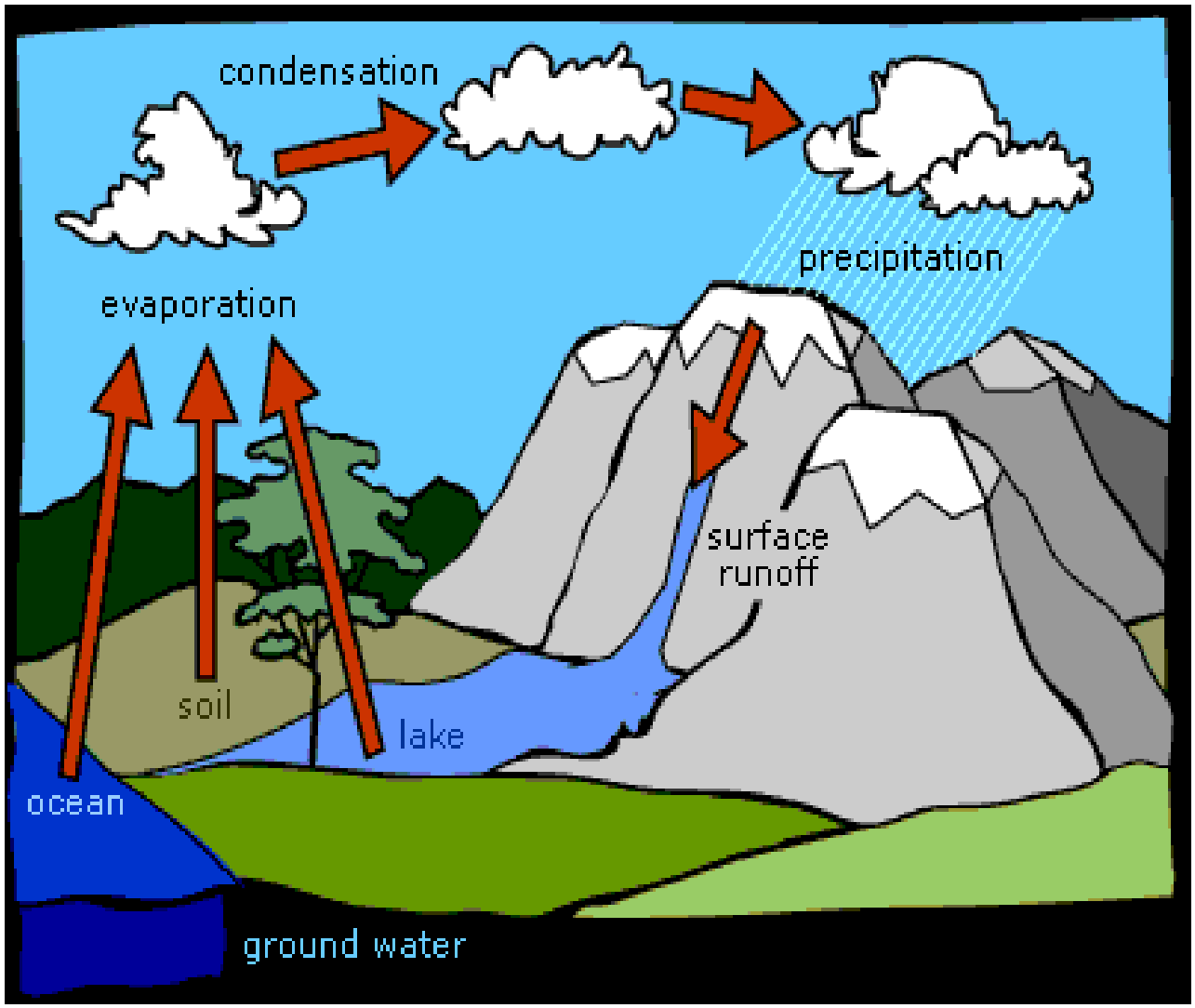
National Meteorological Agency



Hydro Meteorological Bulletin for Belg, 2017

Foreword

This seasonal hydro meteorological bulletin is prepared and disseminated by the National Meteorological Agency (NMA) of Ethiopia, for the purpose of providing hydro meteorological information to different sectors of the community involved in water related activities.

In general, Hydrometeorology is concerned with the study of the atmosphere and land phases of the hydrologic cycle, particularly, on the interrelationships involved. In this bulletin, more emphasis is given to presenting the results of analyses done on the extreme rainfall events as well as the moisture status prevailed over river catchments.

Accordingly, the data used in producing this bulletin are collected from selected indicative meteorological stations, which are believed to represent each of the main river catchments (hydrological regimes) of the country and the results of the hydro meteorological analyses are presented in maps format. Analysis presented in the forms of maps indicates comparisons of the total and extreme monthly rainfall events, monthly mean temperature and aridity index conditions for each basin.

Thus, the information contained in this bulletin is believed to be helpful in monitoring the performances of many hydraulic structures such as culverts, bridges, reservoir spillways, road embankments, dikes, flood prone areas as well as in planning and designing such new structures over the respective basins. It also gives the user an insight into the value as well as the contributions of the hydro-meteorological information towards the accomplishment of water resources assessment and management with respect to sustainable development of the country. Meanwhile, your comments and constructive suggestions are highly appreciated to make the objectives of this bulletin a success.

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I. Introduction

Ethiopia is located between latitudes of 3.8°N to 14.5°N and longitudes of 33°E to 48°E with an area of about 1.12 million km^2. The varied topography of the country shows extreme changes in altitude with its lowest point at about 120meters below sea level (Kobat Sink Afar depression) and its highest point about 4620 meters above sea level (Ras dashen.).These physographic variations create a large difference in meteorological and hydrological condition both by time and space.

From meteorological point of view, there are three seasons in Ethiopia; Belg, Kiremt and Bega.

Belg (February-May) is the small rainy season in Ethiopia. Much of the northeastern, central, southern, southwestern, eastern and southeastern parts of the country receive considerable amount of rainfall during this season.

Kiremt (June-September) is the main rainfall season for most parts of the country except for the lowlands of southern and southeastern Ethiopia.

Bega (October-January) is mostly a dry season for most parts of the country except for southwestern as well as the lowlands of south and southeast Ethiopia.

In general the mean annual rainfall amount ranges from 2400mm (over south western) to 500 and below over the northeastern and southeastern lowlands. Hydro meteorologically a rainy day is considered as the one with 2.5 mm of rain or more but in this publication a rainy day is one regardless of the amount.

In Ethiopia, water resources availability in terms of space shows a marked discrepancy when one goes from east to west. The eastern part of the region compromise 7 catchments with only 11 percent of the water resource and while the west compromise 5 catchments with 89 percent of water resources.

II. Catchments profile

Catchment	Location
Mereb – Gash Catchment: -	Northwestern tip of Tigray.
Atbara-Tekeze Catchment: -	The Tekeze river basin is situated in the northwest of Ethiopia between 11 ^{0}40` and 15 $^0$12` N, and 36 ^{0} 30` and 39$^0$ 50` E. It is bordered by the Mereb river basin and by Eritrea in the north, the Atbara river plains in Sudan in the west, the Abay river basin in the south and Danakil basin in the east.
Blue Nile/ Abbay Catchment: -	Roughly 13^0 N south of Gondar to 11^0 30'N, and west of 39^0 45'E of Wello, northwestern parts of Shoa; Gojam except the south western and western narrow area, Wellega and extreme eastern tip of Illubabor together with a narrow northeastern strip of Keffa. It is the largest catchment that covers about 16 percent of the total area of Ethiopia. The catchment that includes the Lake Tana, upper Abbay(to Guder confluence),middle Abbay (to didessa confluence), Didessa, Dabus ,lower Abbay,Dinder and Rahad sub-basin.
Baro –Akobo Catchment: -	The south western and western narrow strip of Wellega, except the eastern tip, the whole of Illubabor and southwestern tip of Keffa. The catchment has upper and lower sub-basins along Baro River. The catchment It is the wettest catchment because of the highest rainfall over the area.
Danikil – Afar Catchment: -	East of 40^0 E of Tigray, North of 11^{0}N of Wollo, narrow coastal strip south of 14^{0}30'N of Eritrea. The basin is the lowest region in the country where the Kobar sink; with an elevation of about 120 meters b.s.l is found.
Awash Catchment: -	North of Garamuleta mountains, south of 11^0 40$^{'}$ N of Wollo, south of 9^0 N of Shoa, northern tip of Bale and north part of Arsi. The catchment has upper, middle and lower sub-catchments. In general the catchment is narrow at the upper part marked by numerous volcanic mountains and wider at the

lower part joining major tributaries from northwestern highlands and a number of seasonal wadies from the southeast highlands.

Gulf of Aden – Aysha Catchment): - Eastern narrow strip of Hararghe. It is a very dry area with no stream flow representative meteorological station. Thus, no assessment is done for this catchment in this publication**.**

Omo-Ghibe Catchment: - Southwestern narrow strip of Shoa, the whole of Keffa except the southwestern tip, southwestern tip of Wellega, western half of northern Omo and northwestern tip of Sidamo. The upper part of the catchment starts from the plateaus in north part of Ghibe and extends southward to the lower part of it (known as Omo River).

Central Lakes-Rift Valley Catchment: - The whole of north and south Omo, west and southwestern narrow strip of Sidamo, southwestern portions of Shoa and western narrow tip of Bale and western part of Arsi. The catchment is found in the Great Rift Valley system and typically known by its lakes and streams. Lakes which adjoin the Awash catchment are found in its upper part, while Lake Awassa and Bilate in its central part and end to chamo Bahr in its lower part**.**

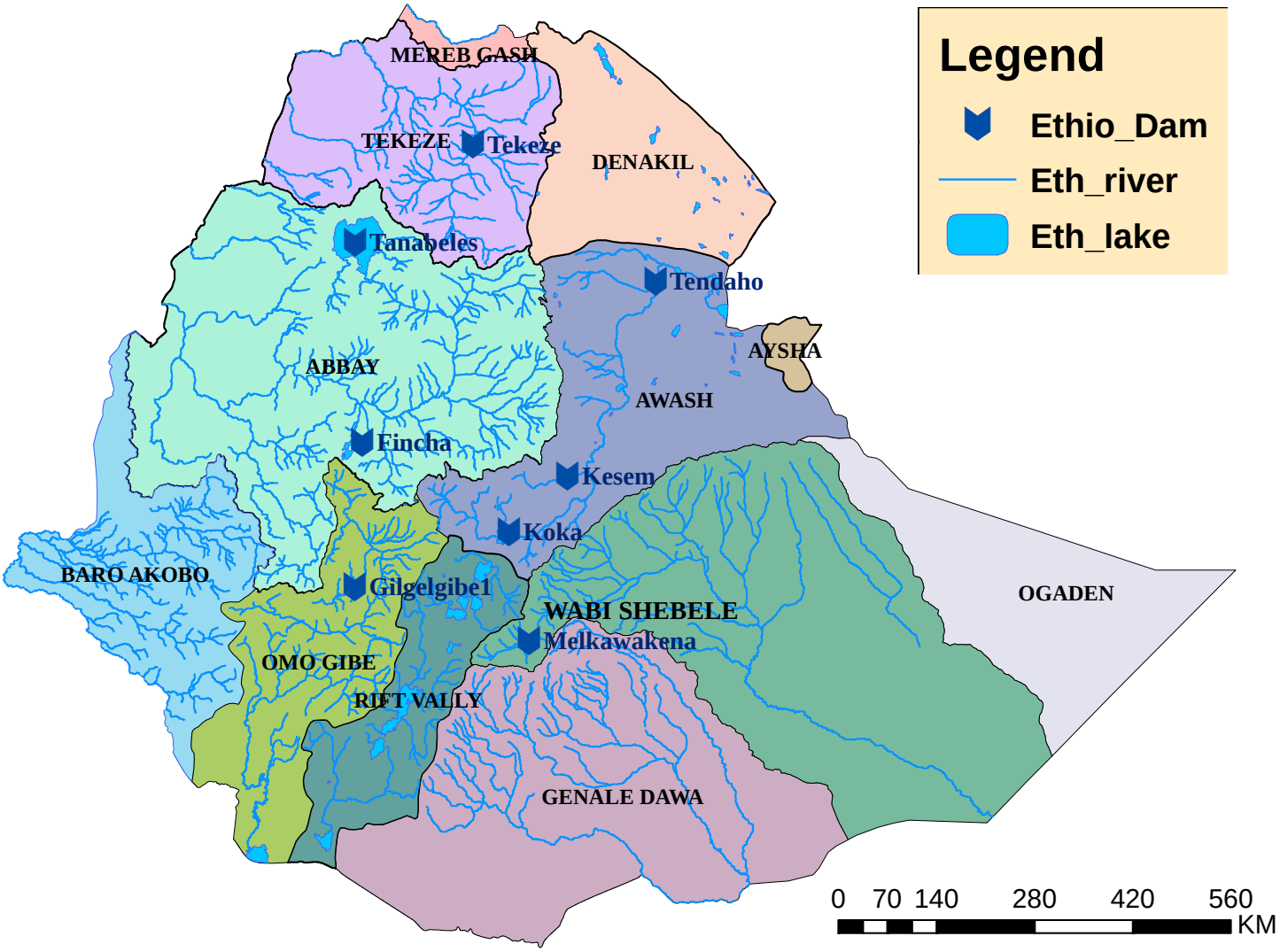
Genale Dawa Catchment: - The western half of Bale (South of Goba) and southeast, southwestern and northeastern parts of Sidamo. The catchment constitute three river systems namely Dawa ,Genalle and Wabi Gestaro that meet each other before they cross the Ethio-Somalia border.

III. Major River Catchments in Ethiopia, Location and Spatial Status

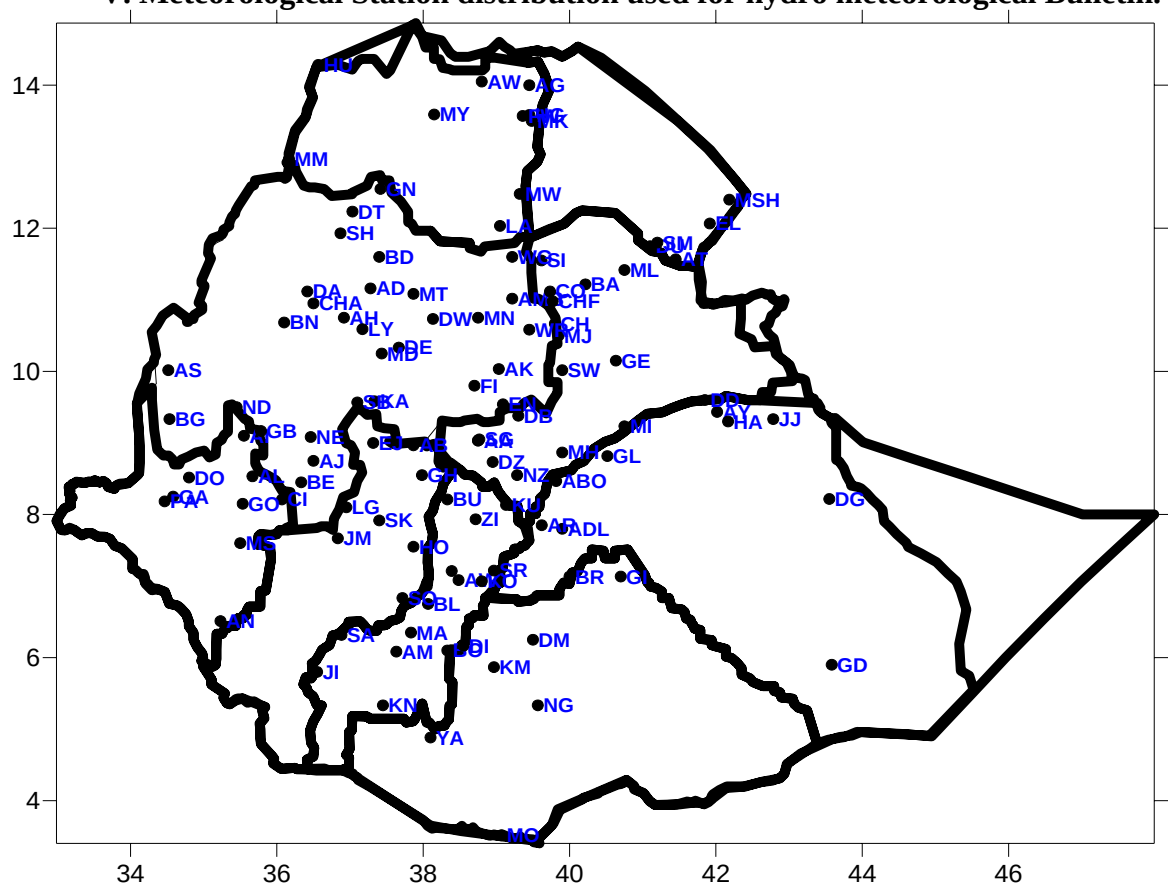
No.	Catchement	Area	Length in Kilo meter	Volume	Altitude (meter)

	Name	**($km^{2)}$**	**Within Eth.**	**Outside Eth.**	*Total*	**of water bm^3/Annum**	***Peaks*** **(Highest & Lowest)**
01	Mereb-Gash	5,700	440	160	600	0.15	North tip of Tigray
02	Tekaze – Atbar	90,001	608	560	1168	8.13	4620 Ras Dashen 125 Tikil -Dengay
03	Blue Nile(Abbay)	204,100	800	650	1450	52.62	4231 Guna 200 Horekelife
04	Baro - Akobo	75,912	227	280	557	23.55	3700 Masha 410 Jikawo
05	Afar (Denakil)	62,882	-	-	-	0.86	
06	Awash	112,696	1200	-	1200	4.6	4000 N.Shewa 4001 NW mt. 4002 of A.A 250 L.Abe
07	Aysha	2223				0.86	
08	Omo-Ghibe	78,213	760	-	760	17.96	4203Guge/Gurage Mt. 195 Chiri
09	Rift valley	54,900	-	-	-	5.63	
10	Genale - Dawa	171,042	480	570	1050	5.88	4310 Bale mt./Batu 500 Dolo Odo
11	Wabi - Shebele	205,697	1340	660	2000	3.16	3626 Mt.Gololcha 200 Somalia Desert
12	Ogaden	77,121	-	-	-	-	1500 Turkile 350 Gelad

IV. Basin map of Ethiopia



V. Meteorological Station distribution used for hydro meteorological Bulletin.



STATION	CODE	STATION	CODE	STATION	CODE	STATION	CODE
A.A (Bole)	**AA**	Cheffa	**CHF**	Gonder	**GN**	Mille	**ML**
Abomsa	**ABO**	Chercher	**CH**	Gore	**GO**	Mira Abaya	**MR**
Adet	**AD**	Chira	**CI**	Hageremariam	**HG**	Motta	**MT**
Adigrat	**AG**	Combolcha	**CO**	Harer	**HA**	Moyalle	**MO**
Adwa	**AW**	Dangla	**DA**	Hossana	**HO**	Mytsebery	**MY**
Aira	**AI**	Debrebrhan	**DB**	Humera	**HU**	Nazaret	**NZ**
Alem ketema	**AK**	Degehabur	**DG**	Jijiga	**JJ**	Nedjo	**ND**
Alemaya	**AY**	Debremarkose	**DE**	Jimma	**JM**	Negele	**NG**
Alge	**AL**	Debre Tabore	**DT**	Jinka	**JI**	Nekemt	**NE**
Ambamariam	**AMB**	Debre Zeit	**DZ**	Kachise	**KA**	Pawe	**PA**
Ambo	**AB**	DembiDolo	**DO**	Kibremengist	**KM**	Sawla	**SA**
Arbaminch	**AM**	Dilla	**DI**	Konso	**KN**	Sekoru	**SK**
Arjo	**AJ**	DireDawa	**DD**	Kulumsa	**KU**	Semera	**SM**
ArsiRobe	**AR**	Dolomena	**DM**	Koffele	**KO**	Freweyni	**FW**
Assaita	**AT**	Dubti	**DU**	Konso	**KN**	Shahura	**SH**
Assossa	**AS**	Ejaji	**EJ**	Kulumsa	**KU**	Shambu	**SB**
Awassa	**AW**	Elidar	**EL**	Lalibela	**LA**	ShewaRobit	**SW**
Ayehu	**AH**	Enewary	**EN**	Layber	**LY**	Shire	**SR**
Aman	**AN**	Elidar	**EL**	Limugenet	**LG**	SholaGebeya	**SG**
Bale Robe	**BR**	Enewary	**EN**	Maichew	**MW**	Sirinka	**SI**
BahiDar	**BD**	Fitche	**FI**	Mankush	**MA**	Sodo	**SO**
Bati	**BA**	Gambella	**GA**	Masha	**MSH**	WegelTena	**WT**
Beddele	**BE**	Gelemso	**GL**	Mehalmeda	**MD**	Wereillu	**WR**

Begi	**BG**	Gewane	**GE**	Mekaneselam	**MN**	Yabello	**YB**
Blate	**BL**	Ghion	**GH**	Mekele	**MK**	Ziway	**ZY**
Bui	**BU**	Gimbi	**GB**	Metehara	**ME**		
Bullen	**BN**	Ginir	**GI**	Meisso	**MS**		
Chagni	**CG**	Gode	**GD**	Metema	**MM**		

The above stations have five basic meteorological elements they send daily records for Addis Ababa main office of NMA. We use the meteorological elements which are the main factors for hydro meteorological impacts. These are rainfall, temperature, wind speed, evaporation and sunshine duration. This information is important to guide for different water resource activities.

Part one

Hydro meteorological assessment of Belg, 2017 over different basins

Belg (February –May):- Belg rain benefiting catchments are found across eastern half, central and southern portion of the country. Among this season April is the pick rainy months over those catchments. In weak rainfall Belg season exacerbate shortage of water due to occurrence of high temperature. It has more benefited to compensate the loss of water during the previous dry condition effect which is during Bega season and important to minimize evaporation from open water surface due to the presence of cloud coverage and some amount of rainfall. Belg rainfall contributed for surface runoff about 5 to7% during wet season. Due to this in some catchments availability of water is increase over small stream and ponds.

Methods

To compute the aridity index we use Thornthwait method, which is computed from the monthly values of rainfall and evaporation. The evaporation is computed empirically from mean monthly air temperature. In assessing the effectiveness of rainfall, in terms of water availability relationships between the rainfall and air temperature has been worked out in terms of moisture indices. The aridity index values above 128 which shaded in deep green were show wet condition. Light green to yellow value indicates humid to semi humid and pink to red values show semi dry to dry condition.

Where Rf= monthly rainfall in mm; T= monthly mean temperature in °C

1. Aridity status for Belg, 2017 over different basins

The moisture performance of February was insignificant over all river basins. However some Belg rain benefiting catchments of north eastern and south western catchments received some amount of rainfall. Accordingly adjacent places of Tekeze, Afar Denakel, lower Awash and eastern Abay, some places of eastern BaroAkobo, middle and lower OmoGibe and southern Abay catchments were preformed wet to humid weather condition. After mid March most parts of Belg rain benefiting catchments of central, eastern, southern and north eastern were received rainfall. In line with this the divide places of Wabishebele and Genale Dawa, middle and lower OmoGibe and eastern Baro Akobo, eastern Abay, upper and west of middle Awash and upper Rift Valley, upper Tekeze and most of Afardenakel catchments were experienced wet to semi humid condition. During April better moisture condition was observed across south western and southern parts of the country. Among those catchments upper and middle Genaledawa, middle and lower Rift valley, eastern half of BaroAkobo, middle and lower Omogibe, southern and central parts of Abay and the divide of GenaleDawa and Wabishebele catchments were experienced wet to humid condition. In May most parts of the main river basin received high rainfall, likewise the better moisture performance was observed over all main Belg benefiting catchments including western parts of the country shown below in figure (1a-d).

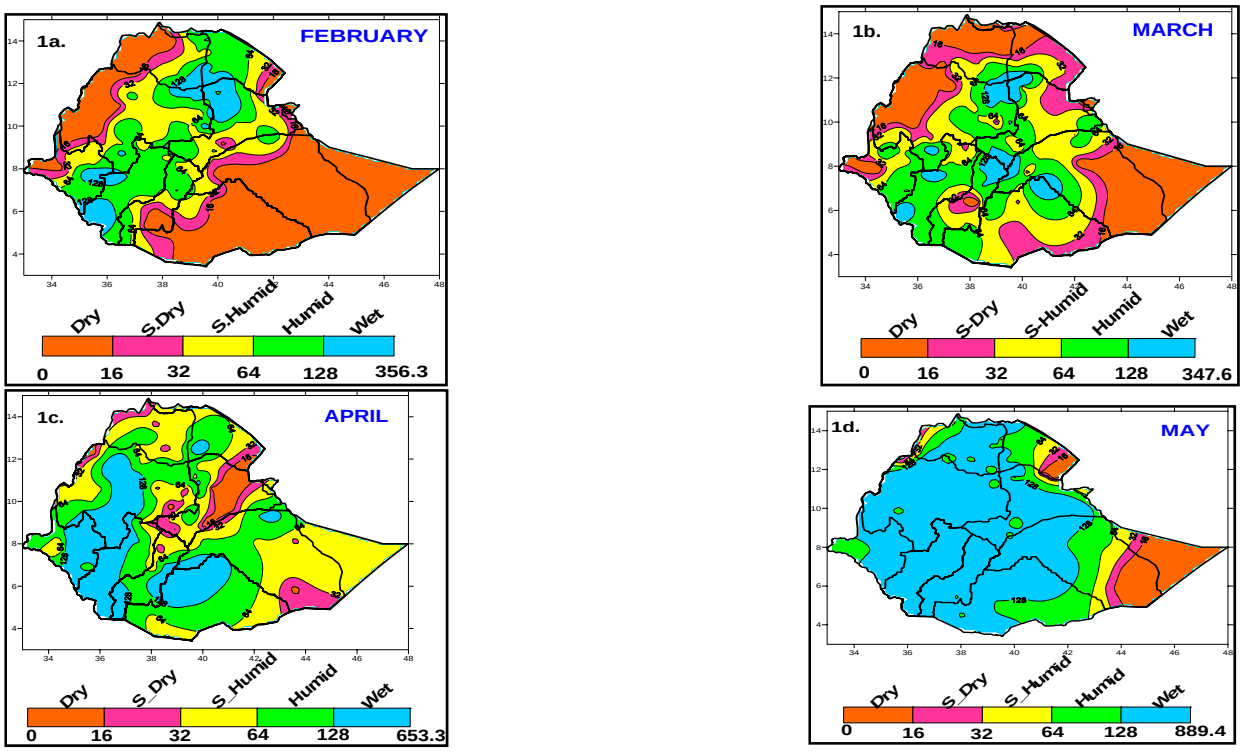
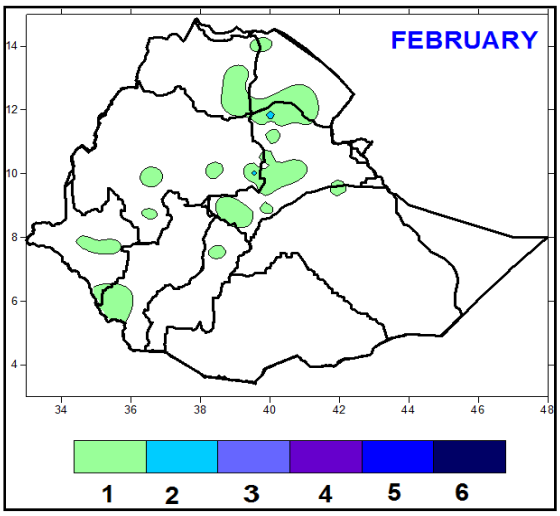


Fig.(1a-d) Aridity Index for February, 2017 to May, 2017.

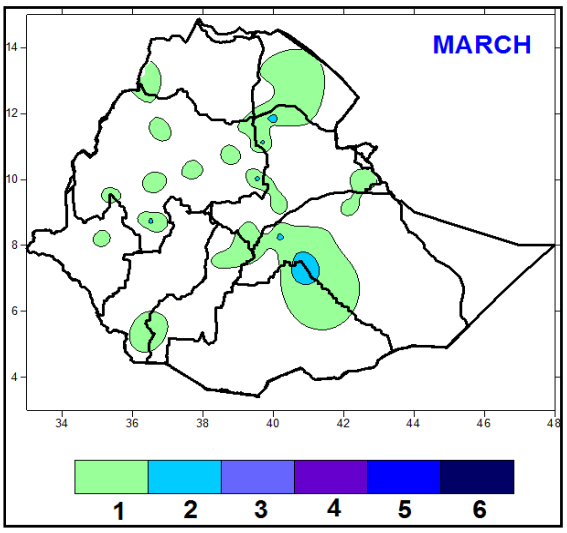
2. Distribution of heavy fall days exceeding 30mm during February to May, 2017 over different river basins.

The occurrence of heavy fall in this season was observed from February to May. During February most parts of Awash, eastern Tekeze, Abay and Baro Akobo, upper Afar Denkile, lower Omo Gibe and upper Rift valley catchments were received heavy fall in some places. The maximum frequency of heavy fall days was observed over middle Awash catchments for 2 days at Shoarobit and Sirinka stations respectively**.** During March the occurrence of heavy fall were observed over the upper and middle Awash, lower Tekeze, southern and eastern Abay, middle Afar Denkile, lower Rift valley, upper Wabishebele and adjacent of Genaledawa catchments. The maximum frequency of heavy fall were observed over Abay, Awash, Wabishebele and GenaleDawa catchments at Arjo , Combolcha, Shoarobit, Sirinka, Gololcha, Jara, and Ginnir stations for 2 days respectively. During April over the middle and eastern Baro Akobo, middle and lower Omo Gibe, middle and lower Rift valley, upper and middle Genale Dawa, middle and lower Wabishebele, middle Awash, upper Afar Denkile, lower Tekeze and the eastern and southern Abay catchments were recorded heavy fall. The maximum frequency of heavy fall days were observed over eastern BaroAkobo and southern Abay catchments at Masha and Arjo stations for 6 and 5 days respectively. During May the occurrence of heavy fall were observed over all catchments except western and eastern Tekeze, lower Wabishebele, Ogaden and some pocket places of other catchments shown below (2a-d).

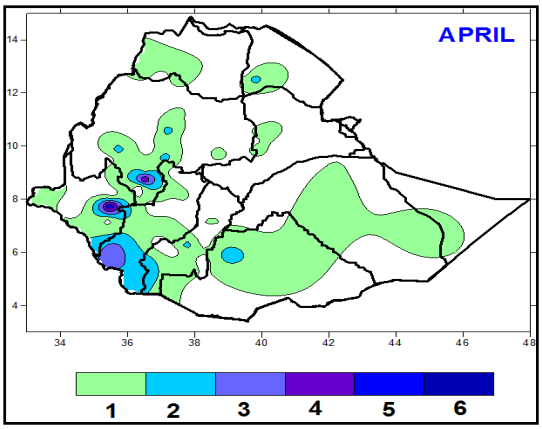
2a.



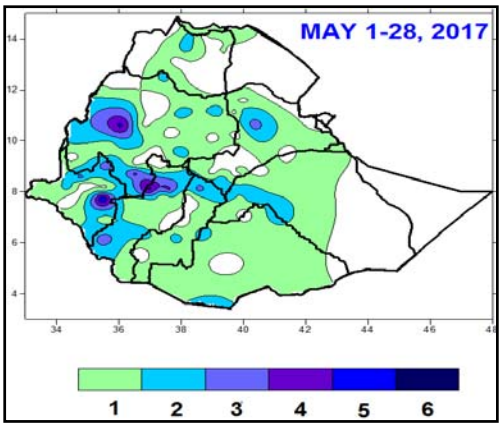
2b.



2c.



2d.

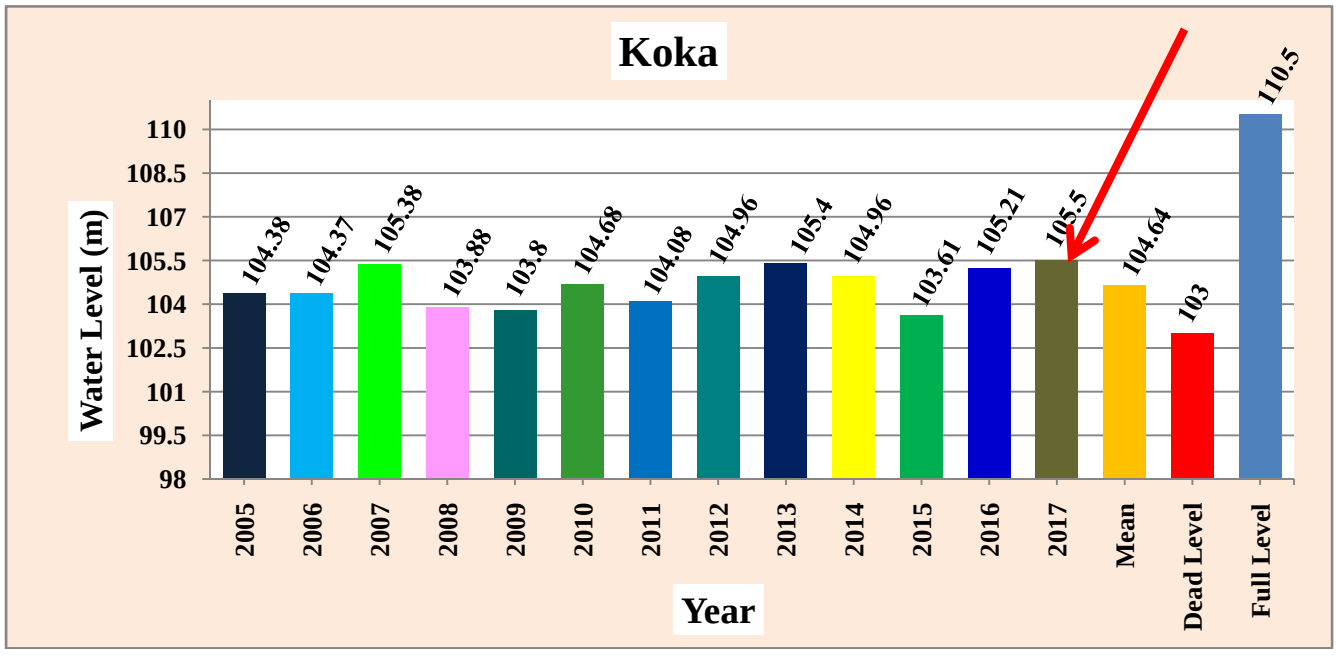


(Fig.2a-d) Distribution of heavy fall February to May, 2017

3. Performance of Dams and Reservoirs water level in Belg, 2017 season

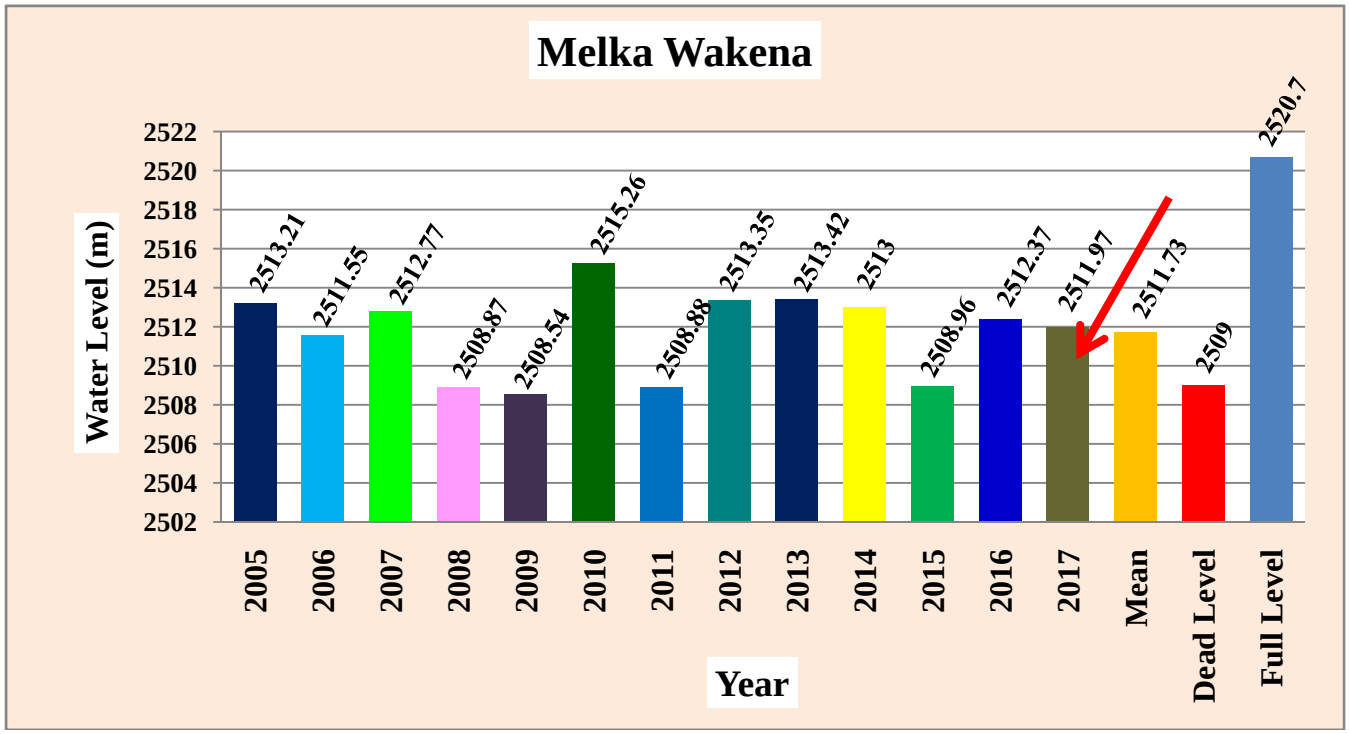
The main source of runoff is rainfall which is the input of surface water for Dams, reservoirs and ponds but from Bega season to end of Belg season runoff is very little and flow of river is low. According to this at the end of Belg season the level of water in river, ponds, reservoirs and dams reaches at low level. In the case of Belg, 2017 season the occurrence of heavy fall had better contribution for water resource. In line with this the performance of Koka, Fincha, Lake Tana and Tekeze dams shown slight increment of water level shown below in figure (3a-f).

3a.

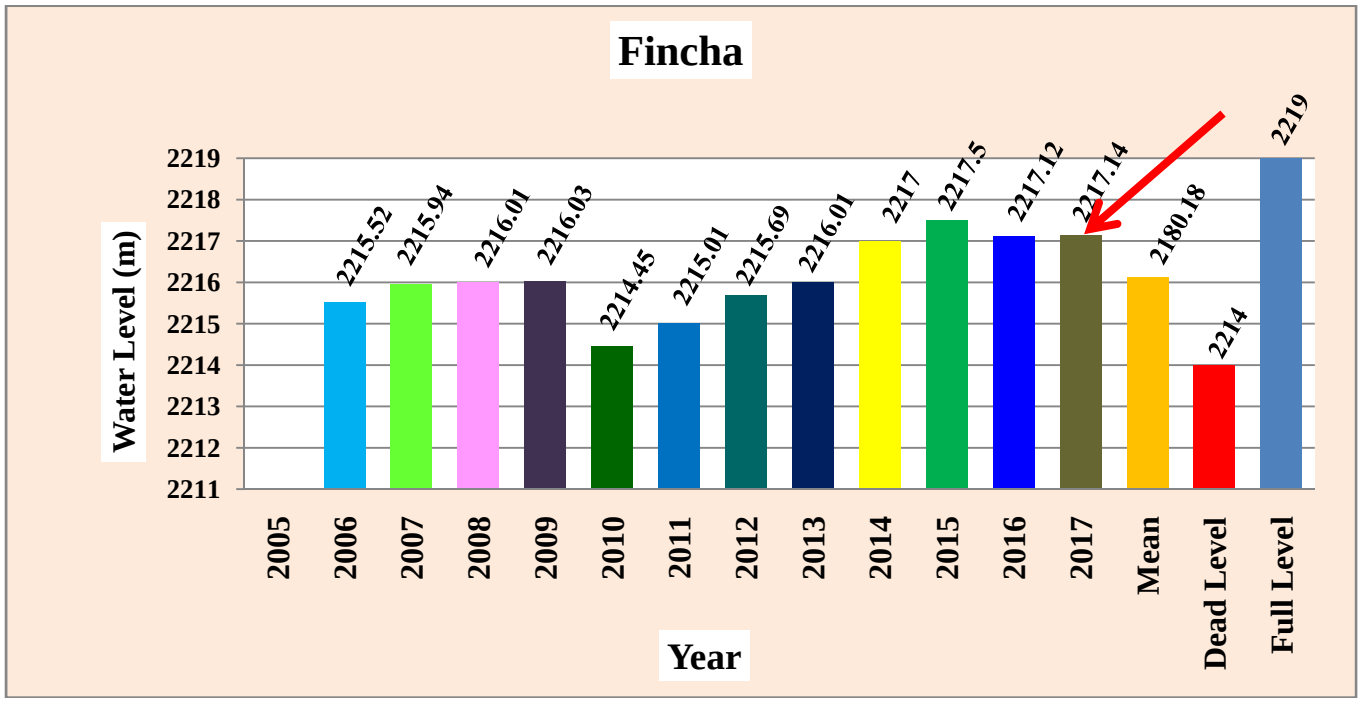


Data source: EEPU

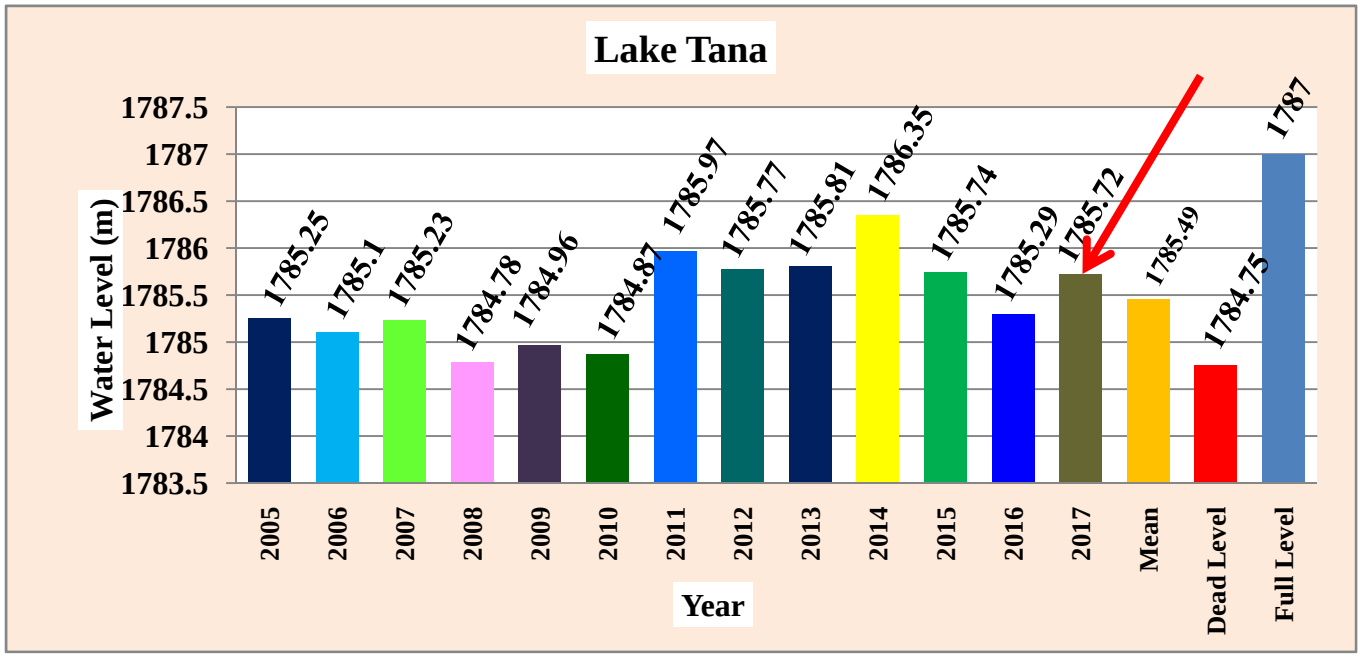
3b.


Melka Wakena
Water Level (m)
2522
2520
2518
2516
2514
2512
2510
2508
2506
2504
2502
2513.21
2511.55
2512.77
2508.87
2508.54
2515.26
2508.88
2513.35
2513.42
2513
2508.96
2512.37
2511.97
2511.73
2509
2520.7
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Mean
Dead Level
Full Level
Year

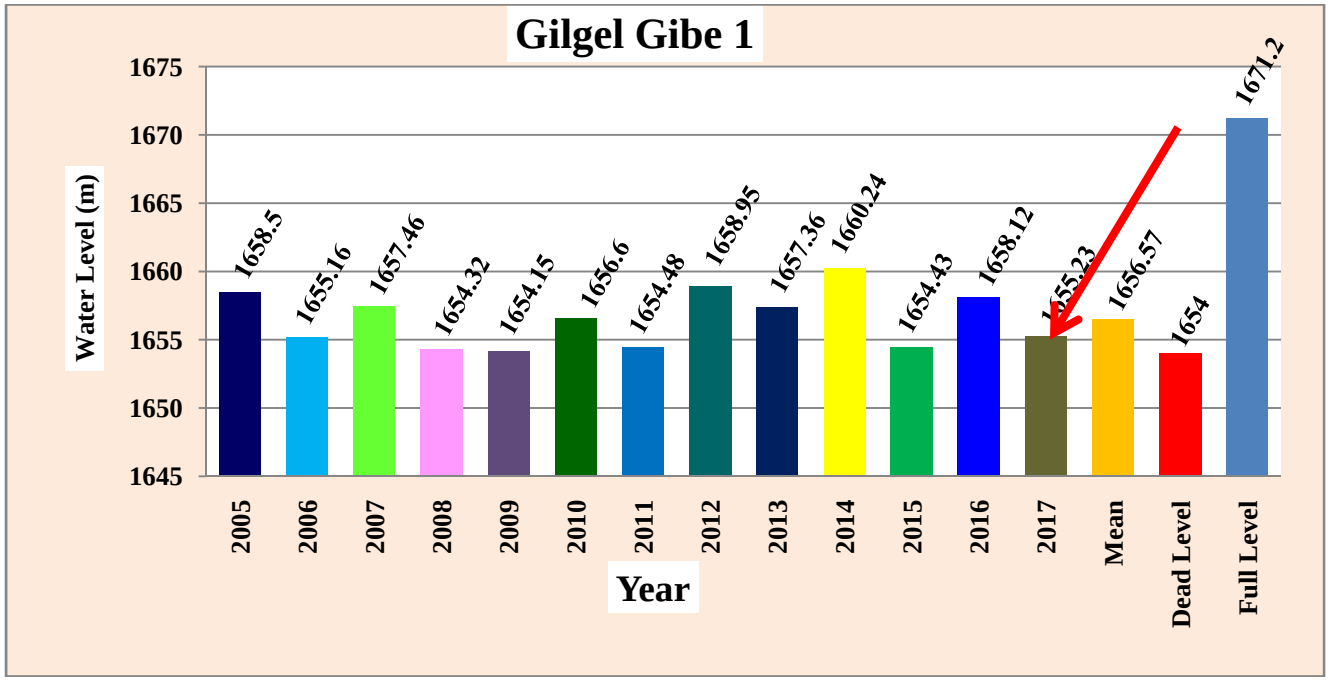
3c.


Fincha
Water Level (m)
2219
2218
2217
2216
2215
2214
2213
2212
2211
2215.52
2215.94
2216.01
2216.03
2214.45
2215.01
2215.69
2216.01
2217
2217.5
2217.12
2217.14
2180.18
2214
2219
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Mean
Dead Level
Full Level
Year

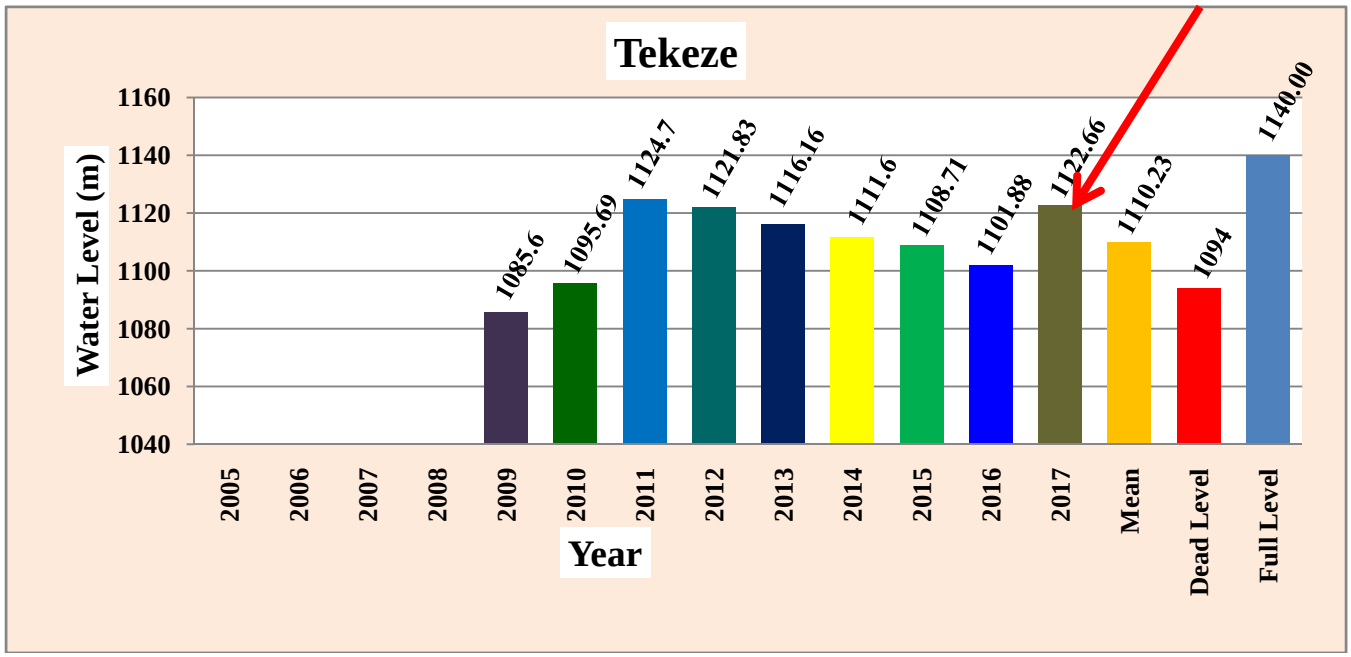
3d.


Lake Tana
Water Level (m)
1787.5
1787
1786.5
1786
1785.5
1785
1784.5
1784
1783.5
1785.25
1785.1
1785.23
1784.78
1784.96
1784.87
1785.97
1785.77
1785.81
1786.35
1785.74
1785.29
1785.72
1785.49
1784.75
1787
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Mean
Dead Level
Full Level
Year

3e.


Gilgel Gibe 1
Water Level (m)
1675
1670
1665
1660
1655
1650
1645
1658.5
1655.16
1657.46
1654.32
1654.15
1656.6
1654.48
1658.95
1657.36
1660.24
1654.43
1658.12
1655.23
1656.57
1654
1671.2
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Mean
Dead Level
Full Level
Year

3f.



(Fig.3a-f) Water level of different dams.

4. Seasonal aridity depth of Belg, 2017

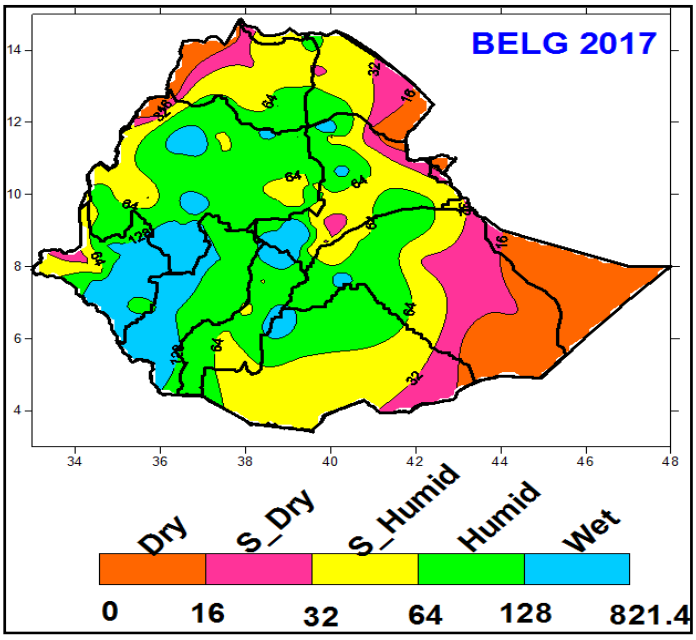


Fig. 4a. Seasonal aridity depth of Belg, 2017

Summary of Belg, 2017 season

Most of Belg rain benefiting catchments of north eastern, central, eastern and south eastern catchments were received normal to below normal amount of rainfall. According to this most parts of eastern Abay, south eastern Tekeze, south western Afar Denakil, upper Awash, most places of Baro Akobo and Rift valley, over all Omogibe, upper Genale Dawa and upper Wabishebele were performed humid to wet condition. The rest lower parts of Genale Dawa and Wabishebele, all parts of Ogaden, middle and lower Awash, most parts of Afar Denakel and Tekeze and some parts of lower Abay and Baro Akobo catchments were experienced semi dry to dry condition. From February to May, the occurrence of heavy fall were observed over all catchments except lower Wabishebele, all Ogaden and some pocket places of Tekeze, Abay, Afar Denakil, Awash and Rift Valley catchments. The occurrence of heavy fall caused flash flood and land slide cause loss of life and property. However, good availability of rainfall contributed for runoff and enhanced the level of dams and reservoirs. Due to this, Koka, Fincha, Lake Tana and Tekeze are show slight increment of water level. In addition to this the water level status is better as compare to 2016 Belg season over those dams. In general Belg 2017 season rainfall performance was experienced mostly with wet condition in April and May over western half and central basins of the country.

Part two

Hydro meteorological outlook for the coming Kiremt, 2017 over different river basins.

1. Introduction

The availability of water resource depends mainly on the performance of the two seasons that is Kiremt and Belg rainfall. Kiremt season is the main rainy season which occur high flow of river water across most basins. It has significant importance for water resource of the country. Dams, reservoirs and ponds can capture the highest volume of water during this season. The upper catchments of all main river basins are benefited for Kiremt rainfall. The occurrence of flood and land slide is widely known phenomenon in flood prone areas and rugged surface of the country during Kiremt season respectively.

2. Selected analogue Year

For the coming season the selected analogue year **1982, 1997, 2002, 2006, 2009 and 2012** were compared based on probabilistic seasonal forecast for **Kiremt 2017** and viewed out on catchments based map using geostatistical kriging method. Among those are **2002, and 2006** are the best analogue year that can enlighten the Aridity status in the coming Kiremt season.

3. Methods

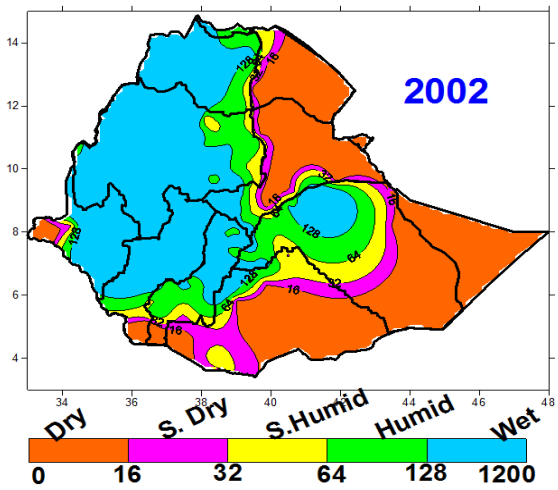
Thornthwaite introduced the concept of the precipitation effectiveness index, which is computed from the monthly values of rainfall and evaporation. The evaporation is computed empirically from mean monthly air temperature. In assessing the effectiveness of rainfall, in terms of water availability relationships between the rainfall and air temperature has been worked out in terms of moisture indices.

Where, Rf= monthly rainfall in mm;

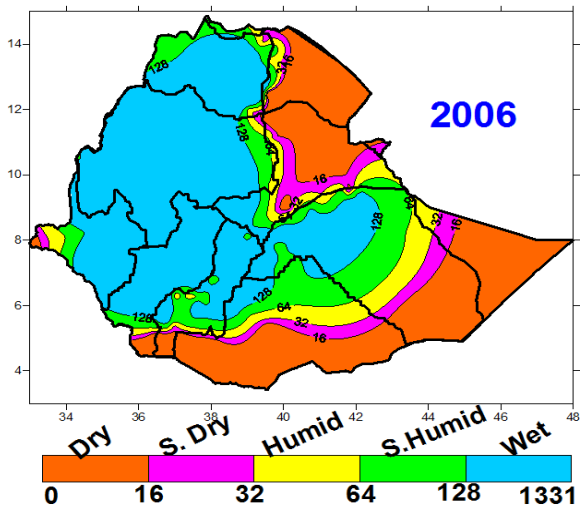
T = mean monthly temperature in C°

3.1 June- The wet weather condition was observed over western half of the country. According to this most of Abay, OmoGibe and BaroAkobo and lower and middle parts of Tekeze, upper Rift Valley, some parts of upper Wabishebele, upper Awash and upper GenaleDawa were performed wet condition shown below in Figure(3.1a-b).

3a.

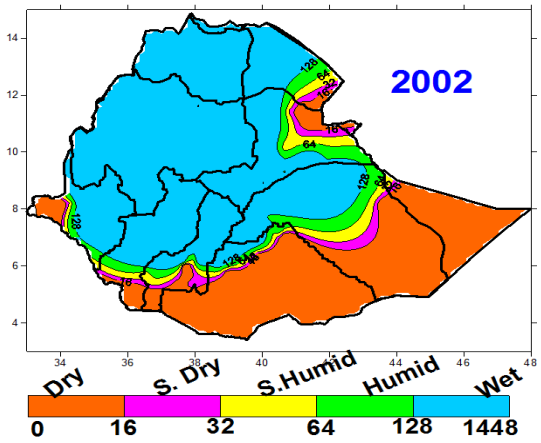


3b.

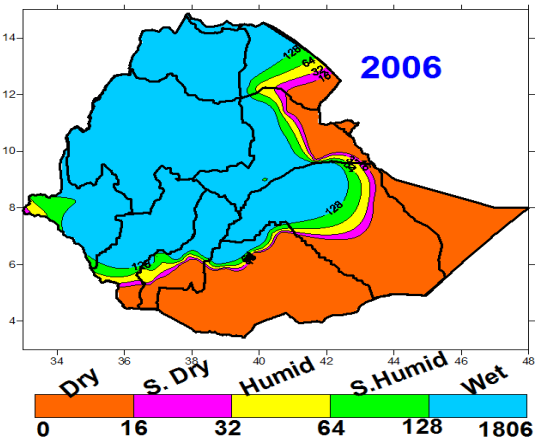


3.2 July- The wet weather condition was covered over most parts of upper catchments including eastern catchments of main river basins. High aridity index was performed during the two analogue years shown below in Figure(3.2a-b).

3.2a

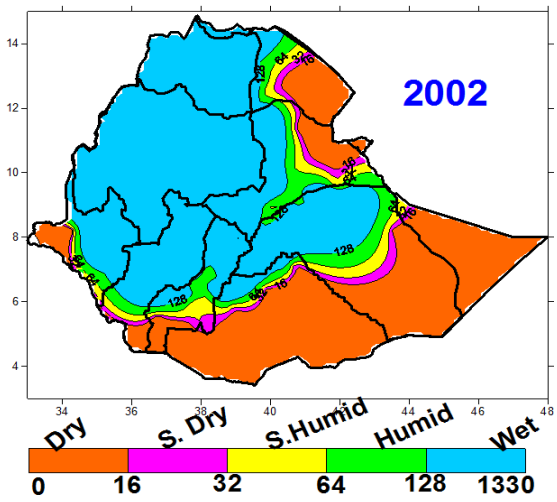


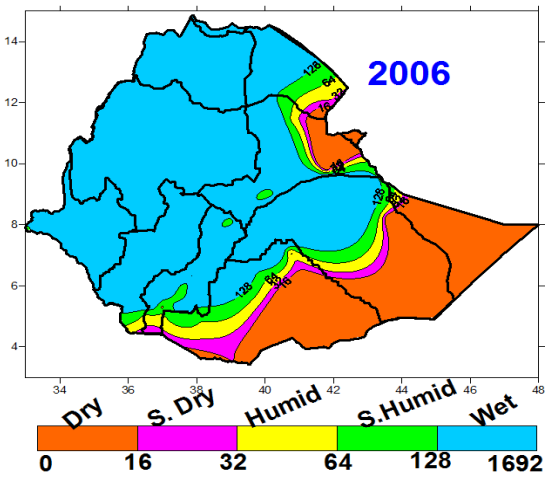
3.2b



3.3 August- The wet weather condition and high aridity index was observed over most parts of upper and middle catchments of all Kiremt rain benefiting river basins based on the analogue years shown below in fgure(3.3a-b).

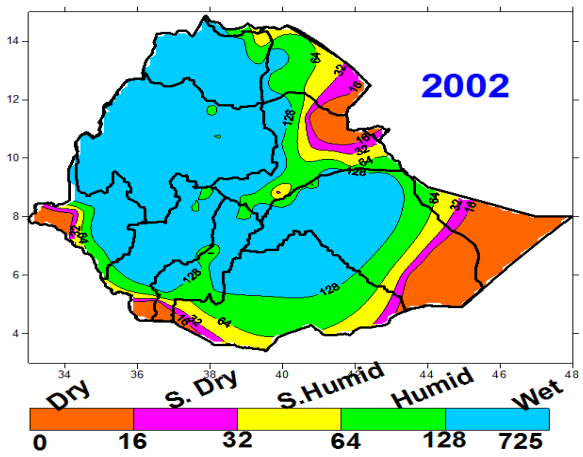
3.3a **3.3b**

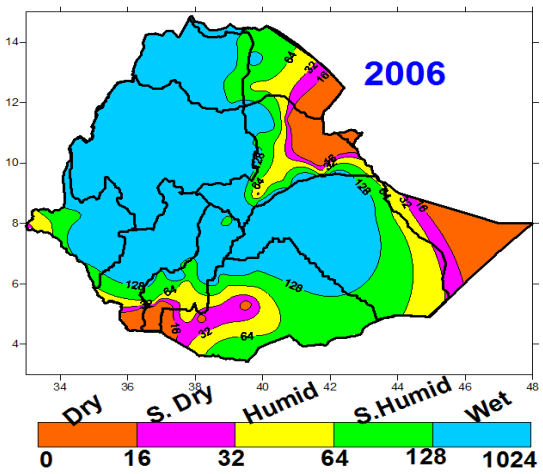




3.4 September- The spatial coverage of wet condition was extended towards eastern, south eastern and southern catchments. Accordingly in addition to the western catchments over middle and lower Genaledawa and Wabishebele catchments were performed wet to humid condition based on both analogue years shown below in Figure(3.4a-b).

3.4a **3.4b**

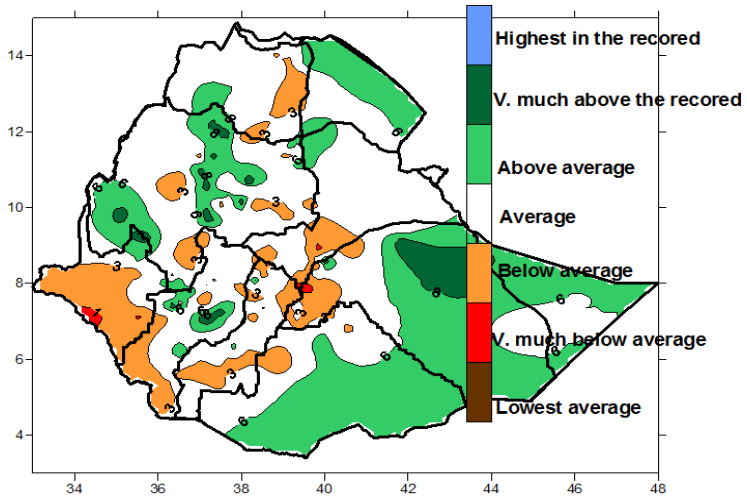




4. Decile rainfall ranking analogue year for Kiremt 2017 season

Based on analogue year 2002 the above average and average the recorded rainfall distribution was observed over western, northern and eastern catchments and average and below average rainfall ranking was observed most of central and south western catchments of main basins. Based on analogue year 2006 above average and average rainfall ranking was observed over most Kiremt benefiting river basin shown below figure (4a -b).

4a. Kiremt 2002



4b. Kiremt 2006

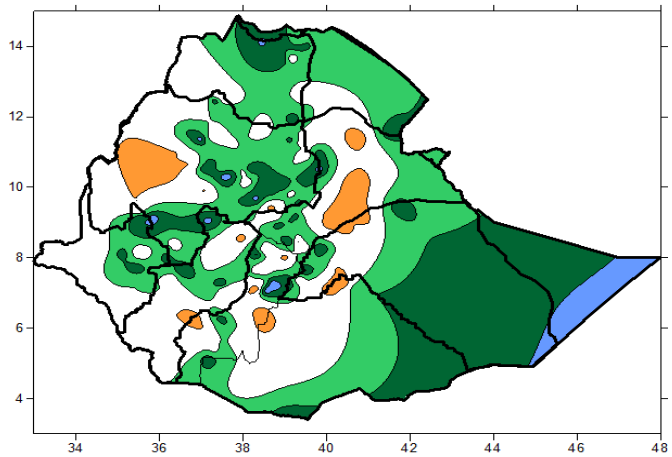


Fig.4a-b Kiremt, 2002 and 2006 decile rainfall ranking

5. Tercile rainfall probability for Kiremt 2017 season

The rainfall tercile probability map also indicated that western catchments of most of Abay, BoroAkobo, Tekeze and upper OmoGibe catchments will be perform normal tends to above normal rainfall. Central, eastern half and northern parts of Kiremt benefiting catchments of the country will have normal to below normal rainfall. Lower Wabishebele, Ogaden and middle and lowr Genaledawa catchments will have high probability of enhanced rainfall shown below in figure(5a)

5a.

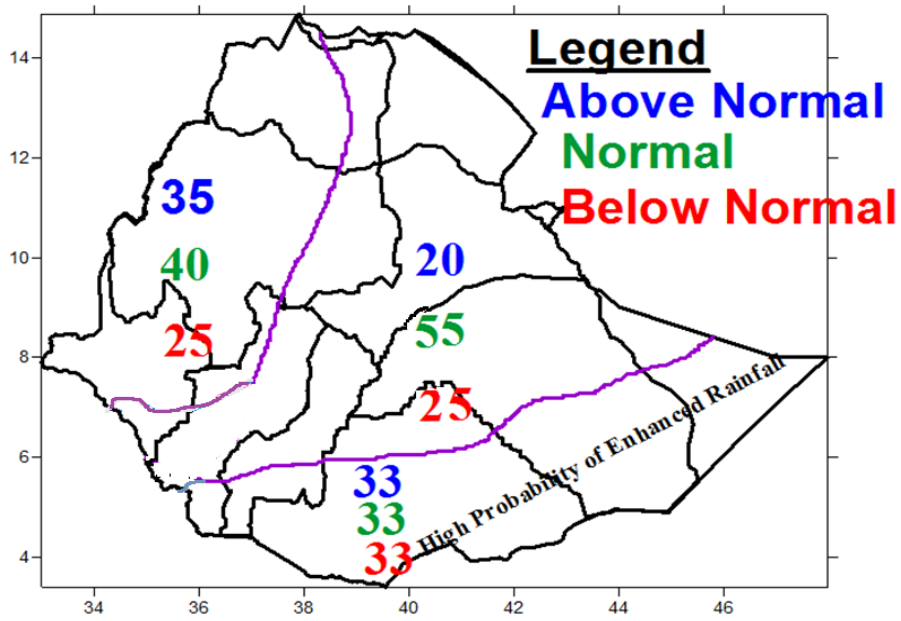


Fig. 5a. Tercile probability for Kiremt ,2017

Conclusion

In the coming Kiremt, during June some parts of upper of Tekeze, middle Awash, upper Wabishebele and eastern Abay catchments will experienced humid to semi dry condition. From July to September all kiremt benefiting catchments will be remain under wet condition. The occurrence of heavy fall is significant across many portions of Kiremt rain benefiting basins. As a result, probability of flood, flash flood and land slide is expected at places of flood prone area and rugged places of the country respectively. Reservoirs and dams such as Tana beles, OmoGibe1 and Fincha have high probability than Koka, Tekeze and Wabishebele to capture better amount of water during the coming season. Sectors involving water development and early warning activities should be aware and prepared to manage this seasonal water resource.