CHAPTER 1 INTRODUCTION

1.1 Background of Project

The study area of the Meki Irrigation and Rural Development Project (hereinafter referred to "the Project") lies in the Northern Rift Valley Lakes Basin and this sub-basin is shared by East Shewa and Arsi Administrative Zones. It is administratively located in Dugda Bora Wareda, East Shewa Zone of Oromia Regional State. The Study focuses on the water resources potentials of the Meki-Ziway-Abijata basin.

The climate of the area is semi-arid and average annual rainfall is 774 mm. The inadequacy and erratic nature rainfall causes frequent drought and crop failure that accentuating the need for irrigated farming. The supplemental irrigation is one the means to minimize drought risk and sustain small holders agricultural production. The Project was initiated by OIDA as a part of its development effort. It is an integrated rural development project in which the irrigation development is one of the components.

The construction of dam and diversion weir on the Meki river are alternatives for irrigation to the study area. The diversion weir or dam will regulate the river water and supply it to the project area. The Meki-Ziway-Abijata sub-basin is important in the Rift Valley in terms of potentials for water resources exploitation. However, the lakes and rivers have interconnected system and the constraints for water resources development are complex. Therefore, the diversion of water from the Meki river will affect the water recharge of the Ziway lake, which can lead to change in outflow to the Bulbula river and affect water level of the Abijata lake. Therefore, the water resources development of the basin requires a judicious planning for protection of the fragile eco-system.

1.2 Climate

The climate in the study area and around the lakes is arid or semi-arid. However, it is humid to dry sub-humid in the river catchment areas in the highlands, west of Butajira and east of Assela. The climate of the basin is governed mainly by the movement of Equatorial low-pressure zones; the dry northwest trade winds from Arabian Peninsula, which occur during the dry season of November to February, southeast winds that occur during the short rainy season (Belg season) from March to June and moist southwest winds occurring during the rainy season (Meher) from July to October as shown in the following table.

Rainfall Season in the Area

S.N.	Season	Month	Location of Low Pressure	Wind Direction	Rainfall Condition
1	Dry	November to February	South of the Equator	Dry northeast Trade winds from the Arabian Peninsula	Dry
2	Light rain (Belg)	March to June	Southern Sudan	Southeast winds from the Indian Ocean	Light and less reliable rainfall
3	Rainy (Meher)	July to October	Arabian Peninsula & Central Asia	Moist southwest winds from the south Atlantic ocean and central Africa	Area receives most of its rains from July to September

Average annual rainfall increases with altitude, it ranges from about 650 mm in the rift valley floor around the lakes to over 1,100 mm in the east and west highlands of altitude more than 2000 m. The Meki Meteorological station is located at the center of the study area, it receives an average annual precipitation (1966-1999) of 774 mm. The annual rainfall is rather erratic, it ranges from a low of 344 mm in 1995 to a high of 1,091 mm in 1983. About 64% of the annual rainfall is recorded during the period from June to September. The drier months are from November to February, only 8% of the annual rainfall is recorded during this period.

The mean annual temperature is 20.3 ℃ at Ziway Meteorological Station with mild temperature prevailing throughout the year, which is suitable for a wide range of tropical and subtropical crops. Mean monthly air temperature varies from 18.8 ℃ in December to 22 ℃ in May. Period from March to June is relatively warmer, when the mean temperature is generally above 21℃. The air relative humidity is 66% on average, varying from 60% (November) to more than 70% (July-September) on the monthly average. Average monthly wind speed varies from 1.48 m/s in September to 2.56 m/s in June. Sunny months are from November to February, with duration, generally, from 9 to 10 hours/days; whereas in rainy season sunshine duration decreases to around 6 to 7 hours/day. Average annual potential evapotranspiration is 1,658 mm, which more than two times of annual rainfall.

1.3 Hydrology

The northern rift valley sub-catchment has seven (7) major water bodies in its hydrologically closed basins; Meki river, Katar river, Ziway lake, Bulbula river, Horakelo river, Abijata lake, and Langano lake. The Meki and Katar rivers flow into the Ziway Lake. The Bulbula (Kekersitu) river outflows from the Ziway lake and flows south for 30 km before draining into the terminal lake Abijata. Other rivers, which flow into the Abijata lake, are the Horakelo from the Langano lake and the Gogessa river, a branch of the Gidu river draining from west of the Abijata lake. There are also other numerous streams that are drain into both lake Abijata and lake Langano. Therefore, the Meki-Ziway-Abijata sub-system has surface water interconnected. The conceptual diagram of Meki-Ziway-Abijata water resources system is shown in Figure II.1.1.

The total catchment area of the Meki river near Meki town is 2,433 km^2. According to discharge data recorded near Meki town (1965-1999), average annual discharge of the river is 291 MCM or 9.18 m^3/s. The high discharge occurs during the months of August and September, while low discharge generally occurs during the dry season from December to February. River discharge sometimes becomes zero during these months. The main features of rivers and lakes in the basin are summarized in the following table.

Main Features of Rivers/Lakes

S.N.	River/ Lake	Station	Catchment Area (Km^2)	Annual Discharge/ Inflow (MCM)	Lake Area (Km^2)	Runoff Coefficient
1	Meki river	Meki Village	2,433	291		0.12
2	Katar river	Abura	3,350	413		0.14
3	Ziway lake	Bochessa	7,380	704	440	
4	Kekersitu r.	Adamitulu	7,488	180		
5	Langano lake	Near Hotel	2,006		230	
6	Horakelo river	Near Bulbula	2,050	47		
7	Abijata lake	Near Aroressa	10,740	47	180	

1.4 Methodology

The objectives of the preliminary water balance study are to determine the optimum development scale for the irrigation area under the project and to maximize the irrigation benefits without significantly affecting the environment of the lakes system.

The water balance study linked with the Meki-Ziway-Abijata system was carried out under alternative cases (i) proposed dam and (ii) diversion dam on the Meki river. The water balance model is formulated from the conceptual diagram (Figure II.1.1) of the water resources system that includes the Meki river, Ziway, Abijata lake and a dam to supply the water to the new area. Based on the results of the water balance study, the evaluation of the potential irrigation area in the Meki Irrigation Project is made under the alternative conditions. By applying the river discharges and the estimated irrigation water requirements of the system, the water balance simulation model is operated to maximize the irrigation benefit from the project area. The simulation study operated with a dam and two lakes (Ziway and Abijata) on a monthly basis. Using the simulation study, the optimum development scale for the irrigation area was assessed and determined. The impacts of water diversion from the Meki river on the downstream lakes system were also assessed.

CHAPTER 2 AVAILABLE DATA

2.1 Rainfall Data

Rainfall and climatic stations are operated and maintained by the National Meteorological Services Agency (NMSA), Ethiopia. NMSA divided Ethiopia into 6 meteorological zones and the Study area is located in the Central Meteorological Zone. There are 156 stations in the Central Meteorological Zone and those are divided into three types; (i) principal (Class I), (ii) ordinary (Class III) and (iii) rainfall (Class IV).

(1) Monthly/10-day Rainfall

Total 18 stations were selected in the Study area, which are shown in Figure II.2.1. 10-day/monthly rainfall data of these 18 rainfall stations were collected. These stations were selected because of their longer period of records and proximity to the catchment and service areas. These rainfall stations were used for estimating the areal rainfall in the Meki and Katar river basins. The 10-day rainfall data for these stations have been processed, checked for consistency and corrected wherever necessary while any missing records were augmented and later summarized into monthly totals.

The periods of available rainfall data of the 18 stations are shown in Figure II.2.2. The period of the observed rainfall data varies between stations as shown in Figure II.2.2. Most of stations rainfall records are available from 1974 to 1999, however, Kulumsa, Meki, Assela and Ziway stations rainfall records are available for longer Period. Short period of records are available for Bui and Alem-Tena stations in the Meki basin, which have established in 1987. These stations records were used for the correlation analysis and estimates of the basin rainfall.

(2) Maximum Daily Rainfall

The maximum daily monthly rainfall data at 5 stations were collected in the Study area. Tables II.2.1 to II.2.5 show the maximum daily rainfall data recorded at Butajira, Ejersalele, Meki, Ziway and Bulbula.

(3) Number of Rainy Days

Data on number of rainy days were collected of 5 stations, which are Butajira, Ejersalele, Meki, Ziway and Adamitulu. Tables II.2.6 to II.2.10 show the data on number of rainy days at these stations. Number of rainy days in a year vary from a low of 71 at Meki to a high of 103 at Butajira. All stations have an average rainy days more than 10 during the rainy season from July to September.

(4) Rainfall Intensity

Rainfall intensity data are available at only Bui and Ziway stations for a short period. Rainfall intensity was measured as hourly maximum rainfall. Bui station recorded a maximum value of 36 mm/hr during the period 1990-1999, while Ziway station recorded a maximum value of 40 mm/hr during the period 1987-1990. Rainfall intensity data at these stations are presented in Tables II.2.11 and II.2.12.

2.2 Climate Data

The Meki Meteorological is a class III station, which records only rainfall data. However, a complete set of data is recorded at a class I Ziway Meteorological Station, located at almost the same altitude that of Meki in 30 km south of Meki town. The climate of the study area is characterized by the data from the Ziway Meteorological Station. Climatic records such monthly minimum and maximum temperatures, relative humidity, sunshine duration, wind speed observed at the Ziway Meteorological Station were collected from the NMSA. The recorded period is 1990-1999. The average values of the climatic parameters are summarized in the following table while the seasonal variation of climatic parameters are plotted and presented in Figure II.2.3.

Average Climate Parameters

Month	Temperature			Relative Humidity	Wind Speed	Sunshine Duration
	Min. (˚C)	Max. (˚C)	Mean (˚C)	(%)	(m/s)	(hrs)
Jan	12.6	26.5	19.5	63.4	1.87	9.47
Feb	13.9	27.3	20.6	63.8	1.89	9.15
Mar	15.0	28.4	21.7	64.4	1.76	8.47
Apr	15.3	28.1	21.7	61.3	1.70	8.28
May	15.2	28.8	22.0	64.8	1.93	9.01
Jun	15.0	27.5	21.2	66.8	2.56	8.45
Jul	14.7	24.9	19.8	72.7	2.36	6.28
Aug	14.6	25.2	19.9	74.0	2.05	6.64
Sep	13.9	26.0	20.0	70.7	1.48	7.07
Oct	12.6	26.7	19.7	63.2	1.68	9.07
Nov	11.6	26.8	19.2	60.1	1.88	10.28
Dec	11.4	26.3	18.8	63.0	1.94	10.29
Annual	13.8	26.9	20.3	65.7	1.93	8.54

2.2.1 Air Temperature

The mean annual temperature is 20.3 °C at Ziway station with mild temperature prevailing throughout the year, which is suitable for a wide range of tropical and subtropical crops. Mean monthly air temperature varies from 18.8 °C in December to 22 °C in May. Period from March to June is relatively warmer, when the mean temperature is generally above 21 °C. May is the hottest month with mean maximum temperature of 28.8 °C and December is the coolest month with mean minimum temperature of 11.4 °C. There is a gradual increase in temperature from January to May. The temperature remains almost constant from July to October due to the effect of rainy season (Meher). The monthly mean maximum and minimum temperatures recorded at Ziway from 1990 to 1999 are presented in Tables II.2.13 and II.2.14, respectively.

2.2.2 Relative Humidity

The air relative humidity is 66% on average, varying from 60% (November) to more than 70% (July-September) on the monthly average. Average monthly relative humidity decreases from a peak of 74% in August to 60.1% in November. In the remaining months from May to August, a constant increase in relative humidity occurs due to the southwest rain. The monthly relative humidity values from 1990 to 1999 are presented in Table II.2.15.

2.2.3 Wind Speed

Average monthly wind speed varies from 1.48 m/sec in September to 2.56 m/sec June. The average wind speed varies from 1.77 m/sec in July to 3.31 m/sec in January. Wind speed is high during December to February. The mean wind speed is 1.93 m/sec. The prevailing wind directions are southwest from May to October and northeast from November to April in concordance with movement of low pressure. The monthly wind speed values at Ziway from 1990 to 1999 are presented in Table II.2.16.

2.2.4 Sunshine Duration

Sunny months are from November to February, with duration, generally, from 9 to 10 hours/days; whereas in rainy season sunshine duration decreases to around 6 to 7 hours/day. Average annual potential evapotranspiration is 1,658 mm, which more than two times of annual rainfall.

The annual mean sunshine duration at Ziway is 8.5 hour a day. The longer sunshine period occurs in November and December (10.3 hours) and shorter duration is in July (6.28 hours). The monthly sunshine duration values at Ziway are presented in Table II.2.17.

2.2.5 Evaporation

Monthly evaporation data are available at Ziway station for short period from 1995 to 2000, which is presented in Table II.2.18. Monthly evaporation is low during the rainy season from July to September and increase thereafter. Total average annual evaporation was 1,456 mm.

2.3 Stream Flow Data

The daily river discharge data of 11 stream flow stations were collected. Figure II.2.4 lists the stations used and these were operated by the Ministry of Water Resources. These stations were selected because of the proximity to lakes and their longer period of records. The conceptual diagram of the Meki-Ziway-Abijata water resources system is shown Figure II.1.1. The periods of available river discharge data of the 11 stations are shown in Figure II.2.5. The periods of the observed discharges varies from station to station as shown in Figure II.2.5. Short period of records are available at Dugda station on the Meki river and Gogessa river at Jidu and these stations have long been abandoned. These station records were used for the estimating river discharges. The monthly stream flow data of these stations are processed, checked for consistency and corrected wherever necessary, while missing records were augmented. These stream flow records were also used for carrying water balance study. The selected stream flow stations and their drainage areas are presented in the following table.

Salient Feature of Stream flow Gauging Stations

S. N.	River	Station	Coordinates		Drainage Area (Km^2)	Installation Date	Remarks
			Latitude	Longitude			
1	Meki	Dugda	8°12' N	38°42' E	2,040	Jul-68	Abandon
2	Meki	Meki Village	8°09' N	38°50' E	2,433	Jun-62	
3	Katar	Abura	8°04' N	39°03' E	3,350	Aug-68	
4	Kekersitu	Adamitulu	7°51' N	38°43' E	7,488	Mar-79	
5	Bulbula	Bulbula	7°43' N	38°39' E	8,155	Aug-68	
6	Gedemso	Near Langano	7°28' N	38°44' E	213	Sep-68	Abandon
7	Horakelo	Near Bulbula	7°41' N	38°40' E	2,050	Aug-68	
8	Gogessa	Near Jidu	7°38' N	38°32' E			Abandon

2.4 Water Level of Lakes

Monthly water level data of three (3) lakes were collected. The lakes are the Ziway, Langano and Abijata lakes. The period of available records are presented in Figure II.2.5. The salient features of water level gauging station are presented in the following table.

Salient Features of Water Level Gauging Stations

S. N.	Lake	Station	Coordinates		Drainage Area (Km^2)	Installation Date	Remarks
			Latitude	Longitude			
1	Ziway	Bochessa	7°54' N	38°45' E	7,380	May-74	
2	Langano	Near Hotel	7°32' N	38°41' E	2,006	Sep-68	
3	Abijata	Near Aroressa	7°33' N	38°36' E	10,744	Jan-76	

2.5 Water Quality Data

The water quality analysis was carried out at total four points for river, ground water and lake water through sublet contract. The results of water quality analysis were shown in Table II.2.19. The results show that the Meki river water is of good quality as it contents low amount of salt and fluoride those were found higher in groundwater. The electrical conductivity of the Meki river was 0.295 ms/cm, which indicates water is suitable for irrigation. The electrical conductivity and pH of the Ziway lake was higher than that of the Meki river. Therefore, use of lake water for irrigation without proper drainage may cause increase in salinity/alkalinity of soil.

CHAPTER 3 MEKI-ZIWAY-ABIJATA WATER RESOURCES SYSTEM

3.1 General Hydrological Conditions

The northern rift valley sub-catchment has seven (7) major water bodies in its hydrologically closed basins; (i) Ziway lake, (ii) Langano lake, (iii) Abijata lake, (iv) Meki river, (v) Katar river, (vi) Bulbula (Kekersitu) river and (vii) Horakelo river. There are also other numerous streams that drain into both the Abijata lake and the Langano lake. The Shalla lake is located just below the Abijata lake and it is also part of the Abijata-Shalla National Park. The location of water bodies is shown in Figure II.1.1. Main features of lakes are shown in the following table.

Main Features of Lakes

S.N.	Lake	Lake Area (km^2)	Storage Volume (MCM)	Mean Depth (m)	Altitude (m)	Catchment Area (km^2)	Annual Inflow (MCM)
1.	Ziway	440	1,466	2.5	1,636	7,380	704
2.	Langano	230	3,800	17.0	1,590	2,006	
3.	Abijata	180	954	7.6	1,580	10,740	227
4.	Shalla	370	37,000	86.0	1,567	2,300	

The Meki and Katar rivers replenish the Ziway Lake, which in turn give rise to the outflow to Bulbula (Kekersitu) river that flows south for 30 km before draining into the terminal lake Abijata. Other rivers, which flow into Abijata, are the Horakelo from the Langano lake and the Gogessa river, a branch of the Gidu river draining from west of the Abijata. The Gedemso river supplies water to the Langano lake. These lakes and rivers have interconnected system and the constraints for water resources are complex. Therefore, the water resources development of the basin requires a judicious planning for protection of the fragile ecosystem. The main features of rivers are presented in the following table.

Main Features of Rivers

S.N.	River	Station	Catchment Area (Km^2)	Annual Rainfall (mm)	Annual Discharge (MCM)	Runoff Coefficient	Drain Into Lake
1	Meki	Meki Village	2,433	1,006	291	0.12	Ziway
2	Katar	Abura	3,350	874	413	0.14	Ziway
3	Kekersitu	Adamitulu	7,488		180		Abijata
4	Gedemso	Near Langano	213		76		Langano
5	Horakelo	Near Bulbula	2,050		47		Abijata

The outflow from Ziway lake generates a flow in the Bulbula river, which later drains into Abijata lake. Similar phenomena also takes place in the case of Langano lake, whereby, numerous small streams entering into the lake increase the level to originate Horakelo which flows into Abijata lake. No outflow is generated from Abijata lake. Neglecting the groundwater inflow/outflow it can be said that surface inflow plus direct rain into the lakes is in long term balance with the evaporation.

3.2 Ziway Lake

The main source of water for the lake is the flows of the Meki and Katar rivers. The Meki river is gauged at Meki town (CA = 2,433 km^2), while Katar river is gauged near Abura (CA = 3,350 km^2). The mean annual flows recorded at the two stations are 291 MCM and 413 MCM, respectively. The remaining catchment that is surrounding lake passing through swamp contributes little as the large part of the water is evaporating before it contributes to the lake effectively. The total catchment area of the Ziway lake is about 7,380 km^2. The total annual average inflow in the lake is estimated by the sum of the Katar and Meki river flows as recorded at the gauging stations, which is about 704 MCM. The water balance of the Ziway lake consists of the inflow, outflow from the lake (Bulbula river) and evaporation from and precipitation on the lake surface. The water level of the lake is shown in Table II.3.1 and plotted in Figure II.3.1.

3.3 Meki River

The Meki river originates in the highlands of Guraghe and travels a distance of about 100 km from the highlands at altitude of 3,600 m to 1,636 m before draining into the Ziway lake. The upper reaches of the basin are steep and mountainous, while the lower basin is flat with broad valley. The total catchment area of the river near Meki town is 2,433 km^2. According to discharge data recorded near Meki town (1965-1999), average annual discharge of the river is 291 MCM or 9.18 m^3/s. A few year old records of the Meki river is also available at abandon station near Dugda and presented in Table II.3.2. Monthly discharge of the river at Meki town station is presented in Table II.3.3 and summarized in the following table.

Monthly Discharge of Meki River Near Meki Town

Average River Discharge (m^3/s)													Annual
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Volume (MCM)
0.94	2.28	5.01	7.01	7.31	6.29	18.75	29.64	19.93	8.77	3.29	0.90	9.18	291

The high discharge occurs during the months of August and September, while low discharge generally occurs during the dry season from December to February (Figure II.3.2). River discharge sometimes becomes zero during these months.

3.4 Katar River

The Katar river originating in the highlands of Arsi has a drainage area of about 3,400 km^2. The seasonal discharge of the Katar river varies of 6.64 MCM in January to 140.68 MCM in August. The average annual discharge at the Abura station near Ziway lake is 413 MCM. Monthly discharge of the Katar river is presented in Table II.3.4 and summarized in the following table.

Average Monthly Discharge of the Katar River during 1979-1999

Discharge (MCM)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
6.64	7.49	12.67	17.53	15.77	15.34	49.13	140.68	87.74	40.22	12.78	7.10	413.1

3.5 Bulbula river

The water level of Ziway lake influences the outflow to the Bulbula river. The upper part of the Bulbula river is also known as the Kekersitu river. The water level of the Ziway lake is controlled by a natural basalt bar on the Bulbula river lying some 6 km downstream the from river outflow at the lake. An average annual flow of 180 MCM flow down to the Abijata lake. Figure II.3.3 shows the annual variation of river discharge at Adamitulu. Monthly discharge of the Bulbula river at the Adamitulu station is presented in Table II.3.5. There are some old records of river flow available at abandon station Bulbula and they are presented in Table II.3.6. This station is near to the Abijata lake and can be used to estimate the water intake of the river between the Adamitulu and Bulbula station. The average lake water level and monthly discharge of the river recorded at the Adamitulu station are shown in the following table.

Average Water Level of Ziway Lake and Outflow to Bulbula River

Station	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
ZiwayW. Level	(m)	1.06	0.95	0.85	0.80	0.76	0.74	0.83	1.19	1.50	1.53	1.34	1.23	1.07
River Q at Adami	(m^3/s)	4.07	2.56	1.23	1.34	1.27	1.38	1.98	6.16	13.68	15.09	11.84	7.50	5.70

3.6 Langano Lake

The Langano lake is known for its recreational value and it is relatively less affected by irrigation or industry. Monthly water level data of lake is presented in Table II.3.5. There is a small-scale irrigation development in the upper catchment of the Gedemso river. Nevertheless any development on the rift valley lakes basin has it effect on lake water level and volume. The lake is recharge by the flow of Gedemso, Lipis and Huluka rivers, which are originating from the Arsi highland around Kaka mountain. The Gedemso river is the only gauged river in the Langano catchment and its monthly discharge is presented in Table II.3.8. It has a catchment area of 213 km^2 near Langano.

3.7 Abijata Lake

The Abijata lake is located in the Abijata-Shella National Park and particularly known for its migratory pelican and flamingo birds. The lake is mainly recharged by the Bulbula and Horakelo rivers. These rivers outflows or spills from Ziway and Langano lakes respectively, therefore, the three lakes form an interconnected sub-system. Monthly water level records of the Abijata lake are presented in Table II.3.10. The average annual flows of the Bulbula river at the Kekersitu station is 180 MCM. There are some old data of the Bulbula river available at Bulbula town near the Abijata lake from 1970 to 87 (Table II.3.6), which show flow at the Bulbula station is about 70% of that at the Adamitulu. Therefore, the Bulbula river contributes about 125 MCM annually to the Abijata lake. The other river Horakelo from the Langano lake contributes about 46 MCM to the lake (Table II.3.9). The rest of the Abijata catchment contributes relatively little. The Gogessa river, which is a small eastern tributary of the Jidu river, has some old data from which the yield is estimated at 10 MCM (Table II.3.11). The other wetter catchment between Shala and Abijata with a catchment area of 60 km^2 and a runoff coefficient of 20% yields to about 7 MCM. The remaining catchment of Abijata does not have any permanent drainage and only contribute water to the lake during heavy rains as overland flow. The Abijata lake is highly mineralized and is not important for use in irrigated agriculture. However, the Abijata Soda Ash Enterprise is extracting about 2 MCM of water annually for soda ash production from the lake water since 1990.

The water level data of the Abijata lake are available from 1977 to 1999 (Table II.3.10). There is a sharp decrease in water level of the lake during 1986 to 1992 due to reduced inflow from the Bulbula and Horakelo rivers (Figure II.3.4). The water level of the lake reached at 0.78 m in 1992 and although it increased afterwards, however still much lower than original water level.

3.8 Water Use

There are several small and medium scale irrigation schemes and state farm developed by abstraction of water from the Ziway lake, Bulbula, and Katar rivers. Figure II.1.1 shows the water use for irrigation in the Meki-Ziway water resources system. Most of irrigation schemes in the area are pumping water from the Ziway lake or the Bulbula river. There is also some abstraction from the Meki and Katar rivers. The following table shows the irrigation system utilizing the water abstraction from lakes and rivers.

Water Use in the Meki-Ziway System

S.N.	Irrigation System	Irrigation Area (ha)	Water Source
1.	Katar Irrigation	420	Katar River
	Sheled	75	
2.	Pumping Schemes on Meki	157	Meki river
3.	Meki Ziway Project	380	Ziway Lake
	Ziway Prison Farm	265	
	Others	300	
4.	Ziway State Hort. Farm	733	Bulbula
	Dodicha	69	
	Gerbi and Bochessa	40	
	Others	100	

The Meki Ziway irrigation project is originally planned for an area of 3,000 ha, however, it is presently irrigated for only 380 ha using two (2) pumps. The Meki river and the Ziway lake are being exploited by individual and groups of individual for irrigation. The Bulbula river is currently a source of water for several irrigation schemes.

CHAPTER 4 RAINFALL ANALYSIS

4.1 Screening of Data

The monthly records of these selected stations have been used to assess the areal distribution of rainfall in the study area, check the consistency of available records and extend the rainfall series of the stations of interest. Ziway and Kulumsa rainfall stations were chosen as the reference stations because of their proven reliability and long series of records. The other stations were used to study the areal rainfall distribution.

The reliability and consistency of the collected records are examined by comparing the annual rainfall, plotting daily values and by employing the double mass curve analysis. In double mass curve analysis, accumulated rainfall of two stations is plotted against each other to detect any change in the slope.

4.2 Cross Correlation

The cross correlation analysis of monthly rainfall values was carried out for both the Meki and Katar basins. The results of correlation analysis are shown in the following tables.

Correlation Coefficient of Monthly Rainfall Data in the Meki Basin

	Correlation Coefficient										
Station	Alem-T	Adami	Bui	Buta	Ejersa	Hombo	Koshe	Kulum	Meki	Tora	Ziway
Alem-T	1.00										
Adami	0.78	1.00									
Bui	0.81	0.75	1.00								
Butajira	0.66	0.64	0.79	1.00							
Ejersa	0.85	0.74	0.82	0.71	1.00						
Hombole	0.82	0.66	0.91	0.63	0.79	1.00					
Koshe	0.79	0.69	0.79	0.66	0.70	0.71	1.00				
Kulumsa	0.73	0.72	0.74	0.75	0.74	0.68	0.77	1.00			
Meki	0.85	0.77	0.78	0.66	0.79	0.77	0.75	0.75	1.00		
Tora	0.69	0.70	0.78	0.78	0.71	0.62	0.71	0.77	0.69	1.00	
Ziway	0.79	0.84	0.76	0.66	0.75	0.71	0.74	0.75	0.82	0.74	1.00

Correlation Coefficient of Monthly Rainfall Data in the Katar Basin

Station	Correlation Coefficient											
	Arata	Assela	Bekoji	Bulbula	Hombo	Kersa	Kulum	Lang.	Meki	Sagure	Tora	Ziway
Arata	1.00											
Assela	0.82	1.00										
Bekoji	0.76	0.76	1.00									
Bulbula	0.71	0.68	0.72	1.00								
Hombo	0.69	0.75	0.77	0.63	1.00							
Kersa	0.66	0.66	0.71	0.69	0.52	1.00						
Kulumsa	0.84	0.81	0.79	0.69	0.68	0.70	1.00					
Langano	0.65	0.67	0.68	0.70	0.61	0.59	0.67	1.00				
Meki	0.77	0.73	0.74	0.74	0.77	0.58	0.75	0.68	1.00			
Sagure	0.72	0.75	0.83	0.70	0.76	0.66	0.75	0.66	0.73	1.00		
Tora	0.70	0.70	0.75	0.72	0.62	0.72	0.77	0.63	0.69	0.65	1.00	
Ziway	0.79	0.73	0.76	0.73	0.71	0.58	0.75	0.70	0.82	0.72	0.74	1.00

In the Meki basin, Meki station rainfall data showed high correlation with the Ziway and Ejersa station data while the Butajira station showed high correlation with the Bui and Tora Station data. In the Katar basin, most of the stations rainfall data showed high correlation with Kulumsa station.

4.3 Estimation of Missing Data

In cases where portions of observed rainfall records are missing, the missing records are estimated by correlation with those recorded at other observation stations. The correlation analysis is performed with other stations to get the highest correlation coefficient. The missing values are then estimated by applying correlation equation with the observation stations having the highest correlation. The correlation analysis can be a simple bivariate correlation or a multivariate regression analysis.

As earlier mentioned, the period of the observed record varies from station to station with some of the rainfall station only started in the 1987's. The missing data were filled-in using the regression equation in order to complete the record from 1979 through 1999. The regression equation is expressed as follows:

$$R_X = a\,R_1 + d \qquad \text{or} \qquad R_X = a\,R_1 + b\,R_2 + c\,R_3$$

where, R_X = dependent variable

R_1, R_2, R_3 = independent variable

a, b, c = regression coefficient

d = constant

The equation coefficient "a", "b" and "c" and correlation coefficient (coefficient of determination) "r" for each station are presented in the following table. The results show good correlation among the stations with "r" being more than 0.8.

Regression Equations for Meki Basin

Station	Regression Equation	r
Ziway	$R_{Ziway} = 0.474\ R_{Adami} + 0.329\ R_{Meki} + 0.174\ R_{Tora}$	0.88
	$R_{Ziway} = 0.352\ R_{Kulumsa} + 0.561\ R_{Meki}$	0.84
Meki	$R_{Meki} = 0.314\ R_{Ejersa} + 0.222\ R_{Kulumsa} + 0.471\ R_{Ziway}$	0.87
	$R_{Meki} = 0.38\ R_{Kulumsa} + 0.623\ R_{Ziway}$	0.85
Ejersalele	$R_{Ejersa} = 0.298\ R_{Hombole} + 0.522\ R_{Meki}$	0.84
	$R_{Ejersa} = 0.554\ R_{Bui} + 0.481\ R_{Meki}$	0.86
Bui	$R_{Bui} = 0.234\ R_{Butajira} + 0.213\ R_{Ejersa} + 0.614\ R_{Hombole}$	0.95
Koshe	$R_{Koshe} = 0.446\ R_{Bui} + 0.309\ R_{Meki} + 0.27\ R_{Ziway}$	0.85
Tora	$R_{Tora} = 0.307\ R_{Bulula} + 0.406\ R_{Butajira} + 0.266\ R_{Ziway}$	0.84
	$R_{Tora} = 0.484\ R_{Butajira} + 0.413\ R_{Ziway}$	0.82
	$R_{Tora} = 0.44\ R_{Bulbula} + 0.495\ R_{Butajira}$	0.83
Butajira	$R_{Butajira} = 0.388\ R_{Ejersa} + 0.817\ R_{Tora}$	0.79
	$R_{Butajira} = 0.461\ R_{Bui} + 0.77\ R_{Tora}$	0.85
Alem-Tena	$R_{Alem\text{-}Tena} = 0.474\ R_{Ejersa} + 0.481\ R_{Meki}$	0.89
	$R_{Alem\text{-}Tena} = 0.335\ R_{Bui} + 0.455\ R_{Ejersa}$	0.87
Hombole	$R_{Hombole} = 0.662\ R_{Ejersa} + 0.564\ R_{Meki}$	0.82
	$R_{Hombole} = 0.117\ R_{AlemT} + 0.414\ R_{Ejersa} + 0.318\ R_{Bui}$	0.90
Adamitulu	$R_{Koshe} = 0.227\ R_{Bulbula} + 0.672\ R_{Ziway}$	0.84

Regression Equations for Katar Basin

Station	Regression Equation	r
Assela	$R_{Asela} = 0.232\ R_{Hombole} + 0.82\ R_{Kulumsa} + 0.237\ R_{Sagure}$	0.84
	$R_{Asela} = 0.347\ R_{Hombole} + 0.953\ R_{Kulumsa}$	0.86
	$R_{Asela} = 0.867\ R_{Kulumsa} + 0.442\ R_{Sagure}$	0.83
Arata	$R_{Arata} = 0.325\ R_{Assela} + 0.491\ R_{Kulumsa}$	0.87
	$R_{Arata} = 0.203\ R_{Bekoji} + 0.662\ R_{Kulumsa}$	0.85
Kulumsa	$R_{Kulumsa} = 0.238\ R_{Bekoji} + 0.391\ R_{Arata} + 0.22\ R_{Assela}$	0.88
	$R_{Kulumsa} = 0.468 R_{Assela} + 0.261\ R_{Meki}$	0.82
Sagure	$R_{Sagure} = 0.552\ R_{Bekoji} + 0.307\ R_{Kulumsa}$	0.85
Bekoji	$R_{Bekoji} = 0.424\ R_{Kulumsa} + 0.545\ R_{Sagure} + 0.256\ R_{Ziway}$	0.87
	$R_{Bekoji} = 0.76\ R_{Kulumsa} + 0.436\ R_{Ziway}$	0.82
Kersa	$R_{Kersa} = 0.259\ R_{Bekoji} + 0.336\ R_{Kulumsa} + 0.28\ R_{Tora}$	0.76
	$R_{Kersa} = 0.42\ R_{Bekoji} + 0.48\ R_{Kulumsa}$	0.71
	$R_{Kersa} = 0.345\ R_{Kulumsa} + 0.306\ R_{Bulbula} + 0.29\ R_{Tora}$	0.74
Bulbula	$R_{Bulbula} = 0.219\ R_{Kulumsa} + 0.282\ R_{Tora} + 0.31\ R_{Ziway}$	0.78
	$R_{Bulbula} = 0.361\ R_{Kulumsa} + 0.451\ R_{Ziway}$	0.76
Langano	$R_{Ejersa} = 0.507\ R_{Bulbula} + 0.369\ R_{Sagure}$	0.74

The Ziway and Kulumsa station is chosen as the key stations due to its longer period of available rainfall records and better reliability. The monthly missing rainfall data of the key station, Ziway, were filled up using the monthly data of Adamitulu, Meki, Kuluma and Tora (whichever is applicable) based on results of monthly correlation. The missing monthly data of other stations were also filled up using the regression equation shown in the above table.

4.4 Seasonal Rainfall Distribution

Monthly rainfalls of all stations were calculated and are presented in Tables II.4.1 to II.4.18, and average monthly rainfalls are summarized in the following table. The annual rainfalls of stations in the Meki river basin are tabulated in Table II.4.19. The average value of annual rainfall in the Meki basin varies from 750 mm at Ziway to 1,131 mm at Butajira. Generally, the rainfall is higher in the northern and eastern part of the basin, and lower in the eastern part of basin around the lake. The variation of annual rainfall of the stations is shown in Figure II.4.1.

Monthly Rainfall in Meki Basin

	Mean Monthly Rainfall (mm)												
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Butajira	36.3	69.9	133.1	132.3	112.6	112.7	176.9	169.0	114.7	52.9	10.3	10.5	1,131
Bui	22.5	59.9	91.2	86.2	61.1	102.5	207.3	192.0	92.6	41.1	3.0	7.2	966
Koshe	22.5	51.3	80.9	93.2	93.7	102.6	177.2	181.4	111.6	49.2	4.6	4.1	972
Tora	23.5	50.0	84.7	121.3	95.6	92.3	132.6	126.3	119.7	54.3	3.7	5.0	909
Ejersalele	11.6	35.4	50.4	81.8	65.6	81.7	207.4	176.8	92.7	28.5	1.1	3.0	836
Alem Tena	10.5	43.5	52.3	71.3	35.7	71.8	197.3	171.8	95.4	29.4	1.7	2.4	783
Hombole	17.9	38.8	63.8	60.7	60.8	105.0	225.8	225.6	108.4	30.7	7.6	2.6	948
Meki	14.9	38.6	55.2	60.9	66.9	81.5	172.0	150.5	88.1	36.7	6.9	1.9	774
Ziway	16.8	34.8	55.9	70.6	74.3	85.5	147.2	127.0	88.2	44.3	2.5	3.2	750
Adamitulu	15.7	41.5	51.9	60.8	69.7	82.9	132.4	129.9	75.9	36.8	5.0	3.9	706

The seasonal variation of rainfall of selected stations is shown in Figure II.4.2. It shows bimodal rainfall pattern, there are two rainfall season, belg season (light rain season) from February to June and Meher or main rainy season from July to September. The rainfall in the basin is governed mainly by the movement of Equatorial low-pressure zones; the dry northwest trade winds from Arabian Peninsula, which occur during the dry season of November to February, southeast winds that occur during the short rainy season (Belg season) from March to June and moist southwest winds occurring during the rainy season (Meher) from July to October.

The rainfall during the belg season is less and also less reliable. About 64% of the annual rainfall is recorded at Meki during the period from June to September. The drier months are from November to February, only 8% of the annual rainfall is recorded during this period.

Monthly rainfall data at 8 stations in the Katar basin are calculated after filling missing data and augmented data are presented in Tables II.4.9 to II.4.14. The annual rainfalls of these stations in the Katar river basin are tabulated in Table II.4.20. The average monthly data at 8 stations in the Katar basin is presented in the following table.

Average Monthly Rainfall in Katar-Abijata Basin

Station	Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Arata	13.9	29.6	74.0	71.2	84.2	94.7	138.9	121.0	105.7	46.1	10.2	4.7	794
Assela	18.0	46.5	94.7	116.0	114.8	129.0	200.5	208.5	162.5	61.6	20.0	12.0	1184
Bekoji	22.7	47.0	84.6	113.4	94.4	116.0	170.6	193.9	87.3	61.9	13.9	14.0	1020
Bulbula	16.5	32.3	48.2	69.3	69.2	65.4	130.7	105.4	72.4	40.9	4.0	3.2	657
Keresa	24.3	43.4	73.9	103.8	95.5	78.7	114.5	123.9	106.3	59.8	22.9	11.3	858
Kulumsa	19.6	46.6	83.4	82.6	84.8	86.1	127.1	138.1	105.9	40.1	13.0	9.7	837
Langano	13.3	21.5	38.6	62.4	74.5	87.8	130.6	110.3	81.4	40.4	6.5	7.9	675
Sagure	13.1	29.7	56.4	70.3	76.5	93.8	160.3	147.3	76.6	37.6	6.2	3.8	772

4.5 Annual Areal Rainfall Distribution

Areal rainfall in basin is calculated by the Thiessen Polygon method using available rainfall data of several stations. In this method, adjacent stations are joined by straight lines thus dividing the entire area into a series of triangles. Perpendicular bisectors are erected on each of these lines, thereby forming a series of polygons, each containing one and only one rainfall station. The entire area within any polygon is nearer to the rainfall station contained therein than to any other, and it is therefore assumed that the rainfall recorded at that station should apply to that area. Six (6) polygons were constructed in the Meki basin and seven polygons in Katar basin. If P_1, P_2, ..,P_n are rainfall records at the stations whose surrounding polygons have areas A_1, A_2, …,A_n, then the mean areal rainfall P on the basin is expressed by

$$P = (P_1 A_1 + P_2 A_2 + \ldots + P_n A_n)/(A_1+A_2+\ldots+A_n)$$

The area of each station in the Meki river basin and the Katar basin was measured using planimeter and presented in the following tables.

Area Covered by Each Station in Meki River Basin

Station	Butajira	Tora	Koshe	Bui	Ejersalele	Meki
Area (km^2)	646.9	266.9	258.8	658.8	186.9	29.4

Area Covered by Each Station in Katar River Basin

Station	Bekoji	Sagure	Keresa	Arata	Assela	Kulumsa	Alem-Tena
Area (km^2)	730.0	11.95.2	536.8	658.8	151.9	252.8	23.8

Areal rainfall in the Meki and Katar river basins was determined applying above equation using rainfall data and area covered by each station. The annual areal rainfall is estimated at 1,006 mm in Meki basin and at 874 mm in the Katar river basin. The monthly areal rainfall in the Meki Basin was calculated from 1979-1999 and presented in Table II.4.21. The average monthly areal rainfall in the Meki basin is presented in the following table.

Monthly Areal Rainfall in Meki Basin

Rainfall (mm)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
27.4	55.4	98.1	110.4	93.6	102.0	182.4	174.5	107.1	45.7	4.0	5.8	1,006

The Isohyetal method was also used to calculate basin rainfall for cross-checking the results of the polygon method. An isohyetal map is prepared based on annual rainfall values of 18 rainfall station and shown in Figure II.4.3. The area between adjacent isohyets was measured by planimeter and basin rainfall is calculated. The areal rainfall calculated by the Isohyet method was similar that of to polygon method.

4.6 Rainfall Probability

The non-exceedance probability of the maximum annual rainfall (Tables II.2.1 to II.2.5) is estimated for 6 rainfall stations by using the Gumbel method as shown below:

Non-Exceedance Probability of Maximum Daily Rainfall

Station	Maximum Daily Rainfall (mm)				
	Return Period				
	1/5 -year	1/10-year	1/20 -year	1/30-year	1/50-year
Butajira	84	95	108	116	126
Ejersalele	56	66	76	82	91
Meki	73	84	94	99	106
Ziway	71	83	94	101	109
Bulbula	64	74	85	91	98

The 5-year return period maximum annual rainfall varies from a low of 56 mm at Ejersalele to a high of 84 mm at Butajira.

The non-exceedance probability of the maximum annual rainfall is estimated for 3 rainfall stations by using the Gumbel method as shown below:

Non-Exceedance Probability of Maximum Daily Rainfall

Station	Maximum Daily Rainfall (mm)				
	Return Period				
	1/5 -year	1/10-year	1/20 -year	1/30-year	1/50-year
Butajira	84	99	114	122	132
Meki	76	91	104	112	122
Ziway	72	85	97	104	113

The 5-year return period maximum annual rainfall varies from a low of 72 mm at Ziway to a high of 84 mm at Butajira.

The rainfall recorded at the Meki station is used for the estimating probable monthly minimum rainfalls. The monthly and monthly drought rainfalls of 5-year return period were estimated using the Gumbel method and the results are shown in the following tables.

Monthly Rainfall with 5-year Return Period

Unit: mm

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	8.7	20.2	15.7	31.9	117.8	99.2	58.7	0.06	0	0

The probable (exceedance) monthly rainfall of 5-year return period is nil (0) during dry season from November to February.

CHAPTER 5 STREAMFLOW AND SEDIMENTATION ANALYSIS

5.1 Streamflow Characteristics

Monthly river discharge of the selected rivers is determined from observed flow data and presented in the following table.

Monthly River Discharge

River	Station	River Discharge (m^3/s)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Meki	Meki	0.95	2.29	5.73	7.03	7.21	6.33	18.52	29.72	19.63	8.86	3.30	0.90	9.21
Katar	Abura	2.48	3.07	4.73	6.76	5.89	5.92	18.34	52.52	33.85	15.02	4.93	2.65	13.01
Kekersitu	Adamitulu	4.07	2.56	1.23	1.34	1.27	1.38	1.98	6.16	13.68	15.09	11.84	7.50	5.70
Bulbula	Bulbula	3.08	2.01	1.67	1.19	1.00	1.21	1.53	3.90	8.18	9.85	6.25	3.70	3.63
Horakelo	Bulbula	0.97	0.68	0.34	0.22	0.20	0.28	0.46	1.71	3.39	4.60	3.15	1.75	1.48

The monthly flow pattern of the streamflow varies widely between rivers. It can grouped into two, streamflow of rivers receiving its water from their catchment and rivers outflowing from lakes. This variation is caused by the different distribution of the basin rainfall in the river catchment. The monthly flow of the Meki and Katar rivers discharges are peak during August and low discharge during December and January. While rivers outflowing from lakes show peak in October and low discharge during month of March to May. Generally, wet season flow occurs during the months of June through November. The dry period is from January to May and stream flow becomes small during this period.

The specific discharge of rivers is presented in the next table. The specific discharge of the Meki and Katar rivers is high compared with other rivers outflowing from lakes.

Discharge Data of Selected Rivers

River	Station	Drainage Area (km^2)	Annual flow (m^3/s)	Specific Discharge ($l/s/km^2$)	Minimum flow (m^3/s)	Maximum flow (m^3/s)
Meki	Meki	2,433	9.21	3.78	0.0	70.1
Katar	Abura	3,350	13.01	3.88	0.43	103.9
Kekersitu	Adamitulu	7,488	5.70	0.76	0.03	35.8
Bulbula	Bulbula	8,155	3.63	0.44	0.0	36.1
Horakelo	Bulbula	2,050	1.48	0.72	0.0	16.6

5.2 Correlation Analysis

The stream flow data of selected rivers are processed, checked for consistency and, later summarized into monthly totals. The cross correlation analysis of monthly discharge data was carried out for the rivers. The results of cross correlation analysis are presented in the following table.

Cross Correlation of Monthly Discharge, Lake Water Level and Rain

River/Lake	Correlation Coefficient					
	Meki at Dugda	Meki at Meki	Katar at Abura	Ziway Lake	Kekersitu at Adami.	Bulbula at Bulbula
Meki at Dugda	1.00					
Meki at Meki	0.94	1.00				
Katar at Abura	0.87	0.79	1.00			
Ziway L.	0.24	0.24	0.29	1.00		
Kekersitu	-	0.20	0.26	0.86	1.00	
Bulbula	0.19	0.21	0.27	0.75	0.73	1.00
Rain -Meki Basin	0.69	0.66	0.50	-	-	-

The cross correlation analysis of monthly water level of lakes and discharge of outflowing rivers was carried out. The results of cross correlation analysis are presented in the following table.

Cross Correlation of Lake Water Level and River Discharge

River/Lake	Correlation Coefficient				
	Ziway Lake	Kekersitu at Adamitulu	Bulbula at Bulbula	Langano Lake	Horakelo at Bulbula
Ziway Lake	1.00				
Kekersitu	0.86	1.00			
Bulbula	0.75	0.73	1.00		
Langano Lake	0.53	0.48	0.04	1.00	
Horakelo	0.65	0.68	0.65	0.79	1.00

The cross-correlation results show that outflowing rivers Kekersitu and Bulbula have correlation with the water level of the Ziway lake and the Horakelo river has high correlation with water level of the Langano lake.

5.3 Estimation of Missing Data

In cases where portions of observed streamflow records are missing, the missing records are estimated by correlation with those recorded at other observation stations. The correlation analysis is performed with other stations to get the highest correlation coefficient. The missing values are then estimated by applying correlation equation with the observation stations having the highest correlation. The correlation analysis can be a simple bivariate correlation or a multivariate regression analysis. The missing data were filled-in using the regression equation in order to complete the record from 1979 through 1999.

5.3.1 Meki River

The Meki river showed high correlation with the discharge of the Katar river and rainfall in Meki basin. The following regression equation fits well and coefficient of determination "r" is 0.86.

$$Q_{Meki} = 0.0465\ R_{Meki\text{-}basin} + 0.322\ Q_{Katar}$$

r=0.86

Missing data were filled using above equation and presented in Table II.3.3.

5.3.2 Kekersitu River

The Kekersitu river outflow from the Ziway lake and its discharge is controlled by the water level of the Ziway lake. It's discharge show high correlation with the Ziway lake water (0.86). The following exponential type regression equation fits well and coefficient of determination "r" is 0.95.

$$Q_{Kekersitu} = 312.172\ \exp\left(\frac{-4.88617}{WL_{Ziway}}\right)$$

Missing data were filled using above equation and presented in Table II.3.5.

5.3.3 Horakelo River

The Horakelo river outflow from the Langano lake and its discharge is controlled by the water level of the Langano lake. It's discharge show high correlation with the Langano lake water (0.79). The following power function type regression equation fits well and coefficient of determination "r" is 0.87.

$$Q_{Horakelo} = 0.001599 \left(WL_{Langano}\right)^{\frac{22.626}{WL_{Langano}}}$$

Missing data were filled using above equation and presented in Table II.3.9.

5.4 Residual Mass Curve

The residual mass curve of flow of the Meki river at Meki town is plotted for past 32 years from 1968 to 1999 and presented in Figure II.5.1. The stream flow tendency can be divided into three episodes, normal years sequence from 1968 to 1983, dry year sequence from 1984 to 1991 and normal years sequence from 1992 to 1999.

5.5 Probable Flood

The instantaneous peak discharge data of the Meki river are not available. Only daily mean discharge data are available for the Meki river. Therefore, it was estimated from the flood study carried out on the rift valley lakes basin by Metaferia Consulting Engineers (1999). The following equation was used for estimation of flood discharge.

$Q= c.\ a.\ A^b$

Where, Q is flood discharge (m^3/s); c is factor based on the ratio of instantaneous to daily maximum discharge; a and b are regression coefficient; A is catchment area (km^2).

The equations were developed by linear regression of the logarithmic specific flood discharge (Q/A) and catchment area for various return periods. The constants of the equation are shown in the following table.

Flood Discharge Equation

Return Period (years)	Coefficient of Equation ($Q= c.\ a.\ A^b$) for $A < 4000\ km^2$		
	c	a	b
5	1.27	0.53	0.665
10	1.29	0.81	0.634
25	1.30	1.18	0.609
50	1.31	1.47	0.596
100	1.32	1.76	0.587

The probable flood discharges were estimated for the Meki and Katar rivers for 5-year, 10-year, 25-year, 50-year and 100-year return periods using above coefficients. The results are presented in the following table.

Flood Discharge

S.N.	Location	River	Drainage Area (Km^2)	Flood Discharge (m^3/s) Return Period (Year) 5	10	25	50	100
1	Meki weir site	Meki	2,433	120.2	146.5	177.0	200.8	225.8
4	Abura	Katar	3,350	148.7	179.5	215.1	242.9	272.5

5.5 Sedimentation

There are some old records of sediment measurements in the Meki river available during the period from 1988 to 1990. Table II.5.1 shows the sediment analysis data of the Meki river. The sediment rate is calculated from fraction of bed sample and flow depth. The total sediment load at each depth is computed by adding the fraction of the computed sediment load. The resulting sediment concentration is converted to tons per day and used in plotting the sediment rating curve together with the corresponding river discharge and presented in Figure II.5.2.

To determine the average annual sediment inflow or yield, the sediment rating curve was applied to the daily flow duration curve. The incremental sediment loads are then integrated or added to arrive at the total suspended sediment load. Bed-load (bigger than sand) is incorporated by adding 10 percent more to the computed sediment load. Sediment yield at dam site is estimated at 25 MCM for 50 years using trapping ratio of 92%.

CHAPTER 6 WATER RESOURCES POTENTIAL AND CONSTRAINTS

6.1 Basic Approach for Water Source Development

The agriculture activities in the study area have been constrained by erratic rainfall, resulting in low and unstable productivity. The Meki river has been exploited for the water source by the small-scale pump irrigation schemes in areas near to the river and the Ziway lake. However, most of the peasants in the study area, who are having their land in other areas, are in an unstable rain-fed cultivation. In order to relieve the areas from the above circumstances, it is crucial to aim at a new water source development so that the land can be fed with water extensively.

It was learned from the existing medium- and large-scale pump schemes that farmers' in these schemes could not afford the operation and maintenance cost, which have led to unsatisfactory performance of the schemes. It is obvious that a gravity type irrigation scheme has more advantage than a pump irrigation scheme in terms of schemes' sustainability.

In this chapter, potential and constraint for water resources development will be assessed, taking optimum use of existing water resource into consideration; the Meki river, as long as the development does not cause an adverse environmental effect on the river basin. The basic approach for formulation of the water source development plan is as follows:

a) New irrigated area shall be fed by the gravity irrigation scheme, which water source is the Meki river,
b) The possibility to construct a diversion weir or a dam on the Meki river is studied,
c) A water balance model in the river basin is formulated, taking present water demand and existing hydrological data into account, and
d) A water balance study is conducted so as to estimate an irrigable area, setting some development alternatives.

6.2 Candidate for New Water Sources

The Meki river is considered as a candidate for new water sources. Hydrological analysis was made for the river as shown in the previous chapters. The Meki river has an annual runoff as much as 290 million m^3 in a year. The river is also featured by a considerable annual variation in runoff, reflecting rainfall pattern in its upstream reach. At the gauging station at Meki town, its mean monthly discharge is 9.2 m^3/s, with a minimum monthly discharge of 0.90 m^3/s in December, whereas it is

30 m^3/s in August. It suggests that the Meki river could be expected as a new water source with double cropping irrigated cultivation if a dam with a regulatory capacity is constructed. In other words, constructing of a diversion weir may contribute mainly to supplemental irrigation in the rainy season.

The field investigation was conducted to seek locations of the water source facility, such as the diversion weir and the dam.

6.3 Water Balance Study

The study area in the Rift Valley is prone to drought because of erratic nature of rainfall. The supplemental irrigation is one of the means to minimize drought risk and sustain small holders agricultural production. The construction of dam and diversion weir on the Meki river are alternatives for irrigation to the study area. The Meki-Ziway-Abijata sub-basin is important in the Rift Valley in terms of potentials for water resources exploitation. However, the lakes and rivers have interconnected system and the constraints for water resources are complex. Therefore, the water resources development of the basin requires a judicious planning for protection of the fragile eco-system.

The objectives of the water balance study are to determine the optimum development scale for the irrigation area under the project and to maximize the irrigation benefits without significantly affecting the environment of the lakes system.

The water balance study linked with the Meki-Ziway-Abijata system was carried out under alternative cases with (i) proposed dam and (ii) diversion dam on the Meki river. Based on the results of the water balance study, the evaluation of the potential irrigation area in the Meki Irrigation Project is made under the alternative conditions. The water balance model is formulated from the conceptual diagram (Figure II.1.1) of the water resources system that includes the Meki river, Ziway, Abijata lake and a dam to supply the water to the new area, the procedure of the study and results are described in the following sections.

6.3.1 Irrigation Requirement

(1) Cropping Pattern

Two (2) alternative cropping patterns are taken for water balance study. Cropping pattern 1 with 105% cropping intensity is taken for diversion weir scheme, while 195% is taken for dam irrigation scheme due to introduction of 5% perennial fruit crop. Only 5% of crops are taken during Belg period (short rain) for cropping pattern 1 and 2% perennial fruit also under cropping during dry season. The short duration crops, such as green maize and vegetables, are planted during the short rain period starting from January 1. The start date for main rainy season crops is taken as 11 June for maize and haricot beans and 1 July for wheat and fruit. The staggered period of planting is taken as 30 days for rainy and Belg seasons. In addition, non-irrigation periods before harvesting were set up to be 20 days. The cropping area in each district is presented in the following table.

Cropping Pattern

Cropping Pattern	Cropping Intensity	Cropping Area (%)							
		Wet Season Crops				Dry Season Crops			
		Maize	Haricot B.	Wheat	Fruit	Wheat	Maize	Vegetables	Pulse
1.	105	33	30	35	2	2.5	-	2.5	-
2.	195	30	30	35	5	28.5	28.5	9.5	28.5

(2) Land Preparation Requirements

Due to the difficulty in manual plowing without pre-saturation of soil, water supply is needed for soaking or saturating the land to soften soil prior to the initial breaking down. The land preparation requirements depend on soil type, moisture content, ground water table, etc. and vary from season to season, and place to place. The land preparation requirement is taken as a water depth of 60 mm.

(3) Effective Rainfall

The US Department of Agriculture, Soil Conservation Service, has developed a procedure for estimating effective rainfall by analyzing long-term climatic and soil moisture data as described in FAO Irrigation and Drainage Paper No 25. The following relationship is used for the calculation of effective rainfall for upland crops:

$ER = 0.38\ R^{0.96}\ Cu^{0.16}$

Where,

ER	:	Effective rainfall in mm/10 day
R	:	Rainfall in mm/10 day
Cu	:	Crop water requirement in mm/10 day

(4) Potential Evapotranspiration

Potential evapotranspiration (ET_0) is calculated using Penman-Monteith Method (Irrigation Drainage Paper 56 FAO, 1998). ET_0 is expressed by the following equation (Penman-Monteith):

$$ET_o = \frac{0.408\ \Delta(R_n - G) + \gamma \frac{900}{T+273} U_2(e_a - e_d)}{\Delta + \gamma(1 + 0.34 U_2)}$$

where,

ETo	:	reference crop evapotranspiration [mm d-1]
R_n	:	net radiation at crop surface [MJ m^{-2} d^{-1}]
G	:	soil heat flux [MJ m^{-2} d^{-1}]
T	:	average temperature [°C]
U_2	:	wind speed measured at 2m height [m s^{-1}]
(e_a-e_d)	:	vapour pressure deficit [kPa]: equation (17)
Δ	:	slope vapour pressure curve [kPa $°C^{-1}$]
γ	:	psychrometric constant [kPa $°C^{-1}$]
900	:	conversion factor

The calculated monthly ET_0 values are presented in the following table.

Potential Evapotranspiration (ET_0)

Parameter	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ETo	mm/day	4.36	4.66	4.84	4.87	5.01	4.90	4.04	4.05	4.12	4.61	4.66	4.42	4.55
Monthly ETo	mm/month	135.1	130.5	149.9	146.1	155.3	147.0	125.2	125.6	123.7	142.8	139.9	137.1	1,658

The average ET_0 value varies from 4.36 mm/day in January to 5.01 mm/day in May. The average annual ET_0 is 1,658 mm, which is calculated based on the average climatic parameters.

(5) Net Water Requirements

The crop water requirements are calculated for 10 days time interval. The consumptive use of water by crops is estimated as a product of the reference crop evapotranspiration (ETo) and crop coefficients (Kc) at a given stage. The crop coefficients of respective crops are determined with reference to the FAO Irrigation and Drainage Paper No. 24 and 46. The consumptive use of water by crops is estimated based on the following equation:

$$ET_C = K_C \times ET_O$$

Where,
K_C : Crop coefficient
ET_O : Reference Evapotranspiration (mm/day)

Field water requirement for upland crop is

$$NWR = (ETc - ER) + LP$$

The net water requirements were calculated on 10-day basis using the cropping calendar.

(6) Irrigation Efficiency

The irrigation water losses are composed of the conveyance losses of the canals, the operation losses and the application losses. These losses vary depending on soil conditions, type of canal regulating structures, water management practices, etc. The adopted overall irrigation efficiency is taken as 44.2%.

(7) Diversion Water Requirement

Overall irrigation water requirements are the sum of the amount obtained by multiplying the each net irrigation water requirements of early, middle and late planted crops by area factor of one third as obtained as a ratio of the planted area of early, middle and late planted crops to the total irrigation area. Then diversion water requirements are calculated by divided the overall net irrigation water requirements by the irrigation efficiencies and multiplying command area.

$$DWR = \frac{1}{n}\sum_{i=1}^{n}\frac{CWR_i}{E_f}\ A$$

Where,

DWR	:	Diversion water requirement in mm (10 days),
E_f	:	Irrigation Efficiency,
A	:	Command area,
i	:	Land preparation period in unit of 10 days e.g. i=1 (0-10), i=2 (11-20), and i = 3 (21-30.days)
n	:	Land preparation period/10

Required discharge at the diversion is calculated by multiplying the unit irrigation requirements by cropped or command area. The monthly diversion requirements per 1000 ha for cropping intensity of 105% and 195% are presented in Tables II.6.1 and II.6.2 and summarized in the following table.

Diversion Water Requirements

Cropping	Diversion Water Requirement (MCM/1000 ha)												
Intensity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
105%	0.15	0.12	0.19	0.17	0.12	0.67	0.93	1.28	2.22	1.13	0.08	0.05	7.11
195%	1.93	1.74	3.03	2.37	0.55	0.74	0.94	1.24	2.17	1.15	0.14	0.12	16.12

The peak diversion requirement for 195% cropping intensity is 1.32 l/s/ha during the month of February.

6.3.2 River Discharges

Monthly discharge data are gauged near Meki town. There are a few year discharge records (1970-1976) of the Meki river available at Dugda station, which is near to the dam site. The river flow at the Dugda is little higher according to the old data. Therefore, river flow at the Meki station can be safely used for estimation of discharge at the dam site. The average annual river discharge at the dam site is estimated at 299 MCM of which 205 MCM (70% of annual total) flow during the rainy period (July-October). The Meki river seasonal discharge at 5-year return period is presented in the following table.

Monthly Discharge of Meki River with 5-year Return Period

Unit: m^3/s

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.14	0.2	0.37	0.85	1.47	1.93	10.77	17.52	12.16	3.34	0.66	0.19

The river discharge at the dam site will be diverted for irrigation and the remaining water flows downstream for the Ziway lake. Since the operation study is done on the monthly basis, it is expected that the daily fluctuation in river flow will cause some stored water in the reservoir to be wasted because of untimely releases done during sudden rise in river flow or significant rainfall in the service area. Furthermore, a certain amount of water is also required to be supplied to the downstream for river maintenance. Therefore to account for these situations, maximum 90% of river flow is considered available for diversion.

6.3.3 Ziway Lake Water Level and Bulbula Outflow

The water level of Ziway lake influences the outflow to the Bulbula river (Kekersitu river). The lake water level data are recorded at Bochessa near outflow to the Bulbula river. Bulbula river discharge data are recorded at the Adami Tulu station, which about 6 km downstream from the Ziway lake.

The cross correlation analysis was carried out between monthly water level of Ziway lake and Kekersitu river discharge at Adami Tulu. Monthly Kekersitu flow showed a correlation coefficient of 0.86 with the water level of the Ziway lake. It shows the Bulbula river outflow is controlled by the water level of the Ziway lake. The regression analysis is carried out using 21 years data of river flow and water level data from 1979 to 1999. The following regression equation fits very well with a coefficient of regression (determination) of 0.91.

$$Q_{Kekersitu} = 312.172 \exp\left(\frac{-4.886}{WL_{Ziway}}\right)$$

Where, $Q_{Kekersitu}$ = Kekersitu river discharge (m^3/s);
WL_{Ziway} = Water level of Ziway level (m)

6.3.4 Elevation-Storage Capacity

The elevation-storage and elevation-area curves of lakes are based on the curves used in previous reconnaissance study carried out done by Halcrow & Partners Ltd. The bathymetric survey data is only available of the Ziway lake. However, there is no data available for the Abijata lake. Therefore, it is estimated based on the water level records, lake area measured from the maps and data from the reconnaissance previous study (Halcrow, 1992). Although, a bathymetric survey is essential to determine the water level, area and storage's relationship of the Abijata lake. the elevation-storage-area curves of the Ziway lake and Abijata lakes are presented in Figure II.6.1 and Figure II.6.2, respectively. The elevation-storage and elevation-area curve of the proposed dam is determined based on the available topographical map and shown in Figure II.6.3.

6.3.5 Operating Rules

The reservoir operation model is used in planning the project potential and, as such, certain conditions were adopted to be able to determine the optimum service area that the available water resources can sustained. In the model, the reservoir water level is allowed to fluctuate between a maximum and minimum limits. If the maximum water level is exceeded then there will be spillage and if the water level goes below the minimum water level then there will be shortage. The number of spillages and shortages determines whether the reservoir has attained its optimum capacity. The reservoir also always supplies maintenance flow downstream of river system.

6.3.6 Water Balance Model

The water balance model is formulated based on the conceptual diagram of the water resources system that includes one storage/diversion dam, 3 lakes, and 5 rivers to supply water to the irrigation areas and Abijata Soda-Ash Enterprise (see Figure II.1.1). The computation of the water balance is performed on a monthly basis for a period of 21 years from 1979-1999.

Computation Procedure

The operation of the combined Meki, Ziway and Abijata system is simulated using a water balance model whereby the change in reservoir storage is equal to inflow minus outflow equals change in storage. It is expressed by the following mass balance equations:

(1) Proposed Dam

The operation of the proposed dam is simulated using a water balance model whereby the change in reservoir storage is equal to inflow minus outflow equals change in storage. It is expressed by the following mass balance equation:

$$V_t = V_{t-1} + I_t - D_t - E_t$$

Where, V_t = reservoir storage at the end of month t, MCM;
V_{t-1} = reservoir storage at the end of previous month $t-1$, MCM;
I_t = total reservoir inflow during the month t, MCM;
E_t = evaporation losses from the reservoir during the month t, MCM;
D_t = total reservoir demand during month t, *MCM;*

The water level in the reservoir is regulated so that if the water level exceeds the maximum operating water level, spillage will occur and when the water level reaches the minimum water level then shortage will occur. The conditions of the computation is as follows:

(i) If reservoir storage (V_t) at decade t is greater than normal reservoir storage (V_{normal}) then there will spillage and reservoir storage will remain at the normal reservoir storage (V_{normal}), which is expressed by the following equation

If $V_t > V_{normal}$ *(Normal Storage)*
then, $Spillage = V_t - V_{normal}$
$Shortage = 0$
$V_t = V_{normal}$

(ii) Else *If* $V_t < V_{min}$ *(Minimum Storage)*
then $Spill = 0$
$Shortage = V_{min} - V_t$
$V_t = V_{min}$

(iii) Else *Then* *(above conditions are not valid)*

The dam always release maintenance flow to the downstream Meki river from the reservoir. The amount of release depends upon the storage of the reservoir, however, always minimum 10% of the river discharge is allowed to flow down. If reservoir level is less than 1/3, 15% of the Meki flow is allowed to flow down, over 1/3and less then 2/3 storage a minimum of 1.0 m^3/s or 25% of river flow is allowed to flow down, and for storage more than 2/3 of total storage, 35% of flow or 1.5 m^3/s is flow down.

(iv) Release from Dam is expressed by

Release = Demand – Shortage

(2) Ziway Lake

The operation of the combined dam and Ziway-lake is carried out using a water balance model whereby the change in lake storage is equal to inflow minus outflow equals change in storage. It is expressed by the following mass balance equation:

$$S_t = S_{t-1} + Q_{Meki-t} + Q_{Katar-t} + R_t - E_t - Q_{bulbula-t} + (Qstr_t - Qirr_t - Qlos_t)$$

Where, S_t = lake storage at the end of month *t* (month time step), MCM;
S_{t-1} = lake storage at the end of previous month *t-1*, MCM;
Q_{Meki-t} = total Meki river inflow during the month *t,* MCM;
$Q_{Katar-t}$ = total Katar river inflow during the month *t,* MCM;
$Q_{Bulbula-t}$ = total Bulbula river outflow during the month *t,* MCM;
R_t = total precipitation during the month *t,* MCM;
O_t = total outflow from lake during the month *t,* MCM;
E_t = evaporation losses from the lake during the month *t*, MCM;
$(Qstr_t - Qirr_t - Qlos_t)$ = other balance in or outflow during month *t, MCM;*

The water level in the lake regulates the outflow into the Bulbula river. The evaporation from the lake is depended upon the surface area of lake water. The evaporation from lake surface is calculated based on 1.10 times of the potential evaporation at the Ziway Meteorological Station. The factor 1.10 for the ratio of open water evaporation to potential evapotranspiration is adopted from the master plan study of development of surface water resources of Awash basin by Halcrow, 1989. First, the model is calibrated using recorded historical data to determine the unknown parameters.

(3) Abijata Lake

The Abijata lake is mainly recharged from the flow of the Bulbula and Horakelo rivers. However, there is a small amount of contribution from the Gogessa river and the flow from the remaining drainage area especially between the Abijata and Shalla lakes. The main source of water loss from the Abijata lake is evaporation. In addition, about 2 MCM of water is taken annually by the Soda Ash Enterprise since 1990. The water balance of the Abijata lake can be described by the following mass balance equation:

$$S_t = S_{t-1} + Q_{Bulbula} + Q_{Horakelo} + Q_{Gogessa} + Q_{other} + R_t - E_t - Q_{so}$$

Where, S_t is storage of lake at time t; $Q_{Bulbula}$ is flow from the Bulbula river into the lake during month t; $Q_{Horakelo}$ is flow from the Horakelo river into the lake during month t; $Q_{Gogessa}$ is flow from the Gogessa river into the lake during month t; Q_{other} is flow from the remaining catchment into the lake; R_t is amount of rainfall on the lake area during month t; E_t is evaporation loss from the lake during month t; and Q_{so} is other water loss such water intake for Soda Ash Enterprise from the lake during month t.

First the water balance was calibrated using the historical records from 1979 to 1999 to determine the unknown parameters.

6.3.7 Data Used

The monthly river discharge data of rivers and water level of lakes related to this study are available from 1979 to 1999. Therefore, this period of 21 years from 1979 to 1999 is selected for the simulation study. The following data are used in the water balance study.

- 10-day rainfall at Meki (1979-1999)
- Monthly rainfall at other stations (1979-99)
- Monthly river discharge (1979-99)
- {Meki, Katar, Kerkersitu, & Horakelo}
- Monthly short duration discharge of other rivers
- {Bulbula, Meki at Dugda, & Gogessa}
- Water level data (1979-99) of Ziway and Abijata lakes
- Monthly Irrigation Requirement
- Storage characteristics of lakes
- Dam storage characteristics curve
- Climatic data at Ziway
- Assumed cropping pattern and characteristics curve of dam

6.3.8 Case Study

Simulation study was carried out for the following four cases:

Case 1 : Diversion Weir constructed on the Meki river
Case 2 : Dam of 30 m height is constructed on the Meki river
Case 3 : Dam of 35 m height is constructed on the Meki river
Case 4 : Dam of 40 m height is constructed on the Meki river

The details of cases are summarized in the following table.

Case Study

Case	Condition	Cropping Intensity (%)	Storage Capacity of Dam (MCM)	Dead Storage of Dam (MCM)
1.	Diversion Weir	105%	-	
2.	Dam (30 m height)	195%	78	25
3.	Dam (35 m height)	195%	125	25
4.	Dam (40 m height)	195%	170	25

6.4 Results of the Study

(1) Cropping Intensity

The river discharge as well as rainfall is significantly low during December and January, therefore with diversion scheme reliable water flow is not available for irrigation area during the period. Therefore, only 5% of area for second cropping period is possible to irrigate from January, which is the start period of the Belg season (short rain season). The cropping intensity of 105% or 2,300 ha is possible to irrigate with the diversion scheme. However, 195% cropping intensity is possible with dam scheme due regulation of the river flow.

(2) Potential Service Area of the Meki Irrigation Project

The viability of the results of the water balance study is measured by the reliability, and effect on the downstream lakes and rivers. The definition of reliability is the number of time the dam/weir is able to supply the reservoir demand over the total period of operation. In the case of irrigation system, a failure to supply for a month period will mean the lost of crop or reduction in yield. Reliability of 80% is adopted for determination of the potential irrigation area. The potential irrigation area is determined at 80% reliability under four alternative cases and presented in the following table.

Potential Irrigation Area

Case	Condition	Cropping Intensity (%)	Potential Area (ha)	Total Irrigation Area (ha)	Reduction in Meki Flow to Ziway Lake (%)
1	Diversion Weir	105	2,300	2,415	5.4
2	Dam H=30m	195	4,700	9,165	29.7
3	Dam H=35m	195	8,000	15,600	48.4
4	Dam H=40m	195	9,400	18,330	57.1

The results of alternatives study show that 2,300 ha of area can be irrigated with 105% cropping intensity with diversion scheme. Dam scheme can irrigate larger area with 195% cropping intensity, from 4,700 ha for 30 m dam height to 9,400 ha for 40 m dam height. However, dam scheme will cause much reduction in Meki river flow to the Ziway lake, from 29.7% for 4,700 ha to 57.1% for 9,400 ha. The reduction in inflow to Ziway lake will result in reduction in water level of the lake that will lead to reduction in Bulbula river outflow and the Abijata lake's water level. The effect on downstream water resources system is discussed in the following sections.

(3) Effect on Ziway Lake Storage

The effects of the Meki river water diversion on the downstream water resources system under different alternatives are presented in the following table.

Effect of Meki River Water Intake on Downstream Lakes and Bulbula River

Case	Condition	Reduction in Ziway Lake Storage (%)	Reduction in Outflow to Bulbula River (%)	Reduction in Abijata Lake Storage (%)	Reduction in Abijata Lake Area (%)
1.	Diversion Weir	1.6	8.0	5.1	2.0
2.	Dam H=30m	10.3	42.5	25.9	10.6
3.	Dam H=35m	19.6	66.4	37.5	17.1
4.	Dam H=40m	24.2	76.3	41.3	20.1

The results show that Ziway lake storage will reduce by 1.6% with diversion scheme, however, it will reduce by 10.3% with dam of 30 m height and by 24.2% with dam of 40 m height. Figure II.6.4 shows the reduction of water level of the Ziway lake under different cases. The increase in dam height causes more reduction in storage of the lake due to increase in water for irrigation and also increase in storage capacity of dam. A large amount reduction in storage of the lake with dam scheme can cause increase in salinity of the lake and will have some impact on existing pumping schemes on the Ziway lake. Moreover, reduction in the Ziway lake storage also has a significant impact on the outflow to the Bulbula river.

(4) Effect on Outflow to Bulbula River

The reduction in the Bulbula river flow under different alternatives is shown in the previous table. The results show that diversion weir will cause 11.3% reduction in the Bulbula flow, however, the dam scheme will cause much reduction in flow from 42% to 76% under various dam heights. It can be seen from results that the effect of dam schemes on the Bulbula outflow is significant compared to that of Ziway lake storage reduction. The seasonal reduction in the Bulbula outflow is shown in Figure II.6.2. It shows the Bulbula river flow with dam scheme will decrease to nearly zero during the period from April to July. There are several irrigation schemes on the Bulbula river, they may also face some problems with decreased discharge. Moreover, the Bulbula river is also used for domestic water supplies along its length from the Adami Tulu to Abijata lake, they may face water problem during dry period. The Bulbula river recharges the Abijata lake and it provides more than half of total inflow into the Abijata lake. Therefore, the decrease in the Bulbula river discharge will also affect the fresh water flow to Abijata lake. Therefore, the effect on the outflow to the Bulbula river is critical in the determination of the potential irrigation area as it has direct effect on the decrease of the water level of the Abijata lake.

(5) Abijata Lake

The reduction in the Abijata lake storage and area is shown in the previous table. The results show a reduction of 5.1% in storage with diversion scheme and from 26% to 41% with dam schemes. Figure II.6.6 shows the average seasonal reduction in the water level of the Abijata lake under different cases. The results also show that dam scheme can have significantly impacts water level of the Abijata lake. The reduction in water level can cause increase in the alkalinity of the lake, which may affect the birds such as Pelican and Flamingo. These are rough estimate to show the possible environmental impacts on the Abijata lake as the storage characteristics of the Abijata lake is assumed based on the previous study. However, for more precise estimate a bathymetric survey of the lake is essential to determine the water level, area and storage's relationship of the lake.

Moreover, higher dam heights significantly reduce the outflow to the Bulbula river and thereby, it will have significant affect on the water level of the Abijata lake. The reduction in fresh water will increase the alkalinity of the Abijata lake. The Abijata lake provides a feeding ground for Pelican, Flamingo and other birds, so they are also influenced by the reduction in water storage

6.5 Conclusions and Recommendations

The following conclusions are made based on the water balance study results:

1. Any new irrigation development or expansion of the existing system on the Bulbula river could have serious environmental impacts on the Abijata lake as well as downstream reach of the river.
2. Irrigation development with diversion weir scheme mainly for wet season on the Meki river will have less adverse environment impacts.
3. There is a possibility of development 2,300 ha area with gravity irrigation for 105% cropping intensity on the Meki river.
4. The expansion of the Abijata Soda Ash Enterprise can cause reduction in water level of the lake, therefore it impacts should be carefully studied before any expansion.

The result of the water balance study revealed that irrigation development plan with the dam will have significant environmental impacts on the river basin. It is, therefore, concluded that the plan with the diversion weir is adopted aiming at supplementary irrigation in the study area.

Recommendations on the future water resources development are as follows.

1. There is a need to monitor the Bulbula river discharge downstream of the Adami Tulu station and to set the maintenance flow to the Abijata lake based on the ecological requirements.
2. There is also a need to monitor the water use of various irrigation projects located on the Ziway lake and Bulbula river and to develop water rights for each scheme.

APPENDIX II

METEOROLOGY AND HYDROLOGY

Tables

Table II.2.1 Maximum Daily Rainfall at Butajira

Year	Maximum Daily Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1968						22	29	16.7	23.5	0	2.3	6	29
1969	5	41	42	31.2	30	69	40	32	0	8.4	7.6	15.1	69
1970	31.4	31.3	55.5	26	45.3	51.1	46.1	27	39.9	3	0	0.3	55.5
1971	1.8	0	21	27	36.2	23.3	28.6	31	28.2	7	7	8	36.2
1972	0	54	82	35	31.2	60.4	21.1	40	20.1	0.3	0	15	82
1973	0	0.2	0	22.7	28.8	40.1	28.2	37.9	21.4	37.7	0	37.3	40.1
1974	0	15.7	21.5	51.5	33.1	17	17	47.3	46.5	0.9	0	0	51.5
1975	5.8	45.2	59	26.4	17.3	32.8	40	21.7	34.5	4.6	0	0	59
1976	4	48.3	90.1	18.9	39.9	14.9	45.9	29.6	23.3	37.8	53.3	8	90.1
1977	28.6	34.6	20.6	35.1	24.6	16.9	23.9	32.8	9.5	48.4	11.2	0	48.4
1978	1	15.4	21.7	37.4	15.2	22.8	16.2	16.1	24.2	13.7	0.3	39.9	39.9
1979	24.1	17.4	40.3	33.4	56.5	18.7	39.6	28.6	61	23	0	7.5	61
1980	18.4	15.3	28.6	41.2	52.8	24.9	34.9	27.8	76	10	0	0	76
1981									27.3	7	0	3	27.3
1982	20.3	18.4	16.1	79.8	28.3	27.6	37.1	28.5	15.6	36.8	12.5	12.3	79.8
1983	18.7	35.6	130	37.9	43.9	27.4	33.1	27.3	16.2	10	0	1.7	130
1984	0	3	15	4.3	39	28.5	47.3	25.3	23.1	0			47.3
1985	6.5	2.1	12.4	35.1	15.4	26.1	38.3	25	18.5	0	0	0	38.3
1986	0	28.1	7.3	52.1	18	33.1	14.1	18.5	32.5	13.4	0	3.6	52.1
1987	0	90	50	33.3	31.3	18.2	15.2	20	44.1	11.4	0	0	90
1988	16	25.5	5.5	32.1	11	43.5	43.2	34.5	24.5	32	0	0	43.5
1989	2	90	63.2	75	10	26.2	51	21.5	26.4	33	0	13.5	90
1990	0	42	45	90.2	53.4	41	38	25.5	29.9	17.8	0	0	90.2
1991	44	50.2	40.1	15.7	0								50.2
1992						10.1	15.2	16.2	14.2	16.5	0	2	16.5
1993													0
1994	0	0	30	15.2	14.2	37	38	15	15.2	0	8.4	2.7	38
1995	0	12	40	65.1	20	11	20	23.5	20	9.5	0	52	65.1
1996	46.6	0	56	30	51	40.1	22	27.3	12	8	5	0	56
1997	42.3	0	21	35	13	46	16.5	62.1	40	40.1	30.1	0	62.1
1998	40.5	30.2	60	38	59	20.3	25.1	39.1	15	12.1	0	0	60
1999			91	35.3	69.4	92.5					0	0	92.5
Maximum	46.6	90.0	130.0	90.2	69.4	92.5	51.0	62.1	76.0	48.4	53.3	52.0	130.0
Std	16.0	25.0	30.2	19.6	17.5	18.3	11.4	10.3	15.7	14.4	11.3	13.3	26.3

Table II.2.2 Maximum Daily Rainfall at Ejersalele

	Maximum Daily Rainfall (mm)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1968	12	58.1	42.1	68.9	12	20	62.2	34.6	21	1	1	3	68.9
1969	19	20	21	20.4	5	30	45	34	26.4	7	2	0	45
1970	42	11.3	47.1	23	18	8	44	39	22	0	0	0	47.1
1971	0	0	13	22	30	25	38	37	19	0	11	10.4	38
1972	4	23	13	37	39	20	30	28	22	0	0		39
1973													
1974	0	6	33	0	12.2	25	21.5	23.4	36.6	0.3	0	0	36.6
1975	0	2	11.3	9	8.3	33.1	51	33.9	21.4	5	0	0	51
1976	0	9	18.5	12.3	35.2	15	24.5	18	5	10.1	18.4	0	35.2
1977	23	13.2	2.2	28	21.5	14	40	33	15	30	25	0	40
1978	3	32.6	1.5	12.2	10.2	31.5	20	30.7	14	48	1.2	6	48
1979	29	2.2	56	7.5	35	29	28.4	32.5	13.4	11	0	0	56
1980	24	13	14.5	20	4.5	25	38	22.1	14.7	2	0	0	38
1981	0	9	30	56	16.5	0	49	45	28	0	0	0	56
1982	0.5	16.2	3					27.5	12.3	37.3	5.3	0.1	37.3
1983	12	27.4	7.7	33.3	18.2	10.1	30	33.5	14.5	10.1	0	0	33.5
1984	0	0		0	21.1	28.5	18	25	7.3		0	10	28.5
1985	17	0	6.9	20	16	13	24	29	31	0	0	0	31
1986	0	21	0	20.2	11.1	26.5	20.6	18.6	22.7	6	0	0	26.5
1987	0	12.2	22.3	45.5	38.7	22.2	20	23.6	18.9	0	0	0	45.5
1988	3.1	37.2	3.2	40.4	5.5	9.7	46.3	42.3	24.3	27.4	0	3.9	46.3
1989	0.6	23.3	45.3	41.3	3.2		20.4	28.4	32.5	20		5.2	45.3
1990	0	36.4	40.5	26.8	19	9.8	43.7	25.4	16.2	0	0	0	43.7
1991	0	6.4	31.5	0	11.1	38	21	55	42.5	0.8	0	0	55
1992	2.1	30	15.6	37	37	30	32	33.2	6.4	32	0	0	37
1993	10.5	15.3	0	97	36	12.5	57	56	10.5	17.3	0	0	97
1994	0	0	24.2	11.3	22	26.1	43.6	59.1	36.7	0	0	0	59.1
1995	0	28.6	19.5	30.1	20.6	19.9	29	26.1	26.7	0	3.1	7.6	30.1
1996	0	0	26.6	23.6	56.4	47.2	49.1	49.3			0	20	56.4
1997	24.5	0	8.3	40.4	3.4	27.8	67.3	26.2	9.6	41.9		0	67.3
1998	28.3	4	34.7	17.1	35.2	17.7	52.2	60.2	23	46.4	0		60.2
1999	0		25.6	19	18	38	43.3	40.1	23.4	35.5	0	0	43.3
Maximum	42.0	58.1	56.0	97.0	56.4	47.2	67.3	60.2	42.5	48.0	25.0	20.0	97.0
Std	11.7	14.3	15.5	20.9	13.3	10.5	13.9	11.6	9.4	16.3	5.9	4.6	14.5

Table II.2.3 Maximum Daily Rainfall at Meki

	Maximum Daily Rainfall (mm)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1966		60	15.5	13	35.2	19.2	27.5	45.8	33.9	25.1	0	0	60
1967	0	1.2	28.9	9.1	19.2	23.3	81.2	21.9	18.4	49	46.3	0	81.2
1968	0	15.6	12.8	35.4	8.6	39.7	42.6	26.7	42.2	3.2	1.6	0	42.6
1969	3.3	42.5	20.9	22.4	8.8	21.9	33.5	19.1	28.1	3.2	0	0	42.5
1970	27	26.5	18.5	4.1	33.6	9.4	33.6	21.8	17.8	8.2	0	0	33.6
1971	0.4	0	9.8	7.6	15.4	38.6	33.5	52.8	25	0	6.1	3.9	52.8
1972	10.3	10.8	12	46	13.8	35.7	37.4	46.8	23.4	0	0	0	46.8
1973													
1974	0	18.7	29.9	0.1	24.7	34.8	41.5	28.5	27.8	4.5	0	0	41.5
1975	2.4	2.8	9.6	28.9	32	33	40	22.3	29.5	4		0	40
1976	0.5	1	50.5	16.7	12.8	20.7	35.1	35.5	17.3	3.9	18.7	0	50.5
1977			15.8	37.5	9.6	36.2	45.5	32.9	34.6	75.8	38.5	0	75.8
1978	8.5	50.9	8.8	42.3	6.6	58.6	37.6	33.2	20.3	18.8	1.1	0	58.6
1979	10.7	7.7	50.3	33.2	23.7	40	66.2	12.5	16	53.7	0	0.3	66.2
1980	18.2	4.1	0.3	20.7	19.8	26	65	35.1	13.4	13.5	0	0	65
1981	0	0	63.5	27.4	15.5	2.9	37	33.6	22.9	18.5	0	0	63.5
1982	10.9	9.4	3.1	23.1	24.5	2	25.9	29.6	69.7	19.2	4.9	2.7	69.7
1983			26	47	50.2	30.8	50.9	66.7	21.5	9.4	0	0	66.7
1984	0	8.6	1.3	7.7	24.5	25	39.3	69.2	23.5	0	0	0	69.2
1985	0	0	4.5	12.2	22	6	38.7	37.1	33.4	0	0	0	38.7
1986	0	61.1	16	22	42.5	50.9	136.2	18.7	29	30.6	0	0	136.2
1987	0	5.3	34	36.7	45.2	26.2	32.2	81.2	28	1.3	0	0	81.2
1988	0.4	15.9	8.4	20.1	14.8	34.8	32	29.5	20.5	28.2	0	0	34.8
1989	3	25.7	28.5	23.5	14.5	76.1	40	29	23.3		0	0	76.1
1990	0	81.5	3.7	30.8	8.2	11.2	45	38.2	31.8	18.6	0	0	81.5
1991	0	17.5	39.5	0.1	11.5	2.8	34.4		8	6.4	0	9.4	39.5
1992	9.9	30	2.2	30.2	37.8	25.5	45.2	32.5	34.9	30.5	0	16.5	45.2
1993	30.6	17	1.4	37.3	39.4	30.4	34.1	36.4	11.7	24.4	0.4	0	39.4
1994	0	0	24.5	4.1	20.3	48.7	42.3	30.6	16.4	0	2.9	0	48.7
1995	0	0.7	20.3	25.5		7.9	29.2	30.8	3.5				30.8
1996													
1997													
1998		32.4	18.8	22.5	17	28.7	22.7	31	32.3	30.3	0	0	32.4
1999			39	7.1	7.8	25.9	37.4	39.4	18.8	66.2	0	0	66.2
Maximum	30.6	81.5	63.5	47.0	50.2	76.1	136.2	81.2	69.7	75.8	46.3	16.5	136.2
Std	8.5	21.8	16.1	13.5	12.3	16.9	21.0	15.2	11.9	20.5	11.3	3.5	21.6

Table II.2.4 Maximum Daily Rainfall at Ziway

Year	Maximum Daily Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1971	6.8	1	15.2	49	16.8	40	30.4	36.6	6.8	0	2.6	1.6	49
1972	0	0	0	28.2	37	12	28	28.5	24.7	10.8	0	0	37
1973	0	0	0	3.2	35.5	13	32.4	24.5	21.8	22.5	0	2.6	35.5
1974	3.6	5.5	44.4	1.2	37	16.4	35.1	64.2	45.7	0	0	0	64.2
1975	0	28.8	2	7.7	52	98	35	11.5	45.5	4.2	0	0	98
1976	0	1.8	21.7	15.3	22.4	26.6	35.7	28	40	4.7	16.5	0	40
1977	21.2	6.7	4.4	49.5	30	48.3	48.3	35.6	14.8	66.6	0	0	66.6
1978	8.2	41.3	20.3	47.7	13.2	64.6	16.5	72.8	25.9	25.4	1.6	5.5	72.8
1979	23.1	51.7	17.9	28.2	42	27.8	54.9	23.2	30	65.6	0	3.5	65.6
1980	23.5	8	9.4	17	2.1	28.1	29	40.7	28.9	28.4	0	0	40.7
1981	0	24.5	34.2	35.5	13.6	2.2	29.8	28.5	80.9	4	0	0.6	80.9
1982			58.7	27.5	15.3	8.7	26.9	44	8.5	40.7	9.5	0	58.7
1983	28.6	22.2	31.8	38.5	31.8	14.5	26.2	20.1	22.8	11.7	0	0	38.5
1984	0	0	5.6		37.7	28.4	76.6	18.2	24.5	0	0	0	76.6
1985	0.4	0	20.4	48.7	40.4	21.7	36.9	23.2	17.4	1.3	0	0	48.7
1986	0	17.9	16.2	17.6	28.5	23.4	18	13.2	35.1	18.4	0	0.6	35.1
1987	0	14.9	24.5	22.5	89.5	8.3	21.7	13.7	16.5	15.6	0	0	89.5
1988	2	7.7	1.8	15.9	9.5	44.7	31.3	20.8	40	47.2	0	0.2	47.2
1989	4.3	40	90.7	39.6	2.6	43.5	32.4	26.5	32	7.3	0	22.7	90.7
1990	0	18.7	6.9	24.4	14.7	21.1	35	29.8	59.3	0.5	0	0	59.3
1991	1.7	32.3	24.7	9.4	6	38.9	24.4	22.7	16.8	6.9	0	5	38.9
1992	10.8	17.3	5	33.4	25.7	21.5	31.3	20.8	12.7	62.5	1.5	4.9	62.5
1993	18	68.5	0.4	27.6	46.6	31.6	29.1	26.6	15	29.5	0	0.2	68.5
1994	0	0	12.5	2.3	13.2	25.5	23.8	23.8	15.3	0	3.5	0	25.5
1995	0	24.2	22.2	44.2	8.9	25.6	17	49.9	9.5	3	0	10.3	49.9
1996	27	8.2	22.1	38.7	42.2	31.8	37.7	27.2	27.7	0	29.2	0	42.2
1997	13	0	20.6	65.7	2.5	51.7	27.2	10	15.4	54.2	0.3	0	65.7
1998	2.1	9.8	20.6	23.7	19.4	17	39.4	45.8	29	26.7	0	0	45.8
1999	5.5	0	12.3	1.9	26.6	33	19.6	15	17.5	28	0	0	33
Maximum	28.6	68.5	90.7	65.7	89.5	98.0	76.6	72.8	80.9	66.6	29.2	22.7	98.0
Std	9.5	17.8	19.3	17.1	18.8	19.3	12.1	14.9	16.2	21.5	6.3	4.7	19.2

Table II.2.5 Maximum Daily Rainfall at Bulbula

Year	Maximum Daily Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1968	3	50	10	30	50	29	31	28	5	0	0	0	50
1969	24	16.7	15.3	10	5.4	14	16	13	19.5	5	0	0	24
1970	30	9	34	8	15.3	5	48	30	24	0	0	0	48
1971	0	0	0.5	12	17	33	21	27	15	0	0	0	33
1972	0	13	6	13	29	18	18	25.8	20	0	0	0	29
1973													
1974	0	0	33		26	20	33	27	16	0	0	0	33
1975	0	11	6	6	14	16	37	23	24	5	0	0	37
1976	0	9	5	16	10	8	49.9	21	7	5	21	0	49.9
1977	20	16	27	37	16	10	27	44	12	24	3	0	44
1978	3	35.5	10.2	23.8	35	31.1	15.8	48.5	34.2	57.7	2.4	22.7	57.7
1979	19.7	13.5	34.2	31.8	16	23.7	39.5	61.3	27.4	54.4	0	0	61.3
1980	5.3	0	0	0	0	0	6	73.8	6.2	30.7	0	0	73.8
1981	0	18.4	45	15.7	8	5.6	32	30.2	42.3	4.2	0	0	45
1982	20.3	14.7	18.2	50.4	37.6	27.5	30.4	30.2	21.3	25.8	10.6	4.3	50.4
1983	1.8	14.9	26.3							38.7	0	0	38.7
1984	0	0	7.3	3.6	31.3	40.5	32.3	35.9	11.4	0	0	0	40.5
1985		0	8.2	57.8	45.2	0	80.3	9.3	35.7	13.6	9.8	3.9	80.3
1986	0	12.2	53.9	62.9	34.3	51.3	32.3	41.2	7.4	23.2	0	3.8	62.9
1987	2.1	14.5	29.7	22.5	57.2	40.5	35.4	19.3	21.3	6.2	0	5.2	57.2
1988													
1989	24.5	50.2		113.2	12.3	33.2	23.2	29.7	69.2	30.2	1.8		113.2
1990	0	27.8	24.8	59.9	31.3	24.1	30.3	26.8	14.4	18.4	0	0	59.9
1991	11.5	13.3	41.3	9.8	9.5	26.9	22.6	9.5	35.8	0	19.7		41.3
1992	6.8	6.3	29.3	15.3	18.5		77.6	35.2	15.2		0	0	77.6
1993	16.1	16.7	0	16.2	18.5	19.5	18.3	33.5	23.3	28.7	0	0	33.5
1994	0	0	12.4	17.6	32.5	45.3	35.1	25.8	44.2	0	5.6	0	45.3
1995	0	16.3	20.3	41.5	22	19	32	36	14	1.2	0	19	41.5
1996	27.6	0	11.7	23.1	28.5	27.7	52.2	44.4			6	0	52.2
1997		9.8	0	20	14.7	5.1		32.5	18.1	38.6	10.2	0	38.6
1998	50.1	20.7	6.2	10.6	10.2	10.8	40.4	36.1	18.6	14.7	0.9	0.5	50.1
1999	1.2		55.5	31.3	14.6	13.7	24.2	21.7	51.7	62.5	0	0	62.5
Maximum	50.1	50.2	55.5	113.2	57.2	51.3	80.3	73.8	69.2	62.5	21.0	22.7	113.2
Std	12.9	13.2	16.2	24.1	13.8	13.6	16.6	13.8	14.9	19.3	5.7	5.5	18.2

Table II.2.6 Number of Rainy Day at Butajira

Year	Number of Rainy Days												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	6	10	10	9	11	14	18	9	0	2	0	3	92
1970	9	6	9	9	5	9	22	14	10	3	0	1	97
1971	2	0	7	8	8	6	15	18	18	5	4	2	93
1972	0	6	10	8	9	4	20	11	13	1	0	1	83
1973	0	1	0	3	9	10	14	11	6	3	0	2	59
1974	0	3	14	3	7	10	6	28	24	2	0	0	97
1975	1	6	6	13	8	21	25	20	18	4	0	0	122
1976	1	1	10	8	15	14	13	15	12	2	6	1	98
1977	9	5	9	10	9	11	15	12	8	11	4	0	103
1978	1	11	7	6	6	8	16	11	9	2	1	2	80
1979	12	6	13	4	7	14	13	13	10	3	0	2	97
1980	4	4	4	8	7	13	11	16	11	2	0	0	80
1981									13	2	0	1	
1982	8	13	7	15	10	14	19	15	7	15	11	2	136
1983	8	3	16	17	17	13	13	24	8	5	0	2	126
1984	0	1	3	1	18	10	14	18	13	0	0	0	78
1985	2	1	5	17	10	7	20	17	15	0	0	0	94
1986	0	13	2	17	11	15	15	13	14	5	0	2	107
1987	0	8	18	9	16	6	13	17	11	4	0	0	102
1988													
1989	2	6	13	9	5	8	24	19	15	3	0	0	104
1990	0	21	9	13	12	11	23	19	16	2	0	0	126
1991	1	10	15	4	0								
1992													
1993													
1994	0	0	8	10	10	18	23	12	12	1	3	1	98
1995	0	9	11	20	8	13	17	13	9	1	0	1	102
1996	7	0	13	11	14	23	20	16	11	2	5	0	122
1997	6	0	13	15	6	18	16	17	11	10	6	0	118
1998	7	11	11	12	15	15	21	19	18	12	0	0	141
1999	1	2	11	3	10	9	22	11	13	15	0	0	97
Average	2.9	5.6	9.4	9.8	9.9	12.1	17.0	16.0	12.6	4.5	1.6	0.8	103
Std	3.6	5.3	4.5	5.2	4.2	4.8	4.7	4.3	4.1	4.5	2.9	0.9	19.7

Table II.2.7 Number of Rainy Day at Ejersalele

Year	Number of Rainy Days												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1968	1	16	3	13	3	10	13	14	14	1	2	1	91
1969	4	9	11	8	7	12	15	16	10	1	1	0	94
1970	7	3	7	2	2	6	16	21	16	0	0	0	80
1971	0	0	5	9	9	12	19	19	16	0	2	5	96
1972	3	18	9	12	5	8	21	16	7	0	0	0	99
1973													
1974	0	1	13	0	9	10	17	13	15	1	0	0	79
1975	0	2	3	6	4	8	15	22	19	2	0	0	81
1976	0	1	13	3	7	8	12	9	6	1	3	0	63
1977	4	2	3	5	8	7	16	19	14	11	1	0	90
1978	2	14	1	5	3	11	14	14	12	5	2	2	85
1979	9	1	5	3	9	9	17	16	13	3	0	0	85
1980	1	2	1	6	5	11	13	9	7	1	0	0	56
1981	0	1	13	4	1	0	17	12	7	0	0	0	55
1982	1	5	1					20	12	8	5	1	
1983	3	6	6	9	18	8	14	19	10	2	0	0	95
1984	0	0	2	0	19	10	16	16	12		0	1	76
1985	1	0	2	9	6	6	23	15	16	0	0	0	78
1986	0	7	0	17	7	14	15	13	15	5		0	93
1987	0	4	14	7	14	8	13	14	7	0	0	0	81
1988	1	6	1	14	2	9	15	15	11	2	0	1	77
1989	1	3	10	12	1		14	19	17	3		3	
1990	0	19	7	8	8	7	19	20	10	0	0	0	98
1991	0	7	10	0	2	4	18	16	13	2	0	0	72
1992	4	4	1	6	1	6	15	18	4	2	0	0	61
1993	4	6	0	7	11	7	23	22	2	6	0	0	88
1994	0	0	3	3	4	13	16	8	10	0	2	1	60
1995	0	3	10	10	3	3	12	7	8	0	0	2	58
1996	0	0	10	4	12	15	16	21				0	
1997	4	0	4	7	3	8	15	15	9	4	0	0	69
1998	3	2	5	4	8	11	20	16	8	4	0	0	81
1999	0	0	6	1	4	8	20	11	9	11	0	0	70
Average	1.7	4.6	5.8	6.5	6.5	8.6	16.3	15.6	11.0	2.6	0.6	0.5	79
Std	2.3	5.4	4.4	4.3	4.7	3.2	3.0	4.1	4.1	3.1	1.2	1.1	13.5

Table II.2.8 Number of Rainy Day at Meki

Year	Number of Rainy Days												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1966	0	9	3	5	2	8	12	17	11	2	0	0	69
1967	0	1	9	6	7	7	13	11	13	5	5	0	77
1968	0	10	3	9	1	8	6	10	11	1	1	0	60
1969	4	7	7	3	5	6	11	12	7	2	0	0	64
1970	6	4	5	2	6	5	12	13	11	2	0	0	66
1971	1	0	3	6	8	9	10	13	9	0	3	3	65
1972	4	6	6	14	4	9	10	11	5	0	0	0	69
1973													
1974	0	1	11	1	10	6	11	15	15	1	0	0	71
1975	1	3	3	8	4	7	20	8	9	3		0	66
1976	1	1	6	4	10	9	16	11	10	3	3	0	74
1977			2	8	6	9	18	11	16	14	3	0	
1978	1	12	7	3	5	13	11	18	14	6	1	0	91
1979	11	2	9	4	8	6	12	15	12	6	0	1	86
1980	2	4	2	7	4	10	17	13	11	5	0	0	75
1981	0	0	10	10	5	2	14	15	13	4	0	0	73
1982	4	3	3	10	7	3	8	13	14	9	4	1	79
1983			8	7	13	6	13	15	12	4	0	0	
1984	0	1	2	1	15	6	17	17	10	0	0	0	69
1985	0	0	2	10	8	2	18	11	10	0	0	0	61
1986	0	10	4	9	8	12	11	10	13	4	0	0	81
1987	0	5	9	3	15	2	11	16	14	2	0	0	77
1988	2	7	3	9	3	9	15	13	11	3	0	0	75
1989	1	2	7	10	1	5	12	14	10		0	0	62
1990	0	12	2	4	3	2	11	20	9	1	0	0	64
1991	0	8	11	1	2	1	6		6	2	0	2	
1992	4	4	1	7	4	3	14	18	5	5	0	1	66
1993	3	5	1	12	12	7	15	15	8	9	1	0	88
1994	0	0	3	8	9	13	14	11	10	0	2	0	70
1995	0	1	6	9		4	7	7	4				
1996													
1997													
1998		2	2	6	5	4	11	13	5	5	0	0	
1999	1	1	5	1	2	6	10	9	6	6	0	0	47
Average	1.6	4.2	5.0	6.4	6.4	6.4	12.5	13.2	10.1	3.6	0.8	0.3	71
Std	2.5	3.8	3.1	3.5	3.9	3.3	3.5	3.1	3.2	3.2	1.4	0.7	9.6

Table II.2.9 Number of Rainy Day at Ziway

Year	Number of Rainy Days												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1971	1	1	5	12	9	12	10	8	15	0	3	1	77
1972	0	0	0	14	7	10	18	14	7	14	0	0	84
1973	0	0	0	4	8	8	16	17	15	4	0	1	73
1974	1	1	14	1	6	6	14	16	15	0	0	0	74
1975	0	3	3	8	10	10	18	13	12	2	0	0	79
1976	0	1	8	6	15	5	14	10	9	2	3	0	73
1977	8	2	3	9	7	11	17	14	9	11	0	0	91
1978	2	11	5	4	1	9	10	21	14	5	1	1	84
1979	10	4	9	3	10	10	14	13	9	3	0	3	88
1980	2	2	4	7	3	10	15	14	13	4	0	0	74
1981	0	2	20	10	3	1	18	14	12	2	0	0	82
1982	6	3	4	7	8	4	11	13	9	7	1	0	73
1983	3	4	6	9	14	7	14	16	9	5	0	0	87
1984	0	0	3		10	5	10	15	5	0	0	0	48
1985	1	0	2	7	8	4	17	14	13	1	0	0	67
1986	0	7	4	8	9	9	11	8	5	2	0	1	64
1987	0	6	9	7	16	4	12	16	11	4	0	0	85
1988	2	6	1	16	2	11	17	16	17	6	0	1	95
1989	3	3	12	13	2	8	15	19	13	4	0	4	96
1990	0	21	6	11	4	8	18	22	14	1	0	0	105
1991	1	9	12	3	9	10	24	18	11	3	0	2	102
1992	9	5	3	7	8	11	19	23	9	10	1	1	106
1993	6	9	1	13	8	9	23	19	18	10	0	1	117
1994	0	0	10	8	8	14	18	8	14	0	3	0	83
1995	0	5	10	13	7	8	12	17	10	2	0	2	86
1996	6	1	11	11	15	17	17	20	15	0	3	0	116
1997	3	0	8	10	3	15	17	17	11	10	1	0	95
1998	6	6	7	7	9	7	16	14	12	10	0	0	94
1999	1	0	6	2	4	12	14	7	8	12	0	0	66
Average	2.4	3.9	6.4	8.2	7.7	8.8	15.5	15.0	11.5	4.6	0.6	0.6	85
Std	3.0	4.5	4.6	3.8	4.0	3.5	3.5	4.2	3.3	4.1	1.1	1.0	15.6

Table II.2.10 Number of Rainy Day at Adamitulu

Year	Number of Rainy Days												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1984	0	0	3	0	15	5	7	14	8	1	0	0	53
1985	0	0	5	9	8	4	17	19	15	1	0	1	79
1986	0	6	5	10	10	10	14	9	9	5	0	1	79
1987	0	4	9	8	13	14	7	13	12	2	0	0	82
1988	3	6	1	14	2	10	15	18	12	6	0	1	88
1989	2	4	10	9	1	8	18	17	6	4	0	5	84
1990		7	9	8	6	9	19		12		0	0	
1991			13	3	10	9	19	17	9			1	
1992	7	4	2	8	5	10	15	19	7	9	1	1	88
1993	5	7	0	10	10	8	14	16	13	6	0	0	89
1994	0	0		6	9	11	14				2	0	
1995	0	5	7	15	4	8	7	13	10	2	0	2	73
1996	5	1	9	9	10	10	14	15	12	0	1	0	86
1997	4	0	8	6	2	8	11	12					
1998			6	7	2	8	9	14					
1999	1	0	4	3	6	7	14	8	9	11	0	0	63
Average	2.1	3.1	6.1	7.8	7.1	8.7	13.4	14.6	10.3	4.3	0.3	0.9	79
Std	2.5	2.9	3.7	3.8	4.2	2.3	4.1	3.4	2.6	3.5	0.6	1.4	11.4

Table II.2.11 Rainfall Intensity at Bui

	Maximum Hourly Rainfall (mm)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1990	2.3	24.3	21.8	13.2	9.5	12.6	36	17.8	9.3	1.8			36
1991		20	14	3.3	6.2	12.8	12.8	19	14.8	4		0.8	20
1992													
1993							17	19.5	21	27	0	1.1	27
1994	0	0	10.7	4.2	16	12	25.7	15.2	30.3	0			30.3
1995	0	6.5											6.5
1996													
1997	10				5.2	12	21	10	5.8	13.3	13	0	21
1998		10	8		7	13	16		12	14.2	0	0	16
1999			17.5		7.5	15		12					17.5
Maximum	10.0	24.3	21.8	13.2	16.0	15.0	36.0	19.5	30.3	27.0	13.0	1.1	36.0
Std	4.7	9.9	5.5	5.5	3.9	1.1	8.4	3.9	8.9	10.2	7.5	0.6	9.2

Table II.2.12 Rainfall Intensity at Ziway

	Maximum Hourly Rainfall (mm)												
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1987		14	21	10.8	22.8	3	20	8	13.5	9.5			22.8
1988	2	3.7	1	5	9.2	23.2	15	15	25	23.5			25
1989	1.5	19.5	29.7	26.3	2.5	28.7	23.8	21	40.3	7.2		16	40.3
1990	0	11.5	5.5	19.4	0.2	16	15	30	26.8	0.4			30
1991	1.5	15.6	14	8.3	5.8	15.7	13.7	13.7	13.5	6.8		3	15.7
1992	6	11.8	5.1	13.2	23.5	19	20.1	14.5	5	16.2	1	2.5	23.5
1993	18	22.5		24.8	23.6	18.2	25.5	16.7	15	28.5	0.2		28.5
1994	0	0	5.7	2.2	13.3	20.5	19.5	18.5	15.3	0			20.5
1995	0	14.4	13.4	21.4	8	6.2		25.1	6	2		7.9	25.1
1996	8.3	8.3	8	10.4	15.8	30	15	17.1	24.4	0	19.3		30
1997					1.6	18		10	16	14	0	0	18
1998		10	17.5	14	6	15.4	18	17.5	14				18
1999	3		15										15
Maximum	18.0	22.5	29.7	26.3	23.6	30.0	25.5	30.0	40.3	28.5	19.3	16.0	40.3
Std	5.6	6.5	8.4	7.9	8.7	7.8	4.0	6.1	9.8	9.8	9.5	6.3	7.0

Table II.2.13 Maximum Temperature

Station Ziway Longituc 38°48' E Latitude 7°50' N Altitude 1640 m

Year	Mean Monthly Maximum Temperature (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	25.8	26.5	24.6	24.4	26.7	26.7	23.1	23.3	23.1	24.5	24.5	24	24.8
1982	25.1	25.3	26.2	25.3	25.7	25.8	23.8	22.5	23.7	22.9	24.8	24.1	24.6
1983	25	25.6	27.1	25.5	24.7	25.8	23.6	25.8	22.8	24.1	24.4	23.5	24.8
1984	23.6	24.4	26.9	30.4	28	26.7	26.7	25.3	26.1	27.3	27.7	27	26.7
1985	27.5	27.9	27.3	27.4	27.8	28.2	24.8	24.3	25	26.6	26.6	25.8	26.6
1986	26.2	24.4	28.8	25.6	28.9	26.2	25	26.6	26.6	28.1	28	27.2	26.8
1987	26.4	27.2	28.5	28.8	30.4	27.6	27.4	27.2	28.5	28.7		27.8	28.0
1988	27.4	28.7	30.9	29.8	30.4	27.9	24.2	25.6	26.1	26.6	26.8	26.4	27.6
1989	25.9	27	28.3	26	29	27.1	24.7	25.7	26	27.2	27.7	26.7	26.8
1990	27.5	26.4	27.7	28.6	30	28.3	25.3	24.8	26.4	27.7	28	26.8	27.3
1991	28.6	27.9	28.2	28.7	30.4	29	23.9	24.6	26.6	27.9	27.5	26.9	27.5
1992	26.3	27.1	30.7	29.9	29.8	28	24.8	24.2	25.8	26.6	26.3		27.2
1993	26	25.9	29.7	28	29.1								27.7
1994						26	24.2	24.9			26.5	25.9	25.5
1995	27.1	28.7	28.8	28.1	29.8	29.7	25.7	25.9	26.8	28.6	28	27.6	27.9
1996	26.6	29.8	29.3	28.8	27.8	25.8	25	25.1	26.3	28	26.9	26.7	27.2
1997	26.7	28.4	30	27.5	29.5	28.2	25.5	26.3	28.5	27.4	27.3	27.2	27.7
1998	27.7	29.3	30	31.5	30.5	29.2	25.5	25	26.8	26.8	27	26.7	28.0
1999	27.5	30.2	28.9	31.1	30.4	28.2	25.5	26.4	27.6	25.7			28.2
Average	26.5	27.3	28.4	28.1	28.8	27.5	24.9	25.2	26.0	26.7	26.8	26.3	26.9
Std	1.2	1.7	1.6	2.1	1.7	1.2	1.1	1.2	1.6	1.6	1.2	1.3	1.2

Table II.2.14 Minimum Temperature

Station Ziway Longituc 38°48' E Latitude 7°50' N Altitude 1640 m

Year	Mean Monthly Minimum Temperature (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	13.2	14.7	16.3	16.5	16	15.4	15.7	15.5	14.9	13.7	12.4	11.1	14.6
1982	14.8	15.6	15.4	15.6	15	15.7	15.4	15.5	14.6	14.5	14.7	15.3	15.2
1983	14	17.2	18.4	17.6	17.7	15.5	15.1	15.5	14.6	12.6	11.9	11.9	15.2
1984	11.3	11.5	13.8	13.6	14.5	13.6	13	13.3	12.4	10.4	12	10.5	12.5
1985	10.9	11.7	12.7	13.8	13.8	13.7	12.9	12.5	12.3	10.6	10	8.4	11.9
1986	8.2	11.5	12.4	13.5	13.2	12.5	12	11.6	11.7	10.6	8.8	9.8	11.3
1987	11.8	12.1	16	14.8	15.6	15.2	14.7	14.8	14	13.9	11.6	11.6	13.8
1988	13	14.9	14.6	15.5	15.5	15.5	15.3	15.1	14.9	13	9.7	11.1	14.0
1989	11.3	13.7	15	15.2	14	15.2	15.1	14.5	14.4	11.8	11.8	13.8	13.8
1990	11.8	15.4	14.2	14.9	15.6	15	14.4	14.4	14.9	11.9	11.9	10.5	13.7
1991	13.3	14.6	15.3	15	15.5	16.2	15.2	15	13.9	11.7	10.9	11.5	14.0
1992	13.4	15	15.6	16.2	15.8	15.6	14.8	15.2	13.4	12.7	11.5	12.7	14.3
1993	13.5	13.1	12.7	15.8	16.7								
1994						15.8	15.3	15.1			12.1	10.4	13.7
1995	11.3	14.7	15.5	16.1	15.8	16	15.5	15.1	13.7	13.2	11.3	13.1	14.3
1996	14.4	13.2	15.9	15.9	15.4	15.4	15	15.1	14.1	11.1	11.4	10.3	13.9
1997	13.5	11.8	15.3	15.5	15.2	15.4	15.4	14.8	14.8	15.1	14.9	12.4	14.5
1998	15.3	16.2	16.4	16.9	17.2	16.6	15.7	15.4	15.2	14.4	10.4	9.4	14.9
1999	11	12.5	15.2	12.9	11.6	11.2	13.4	13.6	12.8				
Average	12.6	13.9	15.0	15.3	15.2	15.0	14.7	14.6	13.9	12.6	11.6	11.4	13.8
Std	1.74	1.76	1.49	1.24	1.44	1.37	1.09	1.11	1.06	1.50	1.54	1.70	1.06

Table II.2.15 Relative Humidity

Station Ziway Longituc 38°48' E Latitude 7°50' N Altitude 1640 m

Year	Mean Monthly Relative Humidity (%)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	51.3	54.7	68.3	70.0	60.0	58.0	73.0	73.7	75.3	61.3	62.3	63.3	64.3
1982	71.0	73.7	70.3	76.3	70.7	70.3	76.7	78.7	67.3	71.3	70.0	85.0	73.4
1983	83.3	86.3	84.0	86.3	86.3	86.7	86.7	87.0	89.0	87.3	86.0	89.0	86.5
1984	88.0	87.7	88.3	0.0	90.7	89.7	81.0	84.7	83.7	84.0	85.3	79.0	78.5
1985													
1986	76.3	84.3	85.3	81.7	79.0	80.3	81.0	82.0	82.0	69.0			
1987	60.0	58.7	68.7	64.0	71.0	57.3	55.7	58.0	55.7	52.3	46.3	54.3	58.5
1988	57.3	54.7	43.0	52.0	51.0	56.3	66.3	61.3	53.0	56.0	51.3	55.3	54.8
1989	55.0	56.3	51.7	61.0	49.3	56.0	62.7	60.7	59.0	52.3	53.7	67.7	57.1
1990	54.7	70.7	68.7	65.0	59.7	58.0	64.3	72.3	75.0	59.0	52.0	53.3	62.7
1991	56.0	63.7	65.7	60.7	58.3	64.3	75.3	76.3	71.3	50.3	49.3	57.7	62.4
1992	63.7	66.0	53.0	55.3	57.3	63.3	74.0	76.7	73.7	65.0	61.0	64.3	64.4
1993	66.3	69.0	50.3	66.3	63.7								
1994						71.3	76.7	75.7	72.3	54.0	60.7	59.3	67.1
1995	51.0	56.3	62.7	66.7	59.7	61.0	71.0	72.7	67.7	53.0	52.7	60.0	61.2
1996	58.7	48.3	61.7	66.7	70.0	74.3	74.7	76.3	75.3	56.3	62.3	56.3	65.1
1997	64.3	49.0	55.0	66.7	58.3	65.3	72.3	70.3	63.7	66.0	66.0	59.3	63.0
1998	67.0	61.7	62.0	55.0	62.0	64.0	71.7	75.7	71.3	68.3	51.7	49.0	63.3
1999	54.3	43.3	55.3	49.0	54.7	60.0	73.3	75.3	66.7	69.3	50.3	54.7	58.9
Average	63.4	63.8	64.4	61.3	64.8	66.8	72.7	74.0	70.7	63.2	60.1	63.0	65.7
Std	5.9	9.9	6.2	6.6	4.4	5.2	3.6	2.2	4.0	7.2	6.2	4.4	2.4

Table II.2.16 Wind Speed

Station Ziway Longituc 38°48' E Latitude 7°50' N Altitude 1640 m

Year	Mean Monthly Wind Speed (m/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1990	2.1	1.5	1.9	1.7	2.4	3.2	2.6	2.4	1.6	1.8	2	2.3	2.1
1991	2.1	1.8	1.6	1.9	1.9	2.6	2.6	1.9	1.5	1.7	1.9	1.9	2.0
1992	1.8	1.9	2	1.9	1.7	2.5	2.2	2	1.4	1.5	1.9	2.1	1.9
1993	2.1	1.9	1.7	1.7	1.7	2.4	2.3	2.1	1.5	1.6	1.8	1.9	1.9
1994	1.8	2.1	1.8	1.9	2.1	2.6	2.2	2.1	1.5	2.1	2.3	2.2	2.1
1995	1.8	1.8	1.8	1.4	1.8	2.4	2.4	2.2	1.4	2.2	1.9	2	1.9
1996	1.8	1.9	1.7	1.6	1.6	2.4	2.2	1.9	1.4	1.6	1.8	1.7	1.8
1997	1.6	2.4	1.8	1.5	1.8	2.1	2.2	1.7	1.4	1.8	1.9	1.9	1.8
1998	1.8	1.6	1.6	1.6	1.9	2.7	2.6	2.3	1.5	1.2	1.6	1.7	1.8
1999	1.8	2	1.7	1.8	2.4	2.7	2.3	1.9	1.6	1.3	1.7	1.7	1.9
Average	1.87	1.89	1.76	1.70	1.93	2.56	2.36	2.05	1.48	1.68	1.88	1.94	1.93
Std	0.17	0.25	0.13	0.18	0.28	0.29	0.18	0.21	0.08	0.32	0.19	0.21	0.10

Table II.2.17 Sunshine Hours

Station Ziway Longituc 38°48' E Latitude 7°50' N Altitude 1640 m

Year	Mean Monthly Sunshine (hours)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	9.5		6.6		10.2	9.2	5.5	6.8	4.7		11.1	10.5	
1982	9.3												
1983													
1984													
1985										9.6	10.4	10.4	
1986	10.4	8.8	9.5	7.4	9.6	7	7.5	8.2	7.6			10.1	
1987	9.4	8.7	7.3	8.7	7.2	8.6	8.6	7.3	8	8.8	11	10.4	8.67
1988			9.5	7.6			4.4	6.6	6.5	9.5		10.5	
1989	9.4	9.6	8				6.8	7.2	7.1	9.8			
1990	10.4	7.8	8.1	8.3	9.3	9.2	6.1	6.3	6.6	9.9	10.4	10.4	8.57
1991	10.1	8.2	8.2	9.1	8.7	8.8	6.5	5.8	7.7	9.3	10		
1992	7.8	8	8.9	8.6	8.9	8.3	6.3	5.4	7.2	9	10.1	9.5	8.17
1993	8.9	8.3	10.1	7.7	8.8	8.5	6	7.5	6.8	8.3	10.8	10.6	8.53
1994	10.7	10	8.2	8.4	9	7.8	5.9	6.7	7	9.7	9.9	10.7	8.67
1995	10.7	9.4	8.4	7.7	10	9.7	6.1	6.1	7.5	10	10.8	9.9	8.86
1996	9.1	10.3	8.5	7.9	8.3	7	6.3	6.1	6.9	10.1	10.1	10.7	8.44
1997	8.5	10.9	8.9	7.7	9.4	8.3	7	7.5	8.3	8	8.4	10	8.58
1998	8.1	8.4	8.3	9	8.9	8.8	5.8	6	6.9	7.7	10.8	10.7	8.28
1999	9.8	10.6	8.5	9.5	8.8	8.6	5.4	6.1	7.3	7.3	9.9	9.7	8.46
Average	9.47	9.15	8.47	8.28	9.01	8.45	6.28	6.64	7.07	9.07	10.28	10.29	8.54
Std	1.08	1.18	0.59	0.65	0.46	0.74	0.43	0.69	0.51	1.03	0.71	0.47	0.20

Table II.2.18 Evaporation at Ziway Station

Station Ziway Longituc 38°48' E Latitude 7°50' N Altitude 1640 m

Year	Monthly Evaporation (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
													0.0
1995		171.6	167.9	124.6	172.0	148.3	104.1	96.9	102.9	234.4	219.7	181.6	1724.0
1996	147.5	229.0	174.9	153.6	121.9	84.8	92.9	77.0	81.7	195.2	179.1	197.0	1734.6
1997	144.6	227.2	203.8	139.3	174.5	126.7	100.4	103.1	136.7	159.8	141.5	181.1	1838.7
1998	143.5	152.2	180.8	207.7	167.9	167.6	102.5	73.4	83.5	116.4	215.2	212.1	1822.8
1999	211.1	255.7			204.6	123.5	116.5	115.9	126.3	93.1	182.4	184.0	1613.1
2000	200.1	243.1	269.2	189.8	155.3								
Average	147.5	200.3	171.4	139.1	147.0	130.2	98.5	87.0	92.3	159.8	199.4	189.3	1455.5
Std	33.3	41.5	41.3	34.8	27.1	31.0	8.5	17.9	24.8	57.3	31.7	13.4	90.5

Table II.2.19 Results of Water Quality Analysis

Date of Test: 22 November 2000

	Parameters	Unit	Meki River (Mukeye)			Ziway Lake (Near Meki)			Groundwater Sample		
			1	2	3	1	2	3	Mukeye	Berta-Sami	Woyo Gebriel
1	pH		8.21	8.23	8.22	7.8	7.82	7.86	8.24	7.91	8.44
2	Biochemical Oxygen Demand (BOD)	mg/l	<1	<1	<1	8.5	8.5	8.52	<1.0	<1.0	<1.0
3	Chemical Oxygen Demand (COD)	mg/l	6.246	6.25	6.25	11.28	11.3	11.3	<1.0	<1.0	<1.0
4	Suspended Solids (SS)	mg/l	111.988	119	118.99	15.98	16	16	<1.0	1.7	<1.0
5	Dissolved Oxygen (DO)	mg/l	6.58	6.6	6.605	5.001	5	5	6.3	6.7	5.9
6	Total Nitrogen as N	mg/l	0.249	0.251	0.253	0.441	0.442	0.442	0.22	0.15	0.245
7	Electrical Conductivity (EC)	μs/cm	294.9	295	295	614.8	615	615.5	868	1126	1932
8	Total Dissolved Solids (TDS)	mg/l	140.9	141	141.01	295	295	294.9	418	547	954
9	Flouride as F	mg/l	0.608	0.61	0.61	1.71	1.71	1.708	3.3	9.4	10.6
10	Phosphate as PO_4	mg/l	0.238	0.24	0.241	0.17	0.17	0.171	0.28	0.28	0.22
11	Calcium as Ca	mg/l	19.202	19.2	19.199	25.59	25.6	25.601	10.4	12	10.4
12	Magnesium as Mg	mg/l	9.27	9.27	9.271	6.338	6.34	6.34	3.66	2.93	1.46
13	Chloride as Cl	mg/l	6.495	6.5	6.5	12.97	13	13	5	16.5	2.5
14	Sulphate as SO_4	mg/l	17.902	17.9	17.9	0.1	0.1	0.101	55.9	0.4	0.7
15	Sodium content	mg/l	34.17	34.17	34.17	76.001	76	75.998	138.5	178.1	338.8
16	Arsenic content	mg/l	ND	ND	ND	ND	ND	ND	ND	ND	0.003

Table II.3.1 Water Level of Ziway Lake at Bochessa

(CA=7,380 km^2)

Year	Mean Monthly Water Level (m)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1975	0.73	0.62	0.46	0.32	0.22	0.13	0.28	0.78	1.46	1.64	1.45	1.23	0.78
1976	1.07	0.92	0.81	0.72	0.68	0.60	0.65	0.95	1.23	1.16	1.04	0.92	0.90
1977	0.83	0.79	0.63	0.55	0.54	0.51	0.72	1.12	1.48	1.56	1.17	1.68	0.97
1978	1.53	1.37	1.36	1.19	1.00	0.86	1.00	1.40	1.68	1.74	1.55	1.37	1.34
1979	1.24	1.20	1.13	1.16	1.09	1.06	1.18	1.49	1.72	1.66	1.52	1.37	1.32
1980	1.18	1.05	0.91	0.79	0.62	0.52	0.56	0.81	1.00	1.01	0.83	0.65	0.83
1981	0.54	0.43	0.38	0.60	0.63	0.50	0.49	0.99	1.45	1.63	1.42	1.24	0.86
1982	1.11	1.04	0.86	0.79	0.77	0.68	0.66	0.99	1.25	1.25	1.31	1.17	0.99
1983	1.02	0.91	0.81	0.89	0.94	1.21	1.23	1.65	2.17	2.17	1.96	1.05	1.33
1984	1.44	1.31	1.09	0.90	0.81	0.78	0.81	1.14	1.31	1.24	1.04	0.87	1.06
1985	0.72	0.60	0.46	0.35	0.35	0.26	0.27	0.68	1.03	1.06	0.91	0.78	0.62
1986	0.58	0.52	0.48	0.41	0.38	0.36	0.63	0.92	1.12	0.98	1.10	0.98	0.71
1987	0.85	0.72	0.69	0.69	0.78	1.06	1.10	1.16	1.20	1.14	1.00	0.85	0.94
1988	0.65	0.53	0.39	0.24	0.20	0.19	0.28	0.67	1.13	1.40	1.33	1.19	0.68
1989	1.02	0.92	0.81	0.82	0.78	0.70	0.76	0.99	1.26	1.36	1.22	1.04	0.97
1990	0.92	0.87	1.09	1.21	1.19	1.08	1.12	1.46	1.74	1.68	1.48	1.64	1.29
1991	1.12	1.00	0.98	0.93	0.82	0.69	0.79	1.24	1.65	1.57	1.35	1.17	1.11
1992	1.07	0.98	0.87	0.74	0.67	0.66	0.89	1.28	1.70	1.74	1.57	1.41	1.13
1993	1.30	1.21	1.07	0.95	1.05	1.13	1.25	1.60	1.80	1.80	1.65	1.47	1.36
1994	1.29	1.15	0.96	0.84	0.72	0.71	0.82	1.33	1.71	1.77	1.46	1.34	1.18
1995	1.21	1.09	0.95	0.89	1.01	0.96	0.91	1.20	1.46	1.41	1.20	1.06	1.11
1996	0.97	0.83	0.72	0.76	0.89	1.07	1.35	1.84	2.24	2.16	1.88	1.68	1.37
1997	1.53	1.40	1.24	1.24	1.22	1.11	1.20	1.36	1.42	1.34	1.31	1.18	1.30
1998	1.06	0.96	0.93	0.87	0.83	0.79	0.89	1.44	1.97	2.13	2.04	1.78	1.31
1999	1.46	1.37	1.22	1.09	0.93	0.82	0.94	1.23	1.38	1.64	1.80	1.60	1.29
Average	1.06	0.95	0.85	0.80	0.76	0.74	0.83	1.19	1.50	1.53	1.34	1.23	1.07
STD	0.29	0.28	0.27	0.28	0.28	0.31	0.31	0.31	0.33	0.34	0.32	0.31	0.24

Table II.3.2 Meki River Discharge at the Dugda Station

(CA=2,040 km^2)

Year	Monthly Discharge (m^3/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1970	3.24	2.27	15.26	2.94	2.46	1.91	23.38	42.69	17.83	4.63	0.69	0.00	9.78
1971	0.00	0.00	0.02	1.11	4.10	15.80	27.06	34.21	20.61	4.12	1.23	0.67	9.08
1972	0.50	6.16	11.93	14.69	10.13	5.16	16.84	28.49	16.01	4.54	0.93	0.00	9.62
1973	0.79	0.64	0.20	0.20	2.30	3.39	16.40	29.32	23.54	12.53	2.30	1.10	7.73
1974	0.55	0.34	3.23	2.61	2.80	4.66	22.95	24.97	29.58	9.13	1.64	0.55	8.58
1975	0.49	0.78	0.26	1.86	1.23	5.86	28.06	31.88	53.54	13.75	4.06	1.46	11.94
1976	0.74	0.49	2.13	3.45	7.58	3.40	18.80	22.21	14.70	3.42	7.24	1.83	7.17
Average	0.90	1.53	4.72	3.84	4.37	5.74	21.93	30.54	25.12	7.45	2.58	0.80	9.13
Std	1.06	2.17	6.25	4.91	3.26	4.63	4.71	6.70	13.51	4.32	2.34	0.70	1.56

Table II.3.3 Meki River Discharge at the Meki Station

(CA=2,433 km^2)

Year	Mean Monthly Discharge (m^3/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1965	0.68	0.55	0.74	0.71	0.33	0.26	4.33	14.08	12.48	9.88	1.45	0.37	3.82
1966	0.29	5.28	4.63	8.96	4.51	1.85	8.26	26.46	28.75	8.79	1.93	0.56	8.36
1967	0.39	0.24	0.32	2.47	17.37	4.63	21.68	26.95	13.14	16.86	18.86	3.86	10.56
1968	0.90	5.03	3.79	9.43	25.55	5.07	10.50	26.33	22.09	6.17	0.99	0.63	9.71
1969	0.75	9.82	19.34	9.51	12.70	7.93	23.60	32.53	22.05	3.68	0.59	0.21	11.89
1970	4.03	1.59	17.21	2.35	2.50	1.75	26.02	41.61	20.57	6.04	1.61	0.87	10.51
1971	0.74	0.46	0.55	2.15	5.09	17.66	30.93	38.56	20.86	2.98	1.00	0.40	10.12
1972	0.41	4.91	10.04	12.65	9.33	3.99	14.12	24.29	13.95	3.38	0.62	0.00	8.14
1973	0.07	0.00	0.00	0.01	0.61	1.04	17.48	24.41	22.96	11.88	1.01	0.09	6.63
1974	0.20	0.00	1.80	1.09	1.22	2.59	21.80	25.14	28.10	7.38	0.89	0.18	7.53
1975	0.11	0.24	0.01	0.61	0.44	4.46	27.17	27.42	44.89	12.07	1.96	0.50	9.99
1976	0.26	0.09	2.39	2.00	5.87	2.08	14.83	18.82	13.93	2.04	5.63	0.74	5.72
1977	2.50	3.93	0.66	3.49	9.96	6.47	31.21	28.76	18.79	17.85	24.47	2.83	12.58
1978	0.46	1.73	5.26	1.20	0.74	3.85	13.21	29.34	16.15	14.26	3.98	0.73	7.58
1979	2.97	5.85	7.91	20.85	13.19	2.98	23.69	29.91	13.91	12.85	3.56	1.16	11.57
1980	0.81	1.00	1.27	2.18	1.51	4.95	16.56	21.07	9.53	4.35	0.82	0.53	5.38
1981	0.40	0.49	13.69	20.03	5.10	1.49	27.23	30.13	22.67	5.11	0.62	1.14	10.68
1982	0.92	1.77	1.29	7.03	7.12	2.53	8.25	30.07	9.63	16.52	2.58	1.74	7.45
1983	0.53	2.76	4.61	11.87	17.96	13.96	9.92	33.39	21.38	7.52	1.61	0.89	10.53
1984	0.61	0.48	0.45	0.32	2.59	4.58	10.01	9.81	13.21	1.08	0.35	0.29	3.65
1985	0.22	0.18	0.17	1.69	6.46	1.26	9.11	27.15	15.52	2.69	0.33	0.17	5.41
1986	0.09	0.52	0.87	4.89	2.55	*8.73*	*14.30*	*21.01*	*17.39*	1.89	0.20	0.04	6.04
1987	0.01	0.28	7.69	18.25	17.26	14.62	7.51	6.27	7.28	2.51	0.39	0.04	6.84
1988	0.03	0.41	0.15	3.06	2.22	3.04	15.67	23.25	22.46	12.62	2.91	0.92	7.23
1989	0.14	2.43	3.30	9.65	2.95	3.91	15.17	15.36	17.64	9.72	1.64	0.89	6.90
1990	0.33	11.35	20.19	22.00	5.28	5.80	17.07	19.80	15.17	6.42	1.85	0.87	10.51
1991	0.50	2.60	7.17	2.77	0.89	3.78	24.48	34.91	20.13	3.48	0.87	0.67	8.52
1992	0.89	5.38	2.15	4.96	4.21	*5.35*	*12.07*	51.05	33.87	12.46	2.98	1.58	11.41
1993	1.06	0.99	0.99	13.45	17.54	12.32	25.19	48.93	19.19	11.23	4.47	0.90	13.02
1994	0.81	0.52	0.61	0.57	*4.51*	*9.9*	30.47	59.39	46.79	4.59	0.99	0.63	13.32
1995	*0.48*	*2.84*	*6.96*	*15.24*	*6.43*	*4.21*	*11.37*	*20.97*	*23.64*	*1.85*	*0.73*	*2.66*	8.12
1996	8.48	5.00	13.31	16.65	26.73	40.82	48.16	61.04	24.51	5.55	1.99	1.21	21.12
1997	0.32	0.27	0.99	9.95	2.89	4.36	16.60	16.60	5.40	*6.49*	6.18	0.92	5.91
1998	1.60	0.74	12.12	3.27	11.77	5.23	27.62	70.11	29.24	23.12	2.55	0.42	15.65
1999	0.09	0.07	2.84	0.12	0.51	2.84	20.64	22.42	10.16	31.76	12.47	1.75	8.80
Average	0.94	2.28	5.01	7.01	7.31	6.29	18.75	29.64	19.93	8.77	3.29	0.90	9.18
Std	1.56	2.80	5.83	6.74	7.15	7.25	9.10	14.16	9.15	6.70	5.18	0.84	3.47

Table II.3.4 Katar River Discharge at the Abura Station

(CA=3,350 km^2)

Year	Mean Monthly Discharge (m^3/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1968	1.94	5.06	12.49	10.87	7.26	3.57	22.95	51.49	20.75	14.28	2.81	1.94	12.95
1969	2.70	6.29	16.86	6.93	8.74	4.46	28.56	61.50	45.14	6.96	2.97	2.28	16.12
1970	4.10	2.87	14.12	12.45	9.10	3.14	23.43	87.25	50.02	16.69	4.07	2.38	19.13
1971	2.45	2.17	2.13	3.03	4.60	11.60	29.26	40.11	28.73	13.24	4.60	3.12	12.09
1972	2.77	3.70	3.63	7.95	7.62	3.89	23.23	38.32	19.28	6.72	3.69	2.64	10.29
1973	2.14	1.76	1.57	1.57	2.46	2.56	13.32	40.62	34.08	16.29	3.22	2.15	10.15
1974	2.17	1.86	4.19	5.19	3.06	4.35	13.98	34.12	28.20	7.24	2.50	2.06	9.08
1975	1.92	1.72	1.32	2.03	1.98	4.59	24.56	91.79	67.31	14.33	3.25	2.52	18.11
1976	2.16	1.95	1.92	13.32	4.03	2.69	11.97	44.89	28.12	4.79	4.57	2.37	10.23
1977	3.28	3.22	2.60	5.69	5.06	4.92	20.47	50.21	43.07	32.90	24.74	4.10	16.69
1978	2.64	2.91	5.54	2.70	3.59	3.64	33.46	58.01	21.49	17.18	4.48	2.96	13.22
1979	4.70	8.45	7.46	9.23	10.21	7.84	21.93	45.54	23.17	12.13	4.34	3.08	13.17
1980	2.58	2.58	2.33	2.37	2.47	3.89	16.96	38.87	18.67	7.92	2.86	2.46	8.66
1981	2.24	2.20	4.11	21.84	9.70	2.83	12.58	64.24	57.12	33.91	3.60	2.75	18.09
1982	2.72	2.60	2.45	5.41	5.47	3.97	12.55	50.53	20.19	15.39	4.55	4.42	10.85
1983	3.36	2.89	3.73	9.67	16.53	23.75	11.91	103.98	41.76	23.61	15.43	4.11	21.73
1984	3.36	2.48	2.24	3.47	3.15	6.28	17.37	25.52	22.66	3.56	2.37	2.28	7.90
1985	1.99	1.77	1.71	3.26	7.95	3.23	16.76	34.05	22.38	15.43	1.94	1.82	9.36
1986	1.85	2.78	3.41	5.10	5.74	9.90	28.18	51.54	35.30	13.13	3.39	2.51	13.57
1987	1.84	1.81	4.87	18.12	9.80	14.78	10.02	19.34	17.06	7.37	2.37	2.01	9.12
1988	1.85	2.12	2.02	2.31	2.52	2.73	22.99	99.43	34.52	20.32	5.17	2.69	16.56
1989	2.41	2.35	2.33	6.39	5.80	3.93	12.26	25.06	29.16	12.13	3.46	3.99	9.11
1990	1.99	10.83	20.00	21.34	5.32	4.31	18.61	54.62	34.91	15.35	4.35	2.38	16.17
1991	2.16	2.24	3.69	5.39	2.75	3.37	14.05	45.46	35.78	6.14	2.57	2.32	10.49
1992	2.02	2.46	1.76	2.97	3.06	3.23	8.18	66.05	53.97	25.08	4.56	2.83	14.68
1993	2.71	6.45	2.19	5.10	11.43	11.57	16.41	52.83	35.71	20.13	7.17	2.70	14.53
1994	2.14	1.92	1.64	1.56	6.53	4.27	22.87	68.87	49.09	7.02	2.81	2.04	14.23
1995	1.56	1.58	7.94	7.22	5.44	2.54	12.68	48.41	59.32	4.59	2.35	2.11	12.98
1996	2.48	1.70	2.86	3.93	6.74	17.94	21.50	64.12	24.38	8.54	2.44	2.16	13.23
1997	2.91	1.67	1.57	6.00	2.60	2.74	13.57	20.98	11.05	5.58	6.96	2.94	6.55
1998	2.19	3.45	5.01	2.38	5.99	3.66	13.40	69.19	49.60	28.12	6.76	2.36	16.01
1999	1.99	0.43	1.71	1.65	1.69	3.19	17.00	33.86	21.21	44.47	7.45	2.34	11.42
Average	2.48	3.07	4.73	6.76	5.89	5.92	18.34	52.52	33.85	15.02	4.93	2.65	13.01
Std	0.68	2.16	4.69	5.47	3.34	4.98	6.32	21.39	14.18	9.67	4.40	0.67	3.64

Table II.3.5 Kekersitu Discharge near Adami Tulu

(CA=7,488 km^2)

Year	Mean Monthly Discharge (m^3/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1979	3.07	1.98	1.18	3.56	1.95	1.86	3.29	10.82	18.37	17.98	12.47	6.83	6.95
1980	3.91	2.19	0.90	0.62	0.93	0.18	0.19	0.84	2.02	2.04	1.20	0.38	1.28
1981	0.21	0.18	0.21	0.20	0.22	0.20	0.22	2.35	12.60	17.78	12.91	7.69	4.56
1982	3.16	1.76	1.00	0.62	0.53	0.30	0.26	2.07	6.76	7.88	6.11	3.66	2.84
1983	1.92	1.29	0.81	0.93	1.51	4.44	*5.88*	*16.16*	*32.85*	*32.85*	32.50	18.75	12.49
1984	10.85	6.13	3.13	1.42	0.67	0.55	0.66	2.90	5.48	4.38	2.14	0.92	3.27
1985	0.39	0.31	0.24	0.19	0.18	0.18	0.18	0.31	2.01	2.56	0.99	0.47	0.67
1986	0.25	0.24	0.21	0.21	0.22	0.19	0.23	1.26	4.67	5.02	2.78	1.20	1.37
1987	0.66	0.26	0.22	0.58	0.81	2.42	1.63	2.40	4.11	5.53	3.28	1.94	1.99
1988	1.19	0.86	0.65	0.67	0.63	0.66	0.66	1.49	5.10	14.02	10.62	6.03	3.55
1989	3.31	1.97	1.13	1.46	0.77	0.81	1.02	2.76	10.56	13.58	7.10	3.74	4.02
1990	0.41	0.46	1.39	3.33	2.74	0.79	1.22	4.24	10.34	11.69	8.75	7.42	4.40
1991	3.47	1.37	0.68	0.27	0.31	0.13	0.41	4.58	18.88	15.61	9.66	5.22	5.05
1992	3.45	1.59	0.65	0.40	0.14	0.08	0.21	5.66	23.66	25.54	20.43	13.16	7.91
1993	8.21	6.80	1.87	1.98	4.79	7.42	10.35	21.25	27.94	24.74	18.64	11.16	12.10
1994	7.94	5.01	3.32	1.90	0.05	0.04	0.03	3.94	14.99	18.14	14.00	10.24	6.63
1995	5.21	2.31	1.50	0.47	1.79	1.00	1.07	3.80	9.34	11.22	8.57	5.05	4.28
1996	1.84	0.61	0.28	0.32	0.86	2.67	7.19	20.86	35.79	28.79	18.73	12.51	10.87
1997	8.59	6.78	4.13	7.26	5.75	3.16	5.39	9.01	10.06	8.49	7.39	4.71	6.73
1998	2.70	1.48	1.19	0.36	0.61	0.57	0.76	9.14	24.43	31.89	27.79	20.74	10.14
1999	14.73	10.13	*5.69*	*3.53*	*1.63*	*0.83*	0.74	3.48	7.33	17.19	22.54	15.69	8.63
Average	4.07	2.56	1.23	1.34	1.27	1.38	1.98	6.16	13.68	15.09	11.84	7.50	5.70
Std	3.90	2.75	1.45	1.74	1.50	1.83	2.83	6.25	10.13	9.43	8.81	5.96	3.57

Table II.3.6 Bulbula River Discharge at the Bulbula Station

(CA=8,155 km^2)

Year	Mean Monthly Discharge (m^3/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1970	8.81	7.23	6.99	5.14	2.72	2.00	2.12	11.70	26.80	27.20	17.30	10.60	10.72
1971	6.85	4.36	2.52	1.97	2.06	1.91	3.73	8.96	19.00	16.50	10.80	6.84	7.13
1972	4.54	3.46	3.48	3.30	3.60	3.22	3.53	8.05	12.30	10.40	6.45	3.86	5.52
1973	1.53	0.76	0.32	0.17	0.09	0.19	0.23	0.11	2.71	4.33	2.49	0.99	1.16
1974	1.95	1.15	1.11	1.77	1.95	1.97	2.28	0.21	2.20	3.31	1.74	0.55	1.68
1975	2.32	0.42	0.41	0.22	0.22	0.03	0.33	0.77	8.29	12.40	8.33	4.66	3.20
1976	2.74	0.76	0.38	0.03	0.23	0.04	0.18	1.21	6.64	5.67	3.38	1.08	1.86
1977	0.50	0.20	0.01	0.10	0.12	0.19	0.69	2.25	8.73	10.40	15.70	11.40	4.19
1978	7.55	4.81	5.45	2.84	1.11	0.46	1.56	7.46	12.40	13.30	9.47	6.21	6.05
1979	4.36	3.78	3.06	2.69	1.52	1.37	2.74	8.46	13.10	13.40	10.40	6.71	5.97
1980	3.85	2.05	0.60	0.17	0.88	1.33	2.69	7.64	1.79	2.12	0.73	0.38	2.02
1981	3.12	1.23	0.30	0.04	0.07	1.15	0.18	2.44	8.47	11.30	7.46	4.49	3.35
1982	1.09	0.69	0.33	0.27	0.21	0.10	0.04	0.68	2.03	2.24	1.96	1.31	0.91
1983	2.26	1.02	1.29	0.93	1.72	5.81	5.74	5.74	13.60	36.10	4.80	4.29	6.94
1984	2.77	2.98	2.58	0.58	0.07	0.25	0.42	2.74	5.48	4.68	1.65	0.52	2.06
1985	0.24	0.50	0.41	0.29	0.25	0.30	0.38	0.97	2.02	1.98	2.51	0.91	0.90
1986	0.30	0.38	0.43	0.40	0.40	0.42	0.50	0.65	1.38	1.45	5.65	1.40	1.11
1987	0.67	0.48	0.47	0.44	0.71	0.98	0.12	0.19	0.27	0.60	1.74	0.31	0.58
Average	3.08	2.01	1.67	1.19	1.00	1.21	1.53	3.90	8.18	9.85	6.25	3.70	3.63
Std	2.53	1.99	1.99	1.46	1.05	1.46	1.64	3.83	7.08	9.46	4.94	3.51	2.84

Table 3.7 Water Level at Langano Lake

(CA=2,006 km²)

Year	Mean Monthly Water Level (m)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1970						0.32	0.35	0.69	0.91	1.01	0.81	0.59	
1971						0.09	0.27	0.54	0.67	0.67	0.53	0.39	
1972	0.26	0.18	0.10	0.05	0.12	0.12	0.24	0.45	0.66	0.68	0.47	0.27	0.30
1973						0.57	0.46	0.54	1.04				
1974								0.94	1.26				
1975													
1976								2.32	2.53	2.43	2.38	2.23	
1977	0.65	0.03				0.65	0.90						
1978													
1979						0.58	0.62	0.85	0.99	1.02	0.95		
1980			0.33	0.21	0.15		0.09	0.24	0.53	0.66		0.22	
1981	0.12	0.01		0.10	0.16		0.01	0.20	0.56	0.95			
1982	0.30	0.23	0.01	0.10	0.16	0.16	0.13	0.32	0.73	0.85	0.41	0.35	0.31
1983													
1984						0.28	0.29	0.56	0.67	0.61	0.46	0.32	
1985	0.16										1.37	1.24	
1986	1.08	0.93	0.86	0.83	0.86	1.04	1.40	1.66	1.86	1.91	1.74	1.58	1.31
1987	1.33	1.25	1.29	1.28	1.34	1.51	1.48	1.50	1.62	1.61	1.48	1.33	1.42
1988	1.19	1.09	0.99	0.87	0.81	0.76	0.83	1.17	1.48	1.72	1.64	1.43	1.17
1989	1.26	1.22	1.13	1.16	1.16	1.13	1.16	1.31	1.47	1.62	1.53	1.41	1.30
1990	1.33	1.28	1.34	1.41	1.42	1.40	1.53	1.76	1.96	1.98	1.80	1.62	1.57
1991	1.46	1.37	1.31	1.26	1.15	1.08	1.17	1.26	1.46	1.49	1.33	1.20	1.30
1992	1.09	1.06	1.04	1.14	1.12	1.00	1.00	1.11	1.40	1.71	1.86	1.73	1.27
1993	1.61	1.56	1.44	1.35	1.41	1.45	1.54	1.78	2.06	2.12	2.11	1.94	1.70
1994	1.77	1.62	1.52	1.44	1.42	1.43	1.56	1.84	2.12	2.28	2.10	1.92	1.75
1995	1.75	1.62	1.55	1.51	1.54	1.46	1.53	1.73	1.96	2.03	1.86	1.68	1.69
1996	1.58	1.49	1.36	1.36	1.49	1.77							1.51
1997	1.69	1.55	1.39	1.39	1.35	1.30	1.45	1.63	1.69	1.67	1.68	1.56	1.53
1998	1.44	1.37	1.30	1.20	1.17	1.12	1.08	1.27	1.51	1.78	1.84	1.66	1.40
1999	1.48	1.31	1.25	1.17	1.08	1.03	1.12	1.32	1.53	1.84	1.93	1.73	1.40
Average	1.12	1.05	1.06	0.98	0.99	0.92	0.83	1.08	1.33	1.44	1.38	1.19	1.26
Std	0.40	0.22	0.20	0.20	0.22	0.27	0.25	0.26	0.26	0.23	0.24	0.23	0.18

Note: New station from Nov 85

Table II.3.8 Gedemso River Discharge Near Langano

(CA=213 km²)

Year	Monthly Discharge (MCM)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1969	1.15	2.21	13.13	5.49	6.29	4.76	16.23	20.01	13.84	4.05	0.81	0.82	88.79
1970	0.49	0.34	2.60	7.87	4.20	1.20	17.04	28.09	19.07	10.42	2.77	0.77	94.86
1971	0.51	0.28	0.37	0.79	1.36	10.92	21.63	20.30	14.31	9.29	2.06	0.92	82.74
1972	0.68	1.44	1.77	6.79	4.82	1.18	13.09	17.27	13.02	4.34	1.41	0.62	66.43
1973	0.39	0.25	0.23	0.24	0.60	1.52	14.10	22.02	13.79	5.99	1.26	0.58	60.97
1974	0.43	0.33	0.98	1.21	0.95	1.35	13.91	17.29	10.49	4.61	0.98	0.50	53.03
1975	0.32	0.27	0.24	0.69	0.61	4.11	21.78	36.31	20.56	9.12	1.80	0.82	96.63
1976	0.59	0.30	0.30	0.35	2.52	1.86	17.32	22.46	14.39	2.93	1.98	0.45	65.45
Average	0.57	0.68	2.45	2.93	2.67	3.36	16.89	22.97	14.93	6.34	1.63	0.69	76.11
Std	0.26	0.74	4.40	3.21	2.18	3.35	3.34	6.39	3.28	2.86	0.65	0.17	16.68

Table II.3.9 Horakelo River Discharge at the Langano Outlet

(CA=2,050 km²)

Year	Mean Monthly Discharge (m³/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1979	0.38	0.21	0.04	1.26	1.00	0.81	1.11	4.66	7.31	6.77	3.85	1.74	2.43
1980	0.66	0.22	0.06	0.05	0.03	0.04	0.04	0.22	1.20	1.52	0.55	0.06	0.39
1981	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	2.31	4.76	3.55	1.32	1.00
1982	0.79	0.39	0.12	0.03	0.07	0.02	0.04	1.14	3.82	10.64	4.58	2.05	1.97
1983	0.82	0.62	0.15	0.17	0.28	1.18	1.48	4.76	6.05	14.30	16.60	12.07	4.87
1984	7.11	4.35	1.69	0.53	0.10	0.13	0.12	1.36	2.68	2.16	0.83	0.11	1.76
1985	0.00	0.00	0.00	0.01	0.03	0.01	0.01	0.02	0.30	1.12	0.28	0.00	0.15
1986	0.00	0.00	0.00	0.01	0.01	0.00	0.37	1.60	3.04	3.41	2.15	1.12	0.98
1987	0.90	0.62	0.25	0.55	0.58	1.19	1.11	1.12	1.52	1.48	0.75	0.11	0.85
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.89	2.59	2.40	1.11	0.58
1989	0.44	0.16	0.00	0.03	0.06	0.01	0.01	0.17	0.97	2.29	1.35	0.44	0.50
1990	0.05	0.01	0.01	0.01	0.01	0.01	0.72	3.56	7.49	5.67	3.17	1.65	1.86
1991	0.77	1.07	0.24	0.03	0.00	0.00	0.01	0.07	0.50	0.58	0.05	0.02	0.28
1992	0.05	0.12	0.02	0.01	0.00	0.00	0.02	0.37	0.52	1.97	1.80	0.58	0.45
1993	0.36	0.35	0.13	0.04	0.02	0.01	0.04	0.30	2.54	4.87	3.96	2.09	1.23
1994	0.86	*1.35*	*0.81*	*0.49*	*0.43*	0.03	0.28	3.42	8.11	9.11	4.05	2.45	2.62
1995	1.51	1.01	0.70	0.70	0.93	0.82	0.98	2.23	5.52	5.92	3.87	2.61	2.23
1996	1.52	1.05	0.65	0.23	0.34	1.22	2.37	7.51	10.37	9.11	5.18	2.80	3.53
1997	2.46	1.76	1.60	0.20	0.18	0.08	0.57	1.33	1.49	1.35	1.48	1.05	1.13
1998	0.86	0.47	0.30	0.06	0.04	0.01	0.00	0.36	1.17	2.44	2.60	1.54	0.82
1999	0.92	0.41	0.27	*0.03*	*0.00*	*0.00*	*0.02*	*0.19*	*0.86*	*2.89*	*3.56*	*2.08*	0.94
Average	0.97	0.68	0.34	0.22	0.20	0.28	0.46	1.71	3.39	4.60	3.15	1.75	1.48
Std	1.54	0.98	0.50	0.32	0.30	0.46	0.64	2.03	2.99	3.66	3.43	2.53	1.18

Table II.3.10 Water Level of Abijata Lake at Aroressa

(CA=10,744 km^2)

Year	Mean Monthly Water Level (m)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1977			4.17	4.08						4.23	4.55	4.80	4.37
1978	4.93	4.92	5.01	5.02	4.91	4.83	4.78	4.87	5.13	5.37	5.46	5.41	5.05
1979	5.33	5.40	5.52	5.70	5.61	5.59	5.54	5.58	5.84	6.02	6.14	6.12	5.70
1980	6.04	5.96	5.76	5.58	5.46	5.34	5.26	5.17	5.12	5.08	5.00	4.92	5.39
1981	4.77	4.55	4.40	4.45	4.31			4.01	4.08	4.21	4.26	4.17	4.32
1982	4.13	4.05	4.05	4.08							3.84	3.84	4.00
1983	3.74	3.62	3.51	4.29	4.15	3.83	3.27	3.67	4.07	4.72	5.16	5.47	4.13
1984	5.58	5.61	5.50	5.35	5.17	5.08	5.04	5.10	5.10	5.08	4.94	4.73	5.19
1985	4.57	4.41	4.23	4.10	4.02	3.88	3.80	3.80	3.74	3.62	3.43	3.26	3.91
1986	3.11						2.77	2.72	2.68	2.78	2.76	2.66	2.78
1987	2.52	2.15	2.13	2.19	2.14	2.19	2.08						2.20
1988					1.40	1.18	1.11	1.09	1.10	1.20	1.25	1.25	1.20
1989	1.12	1.06	1.07	1.08	0.61	0.57	0.33	0.27	0.28	0.42	0.44	0.45	0.64
1990	0.40	0.37	0.39	0.36	0.31	0.38	0.24	0.27	0.40	0.88	1.13	1.13	0.52
1991	0.97	0.95	0.99	0.98	0.76	0.61	0.59	0.64	0.65	0.89	0.96	0.87	0.82
1992	0.84	0.92	0.69	0.44	0.43	0.38	0.48	0.56	0.66	1.06	1.30	1.58	0.78
1993	1.60	1.60	1.54	1.44	1.43	1.50	1.52	1.62	1.82	2.20	2.38	2.36	1.75
1994	2.30	2.30	2.12	1.22	1.13	0.94	0.90	0.96	1.22	1.44	1.47	1.48	1.46
1995	1.44	1.45	1.40	1.44	1.42	1.30	1.22	1.22	1.25	1.51	1.69	1.53	1.41
1996	1.54	1.42	1.24	1.17	1.11	1.14	1.29	1.57	2.08	2.52	2.72	2.79	1.72
1997	2.72	2.65	2.52	2.43	2.41	2.34	2.22	2.27	2.42	2.42	2.47	2.39	2.44
1998	2.30	2.22	2.16	2.01	1.90	1.81	1.74	1.76	1.66	1.52	1.56	1.66	1.86
1999	1.70	1.65	1.65	1.62	1.48	1.39	1.36	1.34	1.33	1.59	1.76	1.83	1.56
Average	2.94	2.86	2.86	2.94	2.61	2.42	2.28	2.42	2.53	2.80	2.94	2.94	2.85
Std	1.75	1.78	1.76	1.83	1.84	1.82	1.75	1.79	1.81	1.75	1.72	1.72	1.71

Table II.3.11 Gogessa River Discharge Near Jidu

Year	Monthly Discharge (MCM)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1970	0.54	0.31	2.01	0.44	0.35	0.16	2.14	5.70	2.49	1.02	1.63	2.09	18.88
1971	1.42	0.92	0.64	0.49	0.59	0.62	0.91	0.80	0.73	1.21	1.35	1.21	10.88
1972	0.94	0.85	0.72	0.83	0.64	0.29	0.78	3.00	1.92	1.15	0.98	0.72	12.82
1973	0.21	0.00	0.00	0.00	0.27	0.41	2.20	2.01	1.92	0.24	0.00	0.00	7.26
1974	0.00	0.00	0.11	0.00	0.00	0.08	0.08	0.03	1.19	0.00	0.00	0.00	1.48
Average	0.62	0.42	0.70	0.35	0.37	0.31	1.22	2.31	1.65	0.72	0.79	0.80	10.27
Std	0.57	0.45	0.80	0.35	0.26	0.22	0.92	2.21	0.69	0.56	0.76	0.88	6.47

Table II.4.1 Rainfall at Butajira Station

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1969	19.7	80.4	75.1	117.5	148.1	262.5	205.8	125.2	0	12	7.6	19.2	1073.1
1970	155.4	112.6	243.8	99.2	138	156.4	278.7	142.1	105.1	8	0	0.3	1439.6
1971	1.9	0	72.8	79.6	126.4	59	192.8	274.9	176.6	21.5	22.3	16	1043.8
1972	0	162.6	283.9	183.4	169.8	131.6	167.3	202	99.2	0.3	0	15	1415.1
1973	0	0.2	0	43.6	102.4	94.4	148.4	123.8	73.1	75.2	0	40.9	702.0
1974	0	37.1	158.8	59.1	75.3	76.8	51.9	226.5	205.8	1.6	0	0	892.9
1975	5.8	65	10	112.5	61.1	126.2	277.2	167.4	201.8	7.3	0	0	1034.3
1976	4	48.3	233.8	54.5	104.9	58.2	132.7	150.8	109.8	38.1	128.8	8	1071.9
1977	121	77.3	86	133.9	76.9	69.2	120.3	93.5	36.2	266.2	33	0	1113.5
1978	1	80.1	72	87.2	39.1	85.6	120.3	86.9	94.2	19.3	0.3	44.4	730.4
1979	109.6	36.8	247.6	64.7	110.3	89.6	237.9	189.8	141.4	35.9	0	8.7	1272.3
1980	30.4	20.6	35.6	105.6	94.2	121.2	133.7	167.6	180.4	18.5	0	*0*	907.8
1981	*0.0*	*2.9*	*262.6*	*102.6*	*23.5*	*29.9*	*222.0*	*174.8*	124.1	7.5	0	3	952.9
1982	49.4	103.1	44.7	176.1	135.2	78.6	175.6	180	50.9	177	45.7	12.6	1228.9
1983	64.6	63.5	296.6	160.1	230.9	104.9	144.7	264	62.8	24.9	0	2.3	1419.3
1984	0	3	31.4	4.3	287.1	100	147.1	125.5	88.5	0	*0*	*0*	786.9
1985	9.7	2.1	29.3	188.1	91.4	73.8	189.3	152.9	151.9	0	0	0	888.5
1986	0	162.5	12.6	254.3	93.8	120.6	100.6	116.4	166.8	28.8	0	4.6	1061.0
1987	0	148.9	328.3	91.4	246.1	60.1	94.7	121.3	135.9	21.2	0	0	1247.9
1988	*2.8*	*63.9*	*9.8*	*250.4*	*47.1*	*54.1*	*196.1*	*171.5*	*132.5*	*118.5*	*0.0*	*1.5*	1048.2
1989	3	129.2	248.7	156.5	24.6	94.5	280.8	143.3	127.4	51	0	27.7	1286.7
1990	0	271.9	120.3	260.5	152.1	132.2	197.5	175.7	134.3	22	0	0	1466.5
1991	44	139.8	200.6	33.1	*17.6*	*74.5*	*253.4*	*221.2*	*131.3*	*7.7*	*0.0*	*36.6*	1159.8
1992	*98.0*	*50.2*	*49.5*	*130.2*	*62.8*	*105.8*	*210.9*	*214.8*	*98.4*	*114.3*	*4.0*	*10.4*	1149.3
1993	*33.7*	*114.9*	*7.0*	*206.7*	*164.3*	*120.0*	*214.2*	*278.6*	*139.4*	*169.7*	*0.0*	*0.0*	1448.5
1994	0	0	118	87.9	80.1	246.6	269	100.9	103.8	3	14.1	2.7	1026.1
1995	0	65.9	105.2	409.2	98.6	62.1	124.2	116.2	66.6	9.5	0	73	1130.5
1996	140	0	314.3	103.9	212.2	277.3	133	199.4	72.5	1	13.2	0	1466.8
1997	111.8	0	118.4	196.8	34.2	199.1	101.1	207.6	108.1	109.8	50.4	0	1237.3
1998	115.7	107.7	217.8	111.9	200.7	88.7	194	223.3	120.7	73.3	0	0	1453.8
1999	3	15.2	91	35.3	*41.1*	*139.1*	*169.3*	*101.7*	*117.2*	*196.7*	*0.0*	*0.0*	909.6
Average	36.3	69.9	133.1	132.3	112.6	112.7	176.9	169.0	114.7	52.9	10.3	10.5	1131.1
Std	50.4	64.8	106.2	84.3	69.8	60.6	60.0	53.1	46.5	68.9	25.8	17.3	225.5

Note: Values in Italics are augmented data

Table II.4.2 Rainfall at Koshe Station

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1974	*1.0*	*18.1*	*159.9*	*6.5*	74.4	106.5	186.9	194.1	132.8	0	0	2.5	882.7
1975	0.8	10.8	14.3	119.2	124.6	58.1	271.9	200.8	186.9	14.7	0	0	1002.1
1976	0	24.4	131.7	34.3	98.8	147.4	145.9	156.1	14.5	11.5	40.8	0	805.4
1977	142.9	2.8	72.6	121.4	128.8	173	151.3	130.4	93.8	225.1	9.7	0	1251.8
1978	0	228.7	29.7	103.5	38.6	82.7	123.1	257.1	120.4	95.7	0	0	1079.5
1979	24.8	64.3	127.4	59.2	244.9	127.1	151.8	417.5	177.5	74.8	0	0	1469.3
1980	0	0	62.1	88.2	81.2	105	246	184.4	101.9	18.8	5.4	0	893.0
1981	0	0	308.6	122.1	40.8	42.5	143.6	147.1	99.8	0	0	0	904.5
1982	91.5	67.8	34.4	95.4	198.5	90.9	81.8	114.1	132.2	97.5	35.4	34.8	1074.3
1983	18	44	71.1	203.1	171.7	62.1	464.4	453	254	44.1	0	0	1785.5
1984	0	*3.0*	10.3	3	154.8	206.4	267.8	311.2	*93.2*	0	3	0	1052.7
1985	0	*0.2*	56.7	173.8	118.6	35.4	227.4	281.2	115.9	3	0	*0*	1012.2
1986	0	118.2	16	84.9	123.9	160.1	57.3	131.5	110.7	45.7	0	8.4	856.7
1987	0	76.4	198.5	86.3	197.1	48.4	71.5	138	73	18.5	0	0	907.7
1988	0	32.8	3.4	102.2	30	52.5	152	82.3	152.4	51.8	0	0	659.4
1989	5	115.5	89.1	*89.7*	34.2	256.1	147.6	203.2	116.7	7.8	0	13.3	1078.2
1990	0	260	38.8	68.4	40.2	61.9	182.6	104.4	75.6	8.6	0	0	840.5
1991	3.5	81.5	155.7	1.5	22.9	34.9	217.9	151.7	89.6	9.4	0	13.8	782.4
1992	36.7	52.5	10	68.1	51.9	106.8	233.9	125.8	54.6	18.9	*2.4*	4.1	765.7
1993	7.3	54.6	2.7	332.3	125.1	56.5	263.4	174.7	143	151.9	0	0	1311.5
1994	0	4	30.8	28.4	22.5	163.3	182.8	89.9	152.8	0	0	0	674.5
1995	0	6.3	166.1	189.9	67.7	51	140.4	83.7	118.3	15.8	0	30.5	869.7
1996	115.7	3.5	88.3	66	143.3	100.2	88.5	189.1	88.6	0	8	0	891.2
1997	47.9	*0*	104.9	125.4	18.3	149.8	123.6	84	38.2	153.1	13.9	0	859.1
1998	88.8	63.5	58.2	20.3	72.2	78.3	112.7	200.3	87.8	84.9	0	0	867.0
1999	0	0	60.8	31.2	10.7	109.6	171.2	110.2	77.5	127.5	0	0	698.7
Average	22.5	51.3	80.9	93.2	93.7	102.6	177.2	181.4	111.6	49.2	4.6	4.1	972.1
Std	40.8	67.5	72.7	72.9	64.5	56.8	84.4	95.7	49.1	60.2	10.5	9.3	253.5

Note: Values in Italics are augmented data

Table II.4.3 Rainfall at Tora Station

Year	Monthly Rainfall (mm)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1974	*1.0*	*16.5*	*154.1*	*24.3*	*72.2*	*73.3*	102.6	99.7	189.4	0	0	0	733.1
1975	0.2	14.5	14.7	85.2	64.9	100.8	230.8	128.3	155	14.6	0	0	809
1976	0	8.8	99.2	113.6	147.8	100	215.9	87	161.5	27.5	25	14.6	1000.9
1977	80.5	18.4	23.3	134.1	101.7	77.9	114.8	123.2	128.3	109.6	0	0	911.8
1978	0	211.7	42	111	43.2	173.6	0	175.3	156.7	66.1	0	18.1	997.7
1979	109.9	79	138.2	49.3	120.7	117.9	183.2	152.8	165.7	64.9	0	0.8	1182.4
1980	8	18.8	27.9	73.7	71.5	109.3	179.8	66.9	53.7	31.6	50.1	0	691.3
1981	0	7.9	249.4	85.7	20.9	36.6	161.5	134.9	123.6	19.4	0	1.3	841.2
1982	51.6	42.1	22.8	167.3	187.5	77	110.4	138.9	75.1	90.5	6.7	0	969.9
1983	31	34.5	163.6	160.1	225.2	48.5	67.4	155.7	126.9	21.4	0	0	1034.3
1984	0	0	43.3	0	99.9	90.6	93.6	106.8	40	0	0	*0*	474.2
1985	1.3	0	45.2	328.5	23.9	36.9	120.9	121.1	120	15.4	2.3	0	815.5
1986	15.5	29.6	82.9	174.5	51.4	124.5	110.9	72.3	176.6	54.8	0	0	893
1987	0	47	245	90	350	61.7	43.1	124	101.5	34	0	0	1096.3
1988	1.9	43.3	10.5	226.1	54.5	46.3	130.8	139.2	111.4	120.8	0	0	884.8
1989	2.7	106.6	115.4	139	18.6	120.5	107.1	127.8	136	53.7	0	0	927.4
1990	0	220.7	64.1	133.9	18.8	73.5	149.5	102.2	143.6	8.2	0	0	914.5
1991	11.1	84.1	70	14.3	20.6	43.5	162.1	128.6	105.2	10	0	47.2	696.7
1992	80.2	35.1	59.4	115	68.7	70.6	140.2	136.8	69.9	110.8	2.6	8.9	898.2
1993	38.7	118.7	2.6	183.3	155.8	107.9	135.3	252.9	118.3	153.1	0	0	1266.6
1994	0.6	10.4	47.6	69.5	45.7	164.4	201.7	149.5	84.4	0	4.1	0	777.9
1995	0	71.7	*70.1*	302.9	51.5	64.3	150.7	104.9	143.1	25.6	0	38.6	1023.4
1996	96.7	0	188.4	71.6	172.3	158.6	147.9	165	151.8	3.4	1	0	1156.7
1997	35.4	0	109.1	160.3	32	145.6	142.4	80.2	51.8	153.4	3.3	0	913.5
1998	44.1	79.6	28.8	113.6	227.9	49	168.4	158.7	113.5	38.7	0	0	1022.3
1999	0	0	84.7	27.9	38.7	127.7	76.6	52	110.1	184.2	0	0	701.9
Average	23.5	50.0	84.7	121.3	95.6	92.3	132.6	126.3	119.7	54.3	3.7	5.0	909.0
Std	33.9	59.8	68.8	80.0	82.3	40.6	52.0	40.7	39.4	53.8	10.7	12.2	174.1

Note: Values in Italics are augmented data

Table II.4.4 Rainfall at Bui Station

Year	Monthly Rainfall (mm)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1969	*34.2*	*81.2*	*95.1*	*85.3*	*57.0*	*155.0*	*240.8*	*266.9*	*45.3*	*4.3*	*2.2*	*4.5*	1071.7
1970	*142.5*	*66.5*	*150.0*	*82.0*	*75.1*	*89.4*	*368.5*	*297.4*	*247.4*	*4.9*	*0.0*	*0.1*	1523.9
1971	*0.4*	*0.0*	*43.3*	*69.3*	*148.6*	*167.9*	*212.3*	*362.0*	*211.3*	*5.0*	*13.9*	*25.0*	1259.0
1972	*1.9*	*140.6*	*118.8*	*198.1*	*93.6*	*123.9*	*310.7*	*280.0*	*108.0*	*9.3*	*0.0*	*3.5*	1388.4
1973	*0.0*	*0.0*	*0.0*	*11.9*	*55.1*	*31.0*	*164.4*	*169.1*	*151.0*	*45.6*	*0.0*	*9.7*	638.0
1974	*0.0*	*24.2*	*159.8*	*13.8*	*58.5*	*71.3*	*224.2*	*159.0*	*173.2*	*0.4*	*0.0*	*0.0*	884.5
1975	*1.4*	*16.9*	*10.1*	*77.7*	*47.7*	*146.1*	*285.7*	*141.6*	*92.5*	*9.4*	*0.0*	*0.0*	829.1
1976	*1.9*	*13.2*	*125.7*	*99.3*	*91.8*	*58.8*	*175.1*	*137.3*	*46.7*	*29.6*	*69.7*	*5.8*	854.9
1977	*87.6*	*24.0*	*32.3*	*97.3*	*38.4*	*98.6*	*232.6*	*159.4*	*84.1*	*211.4*	*30.1*	*0.0*	1095.9
1978	*6.8*	*84.7*	*30.9*	*38.6*	*27.4*	*173.5*	*153.9*	*190.5*	*67.1*	*36.2*	*0.5*	*12.1*	822.4
1979	*106.2*	*15.6*	*143.0*	*34.0*	*130.4*	*87.3*	*211.5*	*150.0*	*113.9*	*66.7*	*0.0*	*2.0*	1060.7
1980	*16.9*	*15.2*	*16.4*	*52.2*	*39.2*	*91.2*	*152.3*	*178.6*	*75.5*	*44.4*	*0.4*	*0.0*	682.2
1981	*0.0*	*13.5*	*179.9*	*61.8*	*21.1*	*0.6*	*297.1*	*195.0*	*178.5*	*4.8*	*0.0*	*0.7*	952.9
1982	*15.8*	*59.6*	*81.8*	*66.2*	*128.5*	*54.8*	*86.5*	*262.2*	*51.0*	*88.3*	*32.0*	*5.2*	932.0
1983	*23.1*	*56.4*	*107.2*	*162.0*	*187.4*	*215.2*	*205.1*	*361.6*	*119.5*	*27.3*	*0.0*	*0.5*	1465.4
1984	*0.0*	*0.7*	*18.4*	*9.1*	*172.8*	*265.0*	*223.0*	*143.6*	*123.3*	*0.0*	*0.0*	*0.0*	956.0
1985	*12.8*	*0.5*	*14.0*	*108.0*	*91.0*	*74.2*	*225.3*	*177.2*	*142.0*	*0.0*	*0.0*	*0.0*	845.0
1986	*36.4*	*136.7*	*23.3*	*117.2*	*51.2*	*128.0*	*173.3*	*119.8*	*130.7*	*9.2*	*0.0*	*1.1*	926.9
1987	0	57.1	207.3	82.5	188	54.6	84.8	98.1	88.7	4.7	0	0	865.8
1988	*1.3*	*40.1*	*3.0*	*139.5*	*20.2*	*45.1*	*207.2*	*201.6*	*149.4*	*38.6*	*0.0*	*1.2*	847.3
1989	0	72.5	106.6	63.7	2.9	60.2	169.4	170.9	90.4	22.1	0	40.2	798.9
1990	2.4	287.6	92.1	109.5	38.8	40.1	213.2	236.8	53.4	1.9	0	*0*	1075.8
1991	2.6	91	163.2	5.9	3.7	88.9	278.8	265.1	109	0	0	0.5	1008.7
1992	78.5	50.3	8.2	90.3	21.5	111.5	223.3	237.5	96.6	62.8	4.4	7.6	992.5
1993	8.4	50.9	10.8	142.1	96.1	80.1	238.7	181.9	104.8	112.3	0	*0*	1026.1
1994	0	0	51.8	27.1	49.5	173	170.7	165.5	91.2	0	10.8	14.6	754.2
1995	0	56.9	89.8	254.5	171	116.2	223	196.4	164.4	3.6	0	29.1	1304.9
1996	116.9	0	191.1	34.9	93	215.7	249.3	268.6	90.3	11.7	4.7	0	1276.2
1997	32.9	0	53.8	81.8	8.8	103.4	158.5	149.4	31.3	78.9	19.3	0	718.1
1998	46	57.4	117	53.2	85.4	134.3	260.2	152.3	65.6	54.8	0	0	1026.2
1999	3	15.2	91	35.3	*15.3*	*109.2*	*217.4*	*172.1*	*68.3*	*142.9*	*0.0*	*0.0*	869.7
Average	22.5	59.9	91.2	86.2	61.1	102.5	207.3	192.0	92.6	41.1	3.0	7.2	966.5
Std	39.4	58.7	62.6	56.3	55.8	59.5	60.0	66.2	50.4	48.8	14.6	9.7	224.0

Note: Values in Italics are augmented data

Table II.4.5 Rainfall at Ejersalele Station

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1968	12	157.3	48.2	170.8	15	61.1	165.2	174	108.5	1	2	3	918.1
1969	35.3	59.3	81.5	55.4	15.8	110.8	227.5	130	85.8	7	2	0	810.4
1970	95	27.4	125.4	44.1	34	37.6	231	179.8	129.6	0	0	0	903.9
1971	0	0	29.5	87	129.4	127.2	199.9	221.8	132.2	0	12	30.7	969.7
1972	9	158	48.4	129.4	83.1	71.1	188.4	165	58	0	0	0	910.4
1973	*0.0*	*0.0*	*0.0*	*7.8*	*88.1*	*41.9*	*137.3*	*120.4*	*119.1*	*32.3*	*0.0*	*0.8*	547.7
1974	0	6	122.4	0	50.5	89	137.8	115.5	115.3	0.3	0	0	636.8
1975	0	3	19.3	33.3	17.4	125.1	244.6	282.7	142.9	8	0	0	876.3
1976	0	9	113	32.5	96	51.7	127.8	58.1	16	10.1	25.4	0	539.6
1977	48.2	18.2	4.4	75	61	59.5	178	127.1	100.8	143.1	25	0	840.3
1978	3.4	104.7	1.5	37.3	16.6	171.4	133.4	155.7	41.7	57.4	2.2	7	732.3
1979	74.9	2.2	78.4	10	177.7	72.3	218.8	158.7	82.6	16.5	0	0	892.1
1980	24	16	14.5	59.5	15.6	77.1	133.5	107.5	50.7	2	0	0	500.4
1981	0	9	151.5	84	16.5	0	231.9	166.4	75.7	0	0	0	735
1982	0.5	33.4	55.5	*47.6*	*81.5*	*19.3*	*73.3*	151.4	34.1	59.2	15.9	0.1	571.8
1983	22.4	65.5	19.1	70.8	123	30.3	129.7	171.1	54.2	16	0	0	702.1
1984	0.0	0.0	*6.3*	0.0	95.8	51.3	115.6	110.1	42.9	*0.0*	0.0	0.0	422.0
1985	17.0	0.0	8.1	70.7	64.2	29.5	166.1	119.2	107.5	0.0	0.0	0.0	582.3
1986	0.0	65.7	0	88.7	40.7	85.3	123.8	104.2	109.7	10.7	*0.0*	0.0	628.8
1987	0.0	32.2	96.3	68.4	182.6	54.7	109.0	99.0	75.3	0.0	0.0	0.0	717.5
1988	3.1	73.4	3.2	169.3	6.7	41.9	230.0	148.8	106.8	51.1	0.0	3.9	838.2
1989	0.6	42.5	96.0	177.0	3.2	*80.3*	121.1	187.3	129.6	22.0	*0.0*	5.9	865.5
1990	0.0	203.3	75.4	93.0	50.8	24.7	185.7	124.3	54.5	0.0	0.0	0.0	811.7
1991	0.0	17.8	118.8	0.0	19.3	89.4	199.2	197.5	134.2	1.4	0.0	0.0	777.6
1992	5.0	51.0	15.6	86.5	39.0	43.0	235.2	234.0	113.0	47.0	0.0	0.0	869.3
1993	27.3	41.1	0.0	165.8	108.3	51.3	337.6	355.1	11.0	60.6	0.0	0.0	1158.1
1994	0.0	0.0	33.2	16.7	47.3	143.9	296.0	190.3	218.6	0.0	4.2	7.6	957.8
1995	0.0	33.0	79.6	144.9	37.9	44.1	171.0	83.7	98.2	0.0	0.0	30.8	723.2
1996	0.0	0.0	91.8	64.3	212.4	285.6	173.1	312.1	*97.9*	*6.7*	*13.0*	0.0	1256.9
1997	73.9	0.0	29.9	116.2	6.4	111.5	291.6	149.5	47.3	56.5	0.0	0.0	882.8
1998	58.2	7.0	101.8	28.5	110.8	80.8	288.7	260.7	66.5	80.8	*0.0*	*0.0*	1083.8
1999	0.0	*0.0*	50.0	19.0	24.5	89.5	274.9	152.5	70.2	119.1	0.0	0.0	799.7
Average	11.6	35.4	50.4	81.8	65.6	81.7	207.4	176.8	92.7	28.5	1.1	3.0	836.0
Std	26.2	51.8	45.7	53.4	55.4	54.0	64.5	66.1	43.1	36.7	7.1	7.6	187.7

Table II.4.6 Rainfall at Meki Station

Latitute = 8.09 , Longitude=38.19, Altitude= 1400 m

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1966	0	111	36.1	29.1	38.5	56.1	154.1	280.4	135.2	36.1	0	0	876.6
1967	0	1.2	91.4	21.9	54.9	83.5	253.3	70.3	96.1	67.7	117.3	0	857.6
1968	0	50.1	27.2	147.1	8.6	95.8	122.6	138.7	118.3	3.2	1.6	0	713.2
1969	9.5	84.6	55	30.8	22.9	34.2	161.9	105.6	79.9	3.8	0	0	588.2
1970	118.5	31	49.6	4.9	59.4	20.2	117.3	155.5	120.4	15.7	0	0	692.5
1971	0.4	0	21.8	21.2	57.8	129.6	100.8	195.6	119.8	0	11.3	7	665.3
1972	30.8	30.7	42.3	167.3	37.4	116.5	116.6	159.3	60	0	0	0	760.9
1973	*0.0*	*0.0*	*0.0*	*14.9*	*157.0*	*80.2*	*169.2*	*123.9*	*126.8*	*42.2*	*0.0*	*1.6*	715.8
1974	0	18.7	153.1	0.1	139.2	80.4	222	157.9	175.6	4.5	0	0	951.5
1975	2.4	7.3	12.7	69	61	118	321.1	61.8	83.3	5.8	*0*	0	742.4
1976	0.5	1	104	40.5	86.3	56.4	180.8	136.5	73.7	4.2	22.6	0	706.5
1977	*69.9*	*12.3*	19.1	78.1	22.5	132.1	253.6	91.6	95	223.7	38.9	0	1036.8
1978	8.5	147.8	53.6	46.9	19.3	229.3	83.2	243.8	102.8	35.4	1.1	0	971.7
1979	68.9	14.8	139.9	37.7	60	135.5	155.1	63.7	83.8	71.6	0	0.3	831.3
1980	20.4	7.2	0.6	57	39.9	98.3	154.1	133.9	52.9	23	0	0	587.3
1981	0	0	185.4	62.2	28.7	3	204.2	218.6	119.4	34.3	0	0	855.8
1982	18.1	18.1	6.5	67.8	65.9	3.1	98.1	122.3	117	65.5	9.9	2.7	595.0
1983	*24.5*	*50.6*	55.2	132.6	245.7	87.4	195.8	183.6	95.4	19.8	0	0	1090.6
1984	0	8.6	1.8	7.7	142	57.3	193.1	230.7	68	0	0	0	709.2
1985	0	0	6.3	58.4	86.2	8.9	225.9	195.4	115.3	0	0	0	696.4
1986	0	167.6	31.1	58.2	101.2	157.9	211.2	67.1	105.7	38	0	0	938.0
1987	0	13.9	116.5	66.1	231.2	27.2	111.6	167.6	67.3	2.3	0	0	803.7
1988	0.7	51	16	83.2	20.3	129.1	142.4	134.6	99.9	51.6	0	0	728.8
1989	3	36.9	112.5	84.8	14.5	122.7	122.7	173.7	109.9	*19.8*	0	0	800.5
1990	0	257.5	7.7	83	13.6	17.2	215.8	211.8	79.9	18.6	0	0	905.1
1991	0	49.2	173.5	0.1	11.6	2.8	66.8	*157.5*	21	7.6	0	11.7	501.8
1992	18.3	54.7	2.2	68.6	56.3	47.9	290.8	243.3	76.2	59.8	0	16.5	934.6
1993	31.4	31.4	1.4	120.2	61.4	65	188.2	147.4	46.1	56.9	0.4	0	749.8
1994	0	0	29.1	14.1	68.1	127	248.2	97.9	44.3	0	5.1	0	633.8
1995	0	0.7	34.6	80.6	*36.5*	19	90.9	46.6	8.4	*1.9*	*0.0*	*25.3*	344.5
1996	*15.8*	*4.8*	*83.7*	*85.3*	*167.1*	*180.1*	*142.4*	*195.9*	*99.5*	*0.5*	*21.7*	*0.0*	996.8
1997	*34.0*	*0.0*	*91.1*	*169.6*	*12.1*	*131.5*	*197.3*	*98.1*	*50.0*	*89.6*	*5.9*	*0.0*	879.2
1998	*27.3*	50.4	37.3	54.1	37.8	50.3	141.2	183.3	88.8	90.7	0	0	761.2
1999	*3.8*	*0.4*	78	7.1	8.3	68.2	196.2	123.6	59.4	154.3	0	0	699.3
Average	14.9	38.6	55.2	60.9	66.9	81.5	172.0	150.5	88.1	36.7	6.9	1.9	774.2
Std	25.9	56.8	52.7	45.7	61.0	55.6	60.9	58.3	34.2	48.2	21.3	5.5	158.5

Table II.4.7 Rainfall at Hombole Station

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1964	0	0	17.2	42.8	90.9	101.6	177.6	210.6	150	32.4	0	0	823.1
1965	0.6	0	45	56.1	0	23.8	237.5	222.9	79	63	5.5	0	733.4
1966	1.4	125.8	42	46.5	27	76	250.7	304	231.0	66	0	0	1170.4
1967	0.0	0.0	55.3	52.0	125.0	128.0	454.2	374.5	231.0	86.0	113.0	0.0	1619.0
1968	0.0	81.0	98.0	75.0	31.0	114.0	235.0	342.0	44	0.0	0.0	0.0	1020.0
1969	36.0	81.0	98	75.0	31.0	114.0	235.0	342.0	44.0	0.0	0.0	0.0	1056.0
1970	140.0	56.0	108.0	80.5	58.0	73.0	414.0	368.0	318.0	5.0	0.0	0.0	1620.5
1971	0.0	0.0	32.6	52.4	149.0	207.0	203.0	408.0	231.0	0.0	10.0	24.0	1317.0
1972	0.0	112.3	68.5	208.0	59.0	127.0	377.0	322.0	118.0	15.0	0.0	0.0	1406.8
1973	0.0	0.0	0.0	0.0	20.2	0.0	163.7	186.6	176.9	34.5	0.0	0.0	581.9
1974	0.0	23.2	157.4	0.0	49.1	56.0	297.6	132.7	163.8	0.0	0.0	0.0	879.8
1975	0.0	1.8	5.9	72.1	48.4	146.6	275.0	68.9	24.2	9.8	0.0	0.0	652.7
1976	1.6	0.0	76.5	129.7	76.3	55.7	190.4	146.0	28.7	30.2	55.6	6.4	797.1
1977	79.9	3.4	18.3	81.5	12.1	113.7	271.4	180.0	88.3	193.3	27.8	0.0	1069.7
1978	9.5	71.2	22.3	16.8	24.0	190.6	158.7	223.3	59.0	31.7	0.0	0.4	807.5
1979	105.3	10.7	111.5	27.3	108.8	83.0	178.0	117.0	103.0	89.3	0.0	0.0	933.9
1980	7.6	11.3	8.1	24.1	22.5	75.7	150.9	189.8	36.7	64.6	0.6	0.0	591.9
1981	0.0	18.8	240.5	71.6	28.7	0.9	403.6	259.9	217.2	5.0	0.0	0.0	1246.2
1982	6.8	46.3	96.9	40.8	157.8	59.3	74.0	306.1	51.9	55.9	29.2	3.6	928.6
1983	5.3	44.9	55.0	178.4	174.7	300.0	234.0	429.2	152.0	29.4	0.0	0.0	1602.9
1984	0.0	0.0	18.0	13.2	138.9	375.7	267.2	148.0	152.3	0.0	0.0	0.0	1113.3
1985	*11.3*	*0.0*	*8.9*	*79.7*	*91.1*	*82.5*	*237.3*	*189.1*	*136.2*	*0.0*	0.0	0.0	836.1
1986	59.3	*138.0*	33.2	63.3	33.5	133.0	*201.0*	114.7	111.3	0.3	0.0	0.0	887.6
1987	0.0	44.4	157.2	13.2	115.0	*40.1*	66.0	86.0	57.2	0.0	0.0	0.0	579.1
1988	0.0	15.6	0.0	73.1	12.7	38.4	183.1	211.5	155.9	0.0	0.0	0.0	690.3
1989	0.0	40.3	108.6	64.5	*2.6*	54.1	147.9	208.4	89.8	12.4	0.0	4.4	733.0
1990	0.0	203.5	69.2	80.3	*34.8*	*26.1*	147.9	*201.7*	88.2	12.4	*0.0*	*0.0*	864.1
1991	0.0	45.8	145.8	14.7	4.4	80.9	249.5	258.4	68.9	8.9	0.0	16.2	893.5
1992	17.8	96.0	3.5	65.2	38.5	91.7	230.8	312.4	*117.8*	54.2	0.0	0.0	1027.9
1993	2.6	72.3	0.0	5.3	*80*	*53.7*	*252.3*	*226.6*	*47.1*	*63.5*	*0*	*0*	803.4
1994	*0*	*0*	*31.2*	*18.5*	*37.3*	*128.3*	*201*	*146.3*	*134.2*	*0*	*7.1*	*9.3*	713.2
1995	*0*	*37*	*71.8*	*146.5*	*72.7*	*58.7*	*160.4*	*113*	*103.4*	*1.8*	*0*	*22*	787.3
1996	*44.8*	*0*	*110.5*	*41.4*	*124.9*	*200.1*	*174.1*	*232.6*	*74.5*	*7.9*	*3.8*	*0*	1014.6
1997	*42.3*	*0*	*33.3*	*84.9*	*6.5*	*97.6*	*194*	127.6	47.9	22.0	3.0	0.0	659.1
1998	17.6	26.3	52.0	43.8	38.0	66.4	230.6	284.3	63.0	62.1	0.0	0.0	884.1
1999	3.2	0.0	7.8	10.2	0.8	93.9	194.4	188.8	42.2	116.5	0.0	0.0	657.8
Average	17.9	38.8	63.8	60.7	60.8	105.0	225.8	225.6	108.4	30.7	7.6	2.6	947.8
Std	32.5	48.7	55.8	47.3	49.4	76.7	84.3	93.5	70.0	41.7	21.3	6.0	287.4

Table II.4.8 Rainfall at Alem Tena Station

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1987	*0.0*	*21.9*	*101.7*	87.5	181.2	0.9	119.3	172.9	123	1.3	0.0	0.0	809.7
1988	11.5	36.8	43.5	47.0	5.7	85.7	161.8	200.1	171.7	19.4	0.0	1.7	784.9
1989	0.9	143.9	129.7	92.7	0.0	123.1	105.6	185.1	136.8	11.6	0.0	2.5	931.9
1990	0.0	166.9	21.1	132.4	11.9	26.3	206.2	*160.8*	*64.3*	0.0	0.0	0.0	789.9
1991	1.2	32.3	90.4	29.5	16.0	45.1	205.7	*178.8*	*73.7*	*4.3*	*0.0*	*5.6*	682.6
1992	*11.2*	*50.5*	*8.4*	*74.0*	*45.6*	*43.4*	*251.4*	*227.9*	*90.2*	*51.0*	*0.0*	*7.9*	861.5
1993	26.3	66.8	0.0	158.9	39.3	59.8	312.3	185.2	78.9	23.6	0.0	0.4	951.5
1994	0.0	0.0	8.6	25.3	17.2	117.1	206.1	126.5	*124.9*	*0.0*	16.0	13.2	654.9
1995	0.0	44.8	87.8	47.5	22.3	29.9	159.8	135.6	89	5.2	0.0	0.0	621.9
1996	65.4	*0.0*	100.0	31.1	63.0	113.4	197.6	153.5	92.5	0.0	0.0	0.0	816.5
1997	10.7	0.0	32.3	92.0	9.3	158.4	194.6	151.2	70.7	48.0	6.0	0.0	773.2
1998	7.1	1.8	36.3	102.6	33.1	49.8	216.4	190.7	52	98.4	0.0	0.0	788.2
1999	2.4	0.0	19.7	6.8	19.2	81.1	227.5	165.6	72.1	119.9	0.0	*0.0*	714.3
Average	10.5	43.5	52.3	71.3	35.7	71.8	197.3	171.8	95.4	29.4	1.7	2.4	783.2
Std	18.2	54.7	43.6	45.0	47.1	45.8	53.9	27.4	34.1	39.6	4.6	4.1	98.3

Table II.4.9 Rainfall at Assela Station

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1966	17	112.5	52.5	111.5	27.5	146.5	162.1	221.5	139	72.5	1.5	0	1064.1
1967	2.5	0	153	71.5	216.5	112.5	367	281.5	211.5	212	100.5	0.0	1728.5
1968	10	125.5	50	278.5	111	199	231.0	267.5	256.5	20	15	17	1581.0
1969	46	131	136	74	84	149	248	246.5	182	39	14	5	1354.5
1970	112	35	273	72.4	77	91.5	282	225.5	187	65	0	0	1420.4
1971	29	2	98	153	185	164	190.5	200	171	39	25	26.5	1283.0
1972	23	43	88.5	256	75.5	134	160.5	341	117	2	6.5	9	1256.0
1973	2	0	1	40.5	194.5	165.8	132.3	195	135	53	0	0	919.1
1974	14.3	35.5	186	23	122	105.5	201.0	133.3	205.5	27	0	0	1053.1
1975	13.9	24.5	15.7	46.5	77.5	237	223	284.2	161.1	31.5	0	0.0	1114.9
1976	2.8	18.6	83.5	137.2	84.1	113.9	259.3	207.8	84.6	74	48.1	21.3	1135.2
1977	36	16.3	113.2	127.1	93.3	183.7	220.5	234	180.1	112.2	0	27.5	1343.9
1978	2.4	152.6	83.5	66.7	153	124.8	285.3	228.6	153.3	60.7	81.5	8.1	1400.5
1979	44	34.2	87.8	52	160.2	103.5	228.8	322.6	290.7	82.4	0	16.7	1422.9
1980	18.7	10.1	109.6	52.4	111.0	106.6	176.5	173	166.1	66.8	12.7	0	1003.5
1981	0	18.8	166.2	145.6	47	79.8	264.4	191.1	280.5	47	10	0	1250.4
1982	22.1	93.4	75.6	94.1	143.8	131.6	168.6	391.8	213.8	48.3	50.1	17.3	1450.5
1983	5.8	78.6	81.3	210.1	255.8	144.9	183.4	290.1	143.0	27.9	7.5	0.0	1428.4
1984	0.3	5.7	11.3	23.6	327.2	135.7	156.5	209.1	244.9	1.6	2.0	13.9	1131.8
1985	14.9	1.8	48.1	175	179	114.5	206.6	150.4	153.8	13.5	26.7	2.7	1087.0
1986	13.8	98.5	84.6	172.2	112.9	118	246.7	166.2	256	43.1	72.3	2.3	1386.6
1987	0	60.1	134.6	105.9	183.4	126.4	103.8	136.5	115	12.2	8.1	13.7	999.7
1988	14.1	52	8.4	75.3	51.1	112.1	219.3	168.2	148.1	66.5	0	0	915.1
1989	1.7	26.7	126.6	268.2	40.2	132.3	111.9	169.3	129.8	54.2	13.2	88.5	1162.6
1990	0	111.5	93	92.1	19.8	87.1	197.8	186.4	153.7	6.9	11.2	0	959.5
1991	0	42.4	162.1	34.4	57.6	117.6	178.8	149.1	39.1	1.5	1.2	20	803.8
1992	36	90.8	58.3	142.1	33.5	44	131.6	206.3	118.7	93.1	32.7	38.7	1025.8
1993	13.2	22.3	20	150.8	181.1	38.7	117.9	166.3	140	172.9	0	0	1023.2
1994	0	0	132.9	44.5	83.8	203.8	249.7	164.5	178.1	5.5	33.5	3.5	1099.8
1995	0	23.2	122.4	151.8	96.7	116.9	202.1	164.2	97.6	21.8	0	69.5	1066.2
1996	69.5	16	171.7	155.9	156.5	193.9	163.3	132.7	133.9	31.5	1.9	4.3	1231.1
1997	18.7	36.8	91.9	214.5	49.8	160	196.6	98.2	99.2	127.2	89.7	1.3	1183.9
1998	27.3	60.6	48.2	94.9	72.6	109	165.4	266.5	135.5	131.3	3.5	0.3	1115.1
1999	0	0	49.8	29.3	39.7	83.5	186.4	120.5	104.2	229.8	11.7	0.9	855.8
Average	18.0	46.5	94.7	116.0	114.8	129.0	200.5	208.5	162.5	61.6	20.0	12.0	1184.0
Std	23.3	43.7	58.7	71.4	71.0	42.8	55.8	67.0	57.1	57.1	28.1	19.9	213.3

Table II.4.10 Rainfall at Kulumsa Station

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1966	8.0	81.7	34.0	59.8	22.9	83.2	116.1	176.9	111.5	22.3	0.3	0	716.7
1967	1.3	0.5	76.3	45.5	87.5	68.8	172.9	150.2	137	66.8	65.9	0	872.7
1968	2.5	163.8	30.5	168.8	54.2	97	156.7	137.9	147.5	1.6	21.8	0	982.3
1969	78.9	98.4	86.2	45.1	50.2	107.7	115.1	110.1	85	4	6.1	0.2	787.0
1970	122.5	31.3	237.8	41.6	49	33.1	112.2	116.2	98.6	2.6	0	0	844.9
1971	1.6	0	42.6	78.2	141.9	95.6	125.5	165.3	60.5	2.4	28.2	66.6	808.4
1972	3.7	87.4	53.4	118.6	75.2	53.6	107.2	186.7	107.2	11.7	8.9	0	813.6
1973	0	0	0	24.4	143.8	95.6	168.8	127.1	151.3	55.7	0	0	766.7
1974	37.8	4.9	222.9	0.9	40.4	123.7	117.4	137.9	120.1	20.4	0	0	826.4
1975	16.1	8.6	34.5	73.7	49.3	121.7	160.1	170.3	156.3	25.5	0	0	816.1
1976	0	14.2	70.1	114.1	109.5	100.1	99.9	167.6	71.9	30.4	84.1	0	861.9
1977	112.5	10.6	77.6	132.3	68.7	120	129.4	139	97.9	156.6	2.3	2.2	1049.1
1978	0	115.3	19.6	8.5	61.3	61.9	142.8	167.5	147	49.2	15.3	3.5	791.9
1979	20	68.7	207.6	55	122.4	56.3	124.9	138.5	99	29.6	0	15	937.0
1980	13.6	4.5	56.8	41.9	127	99	130.9	82.4	70.7	26.5	0	0	653.3
1981	0	28.6	176.7	94.5	16.1	13.5	164	98.1	107	20.4	0	0.2	719.1
1982	29.4	84.4	23.3	95.1	107.8	70.6	132.5	152.2	96.4	83.8	46.1	36.4	958.0
1983	5.6	16	105.4	106.3	239.9	65.1	134.7	183.1	96.9	12.5	4.3	0	969.8
1984	0	0	9.5	2.2	151	84.1	79.4	159.5	131	10.5	0	17	644.2
1985	8.6	8.8	15.3	84.7	56.5	55.6	135.3	95.8	108	25.5	1.2	1	596.3
1986	0	156.5	84.3	123.5	81.2	115.2	107.9	72.4	120	48.7	11.7	16.2	937.6
1987	2.2	21.6	108.8	150.3	158.5	49.4	83.1	116	88.2	5.8	3.1	11.7	798.7
1988	64.2	79.3	25	113.6	60.4	82.7	133.9	122.5	136.4	56.3	0	0.1	874.4
1989	0.2	50.4	69.9	177.9	25	132.4	115.9	180	95.8	31.6	5.4	41.2	925.7
1990	0	160.6	100.6	155.2	30.5	97.1	180.8	109.8	120.3	22.7	5.5	0.9	984.0
1991	10.4	42.7	185.3	11.1	93.1	62.5	158.3	123.7	86.3	10.8	0	12.1	796.3
1992	26.5	96	4.5	65.6	28.8	68	109.1	174.3	104.6	81.5	36.1	14.6	809.6
1993	20.5	72	12.9	148	152	49	112.4	155.2	128.1	59.2	0	30.8	940.1
1994	0	13	34.5	66.7	42.8	148.3	120.1	133.6	105.6	1.1	32.9	15.4	714.0
1995	0	34.1	164	140.3	64.8	79.3	120	142.1	74.4	2.2	0	45.8	867.0
1996	42	4.3	132.4	58.9	182.5	134.6	130.4	98.5	87.5	1.3	3.4	0	875.8
1997	6.4	0	218.2	112.7	35.3	115.5	134.5	108.6	61.2	93.5	25.7	0	911.6
1998	27.8	24.5	42.8	69.1	91.7	84.1	78	186.6	119.8	106.1	35	0	865.5
1999	5.4	1.1	73	25	61	103.5	111.8	110.3	71	184.5	0	0	746.6
Average	19.6	46.6	83.4	82.6	84.8	86.1	127.1	138.1	105.9	40.1	13.0	9.7	837.1
Std	31.2	50.0	69.9	50.0	52.7	31.0	25.4	31.7	26.1	44.0	20.5	16.3	105.4

Table II.4.11 Rainfall at Arata Station

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1974	0	13.5	144.5	30	105	112.6	146	86.5	167	11.5	0	0	816.6
1975	12.4	12.1	5	47.2	53.9	92.9	138.5	136.5	83	9.5	0	0.1	591.1
1976	0	11.6	57.7	66.8	81.1	75.6	153.2	143.8	63.3	58.6	20.4	0.2	732.3
1977	63	3.6	158	111.8	104	118.7	142.6	151.4	106	112	0	0	1071.1
1978	0	75	78	28	37	108	161.8	154	116.9	96.9	40	0	895.6
1979	24.1	44.9	130.5	43.9	112.2	61.3	135.8	173	143.2	41.4	0	12.8	923.1
1980	12.8	7	63.6	44.4	106.6	82.4	130.7	96.8	88.8	34.8	4.1	0	672.0
1981	0	20.2	140.9	113.5	13.8	24.2	150.5	95.1	128.7	34.3	9.7	0	730.9
1982	51	68.7	36	77.3	111.9	77.5	130.3	87	116.9	56.9	38.9	23.5	875.9
1983	4.6	33.4	78.2	120.6	201.1	79.1	125.8	184.3	94.1	15.2	4.6	2.9	943.9
1984	0	0	2.2	0	180.6	41.2	151.6	170.3	60.1	5.7	7.5	13.6	632.8
1985	5.7	2.6	48.1	98	60	46.2	157.3	101.1	106.2	26	6.4	0.2	657.8
1986	0	55.2	79.1	112.9	99.5	133	189.1	86.4	180.9	29.3	10.8	3.8	980.0
1987	0	30.2	53.4	74.7	180.7	52.8	81.5	110.2	58.5	9.3	0	5	656.3
1988	4.5	29.5	2.3	78.9	33.9	159.7	133.7	132.9	109.4	31.4	0	0	716.2
1989	0	21.3	54.4	91.6	13	89.3	139.2	146.3	85.3	16.3	0	0	656.7
1990	0	131.2	42.3	55.1	41	51.1	154.7	131.6	128.1	11.7	5	0.4	752.2
1991	1.4	35.6	176.9	12.5	58.9	97.1	124.8	71.9	107.4	5.8	3.7	34.5	730.5
1992	69.1	42	34.7	81.1	42.6	62.2	131.6	152.7	76.6	79.7	34.4	6.4	813.1
1993	25.4	20.3	19.5	112	134.4	52	216.9	119.9	86.6	53.6	2.8	3.3	846.7
1994	0	0	37	14.5	56.8	177.6	120.9	98.8	120	0.2	9.3	0.1	635.2
1995	0	40.6	181.1	138.8	55.9	138	93.5	137.4	113.7	16.5	0	16.5	932.0
1996	26.6	0	77.7	47.2	152.3	234.8	122.7	127.8	113.7	14.6	2.6	0	920.0
1997	0.7	5.7	105.5	183.9	60.7	91.1	153.4	57.8	80.8	108	31.1	0	878.7
1998	57.2	63.6	83.8	53	66.4	106	111.2	126.2	140	105.9	16	0	929.3
1999	2.7	0.5	34.8	12.8	24.7	98.2	115.1	67	73.5	213.5	17.8	0	660.6
Average	13.9	29.6	74.0	71.2	84.2	94.7	138.9	121.0	105.7	46.1	10.2	4.7	794.3
Std	21.8	30.6	52.8	44.6	52.5	46.6	27.1	34.2	31.0	48.6	12.7	8.7	131.5

Table II.4.12 Rainfall at Sagure Station

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1973	0	0	0	56.6	118.3	90.6	227.8	129.2	94.9	32.1	0	4	753.5
1974	0	0	166.1	14.7	71.5	68.7	150.3	152.3	99.8	3.3	1.3	0.5	728.5
1975	0	6.6	18.8	118.9	84.2	145.3	172.6	227.5	101.2	27	1.3	0	903.4
1976	10.2	29.4	34.7	57.2	119.6	79.8	243.2	164.2	42.5	7.3	19.2	2.3	809.6
1977	41.6	15.5	67.1	72.9	68.5	90.3	114.7	125.6	39.1	114.8	1.6	8.1	759.8
1978	1	93	18.7	58.2	49.9	212.3	242.5	166.4	80.4	55	14.5	0	991.9
1979	80.7	51.5	100.8	13.6	76.5	122.5	233	105.3	75.9	41.2	1.3	6	908.3
1980	22.4	16.1	34.6	52.6	6.9	32.9	144.2	110.4	86.7	34.6	1.5	0	542.9
1981	0	4.8	247.2	73.1	32.5	58	152.5	164.4	131.5	8.3	0	0	872.3
1982	25	56.8	49.1	145.5	79.1	57.4	173.2	122.8	30.8	44.3	9.7	8.1	801.8
1983	17.8	55.9	41.8	50.1	176.8	57.8	78.5	170	119.1	45.6	16.8	0	830.2
1984	2.4	0	27	40.2	206.8	324	249	171.1	58.6	0	8.6	0	1087.7
1985	0	0	0	0	66.8	42.6	98.7	163.2	8	70.1	7.1	0.1	456.6
1986	0.2	56.3	52.9	121.4	93.1	110.4	129.7	151.5	29.8	27.2	1	12.5	786.0
1987	2.0	26.2	37.6	117.1	113	63.2	86	87.5	58.4	31.5	0.7	0	623.2
1988	7.3	29.3	7	116.6	88	73.8	234	175.9	129.8	43	1.4	0	906.1
1989	0	19.6	51.4	79.9	6.3	94.1	104.7	106.4	94.5	23.1	6.6	28.4	615.0
1990	4.9	132.8	120.1	70.9	51.1	80.1	120.3	97.3	95.9	9.5	19.1	0	802.0
1991	4.8	26.5	104.2	16.1	29.7	76	136.5	181.9	122.8	6.5	0.4	5.5	710.9
1992	23.9	81.7	53.6	74.5	38.1	73.4	107.2	224.8	63.3	57.8	13.1	12.6	824.0
1993	10	34.6	21.7	165.4	130.5	60.5	103.3	165.4	77.8	67.5	0	0.2	836.9
1994	0	9.9	33.2	52.1	25.9	138.8	199.8	141.8	105.5	0.1	11.3	2.1	720.5
1995	0	16.9	37.8	114.4	46.6	56.4	248.7	160.9	68.2	13.1	0	10.3	773.3
1996	36.1	0	78.8	10	126.9	161.9	101.2	103.6	59.8	4	3.7	0.6	686.6
1997	31.7	0	39.7	104.1	47.5	44.3	170.6	119.6	67.2	76.8	18.2	0	719.7
1998	24.1	37	61.7	75.6	60.5	59.4	99.8	201.9	35.3	92	9.6	0	756.9
1999	6.5	2.2	17.7	27.3	52.2	58.3	206.7	87.4	90.3	78.5	0	2.2	629.3
Average	13.1	29.7	56.4	70.3	76.5	93.8	160.3	147.3	76.6	37.6	6.2	3.8	771.7
Std	18.5	33.0	53.8	43.6	48.0	61.5	57.7	38.6	32.6	30.8	6.8	6.4	133.6

Table II.4.13 Rainfall at Bekoji Station

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1971	4.1	0.4	45.4	102.8	135.3	172.6	165.5	173.6	91.9	62.3	18.7	12.3	984.9
1972	18.3	155.4	56.4	126.8	42.6	96.4	181.8	129.6	70.8	18.7	22.5	0	919.3
1973	0	8	0	57.6	90.7	83.3	221.1	209	81.3	49.8	1.5	29.7	832.0
1974	0	10.3	162.6	2.4	51.1	32.6	200.6	189.4	128.3	13.7	0.2	0	791.2
1975	0	4.2	6.2	77.5	107	170.4	248.3	206.8	158.4	87.1	0	0.3	1066.2
1976	2.2	10.6	55.3	47.1	144.2	45.7	208	165.6	63.4	29.2	20	2.8	794.1
1977	74.4	28	107.4	105.6	119.1	106.1	188.4	234.8	83.2	253.3	58.7	0	1359.0
1978	0	113.7	38		55.4	132.4	193.9	205.2	96.3	29.7	6.9	30.3	901.8
1979	211.7	54.4	104.8	81.7	140.4	115.6	163.3	126.7	104.6	32.3	2.7	17.6	1155.8
1980	0	20	39.5	82.1	110.7	82.8	216.6	118.5	45.7	30.9	4.1	1.5	752.4
1981	0	47.1	259.9	178.5	8.6	83.5	215.4	220.5	157.4	16.8	6.6	6.3	1200.6
1982	44.4	62.9	65	110.6	199.4	171.8	222.1	174.7	32.5	74	58.3	14.9	1230.6
1983	20.9	51.7	89.5	98.2	237.2	70.2	139.2	208.0	122.9	37.2	11.0	14.5	1100.5
1984	4.6	0.0	10.6	17.7	135.3	183.8	177.8	110.8	66.4	3.5	36.7	11.6	758.8
1985	24.1	1.6	98.1	117.9	194.8	106.3	208.5	148.6	38.8	55.0	4.9	2.0	1000.6
1986	4.5	61.5	52.3	142.2	108.7	210.0	138.3	234.5	62.6	49.1	0.9	14.4	1079.0
1987	2.5	37.5	206.9	123.1	117.5	97.7	67.4	179.6	60.3	44.8	3.2	23.2	963.7
1988	12.5	36.5	81.1	201.3	52.7	109.5	199.6	262.6	103.4	124.6	8.3	5.0	1197.1
1989	20.2	46.2	98.3	155.6	82.8	87.1	172.9	155.0	67.2	101.1	11.6	80.0	1078.0
1990	4.1	224.9	108.1	146.9	38.0	59.5	155.1	136.0	126.1	14.9	17.2	3.3	1034.1
1991	5.3	61.4	140.9	30.9	81.1	123.3	197.2	255.1	97.4	8.9	0.9	24.2	1026.6
1992	112.9	91.2	39.4	121.1	54.7	116.9	164.3	216.0	36.2	126.7	51.8	13.1	1144.3
1993	54.5	99.4	2.7	148.9	175.8	123.9	163.8	221.8	138.2	50.4	3.5	3.2	1186.1
1994	0.8	0.0	37.4	128.2	47.5	168.0	241.5	250.7	89.2	6.3	38.6	5.0	1013.2
1995	0.0	41.4	94.2	151.8	73.4	50.1	181.7	230.0	157.2	17.5	1.2	32.4	1030.9
1996	58.7	12.3	140.2	55.5	154.3	125.1	158.0	229.2	86.1	5.0	3.1	5.9	1033.4
1997	25.1	0.0	132.3	163.4	42.1	111.7	191.4	126.0	74.4	109.3	20.9	0.0	996.6
1998	26.5	36.3	62.9	83.0	86.7	79.6	130.2	234.9	95.0	118.5	20.1	0.0	973.7
1999	7.2	1.7	47.9	26.1	65.7	104.0	182.0	110.8	97.8	155.4	0.0	1.2	799.8
Average	22.7	47.0	84.6	113.4	94.4	116.0	170.6	193.9	87.3	61.9	13.9	14.0	1019.7
Std	44.7	51.7	60.5	50.9	55.5	43.6	36.9	47.3	35.6	56.5	17.7	16.5	153.3

Table II.4.14 Rainfall at Keresa Station

Year	Monthly Rainfall (mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1968	7	138	49	201	165	93.5	64.7	87	74	38	10	11	938.2
1969	65	78	129	43	43	36	117	150	100	10	3	0	774.0
1970	45	33	180	87	58	73	115	81	124	37	0	3	836.0
1971	1.0	1.0	32.0	82.0	87.0	62.0	37.0	102.0	98.0	81.2	107.0	23.0	713.2
1972	22.0	116.0	32.9	191.0	41.0	50.1	67.0	63.0	70.1	37.0	2.0	0.0	692.1
1973	0.0	3.4	0.0	35.9	107.1	80.9	173.9	148.8	106.8	47.7	0.6	12.5	717.6
1974	0.2	2.1	129.3	13.4	84.0	64.0	128.1	90.0	82.0	16.0	16.0	0.0	625.1
1975	0.0	7.0	43.0	144.0	31.0	106.0	142.0	168.0	141.0	64.2	0.0	0.0	846.2
1976	0.0	17.0	69.9	49.5	121.0	49.8	144.6	100.3	93.4	3.2	60.6	13.0	722.3
1977	67.2	36.3	35.6	10.7	77.6	15.1	49.1	133.1	80.6	102.8	4.2	0.0	612.3
1978	0.0	95.0	135.4	82.5	92.6	54.6	102.0	135.9	101.9	78.2	5.6	14.2	897.9
1979	87.6	69.9	119.9	99.3	135.2	53.4	110.8	71.2	75.8	33.7	2.9	3.3	863.0
1980	39.0	38.3	32.6	130.6	62.0	88.6	82.3	11.3	111.0	28.9	3.3	0.0	627.9
1981	0.4	20.4	187.9	169.5	46.5	42.0	121.7	107.2	96.3	14.4	27.0	0.0	833.3
1982	98.8	55.7	44.3	115.7	116.8	65.3	79.9	143.4	67.1	89.3	24.1	21.3	921.7
1983	18.2	18.9	93.1	102.9	184.3	50.5	105.0	164.0	100.7	45.0	80.7	5.0	968.3
1984	0.4	0.0	21.4	20.2	53.0	175.6	109.2	113.3	110.5	2.0	40.3	12.5	658.4
1985	20.0	4.5	44.8	97.7	204.6	57.9	136.6	119.1	146.7	75.1	79.0	35.1	1021.1
1986	21.5	106.2	56.5	199.2	124.1	140.3	118.4	145.4	205.6	70.5	15.9	12.5	1216.1
1987	7.9	63.4	214.5	105.1	197.6	83.3	86.5	123.2	90.7	46.6	5.7	4.4	1028.9
1988	21.4	56.3	17.0	86.0	100.5	107.8	171.3	215.0	143.0	94.7	0.0	6.1	1019.1
1989	1.9	119.7	121.2	156.1	57.4	123.4	106.3	113.0	184.6	57.9	36.9	99.0	1177.4
1990	29.4	82.5	164.5	171.1	112.5	41.9	123.5	78.4	125.0	40.0	20.0	2.8	991.6
1991	15.5	23.4	50.0	68.3	78.8	81.8	158.8	166.5	82.3	8.9	0.4	16.0	750.7
1992	60.1	84.4	18.7	82.4	36.8	81.7	121.4	174.4	65.4	92.3	39.1	12.5	869.2
1993	39.4	78.2	8.4	157.7	106.3	85.3	107.6	140.5	113.6	160.3	1.8	2.9	1002.0
1994	0.2	14.2	60.5	133.5	129.7	102.6	104.2	127.4	136.7	25.6	49.1	4.5	888.2
1995	0.0	95.7	122.3	246.3	63.0	57.3	136.5	164.8	101.7	10.6	0.5	26.9	1025.6
1996	91.5	4.2	122.6	118.9	107.6	163.5	119.5	114.2	110.1	42.6	2.3	1.5	998.5
1997	9.0	1.0	29.2	31.7	27.0	33.6	144.9	105.0	60.6	104.7	21.1	0.0	567.8
1998	47.6	43.5	39.3	78.7	135.0	63.5	124.5	170.3	98.3	78.1	17.1	0.0	895.9
1999	3.7	0.8	95.7	30.6	49.0	99.3	107.5	85.7	83.6	183.6	0.0	0.0	739.5
Average	24.3	43.4	73.9	103.8	95.5	78.7	114.5	123.9	106.3	59.8	22.9	11.3	858.3
Std	30.0	41.8	58.0	60.7	48.3	36.6	31.8	40.8	32.9	43.0	27.6	18.5	164.3

Table II.4.15 Rainfall at Ziway Station

Latitute = 7.56 , Longitude=38.43, Altitude= 1640 m

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1970	66.5	0.0	70.2	43.6	21.2	*23.0*	*105.3*	*128.1*	93.7	*9.7*	0.0	0.0	561.3
1971	6.8	1.0	30.4	100.8	64.0	143.6	116.2	114.4	27.8	0.0	3.4	1.6	610.0
1972	0.0	0.0	0.0	178.9	78.2	46.9	124.8	132.3	67.1	31.4	0.0	0.0	659.6
1973	0.0	0.0	0.0	9.0	164.4	70.5	168.8	121.4	111.4	33.8	0.0	2.6	681.9
1974	3.6	5.5	152.4	1.2	67.6	75.2	118.1	218.7	213.4	0.0	0.0	0.0	855.7
1975	0.0	29.4	3.3	23.6	105.6	187.8	304.1	48.6	246.5	7.1	0.0	0.0	956.0
1976	0.0	1.8	47.3	31.8	96.2	64.2	175.3	76.2	76.3	6.9	21.9	0.0	597.9
1977	63.1	9.0	6.0	154.3	96.4	168.7	180.4	143.9	55.5	218.8	0.0	0.0	1096.1
1978	10.9	178.3	45.6	65.6	13.2	181.9	61.9	221.8	93.4	45.5	1.6	5.5	925.2
1979	91.9	102.4	70.0	61.6	148.6	105.2	150.0	98.0	87.9	71.0	0.0	6.2	992.8
1980	25.8	14.9	14.4	48.3	3.6	53.8	129.3	116.8	63.4	43.6	0.0	0.0	513.9
1981	0.0	28.2	248.9	68.7	21.7	2.2	237.1	145.4	234.2	5.2	0.0	0.6	992.2
1982	51.0	14.7	136.2	76.8	68.0	16.6	117.0	218.7	39.3	142.3	9.5	0.0	890.1
1983	34.4	56.3	85.9	100.6	152.1	43.3	153.2	146.5	65.6	27.2	0.0	0.0	865.1
1984	0.0	0.0	10.6	*2.5*	90.6	57.5	213.0	116.2	63.5	0.0	0.0	0.0	553.9
1985	0.4	0.0	30.6	105.4	118.6	40.0	155.7	138.2	69.0	1.3	0.0	0.0	659.2
1986	0.0	53.0	19.7	53.7	110.3	88.4	70.5	54.0	65.8	22.2	0.0	0.6	538.2
1987	0.0	29.8	56.3	47.6	219.6	16.2	67.5	54.1	44.7	17.1	0.0	0.0	552.9
1988	3.2	20.9	1.8	49.8	13.0	118.9	138.2	92.9	169.3	99.1	0.0	0.2	707.3
1989	4.7	50.3	195.7	129.9	2.9	101.9	120.0	150.5	133.1	12.5	0.0	49.6	951.1
1990	0.0	140.8	16.6	52.1	37.8	49.0	162.2	141.6	88.8	0.5	0.0	0.0	689.4
1991	1.7	98.2	141.0	12.8	26.2	114.0	171.9	144.3	47.0	10.7	0.0	9.2	777.0
1992	20.3	21.8	6.2	58.8	75.2	99.4	208.5	153.6	27.5	116.5	1.5	*8.1*	797.4
1993	42.1	127.4	0.4	100.2	128.5	68.5	223.7	147.5	49.4	71.0	0.0	0.2	958.9
1994	0.0	0.0	24.1	9.0	49.1	145.6	126.4	92.9	*62.0*	0.0	4.6	0.0	513.7
1995	0.0	28.8	68.0	141.3	21.6	49.5	79.9	131.7	28.5	3.1	0.0	11.6	564.0
1996	46.4	8.2	53.9	110.4	127.1	128.4	125.4	161.5	106.4	0.0	32.8	0.0	900.5
1997	20.0	0.0	70.4	229.5	4.7	150.4	161.0	57.4	45.8	108.4	0.3	0.0	847.9
1998	6.1	22.3	43.4	48.7	57.7	44.9	166.5	177.8	97.4	90.8	0.0	0.0	755.6
1999	5.5	0.0	28.5	2.4	44.2	110.3	85.0	63.8	72.0	133.8	0.0	0.0	545.5
Average	16.8	34.8	55.9	70.6	74.3	85.5	147.2	127.0	88.2	44.3	2.5	3.2	750.3
Std	24.8	47.6	62.0	55.8	55.2	51.2	54.3	47.2	57.8	55.3	7.2	9.3	175.1

Table II.4.16 Rainfall at Adamitulu Station

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1974	2.4	3.7	138.7	0.8	36	75.5	58	202.4	108	0	0	0	625.5
1975	0	8.3	0	47.8	65	70.1	147	40.6	130	8	0	0	516.8
1976	0	0	51	20.6	86	80.5	97.5	102.2	51.5	7	32	0	528.3
1977	39.3	41.2	1.3	70.1	64.8	129.3	188.8	74.3	161.5	126.6	26.5	0	923.7
1978	8	174.8	62.7	33.3	4.4	176.8	49.3	169.6	96.5	89.1	0.3	7	871.8
1979	66.6	65.3	42.4	33.7	96.3	152.2	122.1	102.7	47	29.4	0	43.4	801.1
1980	0	27	13	1.3	32.6	20.7	153.2	61.6	64.3	11.4	0	0	385.1
1981	0	46	145.9	99.4	0.4	0	153	83.2	83	0	0	0	610.9
1982	57.5	0	56.3	37	43.3	83	111.6	186.7	28.9	0	0	0	604.3
1983	0	68.4	16.4	50.4	182.9	0	110	102.6	24.4	27.7	0	0	582.8
1984	0	0	11.8	0	135	57.6	126.5	157.5	77.5	0.5	0	0	566.4
1985	0	0	36.8	182	151.6	19	209.3	244.3	102.1	2.2	0	0.9	948.2
1986	0	48.3	23.7	86.1	124.3	79.3	82.2	76.3	69.1	31	0	3.3	623.6
1987	0	19.1	110.4	92.4	190	64.6	44.9	87.7	33.3	9.9	0	0	652.3
1988	5	18.7	5.1	26.3	8.8	57.1	112.7	127.9	121.5	73.2	0	0.8	557.1
1989	18.8	58.6	228.1	92.3	0.1	138.7	142.5	137.1	134.2	15.8	0	33.5	999.7
1990	0.9	167	44.8	91.2	68.1	49.1	173.5	115.9	144.9	4.8	0	0	860.2
1991	3.8	76.5	136.8	4.3	51.2	46.6	199.6	184.9	45.5	7.2	40	2	798.4
1992	35.6	49.1	5.4	45	41.7	139.5	170.4	188	24.4	107.7	4.7	2.3	813.8
1993	92.9	160.2	0	97.5	124.5	87.2	184.9	149.3	44.5	81.9	0	0	1022.9
1994	0	0	21.1	16.5	38.7	209.2	111.1	90.9	33.3	0	18	0	538.8
1995	0	16.6	47.1	117.6	69	39.8	74.3	145.7	32.4	4.8	0	7	554.3
1996	34.3	5.5	46.4	76.1	107.3	96.7	137.3	123.3	102.6	0	4.5	0	734.0
1997	15.5	0	41.1	173.1	12.9	83.6	197.3	77.4	43	99.9	2.9	0	746.7
1998	22.8	23.7	37.4	62.9	7.8	131.6	188.8	261.5	81.4	77.1	0.2	0.1	895.3
1999	4	0	26.8	24	70.5	67.3	95.7	84.9	89	142.6	0	0	604.8
Average	15.7	41.5	51.9	60.8	69.7	82.9	132.4	129.9	75.9	36.8	5.0	3.9	706.4
Std	24.7	52.4	55.9	49.0	55.4	52.4	48.4	56.5	40.6	45.6	11.1	10.5	171.5

Table II.4.17 Rainfall at the Bulbula Station

Year	Monthly Rainfall (mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1968	3	117	17	215	50	68.4	42.3	114.5	25.9	0	0	0	653.1
1969	45.6	66.7	24.7	31.8	13.6	46.5	87	36.4	31.5	5	0	0	388.8
1970	56	22	78.3	34	32.8	10.3	168.8	89	97	0	0	0	588.2
1971	0	0	1	14.1	40.7	102.9	91.7	66.3	18	0	0	0	334.7
1972	0	44	11	41	83	67	100.5	129.3	38	0	0	0	513.8
1973	*0.0*	*0.0*	*0.0*	*12.9*	*126.1*	*66.3*	*137.1*	*100.6*	*104.9*	*35.4*	*0.0*	*1.2*	584.5
1974	0	0	159.6	0	77	72	119	96.5	101.5	0	0	0	625.6
1975	0	14	6	21	43	46	207.8	76	132	5	0	0	550.8
1976	0	9	16	27	46	16	179.9	85	27	9	30	0	444.9
1977	27	16	27	64	37	53	114	105	32	101	3	0	579.0
1978	3	101.9	52.2	27.8	45.4	137.7	76.8	158.4	95.8	109.2	2.4	22.7	833.3
1979	59.9	28.9	88.1	109.2	62	65.7	114.6	129	103	66.9	0	0	827.3
1980	5.3	0	0	0	0	0	6	83.8	17.5	44	0	0	156.6
1981	0	25.4	236.3	65.1	16.5	12.1	167.3	101	103.6	6.3	0	0	733.6
1982	49.5	25.4	30.4	166.3	99.8	51.7	127.9	105.7	70	59	19.9	4.3	809.9
1983	1.8	27.5	103.2	*99.6*	*163.1*	*41.3*	*96.0*	*129.4*	*77.3*	77.3	0	0	816.5
1984	0	0	15.1	3.6	124	67.3	211.6	159.7	37.7	0	0	0	619.0
1985	0	0	18.8	125.3	101.9	0	230	56.3	92.9	22.7	9.8	3.9	661.6
1986	0	16.3	79.4	168.9	77.4	143.3	116	94.7	37.9	26.8	0	3.8	764.5
1987	2.1	42.5	87.9	70	243.2	81.3	106	62.3	64.5	9.9	0	8.9	778.6
1988	*15.6*	*36.0*	*9.0*	*104.0*	*32.6*	*68.0*	*109.0*	*94.8*	*113.7*	*77.1*	*0.0*	*0.1*	659.9
1989	24.5	138	0	191.4	12.3	146.6	73.3	91.5	190.8	35.2	1.8	*24.4*	929.8
1990	0	90.7	80.1	153.7	64.8	65.2	136.1	91.2	54.9	19.7	0	0	756.4
1991	11.5	45.9	112.4	10.4	14.8	104.5	163.8	33.5	65	0	31.5	0	593.3
1992	11.1	18.4	42.9	39.1	58.6	*65.6*	235.6	203.1	15.2	*85.2*	0	0	774.8
1993	45.2	61.3	0	21.5	79.1	70.1	68.9	144.7	52.4	104.8	0	0	648.0
1994	0	0	21.5	52.6	139.6	166.1	288.1	125.1	146.6	0	9.4	0	949.0
1995	0	24.6	30.3	154.2	60.2	36.2	127.5	101.9	63	1.8	0	32.7	632.4
1996	66.4	0	36.7	80	122.9	153	140.9	153.8	*94.9*	*1.2*	6	0	855.8
1997	*17.6*	23.4	0	37.3	69.1	11.5	*119.5*	70	53.7	118.8	11.7	0	532.6
1998	82.2	38.5	6.2	32.7	31.3	17.5	159.1	179.2	69.9	70.7	0.9	0.5	688.7
1999	1.2	*0.2*	150.1	45.4	46.7	39.6	60.4	106.2	88.7	217.1	0	0	755.6
Average	16.5	32.3	48.2	69.3	69.2	65.4	130.7	105.4	72.4	40.9	4.0	3.2	657.5
Std	24.0	36.1	56.3	61.2	51.2	45.5	59.9	38.8	41.2	50.6	8.4	8.0	171.9

Table II.4.18 Rainfall at Langano

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1972	0	0	0	64.2	66.8	161.2	15.5	101.1	70.6	10.6	0	0	490
1973	0	2.6	0	11.5	79.5	42	208.3	55	65.4	2.8	42.5	123.8	633.4
1974	*0*	*0*	*142.2*	*5.4*	*65.4*	*61.8*	*115.8*	123.8	159	*1.2*	*0.5*	*0.2*	675.3
1975	*0*	*9.5*	*10*	*54.5*	*52.9*	*76.9*	*169*	*122.5*	*104.2*	*12.5*	*0.5*	*0*	612.5
1976	*3.8*	*15.4*	*20.9*	*34.8*	*67.4*	*37.6*	98.9	121.8	34.6	10.2	49	0	494.4
1977	81	0	14.6	62.3	94	129.8	58.7	57.7	*30.6*	*93.5*	*2.1*	*3*	627.3
1978	*1.9*	*85.9*	0	45	19.5	117.7	215.9	*141.7*	73.8	38.6	3.6	29	772.6
1979	17.7	19.7	0	39.4	100.4	76	177.9	88.6	84	30	10.4	5.5	649.6
1980	11.2	5	2	27	33.5	39	25.8	66.2	90.9	41.8	0	0	342.4
1981	0	11.9	212.4	42.3	51.1	37.9	171.7	108.5	202.8	17.8	0	0	856.4
1982	64.4	23.1	21.5	93.6	195.7	29	98.3	214.2	70.6	54.6	19.4	14.6	899
1983	6.4	4.6	61.4	104.8	*147.9*	141	216.1	192.4	117.3	55	5.4	0	1052.3
1984	*0.9*	*0*	*17.6*	3.5	118.9	81.1	56	99.3	22.1	0	8	0	407.4
1985	*0*	0	14.4	69.4	118.4	64.7	170.2	102.9	43.1	11.3	0.6	0	595
1986	0	34.3	28.5	115.4	137	161.1	128.2	162.2	60	14.7	0	0	841.4
1987	0	19.5	52.4	137.4	130.6	52.4	100.5	127.6	37.2	37	0	0	694.6
1988	14.1	17.7	5.4	32	51.6	109.9	148.4	97	138	36	0	0	650.1
1989	5	120	100.2	160	3	144	49	65	259.6	27	0	7	939.8
1990	0	40.6	51.1	66.8	22	68.2	142.8	91.3	83.6	0.9	2.5	0	569.8
1991	0	51.5	112.7	1.3	9	93.5	42.8	33.8	28.8	10.1	0	17.2	400.7
1992	33.3	30.2	13.2	102.1	28.5	93.5	136.5	180	48	114.5	16	1	796.8
1993	33.5	71.5	*8.0*	*71.9*	*88.2*	74	158.7	101	82.5	30	0	*0.1*	719.4
1994	0	6	37.3	94.5	62.5	87	233.3	107.7	33.5	0	12	0	673.8
1995	0	9	9	130	10	33	142	142.5	77.5	0	*0*	*20.4*	573.4
1996	*47.0*	*0.0*	*47.7*	*44.2*	*109.1*	10.5	185.1	82	*70.2*	*2.1*	*4.4*	*0.2*	602.5
1997	4.5	0	27	89.2	2.5	177.5	117.4	57	64.5	122	5	0	666.6
1998	44	22.5	54.6	20	171.5	37	*117.4*	*165.3*	*48.4*	*69.8*	0	*0.3*	750.8
1999	*3.0*	*0.9*	17.7	24	50.3	220.7	155.8	79.5	78.1	287.1	0	0	917.1
Average	13.3	21.5	38.6	62.4	74.5	87.8	130.6	110.3	81.4	40.4	6.5	7.9	675.2
Std	21.9	29.3	49.4	42.9	52.2	52.2	59.6	44.1	53.8	59.0	12.3	23.9	170.1

Table II.4.19 Summary of Annual Rainfall in Meki-Ziway Basin

Year	Annual Rainfall (mm)								
	Butajira	Bui	Tora	Koshe	Ejersalele	Hombole	Meki	Ziway	Adamitulu
1964						823.1			
1965						733.4			
1966						1170.4	876.6		
1967						1619	857.6		
1968					918.1	1020	713.2		
1969	1073.1	1071.7			810.4	1056	588.2		
1970	1439.6	1523.9			903.9	1620.5	692.5	561.3	
1971	1043.8	1259.0			969.7	1317	665.3	610	
1972	1415.1	1388.4			910.4	1406.8	760.9	659.6	
1973	702	638.0			547.7	581.9	715.8	681.9	
1974	892.9	884.5	733.1	882.7	636.8	879.8	951.5	855.7	625.5
1975	1034.3	829.1	809	1002.1	876.3	652.7	742.4	956	516.8
1976	1071.9	854.9	1000.9	805.4	539.6	797.1	706.5	558.7	528.3
1977	1113.5	1095.9	911.8	1251.8	840.3	1069.7	1036.8	1096.1	923.7
1978	730.4	822.4	997.7	1079.5	732.3	807.5	970.7	925.2	871.8
1979	1272.3	1060.7	1182.4	1469.3	892.1	933.9	831.3	992.8	801.1
1980	907.8	682.2	691.3	893	500.4	591.9	587.3	513.9	385.1
1981	952.9	952.9	841.2	904.5	735	1246.2	855.8	994.4	610.9
1982	1228.9	932.0	969.9	1074.3	571.8	928.6	595	890.1	604.3
1983	1419.3	1465.4	1034.3	1785.5	702.1	1602.9	1090.6	865.1	582.8
1984	786.9	956.0	474.2	1052.7	422	1113.3	709.2	553.9	566.4
1985	888.5	845.0	815.5	1012.2	582.3	836.1	696.4	659.2	948.2
1986	1061	926.9	893	856.7	628.8	887.6	938	540.1	623.6
1987	1247.9	865.8	1096.3	907.7	717.5	579.1	803.7	552.9	652.3
1988	1048.2	847.3	884.8	659.4	838.2	690.3	728.8	707.3	557.1
1989	1286.7	798.9	927.4	1078.2	865.5	733	800.5	951.1	999.7
1990	1466.5	1075.8	914.5	840.5	811.7	864.06	905.1	689.4	860.2
1991	1159.8	1008.7	696.7	782.4	777.6	893.5	501.8	777	798.4
1992	1149.3	992.5	898.2	765.7	869.3	1027.9	934.6	797.4	813.8
1993	1448.5	1026.1	1266.6	1311.5	1158.1	803.4	749.8	958.7	1022.9
1994	1026.1	754.2	777.9	674.5	957.8	713.2	633.8	514.1	538.8
1995	1130.5	1304.9	1023.4	869.7	723.2	787.3	344.5	564	554.3
1996	1466.8	1276.2	1156.7	891.2	1239.3	1014.6	996.8	867.9	734
1997	1237.3	718.1	913.5	859.1	882.8	659.1	879.2	847.9	746.7
1998	1453.8	1026.2	1022.3	867	1083.8	884.1	761.2	755.6	895.3
1999	909.6	869.7	701.9	698.7	799.7	657.8	699.3	545.5	604.8
Average	1131.1	992.0	909.0	972.1	795.1	944.5	774.1	748.1	706.4
Std	225.5	224.0	174.1	253.5	186.3	287.4	158.5	175.5	171.5

Table II.4.20 Summary of Annual Rainfall in Katar-Abijata Basin

Year	Annual Rainfall (mm)								
	Alem-Tena	Kulumsa	Assela	Arata	Sagure	Bekoji	Kersa	Bulbula	Langano
1966		716.9	1064.1						
1967		872.7	1728.5						
1968		982.3	1581				938.2	653.1	
1969		787	1354.5				774	388.8	
1970		844.9	1420.4				836	588.2	
1971		808.4	1283			984.9	713.2	334.7	
1972		813.6	1256			919.3	692.1	513.8	490
1973		766.7	919.1		753.5	832	717.6	584.5	633.4
1974		826.4	1053.1	816.6	728.5	791.2	625.1	625.6	675.3
1975		816.1	1114.9	591.1	903.4	1066.2	846.2	550.8	612.5
1976		861.9	1135.2	732.3	809.6	794.1	722.3	444.9	494.4
1977		1049.1	1343.9	1071.1	759.8	1359	612.3	579	627.3
1978		791.9	1400.5	895.6	991.9	901.8	897.9	833.3	772.6
1979		937	1422.9	923.1	908.3	1155.8	863	827.3	649.6
1980		653.3	1003.5	672	542.9	752.4	627.9	156.6	342.4
1981		719.1	1250.4	730.9	872.3	1200.6	833.3	733.6	856.4
1982		958	1450.5	875.9	801.8	1230.6	921.7	809.9	899
1983		969.8	1428.4	943.9	830.2	1100.5	968.3	816.5	1052.3
1984		644.2	1131.8	632.8	1087.7	758.8	658.4	619	407.4
1985		596.3	1087	657.8	456.6	1000.6	1021.1	661.6	595
1986		937.6	1386.6	980	786	1079	1216.1	764.5	841.4
1987	809.7	798.7	999.7	656.3	623.2	963.7	1028.9	778.6	694.6
1988	784.9	874.4	915.1	716.2	906.1	1197.1	1019.1	659.9	650.1
1989	931.9	925.7	1162.6	656.7	615	1078	1177.4	929.8	939.8
1990	789.9	984	959.5	752.2	802	1034.1	991.6	756.4	569.8
1991	682.6	796.3	803.8	730.5	710.9	1026.6	750.7	593.3	400.7
1992	861.5	809.6	1025.8	813.1	824	1144.3	869.2	774.8	796.8
1993	951.5	940.1	1023.2	846.7	836.9	1186.1	1002	648	719.4
1994	654.9	714	1099.8	635.2	720.5	1013.2	888.2	949	673.8
1995	621.9	867	1066.2	932	773.3	1030.9	1025.6	632.4	573.4
1996	816.5	875.8	1231.1	920	686.6	1033.4	998.5	855.8	602.5
1997	773.2	911.6	1183.9	878.7	719.7	996.6	567.8	532.6	666.6
1998	788.2	865.5	1115.1	929.3	756.9	973.7	895.9	688.7	750.8
1999	714.3	746.6	855.8	660.6	629.3	799.8	739.5	755.6	917.1
Average	783.2	837.1	1184.0	794.3	771.7	1013.9	857.5	657.5	675.2
Std	98.3	78.2	127.7	113.0	89.1	103.7	159.8	125.7	144.8