The United Republic of Tanzania

Ministry of Water

Wami/Ruvu Basin Water Board

Annual Hydrological Report

Prepared by: Wami/Ruvu Basin Water Board

Tel +255 23 2614748
Fax +255 23 2613519

P.O. Box 826
Morogoro,
TANZANIA.

www.wamiruvu.go.tz
basins.wamiruvu@maji.go.tz

HY: 2017/18

Table of Contents

List of Figures

List of Tables

1. GENERAL INTRODUCTION

1.1 Background

Wami/Ruvu Basin is one of the nine Basins Water Board of Tanzania mainland (**Figure *1-1***). The basin was established in 2002, and it operates under the Wami/Ruvu Water Board and the overall in charge is the Water Officer who is also the secretary of the Board. Wami/Ruvu Basin Water Board has the mandate to manage water resources in the basin. The overall objective is to provide current information and hydrological conditions of the Basin. The hydrologic year is defined as the year-long cycle of the development of hydrologic processes. The year from October to September is the appropriate hydrologic year in the Wami/Ruvu Basin.

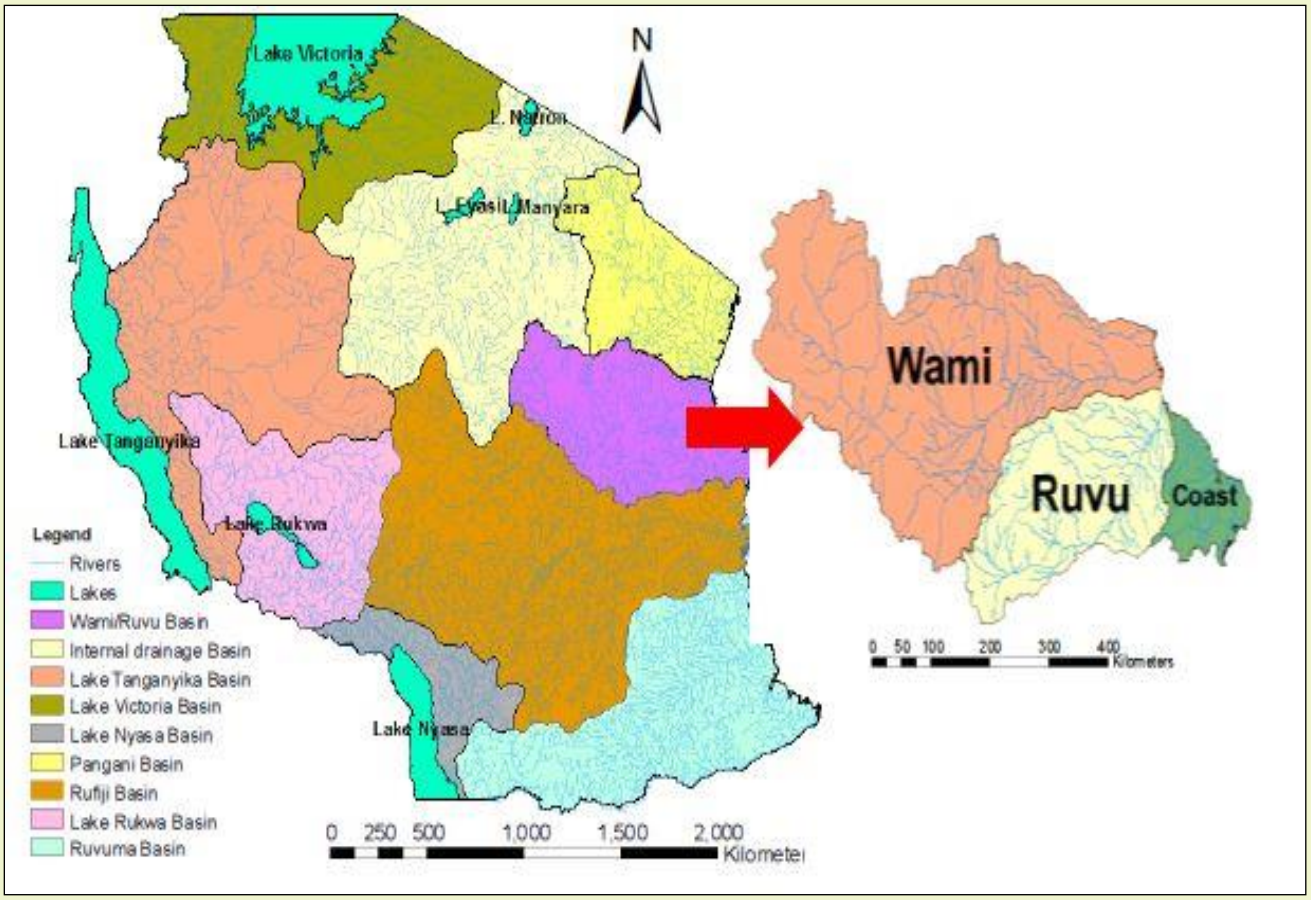

Figure 1-1: Tanzania map shows the location of Wami/Ruvu basin

1.2 Location and Administrative Units of the Basin

The Wami/Ruvu Basin with an area of 66,820 km^2 is located in east-central area of the country lies between Longitudes 35° 30′ 00″ to 40° 00′ 00″ E and Latitudes 05° 00′ 00″ to 07° 30′ 00″. The Basin consists of three sub-basins or catchments namely Wami, Ruvu and Coast. Each of Wami and Ruvu Catchments are further subdivided hydrologically into three Sub-Catchments each. The Sub-Catchments of the Wami catchment (43743 km^2) are Kinyasungwe (16509 km^2), Mkondoa (12,964 km^2) and Wami (14270 km^2); and those of Ruvu Sub-basin (17789 km^2); are Upper Ruvu (7623 km^2), Ngerengere (2913 km^2) and Lower Ruvu (7253 km^2).

Figure 1-2: Wami/Ruvu basin

Due to its size the Coast catchment (4763 km^2) is treated as a single sub-catchment and it consists of Mpiji, Sinza, Mlalakuwa, Msimbazi, Mbezi, Mzinga and Kizinga rivers. The sub

catchments totaling 7 in the Basin are as shown in **Figure *1-2***. The Basin covers the following regions in parts or wholly; Dar es Salaam, Coast, Morogoro, Dodoma, Tanga and Manyara and 27 Local Government Authorities.

1.3 Physiography

1.3.1 Topography

The basin is covered by low lying and mountainous landscapes as follows;

Mountainous landscapes

- Uluguru mountains located south east, the source of Ruvu River (altitude 400 to 2500 m.a.s.l)
- Nguru Mountains located west of Kilosa (altitude 400 to 2000 m.a.s.l)
- Rubeho Mountains located west of Kilosa (altitude 500 to 1000 m.a.s.l)
- Ukaguru Mountains located South west of Wami River (altitude 400 to 1000 m.a.s.l)
- Nguu Mountains located western part of Wami River (altitude 400 to 2000 m.a.s.l)
- Low lying land
- Mkata plains (Altitude 400-800 m.a.m.s.l)
- Lower Wami (Altitude 200-400 m.a.m.s.l)
- Kisaki located south east of Uluguru mountain (altitude 140 – 200 m.a.m.s.l)
- Kimbiji and Mbezi located to the southern coastal area of Dar es Salaam (altitude 50 – 100 m.a.s.l)

1.3.2 Geomorphology

The Uluguru mountains located south east, the source of Ruvu River lies between of altitude of 400m to 2500m above mean the sea level, Nguru Mountains located west of Kilosa lies between of altitude 400m to 2000m above mean the sea level, Rubeho Mountains located west of Kilosa lies between of altitude 500m to 1000m above mean the sea level, Ukaguru Mountains located South west of Wami River lies between of altitude 400m to 1000m above mean the sea level, Nguu Mountains located western part of Wami River lies between of altitude 400m to 2000m above mean the sea level, Mkata plains lies between of altitude

400m to 800m, Lower Wami lies between of altitude 200m to 400m above mean the sea level, Kisaki located south east of Uluguru mountain lies between of altitude 140m to 200m above mean the sea level and Kimbiji and Mbezi located to the southern coastal area of Dar es Salaam lies between of altitude 50m – 100m above mean the sea level.

1.3.3 Drainage Patterns

Many rivers in Wami catchment originate from Chenene, Nguru, Nguu and Rubeho Mountains and flows eastward towards the Indian Ocean. Majority of them are seasonal while few are perennial. Originally, some of Ruvu river tributaries were perennial originating from Uluguru Mountains and flow eastward towards the Indian Ocean but the Basin consists of both seasonal and perennial Rivers. **Figure 1-3** shows major rivers in the Wami/Ruvu Basin.

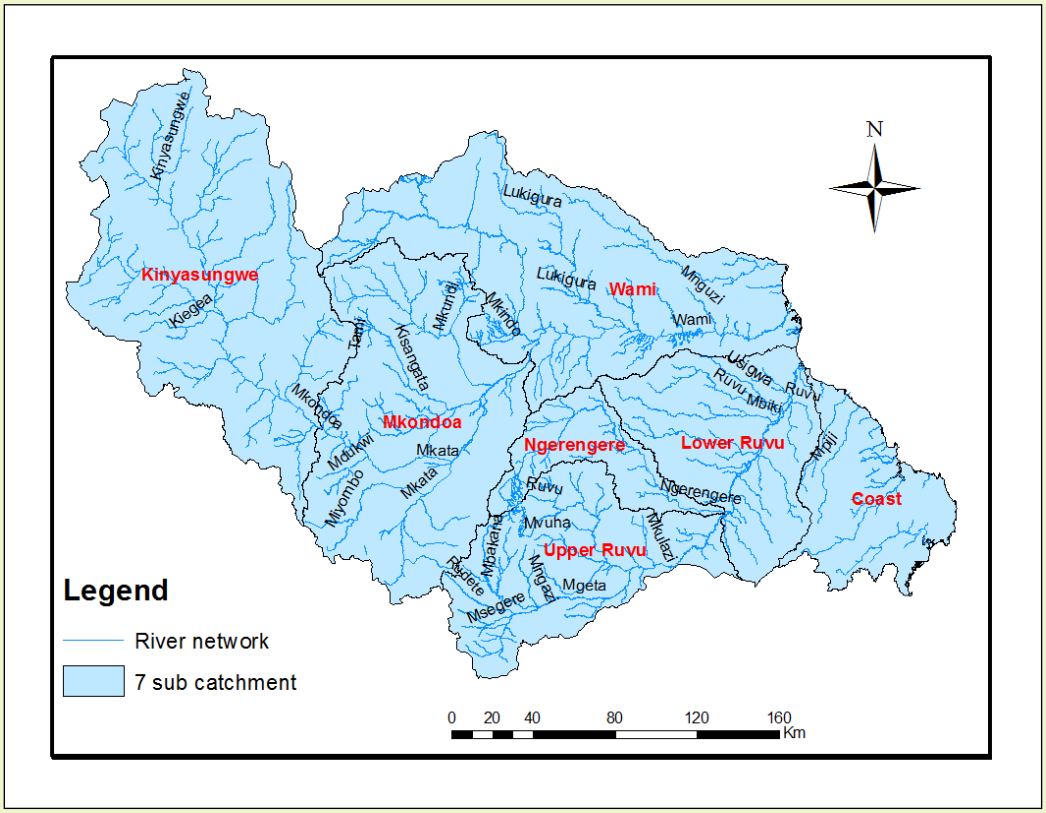

Figure 1-3: Major rivers in Wami/Ruvu Basin

1.3.4 Soils

Generally, the catchment is characterized by 12 main types of soils namely: Cambisols, Ferralsols, Acrisols, Fluvisols, Luvisols, Lixisols, Arenosols, Leptosols, Nitisols, Vertisols,

Planosols and Haplic Phaeozems. The dominant soils are Cambisols which covers parts of Bagamoyo, Kisarawe, Mkuranga, Morogoro Rural, Dodoma Urban, Bahi and Chamwino (**Figure 1-4**).

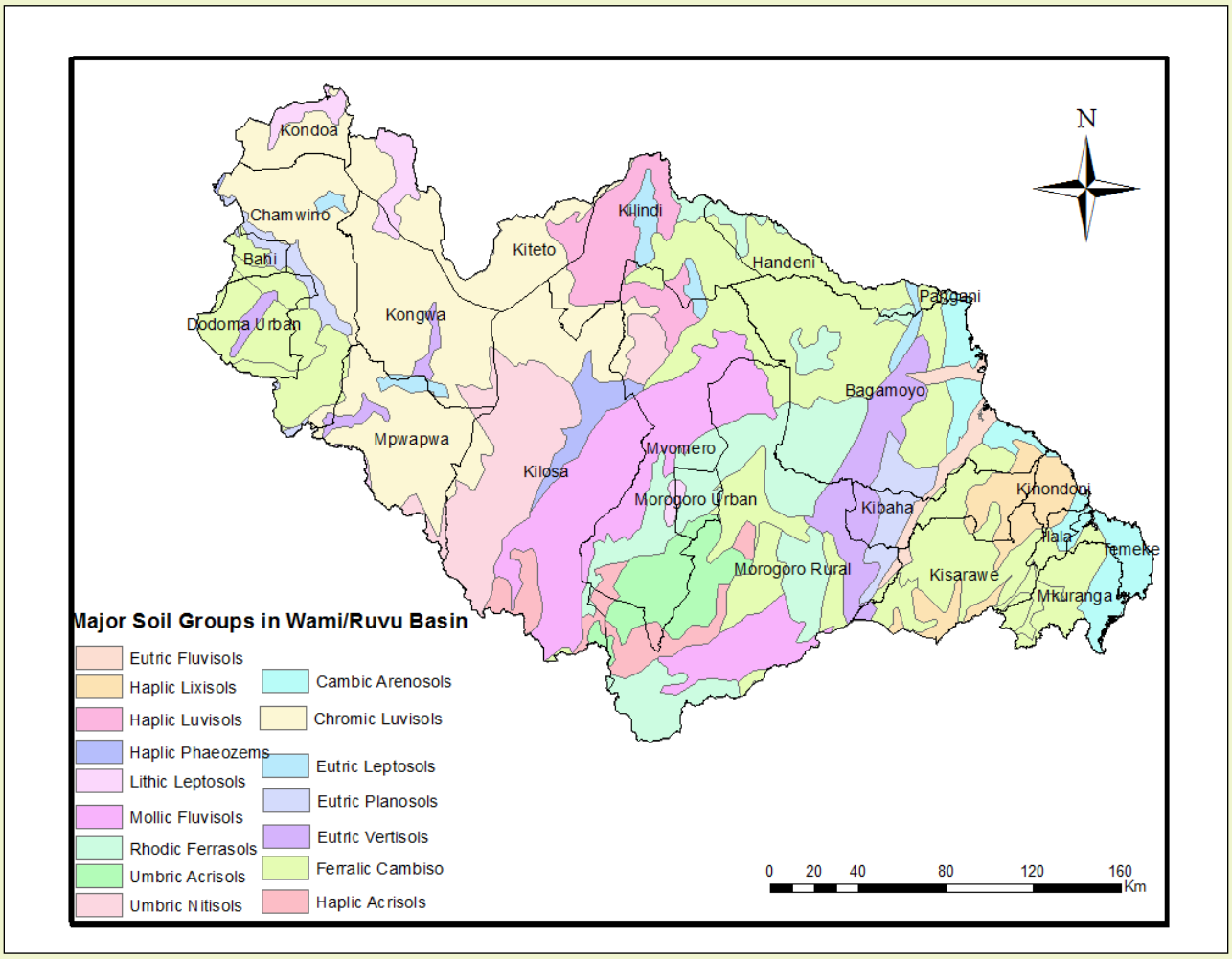

Figure 1-4: Distribution of major soils groups in the basin

1.3.5 Land Use/Cover

The land nature of the Basin is mostly covered by bush lands and bare soils, Mountains, cultivated land, grassland and forest. Woodlands also are extended to different parts of the Basin.

1.4 Geology

The geology of Wami/Ruvu Basin is mainly dominated by the following rocks;

Precambian rocks mostly occur in the Chenene Hills (Dodoma), Kiborian Hills (Mpwapwa) and rolling hills of Ikowa, Mlima wa Nyoka in Dodoma Kongwa and Uluguru Mountains and in the western part of the Ngerengere sub-basin. These rocks are mainly granitoid, gneisses, granulites and crystalline limestone meta-sediments and meta-igneous rocks with synorogenic granite, schist and gneiss and gneisses, granulites and crystalline limestone.

Usagaran occupy Rubeho Mountains in Kilosa area and Ukaguru Mountains, Wota Mountains and area around Lumuma. In the north they occupy Nguru Mountains. They consist of biotitic muscovite gneiss and schist, metadorerite and metagabro, Migmatitic biotite gneiss and hornblende.

Jurassic rocks occur in the eastern margin of the Uluguru Mountains and elevated rolling hills between the Ruvu and Wami rivers. They consist of course sandstone, mudstone, and oolitic limestone deposited under the marine environment (Kapilima, 1988)

The Karoo rocks occupy south-eastern area of the Uluguru Mountains. The rocks consist mainly of sandstone, and shale deposited in the shallow fresh to brackish water. Their ages may vary from Permian to Triassic (Kent at al,1971).

Cretaceous rocks lie on the elevated rolling hills. They consist of clay, shale, calcareous` sandstone, sandy limestone and mudstone.

Tertiary and Quaternary (youngest strata in the basin) occur in the catchment area of the Ngerengere River near Morogoro Municipality, and in the elevated rolling hills and floodplains along the Ruvu River, Kibaha, Bagamoyo and extend up to Dar es Salaam. Pleistocene to recent sediments exists in the area developing as alluvial deposits all detrital deposits resulting from the operations of modern rivers, colluvial deposits alluvium in part but also containing angular fragments of original rocks such as talus and cliff debris, and coastal deposits. Mbugas depression fills and beach deposits.

Neogene Rocks: These are found in floodplains of Mkata, Mpwapwa, Kongwa, Dodoma and along Wami, Mkondoa, Kinyasungwe Rivers and along Saadan and Bagamoyo to Indian Ocean. The deposit consists of calcareous crust, red-brown soils, alluvium, fluvial and sandy

clay, and clayey sand with minor lenses of pure sand/clay, gravel and silt. In coastal areas inter bedded sandy clays and clayey sands with minor lenses of pure sand or clay are found. The distribution of different geology within the basin is summarized in **Table *1-1*** and **Figure *1-5***.

Table 1-1: Summary of different geology in the Wami/Ruvu basin

	Age	**Lithology**	**Remarks**
Cenozoic	Quaternary	Beach sand, dune	
		Alluvial deposits, Fluvial deposits	
		Lacustrine sediments	
	Tertiary	Terrace deposits	
		Fluvial marine sand	
Meso	Cretaceous	Continental and marine sandstone	
	Jurassic	Mudstone and Shale	Karoo series
Palaezoic		Conglomerate and tillite	Karoo series
Proterozoic	Neo-	Marble	Mozambique Belt (Upper nappe)
		Granulite, gneiss and migmatite	
		Composite metamorphic crust domain	Mozambique Belt sandstone
	Palaeo-	Meta-igneous and sedimentary rocks	Mozambique Belt
		Meta-sediments, orthogneiss, granulite, etc	Usagaran Belt
Archean Basement		Migmatite, granite and mafic dykes	Dodoman group
		Migmatite and granite	Isangan group
Int.	Neo-P.	Meta-anorthosite complex (interlayered)	Plutonic rocks
		Meta-anorthosite complex	Plutonic rocks

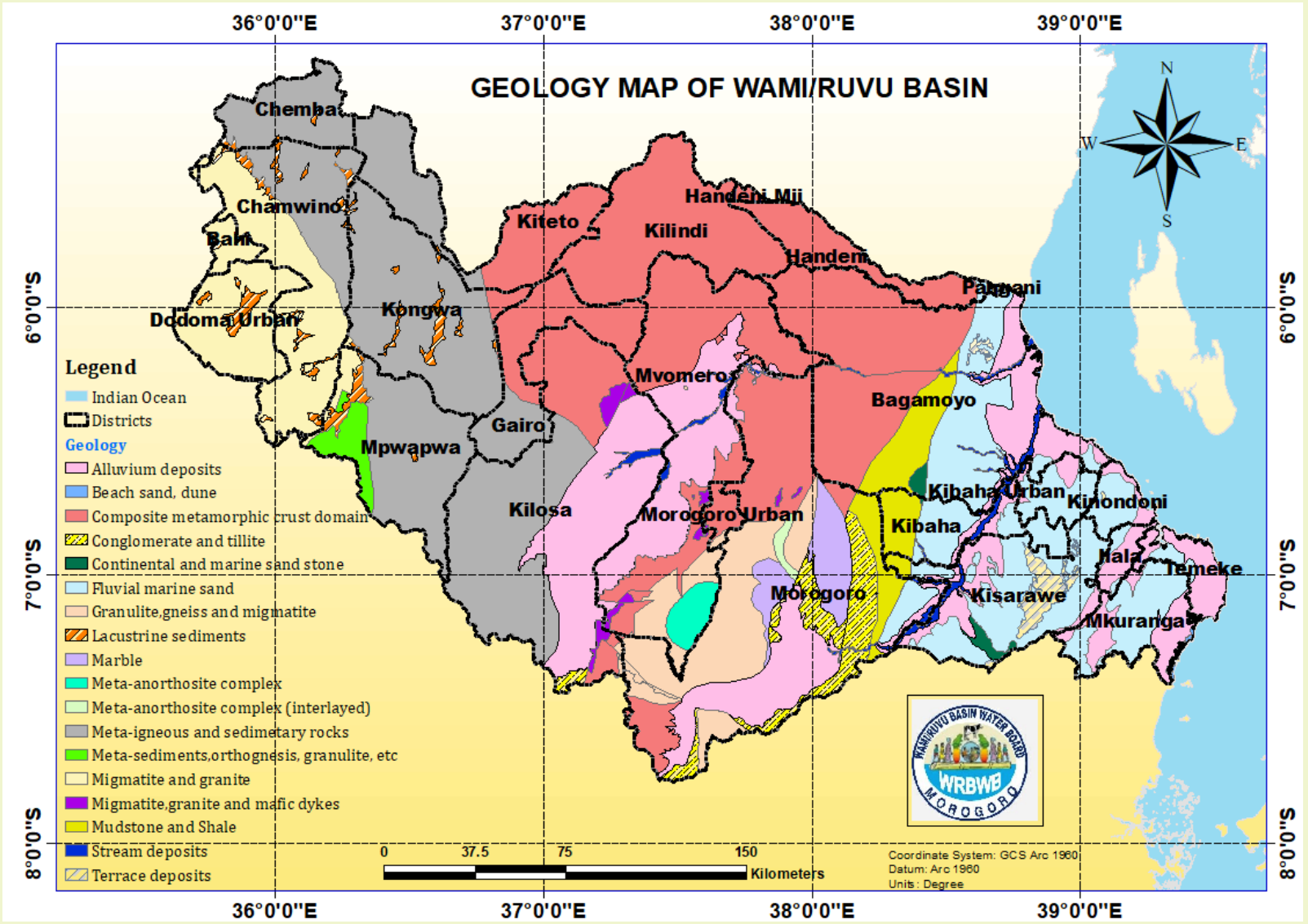

Figure 1-5: Geology Map of Wami/Ruvu Basin

1.5 The purpose of the Annual Hydrological Report

The main objective of this report is to give an overview of water status for 2017/2018 hydrological year (November 2017 to October 2018). Specifically, the report aims to address the following areas:

- Characteristics of the Wami/Ruvu Basin
- Existing hydro met network of the Basin and their status
- Hydrology of the basin and the current water status for the year 2017/2018

2. HYDROLOGICAL NETWORKS

The Basin has 129 hydrological networks distributed in all sub-basins with different status. The Hydrology involves the interactions between precipitation, surface storage, evaporation, evapotranspiration, infiltration, surface runoff and groundwater. Surface water hydrology is the movement of water over land, into and through surface water bodies such as wetlands, lakes and watercourses. Surface runoff is the primary mechanism for transporting sediment from land into watercourses and surface water bodies. Surface water hydrology has a direct linked with other aquatic resources such as fish, water quality as well as groundwater systems.

2.1. Rainfall station

Wami/Ruvu Basin is currently collecting rainfall data from a total of fifty-seven (51) stations whereby thirty-four (34) stations are only manual rain gauges and seventeen (17) stations are automatic rain gauges. The rainfall data are collected one times per day during morning hours at 09:00am for Manual rain gauge and for Automatic stations the data are collected hourly.

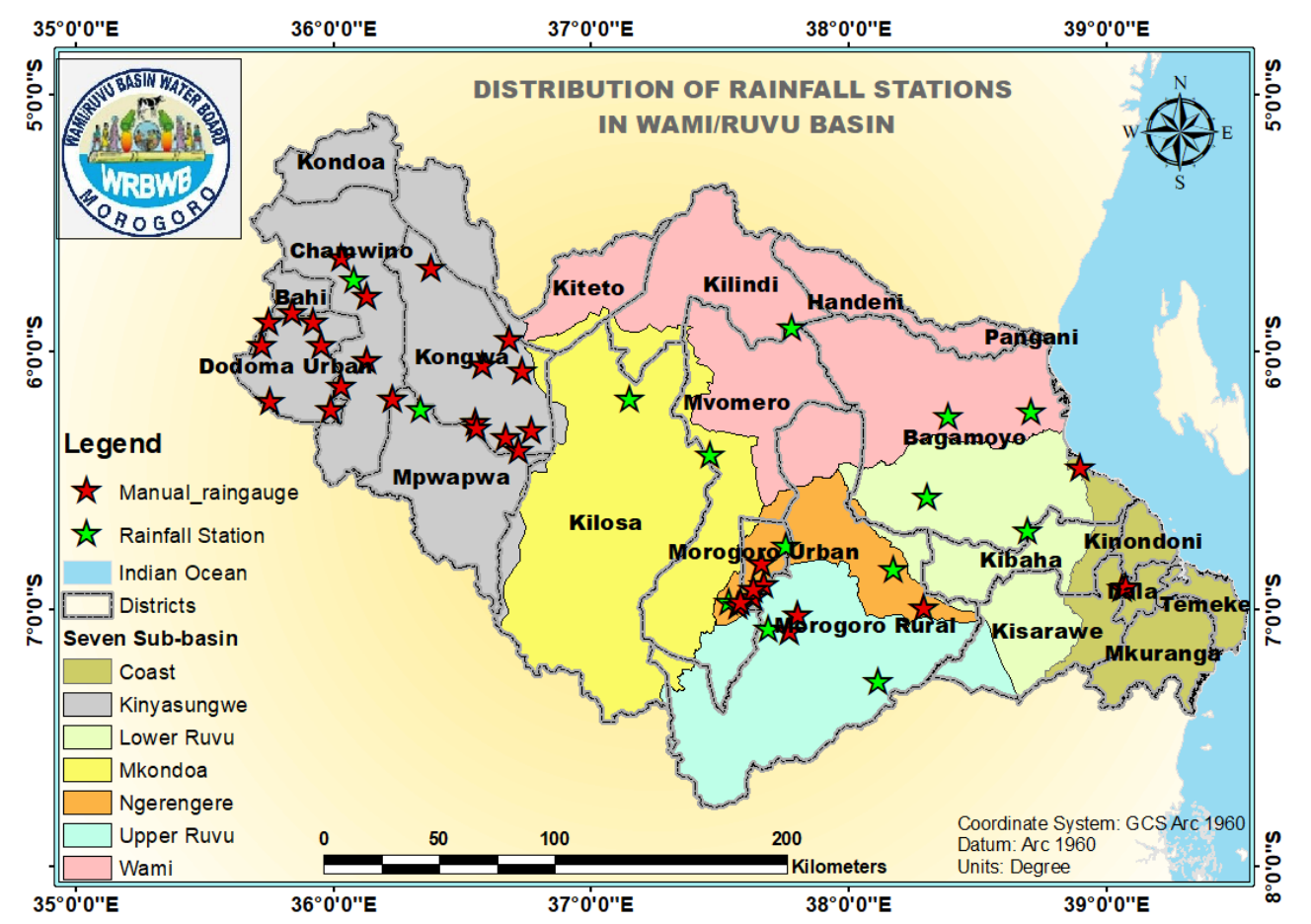

Figure 2-1: Distribution of rainfall stations in Wami/Ruvu Basin

2.2. Hydrometeorological

The Basin has 6 existing functional weather stations although in financial year 2017/2018 a four (4) low cost weather stations were installed under supports of American Aids (WARIDI). As a result of total of 10 weather stations that are functioning fully, the existing meteorological stations data, are collected on hourly basis and available data are precipitation, temperature, radiation, wind speed, Wind direction and relative humidity.

2.3. Hydrometric stations

2.3.1 River Gauging Stations

Most of the hydrometric network stations were established in the early 1950s and records exist since that time. The Basin has 43 river gauge stations distributed in all sub-basins with different status (Annex 2.1). However, there is a serious shortage of usable hydrometric records from 1990s to 2005, as most of the stations were vandalised or were non-operational during that period. Since 2006, most of the network has been rehabilitated and improved. Others were rehabilitated during the IWRM&D study in the Basin by JICA study team in collaboration with the Basin Water Board.

The data are collected on daily basis, whereby for primary stations the data are collected three times a day (Morning, afternoon and evening) while for secondary stations the data are taken two times a day (Morning and Evening).

2.3.2 Reservoir Monitoring Stations

There are about 9 constructed dams in the basin and about 150 reservoirs which collect water from rivers, groundwater and other are rain fed only. Daily monitoring of water levels is done only at the Mindu Dam which is supplying water to Morogoro Municipality. Water levels in the dam decreased due to decreased rainfall amount falling around Uluguru Mountains in Morogoro Municipality area.

2.3.3 Water Quality Stations and Pollution Control

The Basin has established a water quality monitoring network for both ground and surface water. There are 76 stations. The monitoring is conducted in industries, mines, lakes, rivers and springs. Normally the routine is four times a year during wet and dry seasons.

Table: existing water quality Monitoring stations

S/No	TYPE OF MONITORING	TOTAL SAMPLING POINTS

1	GROUNDWATER	14
2	SURFACE WATER	30
3	WASTE WATER	32
TOTAL		76

2.3.4 Sediment Monitoring Stations

Basically, the basin has 10 representative stations which cover the upstream (inlet), middle and downstream (outlet) of the river to know what's happen in the case of sediment within Catchment, for Ruvu river there 3 stations (Ruvu/Kibungo, Ruvu/Kidunda, Ruvu/Morogoro Road Bridge), Ngerengere river all three river were upstream Mindu dam and one station downstream after spillway (Ngerengere/Konga, Lukulunge/Konga, Mzinga/Mzinga and Ngerengere/Mgude) and for Wami river three station (Mkondoa/Kilosa, Wami/Dakawa, Wami/Mandera).

2.4. Groundwater Monitoring Stations

Basically, the basin has a total of twenty-eight (28) monitoring boreholes which covers at least each aquifer type (**Figure *2-2***). Among them, six (6) are operated manually and twenty-two (22) work automatically. Although the stations are not sufficient and lack long-term data, the Makutopora well-field in Dodoma has been being monitored for so long since 1960's. Water level data have been collected by gauge readers from existing monitoring wells in the Makutupora well field. A list of 28 monitoring boreholes is attached on Annex 5.2.

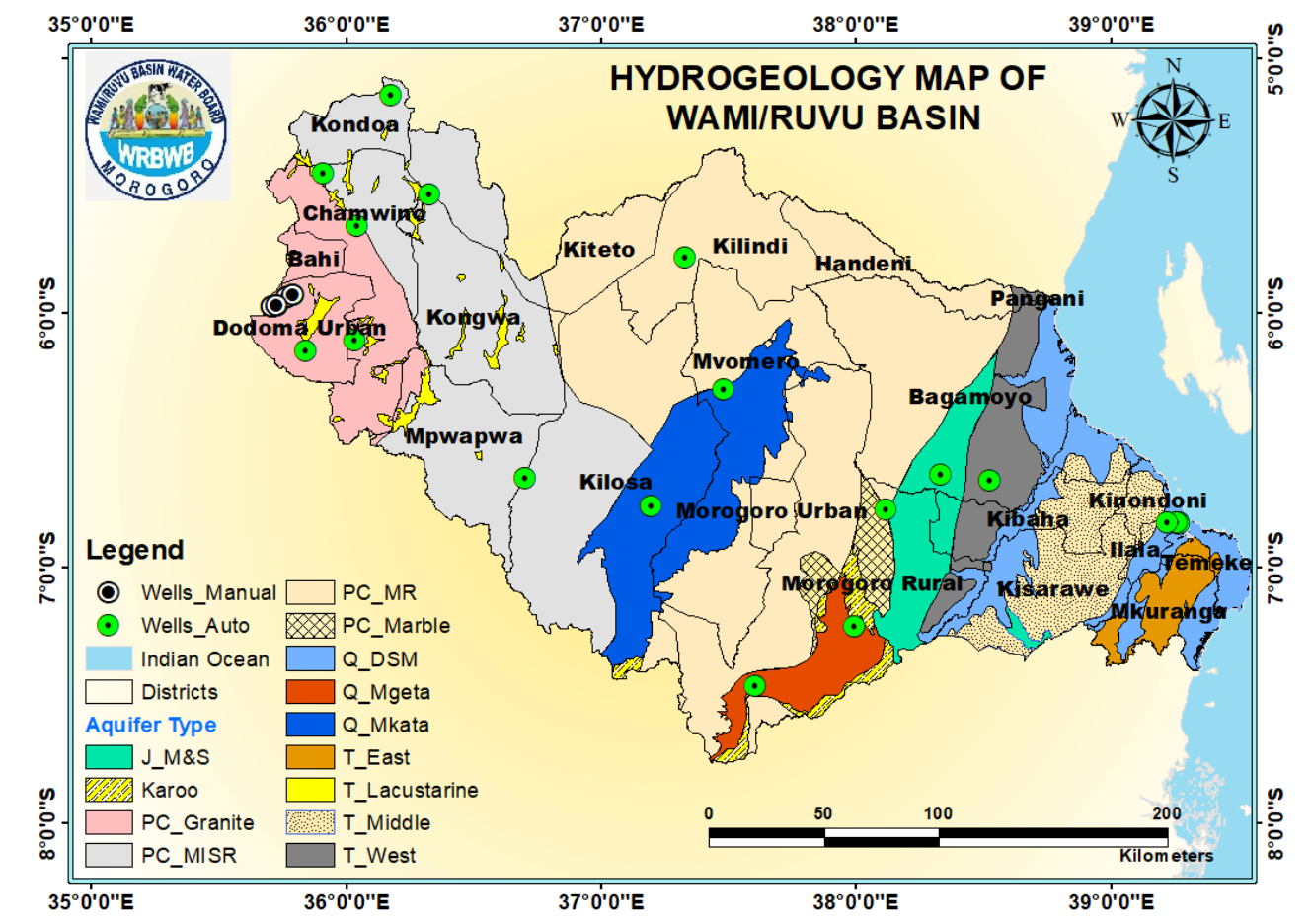

Figure 2-2: Groundwater Monitoring network

3. HYDROLOGY OF THE BASIN AND THE CURRENT WATER STATUS

3.1. Rainfall

Wami/Ruvu Basin has both unimodal and bimodal types of rainfall patterns. The unimodal type is found in the central part of Tanzania in the main Wami Catchment (Kinyasugwe sub catchment) while bimodal type is received in the part of Wami (Mkondoa and Wami sub catchments) Ruvu and Coastal Rivers catchments. In the unimodal type only one rainfall is experienced during the months of January, February and March while in the bimodal type, there are two rainy seasons, short rains (*Vuli rains*) in October to December and heavy rains (*Masika rains*) which is received from March to May.

Characteristics of the rainfall in the Wami/Ruvu Basin are an annual rainfall at the coast is about 1100 mm and decreases towards inland where about 600 mm is received. The biggest rainfall is received in the Uluguru and Nguru Mountains with more than 2500 mm of annual rainfall. The inland has only one rainfall season centered in December whereas the rest of the Basin has two rainfall seasons with major one centered in April and minor one centered in December. Little rain is received in the dry season of June to September.

3.1.1. Wami River Catchment

Wami River catchment has both unimodal and bimodal rainfall patterns. Unimodal pattern is usually observed in Kinyasungwe subcatchment and bimodal pattern is observed in Mkondoa and Wami subcatchments (**Figure *3-1***). The eight (8) presentative stations (**Table *3-1***) were selected (4 presenting Wami and Mkondoa subcatchment namely; Wami Prison, Murad Sadiq, Kutukutu and Berega hospital school and the remain 4 presenting Kinyasungwe sub catchment namely; Dodoma Maji, Dabalo Dam, Zanka and Ikombo), selection basis on the stations that has Long term data as well as shows the amount rainfall received in the elevated parts such as Ukaguru, Nguru, Nguu and Chenene Mountains where the Wami river source and its tributaries originated.

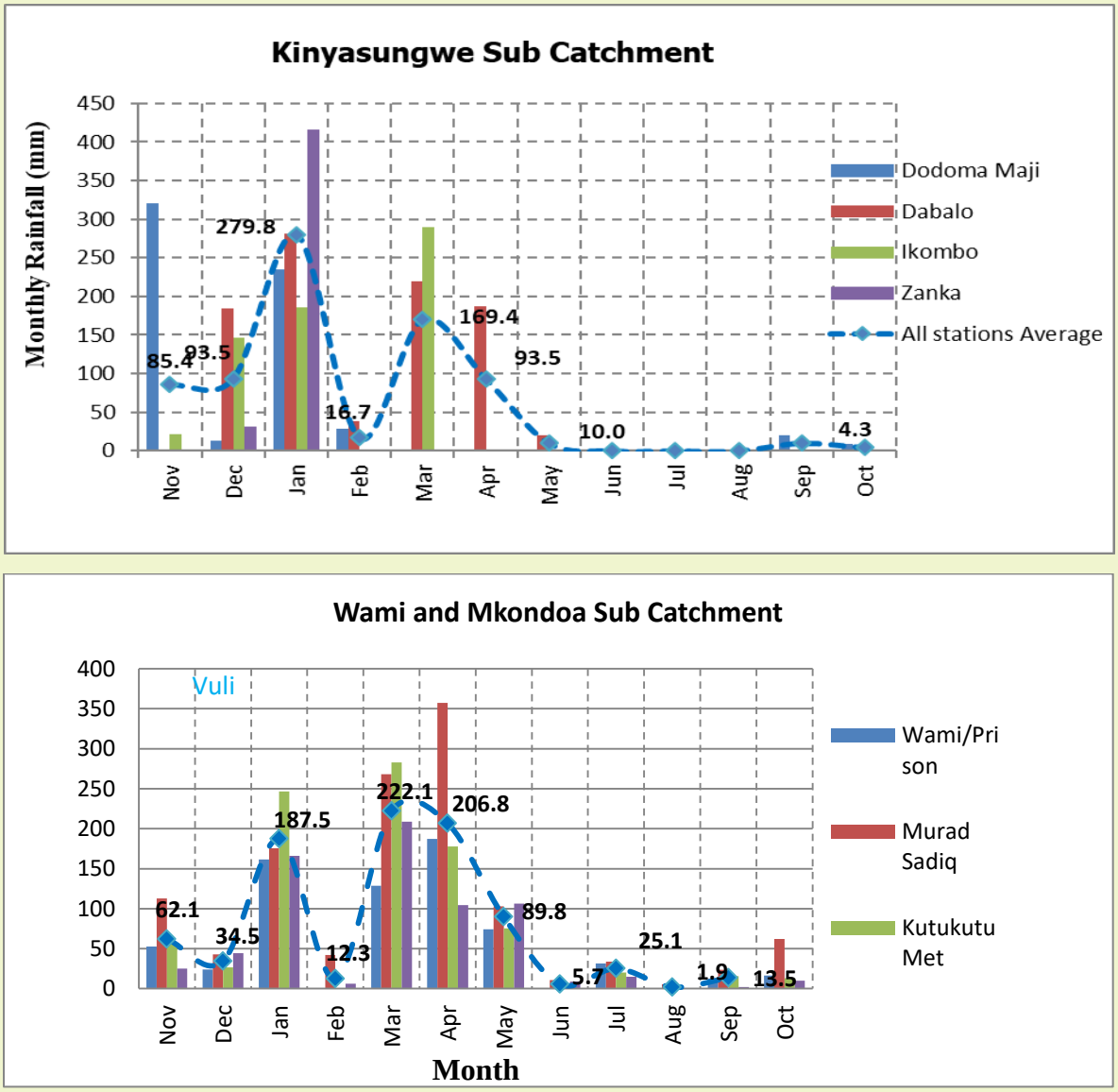

Figure 3-1: Rainfall distribution in Kinyasugwe sub-catchment Mkondoa and Wami sub-catchments covering the period of November 2017 to October 2018.

Table 3-1: Monthly Average of all representative stations and monthly Rainfall in Wami Catchment

Station Name	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Dodoma Maji	320.2	13.2	235.4	28.9	0	0	0	0	0	0	20	8.6
Dabalo	0	183.7	281.6	37.7	219	186.9	20	0	0	0	0	0
Ikombo	21.5	146.4	185.9	0	289.3							
Zanka	0	30.5	416.3	0								
Wami/Prison	52.7	23.8	161.6	0	128.5	187.4	74.4	0	31.7	0	12.6	16.3
Murad Sadiq	112.7	43	175.4	42.2	268.2	357.3	102.9	10.7	33.9	5.6	23.6	62.3
Kutukutu Met	58	26.5										
Berega Hospital	25.1	44.5	166.2	6.2	208.8	104.5	106.4	8.7	14.9	0	2.1	9.8
Average	**45.0**	**52.5**	**221.1**	**9.7**	**223.7**	**216.4**	**94.6**	**6.5**	**26.8**	**1.9**	**12.8**	**29.5**

Wami and Mkondoa sub catchment experiences an initial period of increased rainfall during the *Vuli*, then a slight lull during January and February, followed by the *Masika*. The Catchment receives a total rainfall average of 941mm per annual where the *Vuli* rainfall peaks at 52.5mm/ month in December, whilst March, April and May are the wettest *Masika* months, with average monthly rainfalls of 223.7mm/month, 216.4 mm/month and 94.6mm/month respectively. Thereafter a sustained four-month dry season prevails with 6.5, 26.8, 1.9 and 12.8mm/month falling in June, July, August and September respectively.

The rainfall records of the different stations show that the recorded rainfall is average compared to the long-term average, also there is an increase in rainfall from Vuli towards Masika season/periods while in the months of June to September Catchment receives extremely low rainfall compared to the other Catchment (**Table 3-2**). Therefore, it is recommended that the all project lie under Catchment to harvest rainfall water by adopted

and constructing the storage structural like dams for storage of water so as to overcome the deficit of water during the dry period.

Table 3-2: Comparison of Annual Rainfall and MAP for representative stations in Wami Catchment

Station No.	Station Name	Mean Annual Precipitation (MAP) 1973-2010 [mm]	Nov 2017-Oct 2018		
			Annual Rainfall in 2017/2018 [mm]	%	Description
9635012	Dodoma Maji	1119.5	626.3	55.9	Average
9536004	Dabalo Dam	509.8	928.9	182.2	Above Average
9637056	Wami/Prison	1045.2	689.00	65.9	Average

3.1.2. Ruvu River Catchment

Ruvu River catchment experiences a typical bimodal rainfall pattern were the Catchment comprised of Ngerengere and Upper Ruvu Sub catchments. Ruvu Catchment experiences an initial period of increased rainfall during the *Vuli* (short rains occurring from mid-October to December), then followed by the *Masika* (long rains occurring from March to May) as shown in the **Figure *3-2***.

In 2017/2018 the *Vuli* rainfall peaks at 70.63mm/month and 72.4mm/ month in November for Upper Ruvu and Ngerengere sub catchment respectively, whilst March, April and May are the wettest *Masika* months, where Ngerengere has higher peak average of 565.2mm/ month compared to Upper Ruvu with Averange of 414.1 mm/month. However Upper Ruvu receives high rainfall compared to other sub catchments in the Basin, in hydrological year 2017/2018 it has received about 1535mm per annual followed by Ngerengere sub catchment which receive 1357mm per annual. This is due to the presence of mountains and forests (Eastern Arc Mountains) within the sub catchment (**Table 3-3** and **Table 3-4**).

In comparison to Mean Annual Precipitation, Rainfall in Ruvu River catchment varied between sub catchments. In Upper Ruvu sub catchments all the stations recorded rainfall above the average, this speculates that the sub catchments have received rainfall above normal (**Table 3-5 and Figure *3-2***). In Ngerengere sub catchment most of the station recorded rainfall within average range except for Ruhungo, Mongwe and Mlali stations which were above average.

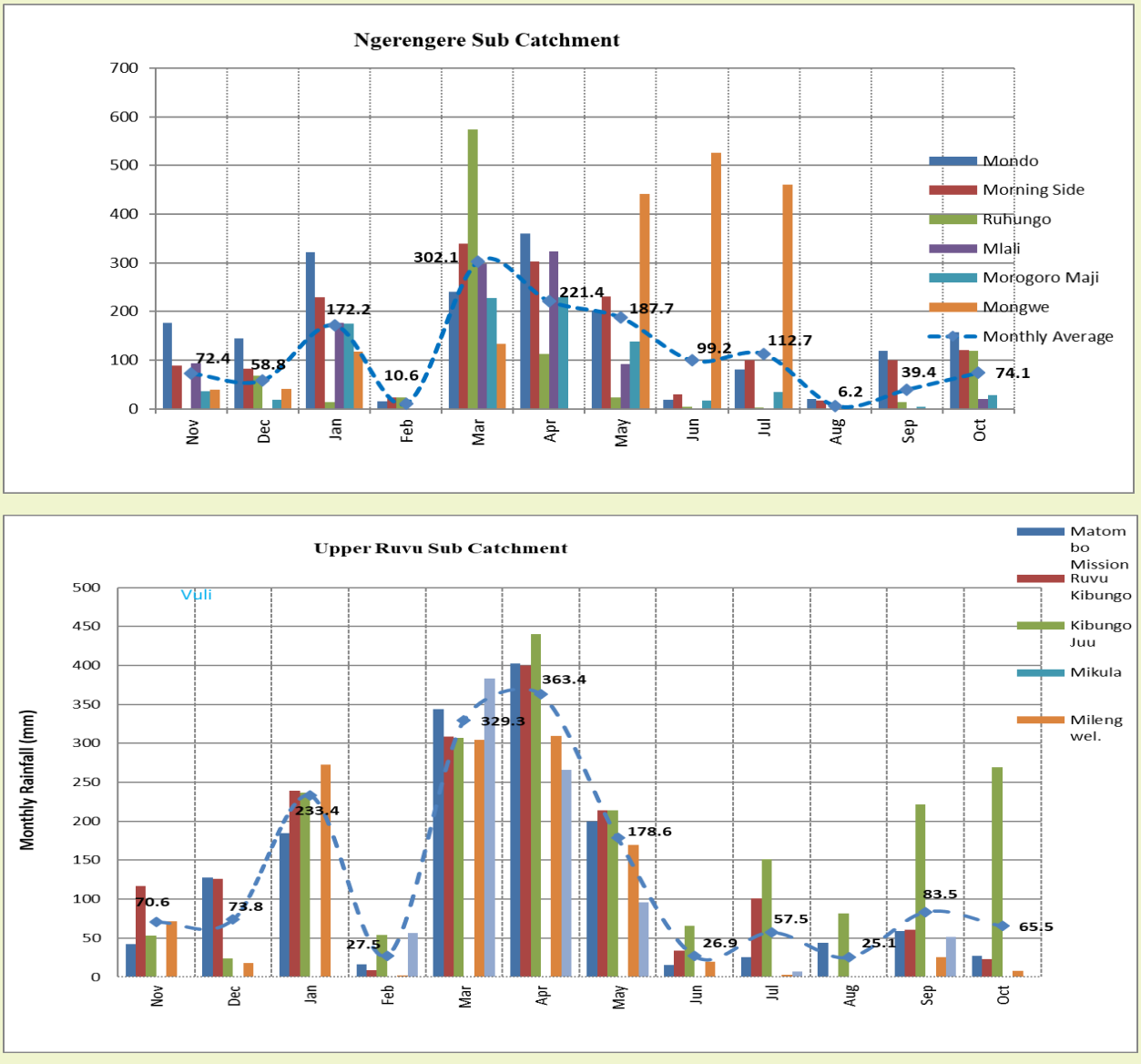

Figure 3-2: Rainfall distribution in Ngerengere sub-catchment and Upper sub-catchment covering the period of November 2017 to October 2018.

Therefore, rainfall records of the different stations show that there is an increase in rainfall from Vuli towards Masika season/periods compared to months of June to September where the Catchment receives low rainfall. It is recommended that the all project lie under Catchment to harvest rainfall water by adopted and constructed the storage structural like dams for storage of water so as to overcome the deficit of water during the dry period

Table 3-3: Average of all representative stations and monthly Rainfall in Ngerengere

Station Name	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Mondo	176.9	144.3	321.9	14.7	240.3	360.7	201.2	18.9	80.1	20.8	119.3	156.6
Morning Side	89.1	82	229.2	22.9	338.5	301.8	231.2	29.2	99.3	16.1	99.4	121
Ruhungo	0	68	14	24	574	113	23	4	2	0	14	119
Mlali	93.6	0	176	0.5	298.5	323.6	92.3	0	0	0	0	19.5
Morogoro Maji	36.6	18.3	175	1.2	227.9	229.3	138	16.7	33.8	0.2	3.8	28.6
Mongwe	38.4	40	117.1	0	133.6	0	440.7	526.6	460.7	0	0	0
Monthly Average	72.4	58.8	172.2	10.6	302.1	221.4	187.7	99.2	112.7	6.2	39.4	74.1

Table 3-4: Average of all representative stations and monthly Rainfall in Upper Ruvu

Station Name	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Matombo Mission	41.8	127.8	184.5	16.2	343.6	402.1	200	15.3	25.7	43.5	58.6	27.2
Ruvu Kibungo	116.4	125.9	239.4	8.7	308.4	399.7	213.8	34.1	100.5	0	60.4	22.9
Milengwel.	71.6	17.8	272.7	1.8	304.4	309.3	169.8	19.4	2.9	0	25.4	7.8
Langali				56.4	382.8	265.7	95.9	0	7.2	0	51.4	0
Kibungo Juu	52.7	23.8	236.9	54.2	307.3	440	213.6	65.8	151	81.9	221.81	269.4
Monthly Average	70.625	73.825	233.375	27.46	329.3	363.36	178.62	26.92	57.46	25.08	83.522	65.46

Table 3-5: Comparison of Annual Rainfall and MAP for representative stations in Ruvu Catchment

Station	Station	Mean	Nov 2017-Oct 2018	

No.	Name	Annual Precipitation (MAP) 1973-2010 [mm]	Annual Rainfall in 2017/2018 [mm]	%	Description
9637045	Mondo	2558.1	1855.7	72.5	Average
9637046	Morning Side	2263.0	1659.7	73.3	Average
9637048	Matombo Mission	1576.7	1486.3	94.3	Average
9637051	Mlali	772.1	1004	130.0	Above Average
9637052	Morogoro Maji	749.5	909.4	121.3	Above Average
9637049	Mongwe	1436.3	1757.1	122.3	Above Average
9737026	Ruvu Kibungo	1605.6	1630.2	101.5	Above average
9737024	Kibungo Juu	2600.8	2118.41	81.5	Average

3.1.3. Coastal Rivers Catchment

Coastal Rivers catchment have bimodal rainfall pattern, where the. *Vuli* started in mid-October to December, then followed by the *Masika* rains from March to May

The catchment has been presented by three rainfall stations (**Figure 3-3**). In hydrological year of (Nov 2017 – Oct 2018) the catchment receive a total rainfall average of 1071mm per annual whereby Ubungo Maji station observed to have the highest rainfall amount followed by Kisarawe FDC and Kisarawe Boma which were 1115.85mm, 1061.3mm and 1035.8mm respectively (**Table *3-6***). In comparison to Mean Annual Precipitation, the catchment has received rainfall below the average.

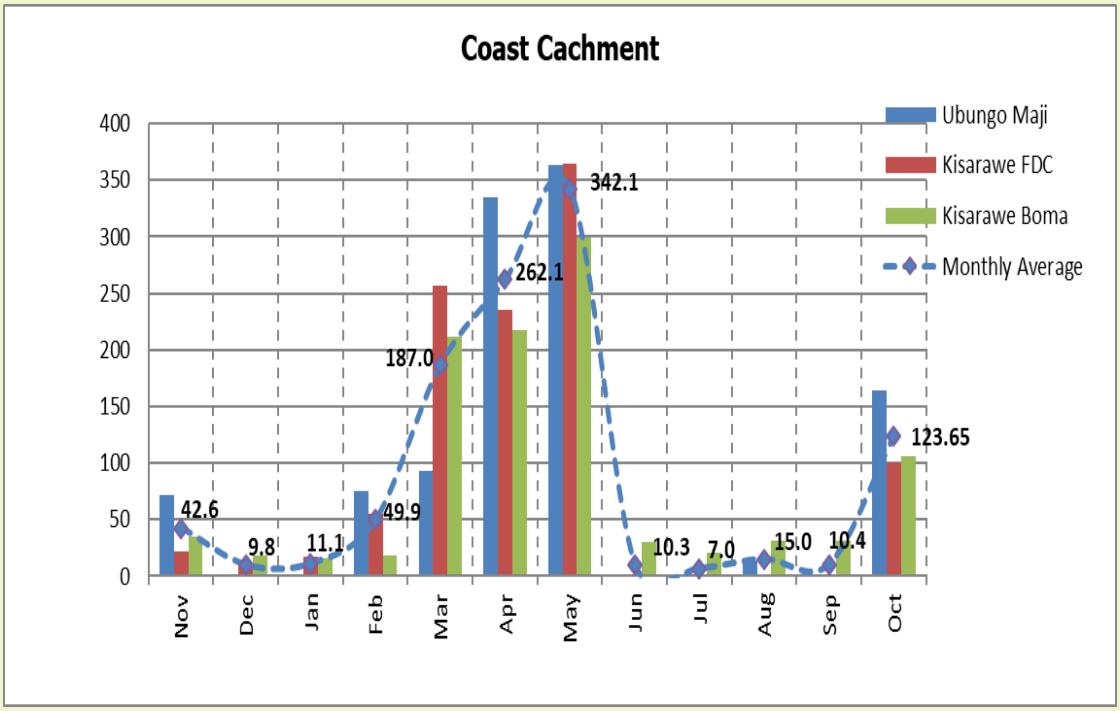

Figure 3-3: Rainfall distribution in Coastal rivers catchment covering the period of November 2017 to October 2018

Table 3-6*:* Comparison of Annual Rainfall and MAP for representative stations in Coast Catchment

Station No.	Station Name	Mean Annual Precipitation (MAP) 1973-2010 [mm]	Nov 2017-Oct 2018		
			Annual Rainfall in 2017/2018 [mm]	%	Description
9636048	Ubungo Maji	1129.5	1115.85	98.8	Average
	Kisarawe FDC	944.6	1061.3	112.4	Above Average
	Kisarawe Boma	978.2	1035.80	105.9	Above Average

3.2. Hydrometeorological

The maximum temperature measured are 30.4c and minimum temperature are 22.67^{0}C while average temperature is 27.15^{0}C (**Figure *3-4***).

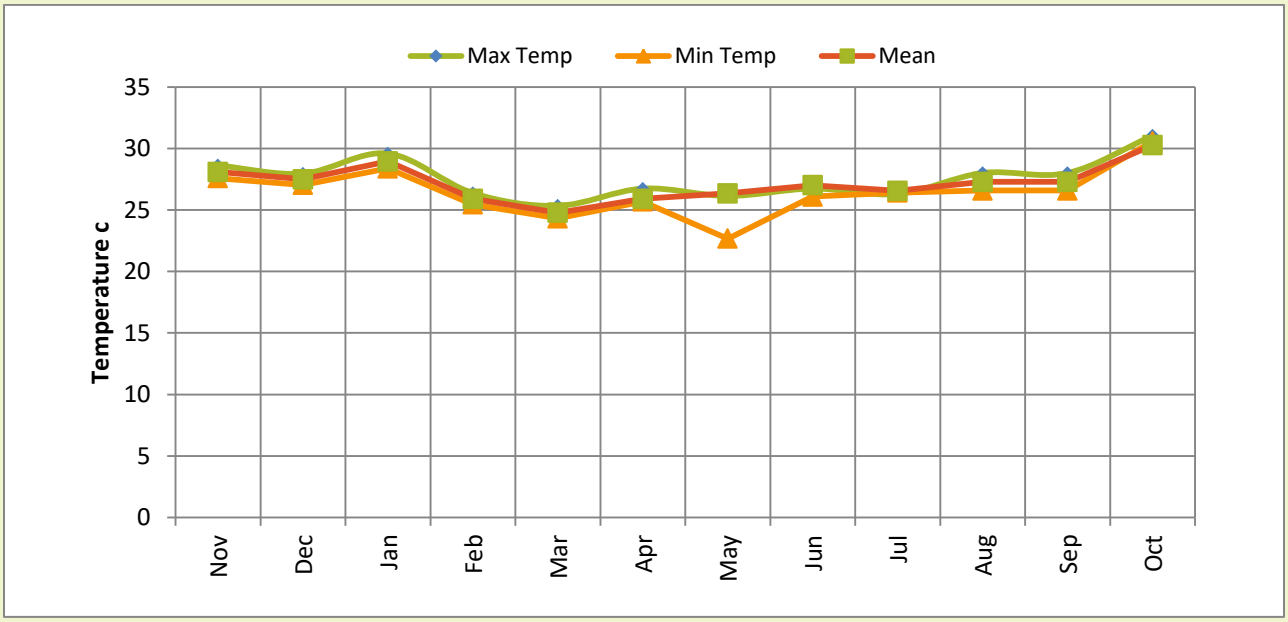

Figure 3-4: Comparison of maximum, Minimum and Average temperature (c) at Millengwelengwe station (2017-2018)

3.3. Discharge

3.3.1. Wami River

The upper part of Wami Basin (Kinyasungwe River) is characterised by intermittent river flows since the rainfall pattern is unimodal, rainfall characteristics could also be explained by soil characteristics which suggests groundwater recharge. In this regard, most of the rainfall is converted to groundwater due to supposedly high infiltration rates of the soils.

Wami sub catchment is represented by Wami at Mandera station (1G2). Due to non-operational for 1G2 (as it needs rehabilitation of 0-1 gauge) the catchment is presented by Wami at Dakawa (1G1) gauge which is upstream of 1G2. The annual average flows recorded in the hydrological year 2017/2018 at 1G1 stations is average compared to Long term average **(Figure *3-5*)**. Also, the peak is above compared to long term average flow for months of March to May, while for the month of November to February there is fluctuation due to Vuli rainfall but also there is decrease of flow for the month of June to October (**Table *3-7***).

It is important to note that, both 1G1 and 1G2 stations are characterised by perennial flow which is attributed to high rainfall and good aquifers which favour river recharge during the dry season.

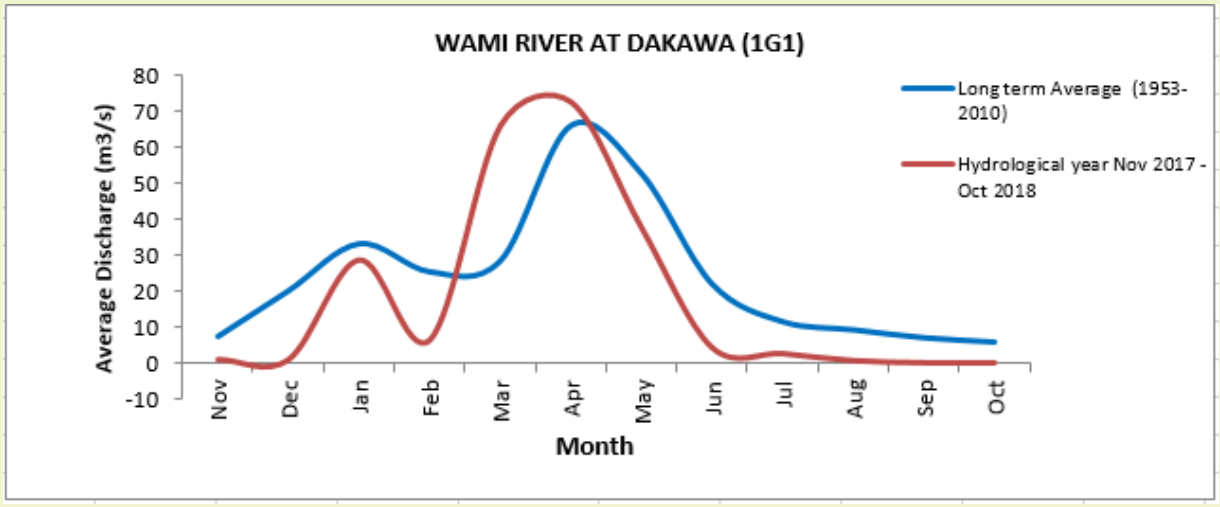

Figure 3-5: Comparison of Average discharge and Long-term Average for representative

Table 3-7: Comparison of Average flows for each month and LTA for representative stations in Wami River

2017/2018	1G1 (m^3/s)	LTA for 1G1(m^3/s)
November	1.335	7.38
December	1.334	20.11
January	28.943	33.20

February	6.734	25.40
March	66.081	28.46
April	72.701	66.14
May	37.883	52.72
June	4.630	21.98
July	2.968	11.49
August	1.034	9.23
September	0.446	7.02
October	0.466	5.82
Annual Average Flow	18.713	24.080
% of LTA	**77.712%**	

Note: LTA = Long – term Average

3.3.2. Ruvu River

Figure 3-6, represents the flow regime at the upstream station 1H5 and 1HA9A whereby the peak is above compared to the long term for 1H5 while for 1HA9A the peak below compared to long term, at a Middle 1H3 and downstream station (outlet) (1H8) of Ruvu River Where by a station shows a more stable flow regime compared to an upstream station.

In comparison with the annual average flow generally at both stations in Ruvu River the annual average flow of 2017/2018 hydrological year recorded to be above average compared to Long-term average, except Ngerengere river at Konga (1HA9A). When analysis was done seasonally it was observed that during the rainy season (March – May) the flow was recorded above average which means the rainfall received were above normal **(Figure 3-6 and *Table 3-8*)**. A similar trend was also observed in rainfall distribution.

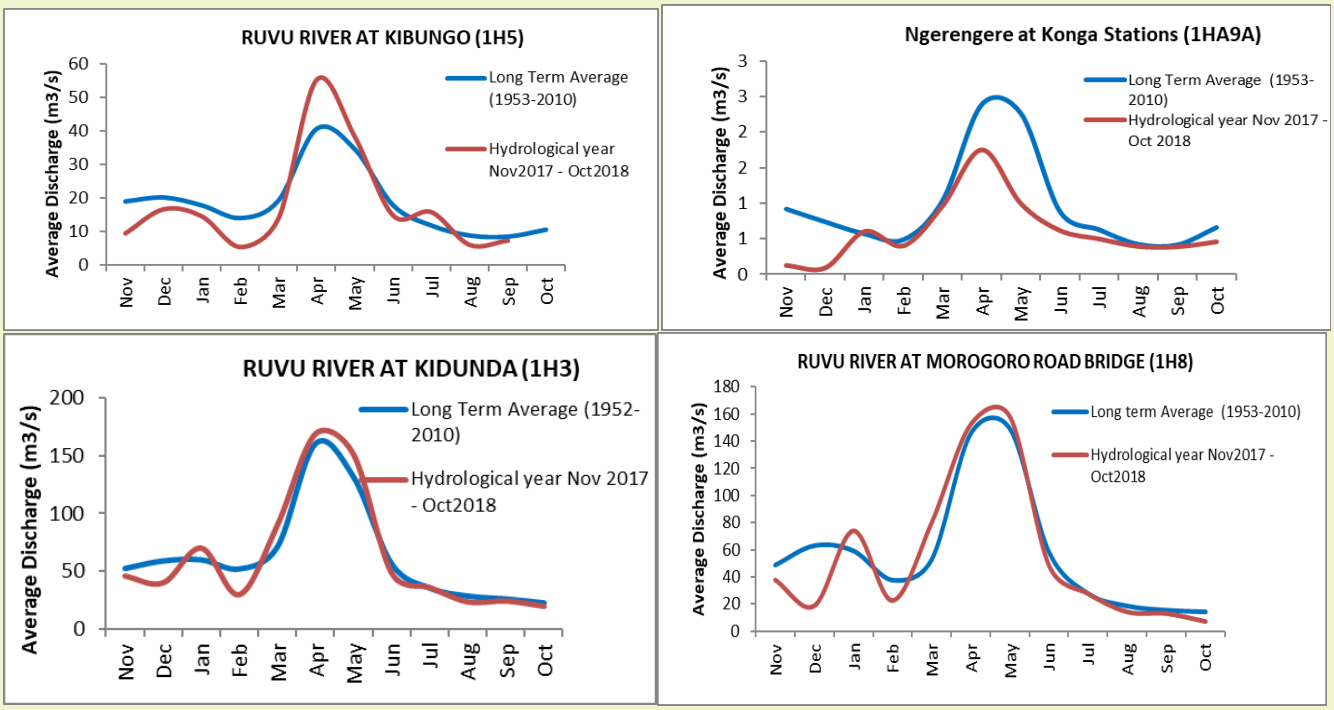

Figure 3-6: Comparison of Average discharge and Long-term Average for representative stations in Ruvu River, namely Ruvu at Kibungo (1H5), Ngerengere River at Konga, Ruvu River at Kidunda and Ruvu at Morogoro Rd Bridge(1H8)

Table 3-8: Summary of Long-term average and mean annual flow.

Months	LTA for 1H8	1H8(17/18)	% of LTA	1H5(17/18)	LTA for 1H5	% of LTA	LTA for 1HA9A	1HA9A(17/18)	% of LTA	LTA for 1H3	1H3(17/18)	% of LTA
Nov	48.85	37.65	77.07	9.56	18.92	50.51	0.91	0.13	14.15	52.21	46.1	88.30
Dec	63.17	18.62	29.48	16.77	20.1	83.41	0.73	0.10	13.12	58.77	40.29	68.56
Jan	59.28	73.82	124.54	14.62	17.73	82.46	0.56	0.61	108.30	59.72	70.23	117.58
Feb	37.71	22.48	59.61	5.48	13.96	39.26	0.48	0.41	84.52	51.78	30.12	58.17
Mar	52.99	80.01	150.99	13.96	19.14	72.93	1.04	0.97	93.28	70.91	90.08	127.04
Apr	145.92	152.41	104.45	55.29	40.6	136.19	2.39	1.76	73.47	160.60	239.73	149.28
May	149.31	157.92	105.77	38.30	34.51	111.00	2.26	1.00	44.13	131.47	162.31	123.46
Jun	58.33	48.17	82.58	14.87	17.78	83.65	0.87	0.62	71.13	56.13	48.62	86.61
Jul	27.78	27.56	99.22	15.89	11.75	135.21	0.62	0.50	80.97	35.20	36.24	102.95
Aug	18.66	14.07	75.39	6.11	8.75	69.86	0.42	0.40	94.39	28.22	23.90	84.70
Sep	15.55	12.87	82.76	7.40	8.4	88.06	0.41	0.39	95.41	25.76	24.63	95.64
Oct	14.29	7.05	49.35	6.04	10.47	57.68	0.65	0.46	71.03	22.27	20.11	90.30
Annual	**57.65**	**54.39**	**86.77**	**17.02**	**18.51**	**84.19**	**0.95**	**0.61**	**70.32**	**62.75**	**69.36**	**99.38**

3.4. Water Storage

3.4.1. Mindu Dam

Daily water level fluctuation in Mindu dam is represented by the graph in **Figure *3-7*** while the general characteristics of the dam showing its storage, Dam crest and Dead storage is shown in **Table *3-9***. Generally, the water level fluctuations in the Mindu dam is highly correlated to the rainfall pattern in the catchment, where by highest levels of about 507.30m were recorded in May 2018 and Minimum level of 506.55m was recorded in January, the situation was not bad compared to hydrological year 2016/2017 where only 2m was remain to reach the dead storage.

Table 3-9: Characteristics of Mindu Dam

Dam	Storage (Mil. m^3)	Max. WL (2017/2018) (masl)	Min. WL (2017/2018) (masl)	Dam crest Level(masl)	Dead storage level(masl)
Mindu	1900	507.30	506.55	512	501

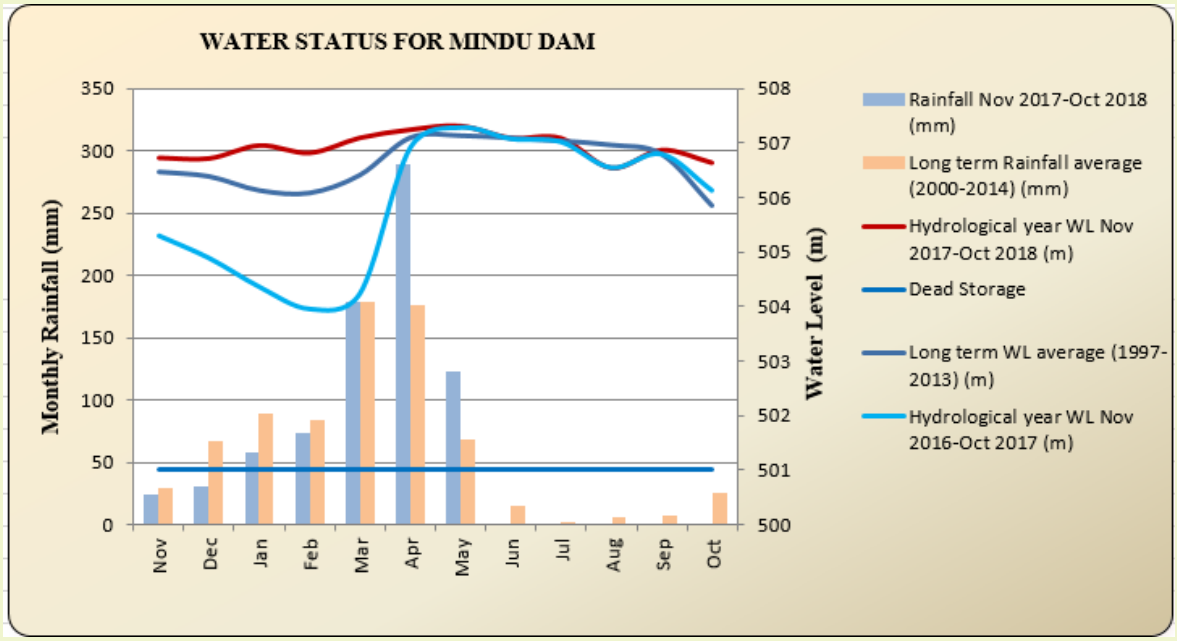

Figure 3-7: Comparison of Water Levels in Mindu Dam and Rainfall characteristics within Mindu catchment.

3.5. Sediment

Acceleration of surface runoff and sediment transportation caused by improper land use management such as deforestation, poor farming practices and human settlement near water courses. Spot measurements of sediment monitoring was done in some river gauging stations for Ruvu Catchment in 2017; The results indicate that Ruvu /Morogoro Rd Bridge station showed high increase of sediment load although in case of sediment yield Ruvu/Kibungo station observed to have the highest (**Table *3-10***).

Table 3-10: Summary of sediment load data for three basic representative stations.

Stations	Sediment Load (Kg/Day)			Catchment Area (Km2)	Sediment Yield (Kg/Km2/Day)			
Year	2010-2015	2016	2017		Recorded sediment load before project	2010-2015	2016	2017
Ruvu/Morogoro Rd Bridge	21332	30299	31006	15,190	136.9	1.4	2	2
Ruvu/Kibungo		22289	25288	420			53	60
Mgeta/Mgeta		2301	4362	101			23	43

3.6. Groundwater

3.6.1. Makutopora Well Field

A total of four (4) monitoring boreholes in Makutopora well field were selected where the trend of hydrological showing that the water table continue to decrease while the demand

increases. This may increase the cone of depression outside the catchment for discharge the field especially during the month of May where the pump age is higher compared to the other months (**Figure *3-8***). These fluctuations are highly link with the pump age taking place on production wells.

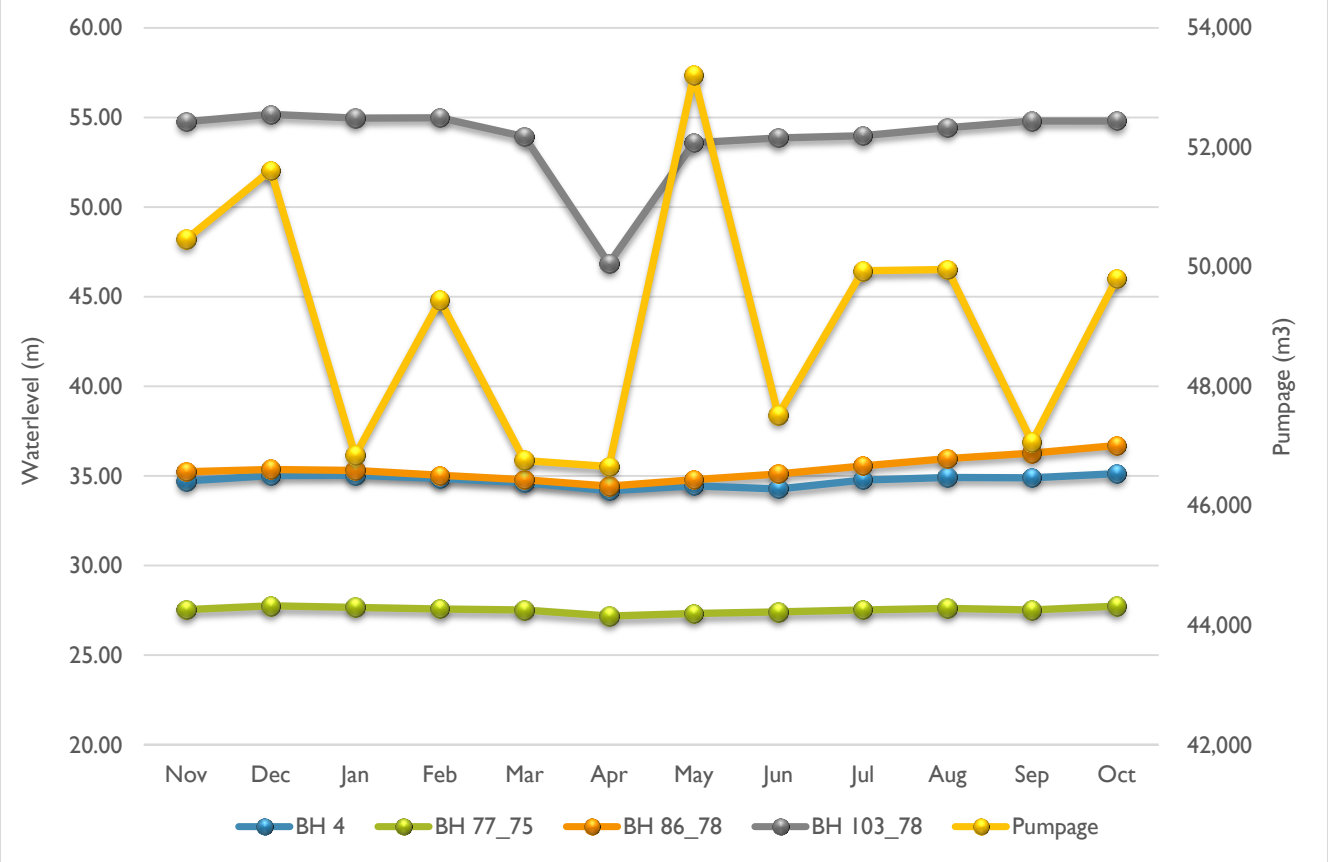

Figure 3-8: Comparison of monthly water level (m) and pump age (m^3) at Makutopora Well Field (2017-2018)

1. GENERAL REMARKS AND WAY FORWARD

1.1. Challenges and interventions

Few primary stations were chosen which can fairly give information of the different parameters of interest, in collecting water resources data (rainfall, surface and ground water levels, ratings, water quality and weather) WRBWB faced the following challenges: -

- Missing of weather and Water Quality data thus become cumbersome to discuss weather situation in the Basin.
- Low coverage of stations that are properly functional especially for Wami catchment.
- Insufficient of instrument for flow measurement which causes challenges during high flow measurement.
- Automatic stations (Groundwater, weather, and gauging) are not continuous visited due to insufficient of fund (amount and timely) therefore ensuring their functionality and accuracy become very challenging.

Key interventions include the following:

- Installation of low cost (4 stations) weather station within the Basin
- Rehabilitation of Wami river at Mandera (0-1) gauge and other 10 secondary stations are under propose for rehabilitation in financial year 2018/2019 within Wami catchment
- Purchasing of fibber boat and ADCP instrument for Flow measurement especially during high flow supported by WARIDI
- Improving monitoring through frequent visits to the same of stations.
- Database management using Acquires, Nile Basin Decision Supporting System (NBDSS) and GIS.
- More study/research on ground water is required to know the source and available storage recharge so as to have sufficient supply for Dodoma urban
- More Training personnel on database management.

- Training gauge readers to read manual gages, record ground water levels, to identify any equipment problems; provide security and to perform minor station maintenance.

2. ANNEXES

2.1. Status of Gauging Station in Wami/Ruvu Basin

Status of Gauging Station Wami/Ruvu Basin

SN.	Station Name	Status of AWL Gauge	Status of Staff Gauge	Lat	Long	Elevation (m.a.s.l)	Catchment Area km2
1	Wami at Dakawa	Functional/sedimentation	Functional/sedimentation	-6.44783	37.53343	361	28,488
2	Wami at Mandera	Non-Functional	Not Functional	-6.24638	38.38732	87	36,450
3	Tami at Msowero	Non-Functional	Not Functional	-6.53173	37.21375	440	37.3
4	Kisangata at Mvumi	Not Functional	Not Functional	-6.58897	37.17288	436	404
5	Wami at Rudewa	Not Functional	Not Functional	-6.67917	37.12418		281
6	Lukigura at Kimamba Rd. Br.	Functional	Functional	-5.81396	37.80101	512	1,060
7	Mziha at Mziha	Functional	Functional	-5.89588	37.78001	443	178
8	Diwale at Ngomeni	Not Functional	Not Functional	-6.13764	37.59020	387	214
9	Mkindo at Mkindo	Not Functional	Not Functional	-6.24762	37.55250		35
10	Mkondoa at Kilosa	Not Functional	Not Functional	-6.83173	36.97824	495	17,560

Status of Gauging Station Wami/Ruvu Basin							
SN.	**Station Name**	**Status of AWL Gauge**	**Status of Staff Gauge**	**Lat**	**Long**	**Elevation (m.a.s.l)**	**Catchment Area km2**
11	Kinyasungwe at Kongwa/Dodoma	Not Functional	Not Functional	-6.21775	36.32700	855	9,570
12	Kinyasungwe at Itiso	Not Functional	Not Functional	-5.59	36.00		36.0
13	Mkondoa at Mbarahwe	Not Functional	Not Functional	-6.60	36.78		475
14	Lumuma at Kilimalulu	Not Functional	Not Functional	-6.68	36.67		502
15	Miyombo at Kivungu	Functional	Functional	-6.90987	37.02422	477	60
16	Mkata at Mkata	Not Functional	Not Functional	-6.75907	37.36130	399	37.4
17	Great Kinyasungwe at Ikombo	Not Functional	Functional	-5.7160	36.0849		32
18	Little Kinyasungwe at Chihanga	Functional	Functional	-5.9047	35.8439		
19	Little Kinyasungwe at Mayamaya	Functional	Functional	-5.81948	35.80410	1153	
20	Ruvu at Kidunda	Non-Functional	Functional	-7.26395	38.24558	86	6,697
21	Ruvu at Kibungo	Functional	Functional	-7.02370	37.80948	203	420
22	Ruvu at Morogoro Rd. Br.	Functional	Functional	-6.69080	38.69427	24	15,190
23	Ruvu at Mikula	Not Functional	Not Functional	-7.27967	38.11447	80	5,870
24	Ngerengere at Utari Bridge	Not Functional	Not Functional	-7.01806	38.32478	101	2,840
25	Ngerengere at Kingolwira	Not Functional	Not Functional	-	37.75762	425	

Status of Gauging Station Wami/Ruvu Basin							
SN.	**Station Name**	**Status of AWL Gauge**	**Status of Staff Gauge**	**Lat**	**Long**	**Elevation (m.a.s.l)**	**Catchment Area km2**
				6.75177			
26	Morogoro at Morogoro	Not Functional	Functional	-6.84562	37.67247	547	23.3
27	Ngerengere at Konga	Functional/sedimentation	Functional/sedimentation	-6.90653	37.59944	531	20.5
28	Ngerengere at Mgude	Not Functional	Not Functional	-6.76507	38.14570	180	2370
29	Mzinga at Mzinga	Not Functional	Not Functional				
30	Ngerengere at Lukwambe	Not Functional	Not Functional	-6.59937	37.99728	332	
31	Mgeta at Mgeta	Functional	Functional	-7.03	37.57	975	89.6
32	Mgeta at Duthumi	Not install	Non-Functional	-7.41009	37.77803	138	
33	Mvuha at Ngagama	Not Functional	Functional	-7.19999	37.83795	138	37.9
34	Mvuha at Tulo School	Functional	Functional	-7.24065	37.91766		37.9
35	Mfizigo at Kibangile	Not Functional	Functional	-7.02970	37.80005	207	147
36	Mfizigo at Lanzi	Not Functional	Not Functional	-7.08922	37.68515	898	
37	Kizinga at Mbagala/Buza	Not Functional	Not Functional	-6.90145	39.24128	88	
38	Mzinga at Majimatitu	Not Functional	Not Functional	-6.95083	39.24633		
39	Mngazi at Vigolegole	Not Functional	Functional	-7.11	37.77	345	

Status of Gauging Station Wami/Ruvu Basin							
SN.	**Station Name**	**Status of AWL Gauge**	**Status of Staff Gauge**	**Lat**	**Long**	**Elevation (m.a.s.l)**	**Catchment Area km2**
40	Mbezi at Kalundwa(Kinole)	Not Functional	Functional	-6.92478	37.77185	496	
41	Mlali at Mlali	Not Functional	Functional	-6.96326	37.53483	584	
42	Mtombozi at Mtombozi	Not Functional	Functional	-7.44	37.63	165	
43	Lukulunge at Konga	Not Functional	Functional	-6.9141	37.5909	539	3

Discharge Monthly Average (m^3/s) 2017/2018														
		2017		2018										Average
NO	STATION NAME/MONTH	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	
1	Wami at Dakawa 1G1	1.34	1.33	28.94	6.73	66.08	72.70	37.88	4.63	2.97	1.03	0.45	0.47	18.71
2	Ngerengere at Konga 1HA9A	0.13	0.10	0.61	0.41	0.97	1.76	1.00	0.62	0.50	0.40	0.39	0.46	0.61
3.	Ruvu at Kibungo 1H5	9.56	16.77	14.62	5.48	13.96	55.29	38.30	14.87	15.89	6.11	7.40	6.04	17.02
4.	Ruvu at Kidunda 1H3	46.10	40.29	70.23	30.12	90.08	239.73	162.31	48.62	36.24	23.90	24.63	20.11	69.36
5.	Ruvu at Morogoro Rd	37.65	18.62	73.82	22.48	80.01	152.41	157.92	48.17	27.56	14.07	12.87	7.05	54.39

	Bridge 1H8													

2.2. Groundwater Monitoring Stations

Borehole_No	Village	District	Region	Recorder_type	Latitude	Longtude	Drilled_year
DO/136/2012	Chamwino	Chamwino	Dodoma	Auto	6.10518	6.03112	2012
DO/356/2011	Chandama	Kondoa	Dodoma	Auto	5.14653	36.17496	2011
DO/354/2011	Ihumwa	Dodoma	Dodoma	Auto	6.14923	35.83805	2011
DO/358/2011	Itiso	Kondoa	Dodoma	Auto	5.6565	36.04152	2011
MRG/359/2011	Kidete	Kilosa	Morogoro	Auto	6.64703	36.70285	2011
MGR/361/2011	Kisaki	Morogoro Rural	Morogoro	Auto	7.46088	37.60179	2011
TA/287/2011	Kuwekive	Kilindi	Tanga	Auto	5.77985	37.33051	2011
DO/135/2012	Kwahemu	Chamwino	Dodoma	Auto	5.45279	35.9071	2012
MRG/131/2012	Magogoni	Morogoro Rural	Morogoro	Auto	7.22678	37.99349	2012
DO/134/2012	Makutapora	Dodoma Urban	Dodoma	Auto	5.96978	35.73061	2012
CO/132/2012	Mbala	Bagamoyo	Coast	Auto	6.65741	38.52399	2012
MGR/363/2011	Mbwade	Kilosa	Morogoro	Auto	6.75777	37.19677	2011
DSM/129/2012	Misimbazi Mseto	Ilala	Dar es Salaam	Auto	6.82085	39.25598	2012
MGR/360/2011	Mvomero	Mvomero	Morogoro	Auto	6.2994	37.4796	2011
89/75	Mzakwe	Dodoma Urban	Dodoma	Manual	5.938	35.769	1960
122/75	Mzakwe	Dodoma Urban	Dodoma	Manual	5.927	35.789	1960
234/75	Mzakwe	Dodoma Urban	Dodoma	Manual	5.975	35.713	1960
103/78	Mzakwe	Dodoma Urban	Dodoma	Manual	5.974	35.707	1960
86/78	Mzakwe	Dodoma	Dodoma	Manual	5.967	35.724	1960

Borehole_No	Village	District	Region	Recorder_type	Latitude	Longtude	Drilled_year
		Urban					
New	Mzakwe	Dodoma Urban	Dodoma	Auto			
New	Mzakwe						
New	Mzakwe						
MGR/362/2011	Ngerengere	Morogoro Rural	Morogoro	Auto	6.77077	38.11496	2011
MNY/653/2011	Osteti	Kiteto	Manyara	Auto	5.5324	36.32644	2011
DSM/490/2011	Shule ya Uhuru(No.1)	Ilala	Dar es Salaam	Auto	6.82302	39.26838	2011
DSM/128/2012	Shule ya Uhuru(No.2)	Ilala	Dar es Salaam	Auto	6.82324	39.26728	2012
New	Sinza	Kinondoni	Dar es Salaam	Auto	6.823	39.221	2014
CO/133/2012		Chalinze	Coast	Auto	6.63518	38.33377	2012