu river as well as its tributaries, such as Karanga, Weruweru and Kuware, originates from the Mt. Kilimanjaro. The flow of those rivers, reflecting the rainfall pattern of the mountainous area, shows considerable annual variation. Meanwhile, water from many springs located in Rundugai village flows into the Kikuletwa river. Thus, the minimum flow of the river is regulated by the latter water inflow. There are two gauging stations on the Kikuletwa river, IDD54 and IDD1.

(2) Available Data and Verification

(a) IDD1 gauging station

The IDD1 gauging station was installed some 400 m downstream of the confluence with the Kikafu river, with a catchment area of 3,840 km$^2$. Daily discharge records are available from 1955 to 1975 and water levels as well as spot discharges have been observed afterwards. As for the data after 1976, the JICA Study Team compiled water level data and converted them to discharge data by using the rating curve (see Figure A.3.6).

(b) IDD54 gauging station

The IDD54 gauging station is located 300 m downstream of the confluence with the Sanya river, with a 2,220 km$^2$ catchment area. Discharge data are available from 1967 and 1975 while only water levels as well as spot discharge have been observed since 1976. The JICA Study Team compiled water level data and converted them to discharge data by using the rating curve as it was carried out for the IDD1 Station (see Figure A.3.5).

(c) Discharges of tributaries

The mean monthly discharges of tributaries of the Kikuletwa River, such as the Karanga, Weruweru and Kikafu rivers, are indicated below.

(Unit : m$^3$/s)

| Station | | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IDD3 | Karanga | 0.64 | 0.94 | 0.48 | 4.89 | 10.74 | 6.53 | 3.17 | 1.39 | 0.42 | 0.27 | 0.46 | 0.72 | 2.55 |
| IDD5A | Weruweru | 1.95 | 0.96 | 0.68 | 1.96 | 3.54 | 1.94 | 1.49 | 0.73 | 0.48 | 0.76 | 0.22 | 0.92 | 1.30 |
| IDD8 | Kikafu | 2.66 | 2.31 | 1.57 | 12.42 | 18.07 | 7.41 | 4.75 | 2.83 | 1.46 | 1.46 | 1.78 | 2.70 | 4.95 |

Source : Regional Water Office, Kilimanjaro

They are perennial rivers having a flow peak during the rainy season from March to July.

(3) Estimated Discharge

(a) Correlation between IDD1 and IDD54

In order to interpolate the discharge data of IDD54, an attempt was made to correlate the data of IDD54 with those of IDD1 on a monthly basis by using available records. Figure A.3.7 shows the relationship of mean monthly discharge records between IDD54 and IDD1. Based on the results of correlation, the lacking monthly discharge records of IDD54 were supplemented.

(b) Mean monthly discharges at IDD1 and IDD54

The mean monthly discharge with a 80 % dependable flow verified and supplemented by the JICA Study Team are presented in Tables A.3.2 and A.3.3 and summarised below:

(Unit : $m^3/s$)

| Station | | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IDD54 | Average | 12.1 | 11.9 | 12.8 | 24.3 | 25.4 | 19.6 | 14.4 | 11.7 | 11.5 | 11.4 | 12.6 | 13.0 | 15.1 |
| | 80 % | 10.4 | 10.5 | 10.6 | 13.2 | 16.4 | 11.8 | 11.1 | 11.0 | 10.7 | 10.9 | 10.4 | 10.3 | 11.4 |
| IDD1 | Average | 15.6 | 14.2 | 16.1 | 40.3 | 56.4 | 34.0 | 22.6 | 17.4 | 14.6 | 13.7 | 17.9 | 18.8 | 23.5 |
| | 80 % | 11.2 | 11.0 | 11.5 | 24.3 | 38.1 | 22.2 | 17.2 | 14.0 | 11.6 | 11.0 | 11.3 | 10.3 | 15.6 |

The runoff of the Kikuletwa river is characterised by base flow from spring water and seasonal flood water in the rainy season during the period from April to June. A base flow of some 10 $m^3/s$ is observed at IDD54. The annual specific discharges at IDD54 and IDD1 are 7.1 $l/s/km^2$ and 5.8 $l/s/km^2$, respectively. Meanwhile, in reverse, the specific discharge in May at IDD1 is higher than that at IDD54 because flood water from Kikafu, Karanga and Weruweru flow into the Kikuletwa river at a rate of 14.7 $l/s/km^2$ at IDD1 and 11.4 $l/s/km^2$ at IDD54.

(c) Low water analysis

The estimated annual minimum discharges at IDD1 and IDD54 were subjected to a statistical frequency analysis using the Gumbel distribution method. The results of analysis are given below.

| Probability (%) | Return Period (years) | Discharge IDD54 ($m^3/s$) | Discharge IDD1 ($m^3/s$) |
|---|---|---|---|
| 50 | 2 | 10 | 10 |
| 20 | 5 | 9 | 9 |
| 10 | 10 | 8 | 8 |
| 5 | 20 | 8 | 7 |
| 2 | 50 | 7 | 7 |

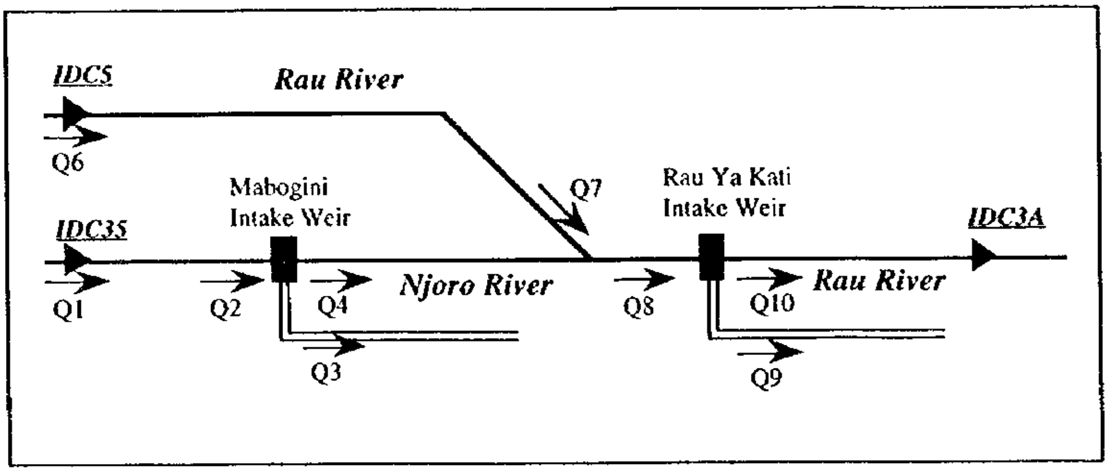
The above table indicates that the low flows at both stations are the same values in spite of the difference of their catchment areas. This could be explained that the base flow of the Kikuletwa river consists of steady water inflow from springs which are located mainly in Rundugai, Hai, upstream of the TANESCO power station. The 80 % dependable water discharge at IDD54 is estimated at 9 $m^3/s$.

### 3.3.2 Rau and Njoro Rivers

(1) General

The water source of the Existing Lower Moshi Project consists of the Rau river and the Njoro river, a tributary of the Rau river. The Rau river originates from the Mt. Kilimanjaro and traverses the Study Area until it is joined by the Ruvu river, collecting water from springs in the mountainous area. The Mwananguruе spring located in Mandaka Mnono has been acting as a stable water source of the river. The Njoro river, collecting water from such springs as the Njoro ya Dobi spring and Goa spring, has a relatively stable flow throughout the year. It passes along the Mabogini Intake Weir and flows into the Rau river at a place upstream of the Rau Ya Kati Intake Weir.

There had been three gauging stations maintained by the Regional Water Office: IDC35 on the Njoro river, and IDC5 and IDC3A on the Rau river, but these are no longer operational. Further, although KADP had been conducting river discharge measurement at the Mabogini and Rau Ya Kati Intakes since 1986, and measurement of water level at intake weirs and measuring devices on the main canal, the observation was interrupted due to disputes about water distribution in 1995. A schematic model of the Rau river is illustrated below. The observation of water level were resumed in July 1997 since the staff gauges were re-installed by the JICA Study Team.




The Njoro river at the Mabogini Intake Weir has a continuous flow because it originates from upstream while the flow of the Rau river is featured by a base flow from mountainous springs as well as flood in the rainy season. The monthly discharges of the Rau and Njoro rivers are shown in Table A.3.4.

(2) Njoro river

(a) Available data

A gauging staff was installed at IDC35 by the Regional Water Office. Reading of water levels was carried out periodically and the daily discharge was generated by the rating curve. Monthly discharge data are shown in Table A.3.5.

The monthly discharge of the Njoro river at Mabogini Intake Weir are presented below.

Recorded Mean Monthly Discharge of the Njoro River at the Mabogini Intake Weir Site (Q2)

(Unit : m$^3$/s)

| Mabogini | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1986 | | | | | | | | | | | 1.43 | 1.23 | |
| 1987 | | 1.14 | 1.12 | 1.14 | 1.52 | 1.16 | 1.06 | 1.15 | 1.08 | 0.98 | 1.01 | 1.00 | |
| 1988 | 0.95 | 0.78 | 0.95 | 2.07 | 1.28 | 1.25 | 1.34 | 1.38 | 1.34 | 1.30 | 1.29 | 1.14 | 1.25 |
| 1989 | 1.28 | 1.11 | 0.93 | 1.25 | 1.28 | 1.11 | 1.25 | 1.62 | 1.80 | 1.72 | 1.68 | 1.70 | 1.39 |
| 1990 | 1.57 | 1.38 | 1.67 | 1.81 | 1.89 | 1.95 | 2.24 | 2.35 | 2.20 | 2.00 | 1.92 | 1.72 | 1.89 |
| 1991 | 1.47 | 1.52 | 1.41 | 1.45 | 1.77 | 1.51 | 1.28 | 1.29 | 1.24 | 0.97 | 0.43 | 0.29 | 1.22 |
| 1992 | 0.98 | 0.96 | 0.90 | 1.00 | 1.58 | 1.41 | 1.43 | 1.47 | 1.47 | 1.43 | 1.54 | 1.41 | 1.30 |
| 1993 | 1.40 | 1.32 | 1.20 | 1.14 | 1.22 | | | | | | | | |
| 1994 | 1.03 | 1.01 | 1.32 | 1.28 | 1.72 | 1.38 | 1.07 | 1.15 | 1.16 | 1.16 | 1.11 | 1.05 | 1.20 |
| 1995 | 0.86 | 0.81 | 0.90 | | | | | | | | | | |
| 1996 | | | | | | | | | | | | | |
| 1997 | | | | | | | 1.62 | 1.55 | 1.57 | 1.71 | 1.74 | 1.97 | |
| Average | 1.19 | 1.11 | 1.15 | 1.39 | 1.53 | 1.40 | 1.41 | 1.49 | 1.48 | 1.41 | 1.35 | 1.28 | 1.35 |

*Source : KADP (1986 - 1995)*

The Njoro river at the Mabogini Intake Weir has a continuous flow because it originates from upstream springs.

(b) Estimated Discharge

The relation between the discharge at 1DC35 and that at the Mabogini Intake site was clarified at the detailed design stage of the Lower Moshi Agricultural Development Project (see Figure A.3.4), in which the ratio of the discharge at the Mabogini intake site to the discharge at 1DC35 were expressed by a hyperbolic equation. By using this relation, both discharges at 1DC35 and the Mabogini intake weir, discharges of Njoro river at IDC35 and the Mabogini intake weir, were estimated as shown in Tables A.3.6 and A.3.7. The results are indicated below.

Estimated Discharge of Njoro River at 1DC35 (Q1) and Mabogini Intake Weir Site (Q2)

(Unit : m$^3$/s)

| | | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q1 | Average | 0.82 | 0.78 | 0.77 | 0.93 | 1.03 | 1.03 | 1.11 | 1.04 | 1.04 | 0.99 | 0.93 | 0.95 | 0.95 |
| | 80 % | 0.52 | 0.49 | 0.49 | 0.66 | 0.70 | 0.71 | 0.76 | 0.69 | 0.68 | 0.56 | 0.58 | 0.65 | 0.62 |
| Q2 | Average | 1.30 | 1.23 | 1.25 | 1.40 | 1.44 | 1.49 | 1.59 | 1.52 | 1.50 | 1.44 | 1.38 | 1.39 | 1.41 |
| | 80 % | 0.97 | 0.94 | 0.95 | 1.12 | 1.25 | 1.16 | 1.24 | 1.15 | 1.13 | 1.01 | 1.03 | 1.10 | 1.09 |

As mentioned in the sub-section 3.2.1, the estimated flows from the springs, which are located along the Njoro River are 30 l/s from northern Kaloleni, 100 l/s from eastern Kaloleni, and 80 l/s from the Goa Spring.

(3) Rau river

(a) Available Discharge

The monthly discharges of the Rau river at the Rau Ya Kati Intake Weir are presented below.

Recorded Mean Monthly Discharges of the Rau River at the Rau Ya Kati Intake Weir Site (Q8)

(Unit : $m^3/s$)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1987 | | 0.64 | 0.76 | 0.94 | 2.57 | 1.93 | 1.21 | 1.25 | 1.01 | 0.86 | 0.88 | 1.02 | |
| 1988 | 0.97 | 0.49 | 0.97 | 9.45 | 5.53 | 3.48 | 2.60 | 1.66 | 1.39 | 1.11 | 1.15 | 1.07 | 2.63 |
| 1989 | 1.13 | 0.79 | 0.70 | 4.15 | 7.36 | 4.86 | 3.88 | 3.32 | 3.92 | 1.52 | 1.48 | 1.37 | 3.03 |
| 1990 | 1.51 | 1.21 | 2.80 | 11.80 | 11.31 | 5.42 | 3.27 | 2.82 | 1.78 | 1.40 | 1.87 | 1.62 | 4.12 |
| 1991 | 1.39 | 1.74 | 1.49 | 2.19 | 4.94 | 2.31 | 1.06 | 0.95 | 0.63 | 0.50 | 0.93 | 1.12 | 1.62 |
| 1992 | 1.01 | 0.84 | 0.60 | 5.87 | 5.86 | 3.70 | 3.00 | 2.02 | 2.13 | 0.96 | 1.32 | 1.09 | 2.49 |
| 1993 | 1.80 | 1.83 | 1.23 | 1.24 | 2.13 | | | | | | | | |
| 1994 | 0.52 | 0.54 | 1.00 | 1.03 | 3.43 | 1.82 | 0.95 | 0.55 | 0.72 | 0.42 | 0.52 | 0.57 | 1.05 |
| 1995 | 0.46 | 0.44 | 0.63 | | | | | | | | | | |
| 1996 | | | | | | | | | | | | | |
| 1997 | | | | | | | 2.69 | 1.48 | 0.99 | 1.61 | 2.38 | 3.81 | |
| Average | 1.10 | 0.95 | 1.13 | 4.58 | 5.39 | 3.36 | 2.33 | 1.76 | 1.57 | 1.05 | 1.32 | 1.46 | 2.26 |

*Source : KADP (1986 - 1995)*

The Rau river flow of is featured by a base flow from mountainous springs as well as flood in the rainy season. It should be stressed that the Rau river flow at the confluence with the Njoro river decrease remarkably since 1994, especially in the dry season from August to November as shown below.

Recorded Mean Monthly Discharges of the Rau River at the Confluence with the Njoro River (Q7)

(Unit : $m^3/s$)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1987 | | 0.09 | 0.50 | 0.65 | 1.72 | 1.08 | 0.42 | 0.49 | 0.32 | 0.27 | 0.21 | 0.51 | |
| 1988 | 0.24 | 0.26 | 0.51 | 7.84 | 4.90 | 2.82 | 1.80 | 0.82 | 0.63 | 0.40 | 0.42 | 0.52 | 1.76 |
| 1989 | 0.44 | 0.36 | 0.35 | 3.47 | 6.72 | 4.73 | 3.52 | 2.44 | 3.12 | 0.74 | 0.66 | 0.41 | 2.25 |
| 1990 | 0.67 | 0.65 | 1.87 | 10.69 | 10.06 | 4.29 | 1.82 | 1.32 | 0.66 | 0.59 | 0.88 | 0.66 | 2.85 |
| 1991 | 1.65 | 0.42 | 0.11 | 0.83 | 3.37 | 1.80 | 1.05 | 0.94 | 0.60 | 0.50 | 0.93 | 1.12 | 1.11 |
| 1992 | 0.40 | 0.26 | 0.14 | 5.12 | 4.50 | 2.89 | 2.32 | 1.30 | 1.57 | 0.28 | 0.58 | 0.48 | 1.65 |
| 1993 | 1.24 | 1.47 | 0.94 | 0.78 | 1.55 | 2.20 | 1.35 | | | | | | |
| 1994 | 0.06 | 0.10 | 0.26 | 0.32 | 2.21 | 1.05 | 0.55 | 0.06 | 0.19 | 0.03 | 0.03 | 0.04 | 0.41 |
| 1995 | 0.03 | 0.04 | 0.10 | | | | | | | | | | |
| 1996 | | | | | | | | | | | | | |
| 1997 | | | | | | | 1.70 | 0.66 | 0.16 | 0.59 | 1.21 | 2.53 | |
| Average | 0.59 | 0.41 | 0.53 | 3.71 | 4.38 | 2.61 | 1.60 | 1.05 | 1.02 | 0.40 | 0.53 | 0.53 | 1.45 |

*Source : KADP (1986 - 1995)*

(b) Tank Model Simulation

It is remarked that, in the case of the Rau river, water is abstracted upstream of the confluence with the Njoro river, at Mandaka Mnono village. However, data and information such as abstraction discharge, period as well as actual irrigated area, are not available yet. Thus, the tank model adopted at the detailed design stage of the Lower Moshi Agricultural Development Project is used in order to estimate the river flow of the Rau river with natural condition. The model is presented in Figure A.3.8, in which the conversion rate from point rainfall to areal rainfall and areal evapotranspiration on a monthly basis are also given.

The runoff of the Rau river at the 1DC5 station is calculated by use of the model applying daily rainfall data recorded at the Moshi meteorological station from 1967 to 1992. The estimated monthly runoff is shown in Table A.3.8.

The relation between the discharge at 1DC5 and that at the confluence with the Njoro river generated based on the hydrological study on the detailed design of the Lower Moshi Agricultural Development Project is shown in Figure A.3.3. By using the relation of both discharges, the monthly discharges of the Rau river at the confluence of the Njoro River are estimated. The results are shown in Table A.3.9. The simulated monthly discharges are compared with the measurement carried out in the field investigation from 1987 to 1992 as shown in Figures 3..9 and 3.10. The graph indicates the both values are correlative with correlation coefficient of 0.63. The tank model thus settled is applicable for estimation of discharge of the Rau River.

(c) Estimated Discharge

Average discharges are shown below.

Estimated Mean Monthly Discharges of the Rau River at IDC5 (Q6) and the Confluence with the Njoro River (Q7)

(Unit : $m^3/s$)

| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q6 | Average | 0.83 | 0.78 | 1.25 | 2.34 | 1.67 | 1.08 | 0.91 | 0.67 | 0.57 | 0.61 | 0.75 | 1.27 | 1.06 |
| | 80 % | 0.35 | 0.38 | 0.42 | 0.84 | 0.93 | 0.64 | 0.48 | 0.42 | 0.36 | 0.34 | 0.30 | 0.41 | 0.49 |
| Q7 | Average | 1.09 | 1.04 | 1.53 | 2.76 | 1.91 | 1.32 | 1.18 | 0.92 | 0.84 | 0.88 | 1.01 | 1.61 | 1.34 |
| | 80 % | 0.66 | 0.68 | 0.71 | 1.05 | 1.13 | 0.88 | 0.75 | 0.71 | 0.66 | 0.65 | 0.62 | 0.70 | 0.77 |

Estimated discharge records at the bridge in the Rau Forest Reserve are the same as those at the IDC5 station from the result of the discharge measurement. Further, as indicated in sub-section 3.2.1, the discharge from the Mwanangurue spring is estimated at 300 l/s throughout the year .

Estimated mean monthly discharge records on the Rau river at the Rau Ya Kati Intake Weir site are given in Table A.3.10 and summarised below.

Estimated Mean Monthly Discharges of the Rau River at the Rau Ya Kati Intake Weir Site (Q8)

(Unit : $m^3/s$)

| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q8 | Average | 2.42 | 2.24 | 2.86 | 4.35 | 3.45 | 2.88 | 2.85 | 2.50 | 2.38 | 2.35 | 2.44 | 3.13 | 2.82 |
| | 80 % | 1.86 | 1.74 | 1.91 | 2.63 | 2.77 | 2.18 | 2.16 | 2.04 | 1.93 | 1.83 | 1.82 | 2.02 | 2.07 |

### 3.3.3 Ruvu River

(1) General

The Ruvu river originates from the Lake Jupe and flows eastwards, joining such tributaries as the Himo, Mue and Rau rivers. The tributaries originate from the skirts of the Mt. Kilimanjaro where some springs discharge their base flow into the rivers. The Miwaleni spring, one of major springs, is a water source of the Mue river. The Ruvu river flows into the Nyumba Ya Mungu reservoir at a place near the railway bridge. Two gauging stations were operated on the river: IDC1 and IDC2A.

(2) Available Data

(a) IDC2A gauging station

The IDC2A gauging station is located near the Moshi - Tanga road bridge at Kifaru Village with a 2,510 $km^2$ catchment area.. Discharge data are available from 1955 to 1975 and water levels as well as spot discharge have been observed afterwards. By using the rating curve generated by the Regional Water Office, water level records were converted to discharge records by the JICA Study Team. The rating curve is shown in

Figure A.3.11. Table A.3.11 indicates mean monthly records at IDC2A.

(b) IDC1 gauging station

The IDC1 gauging station has been established at the railway bridge on the Ruvu river. It has a catchment area of 2,510 km$^2$. However, monthly records are available only for the period of 8 years from 1958 to 1965 and the station is no longer operative at present. Table A.3.12 shows mean monthly records at IDC1.

(3) Estimated Discharge

Since it is essential to estimate the monthly discharges at IDC1 to conduct the water balance study, they would be generated based on the relationship between discharge records of IDC1 and IDC2A. Although records of both stations have been observed simultaneously for only five years (1961 - 1965), a correlation analysis for both records was carried out. The results of analysis are graphed in Figure A.3.12. The estimated monthly discharges recorded at IDC1 for the last ten years are presented in Table A.3.13.

## 3.4 Flood Analysis

### 3.4.1 Flood Analysis of the Kikuletwa River

Probable flood discharges are estimated on the basis of annual maximum discharges. Number of available annual maximum discharge records at IDD54 and IDD1 are 29 and 39, respectively. The following table shows the flood discharges according to their probability.

| Probability (%) | Return Period (years) | Discharge IDD54 (m$^3$/s) | Discharge IDD1 (m$^3$/s) |
|---|---|---|---|
| 10 | 10 | 136 | 235 |
| 5 | 20 | 166 | 275 |
| 2 | 50 | 205 | 327 |
| 1 | 100 | 234 | 366 |
| 0.5 | 200 | 263 | 404 |

The discharge of a probable flood with a 100-years re-occurrence period at IDD54 is estimated at some 240 m$^3$/s, that is extremely low considering its catchment area. This might be related to the rainfall intensity, vegetation or topography in the upstream area. There exists a swampy area upstream of the Kikuletwa river in the Arusha region and it could act as a buffer to eliminate peak flood discharge.

### 3.4.2 Flood Analysis of the Rau River

(1) Basic approach

In the detailed design of the Lower Moshi Agricultural Development Project, flood discharge of the Rau river and its tributaries was estimated by use of the Rational formula as shown below.

$$Q_p = \frac{1}{3.6} * r_e * A$$

where, $Q_p$ = peak flood discharge (m$^3$/s)
$r_e$ = effective rainfall intensity (mm)
A = Catchment area (km$^2$)

The relation between effective rainfall intensity and the flood concentration time was generated based on runoff analysis of the Kikafu River and the hourly rainfall records at the Lyamungu meteorological station for a period of 1978 to 1982. Consequently, the peak flood discharge for each catchment was calculated based on the relation mentioned above and areal rainfall intensity. Since no flood pattern of the Rau and the Njoro Rivers as well as the Kikafu River are collected additionally, the flood discharge are estimated by use of the same procedure as that adopted in the detailed design period, updating only areal rainfall intensity for each catchment. The procedure adopted in the previous study is outlined below.

(2) Analysis of records of the Kikafu river

The following empirical formula is prepared a based on the flood records of the Kikafu River and the hourly rainfall data at the Lyamungu meteorological station.

$$Tp = 166 * A^{0.22} * r_e^{-0.45} \qquad \text{---(1)}$$

where, Tp = time from start of rise to peak (min)
$r_e$ = effective rainfall intensity (mm/hr)
A = catchment area ($km^2$)

(3) Procedure of Estimation of peak flood discharge

The procedure of estimation of peak flood is as follows:

(a) Estimation of probable daily rainfall ($R_{24}$)

Probable daily rainfall for respective catchment area is determined by Figure A.2.2.

(b) Estimation of effective rainfall intensity

Rainfall intensity is calculated using the following formula.

$$rt = \frac{R_{24}}{t}\left(\frac{t}{24}\right)^{1/3} \qquad \text{---(2)}$$

where, rt = rainfall intensity during t hours (mm/hr)
R24 = probable daily rainfall (mm)
t = time (hours)

Effective rainfall intensity (re) can be calculated as follows:

$$r_e = fp * rt = 0.25\ rt \qquad \text{---(3)}$$

where, $r_e$ = effective rainfall intensity (mm/hr)
fp = peak runoff coefficient

(4) Estimation of peak flood discharge

For each river basin, the re-Tp relation is observed by the equation (1) and then, the re-t relation is estimated by the equation (2) and (3). The equation (2) and (3) give also the $r_e$ value. peak flood discharge can be calculated by the rational formula. The sample of analysis is given in Tables A.3.14 to A.3.21 and the results are summarised below.

(Unit : $m^3/s$)

| River | Catchment Area | Return Period | | | |
|---|---|---|---|---|---|
| | ($km^2$) | 5 | 10 | 20 | 50 |
| Rau | 122 | 180 | 237 | 288 | 441 |
| Njoro | 15 | 28 | 34 | 38 | 54 |
| Seasonal Rivers | | | | | |
| Kisiringo | 14 | 32 | 41 | 51 | 68 |
| Msaranga | 17 | 40 | 57 | 66 | 90 |
| Msangaji | 10 | 24 | 33 | 40 | 51 |
| Mola | 7 | 18 | 25 | 30 | 39 |
| Mlalo | 9 | 21 | 29 | 36 | 44 |
| Nanga | 21 | 49 | 67 | 88 | 117 |

Considering the time lag of flood due to the different characteristics of rivers the peak, which were indicated in the hydrological study report of the detailed design of the Lower Moshi Agricultural Development Project, the estimated flood discharge around the Study Area are as follows:

(Unit : $m^3/s$)

| River | Catchment Area | Return Period | | |
|---|---|---|---|---|
| | ($km^2$) | 5 | 10 | 20 |
| Rau | 122 | 180 | 237 | 288 |
| Njoro | 15 | 24 | 29 | 32 |
| Seasonal Rivers | | | | |
| Kisiringo | 14 | 25 | 32 | 39 |
| Msaranga | 17 | 32 | 46 | 53 |
| Msangaji | 10 | 17 | 23 | 28 |
| Mola | 7 | 11 | 16 | 19 |
| Mlalo | 9 | 15 | 21 | 26 |
| Nanga | 21 | 42 | 57 | 75 |

The estimated peak flood discharge for each catchment is increased by 7% in an average compared to those estimated at the detailed design of the Lower Moshi Agricultural Development Project in 1983 because of the increase of the rainfall intensity within the catchment areas.

# 4 WATER QUALITY

## 4.1 Methodology

The water quality survey was carried out so as to verify if the available water is suitable for irrigation and domestic water uses. Eight locations, four on the Kikuletwa river system, and four on the Rau river system including the Existing Lower Moshi Project Area, were selected and water was sampled in each location;. Sampling and field tests were conducted by the JICA Study Team while the laboratory test was entrusted to a local consultant. The water sampling and field tests, such as measurement of pH, temperature, and electric conductivity (EC), were carried out by the JICA Study Team on May 10 and 11 in the Phase I study, and December 8 and 9 in the Phase II study. The water sampling locations are presented in Figure A.4.1 and listed below.

| No. | Location | No. | Location |
|---|---|---|---|
| | Kikuletwa River System | | Rau River System |
| 1 | Proposed headworks on the Kikuletwa river | 5 | Existing Mabogini Intake Weir |
| 2 | Chemuka Spring | 6 | Existing Rau Ya Kati Intake Weir |
| 3 | TPC Pump Station on the Kikuletwa river | 7 | Mabogini Main Canal at Turnout MS-5 |
| 4 | Railway Bridge over the Kikafu river | 8 | Rau Ya Kati Main Canal at No. 1 Bifurcation |

Meanwhile, the laboratory tests on such elements as Sodium, Calcium, Magnesium, Chloride, Fluoride, Total Nitrogen, Bacteria (Coliform), and so on, were carried out by the Chemistry Department of University of Dar Es Salaam. In addition, some tests were executed by the Kenya Bureau of Standards for cross check.

## 4.2 Assessment for Irrigation

(1) Methodology

In order to assess water quality, the "Guideline for Interpretations of Water Quality for Irrigation", which is derived from the FAO Irrigation and Drainage Paper No. 29 Rev. 1, was adopted. The guideline specifies the indexes which affect irrigation as follows:

| Potential Irrigation Problem | Indexes to evaluate |
|---|---|
| Salinity affecting crop water availability | Electric conductivity |
| Infiltration affecting infiltration rate into soil | SAR and Electric Conductivity |
| Specific Ion Toxicity affecting sensitive crop | Sodium, Chloride and Boron |
| Miscellaneous effects affecting susceptible crops | Nitrogen, Bicarbonate and pH |

*Source : FAO Irrigation and Drainage Paper No. 29 Rev. 1*

Remarks : The Sodium Absorption Ratio (SAR) affecting infiltration rate into soil is expressed as follows:

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

where: Na = sodium in me/l
Ca = Calcium in me/l
Mg = Magnesium in me/l

A analysis of the water quality was conducted based on the aforementioned guideline, which classifies the degrees of restriction on use into "None", "Slight to Moderate", and "Severe".

(2) Summary of Analysis

The results of analysis in the Phase - I and the Phase - II study are shown in Table A.4.1, and Table A.4.2, respectively. Evaluation of each location per the FAO standard is summarised below.

Result of Phase - I study

| | Location | Salinity | Infiltration | Specific Ion Toxicity (Na / Cl) | Miscellaneous Effects ($NO_3N$ / $HCO_3$) |
|---|---|---|---|---|---|
| | Kikuletwa River System | | | | |
| 1 | Proposed headworks | SM | SM | SM / N | N / SM |
| 2 | Chemuka Spring | SM | N | SM / N | N / S |
| 3 | TPC Pump Station | N | SM | SM / N | N / SM |
| 4 | Kikafu River | N | S | N / N | N / N |
| | Rau River System | | | | |
| 5 | Mabogini Intake Weir | N | SM | N / N | N / N |
| 6 | Rau Ya Kati Intake Weir | N | S | N / N | N / N |
| 7 | Mabogini Main Canal | N | S | N / N | N / N |
| 8 | Rau Ya Kati Main Canal | N | S | N / N | N / N |

Note : N : None, SM : Slight to Moderate, S : Severe for restriction of water for irrigation use

Result of Phase - II study

| | Location | Salinity | Infiltration | Specific Ion Toxicity (Na / Cl) | Miscellaneous Effects ($NO_3N$ / $HCO_3$) |
|---|---|---|---|---|---|
| | Kikuletwa River System | | | | |
| 1 | Proposed headworks | N | SM | SM / N | N / SM |
| 2 | Chemuka Spring | N | SM | SM / N | N / S |
| 3 | TPC Pump Station | N | SM | N / N | N / SM |
| 4 | Kikafu River | N | S | N / N | N / N |
| | Rau River System | | | | |
| 5 | Mabogini Intake Weir | N | S | N / N | N / N |
| 6 | Rau Ya Kati Intake Weir | N | S | N / N | N / N |
| 7 | Mabogini Main Canal | N | S | N / N | N / N |
| 8 | Rau Ya Kati Main Canal | N | S | N / N | N / N |

Note : N : None, SM : Slight to Moderate, S : Severe for restriction of water for irrigation use

The test results by the Kenya Bureau of Standards also presents the "Slight to Moderate (0.94 dS/m)" for salinity and "None (2.37 me/l)" for infiltration at the proposed intake site in the Kikuletwa river.

(3) Water Quality Assessment for the Kikuletwa River System

The result of the water quality tests indicates that the sampled waters at the proposed intake site on the Kikuletwa river are classified into the category of "No restriction" for irrigation water use in terms of salinity, and "Slight to Moderate" for irrigation use in terms of infiltration.

Since water of the Kikuletwa river is featured by a high concentration of sodium and bicarbonates and is slightly acid, the EC as well as SAR values of the river water are relatively high. The water of the Chemuka Spring indicates high contents of bicarbonate as well as sodium. On the other hand, the values of these elements in the water at the proposed headwork site located downstream are lower than those in the upstream area. This is due to the reason that excessive flood water during the rainy season, which flows into the Kikuletwa river from such tributaries as the Sanya and Kikafu rivers, dilutes the concentration. In this connection, it could be predicted that the sodium concentration in the Kikuletwa river water in the dry season would be higher than that in rainy season because the spring water with high sodium contents is dominant in the river in the dry season. Thus, the water quality tests in the Phase - II study were proposed by the JICA Study Team.

In succession with the Phase - I study, the water quality analysis were carried out in the Phase - II study to confirm suitability of water in the dry season for irrigation and domestic water uses. Although the period of the Phase - II Study is generally regarded as the dry season, more rainfall than usual were recorded in this year. The above tables indicate the similar results to those in the Phase - I study in terms of salinity , infiltration, and other indexes. The water quality for the proposed Kikuletwa intake site was re-examined in January 1998 since the water level on the river was lower than in December 1997. The results also showed the samples are in the same categories as that in the Phase - I study.

Water of the Kikuletwa river contents sodium bicarbonates, calcium bicarbonates as well as magnesium bicarbonates. The irrigation by such water that contains such cations results in sedimentation of calcium bicarbonates and magnesium bicarbonates in the soils because the sodium bicarbonates is more solvent than other bicarbonates. The sodium bicarbonates in the water will be discharged in the case that the soil is permeable. It should be pointed out that soil with low permeability may cause stagnation of the sodium bicarbonates and accumulation of the sodium in the soil. Therefore, such measures to sustain soil permeability should be taken, that would includes introduction of fodder crops in the proposed cropping pattern, provision of organic residues.

(4) Water Quality Assessment for the Rau River System

The result of the water quality tests indicates that the sampled waters on the Rau and Njoro rivers are classified into the category of no restriction for irrigation water use in terms of salinity. As for the infiltration problem, which is evaluated by a combination of SAR and EC, the waters sampled at Rau Ya Kati Intake Weir and the Rau Ya Kati Intake Weir are judged to have "Severe" and "Slight to Moderate" restriction.

Water of the Rau and Njoro rivers are characterised by low salinity and low SAR. According to the FAO paper, low salinity water is corrosive and tends to leach surface soils free of soluble minerals and salts, especially calcium, reducing their strong stabilising influence on soil aggregates and soil structure. Without salts and without calcium, the soil disperses and the dispersed finer soil particles fill many of the smaller pore spaces, sealing the surface and greatly reducing the rate at which water infiltrates the soil surface. Soil crusting and crop emergence problems often result, in addition to a reduction in the amount of water that will enter the soil in a given amount of time and which may ultimately causes water stress between irrigations.

The infiltration problem above mentioned could also be overcome through proper farming practice, such as provision of organic matters as described in sub-section (3).

(5) Assessment by use of USDA Standard

Figure A.4.2 indicates the classification of irrigation water by United States Department of Agriculture, which categorises the water according to salinity hazard and sodium hazard. The sampled waters are categorised as low/low (C1-S1) to medium-high/medium (C3-S2) and, accordingly, it is concluded that they do not present a high hazard for irrigation use.

## 4.3 Assessment for Domestic Water Use

(1) Result of analysis

The suitability for the domestic water was examined by use of the "Tanzanian Temporary Standards of Quality of Domestic Water." The test results in the Phase - I and Phase - II are shown in Table A.4.3 and 4.4, respectively. Except the ammonium contents at the Mabogini Intake Weir, which may be caused by the sewerage water from the Moshi DC, the samples meet the standards. The water analysis study also showed the higher BOD than the standard value at the Mabogini and Rau Ya Kati intake weir sites. In addition, the BOD values in the existing main canals were much higher than those at the intake sites. This might be due to washing and bathing in the canals.

(2) Assessment

It is observed the water samples are free from substances affecting human health, such as Fluoride, and Nitrate. Although the BOD values of water sampled in the Existing Lower Moshi Project Area exceed the Tanzanian standard, it is concluded that assessment should be made excluding the BOD considering the following reasons:

- BOD is the index related to environment and not direct impact for human health,
- Inhabitants in the Existing Lower Moshi Project Area actually utilise the canal water,
- No BOD description is indicated in WHO drinking water standard.

Taking into consideration organic pollution of water represented by BOD, some measure to prevent pollution of the canal water should be taken to improve the environment of human life. First, it should be stressed that, in the Study Area, the inhabitants are strongly instructed to follow the by law, that prohibits direct water use for bathing and washing in canals. Secondly, to make up for the prohibition, some water supply facilities, such as wash and drinking places, would be proposed in the Project so that the inhabitants can use the canal water.

# 5 WATER RIGHT

## (1) Existing Water Rights

With regard to existing water rights, data were obtained from the Regional Water Office in Kilimanjaro, Moshi.

The Water Utilisation (Control and Regulation) Act was enacted in 1974 and then supplemented by the subsequent legislation of the Government Notice No. 242 in October, 1975. The Notice designated the major water sources in the country as national water supply sources. Granted water rights in major river basin are summarised as follows:

| River System | Number of Granted Water Rights | Granted Discharge ($m^3/s$) | Annual Consumption (million $m^3$) |
|---|---|---|---|
| Rau | 36 | 3.00 | 95 |
| Mue | 4 | 3.19 | 101 |
| Himo | 16 | 2.15 | 68 |
| Kikuletwa | 4 | 0.20 | 6 |
| Karanga | 70 | 1.24 | 39 |
| Weruweru | 48 | 3.94 | 124 |
| Kikafu | 10 | 0.81 | 26 |
| Longoi | 1 | 0.05 | 2 |
| Kware | 1 | 0.00 | 0 |
| Sanya | 20 | 0.66 | 21 |
| Total | 210 | 15.25 | 481 |

*Source : Regional Water Office, Kilimanjaro*

Some 200 water rights have been granted in the Kilimanjaro Region, among which 176 are for irrigation use with a total granted discharge of 12 $m^3/s$. Granted water rights in the Rau river system total 3.00 $m^3/s$ for 36 users including the Existing Lower Moshi Project, which is authorised to abstract 804 l/s of water at the Mabogini Intake Weir and 1,135 l/s at the Rau Ya Kati Intake. Those water rights were granted on May 16, 1990, with registration No. 4807 and No.4808 for the Mabogini and Rau Ya Kati Intakes, respectively. As for the Kikuletwa river system, 4 water users have been allowed to abstract 200 l/s of water in total. The existing water rights in the Kikuletwa river and Rau river system are given in Tables A.5.1 and A.5.2, respectively.

However, there is a necessity to verify whether the granted water rights are presently implemented or not because some of them were registered some decades ago. At present, a review study is being conducted under the Water Basin Management and Smallholder Irrigation Improvement Project financed by IBRD and the Regional Water Office to clarify the status of water rights including the abstraction volume and location. In this Study, it is assumed from the present river flow condition that all existing water rights are performed.

## (2) Additional data collection

With regard to water rights, additional data collection was carried out at the Regional Water Office in Kilimanjaro, Moshi. The provisional water right applied recently is described as follows:

| | Description | |
|---|---|---|
| 1. | Water right No. | 140005 |
| 2. | Region | Arusha |
| 3. | District | Simanjiro |
| 4. | Village | Msitu wa Tembo |
| 5. | Name of holder | Mwenyekiti |
| 6. | Particulars of Water Right | To abstract 100 litres of water per second by pump, for irrigation purposes on Land Reg. No.11 |

The village is located on the right bank of the Kikuletwa River, by the bridge crossing the river near the TPC compounds. The application was received by the water officer of the Pangani Basin Water Office on 5th may, 1997. Afterwards, the letter was sent to the applicant, commenting that the pump irrigation should be substituted by the gravity irrigation system.

# *Tables*

**Table A.2.1 Summary of Meteorological Records**

**TPC Langasani**

| | Unit | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | | | | | | | | | | | | | |
| Max. | ℃ | 32.5 | 33.1 | 32.9 | 30.4 | 28.3 | 27.0 | 26.7 | 27.8 | 29.3 | 31.2 | 31.7 | 31.8 |
| Min | ℃ | 19.5 | 19.5 | 20.0 | 20.1 | 18.8 | 16.5 | 15.7 | 15.9 | 16.7 | 18.2 | 19.3 | 19.4 |
| Relative Humidity | | | | | | | | | | | | | |
| 9 AM | % | 80 | 78 | 82 | 86 | 86 | 81 | 84 | 81 | 79 | 79 | 79 | 80 |
| 3 PM | % | 48 | 46 | 50 | 60 | 64 | 60 | 57 | 54 | 52 | 49 | 50 | 50 |
| Evaporation | mm/day | 6.9 | 7.1 | 6.6 | 4.9 | 4.2 | 4.1 | 4.2 | 4.7 | 5.8 | 6.4 | 6.7 | 6.8 |
| Wind Speed | m/s | 1.56 | 1.46 | 1.32 | 1.04 | 0.86 | 0.80 | 0.84 | 0.95 | 1.11 | 1.26 | 1.45 | 1.61 |
| Sunshine Hours | hrs | 8.5 | 8.6 | 7.9 | 6.8 | 5.7 | 5.3 | 5.4 | 6.0 | 7.6 | 8.1 | 8.1 | 8.1 |
| Radiation | cal/cm2/day | 576 | 598 | 583 | 513 | 467 | 403 | 425 | 461 | 548 | 584 | 585 | 567 |

**Moshi**

| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | | | | | | | | | | | | | |
| Max. Temp | ℃ | 32.1 | 32.9 | 32.4 | 29.1 | 26.8 | 25.6 | 25.5 | 26.2 | 28.5 | 30.7 | 31.4 | 31.4 |
| Min. Temp | ℃ | 18.0 | 18.4 | 18.8 | 19.5 | 18.7 | 17.1 | 16.3 | 16.0 | 16.4 | 17.5 | 18.2 | 18.1 |
| Relative Humidity | | | | | | | | | | | | | |
| 9 AM | % | 73 | 72 | 75 | 85 | 86 | 80 | 81 | 80 | 78 | 72 | 73 | 72 |
| 3 PM | % | 43 | 41 | 42 | 57 | 62 | 58 | 53 | 49 | 43 | 38 | 40 | 47 |
| Evaporation | mm/day | 7.4 | 8.6 | 8.1 | 5.7 | 4.0 | 3.6 | 3.8 | 4.9 | 6.6 | 8.1 | 8.0 | 7.2 |
| Wind Speed | m/s | 2.18 | 2.22 | 2.71 | 1.69 | 1.13 | 0.97 | 1.09 | 1.49 | 2.35 | 3.11 | 2.84 | 2.02 |
| Sunshine Hours | hrs | 8.9 | 8.4 | 7.7 | 6.3 | 4.7 | 4.6 | 4.7 | 5.3 | 7.1 | 7.9 | 8.0 | 8.4 |

**Lyamungu**

| | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | | | | | | | | | | | | | |
| Max. Temp | ℃ | 27.5 | 28.2 | 27.5 | 24.7 | 22.3 | 21.1 | 20.7 | 21.4 | 23.6 | 25.8 | 26.3 | 26.8 |
| Min. Temp | ℃ | 14.0 | 14.0 | 14.6 | 15.7 | 15.3 | 13.7 | 12.9 | 12.6 | 12.7 | 13.1 | 14.0 | 14.2 |
| Relative Humidity | | | | | | | | | | | | | |
| 9 AM | % | 77 | 75 | 80 | 90 | 91 | 88 | 88 | 88 | 84 | 80 | 80 | 79 |
| 3 PM | % | 57 | 56 | 59 | 71 | 75 | 71 | 67 | 63 | 57 | 55 | 59 | 61 |
| Evaporation | mm/day | 3.5 | 3.9 | 3.2 | 1.6 | 1.2 | 1.6 | 1.8 | 2.2 | 2.9 | 3.5 | 3.2 | 3.0 |
| Wind Speed | m/s | 0.92 | 0.94 | 0.90 | 0.80 | 0.84 | 0.81 | 0.83 | 0.87 | 0.99 | 1.17 | 0.98 | 0.91 |
| Sunshine Hours | hrs | 7.8 | 8.0 | 6.8 | 4.5 | 3.1 | 3.5 | 3.7 | 4.3 | 5.6 | 6.9 | 6.2 | 6.8 |
| Radiation | cal/cm2/day | 468 | 460 | 439 | 292 | 240 | 226 | 249 | 302 | 385 | 451 | 416 | 447 |

## Table A.2.2 Monthly Rainfall Data at Chekereni Station

(Unit :mm)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | | | | | | | | | | 58.5 | 17.9 | 58.7 | 135.1 |
| 1982 | 12.8 | 8.4 | 4.1 | 74.8 | 267.3 | 56.7 | 35.9 | 7.8 | 23.8 | 137.6 | 119.3 | 43.9 | 792.4 |
| 1983 | 11.4 | 27.7 | 12.4 | 130.0 | 116.0 | 16.7 | 4.8 | 0.0 | 1.7 | 4.3 | 2.7 | 89.6 | 417.3 |
| 1984 | 11.0 | 5.8 | 14.8 | 228.5 | 45.5 | 29.8 | 49.4 | 4.0 | 4.0 | 5.5 | 54.6 | 57.0 | 509.9 |
| 1985 | 43.0 | 138.9 | 86.0 | 58.0 | 100.5 | 6.0 | 12.0 | 1.0 | 0.5 | 20.1 | 46.0 | 55.5 | 567.5 |
| 1986 | 86.5 | 58.5 | 11.0 | 98.2 | 159.8 | 1.2 | 0.0 | 7.8 | 0.0 | 11.5 | 7.8 | 154.2 | 596.5 |
| 1987 | 48.0 | 6.6 | 57.7 | 72.1 | 79.0 | 10.7 | 33.1 | 40.6 | 3.5 | 1.0 | 48.8 | 0.0 | 401.1 |
| 1988 | 18.7 | 0.0 | 165.8 | 200.1 | 41.1 | 2.0 | 3.4 | 23.0 | 18.1 | 0.0 | 19.6 | 53.7 | 545.5 |
| 1989 | 67.4 | 22.2 | 53.0 | 336.6 | 35.1 | 2.1 | 0.0 | 5.5 | 15.6 | 23.5 | 8.7 | 87.2 | 656.9 |
| 1990 | 36.5 | 34.5 | 268.3 | 456.3 | 19.9 | 1.9 | 0.0 | 0.0 | 3.0 | 30.6 | 40.9 | 40.4 | 932.3 |
| 1991 | 148.3 | 0.0 | 34.5 | 91.9 | 138.4 | 1.6 | 12.1 | 18.4 | 12.1 | 0.0 | 22.4 | 89.0 | 568.7 |
| 1992 | 0.0 | 0.0 | 34.0 | 235.5 | 95.7 | 7.0 | 1.9 | 0.0 | 0.0 | 1.4 | 0.0 | 43.4 | 418.9 |
| 1993 | 90.5 | 100.5 | 56.8 | 36.4 | 117.1 | 0.0 | 0.0 | 0.0 | 0.0 | 11.1 | 35.6 | 42.4 | 490.4 |
| 1994 | 0.0 | 0.0 | 104.9 | 114.7 | 143.3 | 14.6 | 0.0 | 0.0 | 4.4 | 0.0 | 31.9 | 111.5 | 525.3 |
| 1995 | 7.5 | 46.8 | 20.9 | 166.6 | 134.6 | 0.0 | 0.0 | 35.9 | 0.0 | 22.0 | 17.5 | 38.2 | 490.0 |
| 1996 | 28.0 | 116.2 | 93.6 | 119.0 | 0.0 | 112.4 | 0.0 | 0.0 | 0.0 | 4.5 | 0.0 | 0.0 | 473.7 |
| Average | 40.6 | 37.7 | 67.9 | 161.2 | 99.6 | 17.5 | 10.2 | 9.6 | 5.8 | 20.7 | 29.6 | 60.3 | 560.7 |

Source : KADP

# Table A.2.3 Monthly Rainfall Data at TPC Langasani Station

Station Name: TPC Langasani        Station No: 93.37/028

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1971 | - | - | - | - | - | - | 28 | 0 | 1 | 2 | 16 | 59 | - |
| 1972 | 28 | 29 | 94 | 133 | 115 | 2 | 1 | 1 | 27 | 31 | 239 | 50 | 748 |
| 1973 | 153 | 56 | 3 | 67 | 40 | 5 | 0 | 1 | 2 | 20 | 48 | 3 | 396 |
| 1974 | 7 | 0 | 35 | 337 | 129 | 6 | 32 | 1 | 0 | 0 | 8 | 5 | 558 |
| 1975 | 17 | 6 | 45 | 51 | 53 | 3 | 9 | 1 | 25 | 3 | 1 | 36 | 251 |
| 1976 | 35 | 12 | 72 | 102 | 32 | 10 | 1 | 0 | 69 | 3 | 22 | 4 | 362 |
| 1977 | 33 | 21 | 49 | 183 | 40 | 5 | 1 | 13 | 9 | 65 | 50 | 32 | 501 |
| 1978 | 112 | 108 | 154 | 213 | 56 | 1 | 1 | 0 | 0 | 6 | 138 | 80 | 870 |
| 1979 | 72 | 16 | 102 | 290 | 197 | 6 | 8 | 2 | 4 | 4 | 2 | 9 | 714 |
| 1980 | 23 | 1 | 15 | 166 | 22 | 0 | 4 | 22 | 7 | 33 | 62 | 60 | 415 |
| 1981 | 34 | 7 | 232 | 231 | 117 | 2 | 0 | 15 | 12 | 113 | 29 | 41 | 832 |
| 1982 | 4 | 6 | 38 | 199 | 126 | 10 | 15 | 6 | 31 | 159 | 137 | 109 | 840 |
| 1983 | 0 | 13 | 35 | 131 | 112 | 13 | 1 | 0 | 0 | 5 | 10 | 34 | 354 |
| 1984 | 16 | 0 | 70 | 114 | 9 | 17 | 16 | 0 | 0 | 19 | 72 | 42 | 375 |
| 1985 | 3 | 60 | 131 | 219 | 76 | 0 | 3 | 0 | 36 | 46 | 81 | 20 | 674 |
| 1986 | 70 | 3 | 84 | 93 | 128 | 9 | 0 | 35 | 0 | 11 | 18 | 94 | 546 |
| 1987 | 35 | 1 | 165 | 153 | 62 | 1 | 14 | 56 | 0 | 4 | 24 | 0 | 513 |
| 1988 | 43 | 0 | 149 | 233 | 5 | 7 | 0 | 10 | 24 | 20 | 28 | 53 | 572 |
| 1989 | 56 | 6 | 63 | 243 | 35 | 3 | 0 | 2 | 4 | 32 | 45 | 24 | 513 |
| 1990 | 12 | 37 | 303 | 611 | - | 0 | - | - | 0 | 30 | 67 | 51 | - |
| 1991 | 23 | 0 | 45 | 36 | 57 | 4 | 50 | 31 | 0 | 0 | 28 | 54 | 326 |
| 1992 | 0 | 36 | 9 | 149 | 135 | 0 | 3 | - | 8 | 0 | 15 | 16 | - |
| 1993 | 99 | 56 | 19 | - | 25 | 0 | 0 | 4 | 0 | 42 | 37 | 4 | - |
| 1994 | 2 | 34 | 77 | 116 | 40 | 0 | 3 | - | 0 | 17 | 17 | 48 | - |
| 1995 | 12 | 31 | 103 | 368 | 56 | 0 | 2 | 10 | 31 | 62 | - | 7 | - |
| 1996 | 87 | 50 | 185 | 173 | 40 | 0 | 0 | 0 | 0 | 12 | 21 | 0 | 568 |
| 1997 | 0 | 0 | 13 | - | - | - | - | - | - | - | - | - | - |
| Average | 37 | 23 | 88 | 192 | 71 | 4 | 8 | 9 | 11 | 29 | 49 | 36 | 556 |

Source : Regional Water Office, Moshi

# Table A.2.4 Monthly Rainfall Data at Moshi Station

Station Name: Moshi Meteo Station Station No: 93.37/004

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1930 | 11 | 32 | 247 | 434 | 124 | 7 | 4 | 9 | 12 | 45 | 102 | 11 | 1,038 |
| 1931 | 22 | 52 | 46 | 752 | 305 | 8 | 15 | 12 | 13 | 17 | 16 | 62 | 1,320 |
| 1932 | 0 | 72 | 74 | 392 | 220 | 77 | 6 | 2 | 14 | 13 | 9 | 27 | 906 |
| 1933 | 165 | 57 | 75 | 49 | 44 | 25 | 13 | 28 | 0 | 0 | 27 | 39 | 522 |
| 1934 | 48 | 53 | 71 | 68 | 231 | 62 | 28 | 8 | 0 | 4 | 68 | 37 | 678 |
| 1935 | 1 | 113 | 173 | 205 | 245 | 38 | 13 | 37 | 22 | 7 | 22 | 52 | 928 |
| 1936 | 111 | 53 | 110 | 458 | 132 | 88 | 7 | 62 | 44 | 14 | 19 | 76 | 1,174 |
| 1937 | 6 | 11 | 128 | 703 | 348 | 19 | 1 | 16 | 0 | 1 | 58 | 49 | 1,340 |
| 1938 | 5 | 99 | 331 | 240 | 330 | 13 | 4 | 7 | 3 | 149 | 53 | 23 | 1,257 |
| 1939 | 11 | 8 | 119 | 401 | 326 | 10 | 4 | 13 | 11 | 8 | 11 | 27 | 949 |
| 1940 | 103 | 105 | 113 | 240 | 138 | 10 | 5 | 25 | 0 | 3 | 73 | 0 | 815 |
| 1941 | 26 | 18 | 68 | 181 | 28 | 34 | 0 | 2 | 11 | 0 | 46 | 213 | 627 |
| 1942 | 13 | 0 | 360 | 339 | 331 | 2 | 0 | 13 | 0 | 0 | 41 | 34 | 1,133 |
| 1943 | 7 | 97 | 82 | 70 | 345 | 36 | 64 | 0 | 13 | 1 | 33 | 28 | 776 |
| 1944 | 48 | 27 | 121 | 387 | 136 | 5 | 5 | 8 | 47 | 73 | 98 | 107 | 1,062 |
| 1945 | 18 | 15 | 101 | 105 | 223 | 8 | 24 | 16 | 2 | 0 | 44 | 20 | 576 |
| 1946 | 1 | 11 | 14 | 324 | 123 | 1 | 7 | 7 | 155 | 117 | 7 | 57 | 824 |
| 1947 | 90 | 33 | 88 | 399 | 248 | 110 | 3 | 267 | 16 | 23 | 34 | 23 | 1,330 |
| 1948 | 0 | 2 | 111 | 197 | 154 | 20 | 8 | 8 | 1 | 24 | 5 | 127 | 657 |
| 1949 | 25 | 65 | 12 | 277 | 60 | 0 | 16 | 0 | 5 | 4 | 7 | 35 | 506 |
| 1950 | 9 | 35 | 219 | 180 | 254 | 17 | 18 | 16 | 16 | 2 | 12 | 62 | 840 |
| 1951 | 75 | 48 | 97 | 388 | 277 | 70 | 15 | 3 | 2 | 100 | 101 | 52 | 1,227 |
| 1952 | 44 | 21 | 94 | 209 | 79 | 11 | 0 | 2 | 8 | 3 | 38 | 17 | 525 |
| 1953 | 9 | 0 | 66 | 176 | 177 | 5 | 16 | 32 | 21 | 49 | 78 | 20 | 648 |
| 1954 | 25 | 65 | 8 | 349 | 263 | 8 | 40 | 1 | 3 | 13 | 33 | 12 | 820 |
| 1955 | 14 | 103 | 153 | 323 | 103 | 68 | 9 | 13 | 0 | 0 | 18 | 114 | 918 |
| 1956 | 107 | 6 | 56 | 260 | 54 | 12 | 1 | 14 | 5 | 3 | 19 | 0 | 536 |
| 1957 | 166 | 17 | 21 | 261 | 198 | 6 | 9 | 5 | 5 | 104 | 69 | 81 | 941 |
| 1958 | 4 | 112 | 139 | 176 | 168 | 57 | 2 | 1 | 0 | 0 | 4 | 52 | 715 |
| 1959 | 39 | 45 | 38 | 186 | 44 | 11 | 31 | 17 | 0 | 6 | 20 | 21 | 458 |
| 1960 | 135 | 14 | 141 | 665 | 82 | 42 | 5 | 0 | 1 | 35 | 10 | 4 | 1,133 |
| 1961 | 11 | 13 | 38 | 140 | 104 | 3 | 93 | 0 | 47 | 259 | 425 | 140 | 1,272 |
| 1962 | 61 | 5 | 13 | 128 | 56 | 18 | 15 | 28 | 1 | 12 | 113 | 58 | 508 |
| 1963 | 14 | 136 | 268 | 246 | 62 | 59 | 16 | 0 | 8 | 0 | 173 | 88 | 1,068 |
| 1964 | 3 | 65 | 77 | 286 | 120 | 7 | 3 | 6 | 16 | 43 | 23 | 33 | 682 |
| 1965 | 99 | 9 | 48 | 54 | 62 | 0 | 5 | 5 | 6 | 32 | 48 | 22 | 389 |
| 1966 | 21 | 31 | 156 | 165 | 105 | 48 | 9 | 0 | 1 | 3 | 6 | 46 | 588 |
| 1967 | 8 | 35 | 16 | 139 | 404 | 25 | 61 | 40 | 57 | 156 | 62 | 0 | 1,001 |
| 1968 | 0 | 134 | 136 | 331 | 207 | 91 | 20 | 21 | 52 | 29 | 104 | 170 | 1,295 |
| 1969 | 6 | 64 | 28 | 58 | 189 | 49 | 11 | 56 | 2 | 78 | 66 | 6 | 612 |
| 1970 | 93 | 45 | 257 | 396 | 76 | 10 | 5 | 26 | 1 | 6 | 6 | 37 | 957 |
| 1971 | 43 | 2 | 58 | 537 | 152 | 47 | 22 | 2 | 0 | 0 | 15 | 144 | 1,023 |
| 1972 | 15 | 57 | 132 | 244 | 234 | 5 | 23 | 6 | 37 | 57 | 145 | 22 | 976 |
| 1973 | 93 | 34 | 3 | 187 | 75 | 27 | 2 | 5 | 0 | 8 | 44 | 37 | 514 |
| 1974 | 34 | 9 | 44 | 724 | 50 | 82 | 5 | 7 | 1 | 1 | 40 | 15 | 1,011 |
| 1975 | 24 | 24 | 62 | 345 | 63 | 6 | 37 | 1 | 65 | 2 | 16 | 11 | 657 |
| 1976 | 8 | 35 | 128 | 228 | 93 | 32 | 4 | 2 | 21 | 0 | 16 | 52 | 617 |
| 1977 | 11 | 79 | 81 | 456 | 166 | 11 | 8 | 28 | 11 | 69 | 71 | 16 | 1,007 |
| 1978 | 72 | 62 | 295 | 276 | 118 | 26 | 15 | 0 | 0 | 4 | 135 | 58 | 1,061 |
| 1979 | 107 | 40 | 127 | 710 | 229 | 48 | 81 | 11 | 24 | 1 | 41 | 37 | 1,456 |
| 1980 | 14 | 12 | 90 | 346 | 215 | 5 | 8 | 60 | 4 | 33 | 82 | 10 | 879 |
| 1981 | 16 | 11 | 120 | 556 | 245 | 10 | 3 | 14 | 5 | 76 | 33 | 38 | 1,125 |
| 1982 | 14 | 19 | 114 | 91 | 217 | 84 | 45 | 14 | 23 | 52 | 264 | 112 | 1,047 |
| 1983 | 12 | 32 | 54 | 217 | 217 | 35 | 27 | 1 | 3 | 9 | 35 | 68 | 710 |
| 1984 | 39 | 2 | 14 | 554 | 59 | 72 | 77 | 1 | 4 | 31 | 95 | 58 | 1,004 |
| 1985 | 14 | 99 | 147 | 201 | 173 | 28 | 12 | 15 | 3 | 40 | 116 | 64 | 913 |
| 1986 | 88 | 5 | 167 | 393 | 209 | 33 | 2 | 7 | 1 | 44 | 58 | 89 | 1,095 |
| 1987 | 40 | 9 | 25 | 116 | 97 | 0 | 59 | 61 | 3 | 1 | 13 | 15 | 439 |
| 1988 | 61 | 9 | 180 | 535 | 129 | 22 | 7 | 5 | 38 | 1 | 28 | 79 | 1,092 |
| 1989 | 76 | 1 | 103 | 279 | 157 | 16 | 3 | 18 | 10 | 14 | 6 | 107 | 790 |
| 1990 | 52 | 44 | 245 | 632 | 50 | 6 | 9 | 6 | 4 | 40 | 174 | 43 | 1,305 |
| 1991 | 126 | 18 | 78 | 169 | 284 | 6 | 7 | 30 | 27 | 17 | 38 | 106 | 905 |
| 1992 | 3 | 17 | 38 | 415 | 216 | 3 | 14 | 24 | 1 | 0 | 92 | 52 | 875 |
| 1993 | 111 | 55 | 74 | 47 | 104 | 6 | 8 | 13 | 0 | 35 | 45 | 32 | 528 |
| 1994 | 5 | 42 | 71 | 174 | 178 | 9 | 14 | 3 | 3 | 71 | 28 | 68 | 666 |
| 1995 | 11 | 39 | 72 | 508 | 211 | 4 | 8 | 18 | 2 | 34 | 10 | 55 | 970 |
| 1996 | 13 | 77 | 42 | 219 | 194 | 7 | 8 | 2 | 5 | 6 | 19 | 0 | 590 |
| 1997 | 0 | 13 | 128 | 375 | 182 | 26 | 14 | 1 | 1 | 126 | 107 | 65 | 1,038 |
| Average | 40 | 41 | 106 | 307 | 169 | 27 | 17 | 17 | 13 | 32 | 58 | 52 | 880 |

Source : Regional Water Office, Moshi

# Table A.2.5 Monthly Rainfall Data at Lyamungu Station

Station Name: Lyamungu Station No: 93.37/021

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1931 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1932 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1933 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1934 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1935 | 3 | 244 | 112 | 371 | 690 | 156 | 40 | 41 | 12 | 25 | 70 | 102 | 1,866 |
| 1936 | 82 | 144 | 57 | 927 | 806 | 199 | 102 | 68 | 46 | 10 | 138 | 131 | 2,710 |
| 1937 | 5 | 3 | 258 | 972 | 999 | 171 | 42 | 59 | 19 | 108 | 102 | 48 | 2,785 |
| 1938 | 14 | 75 | 350 | 294 | 550 | 76 | 49 | 16 | 6 | 66 | 78 | 31 | 1,605 |
| 1939 | 7 | 12 | 115 | 669 | 585 | 247 | 25 | 13 | 44 | 2 | 16 | 13 | 1,748 |
| 1940 | 82 | 121 | 107 | 575 | 234 | 88 | 60 | 75 | 9 | 34 | 22 | 32 | 1,438 |
| 1941 | 30 | 52 | 63 | 450 | 292 | 137 | 24 | 67 | 80 | 2 | 122 | 256 | 1,573 |
| 1942 | 39 | 12 | 341 | 1,020 | 520 | 103 | 60 | 30 | 5 | 10 | 83 | 47 | 2,270 |
| 1943 | 1 | 66 | 36 | 196 | 521 | 116 | 110 | 12 | 11 | 5 | 52 | 6 | 1,131 |
| 1944 | 28 | 41 | 154 | 775 | 333 | 98 | 104 | 39 | 57 | 79 | 79 | 111 | 1,896 |
| 1945 | 35 | 36 | 71 | 424 | 537 | 109 | 65 | 35 | 6 | 1 | 122 | 10 | 1,451 |
| 1946 | 0 | 30 | 15 | 431 | 551 | 66 | 17 | 29 | 166 | 138 | 15 | 63 | 1,521 |
| 1947 | 37 | 14 | 89 | 983 | 638 | 290 | 42 | 39 | 33 | 27 | 20 | 42 | 2,254 |
| 1948 | 18 | 26 | 81 | 382 | 404 | 98 | 37 | 14 | 9 | 59 | 47 | 170 | 1,346 |
| 1949 | 40 | 99 | 4 | 304 | 314 | 48 | 54 | 28 | 9 | 22 | 6 | 40 | 967 |
| 1950 | 48 | 80 | 187 | 437 | 660 | 141 | 59 | 46 | 54 | 15 | 22 | 20 | 1,767 |
| 1951 | 118 | 72 | 104 | 540 | 509 | 210 | 65 | 46 | 8 | 82 | 148 | 189 | 2,091 |
| 1952 | 27 | 40 | 84 | 329 | 351 | 95 | 54 | 18 | 80 | 12 | 66 | 11 | 1,167 |
| 1953 | 19 | 215 | 109 | 402 | 466 | 166 | 59 | 18 | 2 | - | 94 | 33 | - |
| 1954 | 42 | 63 | 4 | 629 | 423 | 37 | 12 | 45 | 11 | 11 | 33 | 31 | 1,341 |
| 1955 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1956 | 202 | 25 | 112 | 413 | 218 | 88 | 45 | 34 | 76 | 5 | 44 | 14 | 1,274 |
| 1957 | 90 | 19 | 50 | 678 | 620 | 108 | 76 | 6 | 22 | 41 | 268 | 127 | 2,105 |
| 1958 | 12 | 186 | 127 | 345 | 380 | 176 | 65 | 4 | 4 | 0 | 10 | 66 | 1,375 |
| 1959 | 19 | 28 | 60 | 446 | 111 | 47 | 135 | 53 | 0 | 10 | 53 | 60 | 1,023 |
| 1960 | 125 | 6 | 115 | 845 | 300 | 141 | 27 | 5 | 0 | 39 | 28 | 6 | 1,638 |
| 1961 | 6 | 23 | 25 | 133 | 142 | 14 | 135 | 16 | 111 | 125 | 666 | 245 | 1,642 |
| 1962 | 174 | 33 | 41 | 360 | 273 | 50 | 82 | 30 | 12 | 11 | 41 | 123 | 1,229 |
| 1963 | 49 | 40 | 168 | 361 | 316 | 133 | 45 | 34 | 5 | 2 | 246 | 257 | 1,655 |
| 1964 | 28 | 13 | 271 | 923 | 478 | 37 | 40 | 21 | 25 | 23 | 30 | 36 | 1,925 |
| 1965 | 103 | 17 | 42 | 512 | 155 | 9 | 28 | 20 | 11 | 39 | 160 | 56 | 1,153 |
| 1966 | 24 | 37 | 265 | 433 | 282 | 119 | 21 | 8 | 5 | 13 | 35 | 32 | 1,273 |
| 1967 | 3 | 99 | 10 | 346 | 614 | 164 | 151 | 50 | 151 | 131 | 148 | 6 | 1,871 |
| 1968 | 2 | 78 | 158 | 660 | 316 | 148 | 100 | 62 | 22 | 29 | 152 | 142 | 1,868 |
| 1969 | 15 | 96 | 78 | 161 | 341 | 139 | 45 | 108 | 13 | 71 | 102 | 11 | 1,181 |
| 1970 | 160 | 20 | 164 | 485 | 271 | 47 | 22 | 20 | 4 | 18 | 9 | 27 | 1,246 |
| 1971 | 37 | 44 | 87 | 685 | 401 | 106 | 91 | 19 | 11 | 1 | 4 | 101 | 1,587 |
| 1972 | 19 | 106 | 128 | 364 | 561 | 37 | 71 | 36 | 66 | 168 | 331 | 38 | 1,922 |
| 1973 | 176 | 147 | 17 | 412 | 343 | 92 | 8 | 22 | 3 | 19 | 35 | 32 | 1,306 |
| 1974 | 3 | 11 | 30 | 966 | 234 | 180 | 53 | 14 | 10 | 5 | 22 | 67 | 1,594 |
| 1975 | 32 | 9 | 317 | 524 | 289 | 74 | 124 | 16 | 77 | 5 | 21 | 42 | 1,528 |
| 1976 | 19 | 122 | 52 | 260 | 364 | 135 | 52 | 19 | 23 | 10 | 40 | 51 | 1,146 |
| 1977 | 43 | 57 | 116 | 838 | 249 | 38 | 18 | 102 | 8 | 151 | 105 | 108 | 1,832 |
| 1978 | 106 | 56 | 178 | 388 | 358 | 214 | 62 | 28 | 10 | 0 | 193 | 270 | 1,863 |
| 1979 | 77 | 134 | 66 | 592 | 588 | 139 | 60 | 68 | 70 | 7 | 31 | 41 | 1,872 |
| 1980 | 40 | 43 | 67 | 348 | 756 | 24 | 85 | 83 | 9 | 79 | 114 | 173 | 1,821 |
| 1981 | 37 | 17 | 83 | 311 | 568 | 84 | 22 | 48 | 11 | 75 | 17 | 60 | 1,333 |
| 1982 | 9 | 45 | 13 | 385 | 526 | 166 | 112 | 40 | 33 | 135 | 171 | 73 | 1,705 |
| 1983 | 1 | 25 | 84 | 314 | 443 | 259 | 79 | 18 | 28 | 50 | 20 | 63 | 1,383 |
| 1984 | 23 | 37 | 64 | 789 | 305 | 161 | 87 | 21 | 24 | 27 | 141 | 101 | 1,781 |
| 1985 | 2 | 245 | 100 | 376 | 322 | 32 | 56 | 15 | 16 | 31 | 50 | 100 | 1,344 |
| 1986 | 118 | 0 | 29 | 553 | 527 | 139 | 55 | 10 | 9 | 70 | 67 | 178 | 1,753 |
| 1987 | 42 | 10 | 53 | 135 | 344 | 46 | 76 | 140 | 17 | 2 | 49 | 10 | 924 |
| 1988 | 60 | 7 | 106 | 684 | 226 | 147 | 17 | 8 | 23 | 3 | 58 | 85 | 1,423 |
| 1989 | 95 | 12 | 29 | 302 | 819 | 140 | 64 | 65 | 22 | 25 | 33 | 73 | 1,678 |
| 1990 | 0 | 0 | 0 | 725 | 509 | 87 | 21 | 43 | 6 | 56 | 175 | 118 | 1,740 |
| 1991 | 73 | 0 | 140 | 174 | 549 | 48 | 9 | 70 | 9 | 7 | 88 | 109 | 1,275 |
| 1992 | 0 | 67 | 25 | 516 | 425 | 45 | 76 | 35 | 4 | 2 | 59 | 50 | 1,305 |
| 1993 | 177 | 59 | 29 | 151 | 298 | 78 | 51 | 19 | 2 | 29 | 18 | 79 | 988 |
| 1994 | 14 | 46 | 119 | 199 | 382 | 36 | 71 | 21 | 6 | 42 | 50 | 241 | 1,226 |
| 1995 | 10 | 39 | 118 | 369 | 574 | 51 | 41 | 46 | 10 | 22 | 5 | 61 | 1,346 |
| 1996 | 29 | 169 | 147 | 811 | 458 | 104 | 38 | 19 | 14 | 16 | 33 | 3 | 1,839 |
| 1997 | 4 | 34 | 147 | 628 | 397 | 115 | 64 | 9 | 297 | 149 | 274 | 0 | 2,117 |
| Average | 47 | 60 | 103 | 500 | 436 | 110 | 59 | 36 | 31 | 40 | 89 | 79 | 1,591 |

Source : Regional Water Office, Moshi

## Table A.2.6 Monthly Rainfall Data at Himo Sisal Estate Station

Station Name: Himo Sisal Estate Station No: 93.37/031

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1938 | 11 | 88 | 355 | 185 | 329 | 0 | 13 | 4 | 0 | 5 | 153 | 107 | 1,250 |
| 1939 | 0 | 0 | 93 | 198 | 202 | 12 | 9 | 30 | 26 | 5 | 16 | 40 | 631 |
| 1940 | 135 | 150 | 141 | 275 | 113 | 10 | 0 | 29 | 10 | 0 | 44 | 25 | 932 |
| 1941 | 40 | 40 | 26 | 94 | 96 | 36 | 0 | 64 | 0 | 21 | 421 | 331 | 1,169 |
| 1942 | 52 | 5 | 280 | 256 | 103 | 13 | 0 | 10 | 0 | 36 | 57 | 142 | 954 |
| 1943 | 19 | 177 | 64 | 102 | 71 | 27 | 17 | 0 | 0 | 1 | 57 | 4 | 539 |
| 1944 | 70 | 3 | 88 | 153 | 87 | 31 | 0 | 24 | 8 | 87 | 216 | 106 | 873 |
| 1945 | 51 | 13 | 24 | 82 | 172 | 13 | 24 | 10 | 0 | 0 | 110 | 15 | 514 |
| 1946 | 0 | 7 | 11 | 210 | 113 | 62 | 24 | 11 | 81 | 104 | 50 | 48 | 721 |
| 1947 | 37 | 18 | 118 | 283 | 148 | 119 | 9 | 5 | 10 | 6 | 106 | 28 | 887 |
| 1948 | 31 | 1 | 114 | 100 | 116 | 12 | 10 | 6 | 0 | 8 | 42 | 79 | 519 |
| 1949 | 42 | 82 | 0 | 105 | 82 | 0 | 0 | 10 | 0 | 13 | 3 | 150 | 487 |
| 1950 | 42 | 13 | 331 | 179 | 62 | 13 | 5 | 15 | 11 | 0 | 58 | 12 | 741 |
| 1951 | 37 | 41 | 59 | 360 | 186 | 48 | 19 | 0 | 2 | 58 | 114 | 95 | 1,019 |
| 1952 | 50 | 141 | 181 | 242 | 45 | 0 | 12 | 3 | 9 | 50 | 27 | 7 | 767 |
| 1953 | 30 | 2 | 182 | 110 | 127 | 3 | 24 | 32 | 21 | 37 | 75 | 11 | 654 |
| 1954 | 47 | 3 | 46 | 348 | 408 | 7 | 0 | 7 | 17 | 169 | 34 | 42 | 1,128 |
| 1955 | 20 | 63 | 103 | 127 | 69 | 30 | 16 | 0 | 0 | 37 | 154 | 86 | 705 |
| 1956 | 122 | 123 | 94 | 141 | 49 | 0 | 4 | 26 | 7 | 1 | 88 | 15 | 670 |
| 1957 | 181 | 36 | 86 | 173 | 254 | 0 | 4 | 0 | 2 | 10 | 145 | 77 | 968 |
| 1958 | 17 | 171 | 192 | 78 | 102 | 69 | 3 | 0 | 0 | 1 | 34 | 54 | 721 |
| 1959 | 54 | 86 | 134 | 204 | 94 | 1 | 44 | 11 | 0 | 6 | 131 | 11 | 776 |
| 1960 | 48 | 23 | 125 | 259 | 65 | 4 | 4 | 0 | 0 | 30 | 17 | 0 | 575 |
| 1961 | 7 | 82 | 117 | 193 | 56 | 10 | 60 | 7 | 42 | 118 | 369 | 199 | 1,260 |
| 1962 | 146 | 30 | 25 | 78 | 72 | 16 | 12 | 11 | 2 | 46 | 81 | 108 | 627 |
| 1963 | 116 | 56 | 179 | 87 | 99 | 47 | 15 | 4 | 4 | 2 | 190 | 61 | 860 |
| 1964 | 5 | 22 | 139 | 415 | 50 | 4 | 1 | 4 | 1 | 20 | 57 | 124 | 842 |
| 1965 | 39 | 41 | 33 | 70 | 58 | 0 | 7 | 5 | 13 | 106 | 129 | 68 | 569 |
| 1966 | 4 | 94 | 185 | 181 | 32 | 48 | 7 | 13 | 0 | 3 | 15 | 46 | 628 |
| 1967 | 0 | 67 | 31 | 272 | 135 | 0 | 34 | 76 | 76 | 8 | 272 | 66 | 1,037 |
| 1968 | 0 | 0 | 239 | 290 | 88 | 5 | 0 | 58 | 0 | 4 | 85 | 18 | 787 |
| 1969 | 5 | 183 | 38 | 69 | 8 | 4 | 2 | 37 | 0 | 33 | 38 | 6 | 423 |
| 1970 | 60 | 36 | 243 | 415 | 63 | 0 | 8 | 10 | 15 | 2 | 82 | 109 | 1,044 |
| 1971 | 138 | 0 | 67 | 271 | 218 | 73 | 25 | 17 | 0 | 27 | 39 | 113 | 989 |
| 1972 | 77 | 95 | 211 | 100 | 233 | 58 | 22 | 24 | 45 | 35 | 212 | 64 | 1,174 |
| 1973 | 98 | 40 | 0 | 84 | 73 | 28 | 0 | 0 | 0 | 0 | 39 | 8 | 369 |
| 1974 | 0 | 3 | 9 | 406 | 80 | 43 | 44 | 0 | 0 | 20 | 1 | 0 | 605 |
| 1975 | 10 | 8 | 22 | 54 | 7 | 26 | 18 | 52 | 36 | 17 | 61 | 43 | 353 |
| 1976 | 90 | 261 | 146 | 348 | 81 | 20 | 9 | 0 | 21 | 26 | 138 | 41 | 1,181 |
| 1977 | 76 | 65 | 127 | 353 | 58 | 23 | 3 | 46 | 5 | 71 | 177 | 88 | 1,093 |
| 1978 | 144 | 83 | - | - | - | - | 7 | 0 | 0 | 7 | 101 | 68 | - |
| 1979 | 46 | 130 | 110 | 204 | 172 | 17 | 13 | 47 | 14 | 3 | 12 | 185 | 955 |
| 1980 | 33 | 11 | 54 | 123 | 86 | 0 | 10 | 22 | 0 | 8 | 142 | 49 | 537 |
| 1981 | 22 | 35 | 148 | 146 | 139 | 0 | 1 | 6 | 33 | 34 | 40 | 66 | 668 |
| 1982 | 0 | 0 | 24 | 108 | 159 | 47 | 58 | 5 | 32 | 69 | 40 | 104 | 646 |
| 1983 | 0 | 52 | 3 | 52 | 52 | 14 | 5 | 0 | 10 | 4 | 18 | 99 | 309 |
| 1984 | 21 | 4 | 45 | 178 | 48 | 49 | 3 | 0 | 0 | 15 | 153 | 25 | 542 |
| 1985 | 4 | 90 | 76 | 155 | 68 | 10 | 19 | 0 | 0 | 69 | 94 | 70 | 655 |
| 1986 | 69 | 3 | 67 | 179 | 153 | 9 | 6 | 3 | 18 | 22 | 89 | 181 | 797 |
| 1987 | 21 | 3 | 45 | 77 | 72 | 5 | 10 | 35 | 10 | 3 | 30 | 8 | 318 |
| 1988 | 112 | 13 | 379 | 171 | 45 | 40 | 2 | 5 | 16 | 0 | 272 | 0 | 1,056 |
| 1989 | 50 | 49 | 117 | 207 | 81 | 3 | 0 | 25 | 4 | 53 | 81 | 133 | 803 |
| 1990 | 24 | 28 | 112 | 123 | 57 | 1 | 15 | 6 | 0 | 17 | 94 | 76 | 551 |
| 1991 | 78 | 7 | 31 | 270 | 142 | 11 | 51 | 0 | 10 | 0 | 104 | 63 | 768 |
| 1992 | 0 | 20 | 50 | 149 | 48 | 3 | 0 | 3 | 0 | 0 | 105 | 68 | 447 |
| 1993 | 102 | 0 | 21 | 168 | 48 | 6 | 2 | 1 | 1 | 7 | 147 | 87 | 589 |
| 1994 | 14 | 143 | 56 | 69 | 117 | 20 | 5 | 7 | 3 | 11 | 39 | 170 | 652 |
| 1995 | 5 | 31 | 45 | 211 | 114 | 0 | 1 | 37 | 0 | 12 | 45 | 92 | 593 |
| 1996 | 30 | 130 | 12 | 264 | 158 | 0 | 1 | 6 | 2 | 0 | 77 | 0 | 680 |
| 1997 | 0 | 0 | 33 | 245 | - | - | - | - | - | - | - | - | - |
| Average | 46 | 53 | 103 | 187 | 108 | 20 | 12 | 15 | 10 | 26 | 99 | 71 | 751 |

Source : Regional Water Office, Moshi

# Table A.2.7 Monthly Rainfall Data at Kilema Mission Station

Station Name: Kilema Mission　　Station No: 93.37/015

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1930 | 68 | 66 | 320 | 520 | 187 | 86 | 49 | 70 | 70 | 86 | - | 53 | - |
| 1931 | 13 | - | 216 | 573 | 290 | 63 | 56 | 5 | 47 | 74 | 31 | 112 | - |
| 1932 | 53 | 134 | 180 | 631 | 419 | 194 | 44 | 116 | 84 | 25 | 147 | 127 | 2,152 |
| 1933 | 200 | 87 | 166 | 118 | 117 | 45 | 162 | 178 | 45 | 92 | 145 | 90 | 1,443 |
| 1934 | 29 | 160 | 105 | 252 | 475 | 264 | 88 | 126 | 15 | 99 | 159 | 284 | 2,054 |
| 1935 | 2 | 156 | 390 | 201 | 515 | 48 | 12 | 93 | 67 | 60 | 311 | 163 | 2,018 |
| 1936 | 129 | 126 | 134 | 512 | 524 | 0 | 56 | 118 | 96 | 84 | 110 | 245 | 2,133 |
| 1937 | 29 | 54 | 537 | 959 | 743 | 287 | 26 | 178 | 12 | 366 | 193 | 179 | 3,561 |
| 1938 | 29 | 100 | 492 | 361 | 407 | 35 | 69 | 48 | 10 | 42 | 258 | 96 | 1,946 |
| 1939 | 20 | 30 | 397 | 515 | 387 | 153 | 23 | 75 | 75 | 4 | 158 | 5 | 1,843 |
| 1940 | 194 | 193 | 218 | 637 | 264 | 72 | 52 | 86 | 18 | 11 | 95 | 51 | 1,888 |
| 1941 | 43 | 39 | 173 | 431 | 262 | 163 | 35 | 92 | 0 | 0 | 250 | 447 | 1,936 |
| 1942 | 153 | 318 | 546 | 667 | 288 | 87 | 44 | 50 | 3 | 66 | 121 | 81 | 2,424 |
| 1943 | 4 | 159 | 412 | 226 | 207 | 111 | 95 | 4 | 19 | 31 | 76 | 20 | 1,363 |
| 1944 | 168 | 5 | 241 | 328 | 202 | 107 | 71 | 67 | 61 | 146 | 215 | 179 | 1,790 |
| 1945 | 140 | 50 | 229 | 156 | 436 | 65 | 80 | 77 | 22 | 0 | 265 | 1 | 1,520 |
| 1946 | 2 | 67 | 9 | 497 | 325 | 53 | 19 | 93 | 276 | 102 | 65 | 141 | 1,647 |
| 1947 | 14 | 43 | 65 | 466 | 357 | 419 | 23 | 38 | 68 | 30 | 124 | 20 | 1,665 |
| 1948 | 32 | 35 | 92 | 288 | 199 | 64 | 46 | 21 | 22 | 75 | 53 | 115 | 1,040 |
| 1949 | 28 | 46 | 0 | 546 | 60 | 20 | 83 | 45 | 5 | 20 | 3 | 90 | 945 |
| 1950 | 125 | 13 | 664 | 633 | 233 | 97 | 40 | 30 | 87 | 0 | 100 | 15 | 2,039 |
| 1951 | 80 | 66 | 199 | 677 | 555 | 177 | 46 | 20 | 11 | 212 | 331 | 138 | 2,512 |
| 1952 | 29 | 136 | 100 | 349 | 202 | 69 | 58 | 19 | 38 | 29 | 135 | 21 | 1,184 |
| 1953 | 33 | 17 | 170 | 228 | 328 | 44 | 74 | 156 | 72 | 142 | 310 | 21 | 1,595 |
| 1954 | 26 | 34 | 161 | 803 | 328 | 40 | 0 | 47 | 19 | 109 | 318 | 74 | 1,961 |
| 1955 | 84 | 149 | 153 | 233 | 214 | 121 | 61 | 17 | 9 | 47 | 123 | 133 | 1,344 |
| 1956 | 342 | 103 | 227 | 455 | 322 | 94 | 22 | 161 | 41 | 28 | 164 | 3 | 1,963 |
| 1957 | 96 | 119 | 103 | 325 | 545 | 77 | 61 | 47 | 74 | 201 | 193 | 324 | 2,166 |
| 1958 | 31 | 92 | 253 | 525 | 584 | 110 | 96 | 52 | 25 | 10 | 102 | 73 | 1,952 |
| 1959 | 106 | 12 | 270 | 341 | 267 | 16 | 181 | 79 | 16 | 28 | 47 | 26 | 1,388 |
| 1960 | 136 | 88 | 333 | 527 | - | 148 | 10 | 17 | 13 | 110 | 198 | 1 | - |
| 1961 | 9 | 173 | 24 | 380 | - | 21 | 171 | 142 | - | 408 | - | 466 | - |
| 1962 | 208 | 25 | 80 | - | 413 | - | - | 268 | 81 | 78 | 111 | 198 | - |
| 1963 | 174 | 168 | - | - | - | - | 44 | 37 | 29 | - | 437 | - | - |
| 1964 | 5 | 152 | 265 | 919 | 298 | 63 | 18 | 55 | 13 | 76 | 176 | 127 | 2,167 |
| 1965 | 72 | 33 | 71 | 466 | - | 5 | 107 | 2 | 51 | 215 | 243 | 216 | - |
| 1966 | 125 | 85 | 541 | 543 | - | 93 | 25 | 0 | 0 | 38 | 77 | 37 | - |
| 1967 | 0 | 0 | 107 | 501 | 542 | 217 | 167 | 0 | 130 | 328 | 319 | 38 | 2,348 |
| 1968 | 0 | 92 | 201 | 411 | 412 | 252 | 34 | 102 | 40 | 77 | 353 | 227 | 2,203 |
| 1969 | 51 | 158 | 245 | 181 | 180 | 51 | 71 | 73 | 53 | 197 | 266 | 23 | 1,548 |
| 1970 | 182 | 43 | 540 | 905 | 164 | 152 | 88 | 67 | 29 | 26 | 97 | 42 | 2,334 |
| 1971 | 160 | 17 | 106 | 1,021 | 390 | 110 | 78 | 68 | 21 | 37 | 33 | 82 | 2,122 |
| 1972 | 63 | 108 | 134 | 373 | 334 | 121 | 91 | 68 | 85 | 208 | 373 | 119 | 2,076 |
| 1973 | 148 | 109 | 122 | 286 | 152 | 80 | 28 | 41 | 4 | 12 | 60 | 36 | 1,076 |
| 1974 | 19 | 15 | 91 | 727 | 282 | 228 | 126 | 40 | 35 | 17 | 144 | 4 | 1,727 |
| 1975 | 59 | 67 | 233 | 385 | 115 | 56 | 129 | 18 | 177 | 46 | 34 | 83 | 1,400 |
| 1976 | 100 | 148 | 186 | 415 | 171 | 89 | 22 | 22 | 90 | 41 | 66 | 32 | 1,383 |
| 1977 | 75 | 49 | 207 | 683 | 115 | 31 | 58 | 58 | 39 | 110 | 271 | 161 | 1,856 |
| 1978 | 106 | 55 | 297 | 458 | 259 | 141 | 8 | 25 | 3 | 78 | 130 | 148 | 1,707 |
| 1979 | 109 | 312 | 212 | 602 | 408 | 92 | 88 | 118 | 145 | 67 | 92 | 61 | 2,303 |
| 1980 | 67 | 41 | 156 | 237 | 527 | 12 | 69 | 122 | 12 | 20 | 156 | 129 | 1,547 |
| 1981 | 28 | 61 | 191 | 494 | 277 | 79 | 37 | 68 | 56 | 87 | 36 | 176 | 1,590 |
| 1982 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1983 | 44 | 78 | 250 | 329 | 176 | 80 | 75 | 11 | 103 | 42 | 59 | 53 | 1,299 |
| 1984 | 27 | 37 | 112 | 337 | 259 | 117 | 97 | 27 | 16 | 205 | 445 | 87 | 1,766 |
| 1985 | 0 | 201 | 280 | 351 | 254 | 57 | 57 | 56 | 27 | 104 | 345 | 106 | 1,837 |
| 1986 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1987 | 91 | 21 | 60 | 514 | 321 | 29 | 98 | - | - | - | - | - | - |
| 1988 | 62 | 6 | 78 | 720 | 381 | 119 | 4 | 27 | 102 | 75 | 137 | - | - |
| 1989 | 104 | 150 | 102 | - | 324 | 99 | 87 | 77 | 28 | 141 | 106 | 63 | - |
| 1990 | 62 | 59 | 304 | 301 | 5 | 13 | 0 | 53 | 0 | 3 | 5 | 11 | 817 |
| 1991 | - | - | 101 | 232 | 405 | 41 | 72 | 98 | 7 | 4 | 276 | 116 | - |
| 1992 | 0 | 49 | 48 | 437 | 233 | 33 | 55 | 43 | 34 | 3 | 290 | 206 | 1,431 |
| 1993 | 206 | 59 | 105 | 252 | 114 | 84 | 67 | 28 | 15 | 93 | 253 | 70 | 1,344 |
| 1994 | 25 | 96 | 172 | 210 | 275 | 39 | 30 | 56 | 102 | 78 | 117 | 237 | 1,436 |
| 1995 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1996 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1997 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Average | 74 | 84 | 203 | 439 | 295 | 93 | 60 | 63 | 46 | 82 | 164 | 106 | 1,707 |

Source : Regional Water Office, Moshi

# Table A.2.8 Monthly Rainfall Data at Old Moshi Nursery Station

Station Name: Old Moshi Nursery Station No: 93.37/064

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1941 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1942 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1943 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1944 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1945 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1946 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1947 | 60 | 30 | 108 | 662 | 434 | 225 | 84 | 76 | 43 | 6 | 72 | 28 | 1,829 |
| 1948 | 35 | 10 | 72 | 306 | 272 | 123 | 106 | 33 | 33 | 107 | 69 | 191 | 1,356 |
| 1949 | 66 | 73 | 6 | 533 | 222 | 45 | 105 | 70 | 24 | 25 | 20 | 159 | 1,348 |
| 1950 | 103 | 67 | 398 | 395 | 453 | 159 | 87 | 31 | 124 | - | 88 | 95 | - |
| 1951 | 72 | 162 | 348 | 597 | 668 | 193 | 128 | 82 | 24 | 225 | 294 | 158 | 2,951 |
| 1952 | 33 | 115 | 82 | 487 | 364 | 134 | 88 | 52 | 53 | 28 | 87 | 40 | 1,564 |
| 1953 | 34 | 16 | 212 | 520 | 537 | 101 | 79 | 124 | 47 | - | - | - | - |
| 1954 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1955 | - | - | - | - | - | - | - | - | - | 26 | 54 | 178 | - |
| 1956 | 212 | 117 | 326 | 441 | 355 | 152 | 61 | 22 | 81 | 22 | 72 | 31 | 1,892 |
| 1957 | 189 | 94 | 510 | 86 | 680 | 138 | 100 | 55 | 35 | 216 | 180 | 259 | 2,541 |
| 1958 | 41 | 170 | 192 | 745 | 648 | 205 | 119 | 15 | 23 | - | 61 | 100 | - |
| 1959 | 40 | 47 | 119 | 482 | 242 | 87 | 234 | 79 | 14 | 17 | 44 | 63 | 1,468 |
| 1960 | 110 | 52 | 310 | 565 | 212 | 201 | 61 | 15 | 14 | 90 | 27 | 31 | 1,688 |
| 1961 | 22 | 37 | 72 | 660 | 230 | 14 | 73 | 26 | 18 | 144 | 192 | 83 | 1,570 |
| 1962 | 225 | 45 | 76 | 378 | 365 | 53 | 156 | 98 | 14 | 27 | 330 | 144 | 1,910 |
| 1963 | 171 | 115 | 358 | 523 | 411 | 229 | 58 | 48 | 20 | 26 | 526 | 320 | 2,803 |
| 1964 | 17 | 81 | 224 | 1,005 | 591 | 66 | 51 | 72 | 17 | 153 | 338 | 189 | 2,805 |
| 1965 | 54 | 95 | 180 | 1,594 | 584 | 36 | 183 | 68 | 45 | 262 | 489 | 151 | 3,741 |
| 1966 | 190 | 126 | 1,013 | 1,221 | 602 | 375 | 127 | 87 | 12 | - | - | - | - |
| 1967 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1968 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1969 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1970 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1971 | 79 | 20 | 134 | 1,055 | 354 | 74 | 139 | 126 | 59 | 16 | 40 | 113 | 2,207 |
| 1972 | 6 | 100 | 182 | 721 | 205 | - | - | - | - | - | - | - | - |
| 1973 | 146 | 102 | 41 | 464 | - | - | - | - | - | - | - | - | - |
| 1974 | 45 | - | 24 | 537 | 95 | 50 | - | 4 | - | - | 26 | 14 | - |
| 1975 | 68 | 57 | 511 | 474 | 284 | 136 | 183 | 35 | 52 | 34 | 19 | 119 | 1,972 |
| 1976 | 76 | 74 | 179 | 345 | 306 | 53 | 65 | 25 | 48 | 8 | 47 | 75 | 1,301 |
| 1977 | 97 | 77 | 120 | 940 | 301 | 62 | 53 | 77 | 29 | 63 | 65 | 93 | 1,976 |
| 1978 | 319 | 53 | - | 519 | 262 | 241 | 136 | 35 | - | 39 | 125 | 143 | - |
| 1979 | - | - | 138 | - | 413 | 126 | 90 | 71 | 31 | - | - | - | - |
| 1980 | 49 | 81 | 128 | 244 | 651 | 42 | 156 | 107 | 6 | 37 | 96 | 22 | 1,617 |
| 1981 | 58 | 43 | 123 | 418 | 882 | 245 | 89 | 67 | 45 | 146 | 91 | 220 | 2,426 |
| 1982 | 41 | 67 | 101 | 398 | 0 | 225 | 0 | 129 | 100 | 225 | 118 | 106 | 1,510 |
| 1983 | 15 | 42 | 46 | 247 | 206 | 75 | 38 | 7 | 20 | 13 | 14 | 122 | 845 |
| 1984 | 73 | 17 | 72 | 786 | 774 | 498 | 298 | 80 | 70 | 481 | 989 | 279 | 4,417 |
| 1985 | 43 | 541 | 1,085 | 1,262 | 919 | 218 | 316 | 105 | 88 | 180 | 339 | 170 | 5,267 |
| 1986 | 0 | 22 | 122 | 811 | 461 | 176 | 62 | 17 | 22 | 72 | 132 | 0 | 1,897 |
| 1987 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1988 | 371 | 0 | 325 | - | - | - | - | - | - | - | - | - | - |
| 1989 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1990 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1991 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1992 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1993 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1994 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1995 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1996 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1997 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Average | 93 | 83 | 233 | 619 | 424 | 149 | 114 | 61 | 40 | 100 | 168 | 123 | 2,206 |

Source : Regional Water Office, Moshi

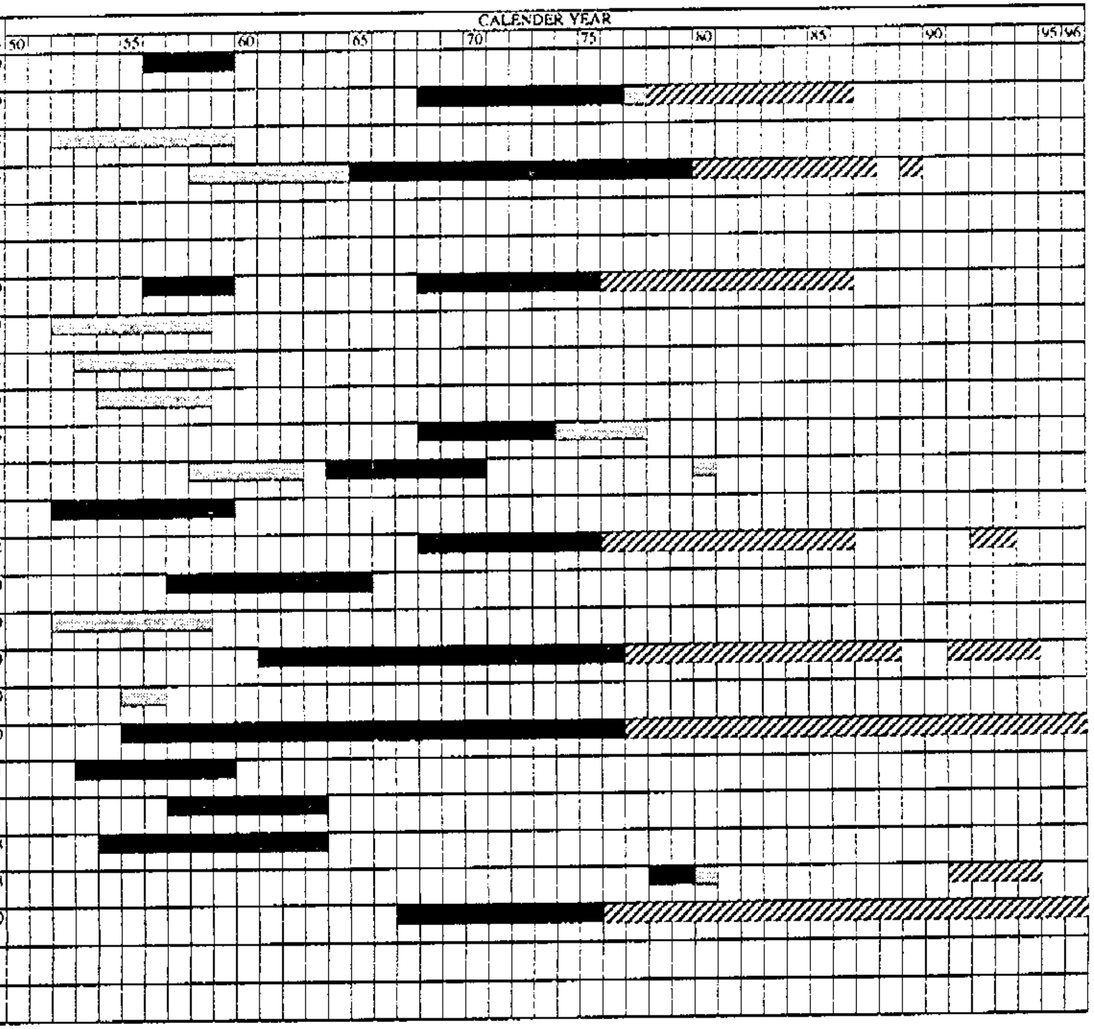
## Table A. 2. 9 Annual Maximum Daily Rainfall

| | Moshi | Kilema Misssion | Lyamungu | Old Moshi Nursery | TPC Langasan i | TPC Langasan i North | NAFCO Kahe | Himo Sisal Estate | Chekeren i |
|---|---|---|---|---|---|---|---|---|---|
| 1930 | | 95.0 | | | | | | | |
| 1931 | | 70.1 | | | | | | | |
| 1932 | | 150.6 | | | | | | | |
| 1933 | | 95.5 | | | | | | | |
| 1934 | | 109.2 | | | | | | | |
| 1935 | | 108.2 | 123.2 | | | | | | |
| 1936 | | 115.9 | | | | | | | |
| 1937 | | 172.2 | 181.6 | | | | | | |
| 1938 | | 170.2 | 110.4 | | | | | | |
| 1939 | | 227.8 | 104.5 | | | | | | |
| 1940 | | 102.1 | 103.2 | | | | | | |
| 1941 | | 208.3 | 111.0 | | | | | | |
| 1942 | | 317.5 | 251.8 | | | | | | |
| 1943 | | 127.0 | 70.9 | | | | | | |
| 1944 | | 93.2 | 96.5 | | | | | | |
| 1945 | | 137.4 | 100.6 | | | | | | |
| 1946 | | 131.8 | 188.7 | | | | | | |
| 1947 | 254.0 | 280.7 | 202.4 | 38.1 | | | | | |
| 1948 | 86.9 | 72.6 | 87.6 | 99.1 | | | | | |
| 1949 | 67.1 | 127.5 | 97.3 | 87.1 | | | | | |
| 1950 | 64.0 | 107.2 | 205.7 | 83.8 | | | | | |
| 1951 | 69.6 | 150.2 | 82.8 | 127.0 | | | | | |
| 1952 | 88.4 | 106.7 | 96.5 | 137.4 | | | | | |
| 1953 | 72.9 | 98.0 | 108.0 | 98.6 | | | | | |
| 1954 | 71.6 | 153.2 | | | | | | | |
| 1955 | 123.2 | 69.1 | | 40.4 | | | | | |
| 1956 | 178.3 | 101.6 | 75.2 | 94.0 | | | | | |
| 1957 | 102.1 | 203.7 | 84.1 | 165.1 | | | | | |
| 1958 | 62.0 | 77.0 | 93.2 | 160.0 | | | | | |
| 1959 | 53.8 | 130.3 | 90.9 | 191.3 | | | | | |
| 1960 | 158.2 | 132.1 | 124.5 | 92.2 | | | | | |
| 1961 | 107.7 | 153.7 | 128.0 | 131.1 | | | | | |
| 1962 | 104.9 | 97.8 | 89.7 | 193.0 | | | | | |
| 1963 | 130.0 | 127.0 | 107.4 | 138.1 | | | | | |
| 1964 | 77.3 | 173.5 | 141.7 | 119.4 | | | | | |
| 1965 | 51.5 | 162.6 | 91.4 | 333.0 | | | | | |
| 1966 | 79.0 | 208.8 | 86.4 | 183.9 | | | | | |
| 1967 | 76.3 | 114.8 | 115.3 | | | | 44.7 | | |
| 1968 | 130.5 | 83.3 | 156.5 | | | | 108.0 | | |
| 1969 | 68.2 | 137.0 | 93.2 | | | | 20.3 | | |
| 1970 | 176.8 | 92.3 | 78.6 | | | | 32.0 | 144 | |
| 1971 | 117.8 | 180.8 | 121.3 | 122.4 | | | 48.0 | 80 | |
| 1972 | 78.3 | 78.3 | 101.9 | 109.2 | 98.0 | | 78.5 | 72 | |
| 1973 | 83.0 | 90.8 | 114.7 | 78.7 | 82.5 | | 65.1 | 43 | |
| 1974 | 104.3 | 115.5 | 130.4 | 114.3 | 110.5 | 114.0 | 54.8 | 107.5 | |
| 1975 | 93.0 | 75.2 | 98.4 | 259.6 | 25.0 | 35.7 | 30.9 | 54 | |
| 1976 | 77.2 | 134.3 | 105.0 | 74.4 | 37.4 | 46.1 | 36.0 | 148.4 | |
| 1977 | 111.8 | 128.0 | 180.3 | 117.1 | 46.5 | 61.5 | 56.0 | 78 | |
| 1978 | 53.1 | 88.2 | 61.2 | 244.0 | 66.2 | 76.8 | 54.6 | | |
| 1979 | 147.0 | 126.0 | 233.3 | 55.9 | 56.0 | 75.3 | 60.0 | 101.3 | |
| 1980 | 150.1 | 103.0 | 113.3 | 61.0 | 63.4 | 63.1 | 57.5 | 51.7 | |
| 1981 | 143.7 | 80.2 | 98.4 | 122.7 | 84.0 | 80.0 | 92.8 | 83.8 | |
| 1982 | 87.8 | | 126.0 | 121.9 | 147.1 | 58.0 | | 39.8 | 62.7 |
| 1983 | 110.9 | 176.0 | 86.4 | 78.7 | 52.5 | 48.0 | 48.6 | 37.1 | 53.1 |
| 1984 | 282.0 | 74.4 | 159.8 | 254.8 | 55.4 | 60.5 | 51.0 | 65 | 86.5 |
| 1985 | 86.1 | 97.0 | 147.0 | 358.6 | 63.1 | 59.7 | 27.2 | 67 | 46.5 |
| 1986 | 174.7 | | 196.0 | 123.9 | 68.0 | 54.0 | 51.5 | 73.2 | 110 |
| 1987 | 48.2 | 160.0 | 49.9 | | 84.4 | 49.8 | 41.6 | 19.2 | 43.5 |
| 1988 | 144.1 | 168.0 | 95.0 | 93.0 | 66.8 | 56.3 | 51.6 | 125.4 | 198.1 |
| 1989 | 105.2 | 105.4 | 168.8 | | 84.7 | 96.8 | 80.0 | 64.5 | 137 |
| 1990 | 194.2 | 100.0 | 129.1 | | 106.9 | 183.0 | 53.1 | 58 | 202.7 |
| 1991 | 105.0 | 150.4 | 83.3 | | 45.8 | 130.0 | 50.0 | 140 | 138.4 |
| 1992 | 107.6 | 105.5 | 102.8 | | 48.8 | 203.2 | 74.6 | 63.3 | 43.2 |
| 1993 | 59.4 | 132.1 | 76.7 | | 37.2 | 252.7 | 100.0 | 119.6 | 63.8 |
| 1994 | 49.0 | 70.5 | 91.8 | | 34.0 | 140.5 | 35.4 | 79.2 | 45 |
| 1995 | 226.0 | | 110.1 | | 126.2 | | 83.5 | 59.3 | 61.2 |
| 1996 | 49.6 | | 116.0 | | 83.5 | | 44.6 | 58.5 | 72.7 |

Source : Regional Water Office, Moshi

# Table A.3.1 List of Gauging Stations

| No. | System | River | Station No. | Catchment Area (km2) |
|---|---|---|---|---|
| 1 | Rau | Rau | IDC 3 | 300 |
| 2 | | Rau | IDC 3A | 300 |
| 3 | | Rau | IDC 5 | 122 |
| 4 | | Njoro | IDC 35 | 24 |
| 5 | | Rau | Mabogini Intake | |
| 6 | | Njoro | Rau Intake | |
| 7 | Mue | Mue | IDC 6 | 250 |
| 8 | | Cholo | IDC 9 | 9 |
| 9 | | Uchira | IDC 10 | 24 |
| 10 | | Soko | IDC 30 | 26 |
| 11 | | Soko | IDC 30A | 26 |
| 12 | | Miwaleni | IDC 33 | 81 |
| 13 | Himo | Himo | IDC 11 | 194 |
| 14 | | Himo | IDC 11A | 272 |
| 15 | Ruvu | Ruvu | IDC 1 | 2,590 |
| 16 | | Ruvu | IDC 2 | 1,810 |
| 17 | | Ruvu | IDC 2A | 1,810 |
| 18 | | Ruvu | IDC 32 | 1,800 |
| 19 | Kikuletwa | Kikuletwa | IDD 1 | 3,840 |
| 20 | | Karanga | IDD 3 | 211 |
| 21 | | Weru Weru | IDD 5A | 141 |
| 22 | | Kikafu | IDD 8 | 198 |
| 23 | | Kikafu | IDD 8A | 198 |
| 24 | | Kikuletwa | IDD 54 | 2,220 |
| 25 | | | | |
| 26 | | | | |




Note : Daily discharge available   Spot discharge available   Water level available

## Table A.3.2 Mean Monthly Discharge at IDDI

(Unit : m3/s)

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1955 | | | | | | | | | | | 9.81 | 11.27 | |
| 1956 | 15.38 | 13.63 | 13.46 | 22.58 | 35.94 | 26.97 | 16.09 | 13.56 | 11.19 | 11.17 | 11.24 | 11.12 | 16.86 |
| 1957 | 13.52 | 14.05 | 10.53 | 30.10 | 91.37 | 34.06 | 22.08 | 16.50 | 12.89 | 11.89 | 21.61 | 29.98 | 25.72 |
| 1958 | 14.78 | 18.93 | 16.82 | 27.27 | 59.84 | 51.60 | 26.37 | 17.95 | 13.40 | 11.61 | 11.80 | 14.56 | 23.74 |
| 1959 | 12.08 | 11.87 | 12.42 | 28.65 | 30.29 | 16.69 | 18.40 | 16.25 | 29.14 | 12.06 | 12.20 | 15.07 | 17.93 |
| 1960 | 14.93 | 12.14 | *** | 47.93 | 77.89 | 36.58 | 25.29 | 19.58 | 16.28 | 21.19 | 10.26 | 10.63 | |
| 1961 | 9.89 | 10.04 | 9.90 | 15.56 | 13.72 | 10.10 | 13.86 | 11.54 | 11.13 | 18.33 | 98.47 | 60.94 | 23.62 |
| 1962 | 51.04 | 23.86 | 16.08 | 25.24 | 61.65 | 24.03 | 20.25 | 16.34 | 12.71 | 9.60 | 10.07 | 14.11 | 23.75 |
| 1963 | 12.87 | 10.84 | 13.25 | 49.65 | 69.88 | 32.53 | 27.17 | 16.33 | 12.84 | 10.78 | 23.60 | 27.89 | 25.64 |
| 1964 | 23.45 | 12.74 | 18.84 | 100.80 | 99.27 | 48.89 | 27.37 | 20.98 | 17.05 | 15.59 | 14.54 | 16.20 | 34.64 |
| 1965 | 19.97 | 13.21 | 12.90 | 42.20 | 35.04 | 19.58 | 13.31 | 12.34 | 10.89 | 12.66 | 19.47 | 14.12 | 18.81 |
| 1966 | 11.93 | 13.35 | 22.79 | 61.79 | 59.53 | 42.52 | 27.28 | 14.57 | 11.13 | 10.40 | 12.34 | 11.45 | 24.92 |
| 1967 | 10.42 | 10.61 | 10.64 | 21.64 | 64.58 | 39.97 | 30.01 | 24.78 | 24.49 | 19.77 | 29.46 | 22.20 | 25.71 |
| 1968 | 10.74 | 14.19 | 31.54 | 79.31 | 80.59 | 73.84 | 38.51 | 28.04 | 18.23 | 13.76 | 26.44 | 50.59 | 38.82 |
| 1969 | 20.10 | 25.59 | 24.00 | 20.61 | 38.34 | 28.88 | 21.41 | 19.74 | 14.13 | 15.07 | 15.19 | 13.09 | 21.35 |
| 1970 | 16.66 | 14.79 | 18.99 | 59.70 | 66.34 | 28.86 | 19.08 | 13.76 | 12.74 | 11.00 | 11.08 | 11.98 | 23.75 |
| 1971 | 8.38 | 9.41 | 9.64 | 44.97 | 79.66 | 45.26 | 32.40 | 27.60 | 17.67 | 13.76 | 13.17 | 17.40 | 26.61 |
| 1972 | 16.61 | 19.52 | 20.60 | 36.50 | 56.02 | 41.75 | 26.78 | 19.30 | 18.92 | 15.48 | 32.18 | 25.80 | 27.46 |
| 1973 | 28.12 | 19.91 | 13.81 | 43.99 | 67.07 | 35.76 | 28.15 | 20.37 | 14.71 | 12.53 | 14.23 | 13.12 | 25.98 |
| 1974 | 13.15 | 12.92 | 12.85 | 66.35 | 42.07 | 31.97 | 33.70 | 24.62 | 15.22 | 14.66 | 15.39 | 14.64 | 24.80 |
| 1975 | 15.59 | 17.21 | 15.06 | 38.41 | 45.28 | 32.22 | 29.71 | 20.39 | 15.47 | 16.41 | 15.73 | 15.72 | 23.10 |
| 1976 | 10.67 | 10.74 | 11.12 | 15.72 | 18.46 | 20.26 | 13.18 | 10.07 | 10.29 | 10.08 | 9.89 | 8.79 | 12.44 |
| 1977 | 9.83 | 10.23 | 10.96 | (35.85) | (18.39) | (16.69) | (11.33) | (23.63) | *** | *** | *** | *** | |
| 1978 | 18.37 | 13.65 | 24.33 | 44.60 | 47.30 | 28.27 | 26.06 | 17.25 | 12.19 | 10.28 | 13.58 | 27.69 | 23.63 |
| 1979 | 15.90 | 22.06 | 23.74 | 61.14 | 90.51 | 85.93 | 34.98 | 22.73 | 15.91 | 13.31 | 14.51 | 11.66 | 34.37 |
| 1980 | 10.67 | 10.67 | 13.02 | 22.89 | 103.26 | 30.82 | 17.75 | 15.27 | 12.44 | 11.47 | 14.42 | 16.20 | 23.24 |
| 1981 | 12.52 | 11.17 | 16.51 | 31.57 | 50.56 | 31.47 | 18.25 | 13.77 | 12.27 | 13.74 | 12.48 | 13.93 | 19.85 |
| 1982 | 10.81 | 10.44 | 11.18 | 28.28 | 47.97 | 27.45 | 24.20 | 18.74 | 14.64 | 27.33 | 26.51 | 32.10 | 23.30 |
| 1983 | 14.99 | 13.38 | 13.23 | 19.06 | 47.33 | 35.61 | 21.31 | 15.77 | 13.11 | 12.33 | 12.70 | *** | |
| 1984 | 12.87 | 11.98 | 11.94 | 34.58 | 45.22 | 27.95 | 26.34 | 19.25 | 14.92 | 13.51 | 22.13 | 20.88 | 21.80 |
| 1985 | 14.04 | 17.07 | 15.84 | 48.94 | 46.74 | 26.59 | 19.64 | 15.07 | 13.08 | 13.75 | 16.74 | 17.78 | 22.11 |
| 1986 | 18.99 | 13.71 | 14.11 | 40.23 | 59.72 | (45.54) | 21.94 | 14.57 | 13.83 | 12.83 | 13.78 | 22.84 | 24.34 |
| 1987 | 15.60 | 12.80 | 18.84 | 22.03 | 46.62 | 23.75 | 14.21 | 15.33 | 13.49 | 12.88 | 12.55 | 12.29 | 18.37 |
| 1988 | 12.28 | 12.18 | 16.37 | 55.94 | 41.83 | 28.10 | 20.01 | 14.66 | 14.99 | 14.10 | 15.49 | 15.27 | 21.77 |
| 1989 | 16.49 | 15.59 | 13.76 | 44.60 | 75.02 | 41.76 | 25.32 | 18.39 | 15.97 | 13.60 | 16.40 | 20.07 | 26.41 |
| 1990 | 18.61 | 14.25 | 35.15 | 68.01 | 90.18 | 41.50 | 21.17 | 16.30 | 14.10 | 13.68 | 20.94 | 17.02 | 30.91 |
| 1991 | 13.47 | 13.23 | 15.75 | 21.46 | 55.24 | 28.72 | 16.44 | 14.36 | 14.80 | 14.04 | 15.15 | 19.89 | 20.21 |
| 1992 | 13.52 | 13.48 | 12.26 | 41.93 | 51.85 | 34.39 | 20.41 | 16.63 | 13.97 | 12.66 | 13.78 | 13.98 | 21.57 |
| 1993 | 24.17 | 22.14 | 14.81 | 16.92 | 21.06 | 15.01 | 15.32 | 13.39 | 11.60 | 12.12 | 12.17 | 12.22 | 15.91 |
| 1994 | 12.10 | 12.41 | 18.42 | 21.58 | 49.24 | 21.76 | 15.90 | 13.21 | 12.73 | 13.29 | 14.05 | 22.15 | 18.90 |
| 1995 | 13.75 | 12.37 | 14.12 | 46.34 | 60.70 | 40.25 | 20.00 | 14.78 | 13.56 | 13.40 | 12.84 | 13.08 | 22.93 |
| 1996 | 12.62 | 13.31 | 14.56 | 66.76 | 69.89 | 38.90 | 23.43 | 16.64 | 14.54 | 12.49 | 13.59 | 12.38 | 25.76 |
| 1997 | 11.36 | 11.92 | 14.13 | | | | | | | | | | |
| Average | 15.55 | 14.23 | 16.06 | 40.28 | 56.38 | 33.97 | 22.55 | 17.42 | 14.57 | 13.72 | 17.85 | 18.80 | 23.45 |

Source : Regional Water Office, Kilimanjaro

Data from 1955 to 1975 : Daily discharge records are collected from the Regional Water Office.
Data from 1976 to date : Daily water level records are collected from the Regional Water Office
they are converted to the discharge record by use of the rating curve prepared by the Regional Water O

Remarks : Value in parenthesis is supplemented by correlation

## Table A.3.3 Mean Monthly Discharge at IDD54

(Unit : m3/s)

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1967 | *** | 10.41 | 10.43 | 10.97 | 13.79 | 12.20 | 10.66 | 10.65 | 10.80 | 10.65 | 11.94 | 12.35 | 11.35 |
| 1968 | 11.43 | 11.75 | 13.84 | 24.30 | 24.33 | 25.53 | 14.82 | 12.61 | 11.25 | 11.43 | 14.43 | 17.54 | 16.11 |
| 1969 | 12.15 | 13.42 | 13.21 | 12.57 | 13.90 | 12.37 | 12.28 | 11.91 | 11.91 | 11.33 | 12.23 | 12.11 | 12.45 |
| 1970 | 12.58 | 12.51 | 12.96 | 19.63 | 19.31 | 12.66 | 11.53 | 11.29 | 10.60 | 11.44 | 10.56 | 11.20 | 13.02 |
| 1971 | *** | *** | 11.48 | 20.59 | 26.65 | 10.92 | 10.35 | 9.96 | 10.22 | 9.95 | 9.90 | 9.37 | 12.94 |
| 1972 | 10.60 | 10.10 | 13.21 | 15.98 | 18.94 | 14.86 | 11.91 | 11.13 | 12.17 | 12.44 | 13.16 | 12.26 | 13.06 |
| 1973 | 12.41 | 12.37 | 11.64 | 14.38 | 18.70 | 12.20 | 12.39 | 11.80 | 11.54 | 11.36 | 11.34 | 11.45 | 12.63 |
| 1974 | 12.17 | 13.01 | 11.44 | 35.66 | 15.50 | 11.79 | 11.63 | 11.25 | 11.44 | 11.56 | 11.14 | 11.38 | 14.00 |
| 1975 | 11.15 | 11.25 | 11.05 | 12.47 | 14.07 | 12.90 | 11.43 | 11.28 | 11.44 | 11.33 | *** | 11.36 | 11.79 |
| 1976 | 10.32 | 10.71 | 10.79 | 11.47 | 11.17 | 10.31 | 10.64 | 10.51 | 10.62 | 10.36 | 10.57 | 10.47 | 10.66 |
| 1977 | 10.60 | (10.32) | 11.60 | 25.38 | 15.52 | 12.58 | 11.05 | 12.50 | *** | *** | *** | *** | |
| 1978 | 13.62 | 14.47 | 17.01 | 29.00 | 33.07 | 23.70 | 16.44 | (11.91) | (10.99) | (11.28) | (11.87) | 20.16 | 17.79 |
| 1979 | 14.44 | 16.40 | 19.04 | 42.33 | (41.48) | (53.12) | (22.47) | (12.42) | (12.42) | (11.46) | 13.67 | 11.31 | 22.55 |
| 1980 | 10.80 | 11.17 | 12.03 | 11.91 | 38.94 | 31.49 | 16.41 | 11.52 | (11.09) | (11.35) | (12.43) | (12.83) | 16.00 |
| 1981 | 10.97 | 11.66 | 11.64 | 15.48 | 23.03 | 13.89 | 11.01 | 11.01 | (11.02) | 11.07 | 10.79 | 10.89 | 12.71 |
| 1982 | 10.26 | 10.42 | 10.87 | 17.58 | 19.40 | 14.36 | 11.64 | 11.18 | 10.75 | 12.14 | 18.11 | 22.41 | 14.09 |
| 1983 | 11.73 | 10.85 | 10.63 | 11.06 | 21.53 | 18.48 | 10.79 | 10.68 | 10.77 | 11.24 | 10.71 | *** | |
| 1984 | (11.35) | (11.13) | (10.86) | (24.35) | (25.18) | (19.17) | (18.30) | (12.09) | (12.04) | (11.47) | (17.54) | (14.91) | 15.70 |
| 1985 | 11.55 | 12.27 | (12.98) | (35.96) | 35.72 | 28.66 | 21.17 | 13.50 | 11.94 | 11.73 | 13.53 | 19.77 | 19.07 |
| 1986 | (15.13) | 11.94 | (12.04) | (28.92) | 57.66 | 29.47 | 15.96 | 12.16 | (11.62) | 10.97 | 12.49 | 11.99 | 19.20 |
| 1987 | 12.69 | 11.64 | 14.57 | 17.96 | 18.93 | 14.24 | 12.58 | 12.05 | 12.39 | 12.48 | 11.46 | 11.67 | 13.56 |
| 1988 | 12.45 | (11.22) | (13.27) | 25.32 | 16.96 | 14.23 | 13.71 | 11.63 | 10.47 | 10.65 | 13.44 | 13.30 | 13.89 |
| 1989 | 13.23 | 12.30 | 12.79 | 39.63 | 42.99 | 33.35 | 25.26 | (12.01) | (12.44) | (11.48) | 12.70 | 11.86 | 20.00 |
| 1990 | 12.78 | 13.72 | (23.50) | 51.63 | 33.34 | 25.87 | 19.19 | (11.82) | 13.88 | 12.48 | 22.12 | (13.19) | 21.13 |
| 1991 | (11.72) | (11.71) | (12.93) | (13.75) | (28.78) | 23.59 | 17.84 | 12.19 | (11.99) | (11.51) | 11.49 | 12.29 | 14.98 |
| 1992 | 11.26 | 11.09 | 10.70 | 45.29 | 31.46 | 26.63 | 15.82 | 11.31 | 10.94 | 10.94 | 11.55 | (11.84) | 17.40 |
| 1993 | 20.85 | 15.87 | 12.65 | 10.92 | 11.68 | 10.81 | 10.21 | 10.64 | 9.60 | 11.19 | (10.94) | (11.06) | 12.20 |
| 1994 | 10.14 | 10.71 | (14.39) | (13.84) | (26.62) | 15.89 | 12.74 | 11.55 | 10.72 | 11.39 | 10.71 | 11.65 | 13.36 |
| 1995 | 11.02 | 11.65 | 11.75 | 27.50 | 34.52 | 20.56 | 15.96 | 13.42 | 11.93 | 12.26 | 11.45 | 10.90 | 16.08 |
| 1996 | 10.16 | 9.98 | 10.62 | 62.51 | 28.21 | 22.97 | 14.24 | (11.85) | 13.18 | 12.08 | 11.17 | 11.22 | 18.18 |
| 1997 | 11.49 | 9.88 | (12.05) | | | | | | | | | | |
| Average | 12.11 | 11.86 | 12.84 | 24.28 | 25.38 | 19.63 | 14.35 | 11.66 | 11.45 | 11.41 | 12.62 | 12.96 | 15.05 |

Source : Regional Water Office, Kilimanjaro

Data from 1967 to 1975 : Daily discharge records are collected from the Regional Water Office.
Data from 1976 to date : Daily water level records are collected from the Regional Water Office
they are converted to the discharge records by use of the rating curve prepared by the JICA Study Team.

Remarks : Value in parenthesis is supplemented by correlation

# Table A.3.4 Monthly Discharge of Rau River System (1/2)

(Unit : m3/s)

| Year | Month | Mabogini Intake Weir | | | Inflow | | | Rau Ya Kati Intake Weir | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flow | Intake | Overflow | Njoro R | Rau R | Total | Intake | Overflow |
| | | Q2 | Q3 | Q4 | Q4 | Q7 | Q8 | Q9 | Q10 |
| 1987 | Feb | 1.136 | 0.593 | 0.543 | 0.543 | 0.094 | 0.637 | 0.637 | 0.000 |
| 1987 | Mar | 1.124 | 0.858 | 0.266 | 0.266 | 0.496 | 0.762 | 0.590 | 0.172 |
| 1987 | Apr | 1.141 | 0.857 | 0.284 | 0.284 | 0.654 | 0.938 | 0.631 | 0.307 |
| 1987 | May | 1.523 | 0.676 | 0.847 | 0.847 | 1.723 | 2.570 | 0.502 | 2.068 |
| 1987 | Jun | 1.159 | 0.315 | 0.844 | 0.844 | 1.082 | 1.926 | 0.790 | 1.136 |
| 1987 | Jul | 1.058 | 0.277 | 0.781 | 0.781 | 0.424 | 1.205 | 0.934 | 0.271 |
| 1987 | Aug | 1.145 | 0.381 | 0.764 | 0.764 | 0.489 | 1.253 | 1.033 | 0.220 |
| 1987 | Sep | 1.077 | 0.394 | 0.683 | 0.683 | 0.322 | 1.005 | 0.998 | 0.007 |
| 1987 | Oct | 0.981 | 0.387 | 0.594 | 0.594 | 0.266 | 0.860 | 0.860 | 0.000 |
| 1987 | Nov | 1.014 | 0.346 | 0.668 | 0.668 | 0.210 | 0.878 | 0.798 | 0.080 |
| 1987 | Dec | 1.000 | 0.172 | 0.828 | 0.828 | 0.509 | 1.337 | 0.313 | 1.024 |
| 1988 | Jan | 0.951 | 0.228 | 0.723 | 0.723 | 0.244 | 0.967 | 0.225 | 0.742 |
| 1988 | Feb | 0.778 | 0.557 | 0.221 | 0.221 | 0.264 | 0.485 | 0.479 | 0.006 |
| 1988 | Mar | 0.945 | 0.485 | 0.460 | 0.460 | 0.507 | 0.967 | 0.542 | 0.425 |
| 1988 | Apr | 2.069 | 0.450 | 1.619 | 1.619 | 7.835 | 9.454 | 0.495 | 8.959 |
| 1988 | May | 1.275 | 0.641 | 0.634 | 0.634 | 4.900 | 5.534 | 0.667 | 4.867 |
| 1988 | Jun | 1.248 | 0.593 | 0.655 | 0.655 | 2.823 | 3.478 | 1.236 | 2.242 |
| 1988 | Jul | 1.341 | 0.541 | 0.800 | 0.800 | 1.801 | 2.601 | 1.147 | 1.454 |
| 1988 | Aug | 1.379 | 0.539 | 0.840 | 0.840 | 0.823 | 1.663 | 1.093 | 0.570 |
| 1988 | Sep | 1.339 | 0.579 | 0.760 | 0.760 | 0.626 | 1.386 | 1.110 | 0.276 |
| 1988 | Oct | 1.296 | 0.581 | 0.715 | 0.715 | 0.397 | 1.112 | 1.076 | 0.036 |
| 1988 | Nov | 1.292 | 0.564 | 0.728 | 0.728 | 0.419 | 1.147 | 1.047 | 0.100 |
| 1988 | Dec | 1.140 | 0.584 | 0.556 | 0.556 | 0.516 | 1.072 | 0.945 | 0.127 |
| 1989 | Jan | 1.283 | 0.590 | 0.693 | 0.693 | 0.441 | 1.134 | 0.875 | 0.259 |
| 1989 | Feb | 1.106 | 0.677 | 0.429 | 0.429 | 0.363 | 0.792 | 0.784 | 0.008 |
| 1989 | Mar | 0.927 | 0.569 | 0.358 | 0.358 | 0.345 | 0.703 | 0.703 | 0.000 |
| 1989 | Apr | 1.247 | 0.564 | 0.683 | 0.683 | 3.465 | 4.148 | 0.757 | 3.391 |
| 1989 | May | 1.277 | 0.632 | 0.645 | 0.645 | 6.715 | 7.360 | 0.844 | 6.516 |
| 1989 | Jun | 1.113 | 0.987 | 0.126 | 0.126 | 4.732 | 4.858 | 1.336 | 3.522 |
| 1989 | Jul | 1.254 | 0.891 | 0.363 | 0.363 | 3.519 | 3.882 | 1.110 | 2.772 |
| 1989 | Aug | 1.619 | 0.740 | 0.879 | 0.879 | 2.438 | 3.317 | 0.962 | 2.355 |
| 1989 | Sep | 1.800 | 1.006 | 0.794 | 0.794 | 3.124 | 3.918 | 0.985 | 2.933 |
| 1989 | Oct | 1.724 | 0.944 | 0.780 | 0.780 | 0.739 | 1.519 | 1.178 | 0.341 |
| 1989 | Nov | 1.684 | 0.861 | 0.823 | 0.823 | 0.656 | 1.479 | 1.018 | 0.461 |
| 1989 | Dec | 1.701 | 0.735 | 0.966 | 0.966 | 0.405 | 1.371 | 0.842 | 0.529 |
| 1990 | Jan | 1.567 | 0.813 | 0.754 | 0.754 | 0.669 | 1.423 | 0.894 | 0.529 |
| 1990 | Feb | 1.376 | 0.815 | 0.561 | 0.561 | 0.650 | 1.211 | 0.971 | 0.240 |
| 1990 | Mar | 1.674 | 0.751 | 0.923 | 0.923 | 1.874 | 2.797 | 0.772 | 2.025 |
| 1990 | Apr | 1.811 | 0.698 | 1.113 | 1.113 | 10.686 | 11.799 | 0.566 | 11.233 |
| 1990 | May | 1.888 | 0.638 | 1.250 | 1.250 | 10.064 | 11.314 | 0.756 | 10.558 |
| 1990 | Jun | 1.946 | 0.818 | 1.128 | 1.128 | 4.288 | 5.416 | 0.980 | 4.436 |
| 1990 | Jul | 2.240 | 0.790 | 1.450 | 1.450 | 1.820 | 3.270 | 0.970 | 2.300 |
| 1990 | Aug | 2.350 | 0.848 | 1.502 | 1.502 | 1.315 | 2.817 | 0.998 | 1.819 |
| 1990 | Sep | 2.198 | 1.082 | 1.116 | 1.116 | 0.662 | 1.778 | 1.256 | 0.522 |
| 1990 | Oct | 1.999 | 1.161 | 0.838 | 0.838 | 0.566 | 1.404 | 1.340 | 0.064 |
| 1990 | Nov | 1.931 | 0.936 | 0.995 | 0.995 | 0.879 | 1.874 | 1.149 | 0.725 |
| 1990 | Dec | 1.723 | 0.759 | 0.964 | 0.964 | 0.658 | 1.622 | 0.901 | 0.721 |
| 1991 | Jan | 1.470 | 0.737 | 0.733 | 0.733 | 1.654 | 2.387 | 1.070 | 1.317 |
| 1991 | Feb | 1.515 | 0.202 | 1.313 | 1.313 | 0.424 | 1.737 | 1.353 | 0.384 |
| 1991 | Mar | 1.405 | 0.031 | 1.374 | 1.374 | 0.111 | 1.485 | 1.254 | 0.231 |
| 1991 | Apr | 1.452 | 0.089 | 1.363 | 1.363 | 0.827 | 2.190 | 1.161 | 1.029 |
| 1991 | May | 1.770 | 0.207 | 1.563 | 1.563 | 3.373 | 4.936 | 0.760 | 4.176 |
| 1991 | Jun | 1.510 | 1.003 | 0.507 | 0.507 | 1.800 | 2.307 | 0.430 | 1.877 |
| 1991 | Jul | 0.282 | 0.272 | 0.010 | 0.010 | 1.048 | 1.058 | 0.000 | 1.058 |
| 1991 | Aug | 1.285 | 1.277 | 0.008 | 0.008 | 0.941 | 0.949 | 0.000 | 0.949 |
| 1991 | Sep | 1.242 | 1.219 | 0.023 | 0.023 | 0.604 | 0.627 | 0.257 | 0.370 |
| 1991 | Oct | 0.970 | 0.970 | 0.000 | 0.000 | 0.495 | 0.495 | 0.495 | 0.000 |
| 1991 | Nov | 0.432 | 0.432 | 0.000 | 0.000 | 0.928 | 0.928 | 0.928 | 0.000 |
| 1991 | Dec | 0.286 | 0.286 | 0.000 | 0.000 | 1.116 | 1.116 | 1.116 | 0.000 |
| 1992 | Jan | 0.977 | 0.370 | 0.607 | 0.607 | 0.403 | 1.010 | 1.010 | 0.000 |
| 1992 | Feb | 0.960 | 0.380 | 0.580 | 0.580 | 0.260 | 0.840 | 0.840 | 0.000 |
| 1992 | Mar | 0.896 | 0.442 | 0.454 | 0.454 | 0.143 | 0.597 | 0.507 | 0.090 |
| 1992 | Apr | 0.995 | 0.240 | 0.755 | 0.755 | 5.115 | 5.870 | 0.410 | 5.460 |
| 1992 | May | 1.578 | 0.220 | 1.358 | 1.358 | 4.502 | 5.860 | 0.440 | 5.420 |
| 1992 | Jun | 1.410 | 0.600 | 0.810 | 0.810 | 2.890 | 3.700 | 1.140 | 2.560 |
| 1992 | Jul | 1.430 | 0.750 | 0.680 | 0.680 | 2.320 | 3.000 | 1.250 | 1.750 |
| 1992 | Aug | 1.470 | 0.750 | 0.720 | 0.720 | 1.300 | 2.020 | 1.070 | 0.950 |
| 1992 | Sep | 1.467 | 0.913 | 0.554 | 0.554 | 1.574 | 2.128 | 1.049 | 1.079 |
| 1992 | Oct | 1.430 | 0.750 | 0.680 | 0.680 | 0.280 | 0.960 | 0.960 | 0.000 |
| 1992 | Nov | 1.540 | 0.800 | 0.740 | 0.740 | 0.580 | 1.320 | 1.010 | 0.310 |
| 1992 | Dec | 1.413 | 0.803 | 0.610 | 0.610 | 0.480 | 1.090 | 1.020 | 0.070 |

Source : KADP

# Table A.3.4 Monthly Discharge of Rau River System (2/2)

(Unit : m3/s)

| Year | Month | Mabogini Intake Weir | | | Inflow | | | Rau Ya Kati Intake Weir | |
|---|---|---|---|---|---|---|---|---|---|
| | | Flow | Intake | Overflow | Njoro R | Rau R | Total | Intake | Overflow |
| | | Q2 | Q3 | Q4 | Q4 | Q7 | Q8 | Q9 | Q10 |
| 1993 | Jan | 1.400 | 0.840 | 0.560 | 0.560 | 1.241 | 1.801 | 1.101 | 0.700 |
| 1993 | Feb | 1.320 | 0.960 | 0.360 | 0.360 | 1.470 | 1.830 | 1.170 | 0.660 |
| 1993 | Mar | 1.200 | 0.910 | 0.290 | 0.290 | 0.943 | 1.233 | 1.041 | 0.192 |
| 1993 | Apr | 1.140 | 0.680 | 0.460 | 0.460 | 0.782 | 1.242 | 0.922 | 0.320 |
| 1993 | May | 1.219 | 0.640 | 0.579 | 0.579 | 1.551 | 2.130 | 1.060 | 1.070 |
| 1993 | Jun | 1.235 | 0.835 | 0.400 | 0.400 | 2.202 | 2.602 | 0.969 | 1.633 |
| 1993 | Jul | 1.120 | 0.829 | 0.291 | 0.291 | 1.350 | 1.641 | 1.263 | 0.378 |
| 1993 | Aug | | | | | | | | |
| 1993 | Sep | | | | | | | | |
| 1993 | Oct | | | | | | | | |
| 1993 | Nov | | | | | | | | |
| 1993 | Dec | | | | | | | | |
| 1994 | Jan | 1.025 | 0.565 | 0.460 | 0.460 | 0.064 | 0.524 | 0.524 | 0.000 |
| 1994 | Feb | 1.007 | 0.570 | 0.437 | 0.437 | 0.104 | 0.541 | 0.527 | 0.014 |
| 1994 | Mar | 1.321 | 0.580 | 0.741 | 0.741 | 0.262 | 1.003 | 0.739 | 0.264 |
| 1994 | Apr | 1.276 | 0.565 | 0.711 | 0.711 | 0.323 | 1.034 | 0.641 | 0.393 |
| 1994 | May | 1.724 | 0.512 | 1.212 | 1.212 | 2.213 | 3.425 | 0.658 | 2.767 |
| 1994 | Jun | 1.382 | 0.612 | 0.770 | 0.770 | 1.050 | 1.820 | 0.895 | 0.925 |
| 1994 | Jul | 1.065 | 0.670 | 0.395 | 0.395 | 0.554 | 0.949 | 0.915 | 0.034 |
| 1994 | Aug | 1.146 | 0.656 | 0.490 | 0.490 | 0.063 | 0.553 | 0.553 | 0.000 |
| 1994 | Sep | 1.160 | 0.632 | 0.528 | 0.528 | 0.193 | 0.721 | 0.721 | 0.000 |
| 1994 | Oct | 1.155 | 0.767 | 0.388 | 0.388 | 0.027 | 0.415 | 0.415 | 0.000 |
| 1994 | Nov | 1.105 | 0.612 | 0.493 | 0.493 | 0.030 | 0.523 | 0.523 | 0.000 |
| 1994 | Dec | 1.050 | 0.524 | 0.526 | 0.526 | 0.039 | 0.565 | 0.565 | 0.000 |
| 1995 | Jan | 0.855 | 0.419 | 0.436 | 0.436 | 0.028 | 0.464 | 0.464 | 0.000 |
| 1995 | Feb | 0.809 | 0.409 | 0.400 | 0.400 | 0.040 | 0.440 | 0.440 | 0.000 |
| 1995 | Mar | 0.899 | 0.368 | 0.531 | 0.531 | 0.100 | 0.631 | 0.468 | 0.163 |
| 1995 | Apr | | | | | | | | |
| 1995 | May | | | | | | | | |
| 1995 | Jun | | | | | | | | |
| 1995 | Jul | | | | | | | | |
| 1995 | Aug | | | | | | | | |
| 1995 | Sep | | | | | | | | |
| 1995 | Oct | | | | | | | | |
| 1995 | Nov | | | | | | | | |
| 1995 | Dec | | | | | | | | |
| 1996 | Jan | | | | | | | | |
| 1996 | Feb | | | | | | | | |
| 1996 | Mar | | | | | | | | |
| 1996 | Apr | | | | | | | | |
| 1996 | May | | | | | | | | |
| 1996 | Jun | | | | | | | | |
| 1996 | Jul | | | | | | | | |
| 1996 | Aug | | | | | | | | |
| 1996 | Sep | | | | | | | | |
| 1996 | Oct | | | | | | | | |
| 1996 | Nov | | | | | | | | |
| 1996 | Dec | | | | | | | | |
| 1997 | Jan | | | | | | | | |
| 1997 | Feb | | | | | | | | |
| 1997 | Mar | | | | | | | | |
| 1997 | Apr | | | | | | | | |
| 1997 | May | | | | | | | | |
| 1997 | Jun | | | | | | | | |
| 1997 | Jul | 1.623 | 0.629 | 0.994 | 0.994 | 1.696 | 2.690 | 1.132 | 1.558 |
| 1997 | Aug | 1.548 | 0.732 | 0.816 | 0.816 | 0.664 | 1.480 | 1.021 | 0.459 |
| 1997 | Sep | 1.572 | 0.748 | 0.824 | 0.824 | 0.162 | 0.986 | 0.986 | 0.000 |
| 1997 | Oct | 1.717 | 0.696 | 1.021 | 1.021 | 0.592 | 1.613 | 0.952 | 0.661 |
| 1997 | Nov | 1.800 | 0.670 | 1.130 | 1.130 | 1.254 | 2.384 | 0.690 | 1.694 |
| 1997 | Dec | 1.971 | 0.680 | 1.291 | 1.291 | 2.525 | 3.816 | 0.662 | 3.154 |

Source : KADP

Remarks: Only monthly summary records are available in 1994 and a995.

### Table A.3.5 Mean Monthly Discharge at 1DC35

(Unit : m3/s)

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1965 | 1.43 | 1.28 | 1.21 | 1.43 | 1.21 | 1.18 | 1.17 | 1.17 | 1.17 | 1.11 | 1.09 | 1.06 |
| 1966 | 1.01 | 0.96 | 0.98 | 1.03 | 0.98 | 1.02 | 1.15 | 1.25 | 1.28 | 1.20 | 1.09 | 1.03 |
| 1967 | 0.90 | 0.74 | 0.67 | 0.77 | 0.92 | 0.91 | 1.02 | 1.19 | 1.36 | 1.53 | 1.50 | 1.43 |
| 1968 | 1.33 | 1.22 | 1.24 | 1.39 | 1.36 | 1.65 | 1.83 | 1.94 | 1.85 | 1.74 | 1.68 | 1.80 |
| 1969 | 1.53 | 1.43 | 1.37 | 1.25 | 1.36 | 1.22 | 1.18 | 1.19 | 1.14 | 1.16 | 1.11 | 1.04 |
| 1970 | 0.99 | 0.97 | 1.05 | 1.15 | 1.08 | 1.26 | 1.36 | 1.37 | 1.24 | 1.13 | 0.93 | 0.81 |
| 1971 | 0.25 | 0.56 | 0.66 | 1.30 | 1.13 | 1.35 | 1.73 | 1.73 | 1.57 | 1.50 | 0.95 | 1.57 |
| 1972 | 1.21 | 1.88 | 1.21 | 1.21 | 2.42 | 1.46 | 1.52 | 1.47 | 1.35 | 1.11 | 1.15 | 1.03 |
| 1973 | 0.99 | 0.98 | 0.99 | 0.96 | 1.16 | 1.00 | 1.94 | 0.95 | 0.92 | 0.60 | 0.79 | 0.87 |
| 1974 | 0.79 | 0.77 | 0.63 | 0.89 | 0.89 | 0.87 | 0.89 | 0.89 | 0.92 | 0.92 | 0.90 | 0.88 |
| 1975 | 0.80 | 0.73 | 0.74 | 1.03 | 0.96 | 0.87 | 0.76 | 0.80 | 0.88 | 0.89 | 0.78 | 0.76 |
| 1976 | 0.48 | 0.47 | 0.44 | 0.59 | 0.58 | 0.48 | 0.48 | 0.45 | 0.49 | 0.49 | 0.46 | 0.45 |
| 1977 | 0.47 | 0.49 | 0.50 | 0.73 | 0.70 | 0.66 | 0.56 | 0.60 | *** | *** | *** | *** |
| 1978 | 0.66 | 0.66 | 0.71 | 0.71 | 0.67 | 0.73 | 0.80 | 0.81 | 0.87 | 0.94 | 0.88 | 0.93 |
| 1979 | 0.88 | 0.74 | 0.83 | 1.07 | 1.05 | 1.89 | 1.96 | 1.70 | 1.78 | 1.70 | 1.36 | 1.21 |
| 1980 | 1.29 | 1.16 | *** | *** | 1.36 | 1.43 | 1.72 | *** | *** | 1.36 | 1.27 | *** |
| 1981 | 1.02 | *** | 0.94 | *** | *** | *** | 0.99 | 0.86 | *** | 0.83 | 0.80 | 0.74 |
| 1982 | 0.67 | 0.63 | 0.57 | 0.52 | 0.83 | 0.82 | 0.81 | 0.78 | 0.70 | 0.81 | 0.81 | *** |
| 1983 | *** | *** | *** | *** | 0.67 | *** | 0.50 | 0.55 | 0.52 | 0.51 | 0.47 | 0.50 |
| 1984 | 0.48 | 0.48 | 0.52 | 0.55 | 0.96 | 1.18 | 1.20 | 0.66 | 0.56 | 0.56 | 0.58 | 0.57 |
| 1985 | 0.52 | 0.46 | 0.48 | 0.66 | 0.61 | *** | *** | *** | *** | *** | *** | *** |
| 1986 | *** | *** | *** | *** | *** | 0.71 | 0.71 | 0.71 | 0.68 | 0.62 | 0.65 | 0.65 |
| 1987 | 0.64 | 0.61 | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** |
| 1988 | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** |
| 1989 | *** | *** | *** | *** | *** | *** | 0.50 | 0.53 | *** | *** | *** | *** |
| Average | 0.87 | 0.86 | 0.83 | 0.96 | 1.04 | 1.09 | 1.13 | 1.03 | 1.07 | 1.04 | 0.96 | 0.96 |

Source : Regional Water Office, Kilimanjaro

## Table A.3.6 Estimated Mean Monthly Discharge at IDC35

(Unit : m3/s)

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1967 | 0.90 | 0.74 | 0.67 | 0.77 | 0.92 | 0.91 | 1.02 | 1.19 | 1.36 | 1.53 | 1.50 | 1.43 |
| 1968 | 1.33 | 1.22 | 1.24 | 1.39 | 1.36 | 1.65 | 1.83 | 1.94 | 1.85 | 1.74 | 1.68 | 1.80 |
| 1969 | 1.53 | 1.43 | 1.37 | 1.25 | 1.36 | 1.22 | 1.18 | 1.19 | 1.14 | 1.16 | 1.11 | 1.04 |
| 1970 | 0.99 | 0.97 | 1.05 | 1.15 | 1.08 | 1.26 | 1.36 | 1.37 | 1.24 | 1.13 | 0.93 | 0.81 |
| 1971 | 0.25 | 0.56 | 0.66 | 1.30 | 1.13 | 1.35 | 1.73 | 1.73 | 1.57 | 1.50 | 0.95 | 1.57 |
| 1972 | 1.21 | 1.88 | 1.21 | 1.21 | 2.42 | 1.46 | 1.52 | 1.47 | 1.35 | 1.11 | 1.15 | 1.03 |
| 1973 | 0.99 | 0.98 | 0.99 | 0.96 | 1.16 | 1.00 | 1.94 | 0.95 | 0.92 | 0.60 | 0.79 | 0.87 |
| 1974 | 0.79 | 0.77 | 0.63 | 0.89 | 0.89 | 0.87 | 0.89 | 0.89 | 0.92 | 0.92 | 0.90 | 0.88 |
| 1975 | 0.80 | 0.73 | 0.74 | 1.03 | 0.96 | 0.87 | 0.76 | 0.80 | 0.88 | 0.89 | 0.78 | 0.76 |
| 1976 | 0.48 | 0.47 | 0.44 | 0.59 | 0.58 | 0.48 | 0.48 | 0.45 | 0.49 | 0.49 | 0.46 | 0.45 |
| 1977 | 0.47 | 0.49 | 0.50 | 0.73 | 0.70 | 0.66 | 0.56 | 0.60 | 1.16 | 1.07 | 1.04 | 0.90 |
| 1978 | 0.66 | 0.66 | 0.71 | 0.71 | 0.67 | 0.73 | 0.80 | 0.81 | 0.87 | 0.94 | 0.88 | 0.93 |
| 1979 | 0.88 | 0.74 | 0.83 | 1.07 | 1.05 | 1.89 | 1.96 | 1.70 | 1.78 | 1.70 | 1.36 | 1.21 |
| 1980 | 1.29 | 1.16 | 1.19 | 1.36 | 1.36 | 1.43 | 1.72 | 1.49 | 1.44 | 1.36 | 1.27 | 1.28 |
| 1981 | 1.02 | 0.75 | 0.94 | 0.87 | 0.87 | 0.91 | 0.99 | 0.86 | 0.93 | 0.83 | 0.80 | 0.74 |
| 1982 | 0.67 | 0.63 | 0.57 | 0.52 | 0.83 | 0.82 | 0.81 | 0.78 | 0.70 | 0.81 | 0.81 | 1.14 |
| 1983 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.59 | 0.50 | 0.55 | 0.52 | 0.51 | 0.47 | 0.50 |
| 1984 | 0.48 | 0.48 | 0.52 | 0.55 | 0.96 | 1.18 | 1.20 | 0.66 | 0.56 | 0.56 | 0.58 | 0.57 |
| 1985 | 0.52 | 0.46 | 0.48 | 0.66 | 0.61 | 1.18 | 1.20 | 0.66 | 0.56 | 0.56 | 0.58 | 0.57 |
| 1986 | 0.52 | 0.46 | 0.48 | 0.66 | 0.61 | 0.71 | 0.71 | 0.71 | 0.68 | 0.62 | 0.65 | 0.65 |
| 1987 | 0.84 | 0.68 | 0.67 | 0.69 | 1.07 | 0.71 | 0.61 | 0.69 | 0.62 | 0.53 | 0.56 | 0.55 |
| 1988 | 0.50 | 0.33 | 0.49 | 1.50 | 0.82 | 0.80 | 0.89 | 0.93 | 0.89 | 0.84 | 0.84 | 0.69 |
| 1989 | 0.83 | 0.65 | 0.48 | 0.80 | 0.83 | 0.66 | 0.80 | 1.17 | 1.35 | 1.27 | 1.23 | 1.25 |
| 1990 | 1.11 | 0.92 | 1.22 | 1.36 | 1.44 | 1.49 | 1.50 | 1.50 | 1.50 | 1.50 | 1.48 | 1.27 |
| 1991 | 1.02 | 1.06 | 0.95 | 1.00 | 1.32 | 1.06 | 0.83 | 0.83 | 0.79 | 0.52 | 0.25 | 0.93 |
| 1992 | 0.53 | 0.51 | 0.44 | 0.54 | 1.13 | 0.96 | 0.98 | 1.02 | 1.02 | 0.98 | 1.09 | 0.96 |
| Average | 0.82 | 0.78 | 0.77 | 0.93 | 1.03 | 1.03 | 1.11 | 1.04 | 1.04 | 0.99 | 0.93 | 0.95 |

**Table A.3.7 Estimated Mean Monthly Discharge at Mabogini Intake Weir Site**

(Unit : m3/s)

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1967 | 1.34 | 1.19 | 1.12 | 1.22 | 1.36 | 1.35 | 1.46 | 1.64 | 1.81 | 1.97 | 1.94 | 1.88 |
| 1968 | 1.78 | 1.67 | 1.69 | 1.84 | 1.81 | 2.10 | 2.28 | 2.38 | 2.30 | 2.19 | 2.13 | 2.25 |
| 1969 | 1.97 | 1.88 | 1.82 | 1.70 | 1.81 | 1.67 | 1.63 | 1.64 | 1.59 | 1.61 | 1.55 | 1.48 |
| 1970 | 1.43 | 1.41 | 1.49 | 1.60 | 1.52 | 1.71 | 1.81 | 1.82 | 1.69 | 1.58 | 1.37 | 1.26 |
| 1971 | 1.45 | 1.37 | 1.45 | 1.68 | 1.58 | 1.80 | 2.18 | 2.18 | 2.01 | 1.94 | 1.39 | 1.65 |
| 1972 | 1.66 | 1.66 | 1.66 | 1.66 | 1.68 | 1.90 | 1.96 | 1.91 | 1.80 | 1.55 | 1.60 | 1.47 |
| 1973 | 1.43 | 1.42 | 1.43 | 1.40 | 1.61 | 1.44 | 2.38 | 1.39 | 1.36 | 1.05 | 1.24 | 1.31 |
| 1974 | 1.24 | 1.22 | 1.08 | 1.33 | 1.33 | 1.31 | 1.33 | 1.33 | 1.36 | 1.36 | 1.34 | 1.32 |
| 1975 | 1.25 | 1.18 | 1.19 | 1.47 | 1.40 | 1.31 | 1.21 | 1.25 | 1.32 | 1.33 | 1.23 | 1.21 |
| 1976 | 0.93 | 0.92 | 0.89 | 1.04 | 1.03 | 0.93 | 0.93 | 0.90 | 0.94 | 0.94 | 0.91 | 0.90 |
| 1977 | 0.92 | 0.94 | 0.95 | 1.31 | 1.25 | 1.11 | 1.45 | 1.61 | 1.61 | 1.52 | 1.49 | 1.35 |
| 1978 | 1.11 | 1.11 | 1.24 | 1.30 | 1.24 | 1.31 | 1.24 | 1.25 | 1.31 | 1.38 | 1.32 | 1.37 |
| 1979 | 1.32 | 1.19 | 1.27 | 1.52 | 1.50 | 2.33 | 2.40 | 2.40 | 2.23 | 2.15 | 1.80 | 1.66 |
| 1980 | 1.74 | 1.61 | 1.64 | 1.81 | 1.80 | 1.87 | 2.17 | 1.94 | 1.89 | 1.80 | 1.72 | 1.73 |
| 1981 | 1.47 | 1.20 | 1.38 | 1.32 | 1.32 | 1.36 | 1.44 | 1.30 | 1.38 | 1.27 | 1.24 | 1.19 |
| 1982 | 1.19 | 1.16 | 1.16 | 1.27 | 1.30 | 1.31 | 1.45 | 1.08 | 1.15 | 1.26 | 1.37 | 1.59 |
| 1983 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.03 | 0.95 | 1.00 | 0.97 | 0.96 | 0.92 | 0.95 |
| 1984 | 0.93 | 0.93 | 0.97 | 1.00 | 1.41 | 1.63 | 1.65 | 1.11 | 1.01 | 1.01 | 1.03 | 1.02 |
| 1985 | 0.97 | 0.91 | 0.93 | 1.11 | 1.06 | 1.63 | 1.65 | 1.11 | 1.01 | 1.01 | 1.03 | 1.02 |
| 1986 | 0.97 | 0.91 | 0.93 | 1.11 | 1.06 | 1.16 | 1.16 | 1.16 | 1.13 | 1.07 | 1.10 | 1.10 |
| 1987 | 1.29 | 1.14 | 1.12 | 1.14 | 1.52 | 1.16 | 1.06 | 1.15 | 1.08 | 0.98 | 1.01 | 1.00 |
| 1988 | 0.95 | 0.78 | 0.95 | 2.07 | 1.28 | 1.25 | 1.34 | 1.38 | 1.34 | 1.30 | 1.29 | 1.14 |
| 1989 | 1.28 | 1.11 | 0.93 | 1.25 | 1.28 | 1.11 | 1.25 | 1.62 | 1.80 | 1.72 | 1.68 | 1.70 |
| 1990 | 1.57 | 1.38 | 1.67 | 1.81 | 1.89 | 1.95 | 2.24 | 2.35 | 2.20 | 2.00 | 1.93 | 1.72 |
| 1991 | 1.47 | 1.52 | 1.41 | 1.45 | 1.77 | 1.51 | 1.28 | 1.29 | 1.24 | 0.97 | 0.70 | 1.38 |
| 1992 | 0.98 | 0.96 | 0.90 | 1.00 | 1.58 | 1.41 | 1.43 | 1.47 | 1.47 | 1.43 | 1.54 | 1.41 |
| Average | 1.30 | 1.23 | 1.25 | 1.40 | 1.44 | 1.49 | 1.59 | 1.52 | 1.50 | 1.44 | 1.38 | 1.39 |

Table A.3.8 Estimated Mean Monthly Discharge at IDC5

(Unit : m3/s)

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1967 | 0.13 | 0.48 | 0.13 | 0.30 | 1.36 | 1.15 | 1.44 | 1.04 | 1.51 | 2.09 | 1.55 | 0.82 |
| 1968 | 0.49 | 2.08 | 2.42 | 2.90 | 2.09 | 2.94 | 1.55 | 1.16 | 1.27 | 0.96 | 1.07 | 6.64 |
| 1969 | 1.21 | 0.99 | 1.05 | 0.64 | 1.16 | 0.95 | 0.67 | 0.94 | 0.47 | 1.51 | 0.75 | 0.43 |
| 1970 | 0.81 | 0.90 | 3.13 | 4.69 | 2.06 | 0.96 | 0.71 | 0.65 | 0.57 | 0.48 | 0.42 | 0.49 |
| 1971 | 0.46 | 0.31 | 0.54 | 3.05 | 2.20 | 1.44 | 0.92 | 0.60 | 0.48 | 0.42 | 0.36 | 2.48 |
| 1972 | 1.43 | 1.06 | 1.96 | 1.66 | 1.58 | 0.87 | 0.73 | 0.50 | 0.74 | 0.68 | 1.58 | 0.73 |
| 1973 | 1.47 | 0.60 | 0.42 | 0.66 | 0.82 | 0.44 | 0.30 | 0.26 | 0.22 | 0.19 | 0.24 | 0.60 |
| 1974 | 0.29 | 0.14 | 0.35 | 3.80 | 1.89 | 1.90 | 0.92 | 0.52 | 0.45 | 0.39 | 0.43 | 0.31 |
| 1975 | 0.31 | 0.27 | 0.44 | 1.71 | 0.92 | 0.36 | 0.54 | 0.46 | 1.19 | 0.34 | 0.25 | 0.22 |
| 1976 | 0.19 | 0.33 | 1.05 | 1.70 | 0.93 | 0.66 | 0.34 | 0.28 | 0.32 | 0.22 | 0.18 | 0.38 |
| 1977 | 0.24 | 1.00 | 0.92 | 2.48 | 2.18 | 0.86 | 0.54 | 0.50 | 0.38 | 0.56 | 1.20 | 0.39 |
| 1978 | 1.00 | 0.93 | 3.89 | 3.40 | 2.08 | 1.31 | 0.96 | 0.69 | 0.60 | 0.53 | 1.01 | 1.62 |
| 1979 | 1.31 | 1.81 | 2.40 | 5.70 | 2.81 | 2.54 | 3.25 | 1.64 | 1.10 | 0.89 | 0.85 | 1.09 |
| 1980 | 0.66 | 0.57 | 0.83 | 2.43 | 1.90 | 1.03 | 0.60 | 1.05 | 0.52 | 0.51 | 0.76 | 0.41 |
| 1981 | 0.35 | 0.29 | 1.14 | 3.53 | 3.22 | 1.28 | 0.67 | 0.58 | 0.51 | 1.12 | 0.53 | 0.77 |
| 1982 | 0.39 | 0.38 | 0.93 | 0.84 | 0.97 | 1.37 | 1.64 | 1.03 | 0.53 | 0.83 | 1.85 | 5.82 |
| 1983 | 1.27 | 0.88 | 0.98 | 1.32 | 1.76 | 1.25 | 0.84 | 0.70 | 0.50 | 0.43 | 0.47 | 0.72 |
| 1984 | 0.67 | 0.40 | 0.30 | 2.96 | 1.98 | 1.44 | 3.65 | 0.93 | 0.57 | 0.57 | 1.29 | 1.31 |
| 1985 | 0.62 | 1.70 | 1.60 | 2.51 | 1.72 | 0.98 | 0.74 | 0.58 | 0.48 | 0.64 | 1.14 | 1.20 |
| 1986 | 1.86 | 0.57 | 1.75 | 3.55 | 1.92 | 1.61 | 0.78 | 0.64 | 0.56 | 0.90 | 0.65 | 2.21 |
| 1987 | 0.95 | 0.48 | 0.44 | 0.48 | 0.34 | 0.29 | 1.19 | 1.38 | 0.52 | 0.33 | 0.29 | 0.25 |
| 1988 | 0.58 | 0.22 | 1.90 | 4.85 | 2.01 | 1.11 | 0.67 | 0.56 | 0.79 | 0.45 | 0.41 | 1.15 |
| 1989 | 1.58 | 0.51 | 1.40 | 1.94 | 1.30 | 0.64 | 0.48 | 0.42 | 0.36 | 0.32 | 0.27 | 1.41 |
| 1990 | 1.62 | 0.54 | 3.39 | 5.31 | 2.63 | 1.25 | 0.83 | 0.73 | 0.63 | 0.64 | 2.12 | 1.51 |
| 1991 | 1.90 | 1.69 | 1.07 | 1.34 | 2.03 | 0.96 | 0.58 | 0.67 | 0.63 | 0.44 | 0.40 | 2.20 |
| 1992 | 0.95 | 0.38 | 0.32 | 1.52 | 2.16 | 0.88 | 0.55 | 0.47 | 0.36 | 0.31 | 0.94 | 0.95 |
| 1993 | 1.37 | 1.62 | 1.37 | 0.43 | 0.43 | 0.34 | 0.31 | 0.25 | 0.22 | 0.38 | 0.31 | 0.58 |
| 1994 | 0.17 | 0.53 | 0.41 | 0.48 | 0.80 | 0.29 | 0.26 | 0.18 | 0.15 | 0.50 | 0.70 | 0.71 |
| 1995 | 0.37 | 0.55 | 0.80 | 2.85 | 1.94 | 0.98 | 0.45 | 0.39 | 0.34 | 0.39 | 0.30 | 0.66 |
| 1996 | 0.38 | 1.30 | 0.31 | 1.14 | 0.85 | 0.46 | 0.29 | 0.25 | 0.21 | 0.18 | 0.15 | 0.13 |
| Average | 0.83 | 0.78 | 1.25 | 2.34 | 1.67 | 1.08 | 0.91 | 0.67 | 0.57 | 0.61 | 0.75 | 1.27 |

## Table A.3.9 Estimated Mean Monthly Discharge of Rau River at confluence with Njoro River

(Unit : m3/s)

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1967 | 0.52 | 0.75 | 0.52 | 0.62 | 1.55 | 1.34 | 1.63 | 1.24 | 1.70 | 2.33 | 1.74 | 1.04 |
| 1968 | 0.76 | 2.32 | 2.70 | 3.28 | 2.33 | 3.33 | 1.74 | 1.35 | 1.46 | 1.16 | 1.26 | 8.44 |
| 1969 | 1.40 | 1.19 | 1.25 | 0.88 | 1.35 | 1.15 | 0.91 | 1.14 | 0.75 | 1.70 | 0.97 | 0.72 |
| 1970 | 1.03 | 1.11 | 3.56 | 5.62 | 2.29 | 1.16 | 0.94 | 0.89 | 0.82 | 0.75 | 0.71 | 0.76 |
| 1971 | 0.74 | 0.63 | 0.80 | 3.46 | 2.45 | 1.63 | 1.13 | 0.85 | 0.75 | 0.71 | 0.66 | 2.77 |
| 1972 | 1.62 | 1.26 | 2.18 | 1.86 | 1.77 | 1.08 | 0.96 | 0.77 | 0.97 | 0.92 | 1.77 | 0.96 |
| 1973 | 1.66 | 0.85 | 0.71 | 0.90 | 1.04 | 0.72 | 0.62 | 0.60 | 0.57 | 0.55 | 0.58 | 0.85 |
| 1974 | 0.62 | 0.52 | 0.66 | 4.42 | 2.10 | 2.12 | 1.13 | 0.78 | 0.73 | 0.69 | 0.72 | 0.63 |
| 1975 | 0.63 | 0.60 | 0.72 | 1.91 | 1.13 | 0.66 | 0.80 | 0.74 | 1.38 | 0.65 | 0.59 | 0.57 |
| 1976 | 0.55 | 0.64 | 1.25 | 1.90 | 1.13 | 0.90 | 0.65 | 0.61 | 0.64 | 0.57 | 0.55 | 0.68 |
| 1977 | 0.58 | 1.20 | 1.13 | 2.77 | 2.43 | 1.07 | 0.80 | 0.77 | 0.68 | 0.82 | 1.39 | 0.69 |
| 1978 | 1.20 | 1.13 | 4.54 | 3.90 | 2.32 | 1.50 | 1.16 | 0.92 | 0.85 | 0.79 | 1.21 | 1.82 |
| 1979 | 1.50 | 2.02 | 2.68 | 7.05 | 3.17 | 2.85 | 3.71 | 1.84 | 1.29 | 1.10 | 1.06 | 1.28 |
| 1980 | 0.90 | 0.82 | 1.04 | 2.72 | 2.12 | 1.23 | 0.85 | 1.25 | 0.78 | 0.78 | 0.98 | 0.70 |
| 1981 | 0.66 | 0.62 | 1.33 | 4.07 | 3.67 | 1.47 | 0.91 | 0.83 | 0.78 | 1.31 | 0.79 | 0.99 |
| 1982 | 0.69 | 0.68 | 1.13 | 1.05 | 1.17 | 1.56 | 1.84 | 1.23 | 0.79 | 1.04 | 2.06 | 7.22 |
| 1983 | 1.46 | 1.09 | 1.18 | 1.51 | 1.96 | 1.44 | 1.05 | 0.93 | 0.77 | 0.72 | 0.75 | 0.95 |
| 1984 | 0.91 | 0.69 | 0.62 | 3.35 | 2.20 | 1.63 | 4.22 | 1.13 | 0.82 | 0.82 | 1.48 | 1.50 |
| 1985 | 0.87 | 1.90 | 1.79 | 2.81 | 1.92 | 1.18 | 0.97 | 0.83 | 0.75 | 0.88 | 1.33 | 1.39 |
| 1986 | 2.07 | 0.82 | 1.95 | 4.09 | 2.14 | 1.80 | 1.00 | 0.88 | 0.82 | 1.11 | 0.89 | 2.46 |
| 1987 | 1.15 | 0.75 | 0.72 | 0.75 | 0.65 | 0.62 | 1.38 | 1.57 | 0.78 | 0.64 | 0.62 | 0.59 |
| 1988 | 0.83 | 0.57 | 2.12 | 5.84 | 2.24 | 1.30 | 0.91 | 0.82 | 1.01 | 0.73 | 0.70 | 1.34 |
| 1989 | 1.77 | 0.78 | 1.59 | 2.16 | 1.49 | 0.88 | 0.75 | 0.71 | 0.66 | 0.64 | 0.60 | 1.60 |
| 1990 | 1.82 | 0.80 | 3.89 | 6.49 | 2.95 | 1.44 | 1.04 | 0.96 | 0.87 | 0.88 | 2.36 | 1.70 |
| 1991 | 2.12 | 1.89 | 1.26 | 1.53 | 2.26 | 1.16 | 0.83 | 0.91 | 0.87 | 0.72 | 0.69 | 2.45 |
| 1992 | 1.15 | 0.68 | 0.64 | 1.71 | 2.41 | 1.09 | 0.81 | 0.75 | 0.66 | 0.63 | 1.14 | 1.15 |
| 1993 | 1.56 | 1.82 | 1.56 | 0.72 | 0.72 | 0.65 | 0.63 | 0.59 | 0.57 | 0.68 | 0.63 | 0.83 |
| 1994 | 0.54 | 0.79 | 0.70 | 0.75 | 1.02 | 0.62 | 0.60 | 0.55 | 0.53 | 0.77 | 0.93 | 0.94 |
| 1995 | 0.67 | 0.81 | 1.02 | 3.22 | 2.16 | 1.18 | 0.73 | 0.69 | 0.65 | 0.69 | 0.62 | 0.90 |
| 1996 | 0.68 | 1.49 | 0.63 | 1.33 | 1.06 | 0.74 | 0.62 | 0.59 | 0.56 | 0.55 | 0.53 | 0.52 |
| Average | 1.09 | 1.04 | 1.53 | 2.76 | 1.91 | 1.32 | 1.18 | 0.92 | 0.84 | 0.88 | 1.01 | 1.61 |

## Table A.3.10 Estimated Mean Monthly Discharge of Rau River at Rau Ya Kati Intake Site

(Unit : m3/s)

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1967 | 1.86 | 1.94 | 1.64 | 1.84 | 2.91 | 2.69 | 3.09 | 2.88 | 3.51 | 4.30 | 3.68 | 2.92 |
| 1968 | 2.54 | 3.99 | 4.39 | 5.12 | 4.14 | 5.43 | 4.02 | 3.73 | 3.76 | 3.35 | 3.39 | 10.69 |
| 1969 | 3.37 | 3.07 | 3.07 | 2.58 | 3.16 | 2.82 | 2.54 | 2.78 | 2.34 | 3.31 | 2.52 | 2.20 |
| 1970 | 2.46 | 2.52 | 5.05 | 7.22 | 3.81 | 2.87 | 2.75 | 2.71 | 2.51 | 2.33 | 2.08 | 2.02 |
| 1971 | 2.19 | 2.00 | 2.25 | 5.14 | 4.03 | 3.43 | 3.31 | 3.03 | 2.76 | 2.65 | 2.05 | 4.42 |
| 1972 | 3.28 | 2.92 | 3.84 | 3.52 | 3.45 | 2.98 | 2.92 | 2.68 | 2.77 | 2.47 | 3.37 | 2.43 |
| 1973 | 3.09 | 2.27 | 2.14 | 2.30 | 2.65 | 2.16 | 3.00 | 1.99 | 1.93 | 1.60 | 1.82 | 2.16 |
| 1974 | 1.86 | 1.74 | 1.74 | 5.75 | 3.43 | 3.43 | 2.46 | 2.11 | 2.09 | 2.05 | 2.06 | 1.95 |
| 1975 | 1.88 | 1.78 | 1.91 | 3.38 | 2.53 | 1.97 | 2.01 | 1.99 | 2.70 | 1.98 | 1.82 | 1.78 |
| 1976 | 1.48 | 1.56 | 2.14 | 2.94 | 2.16 | 1.83 | 1.58 | 1.51 | 1.58 | 1.51 | 1.46 | 1.58 |
| 1977 | 1.50 | 2.14 | 2.08 | 4.08 | 3.68 | 2.18 | 2.25 | 2.38 | 2.29 | 2.34 | 2.88 | 2.04 |
| 1978 | 2.31 | 2.24 | 5.78 | 5.20 | 3.56 | 2.81 | 2.40 | 2.17 | 2.16 | 2.17 | 2.53 | 3.19 |
| 1979 | 2.82 | 3.21 | 3.95 | 8.57 | 4.67 | 5.18 | 6.11 | 4.24 | 3.52 | 3.25 | 2.86 | 2.94 |
| 1980 | 2.64 | 2.43 | 2.68 | 4.53 | 3.92 | 3.10 | 3.02 | 3.19 | 2.67 | 2.58 | 2.70 | 2.43 |
| 1981 | 2.13 | 1.82 | 2.71 | 5.39 | 4.99 | 2.83 | 2.35 | 2.13 | 2.16 | 2.58 | 2.03 | 2.18 |
| 1982 | 1.88 | 1.84 | 2.29 | 2.32 | 2.47 | 2.87 | 3.29 | 2.31 | 1.94 | 2.30 | 3.43 | 8.81 |
| 1983 | 2.58 | 2.21 | 2.30 | 2.63 | 3.08 | 2.47 | 2.00 | 1.93 | 1.74 | 1.68 | 1.67 | 1.90 |
| 1984 | 1.84 | 1.62 | 1.59 | 4.35 | 3.61 | 3.26 | 5.87 | 2.24 | 1.83 | 1.83 | 2.51 | 2.52 |
| 1985 | 1.84 | 2.81 | 2.72 | 3.92 | 2.98 | 2.81 | 2.62 | 1.94 | 1.76 | 1.89 | 2.36 | 2.41 |
| 1986 | 3.04 | 1 73 | 2.88 | 5.20 | 3.20 | 2.96 | 2.16 | 2.04 | 1.95 | 2.18 | 1.99 | 3.56 |
| 1987 | 2.44 | 1.89 | 1.84 | 1.89 | 2.17 | 1.78 | 2.44 | 2.72 | 1.86 | 1.62 | 1.63 | 1.59 |
| 1988 | 1.78 | 1.35 | 3.07 | 7.91 | 3.52 | 2.55 | 2.25 | 2.20 | 2.35 | 2.03 | 1.99 | 2.48 |
| 1989 | 3.05 | 1.89 | 2.52 | 3.41 | 2.77 | 1.99 | 2.00 | 2.33 | 2.46 | 2.36 | 2.28 | 3.30 |
| 1990 | 3.39 | 2.18 | 5.56 | 8.30 | 4.84 | 3.39 | 3.28 | 3.31 | 3.07 | 2.88 | 4.29 | 3.42 |
| 1991 | 3.59 | 3.41 | 2.67 | 2.98 | 4.03 | 2.67 | 2.11 | 2.20 | 2.11 | 1.69 | 1.39 | 3.83 |
| 1992 | 2.13 | 1.64 | 1.54 | 2.71 | 3.99 | 2.50 | 2.24 | 2.22 | 2.13 | 2.06 | 2.68 | 2.56 |
| Average | 2.42 | 2.24 | 2.86 | 4.35 | 3.45 | 2.88 | 2.85 | 2.50 | 2.38 | 2.35 | 2.44 | 3.13 |

## Table A.3.11 Mean Monthly Discharge at IDC2A

(Unit : m3/s)

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | | | | | | | | | | 3.11 | 3.21 | 2.85 |
| 1961 | 2.39 | 2.43 | 2.30 | 2.52 | 3.11 | 2.84 | 2.95 | 3.09 | 3.24 | 3.50 | 10.27 | 10.22 |
| 1962 | 19.31 | 9.50 | 6.03 | 6.05 | 5.42 | 4.41 | 4.60 | 4.55 | 3.96 | 3.52 | 3.18 | 4.76 |
| 1963 | 7.81 | 5.25 | 6.36 | 8.55 | 8.03 | 6.80 | 6.55 | 5.48 | 4.91 | 4.44 | 6.87 | 11.62 |
| 1964 | 7.57 | 4.89 | 5.74 | 8.45 | 10.35 | 8.17 | 6.80 | 6.94 | 6.36 | 5.69 | 5.23 | 6.49 |
| 1965 | 9.35 | 6.17 | 5.15 | 7.59 | 6.69 | 6.69 | 6.41 | 6.81 | 5.97 | 6.86 | 6.58 | 7.93 |
| 1966 | 6.18 | 6.19 | 8.66 | 13.88 | 10.28 | 8.71 | 6.95 | 6.00 | 0.27 | 0.72 | 4.49 | 4.39 |
| 1967 | 3.95 | 3.59 | 3.42 | 8.02 | 12.89 | 9.39 | 7.15 | 7.11 | 7.47 | 5.90 | 5.68 | 7.63 |
| 1968 | 4.88 | 3.94 | 13.88 | 49.76 | 29.25 | 17.16 | 11.12 | 8.82 | 6.82 | 5.74 | 7.96 | 15.44 |
| 1969 | 6.84 | 6.60 | 8.18 | 10.03 | 10.31 | 7.45 | 6.78 | 7.61 | 5.91 | 5.98 | 6.71 | 8.03 |
| 1970 | 6.10 | 8.40 | 6.76 | 19.96 | 12.58 | 8.14 | 6.78 | 6.28 | 5.62 | 4.31 | 5.18 | 6.52 |
| 1971 | 6.87 | 7.27 | | 6.78 | 11.47 | 11.23 | 8.20 | 7.57 | | 6.28 | 4.83 | 6.28 |
| 1972 | 5.11 | 8.26 | 6.34 | 5.87 | 8.44 | 7.31 | 6.69 | 6.41 | 5.94 | 6.75 | 9.81 | 10.22 |
| 1973 | | 7.08 | | 11.67 | 10.14 | 6.36 | 7.06 | 6.23 | 5.61 | 5.08 | 7.63 | 7.06 |
| 1974 | 5.14 | 4.17 | | | 5.76 | 5.52 | 5.46 | 5.77 | 5.91 | 4.48 | 4.48 | 4.91 |
| 1975 | 5.13 | 3.99 | 4.50 | 10.39 | 8.57 | 4.69 | 2.75 | 2.86 | 3.12 | 3.34 | 4.61 | 5.08 |
| 1976 | 3.06 | 2.85 | 4.01 | 11.41 | 8.27 | 5.22 | 3.65 | 3.77 | 3.98 | 4.25 | 5.23 | 5.61 |
| 1977 | | | | | | | | | | | | 19.39 |
| 1978 | 13.18 | 13.51 | 13.64 | 24.80 | 13.06 | 7.19 | 5.31 | 4.76 | 3.75 | 3.56 | 5.75 | 10.20 |
| 1979 | 7.36 | 9.08 | 8.28 | 14.61 | 17.72 | 16.43 | 8.72 | 6.57 | 5.25 | 4.37 | 5.73 | 6.56 |
| 1980 | 5.42 | 5.72 | 6.43 | 9.73 | 10.09 | 7.60 | 7.44 | 7.64 | 6.08 | 4.72 | 7.19 | 9.04 |
| 1981 | 6.55 | 4.82 | 4.72 | 24.86 | 22.59 | 12.57 | 7.53 | 6.30 | 4.89 | 4.20 | 3.97 | 4.11 |
| 1982 | 4.14 | 3.01 | 2.66 | 4.36 | 7.52 | 6.21 | 5.71 | 5.68 | 4.88 | 5.76 | 6.33 | 13.17 |
| 1983 | 4.92 | 3.19 | 3.63 | 5.02 | 6.06 | 5.50 | 4.84 | 4.05 | | 4.00 | 3.44 | 4.01 |
| 1984 | 6.07 | 3.54 | 2.70 | 5.71 | | | 5.21 | 4.72 | 4.93 | 4.39 | 11.09 | 10.60 |
| 1985 | 5.17 | 5.19 | 4.25 | 5.69 | 7.97 | 5.25 | 4.90 | | 4.22 | 3.77 | | |
| 1986 | | 9.60 | 2.74 | 4.93 | | | | 4.49 | | 3.12 | 4.15 | 7.34 |
| 1987 | 6.57 | 4.67 | 3.06 | | 9.16 | 5.55 | 5.64 | 5.37 | 3.83 | | | 1.90 |
| 1988 | 1.23 | | 1.12 | | | | | | | | | |
| 1989 | | | | | | | | | | | | |
| 1990 | | | | | | | | | | | | |
| 1991 | 3.04 | | | 4.64 | 6.52 | 7.75 | 6.54 | 7.39 | 6.00 | 4.06 | 1.91 | 6.20 |
| 1992 | 5.20 | 2.76 | 2.21 | 4.76 | 7.75 | 5.22 | 4.73 | 4.36 | 2.41 | | 3.89 | |
| 1993 | 8.70 | 8.44 | 5.28 | 3.38 | 3.46 | | 3.42 | 3.46 | 3.16 | 2.75 | 2.75 | 4.79 |
| 1994 | 2.59 | 2.70 | | 3.88 | 6.57 | 5.29 | 4.20 | 3.83 | 3.62 | 3.17 | 3.22 | 10.11 |
| 1995 | 5.62 | 2.63 | 3.29 | 4.29 | 6.32 | 6.04 | 4.62 | 4.55 | 3.72 | 2.84 | 2.53 | 3.08 |
| 1996 | 2.31 | 2.94 | 3.14 | 7.65 | 7.27 | 6.20 | 4.52 | 3.55 | 2.98 | 2.49 | 2.38 | 2.76 |
| 1997 | 1.38 | 0.86 | 0.33 | 1.89 | | | | | | | | |
| Mean | 5.91 | 5.41 | 5.13 | 10.04 | 9.79 | 7.48 | 5.91 | 5.55 | 4.65 | 4.30 | 5.36 | 7.45 |

Source : Regional Water Office, Kilimanjaro

Data from 1967 to 1976 : Daily discharge records are collected from the Regional Water Office.
Data from 1977 to date : Daily water level records are collected from the Regional Water Office
they are converted to the discharge records by use of the rating curve prepared by the JICA Study Team.

Remarks : Value in parenthesis is supplemented by correlation

**Table A.3.12 Mean Monthly Discharge at IDC1**

(Unit : m3/s)

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | | | | | | | | | | | 10.28 | 16.34 |
| 1958 | 9.73 | 11.22 | 11.56 | 14.67 | 34.45 | 30.45 | 20.10 | 14.49 | 11.13 | 10.07 | 9.55 | 9.40 |
| 1959 | 8.88 | 9.01 | 9.46 | 12.18 | 14.54 | 10.93 | 12.35 | 12.41 | 11.51 | 10.05 | 7.98 | 8.04 |
| 1960 | 8.16 | 8.00 | 7.69 | 29.17 | 26.61 | 16.24 | 11.92 | 10.32 | 8.84 | 8.61 | 8.54 | 7.49 |
| 1961 | 6.57 | 6.33 | 6.12 | 7.53 | 7.88 | 6.80 | 7.36 | 7.24 | 7.29 | 8.94 | 32.24 | 41.62 |
| 1962 | 39.35 | 22.64 | 13.91 | 13.86 | 20.38 | 14.18 | 11.10 | 10.62 | 9.80 | 8.75 | 8.04 | 9.95 |
| 1963 | 13.79 | 10.79 | 11.51 | 19.64 | 34.08 | 21.36 | 18.77 | 14.52 | 12.03 | 10.60 | 14.49 | 22.20 |
| 1964 | 14.89 | 10.48 | 11.06 | 30.66 | 39.53 | 25.82 | 16.77 | 14.85 | 12.94 | 11.77 | 10.78 | 12.30 |
| 1965 | 15.53 | 10.91 | 9.57 | 14.36 | 13.41 | 12.64 | 11.96 | 12.45 | 11.10 | 12.14 | | |
| Mean | 14.61 | 11.17 | 10.11 | 17.76 | 23.86 | 17.30 | 13.79 | 12.11 | 10.58 | 10.12 | 12.74 | 15.92 |

Source : Regional Water Office, Kilimanjaro

**Table A.3.13 Estimated Mean Monthly Discharge at IDC1 (1987 - 1996)**

(Unit : m3/s)

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1987 | 12.81 | 10.10 | 7.23 | 13.12 | 36.35 | 17.02 | 14.67 | 12.55 | 9.13 | 8.42 | 5.15 | 5.26 |
| 1988 | 2.17 | 8.58 | 4.11 | 13.12 | 25.43 | 18.62 | 12.33 | 11.02 | 8.85 | 8.42 | 5.15 | 10.22 |
| 1989 | 8.50 | 8.58 | 7.16 | 13.12 | 25.43 | 18.62 | 12.33 | 11.02 | 8.85 | 8.42 | 5.15 | 10.22 |
| 1990 | 8.50 | 8.58 | 7.16 | 13.12 | 25.43 | 18.62 | 12.33 | 11.02 | 8.85 | 8.42 | 5.15 | 10.22 |
| 1991 | 5.77 | 8.58 | 7.16 | 12.73 | 24.54 | 24.68 | 17.20 | 16.79 | 12.94 | 9.74 | 2.33 | 12.59 |
| 1992 | 10.08 | 5.63 | 5.86 | 13.09 | 30.04 | 15.87 | 12.11 | 10.43 | 6.64 | 8.42 | 8.76 | 10.22 |
| 1993 | 17.05 | 18.93 | 10.79 | 8.97 | 10.86 | 18.62 | 8.42 | 8.54 | 7.95 | 8.01 | 5.06 | 10.19 |
| 1994 | 4.88 | 5.48 | 7.16 | 10.46 | 24.76 | 16.12 | 10.61 | 9.32 | 8.76 | 8.57 | 6.58 | 19.26 |
| 1995 | 10.91 | 5.32 | 7.60 | 11.69 | 23.65 | 18.73 | 11.80 | 10.83 | 8.94 | 8.13 | 4.34 | 7.27 |
| 1996 | 4.32 | 6.05 | 7.35 | 21.73 | 27.89 | 19.28 | 11.52 | 8.73 | 7.64 | 7.67 | 3.85 | 6.73 |
| Mean | 8.50 | 8.58 | 7.16 | 13.11 | 25.44 | 18.62 | 12.33 | 11.03 | 8.86 | 8.43 | 5.15 | 10.22 |

## Table A.3.14 Flood Discharge on the Rau River

River : Rau River

Gauging Station IDC3
Catchment area : 122 km2

(1) Calculation of daily maximum rainfall
i) Elevation of middle point for catchment area 1,140 m

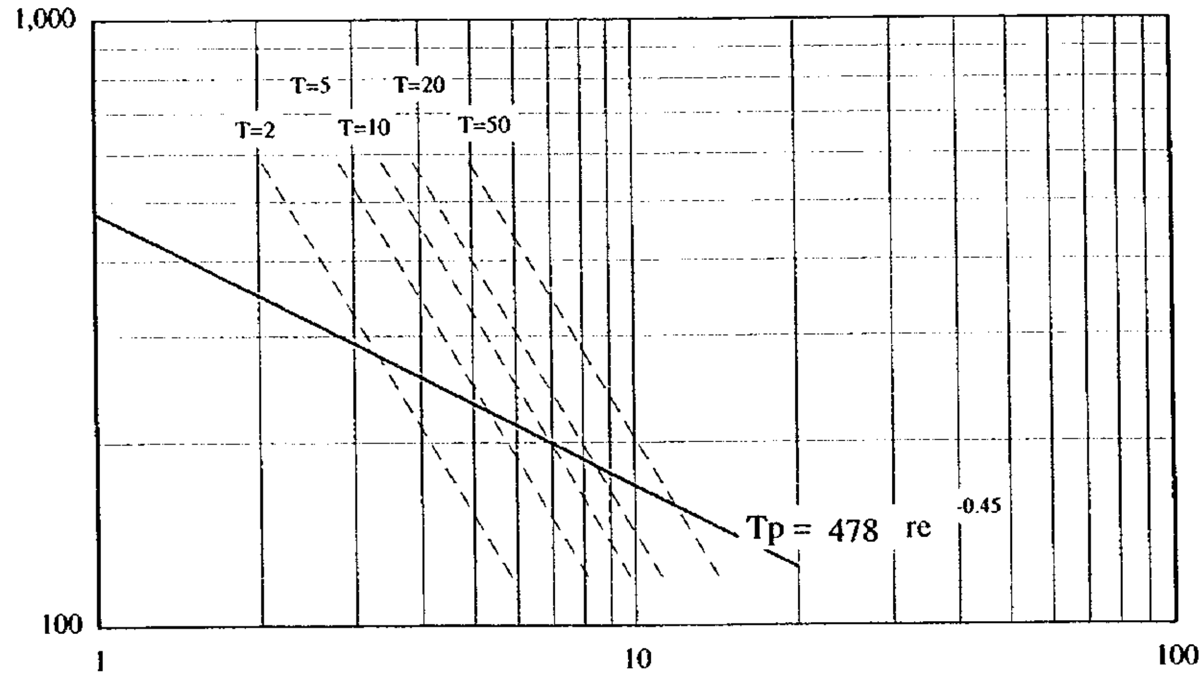
ii) Daily maximum rainfall ($R_{24}$)

| Return period | 2 | 5 | 10 | 20 | 50 |
|---|---|---|---|---|---|
| $R_{24}$ (mm/day) | 106 | 148 | 178 | 204 | 260 |

(2) Calculation of rainfall intensity $rt = R_{24}/t \times (t/24)^{1/3}$ $re = 0.25\ rt$

| T hrs | rt 2 | rt 5 | rt 10 | rt 20 | rt 50 | re 2 | re 5 | re 10 | re 20 | re 50 |
|---|---|---|---|---|---|---|---|---|---|---|
| r2 | 23.4 | 32.6 | 39.2 | 44.8 | 57.1 | 5.9 | 8.1 | 9.8 | 11.2 | 14.3 |
| r5 | 12.7 | 17.6 | 21.2 | 24.3 | 30.9 | 3.2 | 4.4 | 5.3 | 6.1 | 7.7 |
| r10 | 8.0 | 11.1 | 13.3 | 15.3 | 19.4 | 2.0 | 2.8 | 3.3 | 3.8 | 4.9 |

(3) Plotting




(4) Calculation of peak flood discharge (Qp) $Qp = 1/3.6 \times re \times A$

| Return period | re | tp | Qp |
|---|---|---|---|
| 2 | 3.4 | 275 | 115 |
| 5 | 5.3 | 226 | 180 |
| 10 | 7.0 | 199 | 237 |
| 20 | 8.5 | 182 | 288 |
| 50 | 13.0 | 151 | 441 |

## Table A.3.15 Flood Discharge on the Njoro River

River : Njoro River

Gauging Station IDC35
Catchment area : 15 km2

(1) Calculation of daily maximum rainfall
i) Elevation of middle point for catchment area 810 m

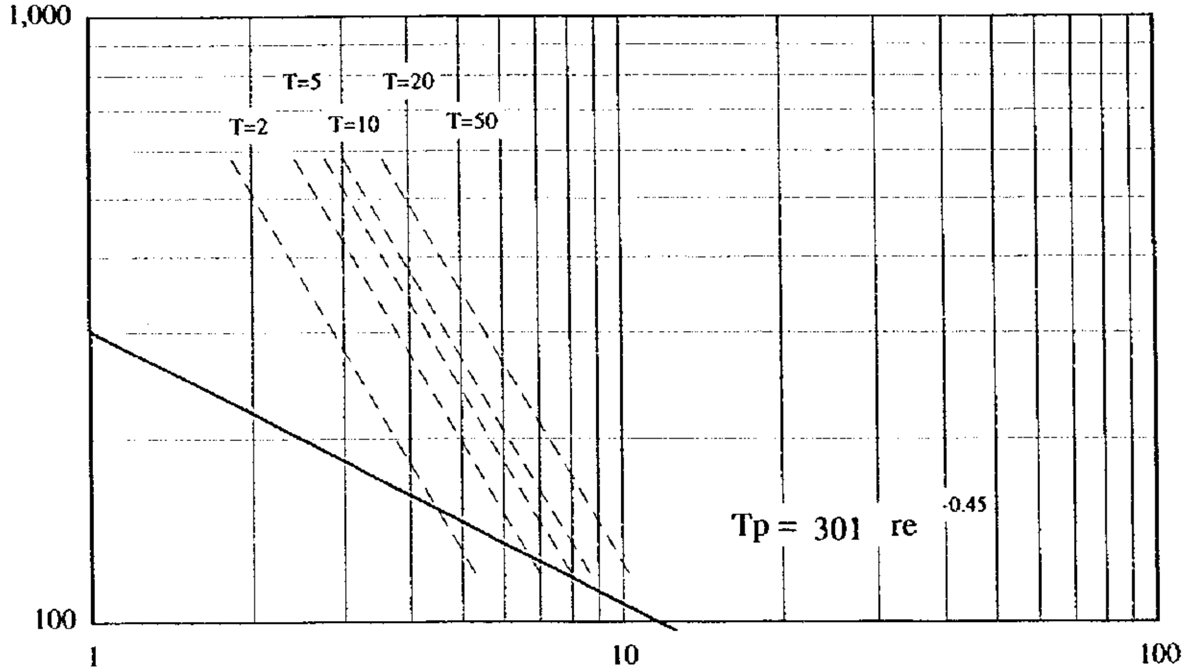
ii) Daily maximum rainfall ($R_{24}$)

| Return period | 2 | 5 | 10 | 20 | 50 |
|---|---|---|---|---|---|
| $R_{24}$ (mm/day) | 96 | 127 | 145 | 157 | 187 |

(2) Calculation of rainfall intensity $rt = R_{24}/t \times (t/24)^{1/3}$ re=0.25 rt

| T hrs | rt 2 | rt 5 | rt 10 | rt 20 | rt 50 | re 2 | re 5 | re 10 | re 20 | re 50 |
|---|---|---|---|---|---|---|---|---|---|---|
| r2 | 21.2 | 28.0 | 32.0 | 34.7 | 41.2 | 5.3 | 7.0 | 8.0 | 8.7 | 10.3 |
| r5 | 11.5 | 15.1 | 17.3 | 18.8 | 22.3 | 2.9 | 3.8 | 4.3 | 4.7 | 5.6 |
| r10 | 7.2 | 9.5 | 10.9 | 11.8 | 14.0 | 1.8 | 2.4 | 2.7 | 2.9 | 3.5 |

(3) Plotting




(4) Calculation of peak flood discharge (Qp) Qp=1/3.6 x re x A

| Return period | re | tp | Qp |
|---|---|---|---|
| 2 | 4.5 | 153 | 19 |
| 5 | 6.8 | 127 | 28 |
| 10 | 8.1 | 117 | 34 |
| 20 | 9.1 | 112 | 38 |
| 50 | 13.0 | 95 | 54 |

**Table A.3.16 Flood Discharge on the Kisiringo River**

River : Kisiringo River

Gauging Station
Catchment area : 14 km2

(1) Calculation of daily maximum rainfall

i) Elevation of middle point for catchment area 1,100 m

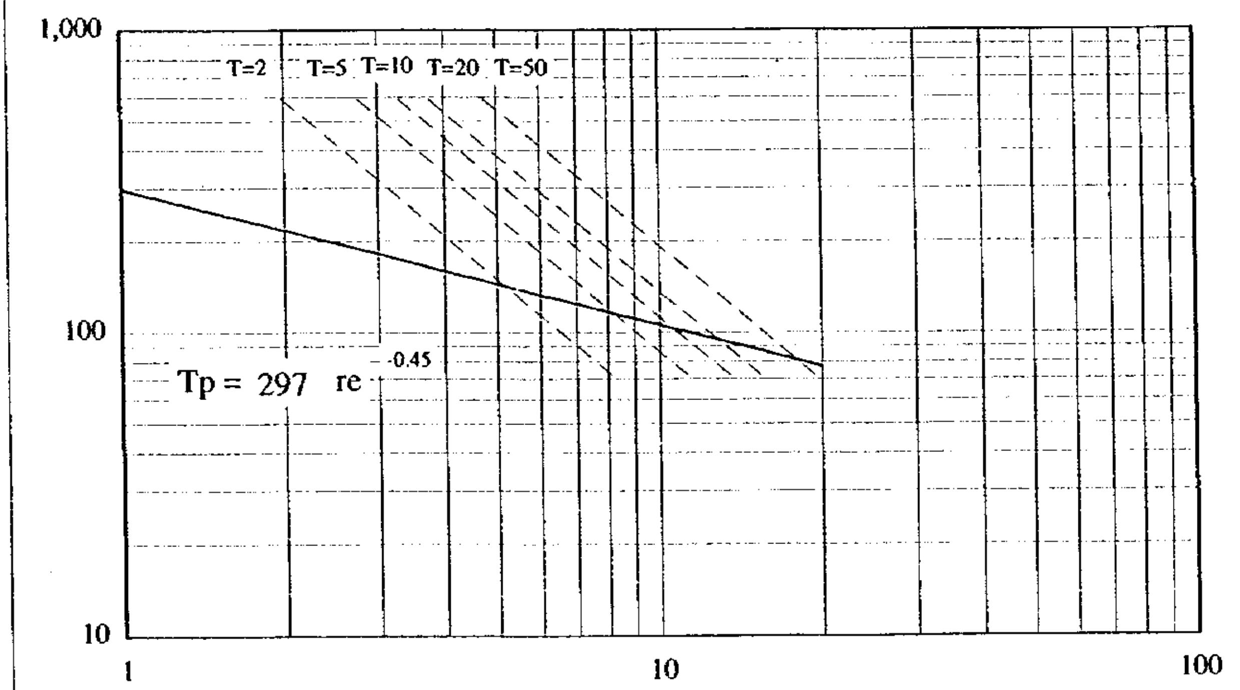
ii) Daily maximum rainfall ($R_{24}$)

| Return period | 2 | 5 | 10 | 20 | 50 |
|---|---|---|---|---|---|
| $R_{24}$ (mm/day) | 105 | 145 | 174 | 198 | 251 |

(2) Calculation of rainfall intensity $rt = R_{24}/t \times (t/24)^{1/3}$ $re=0.25\ rt$

| T hrs | rt 2 | rt 5 | rt 10 | rt 20 | rt 50 | re 2 | re 5 | re 10 | re 20 | re 50 |
|---|---|---|---|---|---|---|---|---|---|---|
| r1 | 32.6 | 45.1 | 53.9 | 61.4 | 77.7 | 8.1 | 11.3 | 13.5 | 15.3 | 19.4 |
| r5 | 12.5 | 17.3 | 20.7 | 23.6 | 29.9 | 3.1 | 4.3 | 5.2 | 5.9 | 7.5 |
| r10 | 7.9 | 10.9 | 13.0 | 14.8 | 18.8 | 2.0 | 2.7 | 3.3 | 3.7 | 4.7 |

(3) Plotting




(4) Calculation of peak flood discharge (Qp) $Qp=1/3.6 \times re \times A$

| Return period | re | tp | Qp |
|---|---|---|---|
| 2 | 5.2 | 141 | 20 |
| 5 | 8.2 | 115 | 32 |
| 10 | 10.5 | 103 | 41 |
| 20 | 13.0 | 93.5 | 51 |
| 50 | 17.5 | 81.8 | 68 |

## Table A.3.17 Flood Discharge on the Msaranga River

River : Msaranga River

Gauging Station
Catchment area : 17 km2

(1) Calculation of daily maximum rainfall
i) Elevation of middle point for catchment area 1,200 m

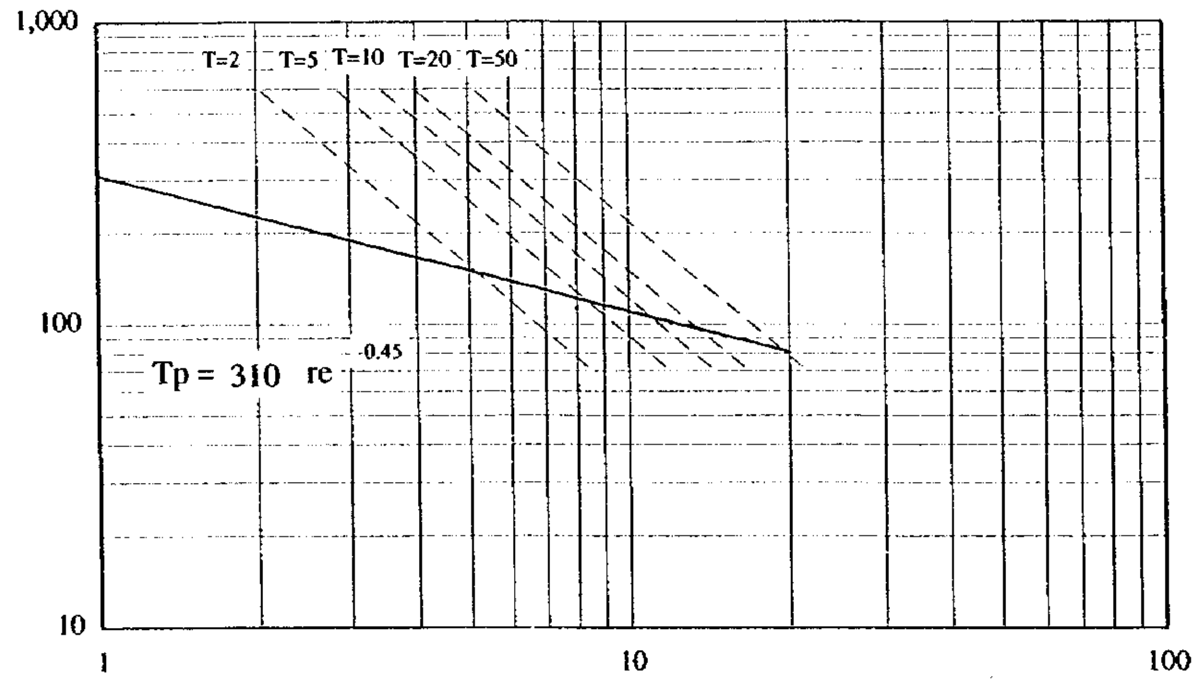
ii) Daily maximum rainfall ($R_{24}$)

| Return period | 2 | 5 | 10 | 20 | 50 |
|---|---|---|---|---|---|
| $R_{24}$ (mm/day) | 108 | 152 | 184 | 212 | 273 |

(2) Calculation of rainfall intensity $rt = R_{24}/t \times (t/24)^{1/3}$ $re=0.25\ rt$

| | rt | | | | | re | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| T hrs | 2 | 5 | 10 | 20 | 50 | 2 | 5 | 10 | 20 | 50 |
| r1 | 33.6 | 47.0 | 57.0 | 65.7 | 84.6 | 8.4 | 11.8 | 14.2 | 16.4 | 21.1 |
| r5 | 12.9 | 18.1 | 21.9 | 25.3 | 32.5 | 3.2 | 4.5 | 5.5 | 6.3 | 8.1 |
| r10 | 8.1 | 11.4 | 13.8 | 15.9 | 20.4 | 2.0 | 2.8 | 3.4 | 4.0 | 5.1 |

(3) Plotting




(4) Calculation of peak flood discharge (Qp) $Qp=1/3.6 \times re \times A$

| Return period | re | tp | Qp |
|---|---|---|---|
| 2 | 5.0 | 150 | 24 |
| 5 | 8.5 | 118 | 40 |
| 10 | 12.0 | 101 | 57 |
| 20 | 14.0 | 94.4 | 66 |
| 50 | 19.0 | 82.3 | 90 |

## Table A.3.18 Flood Discharge on the Msangaji River

River : Msangaji River

Gauging Station
Catchment area : 10 km2

(1) Calculation of daily maximum rainfall

i) Elevation of middle point for catchment area 1,070 m

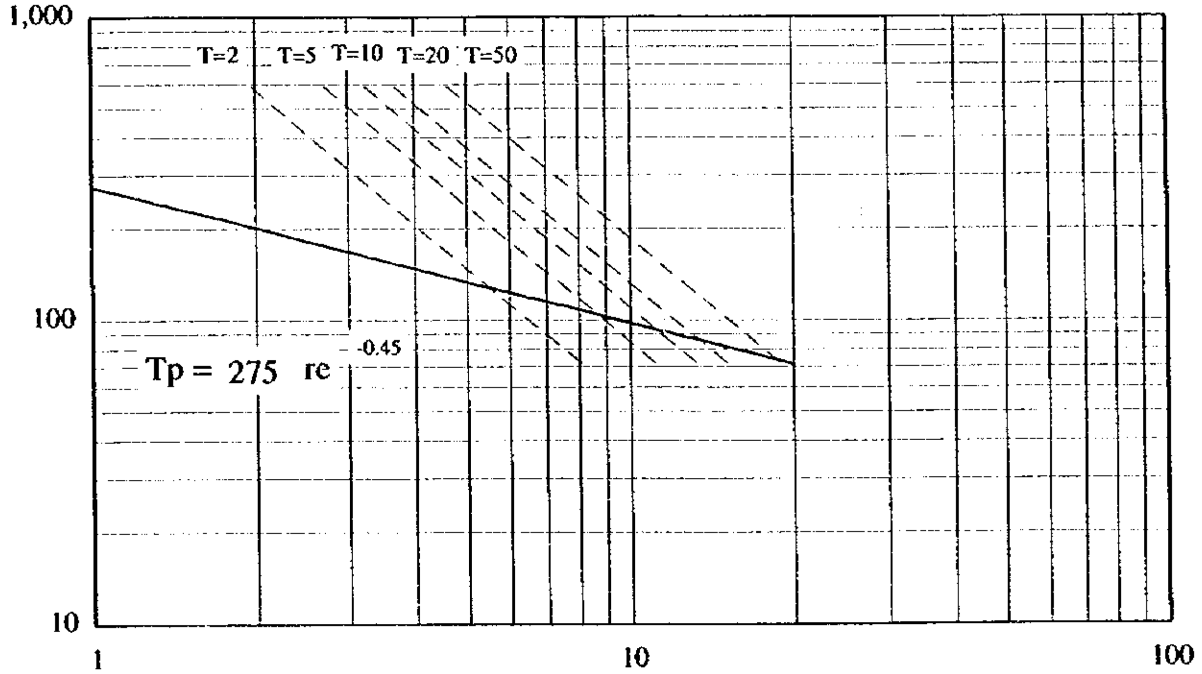
ii) Daily maximum rainfall ($R_{24}$)

| Return period | 2 | 5 | 10 | 20 | 50 |
|---|---|---|---|---|---|
| $R_{24}$ (mm/day) | 104 | 143 | 171 | 194 | 244 |

(2) Calculation of rainfall intensity $rt = R_{24}/t \times (t/24)^{1/3}$ re=0.25 rt

| | rt | | | | | re | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| T hrs | 2 | 5 | 10 | 20 | 50 | 2 | 5 | 10 | 20 | 50 |
| r1 | 32.3 | 44.5 | 53.0 | 60.1 | 75.7 | 8.1 | 11.1 | 13.3 | 15.0 | 18.9 |
| r5 | 12.4 | 17.1 | 20.4 | 23.1 | 29.1 | 3.1 | 4.3 | 5.1 | 5.8 | 7.3 |
| r10 | 7.8 | 10.7 | 12.8 | 14.5 | 18.3 | 2.0 | 2.7 | 3.2 | 3.6 | 4.6 |

(3) Plotting




(4) Calculation of peak flood discharge (Qp) Qp=1/3.6 x re x A

| Return period | re | tp | Qp |
|---|---|---|---|
| 2 | 5.5 | 128 | 15 |
| 5 | 8.6 | 105 | 24 |
| 10 | 12.0 | 90 | 33 |
| 20 | 14.5 | 82.7 | 40 |
| 50 | 18.5 | 74.1 | 51 |

## Table A.3.19 Flood Discharge on the Mola River

River : Mola River

Gauging Station
Catchment area : 7 km2

(1) Calculation of daily maximum rainfall

i) Elevation of middle point for catchment area 1,100 m

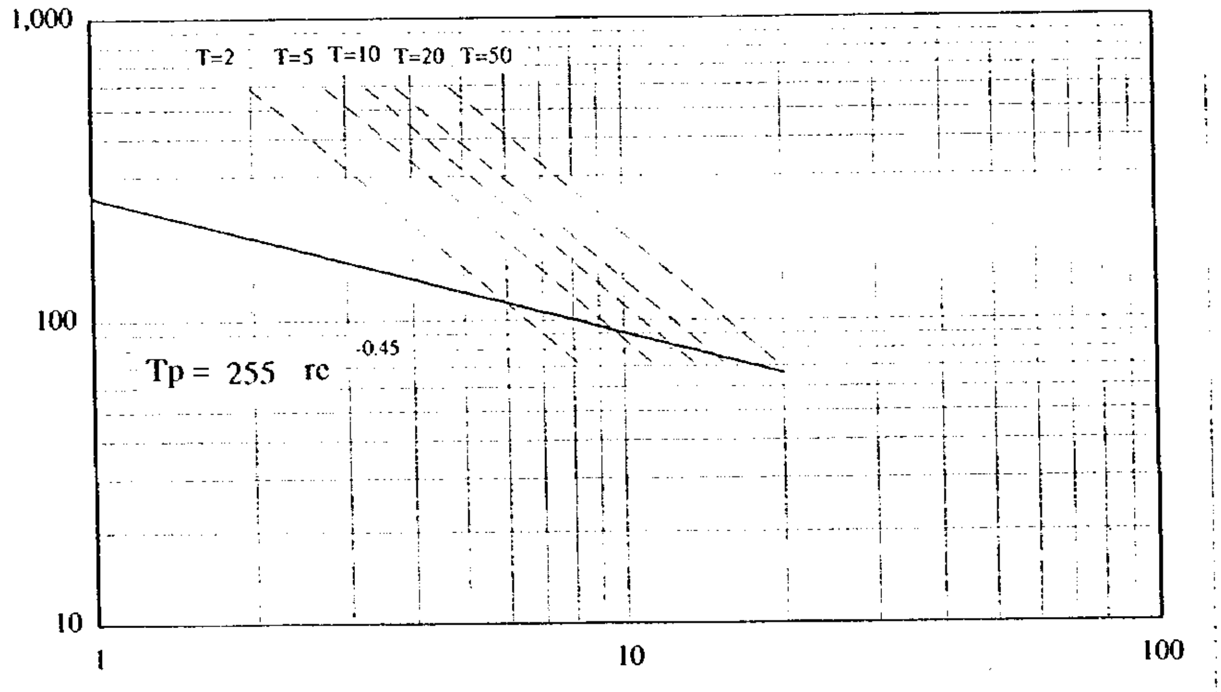
ii) Daily maximum rainfall ($R_{24}$)

| Return period | 2 | 5 | 10 | 20 | 50 |
|---|---|---|---|---|---|
| $R_{24}$ (mm/day) | 105 | 145 | 174 | 198 | 251 |

(2) Calculation of rainfall intensity $rt = R_{24}/t \times (t/24)^{1/3}$ $re = 0.25\ rt$

| T hrs | rt 2 | rt 5 | rt 10 | rt 20 | rt 50 | re 2 | re 5 | re 10 | re 20 | re 50 |
|---|---|---|---|---|---|---|---|---|---|---|
| r1 | 32.6 | 45.1 | 53.9 | 61.4 | 77.7 | 8.1 | 11.3 | 13.5 | 15.3 | 19.4 |
| r5 | 12.5 | 17.3 | 20.7 | 23.6 | 29.9 | 3.1 | 4.3 | 5.2 | 5.9 | 7.5 |
| r10 | 7.9 | 10.9 | 13.0 | 14.8 | 18.8 | 2.0 | 2.7 | 3.3 | 3.7 | 4.7 |

(3) Plotting




(4) Calculation of peak flood discharge (Qp) $Qp = 1/3.6 \times re \times A$

| Return period | re | tp | Qp |
|---|---|---|---|
| 2 | 6.0 | 114 | 12 |
| 5 | 9.5 | 92.5 | 18 |
| 10 | 13.0 | 80.3 | 25 |
| 20 | 15.5 | 74.2 | 30 |
| 50 | 20.0 | 66.2 | 39 |

## Table A.3.20 Flood Discharge on the Mlalo River

River : Mlalo River

Gauging Station
Catchment area : 9 km2

(1) Calculation of daily maximum rainfall
i) Elevation of middle point for catchment area 1,020 m

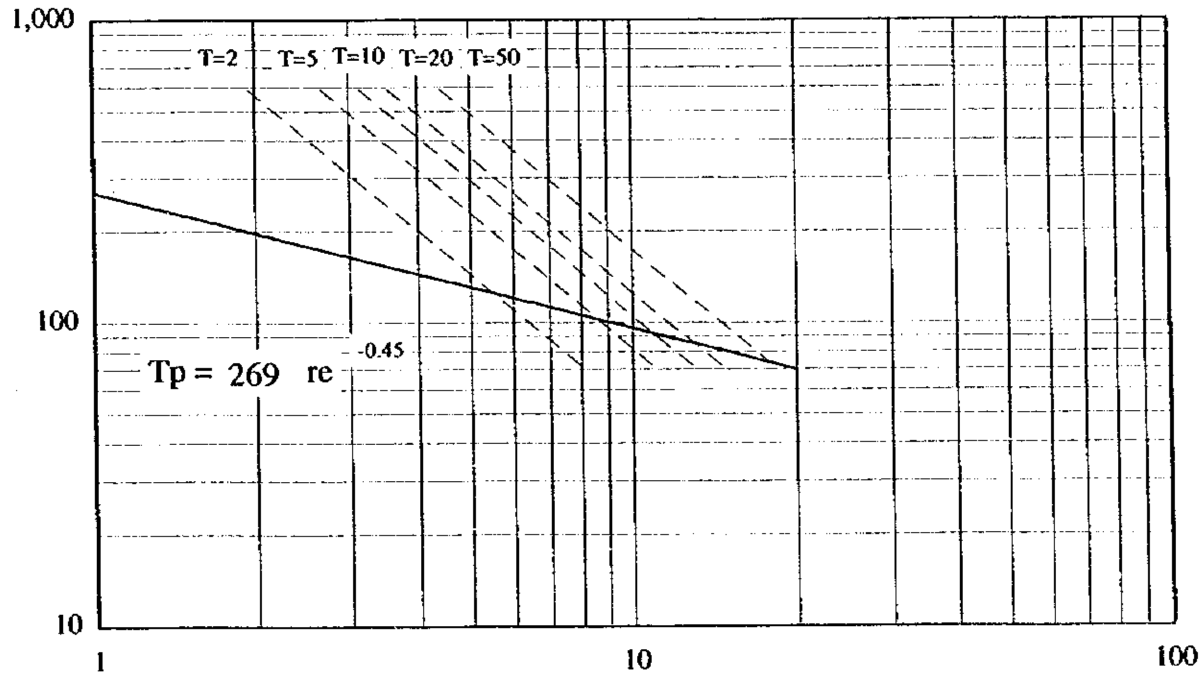
ii) Daily maximum rainfall ($R_{24}$)

| Return period | 2 | 5 | 10 | 20 | 50 |
|---|---|---|---|---|---|
| $R_{24}$ (mm/day) | 103 | 140 | 166 | 187 | 233 |

(2) Calculation of rainfall intensity $rt = R_{24}/t \times (t/24)^{1/3}$ re=0.25 rt

| | rt | | | | | re | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| T hrs | 2 | 5 | 10 | 20 | 50 | 2 | 5 | 10 | 20 | 50 |
| r1 | 31.8 | 43.5 | 51.5 | 57.9 | 72.3 | 8.0 | 10.9 | 12.9 | 14.5 | 18.1 |
| r5 | 12.2 | 16.7 | 19.8 | 22.3 | 27.8 | 3.1 | 4.2 | 4.9 | 5.6 | 6.9 |
| r10 | 7.7 | 10.5 | 12.4 | 14.0 | 17.5 | 1.9 | 2.6 | 3.1 | 3.5 | 4.4 |

(3) Plotting




(4) Calculation of peak flood discharge (Qp) Qp=1/3.6 x re x A

| Return period | re | tp | Qp |
|---|---|---|---|
| 2 | 5.5 | 125 | 14 |
| 5 | 8.5 | 103 | 21 |
| 10 | 11.5 | 89.7 | 29 |
| 20 | 14.5 | 80.8 | 36 |
| 50 | 17.5 | 74.2 | 44 |

## Table A.3.21 Flood Discharge on the Nanga River

River : Nanga River

Gauging Station
Catchment area : 21 km2

(1) Calculation of daily maximum rainfall

i) Elevation of middle point for catchment area 1,250 m

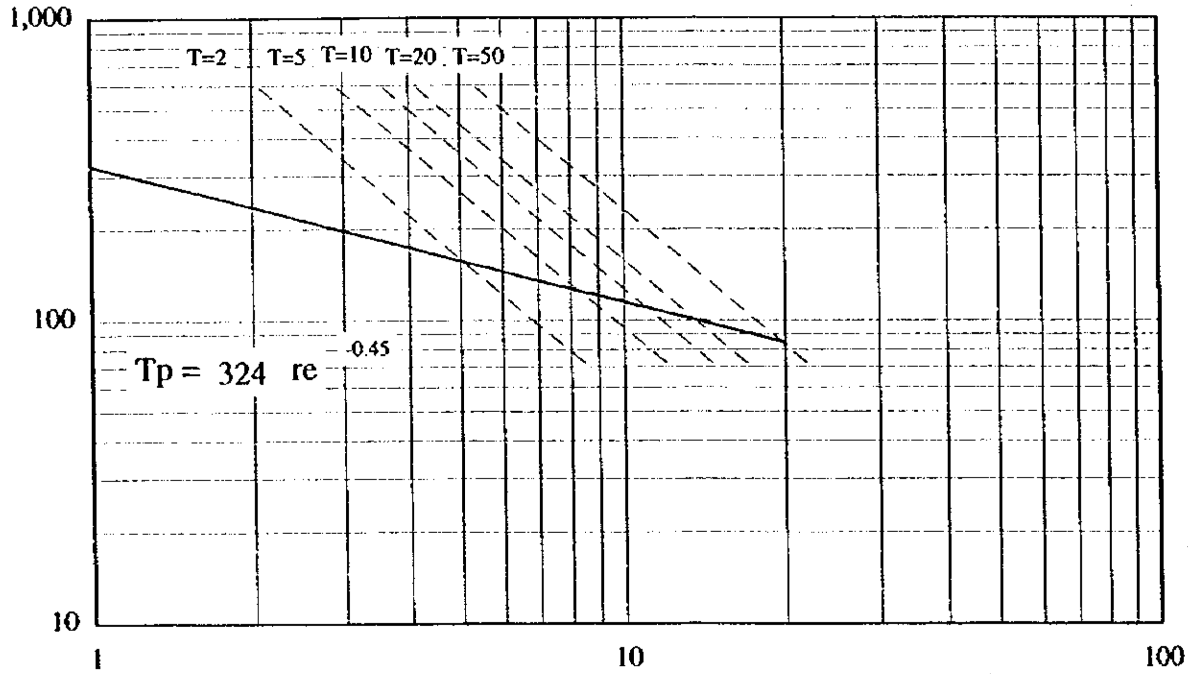
ii) Daily maximum rainfall ($R_{24}$)

| Return period | 2 | 5 | 10 | 20 | 50 |
|---|---|---|---|---|---|
| $R_{24}$ (mm/day) | 110 | 155 | 189 | 219 | 284 |

(2) Calculation of rainfall intensity $rt = R_{24}/t \times (t/24)^{1/3}$ re=0.25 rt

| | rt | | | | | re | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| T hrs | 2 | 5 | 10 | 20 | 50 | 2 | 5 | 10 | 20 | 50 |
| r1 | 34.0 | 48.0 | 58.5 | 67.9 | 88.0 | 8.5 | 12.0 | 14.6 | 17.0 | 22.0 |
| r5 | 13.1 | 18.4 | 22.5 | 26.1 | 33.8 | 3.3 | 4.6 | 5.6 | 6.5 | 8.5 |
| r10 | 8.2 | 11.6 | 14.1 | 16.4 | 21.3 | 2.1 | 2.9 | 3.5 | 4.1 | 5.3 |

(3) Plotting




(4) Calculation of peak flood discharge (Qp) Qp=1/3.6 x re x A

| Return period | re | tp | Qp |
|---|---|---|---|
| 2 | 5.0 | 157 | 29 |
| 5 | 8.4 | 124 | 49 |
| 10 | 11.5 | 108 | 67 |
| 20 | 15.0 | 95.9 | 88 |
| 50 | 20.0 | 84.2 | 117 |

## Table A.4.1 Result of Water Quality Test in PhaseI(1/2)

| Potential Irrigation Problem | Units | Degree of Restriction on Use: None (N) | Slight to Moderate (SM) | Severe (S) | Test Item | Unit | Location No.1 Kukuletwa Intake Site 1-1 | 1-2 | 1-3 | Location No.2 Chemuka Spring 2-1 | 2-2 | 2-3 | Location No.3 Kikuletwa TPC Pump Station 3-1 | 3-2 | 3-3 | Location No.4 Kikafu River 4-1 | 4-2 | 4-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Salinity** | | | | | | | | | | | | | | | | | | |
| ECw | dS/m | < 0.7 | 0.7 - 3.0 | > 3.0 | ECw | dS/m | 0.96 SM | 1.00 SM | 1.00 SM | 1.35 SM | 1.38 SM | 1.29 SM | 0.39 N | 0.39 N | 0.39 N | 0.06 N | 0.06 N | 0.06 N |
| **Infiltration** | | | | | | | | | | | | | | | | | | |
| SAR = 0 - 3 and ECw = | | > 0.7 | 0.7 - 0.2 | < 0.2 | | | | | | | | | | | | | | |
| SAR = 3 - 6 and ECw = | | > 1.2 | 1.2 - 0.3 | < 0.3 | Na | me/l | 8.10 | 7.93 | 7.90 | 8.75 | 8.66 | 8.70 | 4.26 | 4.29 | 0.85 | 0.26 | 0.26 | 0.26 |
| SAR = 6 - 12 and ECw = | | > 1.9 | 1.9 - 0.5 | < 0.5 | Ca | me/l | 0.41 | 0.41 | 0.41 | 0.49 | 0.48 | 0.48 | 0.16 | 0.15 | 0.26 | 0.05 | 0.05 | 0.05 |
| SAR = 12 - 20 and ECw = | | > 2.9 | 2.9 - 1.3 | < 1.3 | Mg | me/l | 2.61 | 2.89 | 2.66 | 4.11 | 4.01 | 4.32 | 1.71 | 1.02 | 0.97 | 0.14 | 0.15 | 0.12 |
| SAR = 20 - 40 and ECw = | | > 5.0 | 5.0 - 2.9 | < 2.9 | adj RNa | | 6.76 SM | 6.32 SM | 6.53 SM | 5.91 N | 5.92 N | 5.74 N | 4.30 SM | 5.39 SM | 1.09 SM | 0.47 S | 0.46 S | 0.46 S |
| **Specific Ion Toxicity** | | | | | | | | | | | | | | | | | | |
| Sodium (Na) | SAR | < 3 | 3 - 9 | > 9 | adj RNa | | 6.76 SM | 6.32 SM | 6.53 SM | 5.91 SM | 5.92 SM | 5.74 SM | 4.30 SM | 5.39 SM | 1.09 N | 0.47 N | 0.46 N | 0.46 N |
| Chloride (cl) | me/l | < 4 | 4 - 10 | > 10 | Cl | me/l | 0.73 N | 0.74 N | 0.75 N | 1.01 N | 1.01 N | 1.01 N | 0.39 N | 0.39 N | 0.39 N | 0.17 N | 0.20 N | 0.17 N |
| Boron (B) | mg/l | < 0.7 | 0.7 - 3.0 | > 3.0 | Boron | mg/l | | | | | | | | | | | | |
| **Miscellaneous Effects** | | | | | | | | | | | | | | | | | | |
| Nitrogen (No3 - N) | mg/l | < 5 | 5 - 30 | > 30 | No3-N | mg/l | 0.20 N | 0.20 N | 0.30 N | 2.60 N | 2.60 N | 2.60 N | 0.65 N | 0.50 N | 0.70 N | 1.19 N | 1.20 N | 1.20 N |
| Bicarbonate (HCO3) | me/l | < 1.5 | 1.5 - 8.5 | > 8.5 | HCO3- | me/l | 7.87 SM | 7.98 SM | 8.10 SM | 11.93 S | 11.70 S | 11.75 S | 2.87 SM | 2.92 SM | 2.89 SM | 0.43 N | 0.43 N | 0.41 N |
| pH | | Normal Range 6.5 - 8.4 | | | pH | | 7.25 OK | 7.25 OK | 7.27 OK | 6.61 OK | 6.59 OK | 6.60 OK | 7.70 OK | 7.71 OK | 7.70 OK | 6.80 OK | 6.80 OK | 6.81 OK |

## Table A.4.1 Result of Water Quality Test in PhaseI(2/2)

| Potential Irrigation Problen | Units | Degree of Restriction on Use: None (N) | Slight to Moderate (SM) | Severe (S) | Test Item | Unit | Location No.5 Njoro River at Mabogini Intake: 5-1 | 5-2 | 5-3 | Location No.6 Rau River at Rau Intake: 6-1 | 6-2 | 6-3 | Location No.7 Mabogini Main Canal: 7-1 | 7-2 | 7-3 | Location No.8 Rau Ya Kati Main Canal: 8-1 | 8-2 | 8-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Salinity** | | | | | | | | | | | | | | | | | | |
| ECw | dS/m | < 0.7 | 0.7 - 3.0 | > 3.0 | ECw | dS/m | 0.22 N | 0.21 N | 0.20 N | 0.18 N | 0.18 N | 0.16 N | 0.19 N | 0.20 N | 0.20 N | 0.16 N | 0.17 N | 0.18 N |
| **Infiltration** | | | | | | | | | | | | | | | | | | |
| SAR = 0 - 3 and ECw = | | > 0.7 | 0.7 - 0.2 | < 0.2 | | | | | | | | | | | | | | |
| SAR = 3 - 6 and ECw = | | > 1.2 | 1.2 - 0.3 | < 0.3 | Na | me/l | 1.39 | 1.43 | 1.39 | 0.84 | 0.88 | 0.83 | 0.88 | 0.87 | 0.88 | 0.83 | 0.83 | 0.83 |
| SAR = 6 - 12 and ECw = | | > 1.9 | 1.9 - 0.5 | < 0.5 | Ca | me/l | 0.13 | 0.14 | 0.12 | 0.13 | 0.13 | 0.11 | 0.13 | 0.12 | 0.13 | 0.12 | 0.12 | 0.12 |
| SAR = 12 - 20 and ECw = | | > 2.9 | 2.9 - 1.3 | < 1.3 | Mg | me/l | 0.53 | 0.57 | 0.48 | 0.72 | 0.87 | 0.92 | 0.63 | 0.40 | 0.45 | 0.42 | 0.42 | 0.45 |
| SAR = 20 - 40 and ECw = | | > 5.0 | 5.0 - 2.9 | < 2.9 | adj RNa | | 1.94 SM | 1.95 SM | 1.99 SM | 1.08 S | 1.06 S | 1.03 S | 1.23 S | 1.38 SM | 1.36 SM | 1.31 S | 1.31 S | 1.28 S |
| **Specific Ion Toxicity** | | | | | | | | | | | | | | | | | | |
| Sodium (Na) | SAR | < 3 | 3 - 9 | > 9 | adj RNa | | 1.94 N | 1.95 N | 1.99 N | 1.08 N | 1.06 N | 1.03 N | 1.23 N | 1.38 N | 1.36 N | 1.31 N | 1.31 N | 1.28 N |
| Chloride (cl) | me/l | < 4 | 4 - 10 | > 10 | Cl | me/l | 0.37 N | 0.39 N | 0.34 N | 0.28 N | 0.31 N | 0.31 N | 0.45 N | 0.45 N | 0.48 N | 0.23 N | 0.25 N | 0.25 N |
| Boron (B) | mg/l | < 0.7 | 0.7 - 3.0 | > 3.0 | Boron | mg/l | | | | | | | | | | | | |
| **Miscellaneous Effects** | | | | | | | | | | | | | | | | | | |
| Nitrogen (No3 - N) | mg/l | < 5 | 5 - 30 | > 30 | No3-N | mg/l | 3.80 N | 3.80 N | 3.81 N | 0.80 N | 0.80 N | 0.90 N | 4.20 N | 4.30 N | 4.00 N | 0.20 N | 0.30 N | 0.30 N |
| Bicarbonate (HCO3) | me/l | < 1.5 | 1.5 - 8.5 | > 8.5 | HCO3- | me/l | 1.07 N | 1.07 N | 1.08 N | 1.16 N | 1.18 N | 1.16 N | 1.05 N | 1.03 N | 1.03 N | 1.16 N | 1.20 N | 1.20 N |
| pH | | Normal Range 6.5 - 8.4 | | | pH | | 6.53 OK | 6.53 OK | 6.52 OK | 6.96 OK | 6.99 OK | 6.95 OK | 7.02 OK | 7.00 OK | 7.02 OK | 7.06 OK | 7.04 OK | 7.06 OK |

## Table A.4.2 Result of Water Quality Test for Irrigation in PhaseII(1/2)

| FAO Standard | | | | | | | Location No.1 | | | Location No.2 | | | Location No.3 | | | Location No.4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Potential Irrigation Problem | Units | Degree of Restriction on Use | | | Test Item | Unit | Kukuletwa Intake Site | | | Chemuka Spring | | | Kikuletwa TPC Pump Station | | | Kikafu River | | |
| | | None (N) | Slight to Moderate (SM) | Severe (S) | | | 1-1 | 1-2 | 1-3 | 2-1 | 2-2 | 2-3 | 3-1 | 3-2 | 3-3 | 4-1 | 4-2 | 4-3 |
| **Salinity** | | | | | | | | | | | | | | | | | | |
| ECw | dS/m | < 0.7 | 0.7 - 3.0 | > 3.0 | ECw | dS/m | 0.59 N | 0.67 N | 0.67 N | 1.32 N | 1.30 N | 1.34 N | 0.29 N | 0.30 N | 0.30 N | 0.05 N | 0.05 N | 0.05 N |
| **Infiltration** | | | | | | | | | | | | | | | | | | |
| SAR = 0 - 3 and ECw = | | > 0.7 | 0.7 - 0.2 | < 0.2 | | | | | | | | | | | | | | |
| SAR = 3 - 6 and ECw = | | > 1.2 | 1.2 - 0.3 | < 0.3 | Na | me/l | 4.28 | 4.59 | 4.70 | 9.98 | 13.74 | 11.89 | 1.93 | 1.75 | 1.84 | 0.16 | 0.15 | 0.15 |
| SAR = 6 - 12 and ECw = | | > 1.9 | 1.9 - 0.5 | < 0.5 | Ca | me/l | 0.26 | 0.27 | 0.26 | 0.84 | 0.84 | 0.88 | 0.14 | 0.14 | 0.14 | 0.06 | 0.06 | 0.06 |
| SAR = 12 - 20 and ECw = | | > 2.9 | 2.9 - 1.3 | < 1.3 | Mg | me/l | 1.30 | 1.43 | 1.29 | 4.35 | 4.55 | 4.06 | 0.55 | 0.54 | 0.57 | 0.09 | 0.09 | 0.09 |
| SAR = 20 - 40 and ECw = | | > 5.0 | 5.0 - 2.9 | < 2.9 | adj RNa | | 4.61 SM | 4.77 SM | 5.08 SM | 6.44 SM | 8.69 SM | 7.92 SM | 2.81 SM | 2.56 SM | 2.64 SM | 0.25 S | 0.24 S | 0.23 S |
| **Specific Ion Toxicity** | | | | | | | | | | | | | | | | | | |
| Sodium (Na) | SAR | < 3 | 3 - 9 | > 9 | adj RNa | | 4.61 SM | 4.77 SM | 5.08 SM | 6.44 SM | 8.69 SM | 7.92 SM | 2.81 N | 2.56 N | 2.64 N | 0.25 N | 0.24 N | 0.23 N |
| Chloride (cl) | me/l | < 4 | 4 - 10 | > 10 | Cl | me/l | 0.74 N | 0.75 N | 0.70 N | 1.30 N | 1.24 N | 1.16 N | 0.39 N | 0.41 N | 0.36 N | 0.20 N | 0.08 N | 0.26 N |
| Boron (B) | mg/l | < 0.7 | 0.7 - 3.0 | > 3.0 | Boron | mg/l | | | | | | | | | | | | |
| **Miscellaneous Effects** | | | | | | | | | | | | | | | | | | |
| Nitrogen (No3 - N) | mg/l | < 5 | 5 - 30 | > 30 | No3-N | mg/l | 0.01 N | 0.01 N | 0.01 N | 1.00 N | 0.80 N | 1.40 N | 0.01 N | 0.01 N | 0.01 N | 0.01 N | 0.30 N | 0.01 N |
| Bicarbonate (HCO3) | me/l | < 1.5 | 1.5 - 8.5 | > 8.5 | HCO3- | me/l | 4.1 SM | 3.7 SM | 4.0 SM | 8.8 S | 9.5 S | 9.4 S | 1.7 SM | 1.6 SM | 1.6 SM | 0.2 N | 0.2 N | 0.2 N |
| pH | | Normal Range 6.5 - 8.4 | | | pH | | 7.3 OK | 7.2 OK | 7.3 OK | 6.8 OK | 6.8 OK | 6.9 OK | 6.8 OK | 6.9 OK | 6.8 OK | 6.3 OK | 6.7 OK | 6.8 OK |

# Table A.4.2 Result of Water Quality Test for Irrigation in PhaseII(2/2)

| FAO Standard<br>Potential Irrigation Problem | Units | Degree of Restriction on Use<br>None (N) | Slight to Moderate (SM) | Severe (S) | Test Item | Unit | Location No.5<br>Njoro River at Mabogini Intake<br>5-1 | 5-2 | 5-3 | Location No.6<br>Rau River at Rau Intake<br>6-1 | 6-2 | 6-3 | Location No.7<br>Mabogini Main Canal<br>7-1 | 7-2 | 7-3 | Location No.8<br>Rau Ya Kati Main Canal<br>8-1 | 8-2 | 8-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Salinity** | | | | | | | | | | | | | | | | | | |
| ECw | dS/m | < 0.7 | 0.7 - 3.0 | > 3.0 | ECw | dS/m | 0.17 N | 0.19 N | 0.17 N | 0.15 N | 0.15 N | 0.15 N | 0.16 N | 0.16 N | 0.16 N | 0.15 N | 0.15 N | 0.14 N |
| **Infiltration** | | | | | | | | | | | | | | | | | | |
| SAR = 0 - 3 and ECw = | | > 0.7 | 0.7 - 0.2 | < 0.2 | | | | | | | | | | | | | | |
| SAR = 3 - 6 and ECw = | | > 1.2 | 1.2 - 0.3 | < 0.3 | Na | me/l | 0.85 | 0.81 | 0.79 | 0.53 | 0.54 | 0.54 | 0.76 | 0.81 | 0.54 | 0.54 | 0.53 | 0.55 |
| SAR = 6 - 12 and ECw = | | > 1.9 | 1.9 - 0.5 | < 0.5 | Ca | me/l | 0.10 | 0.11 | 0.11 | 0.13 | 0.12 | 0.12 | 0.10 | 0.11 | 0.11 | 0.13 | 0.12 | 0.12 |
| SAR = 12 - 20 and ECw = | | > 2.9 | 2.9 - 1.3 | < 1.3 | Mg | me/l | 0.23 | 0.23 | 0.22 | 0.34 | 0.35 | 0.36 | 0.23 | 0.21 | 0.22 | 0.36 | 0.28 | 0.37 |
| SAR = 20 - 40 and ECw = | | > 5.0 | 5.0 - 2.9 | < 2.9 | adj RNa | | 1.41 S | 1.34 S | 1.32 S | 0.77 S | 0.84 S | 0.78 S | 1.27 S | 1.36 S | 0.90 S | 0.77 S | 0.85 S | 0.78 S |
| **Specific Ion Toxicity** | | | | | | | | | | | | | | | | | | |
| Sodium (Na) | SAR | < 3 | 3 - 9 | > 9 | adj RNa | | 1.41 N | 1.34 N | 1.32 N | 0.77 N | 0.84 N | 0.78 N | 1.27 N | 1.36 N | 0.90 N | 0.77 N | 0.85 N | 0.78 N |
| Chloride (cl) | me/l | < 4 | 4 - 10 | > 10 | Cl | me/l | 0.31 N | 0.33 N | 0.32 N | 0.03 N | 0.03 N | 0.03 N | 0.04 N | 0.04 N | 0.05 N | 0.24 N | 0.25 N | 0.25 N |
| Boron (B) | mg/l | < 0.7 | 0.7 - 3.0 | > 3.0 | Boron | mg/l | | | | | | | | | | | | |
| **Miscellaneous Effects** | | | | | | | | | | | | | | | | | | |
| Nitrogen (No3 - N) | mg/l | < 5 | 5 - 30 | > 30 | No3-N | mg/l | 2.30 N | 1.80 N | 2.10 N | 0.70 N | 0.30 N | 0.50 N | 2.00 N | 2.20 N | 2.20 N | 0.01 N | 0.01 N | 0.01 N |
| Bicarbonate (HCO3) | me/l | < 1.5 | 1.5 - 8.5 | > 8.5 | HCO3- | me/l | 0.8 N | 0.9 N | 1.0 N | 0.9 N | 0.9 N | 0.8 N | 0.8 N | 0.9 N | 0.8 N | 0.8 N | 0.9 N | 0.8 N |
| pH | | Normal Range 6.5 - 8.4 | | | pH | | 6.6 OK | 6.3 OK | 6.4 OK | 6.6 OK | 6.9 OK | 6.8 OK | 6.7 OK | 6.8 OK | 6.7 OK | 6.7 OK | 6.7 OK | 6.7 OK |

# Table A.4.3 Result of Water Quality Test for Domestic Water in PhaseI(1/2)

| Group | No | Substance | | Units | Tanzanian Standard Rural Water | Location No.1 Kukuletwa Intake Site | | | Location No.2 Chemuka Spring | | | Location No.3 Kikuletwa TPC Pump Station | | | Location No.4 Kikafu River | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1-1 | 1-2 | 1-3 | 2-1 | 2-2 | 2-3 | 3-1 | 3-2 | 3-3 | 4-1 | 4-2 | 4-3 |
| Toxic | 1 | Lead | Pb | mg/l | 0.1 | | | | | | | | | | | | |
| | 2 | Arsenic | As | mg/l | 0.05 | | | | | | | | | | | | |
| | 3 | Selenium | Se | mg/l | 0.5 | | | | | | | | | | | | |
| | 4 | Chromium (6+) | Cr | mg/l | | | | | | | | | | | | | |
| | 5 | Cyanide | Cn | mg/l | 0.02 | | | | | | | | | | | | |
| | 6 | Cadmium | Cd | mg/l | 0.05 | | | | | | | | | | | | |
| | 7 | Barium | Ba | mg/l | 1 | | | | | | | | | | | | |
| | 8 | Mercury | Hg | mg/l | - | | | | | | | | | | | | |
| | 9 | Silver | Ag | mg/l | - | | | | | | | | | | | | |
| Affecting Human Health | 1 | Fluoride | F | mg/l | 8 | 4.00 ○ | 4.04 ○ | 4.00 ○ | 1.52 ○ | 1.54 ○ | 1.50 ○ | 1.00 ○ | 1.04 ○ | 1.02 ○ | 0.08 ○ | 0.06 ○ | 0.06 ○ |
| | 2 | Nitrate | $NO_3$ | mg/l | 30 | 0.22 ○ | 0.20 ○ | 0.30 ○ | 2.60 ○ | 2.60 ○ | 2.60 ○ | 0.65 ○ | 0.60 ○ | 0.70 ○ | 1.10 ○ | 1.20 ○ | 1.20 ○ |
| Organoleptic | 1 | Colour | | mg pt/l | 50 | | | | | | | | | | | | |
| | 2 | Turbidit | $SiO_2$ | mg/l | 30 | | | | | | | | | | | | |
| | 3 | Taste | | mg/l | - | | | | | | | | | | | | |
| | 4 | Odour | | mg/l | | | | | | | | | | | | | |
| Substances Affecting Potability and Suitability of Water for General Domestic Use | 5 | pH | | | 6.5-9.2 | 7.25 ○ | 7.25 ○ | 7.27 ○ | 6.61 ○ | 6.59 ○ | 6.60 ○ | 7.70 ○ | 7.71 ○ | 7.70 ○ | 6.80 ○ | 6.80 ○ | 6.81 ○ |
| Salinity and Hardness | 6 | Total Filtrable Residue | | mg/l | 200 | | | | | | | | | | | | |
| | 7 | Total Hardness | $CaCO_3$ | mg/l | 600 | | | | | | | | | | | | |
| | 8 | Calcium | Ca | mg/l | - | | | | | | | | | | | | |
| | 9 | Magnesium | Mg | mg/l | 300 | 31.9 ○ | 35.2 ○ | 32.5 ○ | 50.2 ○ | 48.9 ○ | 52.7 ○ | 20.9 ○ | 12.4 ○ | 11.8 ○ | 1.7 ○ | 1.8 ○ | 1.5 ○ |
| | 10 | Magnesium+Sodium | Mg+Na | mg/l | 1000 | 218.3 ○ | 217.5 ○ | 214.1 ○ | 251.4 ○ | 248.1 ○ | 252.7 ○ | 118.9 ○ | 111.0 ○ | 31.4 ○ | 7.8 ○ | 7.8 ○ | 7.4 ○ |
| | 11 | Sulphate | $SO_4$ | mg/l | 600 | 40.0 ○ | 39.0 ○ | 39.0 ○ | 42.0 ○ | 41.0 ○ | 41.0 ○ | 13.0 ○ | 14.0 ○ | 14.0 ○ | 1.0 ○ | 1.0 ○ | 2.0 ○ |
| | 12 | Chloride | Cl | mg/l | 600 | 26.0 ○ | 26.1 ○ | 26.5 ○ | 36.0 ○ | 36.0 ○ | 36.0 ○ | 14.0 ○ | 14.0 ○ | 14.0 ○ | 6.0 ○ | 7.0 ○ | 6.0 ○ |
| Less Toxic Metals | 13 | Iron | Fe | mg/l | 1.5 | 0.24 ○ | 0.21 ○ | 0.22 ○ | 0.05 ○ | 0.05 ○ | 0.04 ○ | 0.25 ○ | 0.25 ○ | 6.27 ○ | 0.19 ○ | 0.15 ○ | 0.16 ○ |
| | 14 | Manganese | Mn | mg/l | 0 | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ |
| | 15 | Copper | Cu | mg/l | 3 | | | | | | | | | | | | |
| | 16 | Zinc | Zn | mg/l | 15 | | | | | | | | | | | | |
| Organic Pollution of Natural Origin | 17 | BOD (5 days, at 65F) | | mg/l | 6 | - | - | - | - | - | - | - | - | - | - | - | - |
| | 18 | PV (Oxgen Abs. KMNO) | | mg/l | 2 | | | | | | | | | | | | |
| | 19 | Ammonium ($NH_4$+$NH_3$) | | mg/l | 0.5 | 0.11 ○ | 0.12 ○ | 0.09 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.12 ○ | 0.14 ○ | 0.11 ○ | 0.08 ○ | 0.06 ○ | 0.06 ○ |
| | 20 | Total Nirtogen excluding $NO_3$ | | mg/l | 1 | | | | | | | | | | | | |
| OrganicPollution Introduced Artificially | 21 | Surfactants (alkyl Benzyl sulphorates) | | mg/l | 2 | | | | | | | | | | | | |
| | 22 | Organic Matter (As carbon in chloriform extract) | | mg/l | 0.5 | | | | | | | | | | | | |
| | 23 | Phenolic Substance As Phenol | | mg/l | 0.002 | | | | | | | | | | | | |

# Table A.4.3 Result of Water Quality Test for Domestic Water in Phase Ⅰ (2/2)

| Group | | No | Substance | | Units | Tanzanian Standard Rural Water | Location No.5 Njoro River at Mabogini Intake | | | Location No.6 Rau River at Rau Intake | | | Location No.7 Mabogini Main Canal | | | Location No.8 Rau Ya Kati Main Canal | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 5-1 | 5-2 | 5-3 | 6-1 | 6-2 | 6-3 | 7-1 | 7-2 | 7-3 | 8-1 | 8-2 | 8-3 |
| Toxic | | 1 | Lead | Pb | mg/l | 0.1 | | | | | | | | | | | | |
| | | 2 | Arsenic | As | mg/l | 0.05 | | | | | | | | | | | | |
| | | 3 | Selenium | Se | mg/l | 0.5 | | | | | | | | | | | | |
| | | 4 | Chromium (6+) | Cr | mg/l | | | | | | | | | | | | | |
| | | 5 | Cyanide | Cn | mg/l | 0.02 | | | | | | | | | | | | |
| | | 6 | Cadmium | Cd | mg/l | 0.05 | | | | | | | | | | | | |
| | | 7 | Barium | Ba | mg/l | 1 | | | | | | | | | | | | |
| | | 8 | Mercury | Hg | mg/l | - | | | | | | | | | | | | |
| | | 9 | Silver | Ag | mg/l | - | | | | | | | | | | | | |
| Affecting Human Health | | 1 | Fluoride | F | mg/l | 8 | 0.27 ○ | 0.29 ○ | 0.27 ○ | 0.20 ○ | 0.20 ○ | 0.22 ○ | 0.24 ○ | 0.24 ○ | 0.22 ○ | 0.21 ○ | 0.20 ○ | 0.21 ○ |
| | | 2 | Nitrate | $NO_3$ | mg/l | 30 | 3.80 ○ | 3.80 ○ | 3.81 ○ | 0.80 ○ | 0.80 ○ | 0.90 ○ | 4.20 ○ | 4.30 ○ | 4.00 ○ | 0.20 ○ | 0.30 ○ | 0.30 ○ |
| Organoleptic | | 1 | Colour | | mg pt/l | 50 | | | | | | | | | | | | |
| | | 2 | Turbidit | $SiO_2$ | mg/l | 30 | | | | | | | | | | | | |
| | | 3 | Taste | | mg/l | - | | | | | | | | | | | | |
| | | 4 | Odour | | mg/l | | | | | | | | | | | | | |
| Substances Affecting Potability and Suitability of Water for General Domestic Use | Salinity and Hardness | 5 | pH | | | 6.5-9.2 | 6.53 ○ | 6.53 ○ | 6.52 ○ | 6.96 ○ | 6.99 ○ | 6.98 ○ | 7.02 ○ | 7.00 ○ | 7.02 ○ | 7.06 ○ | 7.04 ○ | 7.06 ○ |
| | | 6 | Total Filtrable Residue | | mg/l | 200 | | | | | | | | | | | | |
| | | 7 | Total Hardness | $CaCO_3$ | mg/l | 600 | | | | | | | | | | | | |
| | | 8 | Calcium | Ca | mg/l | - | | | | | | | | | | | | |
| | | 9 | Magnesium | Mg | mg/l | 300 | 6.5 ○ | 7.0 ○ | 5.9 ○ | 8.8 ○ | 10.6 ○ | 11.2 ○ | 7.7 ○ | 4.9 ○ | 5.5 ○ | 5.1 ○ | 5.1 ○ | 5.5 ○ |
| | | 10 | Magnesium+Sodium | Mg+Na | mg/l | 1000 | 38.4 ○ | 39.8 ○ | 37.9 ○ | 28.1 ○ | 30.7 ○ | 30.4 ○ | 27.8 ○ | 24.9 ○ | 25.7 ○ | 24.2 ○ | 24.2 ○ | 24.6 ○ |
| | | 11 | Sulphate | $SO_4$ | mg/l | 600 | 3.0 ○ | 3.0 ○ | 3.0 ○ | 1.0 ○ | 1.0 ○ | 1.0 ○ | 3.0 ○ | 4.0 ○ | 3.0 ○ | 1.0 ○ | 2.0 ○ | 1.0 ○ |
| | | 12 | Chloride | Cl | mg/l | 600 | 13.0 ○ | 14.0 ○ | 12.0 ○ | 10.0 ○ | 11.0 ○ | 11.0 ○ | 16.0 ○ | 16.0 ○ | 17.0 ○ | 8.0 ○ | 9.0 ○ | 9.0 ○ |
| | Less Toxic Metals | 13 | Iron | Fe | mg/l | 1.5 | 0.10 ○ | 0.08 ○ | 0.07 ○ | 0.46 ○ | 0.50 ○ | 0.47 ○ | 0.21 ○ | 0.19 ○ | 0.20 ○ | 0.52 ○ | 0.53 ○ | 0.53 ○ |
| | | 14 | Manganese | Mn | mg/l | 0 | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ | 0.00 ○ |
| | | 15 | Copper | Cu | mg/l | 3 | | | | | | | | | | | | |
| | | 16 | Zinc | Zn | mg/l | 15 | | | | | | | | | | | | |
| | Organic Pollution of Natural Origin | 17 | BOD (5 days, at 65F) | | mg/l | 6 | - | - | - | - | - | - | - | - | - | - | - | - |
| | | 18 | PV (Oxgen Abs. KMNO) | | mg/l | 2 | | | | | | | | | | | | |
| | | 19 | Ammonium ($NH_4$+$NH_3$) | | mg/l | 0.5 | 0.81 ? | 0.78 ? | 0.77 ? | 0.21 ○ | 0.18 ○ | 0.22 ○ | 0.18 ○ | 0.18 ○ | 0.19 ○ | 0.20 ○ | 0.25 ○ | 0.22 ○ |
| | | 20 | Total Nitrogen excluding $NO_3$ | | mg/l | 1 | | | | | | | | | | | | |
| | Organic Pollution Introduced Artificially | 21 | Surfactants (alkyl Benzyl sulphorates) | | mg/l | 2 | | | | | | | | | | | | |
| | | 22 | Organic Matter (As carbon in chloroform extract) | | mg/l | 0.5 | | | | | | | | | | | | |
| | | 23 | Phenolic Substance As Phenol | | mg/l | 0.002 | | | | | | | | | | | | |

# Table A.4.4 Result of Water Quality Test for Domestic Water in Phase Ⅱ (1/2)

| Group | No | Substance | | Units | Tanzanian Standard | Location No.1 | | | Location No.2 | | | Location No.3 | | | Location No.4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Kukuletwa Intake Site | | | Chemuka Spring | | | Kikuletwa TPC Pump Station | | | Kikafu River | | |
| | | | | | Rural Water | 1-1 | 1-2 | 1-3 | 2-1 | 2-2 | 2-3 | 3-1 | 3-2 | 3-3 | 4-1 | 4-2 | 4-3 |
| Toxic | 1 | Lead | Pb | mg/l | 0.1 | | | | | | | | | | | | |
| | 2 | Arsenic | As | mg/l | 0.05 | | | | | | | | | | | | |
| | 3 | Selenium | Se | mg/l | 0.5 | | | | | | | | | | | | |
| | 4 | Chromium (6+) | Cr | mg/l | | | | | | | | | | | | | |
| | 5 | Cyanide | Cn | mg/l | 0.02 | | | | | | | | | | | | |
| | 6 | Cadmium | Cd | mg/l | 0.05 | | | | | | | | | | | | |
| | 7 | Barium | Ba | mg/l | 1 | | | | | | | | | | | | |
| | 8 | Mercury | Hg | mg/l | - | | | | | | | | | | | | |
| | 9 | Silver | Ag | mg/l | - | | | | | | | | | | | | |
| Affecting Human Health | 1 | Fluoride | F | mg/l | 8 | 0.24 ○ | 0.23 ○ | 0.24 ○ | 0.53 ○ | 0.41 ○ | 0.46 ○ | 0.45 ○ | 0.48 ○ | 0.46 ○ | 0.06 ○ | 0.05 ○ | 0.07 ○ |
| | 2 | Nitrate | $NO_3$ | mg/l | 30 | 0.01 ○ | 0.01 ○ | 0.01 ○ | 1.00 ○ | 0.80 ○ | 1.40 ○ | 0.01 ○ | 0.01 ○ | 0.01 ○ | 0.01 ○ | 0.30 ○ | 0.01 ○ |
| Organoleptic | 1 | Colour | | mg pt/l | 50 | | | | | | | | | | | | |
| | 2 | Turbidit | $SiO_2$ | mg/l | 30 | | | | | | | | | | | | |
| | 3 | Taste | | mg/l | - | | | | | | | | | | | | |
| | 4 | Odour | | mg/l | | | | | | | | | | | | | |
| Substances Affecting Potability and Suitability of Water for General Domestic Use | 5 | pH | | | 6.5-9.2 | 7.27 ○ | 7.15 ○ | 7.25 ○ | 6.80 ○ | 6.82 ○ | 6.89 ○ | 6.82 ○ | 6.85 ○ | 6.81 ○ | 6.25 ○ | 6.72 ○ | 6.76 ○ |
| Salinity and Hardness | 6 | Total Filtrable Residue | | mg/l | 200 | | | | | | | | | | | | |
| | 7 | Total Hardness | $CaCO_3$ | mg/l | 600 | | | | | | | | | | | | |
| | 8 | Calcium | Ca | mg/l | - | | | | | | | | | | | | |
| | 9 | Magnesium | Mg | mg/l | 300 | 15.9 ○ | 17.4 ○ | 15.8 ○ | 53.1 ○ | 55.6 ○ | 49.5 ○ | 6.7 ○ | 6.5 ○ | 6.9 ○ | 1.1 ○ | 1.0 ○ | 1.1 ○ |
| | 10 | Magnesium+Sodium | Mg+Na | mg/l | 1000 | 114.4 ○ | 122.9 ○ | 123.8 ○ | 282.6 ○ | 371.6 ○ | 323.0 ○ | 51.1 ○ | 46.7 ○ | 49.2 ○ | 4.7 ○ | 4.6 ○ | 4.6 ○ |
| | 11 | Sulphate | $SO_4$ | mg/l | 600 | 30.0 ○ | 29.0 ○ | 31.0 ○ | 41.0 ○ | 41.0 ○ | 42.0 ○ | 4.0 ○ | 3.0 ○ | 5.0 ○ | 2.0 ○ | 1.0 ○ | 1.0 ○ |
| | 12 | Chloride | Cl | mg/l | 600 | 26.3 ○ | 26.6 ○ | 24.9 ○ | 46.2 ○ | 43.9 ○ | 41.3 ○ | 13.9 ○ | 14.6 ○ | 12.8 ○ | 7.1 ○ | 2.8 ○ | 9.2 ○ |
| Less Toxic Metals | 13 | Iron | Fe | mg/l | 1.5 | 1.1 ○ | 1.0 ○ | 1.0 ○ | 0.0 ○ | 0.0 ○ | 0.0 ○ | 0.8 ○ | 0.8 ○ | 0.9 ○ | 0.4 ○ | 0.3 ○ | 0.4 ○ |
| | 14 | Manganese | Mn | mg/l | 0 | 0.03 ○ | 0.04 ○ | 0.04 ○ | 0.01 ○ | 0.01 ○ | 0.01 ○ | 0.01 ○ | 0.02 ○ | 0.02 ○ | 0.03 ○ | 0.02 ○ | 0.02 ○ |
| | 15 | Copper | Cu | mg/l | 3 | | | | | | | | | | | | |
| | 16 | Zinc | Zn | mg/l | 15 | | | | | | | | | | | | |
| Organic Pollution of Natural Origin | 17 | BOD (5 days, at 65F) | | mg/l | 6 | - | - | - | - | - | - | - | - | - | - | - | - |
| | 18 | PV (Oxgen Abs. KMNO) | | mg/l | 2 | | | | | | | | | | | | |
| | 19 | Ammonium ($NH_4$+$NH_3$) | | mg/l | 0.5 | 0.5 ○ | 0.6 ? | 0.6 ? | 0.0 ○ | 0.0 ○ | 0.0 ○ | 0.2 ○ | 0.2 ○ | 0.2 ○ | 0.1 ○ | 0.1 ○ | 0.1 ○ |
| | 20 | Total Nirtogen excluding $NO_3$ | | mg/l | 1 | | | | | | | | | | | | |
| Organic Pollution Introduced Artificially | 21 | Surfactants (alkyl Benzyl sulphorates) | | mg/l | 2 | | | | | | | | | | | | |
| | 22 | Organic Matter (As carbon in chloriform extract) | | mg/l | 0.5 | | | | | | | | | | | | |
| | 23 | Phenolic Substance As Phenol | | mg/l | 0.002 | | | | | | | | | | | | |

# Table A.4.4 Result of Water Quality Test for Domestic Water in Phase Ⅱ (2/2)

| Group | | No | Substance | | Units | Tanzanian Standard Rural Water | Location No.5 Njoro River at Mabogini Intake | | | Location No.6 Rau River at Rau Intake | | | Location No.7 Mabogini Main Canal | | | Location No.8 Rau Ya Kati Main Canal | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 5-1 | 5-2 | 5-3 | 6-1 | 6-2 | 6-3 | 7-1 | 7-2 | 7-3 | 8-1 | 8-2 | 8-3 |
| Toxic | | 1 | Lead | Pb | mg/l | 0.1 | | | | | | | | | | | | |
| | | 2 | Arsenic | As | mg/l | 0.05 | | | | | | | | | | | | |
| | | 3 | Selenium | Se | mg/l | 0.5 | | | | | | | | | | | | |
| | | 4 | Chromium (6+) | Cr | mg/l | | | | | | | | | | | | | |
| | | 5 | Cyanide | Cn | mg/l | 0.02 | | | | | | | | | | | | |
| | | 6 | Cadmium | Cd | mg/l | 0.05 | | | | | | | | | | | | |
| | | 7 | Barium | Ba | mg/l | 1 | | | | | | | | | | | | |
| | | 8 | Mercury | Hg | mg/l | - | | | | | | | | | | | | |
| | | 9 | Silver | Ag | mg/l | - | | | | | | | | | | | | |
| Affecting Human Health | | 1 | Fluoride | F | mg/l | 8 | 0.40 ○ | 0.43 ○ | 0.42 ○ | 0.22 ○ | 0.20 ○ | 0.22 ○ | 0.45 ○ | 0.47 ○ | 0.48 ○ | 0.30 ○ | 0.31 ○ | 0.30 ○ |
| | | 2 | Nitrate | $NO_3$ | mg/l | 30 | 2.30 ○ | 1.80 ○ | 2.10 ○ | 0.70 ○ | 0.30 ○ | 0.50 ○ | 2.00 ○ | 2.20 ○ | 2.20 ○ | 0.01 ○ | 0.01 ○ | 0.01 ○ |
| Organoleptic | | 1 | Colour | | mg pt/l | 50 | | | | | | | | | | | | |
| | | 2 | Turbidit | $SiO_2$ | mg/l | 30 | | | | | | | | | | | | |
| | | 3 | Taste | | mg/l | - | | | | | | | | | | | | |
| | | 4 | Odour | | mg/l | | | | | | | | | | | | | |
| Substances Affecting Potability and Suitability of Water for General Domestic Use | Salinity and Hardness | 5 | pH | | | 6.5-9.2 | 6.60 ○ | 6.27 ○ | 6.40 ○ | 6.63 ○ | 6.86 ○ | 6.83 ○ | 6.73 ○ | 6.77 ○ | 6.72 ○ | 6.71 ○ | 6.72 ○ | 6.74 ○ |
| | | 6 | Total Filtrable Residue | | mg/l | 200 | | | | | | | | | | | | |
| | | 7 | Total Hardness | $CaCO_3$ | mg/l | 600 | | | | | | | | | | | | |
| | | 8 | Calcium | Ca | mg/l | - | | | | | | | | | | | | |
| | | 9 | Magnesium | Mg | mg/l | 300 | 2.9 ○ | 2.9 ○ | 2.6 ○ | 4.1 ○ | 4.2 ○ | 4.4 ○ | 2.8 ○ | 2.6 ○ | 2.6 ○ | 4.4 ○ | 3.4 ○ | 4.5 ○ |
| | | 10 | Magnesium+Sodium | Mg+Na | mg/l | 1000 | 22.4 ○ | 21.4 ○ | 20.7 ○ | 16.3 ○ | 16.7 ○ | 16.9 ○ | 20.3 ○ | 21.1 ○ | 15.3 ○ | 16.7 ○ | 15.5 ○ | 17.1 ○ |
| | | 11 | Sulphate | $SO_4$ | mg/l | 600 | 1.0 ○ | 1.0 ○ | 1.0 ○ | 0.0 ○ | 2.0 ○ | 1.0 ○ | 1.0 ○ | 0.0 ○ | 1.0 ○ | 2.0 ○ | 1.0 ○ | 2.0 ○ |
| | | 12 | Chloride | Cl | mg/l | 600 | 11.0 ○ | 11.8 ○ | 11.4 ○ | 1.1 ○ | 1.1 ○ | 1.1 ○ | 1.5 ○ | 1.3 ○ | 1.6 ○ | 8.5 ○ | 8.9 ○ | 8.9 ○ |
| | Less Toxic Metals | 13 | Iron | Fe | mg/l | 1.5 | 0.1 ○ | 0.1 ○ | 0.1 ○ | 0.8 ○ | 0.9 ○ | 0.8 ○ | 0.1 ○ | 0.2 ○ | 0.1 ○ | 0.8 ○ | 0.9 ○ | 0.8 ○ |
| | | 14 | Manganese | Mn | mg/l | 0 | 0.03 ○ | 0.04 ○ | 0.03 ○ | 0.02 ○ | 0.02 ○ | 0.02 ○ | 0.01 ○ | 0.02 ○ | 0.02 ○ | 0.01 ○ | 0.02 ○ | 0.01 ○ |
| | | 15 | Copper | Cu | mg/l | 3 | | | | | | | | | | | | |
| | | 16 | Zinc | Zn | mg/l | 15 | | | | | | | | | | | | |
| | Organic Pollution of Natural Origin | 17 | BOD (5 days, at 65F) | | mg/l | 6 | - | - | - | - | - | - | - | - | - | - | - | - |
| | | 18 | PV (Oxgen Abs. KMNO) | | mg/l | 2 | | | | | | | | | | | | |
| | | 19 | Ammonium ($NH_4$+$NH_3$) | | mg/l | 0.5 | 0.9 ? | 0.9 ? | 1.0 ? | 0.1 ○ | 0.1 ○ | 0.1 ○ | 0.0 ○ | 0.0 ○ | 0.0 ○ | 0.1 ○ | 0.0 ○ | 0.1 ○ |
| | | 20 | Total Nirtogen excluding $NO_3$ | | mg/l | 1 | | | | | | | | | | | | |
| | OrganicPollution Introduced Artificially | 21 | Surfactants (alkyl Benzyl sulphorates) | | mg/l | 2 | | | | | | | | | | | | |
| | | 22 | Organic Matter (As carbon in chloriform extract) | | mg/l | 0.5 | | | | | | | | | | | | |
| | | 23 | Phenolic Substance As Phenol | | mg/l | 0.002 | | | | | | | | | | | | |

# Table A.5.1 Existing Water Rights at Kikuletwa River System

| Water Right Registration No. | Placename | River System | River | Name of holder | Purpose | Discharge lit/sec | Annual Volume 1000 m3/yr |
|---|---|---|---|---|---|---|---|
| 2475 | Kikuletwa P. Station | Kikuletwa | Kikuletwa | Tanesco | Power | 0.00 | 0 |
| 1117 | Kikuletwa P. Station | Kikuletwa | Kikuletwa | Tanesco | Power | 0.00 | 0 |
| 3068 | Kikuletwa P. Station | Kikuletwa | Kikuletwa | Tanesco | Power | 0.00 | 0 |
| 1781 | Samanga | Kikuletwa | Kikuletwa | Jaggery Estate | Irr/dom | 196.88 | 6,209 |
| Total | | | | | | 196.88 | 6,209 |

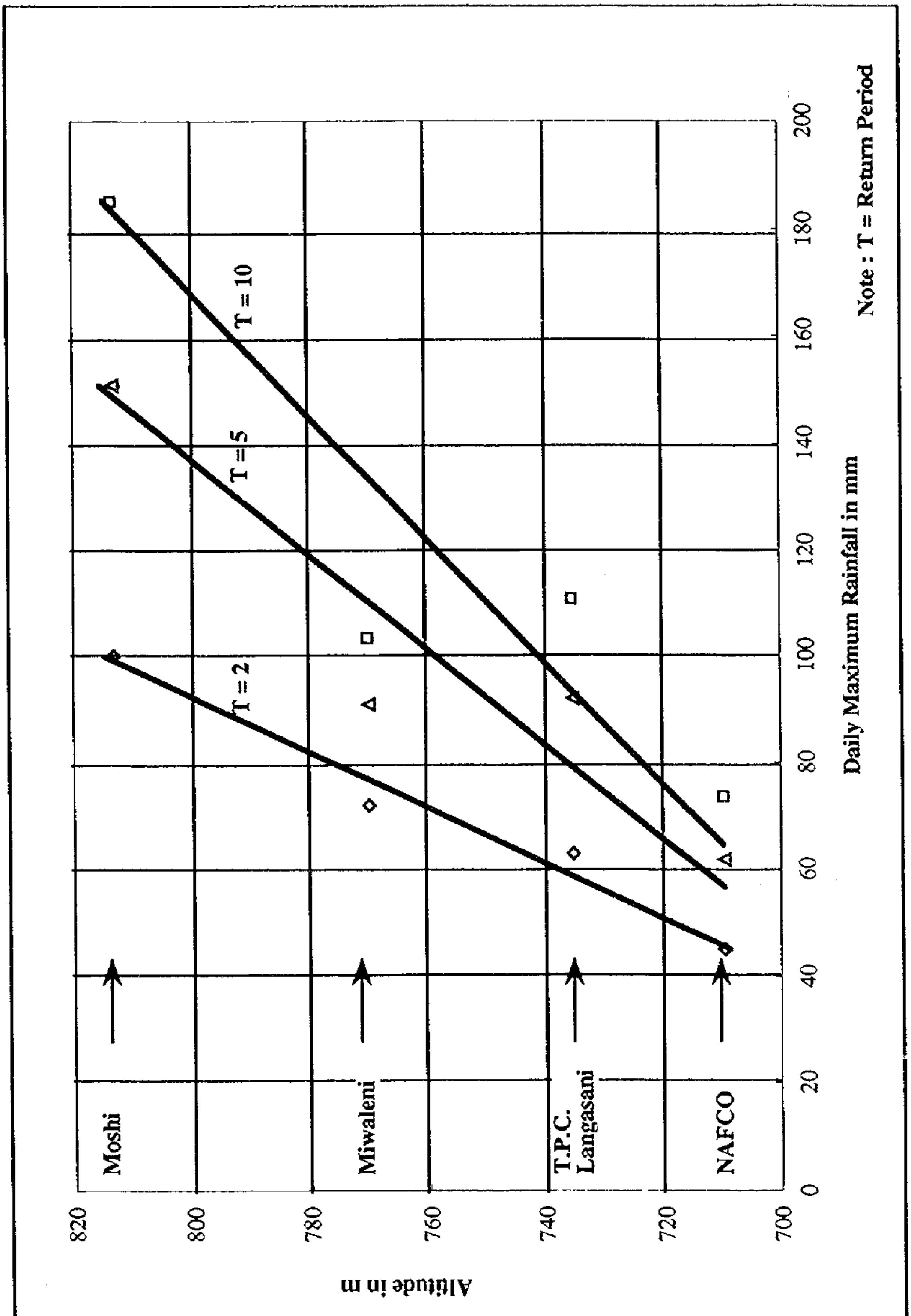
Source : Regional Water Office, Kilimanjaro

# Table A.5.2 Existing Water Rights at Rau River System

| Water Right Registration No. | Placename | River System | River | Name of holder | Purpose | Discharge lit/sec | Annual Volume 1000 m3/yr |
|---|---|---|---|---|---|---|---|
| 2522 | Moshi | Njoro | Njoro ya Dobi | Sefu Msuya H.R | Not Specified | 0.04 | 1 |
| 2271 | Moshi Rly | Njoro | Njoro sprigs | Kilimanjaro District Council | Irrigation | 5.21 | 164 |
| 2280 | Rau Forest | Njoro | Njoro sprigs | District Forest Office Moshi | Irr/dom | 0.10 | 3 |
| 2221 | Moshi | Njoro | Njoro | Tanasco | Irrigation | 28.13 | 887 |
| 25 | Moshi Railway | Njoro | Njoro stream | E.A.R. & H. Moshi Railway Reserve | Domestic w.s | 1.56 | 49 |
| 4811 | Moshi | Njoro | Njoro spring | R.D.D.Kilimanjaro | Dom/indust | 110.00 | 3,469 |
| 4847 | Kaloleni | Njoro | Njoro spring | Kalesa Marthin Almas | Domestic w.s | 0.06 | 2 |
| 4462 | Mabogini-kahe | Njoro | Njoro spring | D.D.D. Moshi | Dom/Livestock | 7.81 | 246 |
| 10 | Kahe Railway Station | Rau | Rau | E.A.R. & H Kahe Railway Station | Domestic w.s | 0.26 | 8 |
| 1332 | Msanga Estate-Uru | Rau | Rau | Malongwe S.E. | Irr/dom | 0.26 | 8 |
| 647 | Okaseni | Rau | Rau | Zambetwa Xinos, Mrs. | Irr/dom | 56.25 | 1,774 |
| 654 | Okaseni | Rau | Rau | Eleftherious C.(farm no 196) | Irr/dom | 56.46 | 1,781 |
| 3071 | Moshi (Farms 181/182) | Rau | Rau | Patel V.U. | Irr/dom | 0.05 | 2 |
| 2379 | Kahe | Rau | Soko | Sammwel John Meen | Irr/dom | 7.03 | 222 |
| 1442 | Uru | Rau | Rau | Malongwe S.E. | Irr/dom | 28.13 | 887 |
| 656 | Kahe Railway Station | Rau | Rau | E.A.R & H.Kahe Railway Station | Dom/indust | 2.08 | 66 |
| 4166 | Uru-Materuni | Rau | Musunga-Mte'e | D.D.D Moshi | Domestic w.s | 9.69 | 306 |
| 2232 | Rau R. Sugar Estate | Rau | Chekereni furr | Kilimanjaro Distrct Council | Irr/dom | 84.38 | 2,661 |
| 970 | Kifumbu Estate Uru | Rau | Rau | Uru Central Co-op, Society | Irr/dom | 0.42 | 13 |
| 971 | Shimbwe, Uru | Rau | Rau | Uru Central Co-op, Society | Irr/dom | 98.44 | 3,104 |
| 426 | Kahe | Rau | Soko | Kahe & Soko Sisal Estate | Mixture | 0.12 | 4 |
| 427 | Chekereni Village | Rau | Rau | Kahe & SOko Sisal estate | Dom/indust | 5.96 | 188 |
| 4808 | Chekereni Village | Rau | Rau | R.D.D Kilimanjaro | Irrigation | 1,135.00 | 35,793 |
| 3321 | Moshi | Rau | Rau | Bulwant Singh | Irr/dom | 0.26 | 8 |
| 1783 | Kahe | Rau | Deho | Mangi of Kahe | Irr/dom | 140.63 | 4,435 |
| 3026 | Mnini | Rau | Rau | Diocese of Moshi | Irr/dom | 0.52 | 16 |
| 4703 | Njoro/Msaranga bridge | Rau | Rau | Joeph Philip Tesha | Irrigation | 0.28 | 9 |
| 4807 | Lower Moshi Irrigation | Rau | Njoro spring | R.D.D. Kilimanjaro | Irrigation | 804.00 | 25,355 |
| 189 | Moshi | Rau | Njoro Swamp | Gupta Stegh | Irr/dom | 56.25 | 1,774 |
| 885 | Njari | Rau | Rau | Mangi Sabbas Laizeri | Irr/dom | 0.00 | 0 |
| 573 | Kahe | Rau | Soko | Kahe & SOko Sisal Estate | Mixture | 1.41 | 44 |
| 574 | Chekereni Village | Rau | Rau | Kahe & SOko Sisal Estate | Irrigation | 161.72 | 5,100 |
| 648 | | Rau | Rau | Kings Z Mrs. | Mixture | 56.88 | 1,794 |
| | Uru Kifungu Estate | Rau | Rau | Uru Central Co-op Society | Irr/dom | 42.66 | 1,345 |
| 2163 | Kahe Sisal Estate | Rau | Rau | Kilimanjaro District Council | Irrigation | 99.12 | 3,126 |
| 3349 | Rau | Rau | Rau | Kibosho entral Co-opSociety | Dom/L'stock/Irr. | 0.00 | 0 |
| Total | | | | | | 3,001.17 | 94,644.90 |

Source : Regional Water Office, Kilimanjaro

# *Figures*




| Figure A.2.1<br>Variation of Daily Maximum Rainfall with Altitude | The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania |
|---|---|
| | Japan International Cooperation Agency |

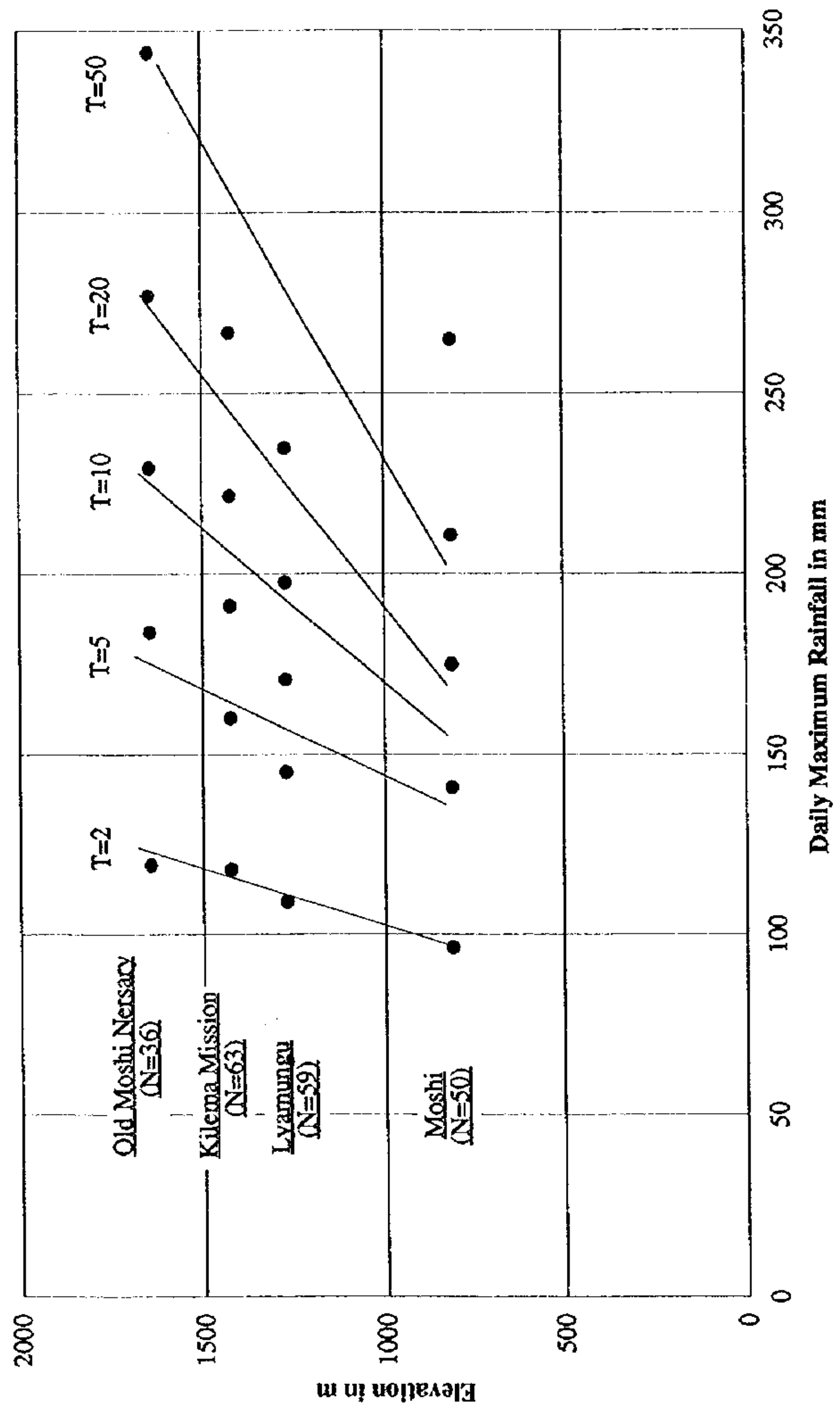



**Figure A.2.2**
**Variation of Daily Maximum Rainfall with Altitude (high Area)**

**The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania**

Japan International Cooperation Agency

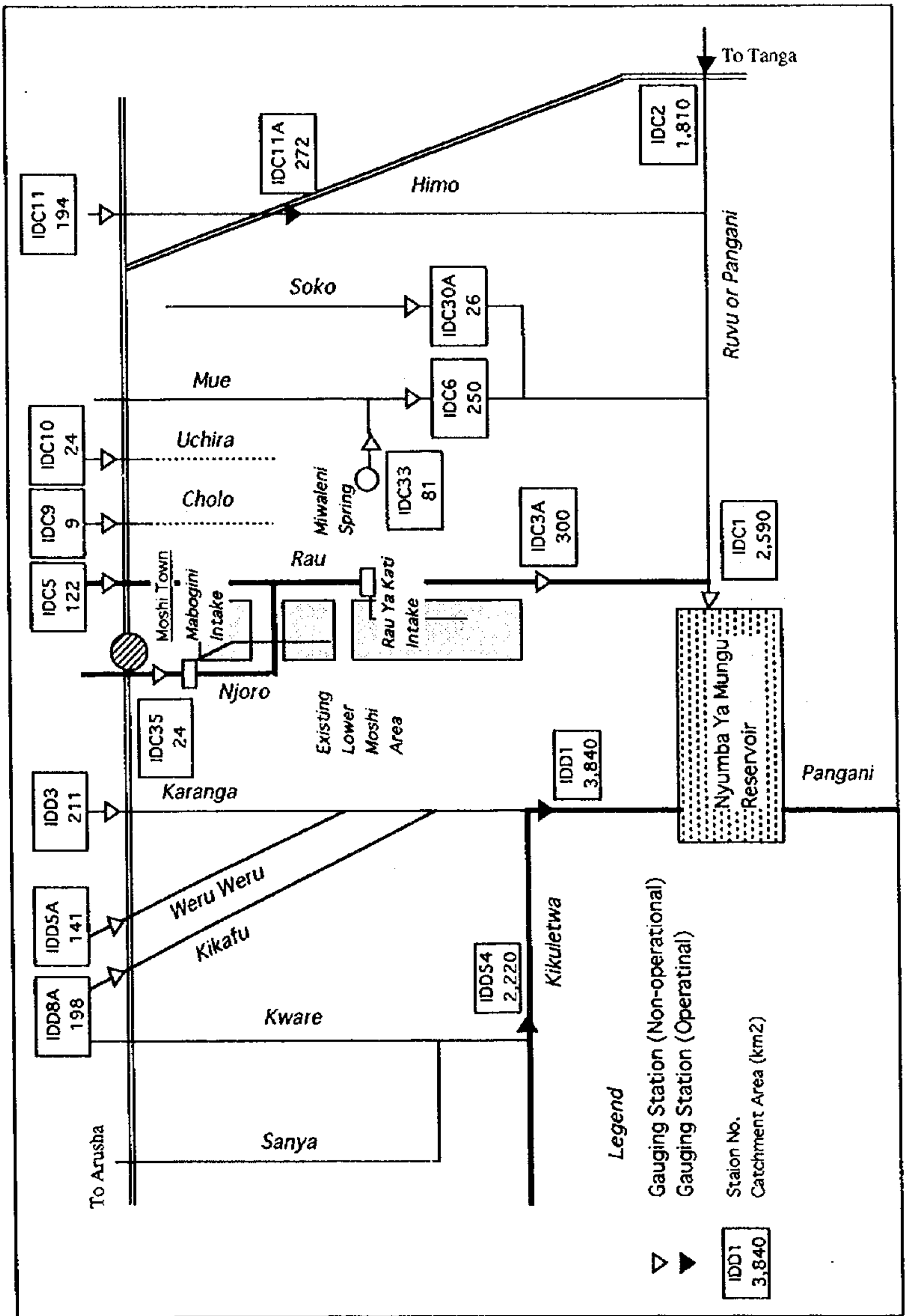
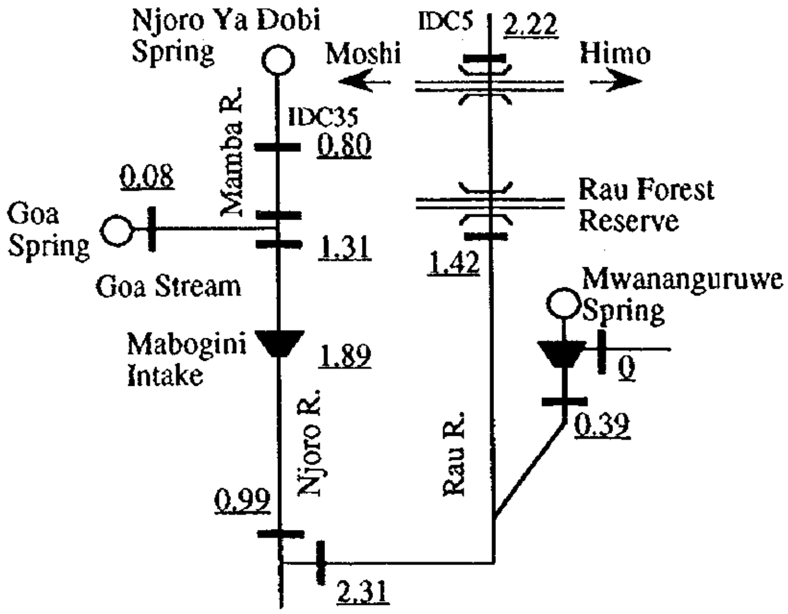


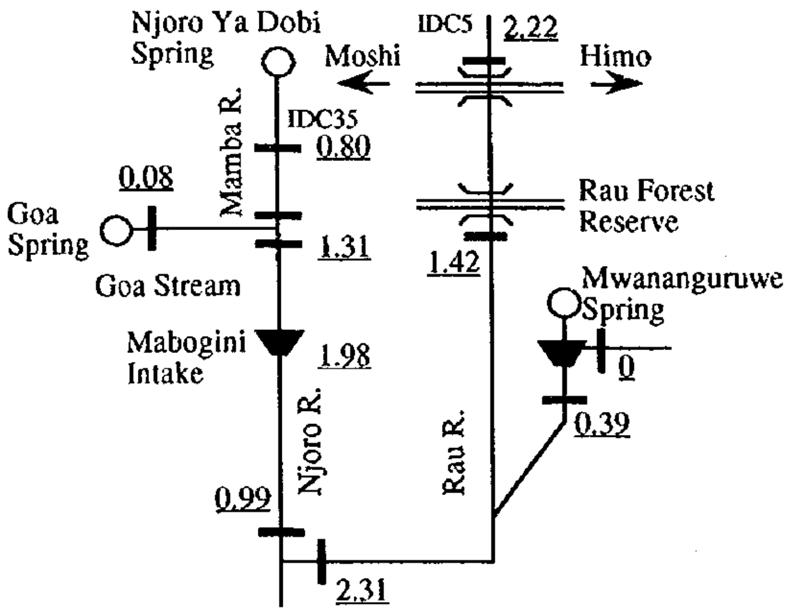

**Figure A.3.1**
**Location of Gauging Stations**

**The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania**

Japan International Cooperation Agency




Measurement on December 1 and 2, 1997




Legend

- ○ Spring
- | Location of Measurement
- ▼ Existing Intake Weir

Measurement on December 16 and 17, 1997

| | |
|---|---|
| **Figure A.3.2**<br>**Results of Discharge Measurement in the Rau River System** | The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania<br>Japan International Cooperation Agency |

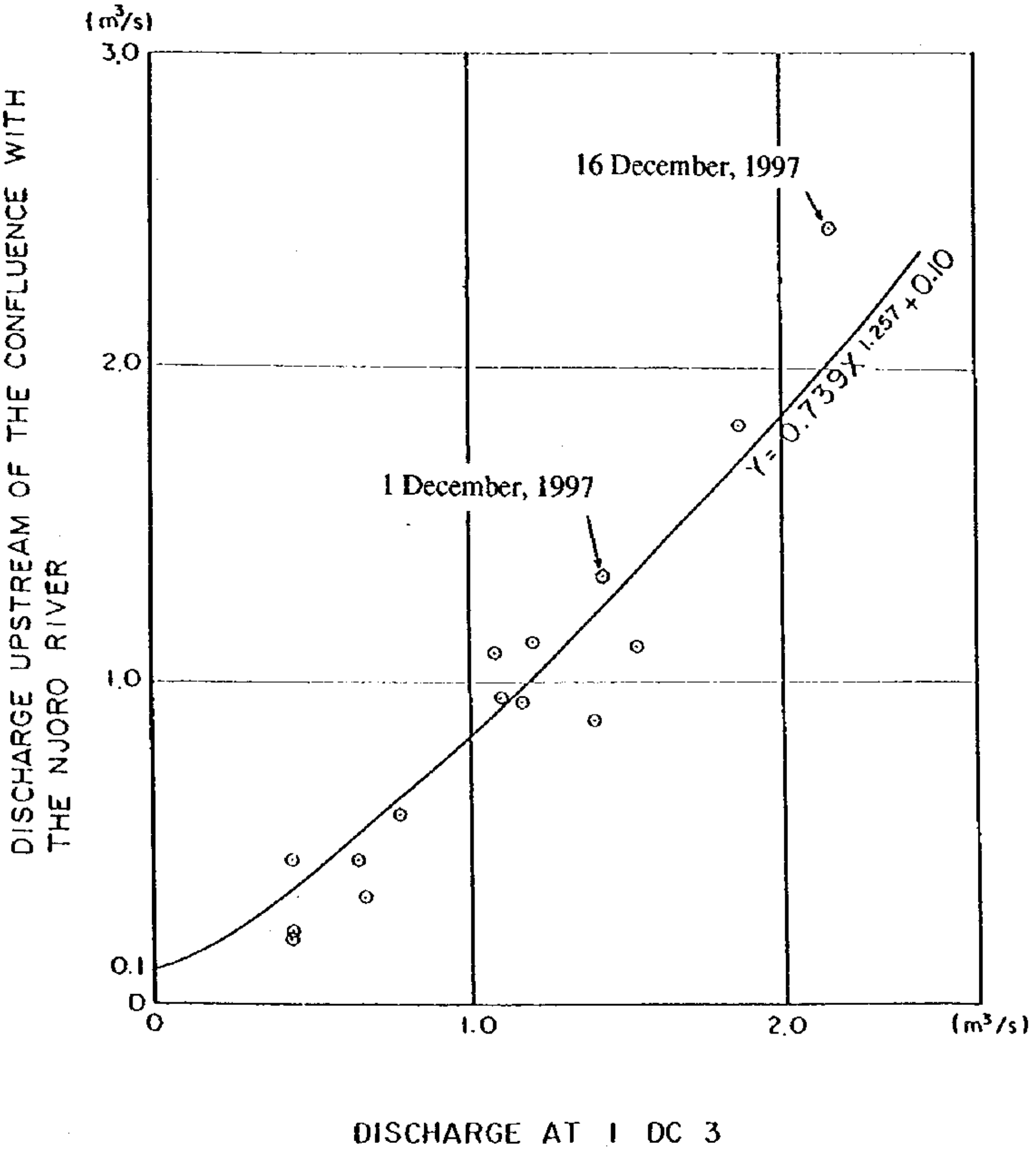
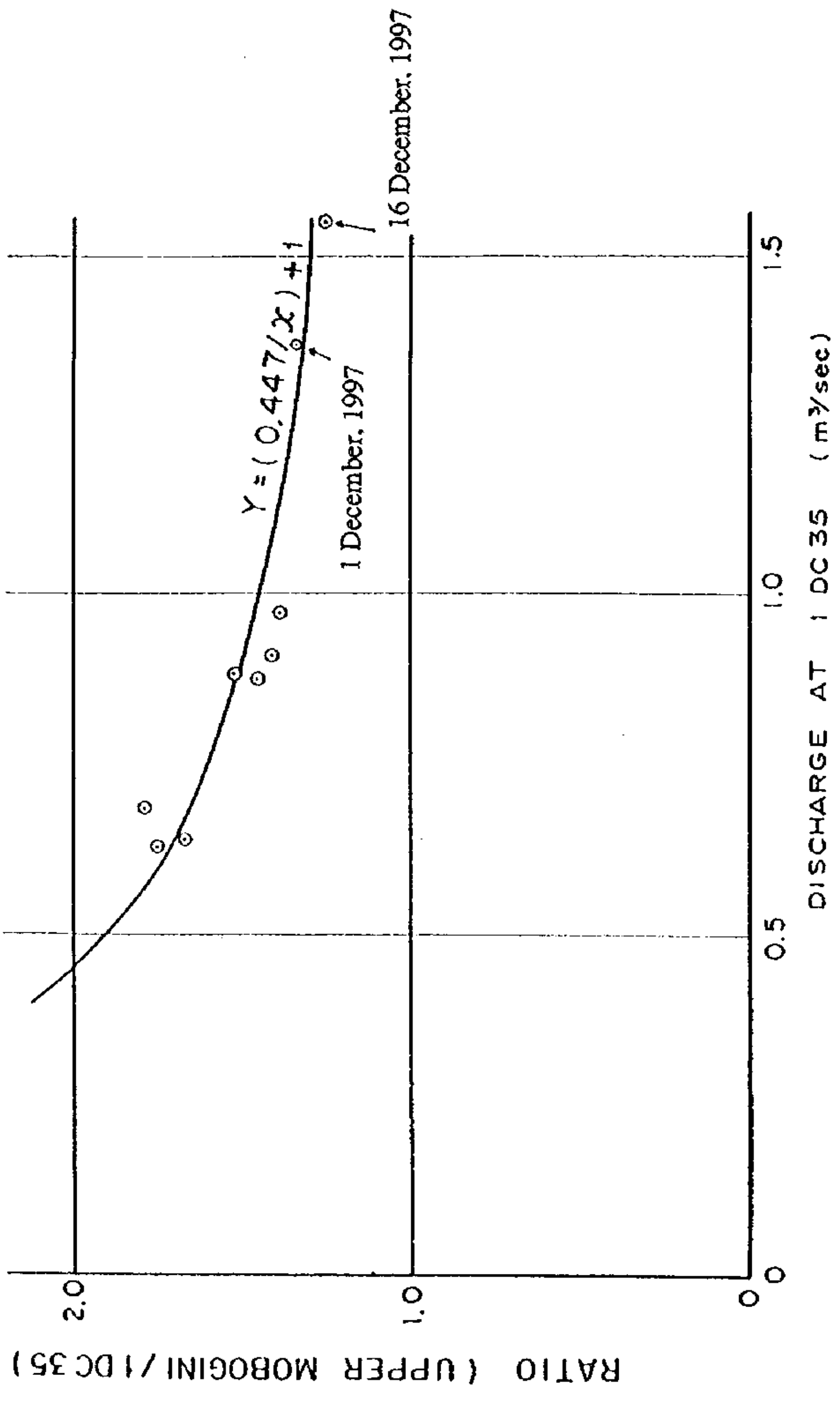


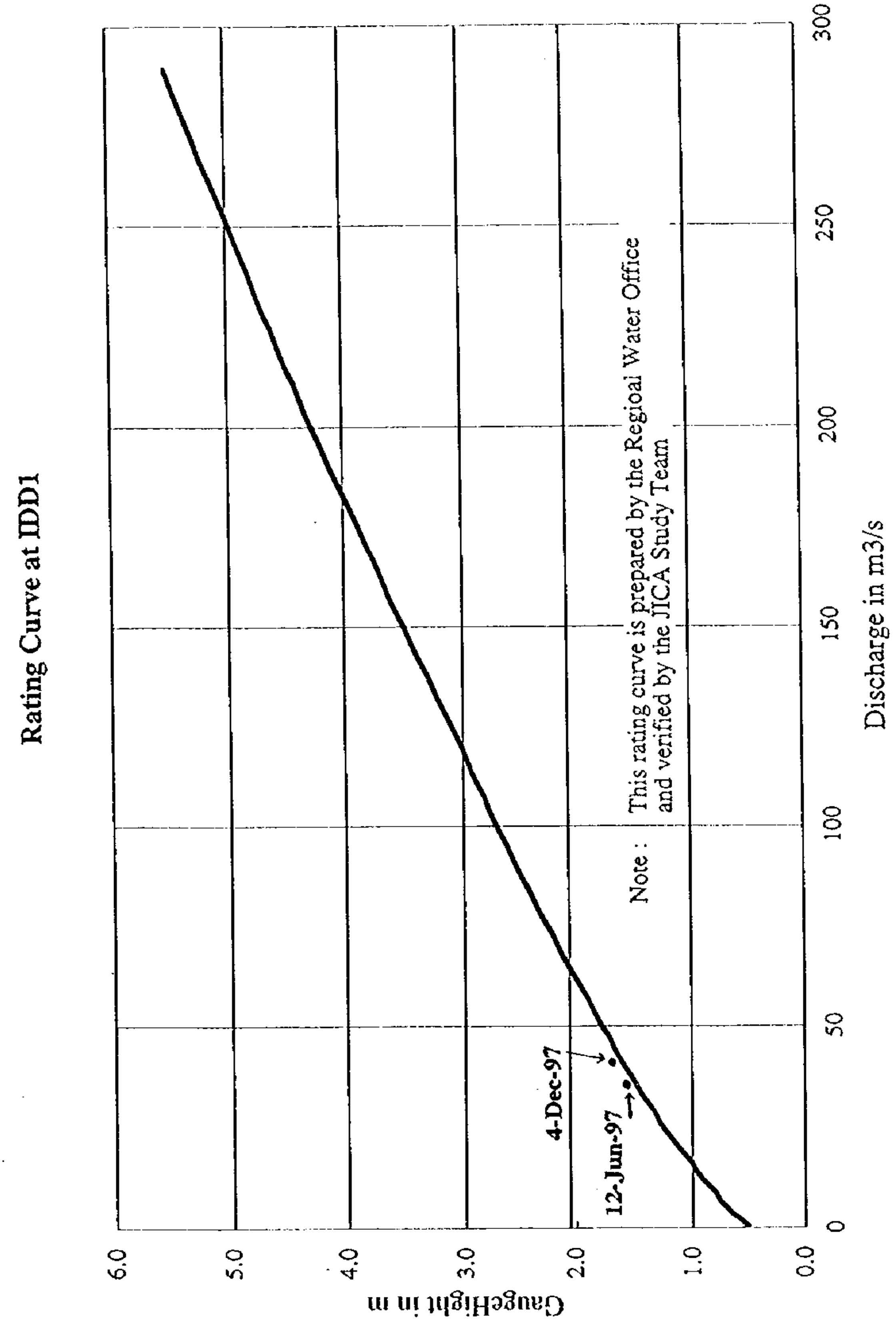

**Figure A.3.3**
**Relation between the Discharge at IDC3 and the Discharge Upstresm of the Confluence with the Njoro River**

The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania

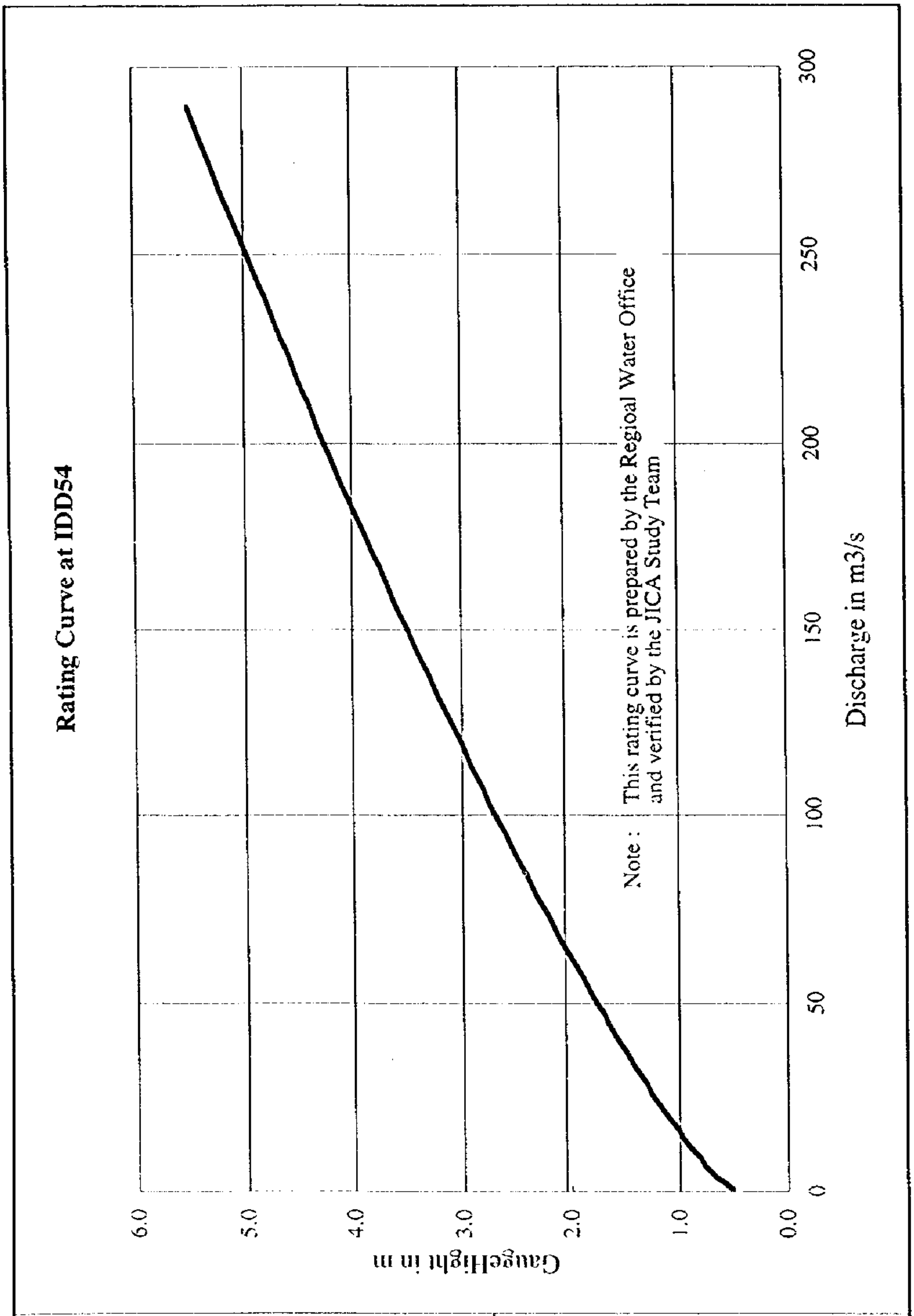
Japan International Cooperation Agency




| **Figure A.3.4**<br>**Relation between the Discharge at IDC35 and the Discharge at Mabogini Intake weir** | **The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania**<br>Japan International Cooperation Agency |
|---|---|




| | |
|---|---|
| **Figure A.3.5**<br>**Rating Curve at IDD1** | **The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania**<br>Japan International Cooperation Agency |




| | |
|---|---|
| **Figure A.3.6**<br>**Rating Curve at IDD54** | **The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania**<br>Japan International Cooperation Agency |

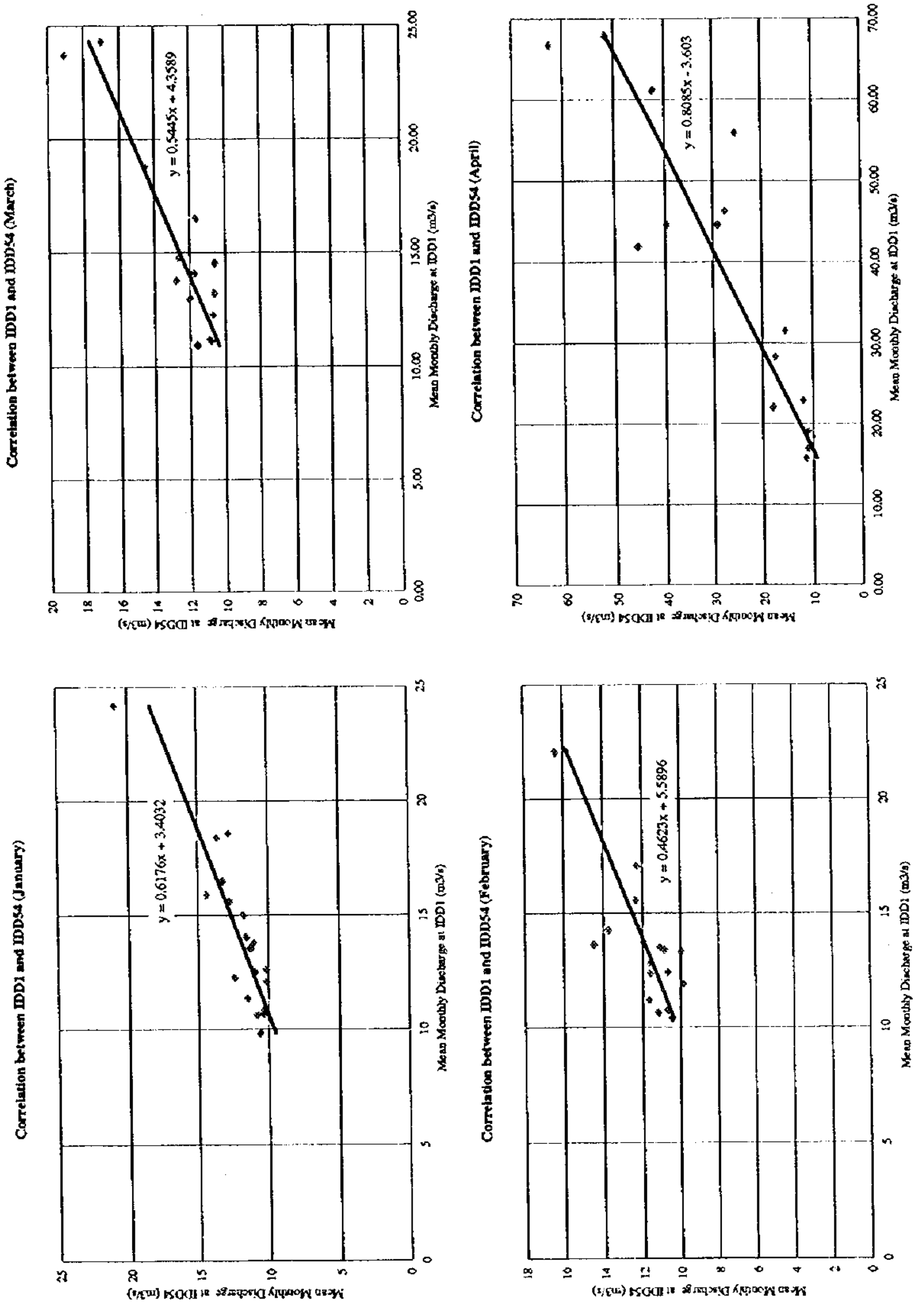



**Figure A.3.7**
**Relation between IDD1 and IDD54 (1/3)**

**The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania**

Japan International Cooperation Agency

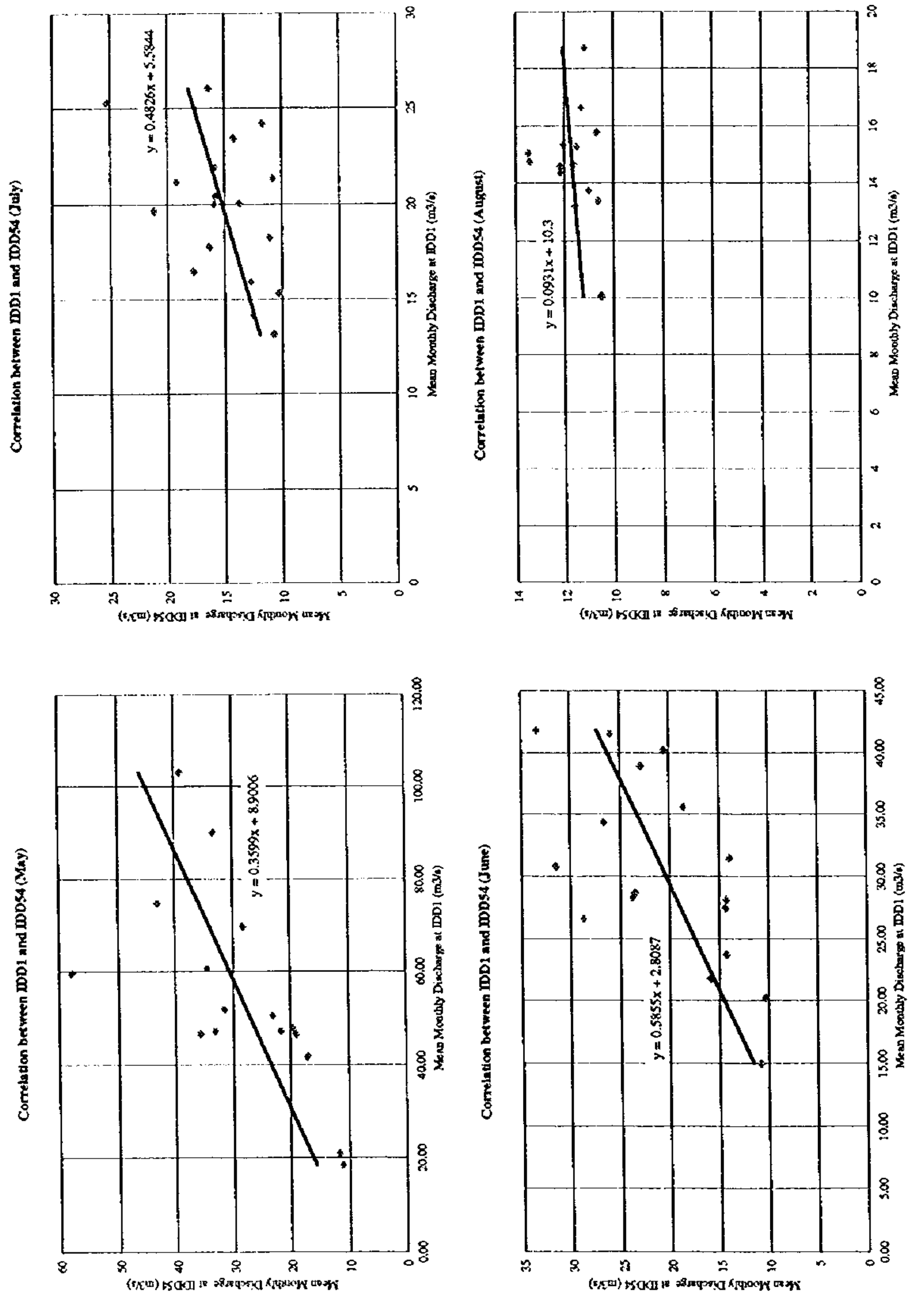
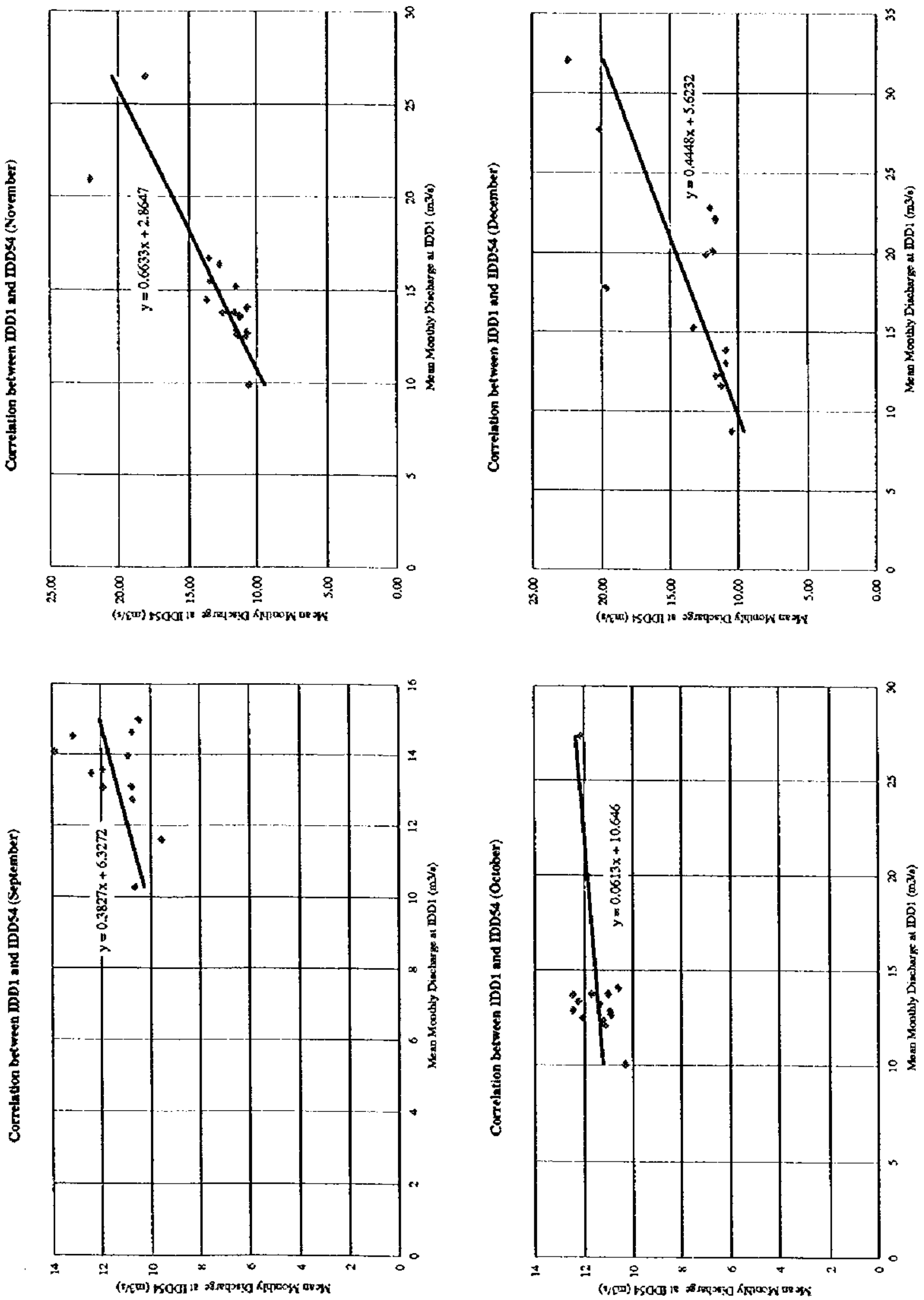


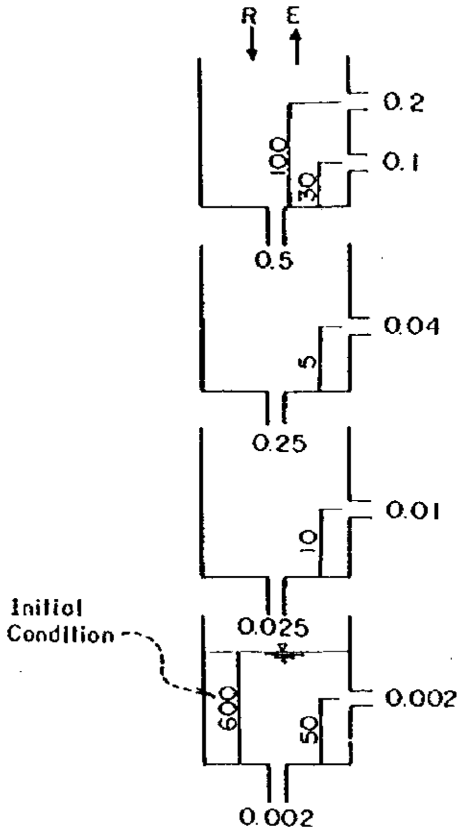

**Figure A.3.7**
**Relation between IDD1 and IDD54 (2/3)**

**The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania**

Japan International Cooperation Agency




| Figure A.3.7<br>Relation between IDD1 and IDD54 (3/3) | The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania |
| --- | --- |
| | Japan International Cooperation Agency |

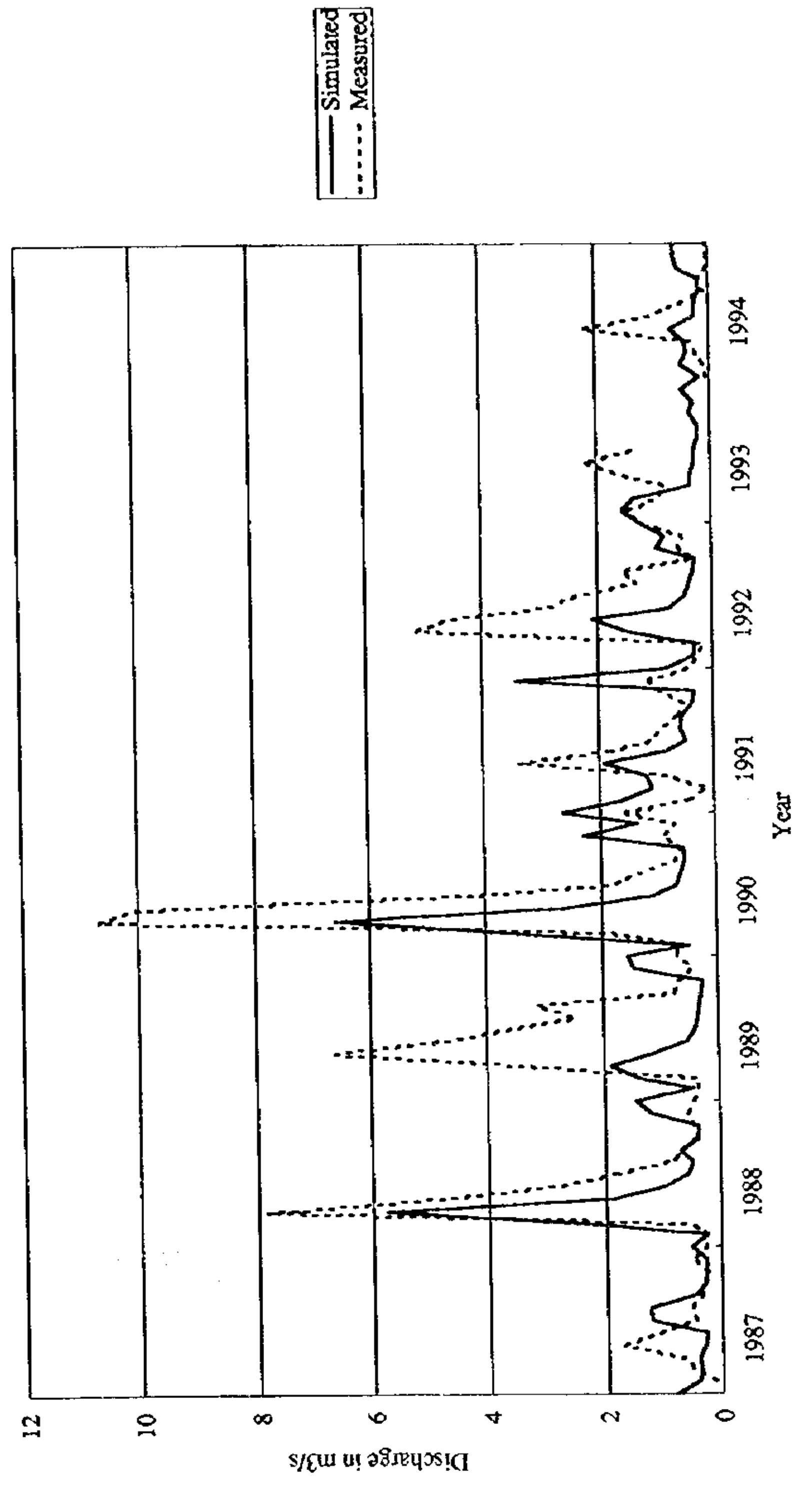



| | Conv.Rate for Rainfall | Areal Evapotrans. (mm/day) | |
|---|---|---|---|
| | | Koranga | Rau |
| J | 1.35 | 1.4 | 1.9 |
| F | 1.56 | 1.4 | 1.8 |
| M | 1.31 | 1.6 | 2.1 |
| A | 0.55 | 1.3 | 1.8 |
| M | 0.48 | 1.1 | 1.4 |
| J | 1.58 | 0.9 | 1.2 |
| J | 2.33 | 0.8 | 1.1 |
| A | 1.25 | 0.8 | 1.1 |
| S | 1.54 | 1.0 | 1.3 |
| O | 1.44 | 1.2 | 1.6 |
| N | 1.06 | 1.4 | 1.8 |
| D | 0.89 | 1.5 | 1.9 |

**Figure A.3.8**
**Simulation Model**

The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania

Japan International Cooperation Agency




| **Figure A.3.9**<br>**Comparison between Simulated and Measured Discharge at the Rau River (Confluence with the Njoro River)** | **The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania** |
|---|---|
| | Japan International Cooperation Agency |

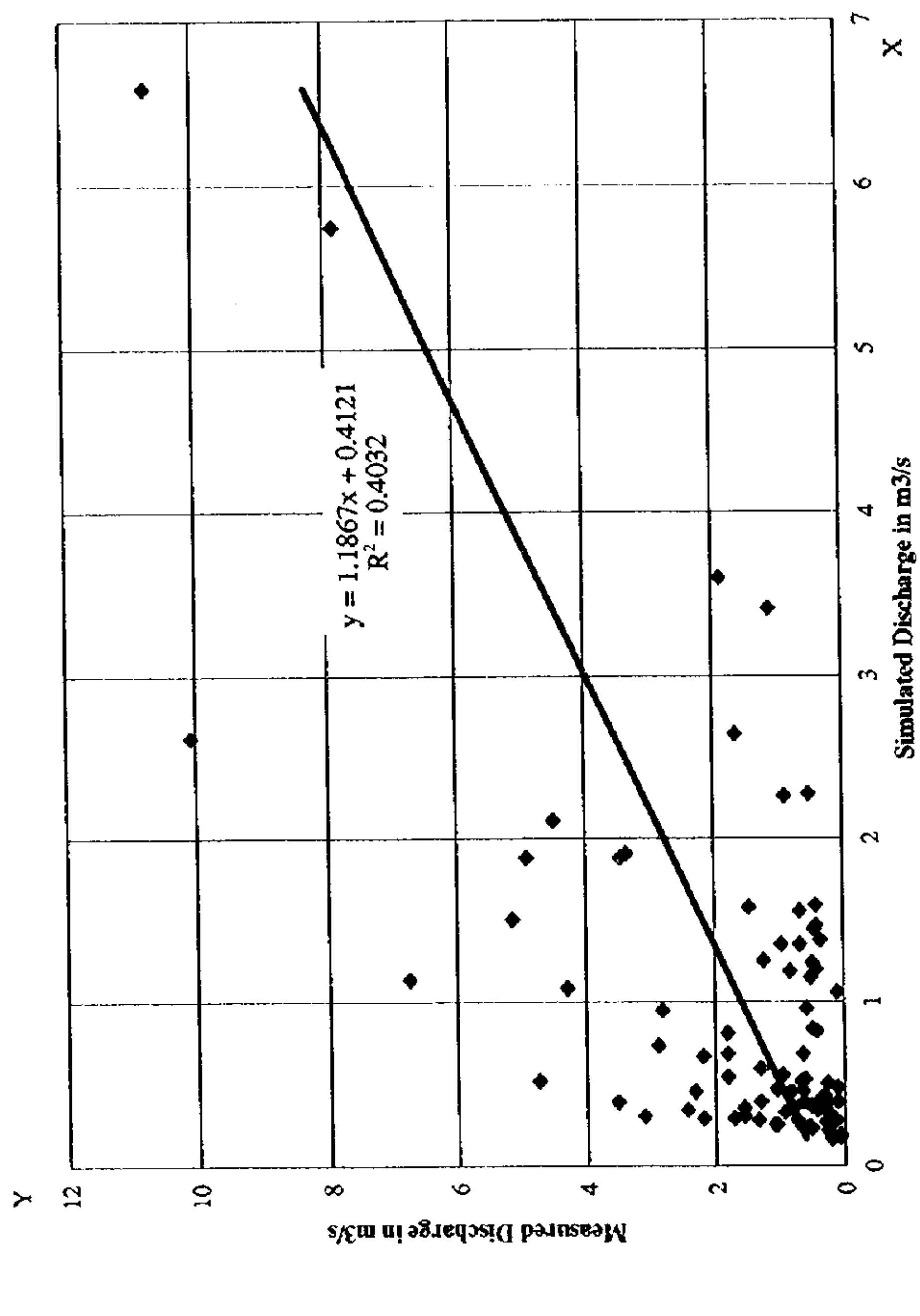



**Figure A.3.10**
**Correlation between Simulated and Measured Discharge at the Rau River (Confluence with the Njoro River)**

The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania

Japan International Cooperation Agency

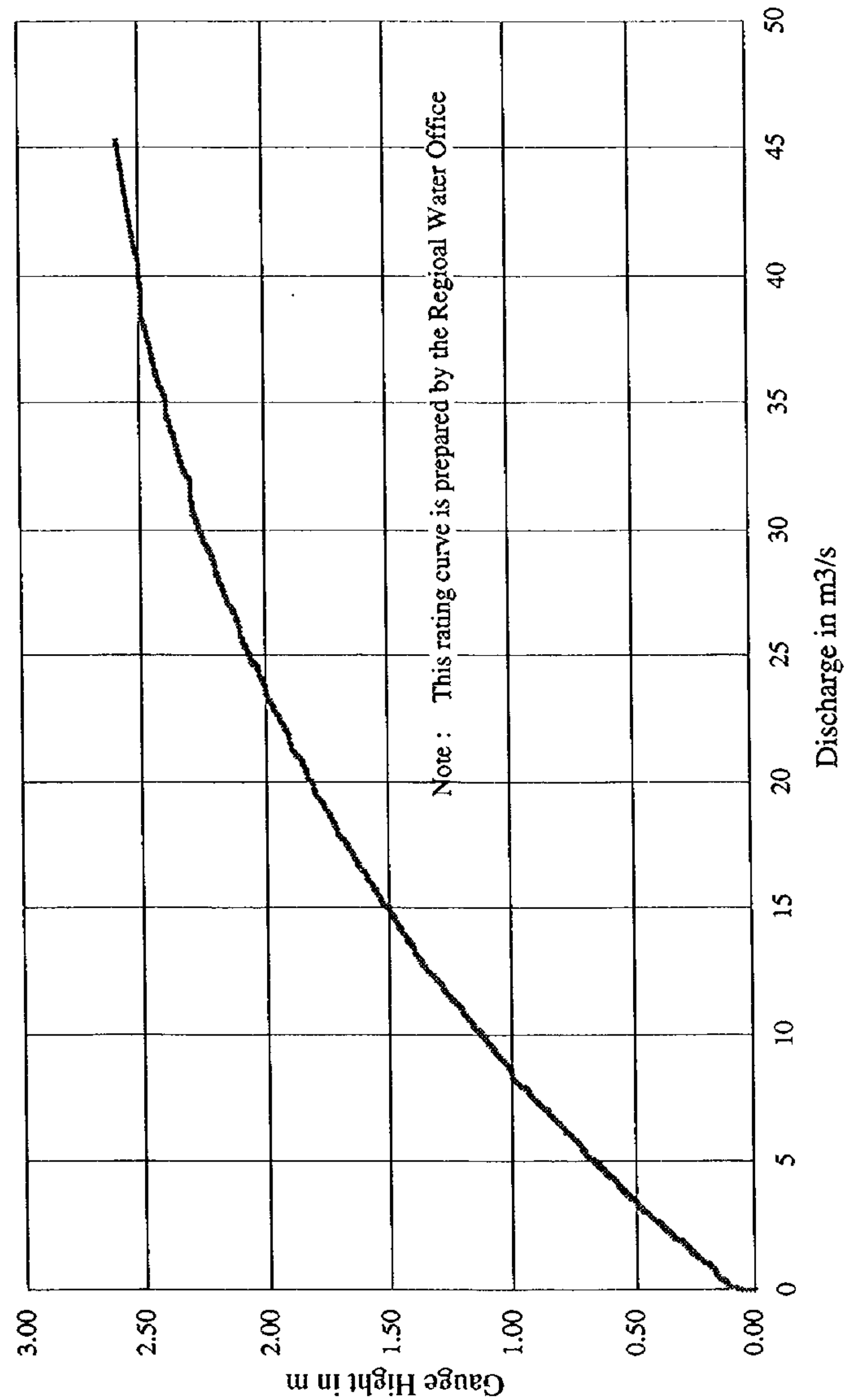



**Figure A.3.11**
**Rating Curve at IDC2A**

**The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania**

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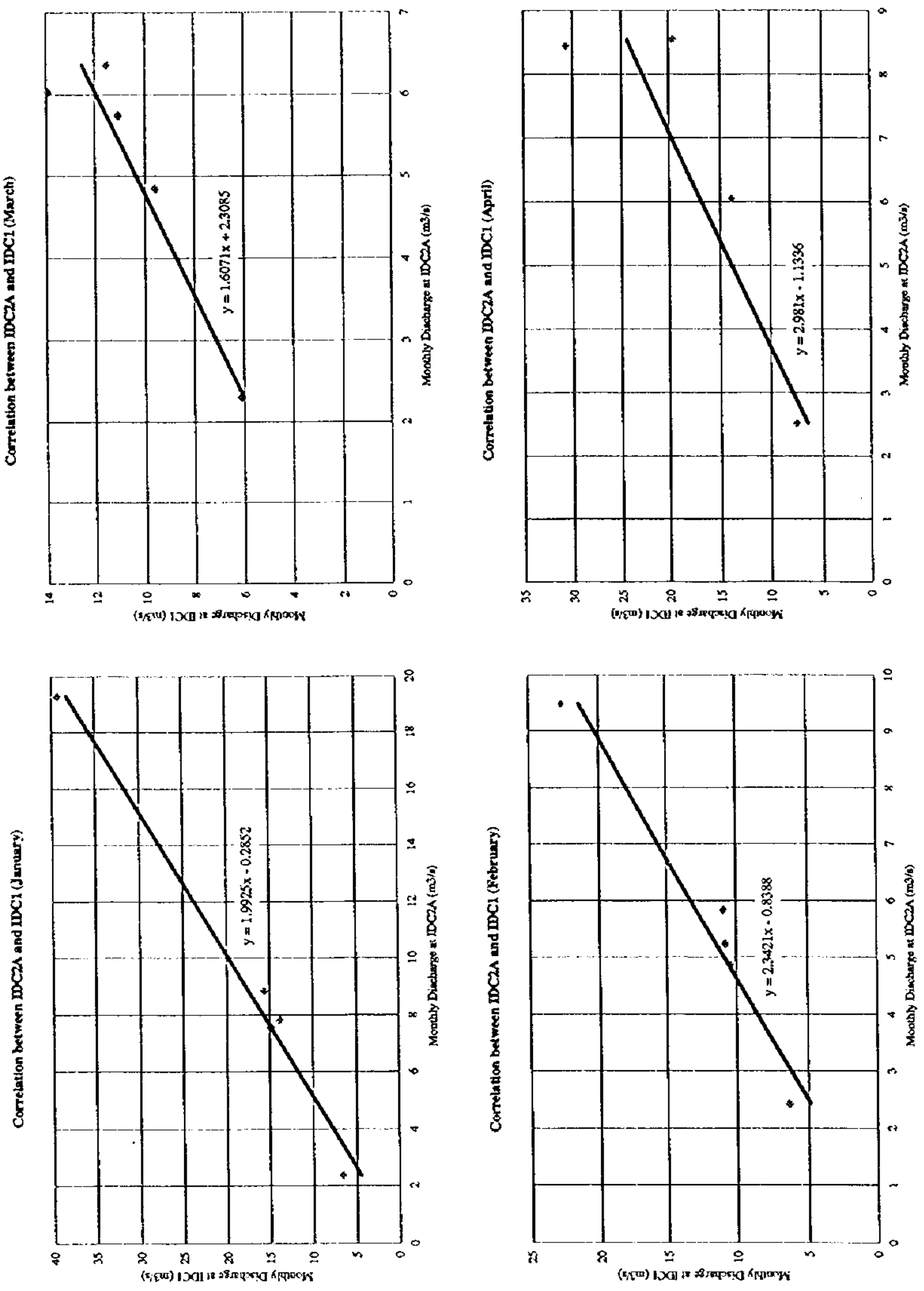
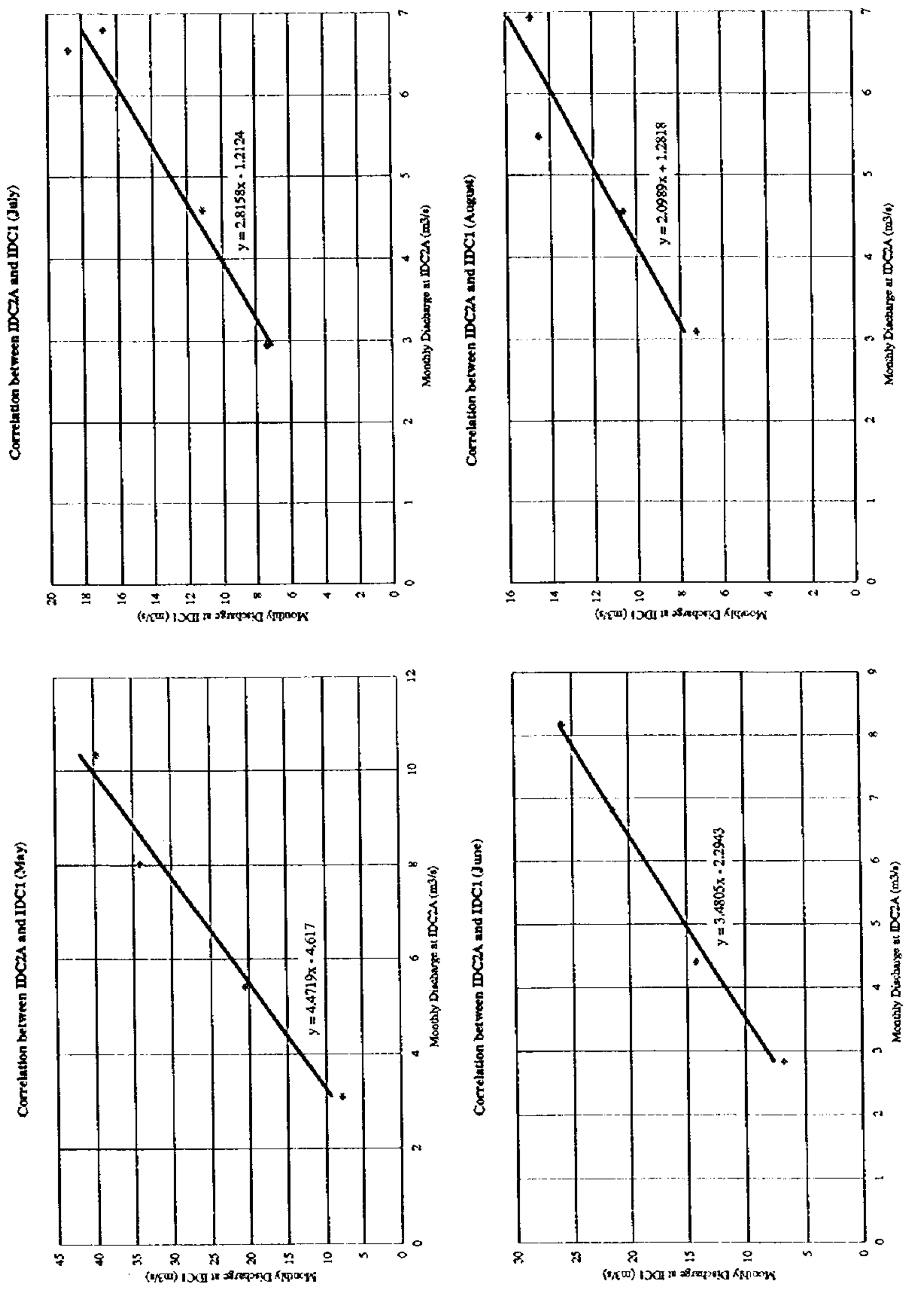



**Figure A.3.12**
**Relation between IDC2A and IDC1 (1/3)**

**The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania**

Japan International Cooperation Agency




| **Figure A.3.12**<br>**Relation between IDC2A and IDC1 (2/3)** | **The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania**<br>Japan International Cooperation Agency |
|---|---|

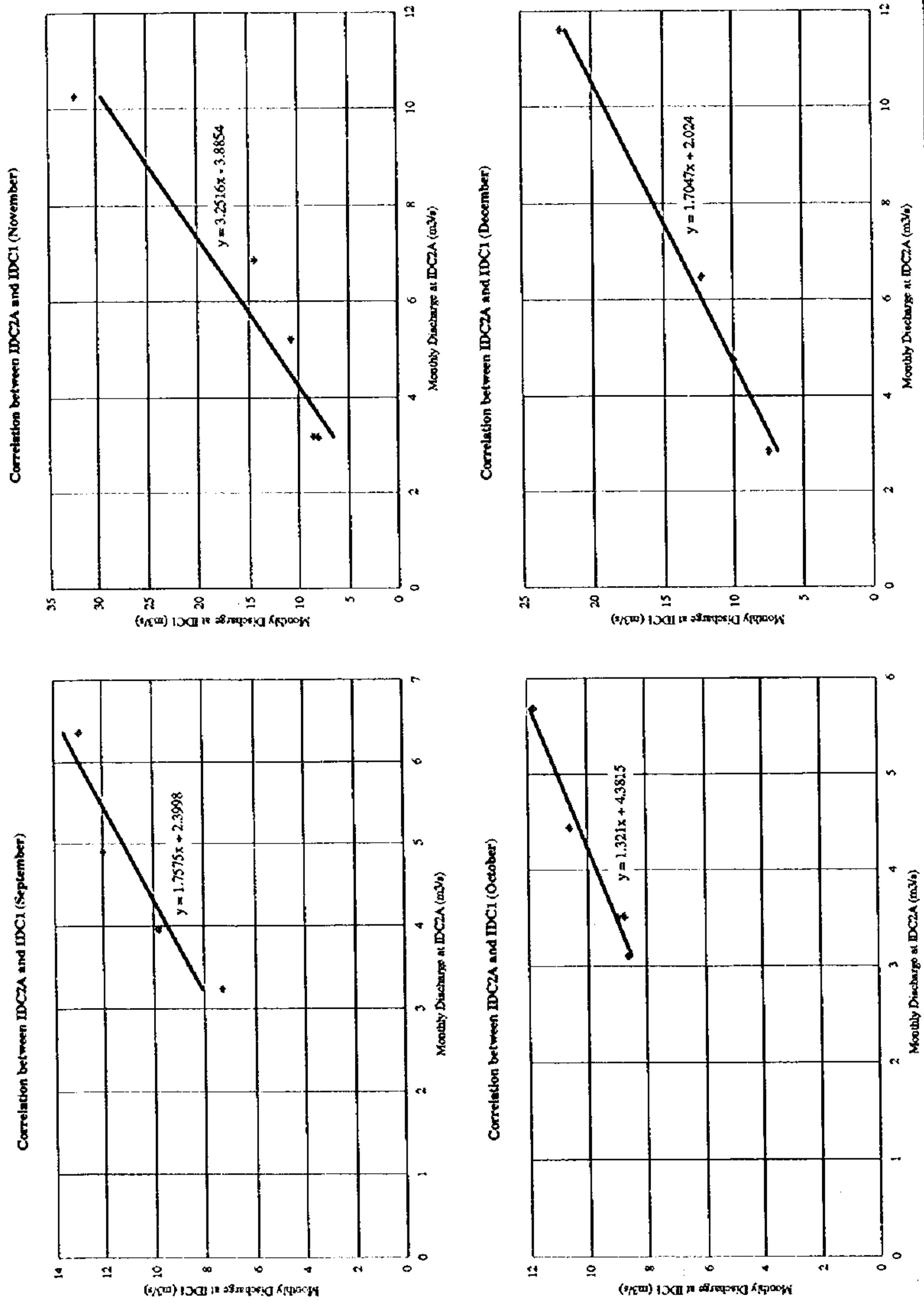



**Figure A.3.12**
**Relation between IDC2A and IDC1 (3/3)**

**The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania**

Japan International Cooperation Agency

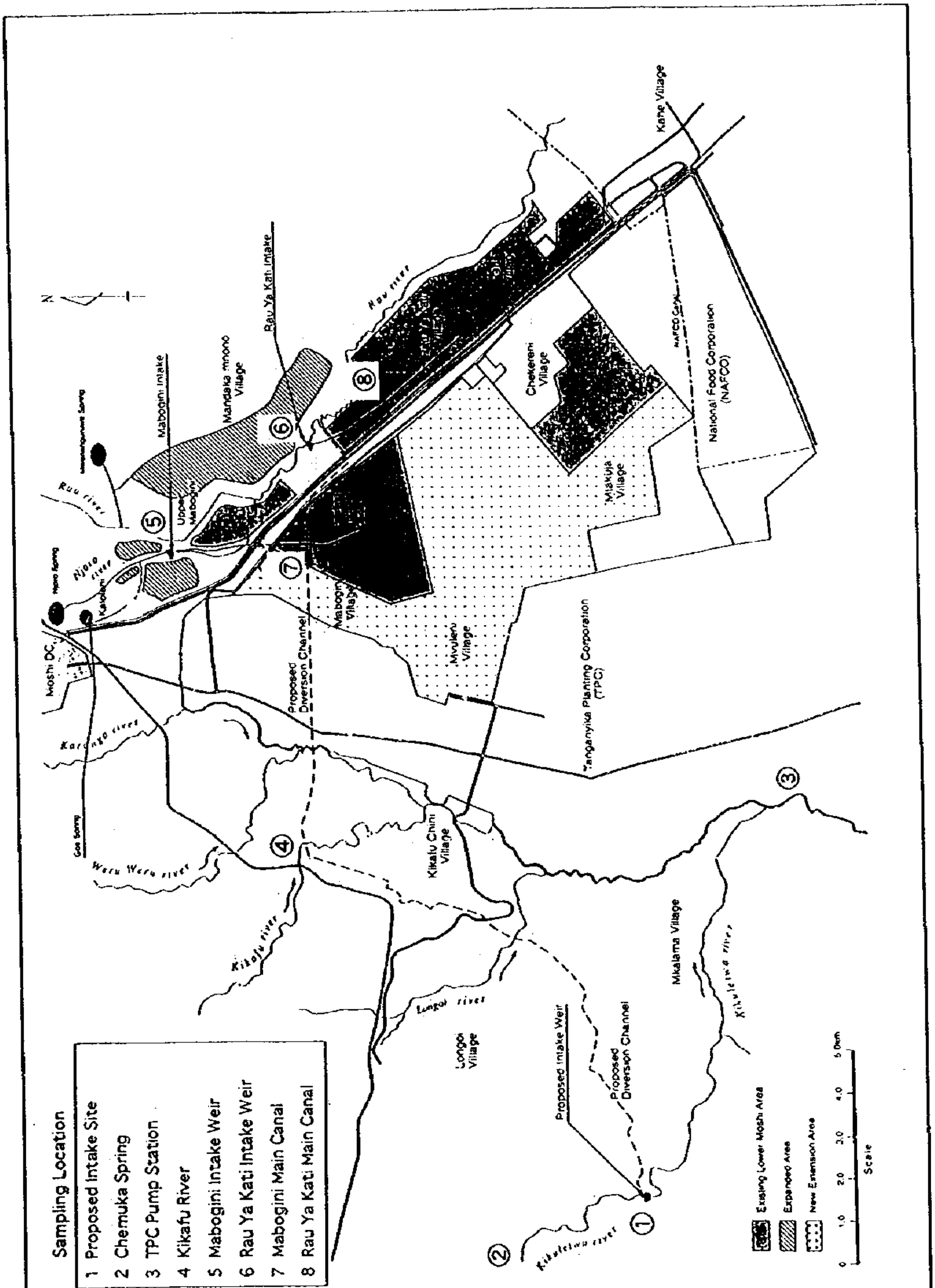
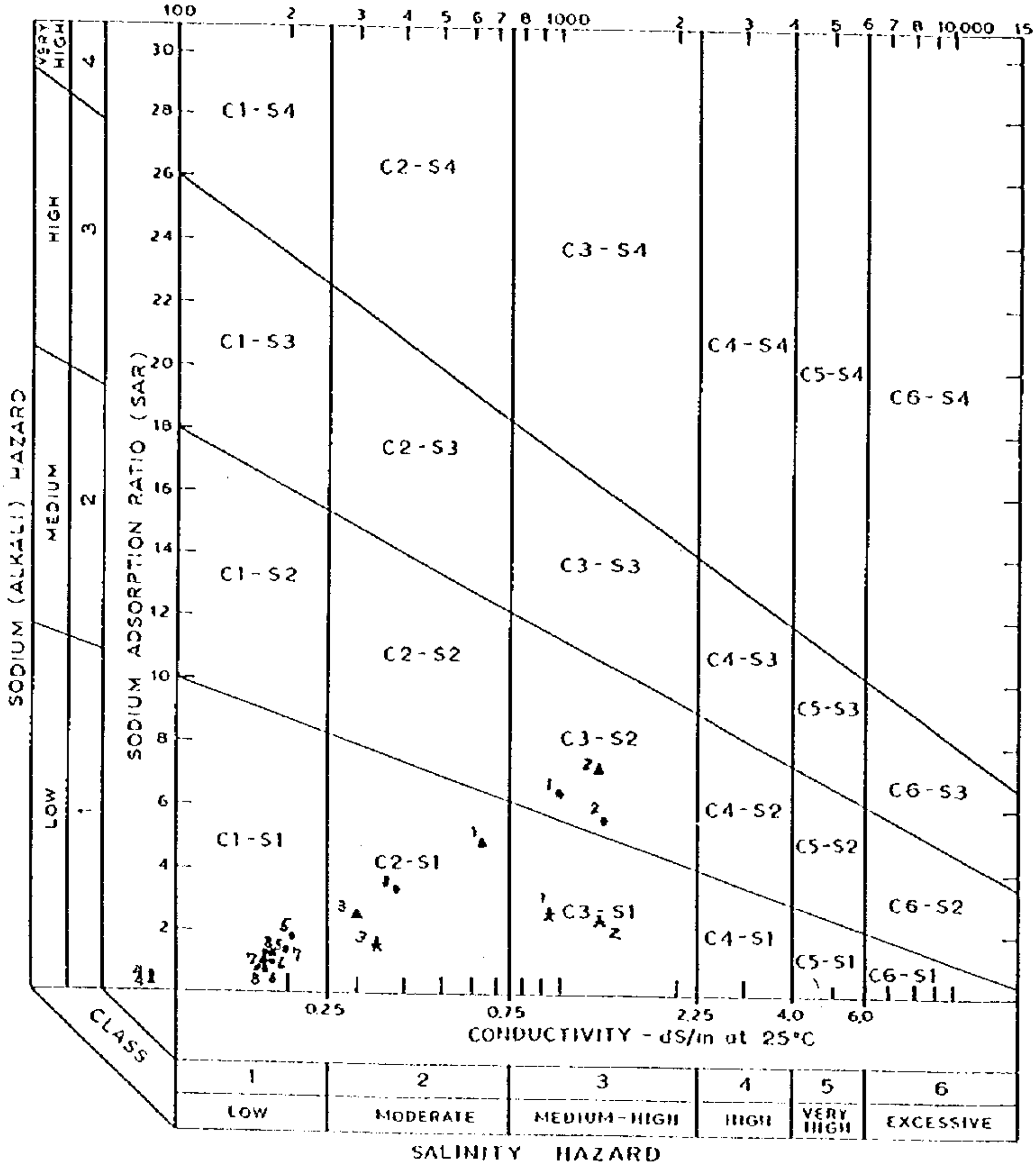



**Figure A.4.1**
**Location of Water Sampling**

**The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania**

Japan International Cooperation Agency




● : Phase-I (Average)
▲ : Phase-II (Average)
★ : Results by Kenya Bureau of Standards

SOURCE: AGRICULTURE HANDBOOK 60, U.S. DEPT. OF AGRICULTURE

1. Kikuletwa Intake
2. Chemuka Spring
3. TPC Pump Station
4. Kikafu River
5. Mabogini Intake Weir
6. Mabogini Main Canal
7. Rau Ya Kati Intake Weir
8. Rau Ya Kati Main Canal

**Figure A.4.2**
**Diagram for the Classification of Irrigation Water**

**The Feasibility Study on Lower Moshi Integrated Agriculture and Rural Development Project in the United Republic of Tanzania**

Japan International Cooperation Agency