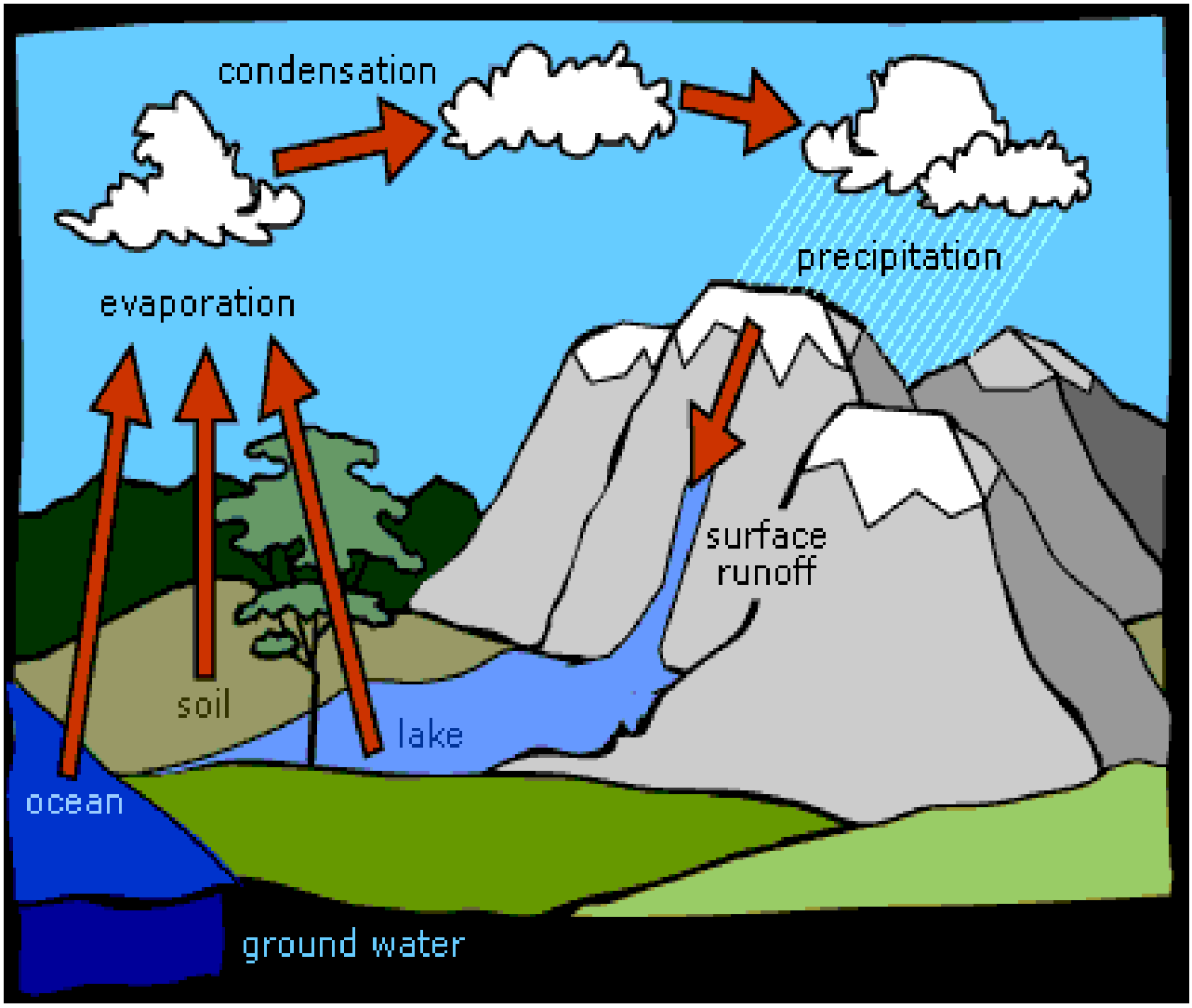
Ethiopia Meteorology Institute



Hydro Meteorological and Flood monitoring Bulletin for Belg, 2023

Assessment and Kiremt outlook for 2023

This seasonal hydro meteorological bulletin is prepared and disseminated by the Ethiopia Meteorological Institution (EMI) 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

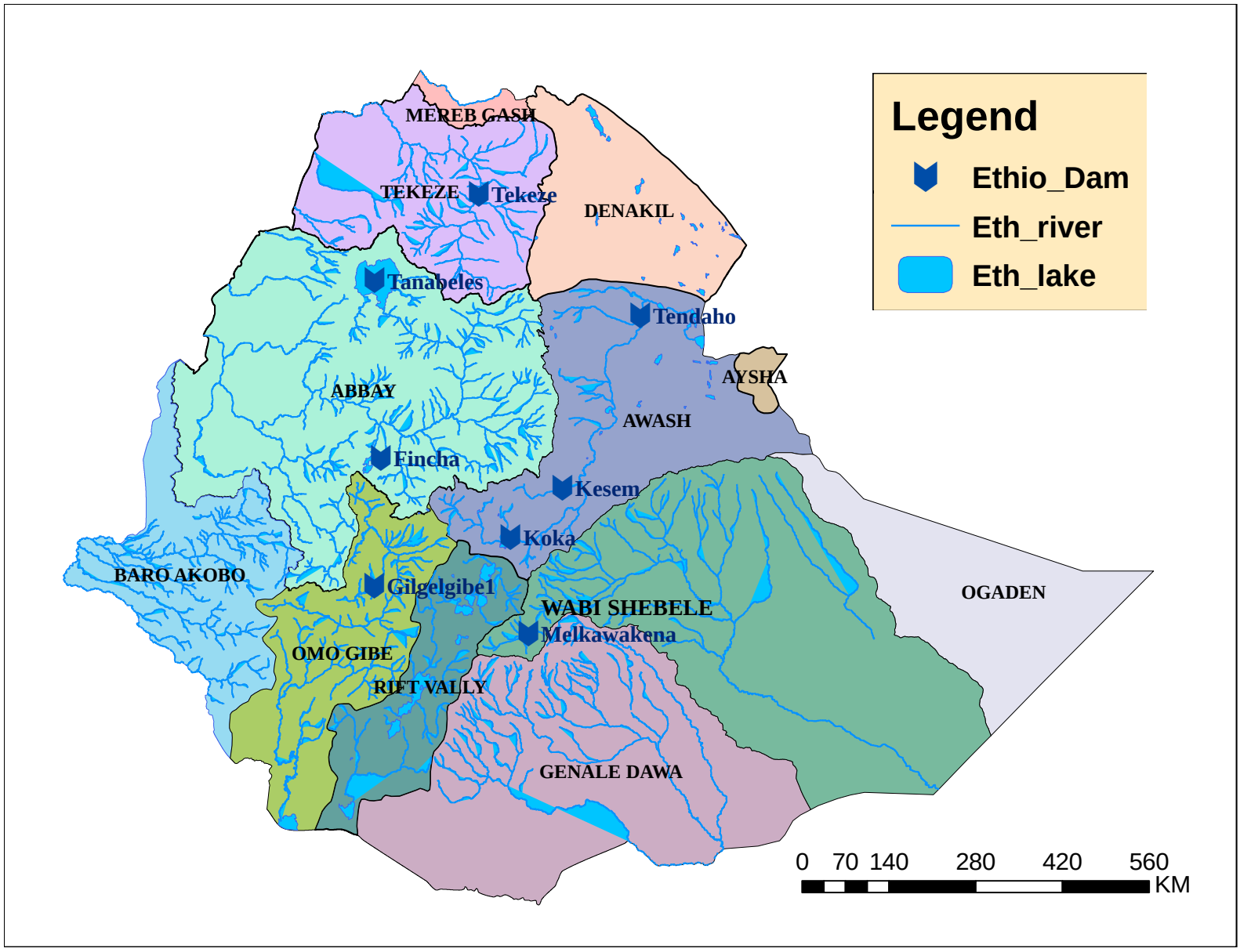
Catchment	**Location**
Mereb – Gash Catchment: -	Northwestern tip of Tigray.
Atbara-Tekeze Catchment: -	The Tekeze river basin is situated in the northwest of Ethiopia between 11 ^{0}40` and 15 $^0$12` N, and 36 ^{0} 30` and 39$^0$ 50` E. It is bordered by the Mereb river basin and by Eritrea in the 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 constitutes three river systems namely Dawa, Genale and Wabi Gestaro that meet each other before they cross the Ethio-Somalia border.

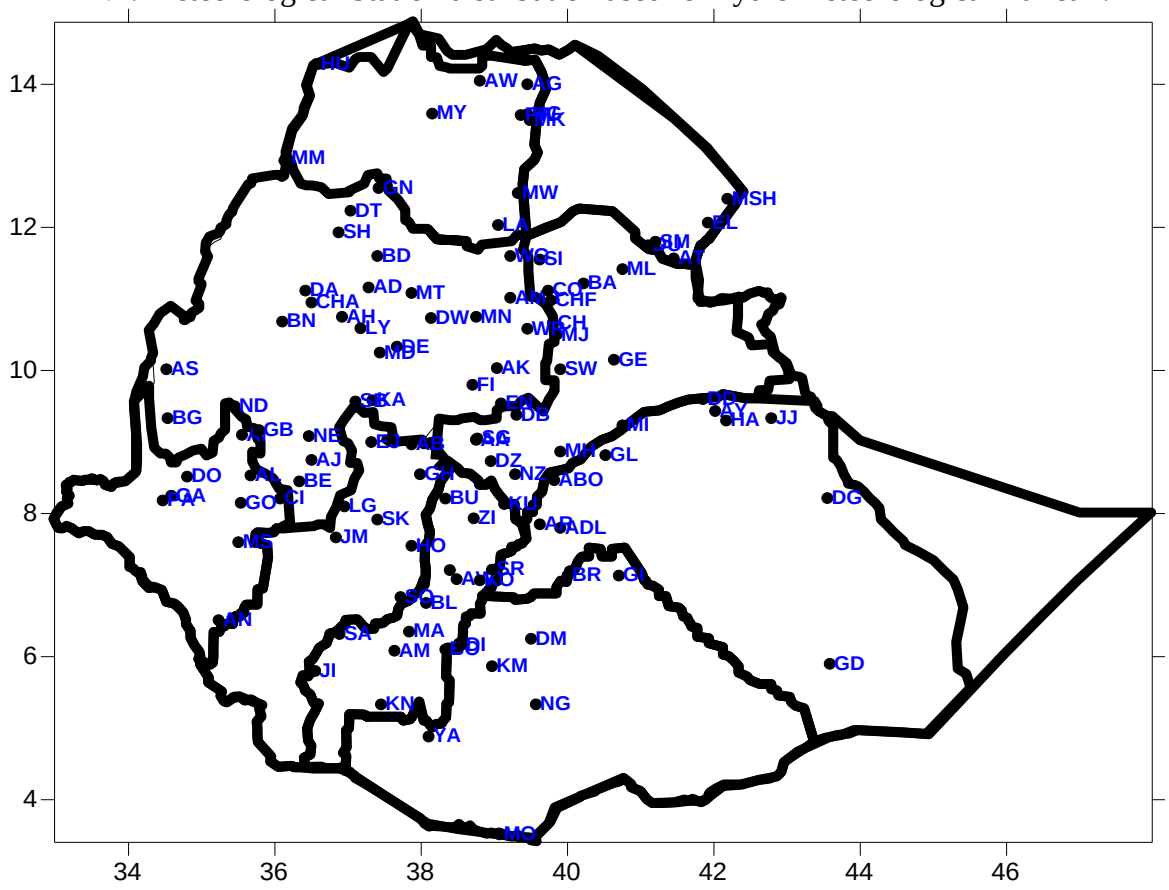
IV. Major River Catchments in Ethiopia, Location and Spatial Status

No.	Catchement Name	Area ($km^{2)}$	Length in Kilo meter			Volume of water bm^3/Annum	Altitude (meter)
			Within Eth.	Outside Eth.	*Total*		***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

V. Basin map of Ethiopia



VI. 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 EMI. 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.

1. Introduction

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.

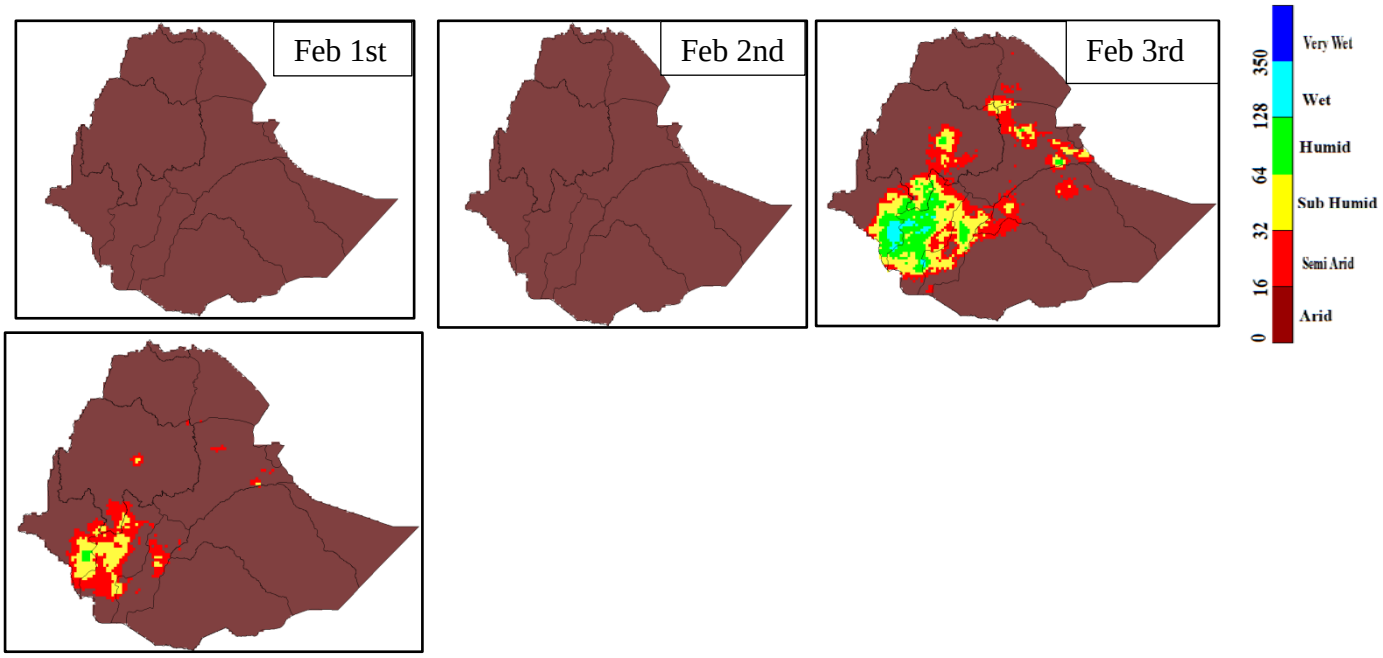
Methods

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 350 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

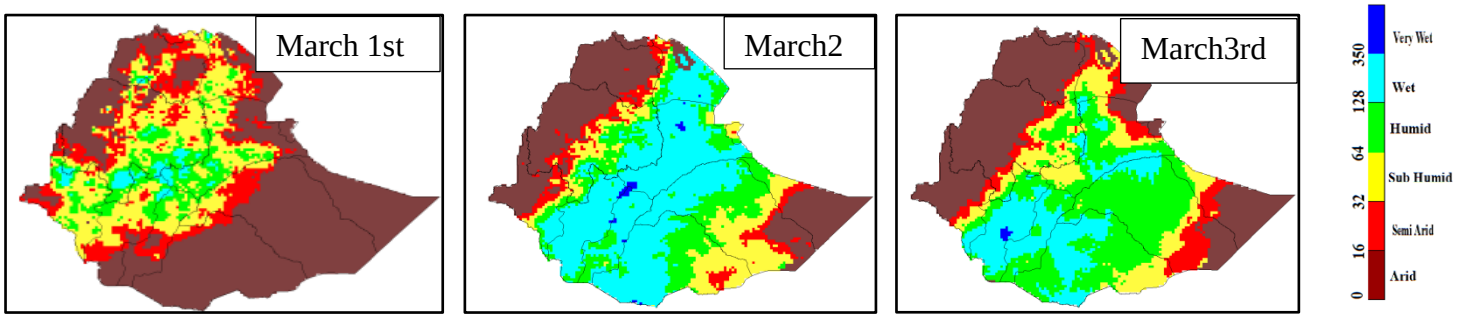
2. Aridity status for Belg, 2023 over different basins

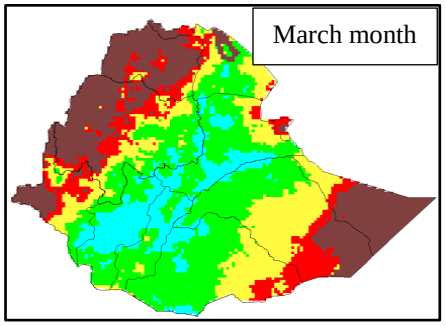
The moisture performance of February was insignificant over all river basins. According to this all catchments were remained under dry condition. After March 3rd some parts of Belg benefiting catchments were received rainfall. In line with this most of Omo Gibe, rift valley, genale dawa ,upper and middle wabe shebele and awash were observed humid to wet condition. During April among Belg benefiting catchments across most of Abay, Rift valley, Omo Gibe, lower GenaleDawa, middle Awash, some parts of upper Tekeze and eastern Abay were experienced humid to wet condition. The better moisture performance was saw during April and May over all main Belg benefiting catchments shown below in figure (1a-d).



February:

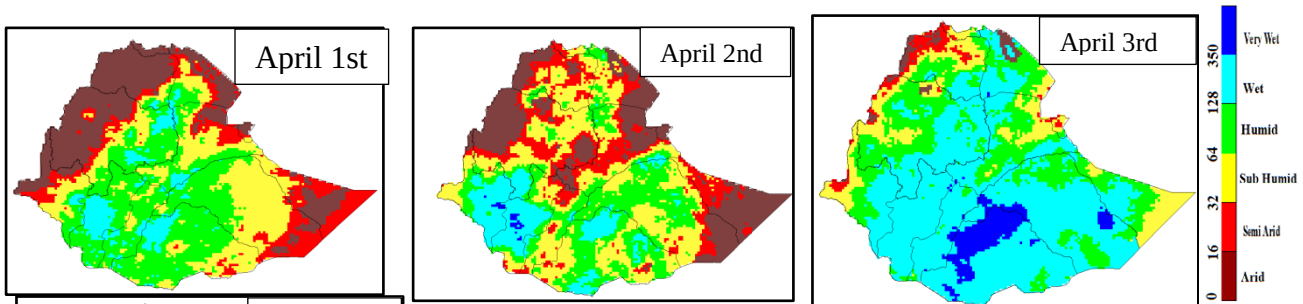
Most catchments was preformed Arid to semi-Arid humid condition except 3rd Decaked of upper BaroAkobo and most parts Omo Gibe, few place of middle Abay. Whereas, most parts of belg benefiting catchments leads to moisture stress.

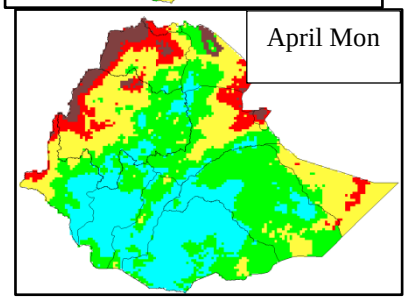




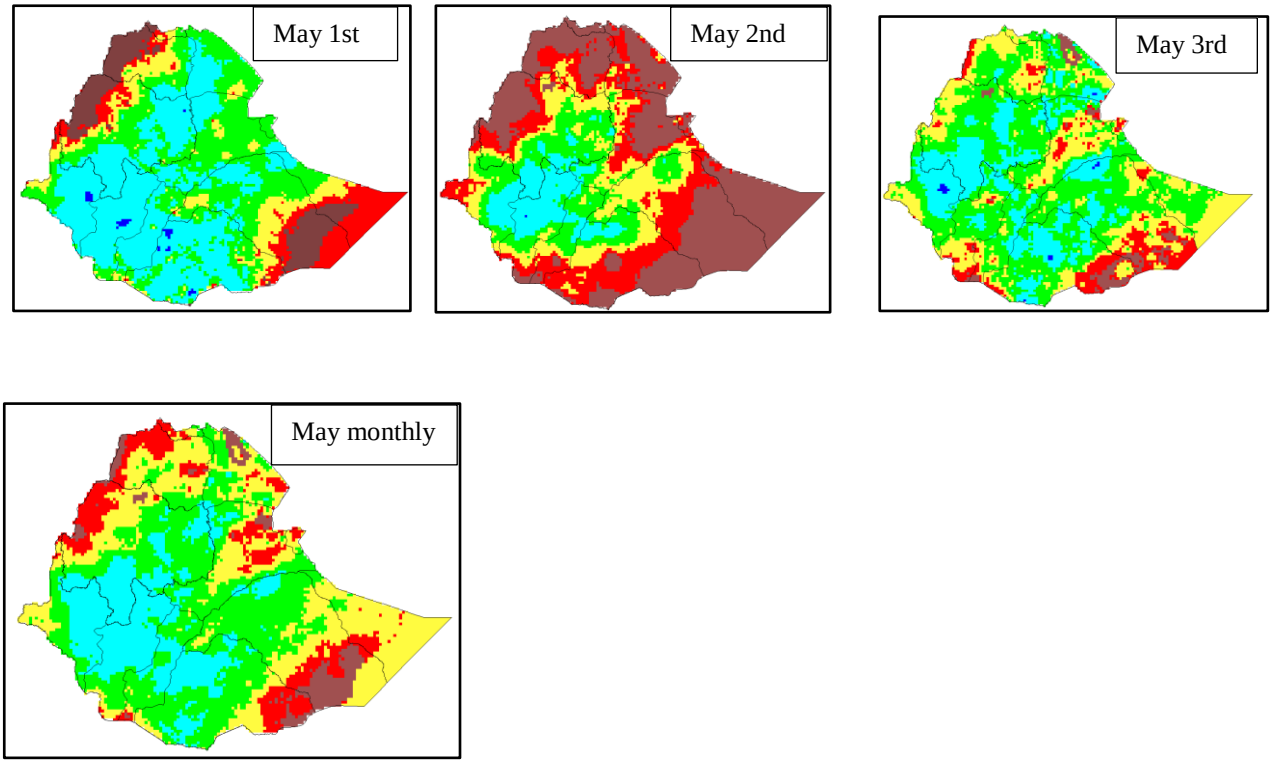
March:

During March, most part of Genale Dawa, Omo Gibe, Awash, upper BaroAkobo, Rift Valley, middle and eastern Abay, upper and middle Wabishebele catchments were preformed sub humid to wet moisture condition





April:- in this month Better moisture *distribution* performed across most of Belg benefiting catchments. In line with this: most parts of BaroAkobo, Wabishebele, Awash, OmoGibe, Rift valley, GenaleDawa, middle and eastern Abay catchments were performed under **Humid** to wet moisture condition.



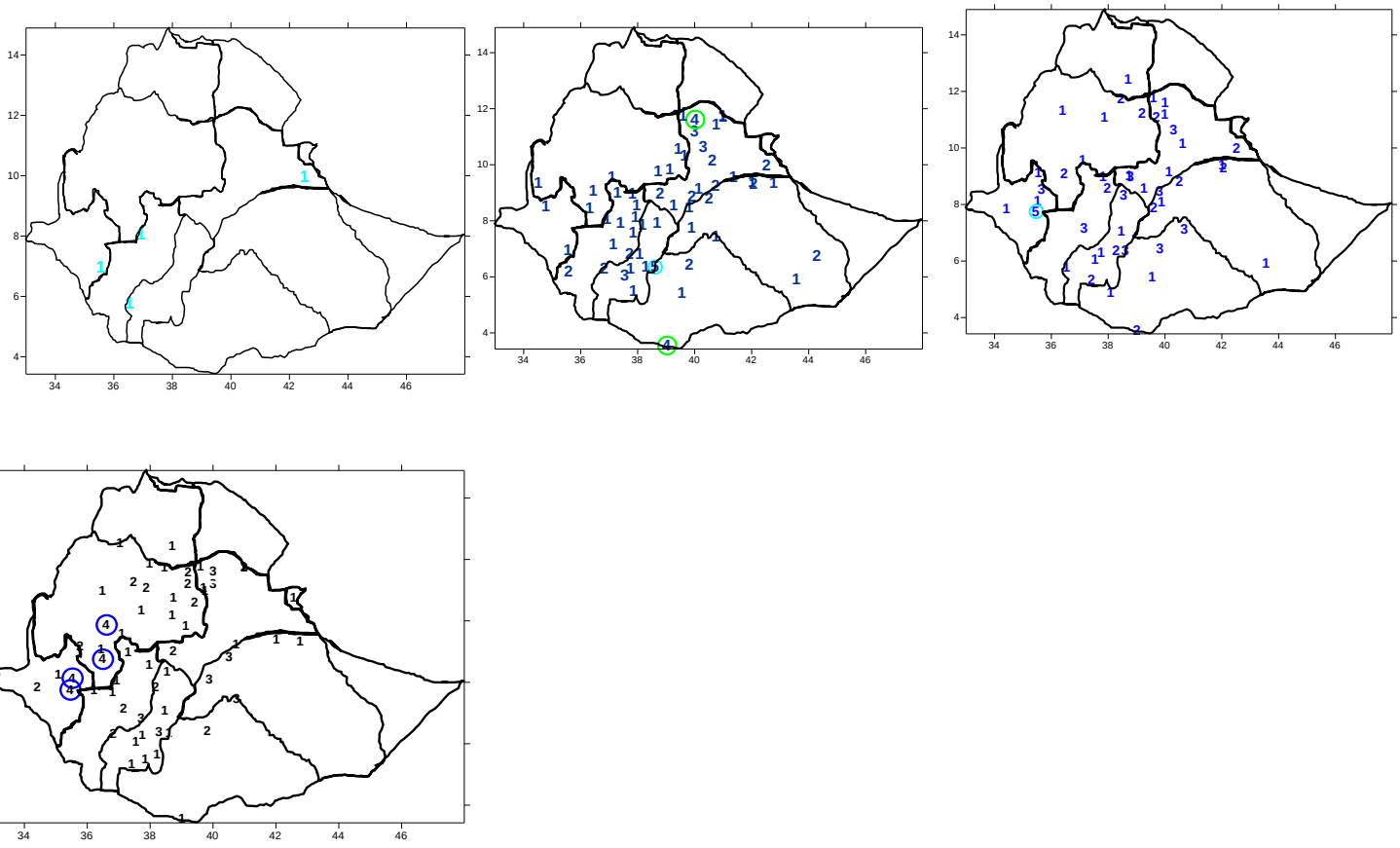
(Fig.1a-d) Aridity Index from February to May, 2023.

3. **Distribution of heavy fall days exceeding 30mm from February to May, 2023 over different river basins.**

The occurrence of heavy fall in this season also was observed during February to May. During February ware no recorded heavy fall all over the catchment except, upper Baroakobo and Omo gibe .During **March** the occurrence of heavy fall distribution was increased compared to the previous month, hence adjacent place of upper Wabishebele, Genaledawa, Omogibe, BaroAkobo, middle and eastern Abay and middle awash catchments were received for one - five days over different stations in the Awash catchments and maximum amount of heavy fall was 107 mm at Dalifagi station. April the occurrence of heavy fall were observed

over most Belg moisture benefiting catchments, hence most of Wabishebele, Omogibe, Rift Valley, Genaledawa, eastern Baroakobo, upper and middle Awash, some parts of southern and eastern Abay and upper Tekeze catchments were received from one to three days. The frequency of heavy fall days was recorded over OmoGibe and BaroAkobo, Genaledawa and Rift valley basins for one to Five days. Maximum of heavy fall on April was 230 mm recorded at kebridar stations on Wabeshebele basin. May month ware heavy fall recorded south western and western catchments such as most Baro Akobo, lower Abay, upper and middle Omo gibe. Maximum rainfall April recorded 100.6 at Hagermariam station.

(2a-d).

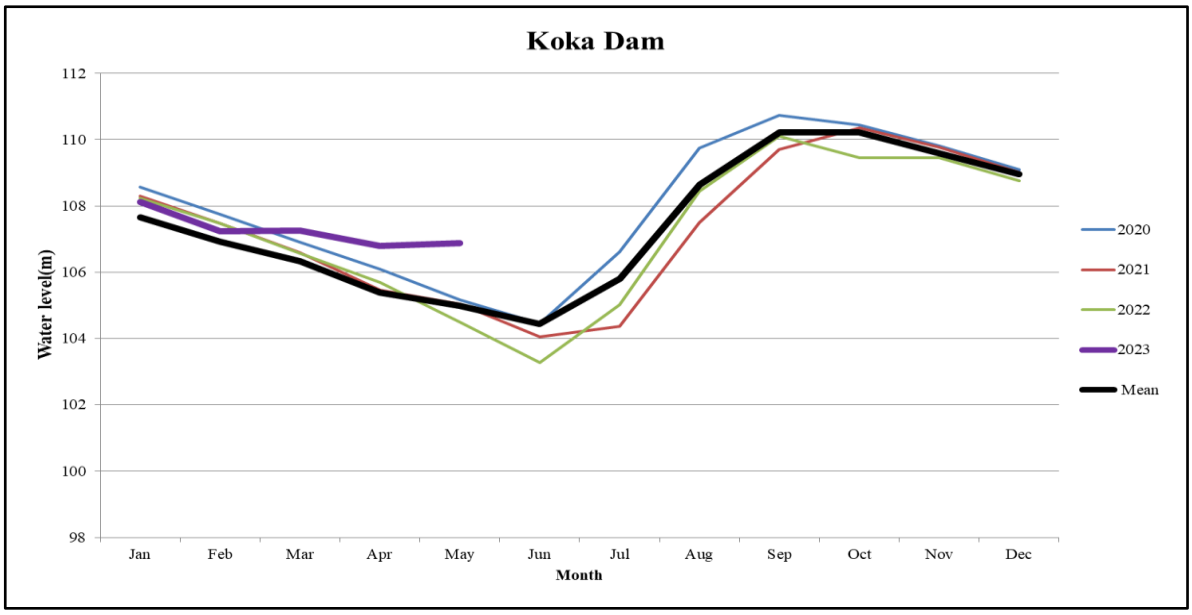


(Fig.2a-d) Distribution **of heavy fall from February to May, 2023**

4. Performance of Dams and Reservoirs water level in Belg, 2023 season

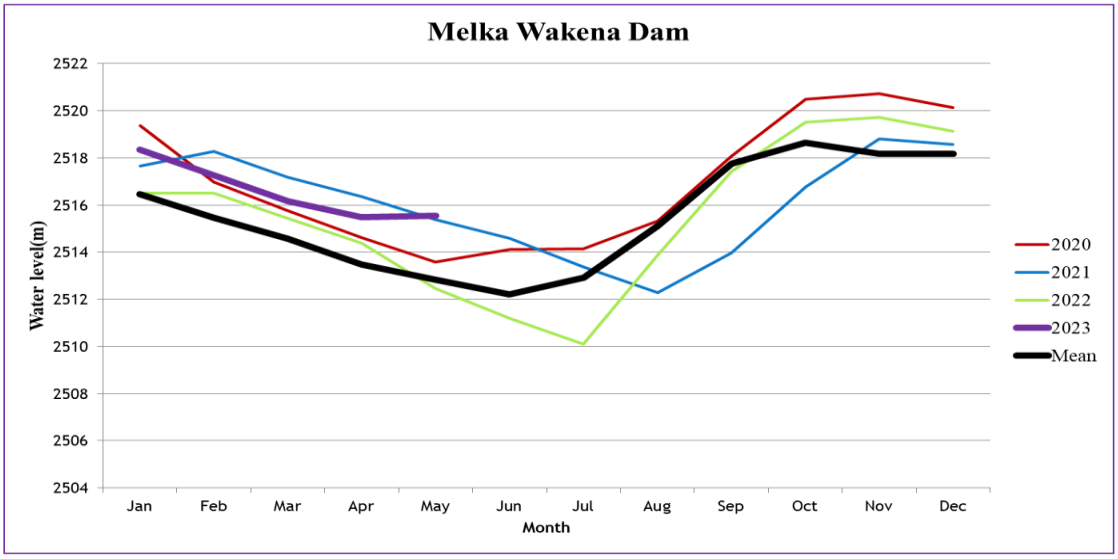
The main source of runoff is rainfall which is the input for Dams, reservoirs and ponds but from Bega season to end of Belg season runoff is very little and flow of river is low. According to this at the end of Belg season the level of water in river, ponds, reservoirs and dams reaches at low level. In the case of 2023 Belg season rain fall had better contribution for water resource. In line with this the performance of 2023 Belg season water level of all dams and reservoirs shown increment of water level. The current performance of most dams and reservoirs in the end of Belg season is shown above compare to the previous years and long mean (3a-f).

3a.

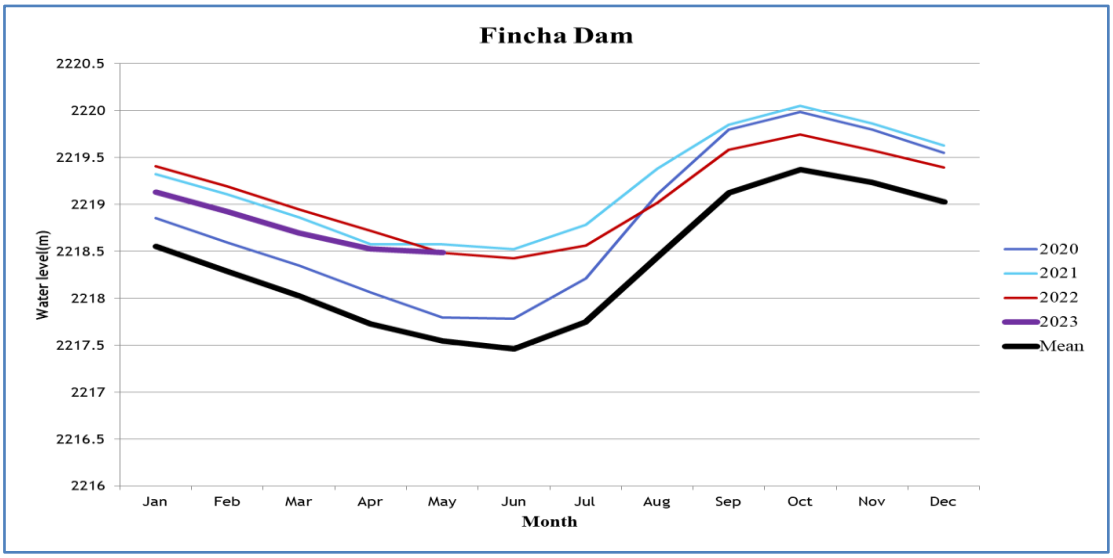


Data source: EEPU

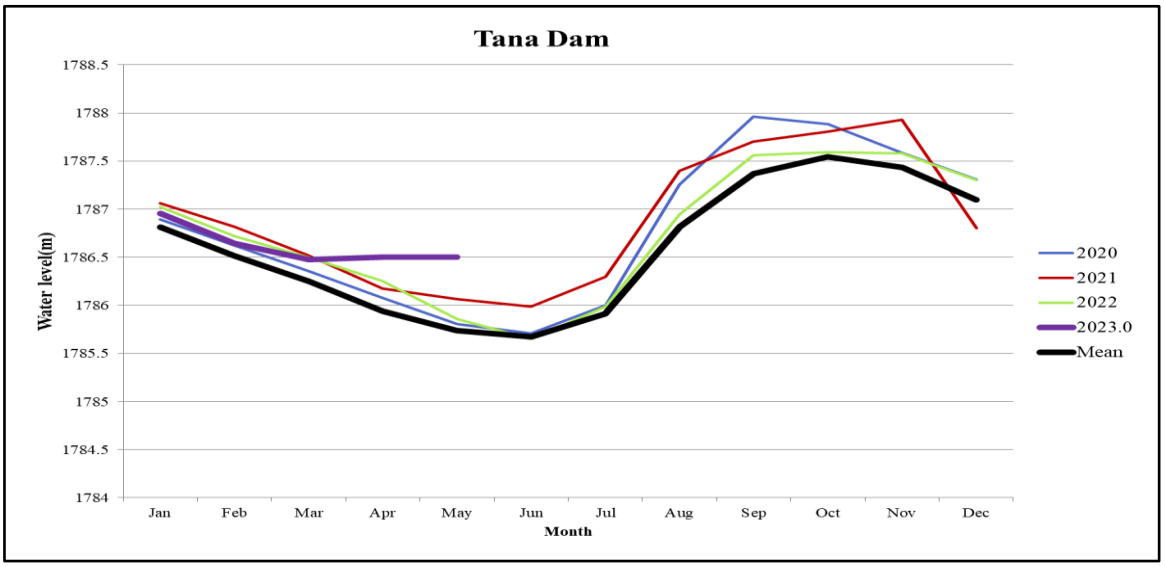
3b.



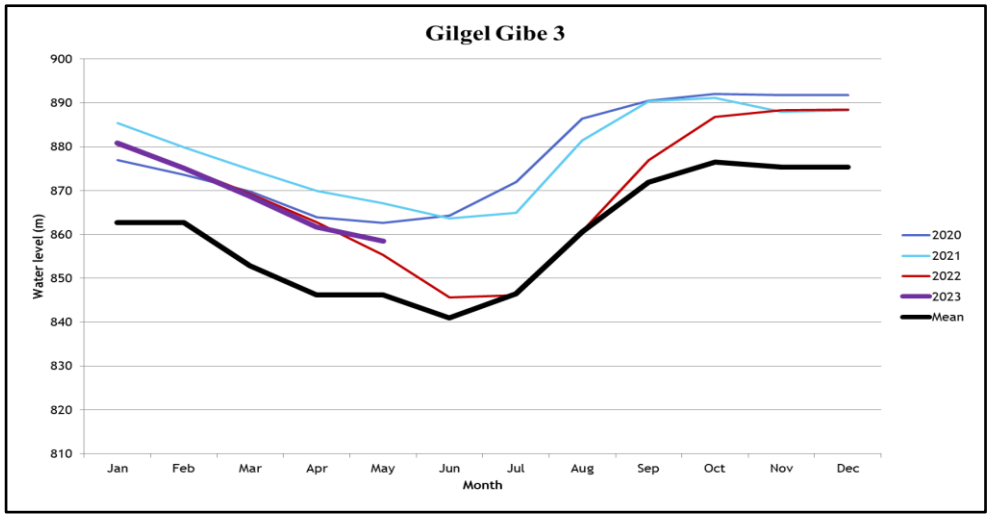
3c.



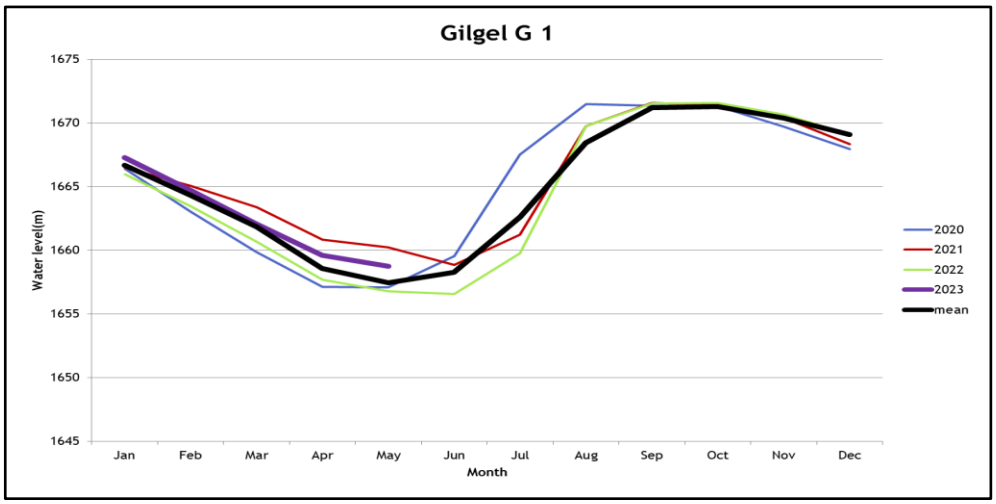
3d.



3e.



3f



(Fig.3a-e) water level of different dams and reservoirs.

Summary of Belg, 2023 season

In the month of February all catchments were remained under arid condition. March most parts of Belg benefiting catchments were received humid to wet moisture. The river basins which were got rainfall during this month had a chance to harvest rain water. During April all Belg benefiting catchments were experienced wet to humid condition and the better moisture performance was observed. This condition had better contribution for water recourse to minimize the shortage of water. In addition to this most dams along Belg benefiting catchments were shown increment of water level. May month many catchments including western and north western catchments received rainfall.

The occurrence of heavy fall was observed during March to May all main river basins. The impact of this event had both negative and positive consequence along those catchments which received heavy fall. The benefiting impact of heavy fall due to high amount of water volume is contributed for the availability of surface and ground water. In the other way short period of duration and intensive amount of heavy fall is the cause of flash flood and landslide. In the case of these phenomena along Awash, Wabishebele, Rift Valley, GenaleDawa, and OmoGibe catchments were experienced flash flood and land slide.

Hydro-meteorological outlook for coming Kiremt, 2023 over different river basins

1. **Introduction**

Kiremt season is the main rainy season 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 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 **2002**, **2009 and 1997 were** compared based on probabilistic seasonal forecast for coming **Kiremt 2023** and viewed out on catchments based map using geostatistical kriging method. Among those **2009 is** the best analogue year that can enlighten the Aridity status in the coming Kiremt season.

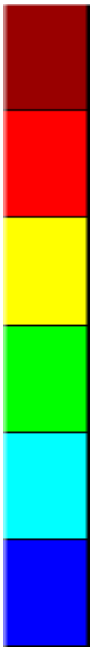
3. Methods

Thornthwait 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;

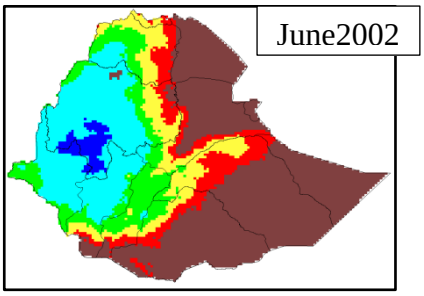
T = mean monthly temperature in C°

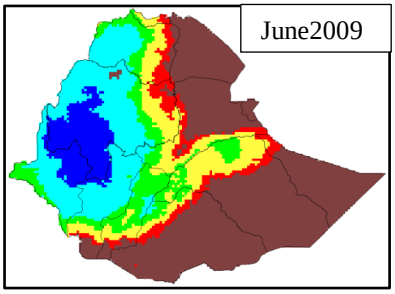
5. **Aridity Index are categorized as RF/PE*100:**

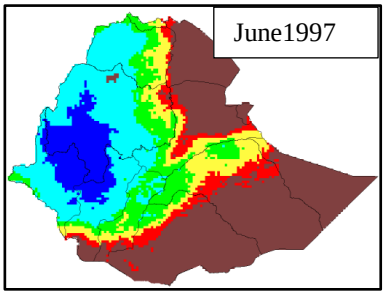
Index	Status	Symbol
< 16	Arid	
16– 31	Semi-Arid	
32 – 63	Sub-humid	
64 – 127	Humid	
128-350	Wet	
>350	Very Wet	

Aridity status for June, 2023

The wet moisture condition observed over south, south eastern, north and western parts of the country. According to this most of Abay, OmoGibe and BaroAkobo, Rift Valley and lower and middle parts of Tekeze, upper Wabishebele, upper and middle Awash and upper GenaleDawa Catchments were under wet condition

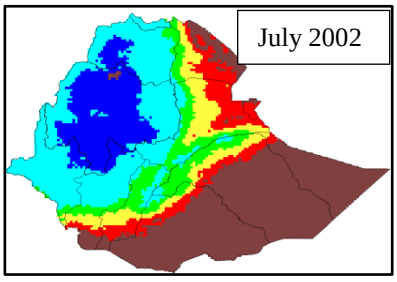


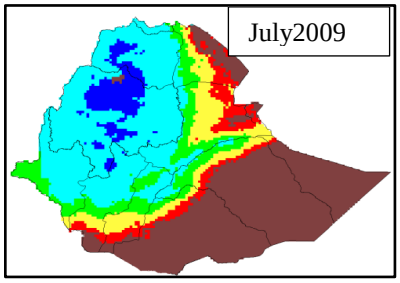


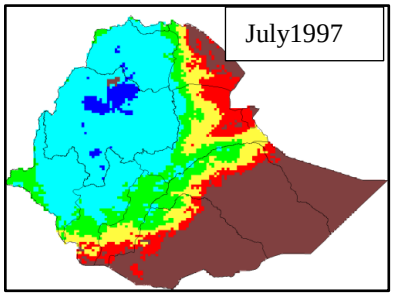


Aridity status for July, 2023

July:-from wet to very wet moisture condition was be experienced over most of Central, south, Western, North and North western catchments of the country. Such as Most of Abay, Tekeze, baro Omo gibe Akobo, apper and middle Awash and upper wabeshebele …etc

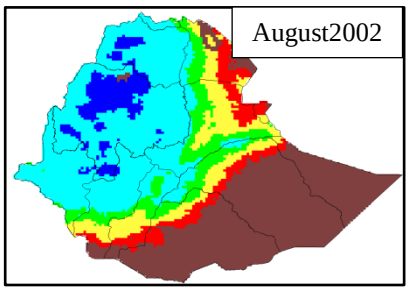


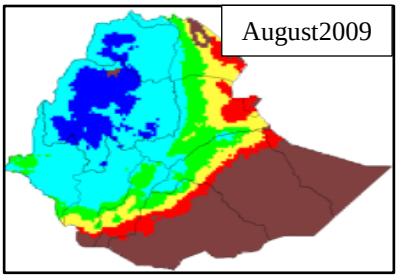


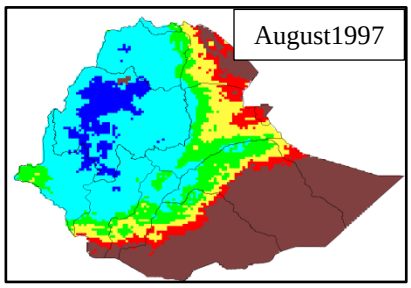


Aridity status for August, 2023

August:- Abay, Tekeze, most part of OmoGibe, Rift valley, upper and middle Awash, GenaleDawa and Wabishebele Catchments experienced under wet to very wet moisture condition.

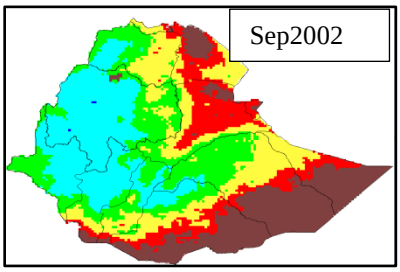


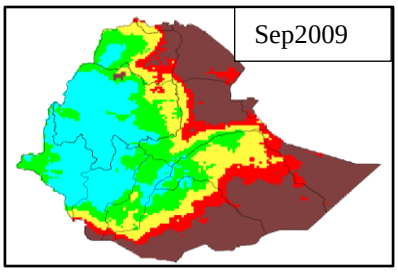


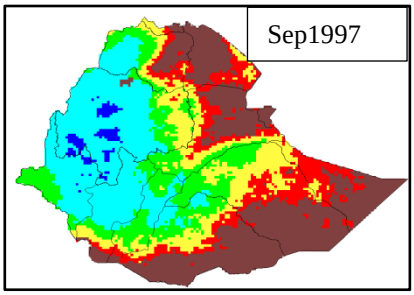


Aridity status for September, 2023

September:- The spatial coverage of wet condition was increased towards North, Southwest and western Catchments of the country, Such as most of Abay, Baro Akobo, Rift Valley and Omo Gibe, upper wabe shebele, Genale and Awash catchments.





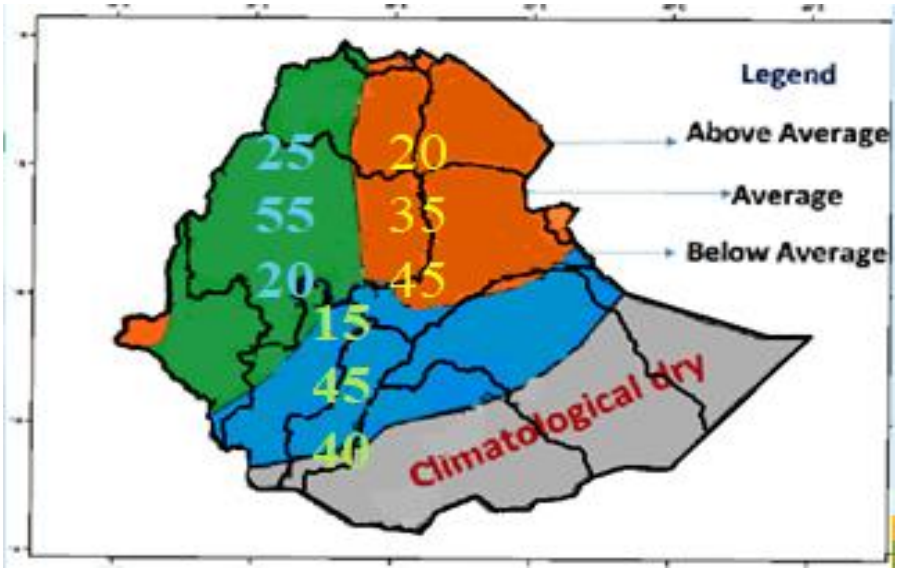


5. Summary of Kiremt (JJAS), 2023:-

- **June:** - The wet moisture condition was experienced over south, south eastern and north eastern parts of the country. According to this most of Abay, OmoGibe and BaroAkobo, upper and middle Rift Valley and lower and middle parts of Tekeze, upper Wabishebele, Awash GenaleDawa Catchments were under wet condition.
- **July**:-from wet to very wet moisture condition was observed over Central, south, Western, North and North western catchments of the country.
- **August:** - Abay, Tekeze, most part of OmoGibe, Rift valley, upper and middle Awash, GenaleDawa and Wabishebele Catchments were under wet to very wet moisture condition. The Aridity was expanded more to the South, South Western, North and North western catchments.
- **September:** - The spatial coverage of wet condition will Decrease towards north to south Catchments of the country shows from selected analogue year.

6. Tercile rainfall probability for Kiremt (JJAS), 2023 season

The rainfall tercile probability map also indicated that except north eastern and south eastern lower cathments of Wabishebele and Genaledawa the rest most of Kiremt benefiting catchments will be remain under normal tends to above normal condition shown below in figure(5a)



Conclusion

Amongst Kiremt rain benefiting catchment during June, except some parts of upper Tekeze, middle awash, Wabishebele and eastern Abay catchments the rest will be experienced wet to humid moisture condition. From July to September all kiremt benefiting catchments will be remain under wet condition. All reservoirs and dams will have a better chance to capture enough water in this Kiremt 2023 season. The occurrence of heavy fall is significant across many portions of Kiremt moisture benefiting basins. Due to this excess rainfall will be expected over Kiremt benefiting catchments. As a result, probability of flood, flash flood, rivers overflow and land slide is expected at places of flood prone area and rugged places of the country respectively. Sectors involving water development and early warning activities should be aware and prepared to protect the adverse effect of intensive rainfall during this season.