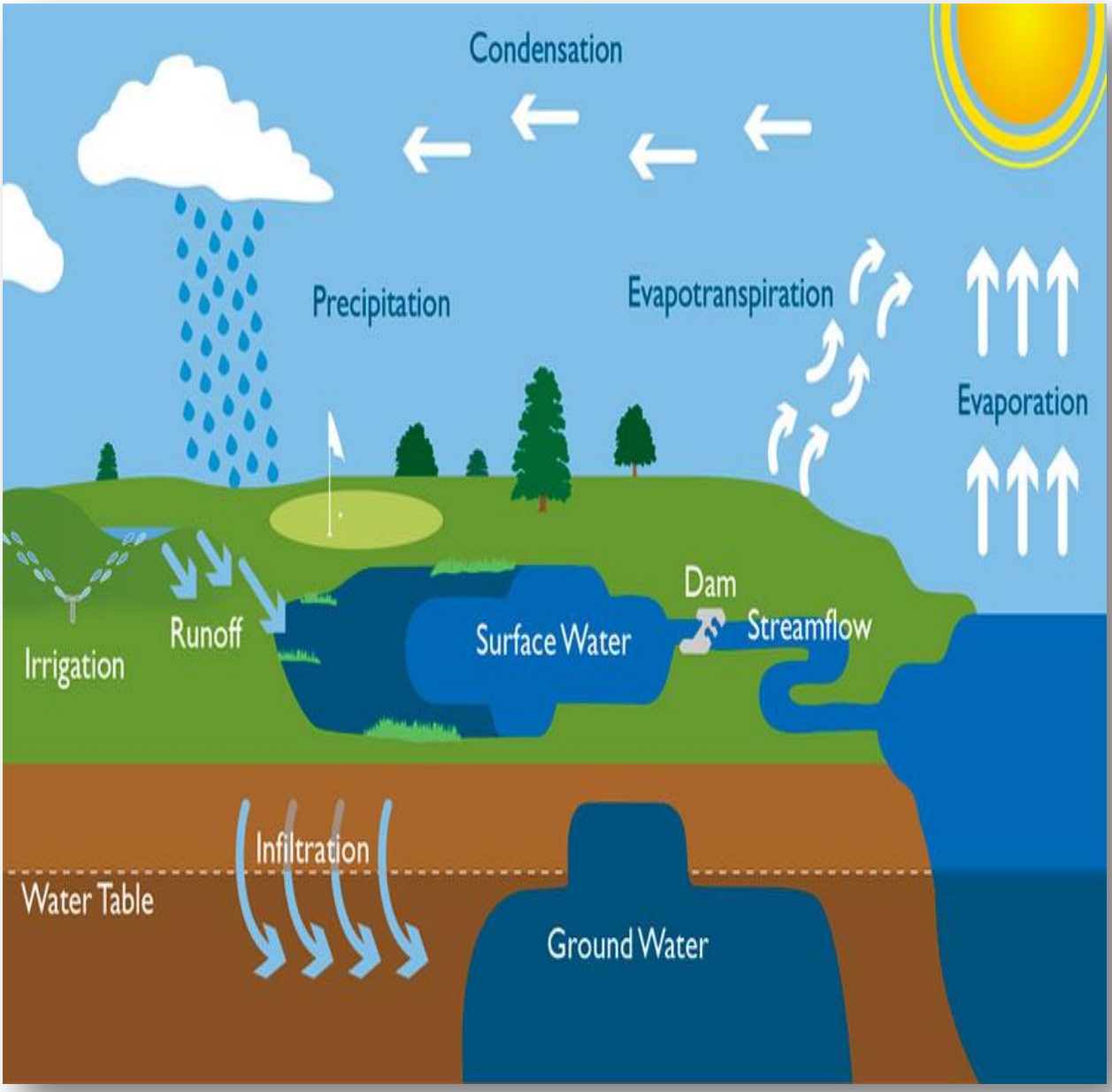
Ethiopia Meteorological Institute



Hydro Meteorological and Flood monitoring Bulletin for Kiremt, 2023 impact assessment and
Hydro meteorological impact outlook for Bega, 2023_24

Foreword

This seasonal hydro meteorological bulletin is prepared and disseminated by the Ethiopia Meteorological Institute (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 for 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 physiographic 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 country 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

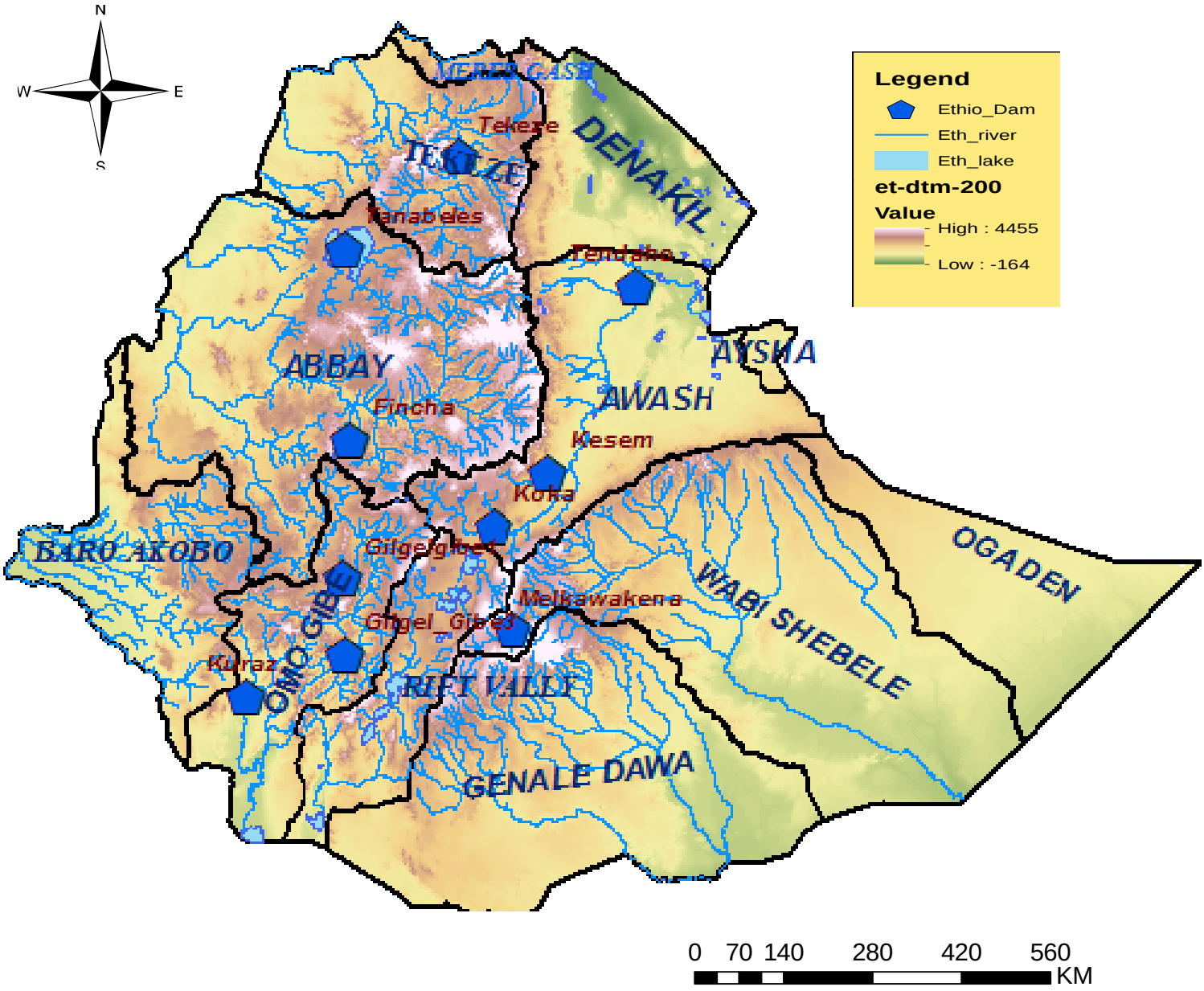
Catchment	Location
Mereb – Gash Catchment: -	Northwestern tip of Tigray.
Atbara-Tekeze Catchment: -	The Tekeze River basin is situated in the northwest of Ethiopia between 11 040` and 15 012` N, and 36 0 30` and 390 50` E. It is bordered by the Mereb River basin and by Eritrea in the north, the Atbara 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 130 N South of Gondar to 110 30'N, and west of 390 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 11^0N 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.

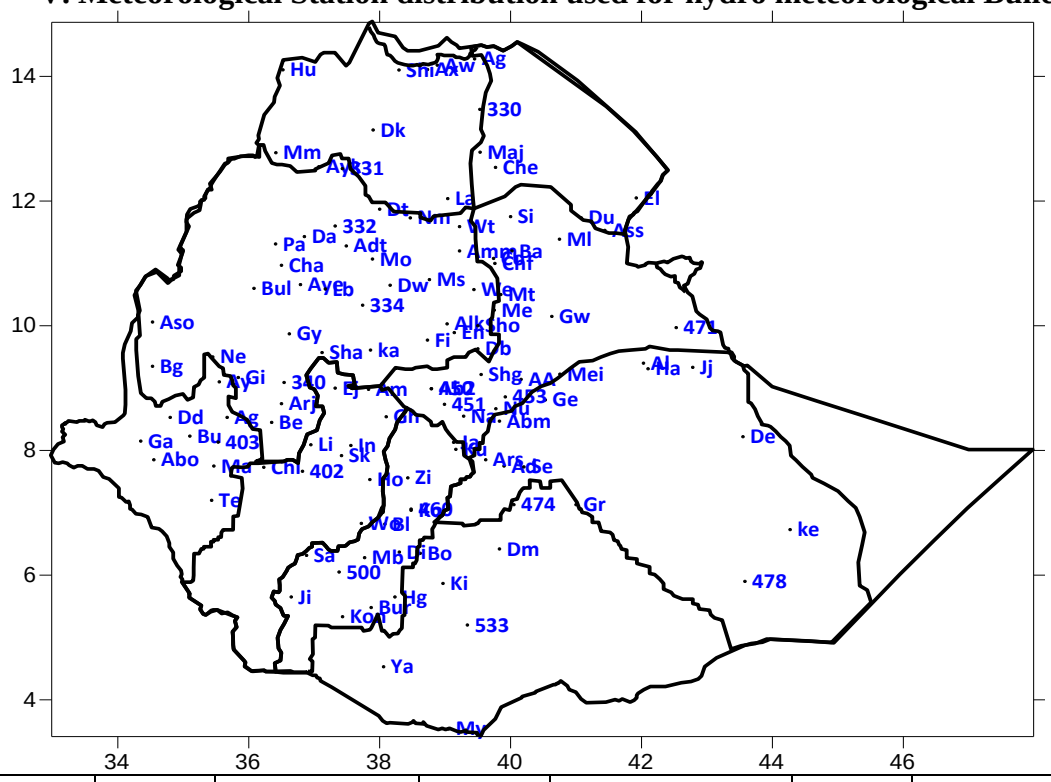
III. Major River Catchments in Ethiopia, Location and Spatial Status

No.	Catchement 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

IV. Basin map of Ethiopia



V. Meteorological Station distribution used for hydro meteorological Bulletin.



STATION	CODE	STATION	CODE	STATION	CODE	STATION	CODE
AA_Bole	**450**	Bore	**Bo**	Gidayana	**Gy**	Metehara	453
Abobo	**Abo**	Bulen	**Bul**	Gimbi	**Gi**	Metema	Mm
Abomsa	**Abm**	Burji	**Bur**	Ginnir	**Gr**	Meiso	Mei
AA_Obs	**Ab2**	Bure	**Bu**	Gode	**478**	Mille	Ml
Addle	**Ad**	Chagni	**Cha**	Gonder	**331**	Mirababaya	Mb
Adet	**Adt**	Cheffa	**Chf**	Gore	**403**	Motta	Mo
Adigrat	**Ag**	Chercher	**Che**	Hageremariam	**Hg**	Moyale	My
Adwa	**Aw**	Chira	**Chi**	Harer	**Ha**	Nazeret	Na
Ayra	**Ay**	Combolcha	**Co**	Hossana	**Ho**	Nejo	Ne
Alemketema	**Alk**	Degehabure	**De**	Humera	**Hu**	Nefasmwecha	Nm
Alemaya	**Al**	Dangla	**Da**	Indibr	**In**	Negelle	533
Alge	**Ag**	Debrebrhan	**Db**	Jara	**Ja**	Nekemt	340
Ambo	**Am**	Debark	**Dk**	Jijiga	**Jj**	Nurara	Nu
Ambamariam	**Amm**	Debremarkose	**334**	Jimma	**402**	Pawe	Pa
Arbaminch	**500**	Debretabore	**Dt**	Jinka	**Ji**	Sawla	Sa
Arjo	**Arj**	Debrework	**Dw**	Kachise	**ka**	Sekoru	Sk
Arsirobe	**Ars**	Debrezeit	**451**	Kebridar	**ke**	Seru	Se
Assaita	**Ass**	Dembidolo	**Dd**	Kibremengist	**Ki**	Shoarobit	Sho
Assosa	**Aso**	Dilla	**Di**	Koffele	**Ko**	Shambu	Sha
Awash_Arba	**AA**	Diredawa	**471**	Konso	**Kon**	Shire	Shi
Awassa	**460**	Dolomena	**Dm**	Kulumsa	**Ku**	Sholagebeya	Shg
Axum	**Ax**	Dubti	**Du**	Lalibela	**La**	Sirinka	Si
Ayehu	**Aye**	Ejaji	**Ej**	Layber	**Lb**	Teppi	Te
Aykel	**Ayk**	Enewary	**En**	Limugenet	**Li**	Wegeltena	Wt
Bale_Robe	**474**	Elidar	**El**	Maichew	Maj	Wereillu	We
Bahirdar	**332**	Fiche	**Fi**	Majete	Mt	Wolaitasodo	Wo
Bati	**Ba**	Gambela	**Ga**	Masha	Ma	Yabello	Ya
Bedele	**Be**	Gelemso	**Ge**	Mehalmeda	Me	Ziway	Zi

Begi	**Bg**	Gewane	**Gw**	Mekaneselam	Ms		
Blate	**Bl**	Ghion	**Gh**	Mekele_Quiha	330		

The above stations have five basic meteorological elements they send daily records to Addis Ababa head 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.

Kiremt (June-September*)* is the main rainy season across most part of the river basins except middle and lower parts of Genale Dawa, lower Wabishebele, lower Rift Valley and Ogaden catchments. It has significant importance for water resource of the country. The main source of runoff is Kiremt season rainfall, which occur high flow period and the maximum availability of surface and ground water over those catchments. It is known that Kiremt season rainfall covers the water demand of all reservoirs and river basin water storage. 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 over flood prone areas and rugged surface of the country during Kiremt season respectively.

Methods

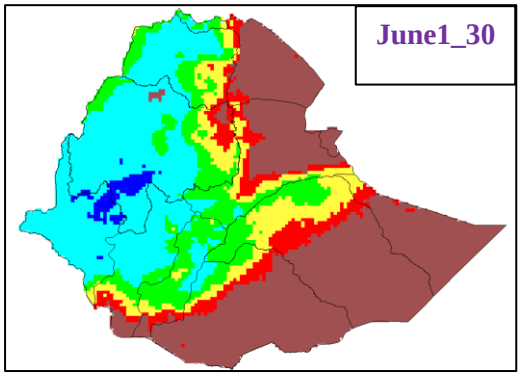
To compute the aridity index we use Thornthwait method, which is computed from the monthly values of rainfall and evaporation. The evaporation is computed empirically from mean monthly air temperature. In assessing the effectiveness of rainfall, in terms of water availability relationships between the rainfall and air temperature has been worked out in terms of moisture indices. The aridity index values above 350 which shaded in Blue were show very wet condition. Deep green to Light Green value indicates wet to humid, yellow value sub humid and pink to red values show semi-Arid to arid condition.

1. Aridity status for Kiremt, 2023 (June to September) over different basins

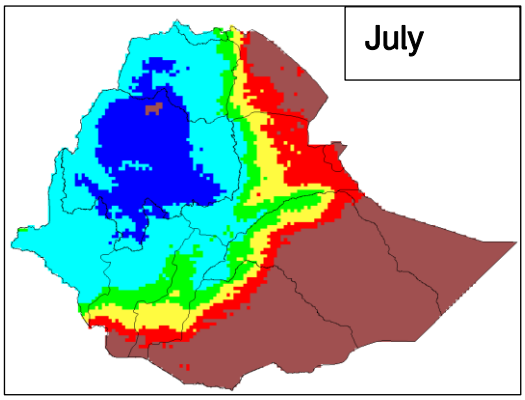
The moisture performance of June was better overall Kiremt benefiting basins. While some places of eastern Abay, lower OmoGibe, lower Rift Valley, middle and lower Awash, lower Wabishebele and lower GenaleDawa catchments were performed under semi-arid to dry weather condition.

During July and August, better moisture performance condition was observed overall Kiremt benefiting basins except climatologically dry catchments during this period. The moisture performance has intensified in July spatially by increasing the wet condition over North Eastern, and most of central catchments, therefore, most Abay, Tekeze, and BaroAkobo and upper Wabishebele, GenaleDawa, adjacent places of Middle Awash, , catchment. The moisture performance of September, were performed, the North Eastern and Eastern catchments wet condition was gradually decreased and the Western half and Southern catchments most of Abay, BaroAkobo and Omogibe was observed better moisture condition continued up to the termination of the season as shown on the figure below (Figure 1a-d).

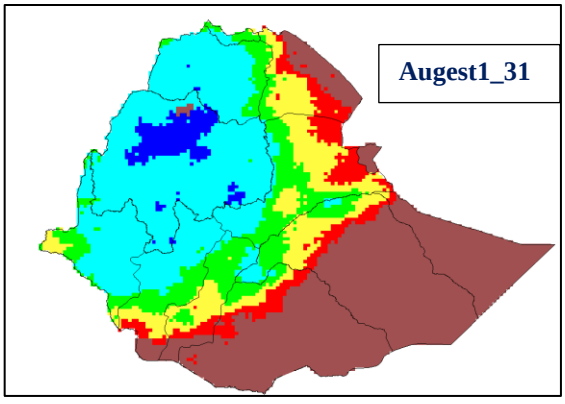
1a.



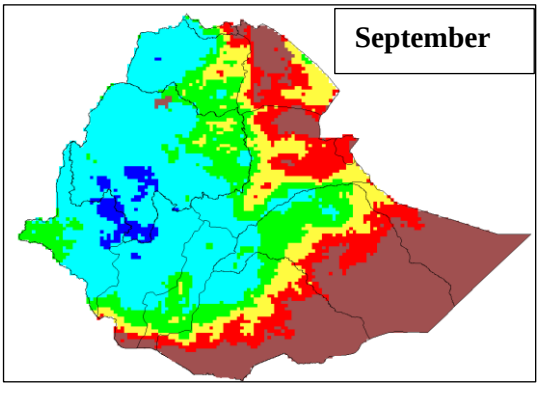
1b.



1c.



1d.



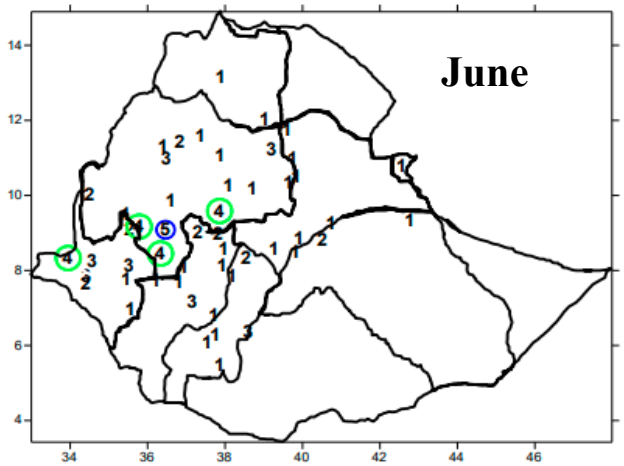
(Fig.1a-d) Aridity Index from June to September, 2023.

2. Distribution of heavy fall days exceeding 30mm from June to September, 2023 over different river basins.

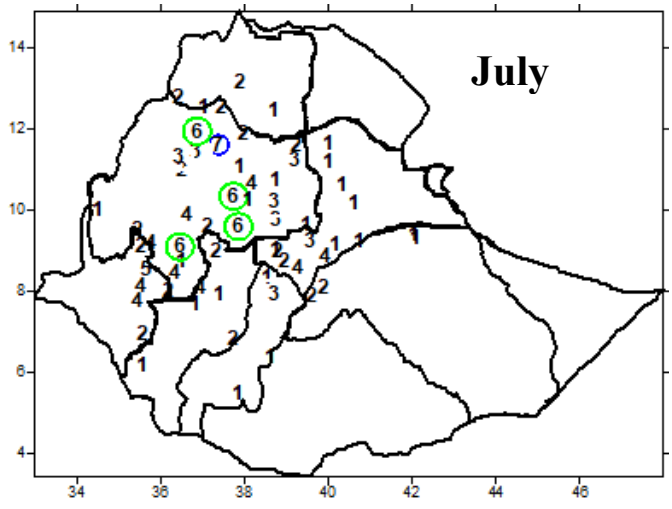
The Rainfall intensity is one of significant weather parameter to contribute for surface runoff which is recorded above 30mm rainfall within a day. The occurrence of heavy fall during **June** was observed over the western half and north parts of the country catchments. In **July,** the distribution of heavy fall events have covered many kiremt benefiting catchments, therefore most of Abay, Tekeze, upper Omogibe, Baroakobo, upper and middle Awash, and catchments have received 1 to 7 days heavy fall. The maximum frequency of heavy fall days was recorded over Abay basin at Arjo station during **June** 5 days and **July** 7 days respectively.

The occurrence of heavy fall during **August** was observed over western half and North Western parts of the country's catchments. In **September** the distribution of heavy fall events was covered many kiremt benefiting catchments, hence most of Abay, Tekeze, upper OmoGibe, Baroakobo, upper and middle awash catchments have received 1 to 6 days. The maximum frequency of heavy fall days was recorded over BaroAkobo basin at Masha station in **september for** 6 days (Figure 2a-2d).

2a.



2b.



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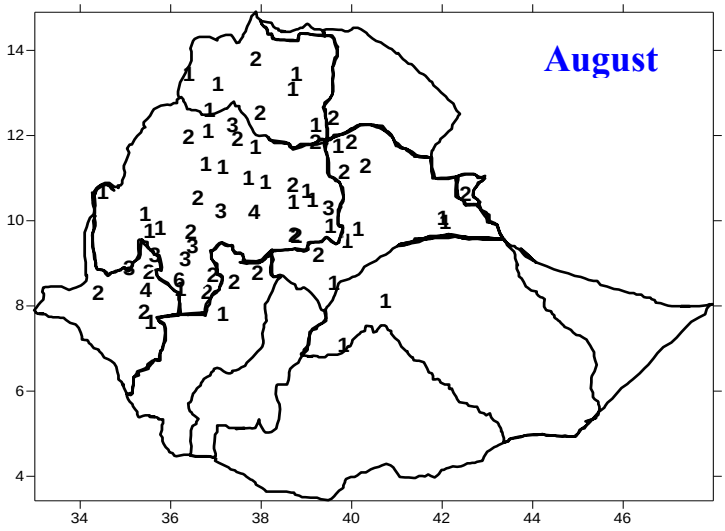


2d.

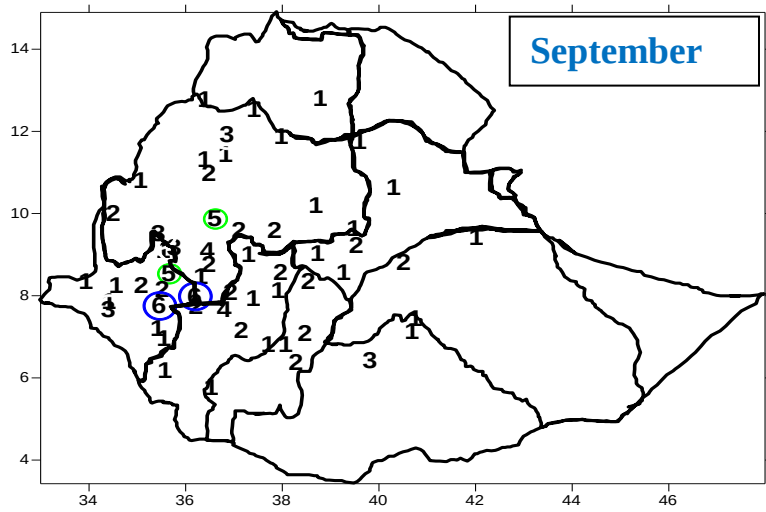
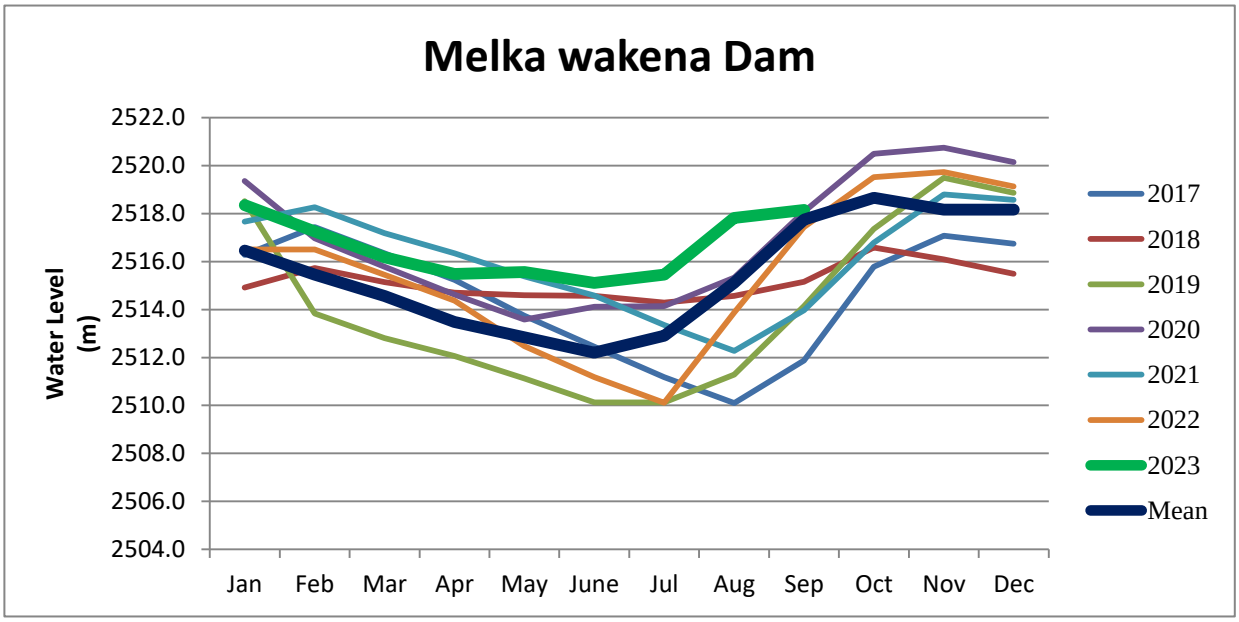


Figure 2 (a-d) Distribution of heavy fall June to September, 2023

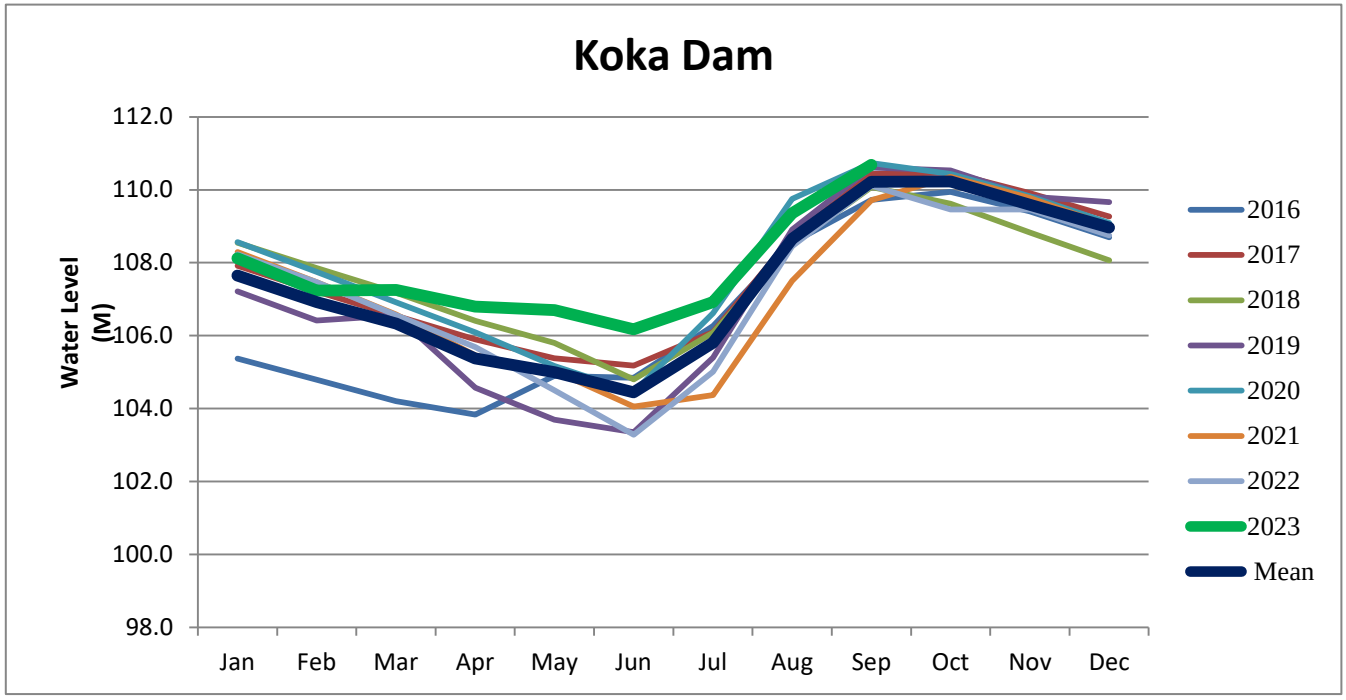
3. Performance of Dams and Reservoirs water level in Kiremt 2023 season

The main source of runoff is rainfall which is input for Dams, Reservoirs and Ponds. Kiremt is the main source of water and flow of river is high during this period. The condition of 2023 Kiremt season rain fall had better contribution to all dams and reservoirs compared to the mean and maximum level except Gilgle Gibe 1 dams. In line with this, the performance of water level of all dams and reservoirs had shown increment of water level until end of Kiremt season (Figure 4a-f).



4a.

Data source EEPU



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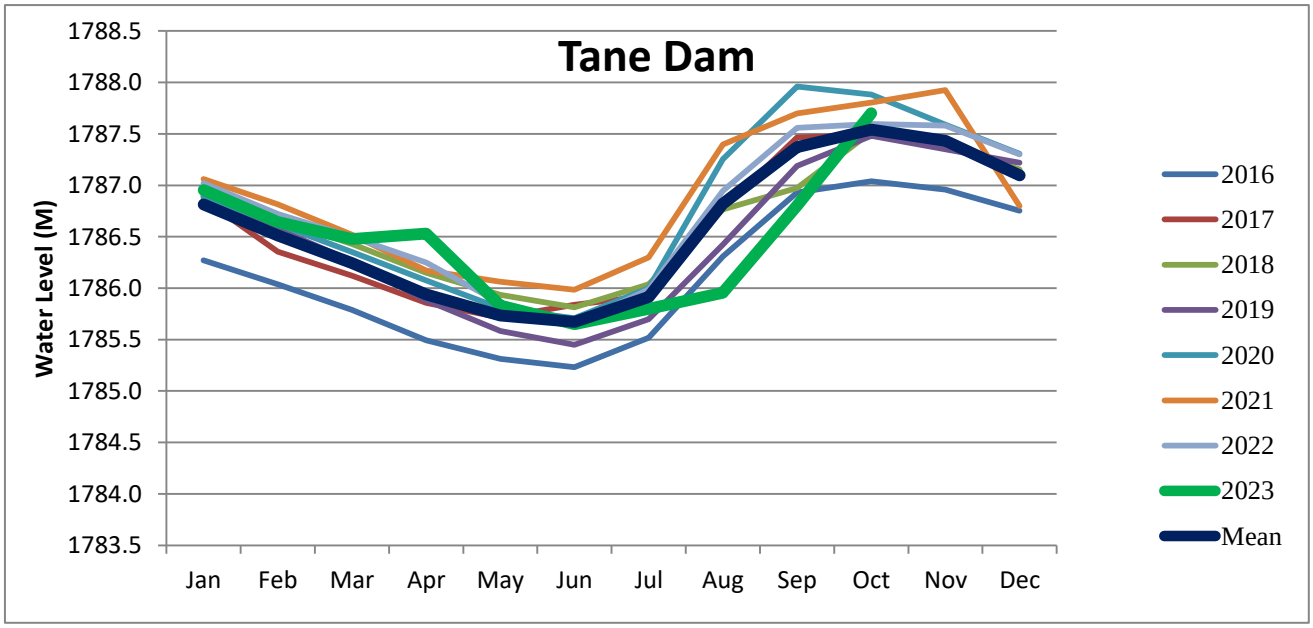
Data source EEPU

4b



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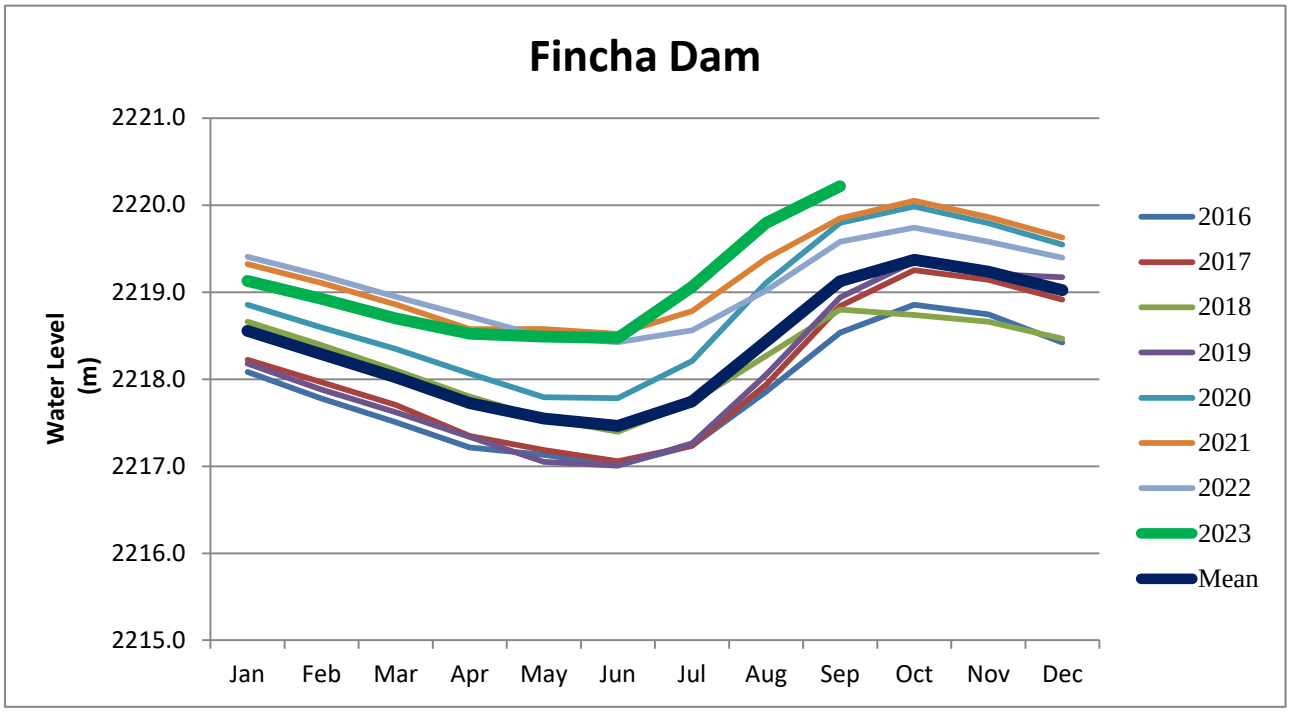
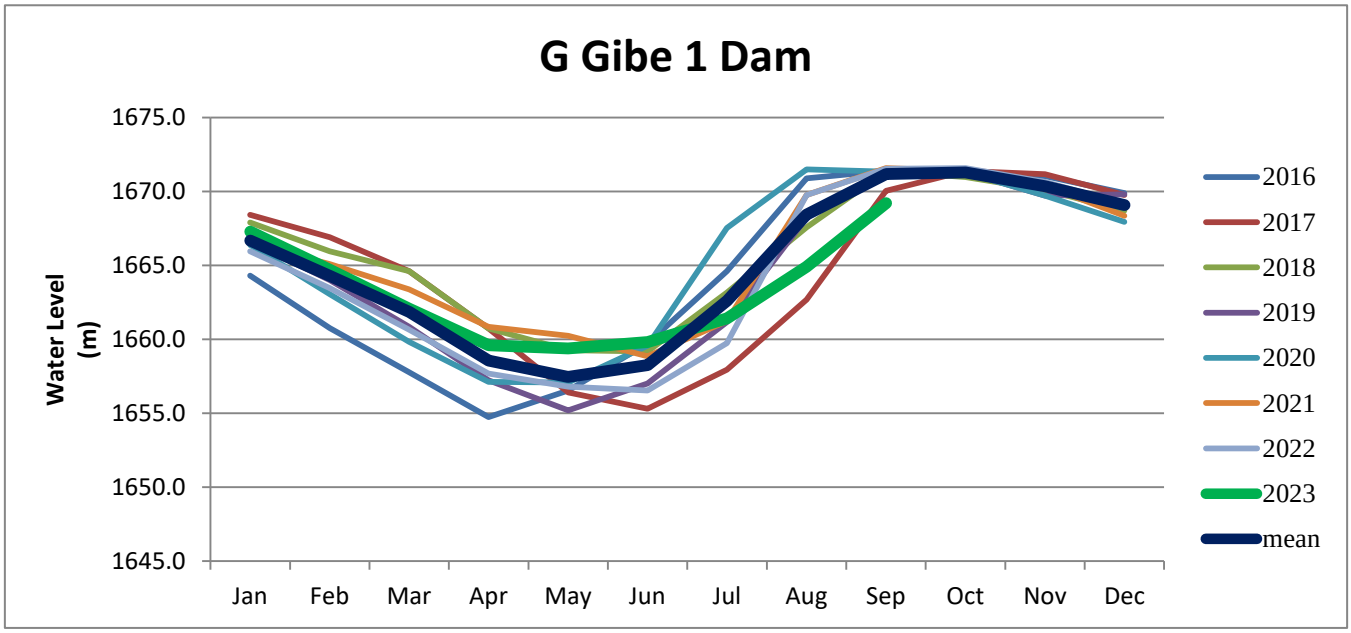
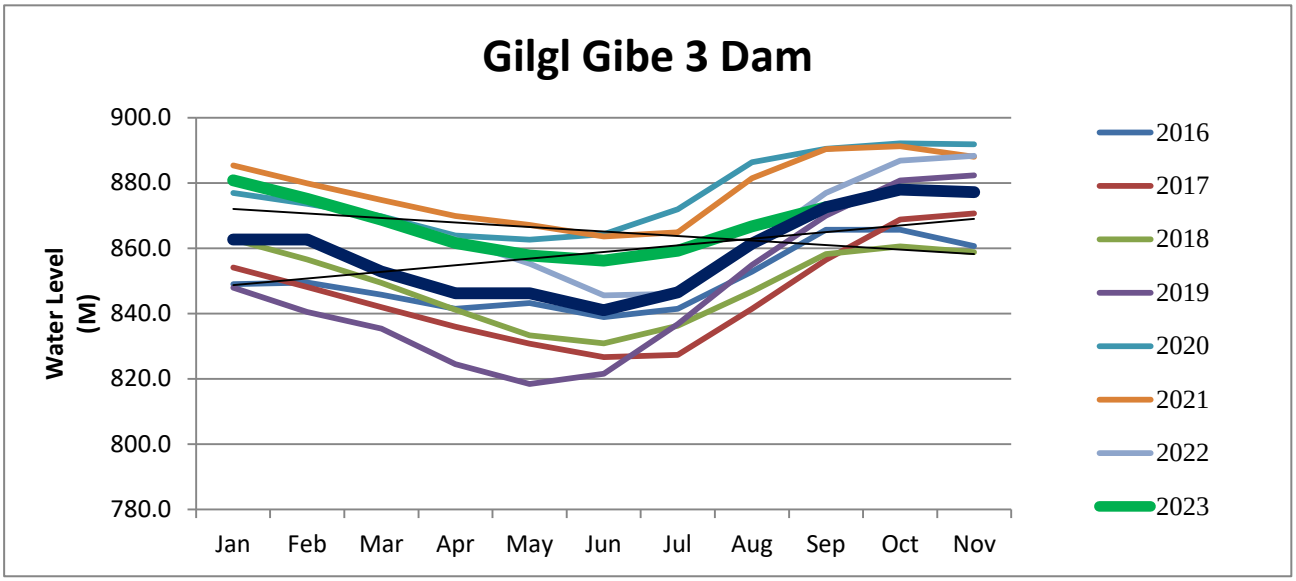

Fincha Dam
Water Level (m)
2221.0
2220.0
2219.0
2218.0
2217.0
2216.0
2215.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2016
2017
2018
2019
2020
2021
2022
2023
Mean

4d.


G Gibe 1 Dam
Water Level (m)
1675.0
1670.0
1665.0
1660.0
1655.0
1650.0
1645.0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2016
2017
2018
2019
2020
2021
2022
2023
mean

4e.



4f.

(Fig.4a-f) Water level performance over different basins

4. Summary

During June most of Western and Central catchments of the country have experienced wet condition while in north eastern and south eastern catchments had shown moisture stress. In July and August, most parts of Kiremt rainfall benefiting catchments received large amount of rainfall. In line with this, those catchments were under humid to wet condition. Similarly the the September month moisture condition was Wet over most part of Kiremt benefiting catchments and also the moisture stared decreasing from Eastern catchments of the country and intensified towards south and south Western catchments such middle GenaleDawa and Wabishebele catchments.

Kiremt 2023 season have had positive impact for water availability for different economic activities of the country. Among these dams, ponds and reservoirs had got enough amount water during this season. In some dams high volume of water has been recorded especially at Tekeze and Koka dams. Heavy fall was recorded over most part of catchments throughout the season. The maximum frequency and intensity was observed across most parts of Abay and Tekeze catchments. In the other hand, this type of rainfall enhanced the level of dams and reservoirs. In general, Kiremt 2023 season rainfall performance had better contribution for the supply of water for different economic sectors.

Bega2023_24 seasonal outlook

Hydro meteorological impact outlook for the coming Bega,2023/24 over different river basins.

1. Introduction

Bega (October-January) is mostly a dry season for most parts of the river basin except Ogaden, lower and middle Wabishebele, middle and lower Genale Dawa as well as lower Rift Valley. Sunny and windy condition dominates across many river basins. Thus, it increases the loss of water by evaporation. Surface runoff does not occur during Bega season. Hence, the flow of river water is becomes low. Springs and ponds start to dry beginning from mid Bega season. Availability of water mainly decrease across upstream of main river basins. In some years unseasonal rain slightly fevers for water availability.

2. Selected analogue Years

For the coming Bega 2023_24 season, the selected analogue years are **1997/98, and 2015/16 which** was compared based on probabilistic seasonal forecast and viewed out on catchments based map using geostatistical kriging method.

3. Methodology

The Thornthwaite precipitation effectiveness index was used to calculate the Aridity index.it 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 have been worked out in terms of moisture indices.

Where, Rf= monthly rainfall in mm;

T = mean monthly temperature in C°

4. Aridity index of analogue years (October to January)

In this section, the aridity index for the selected years are described in monthly basis for October, November, December and January.

October: - Based on both analogue years, in this month, all main river basins especially over most part of Abay, Baro Akobo, Omogibe, genale dawa and upper Wabishebele and Awash have experienced humid to wet condition. This condition has positive impact for water availability over both Kiremt and Bega Benefiting catchments as shown below in figure (1a-1b).

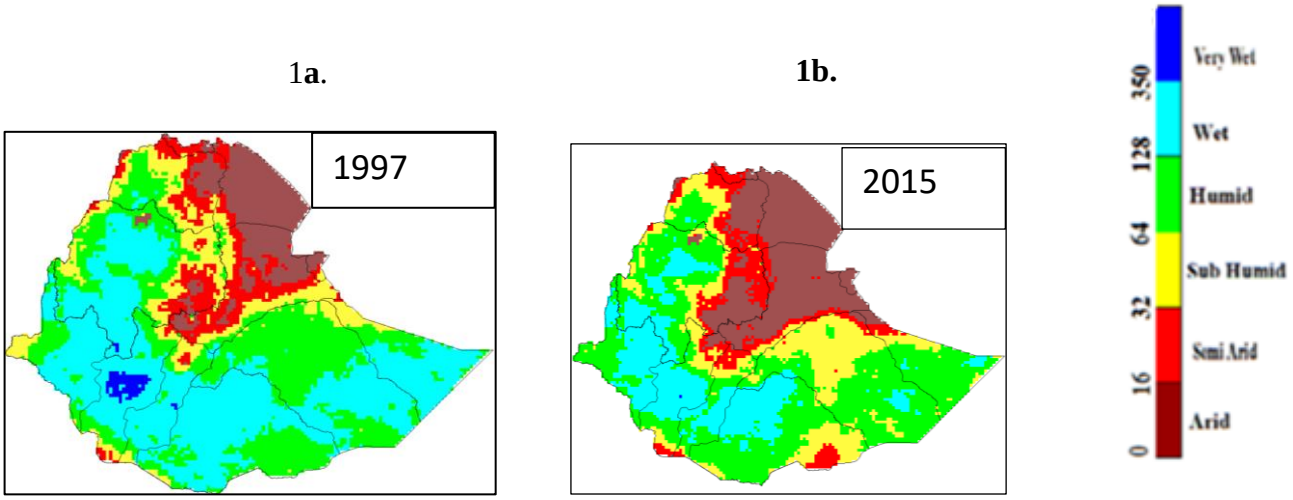


Figure 1. October month aridity index for 1997, and 2015.

November:- in this month, over during both selected analogue yearas, the wet weather condition has decrease from the northern and north west and shifted to South and South Western catchments, especially towards Bega benefiting catchments.

During this month, most part of Baro Akobo, Omo Gibe, Genale dawa, Middle and lower Rift valley, few upper Wabishebele , have had Humid to Wet condition as shown below in figure (2a-2b).

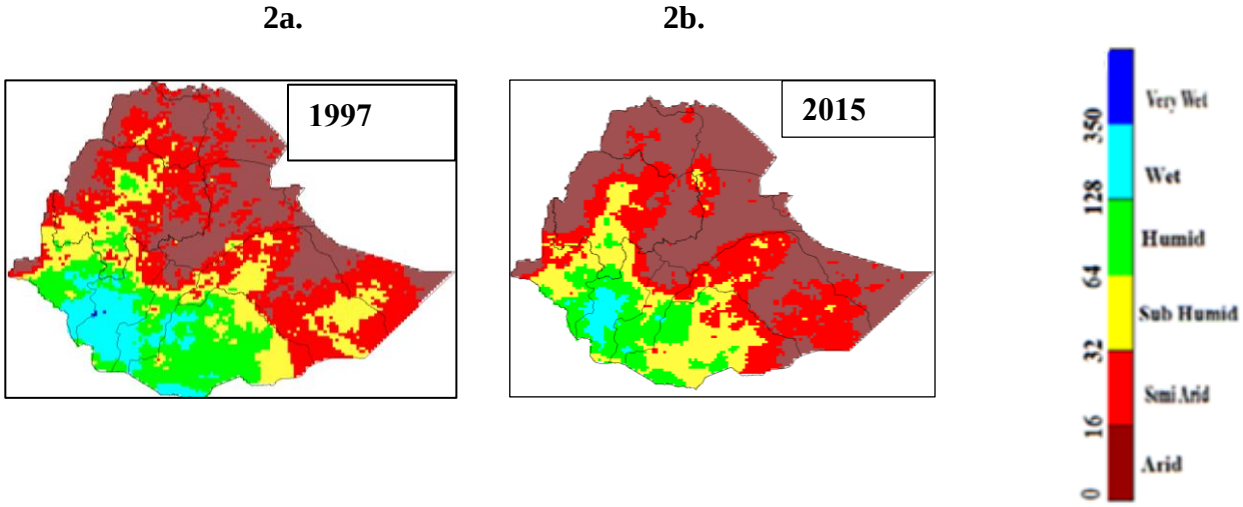


Figure 2. Novemboer month aridity index for 1997, and 2015.

December :- During this month, most of the catchments have had dry aridity index except upper BaroAkobo, middle and lower OmoGibe, middle rift valley and lower Genale Dawa catchments. This situation has negative impact on the activities need water availability especially for Irrigation and drinking water. Therefore, harvesting available water is essential as shown below in figure (3a-3b).

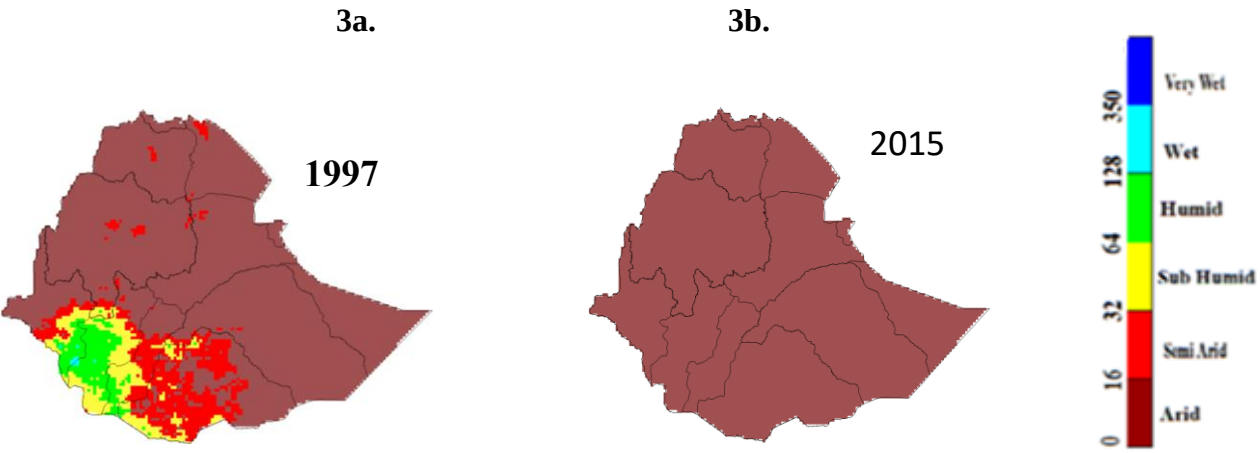


Figure 3. December month aridity index for1997, and 2015

January: - This is the last month of Bega season and almost all of the Bega benefiting catchments have had dry aridity index in the selected analogue years except for 1998, which has got sub humid to humid over upper BaroAkobo, middle and lower OmoGibe and few GenaleDawa, catchments as shown below in figure (4a-4b).

4a. **4b.** **4c.**

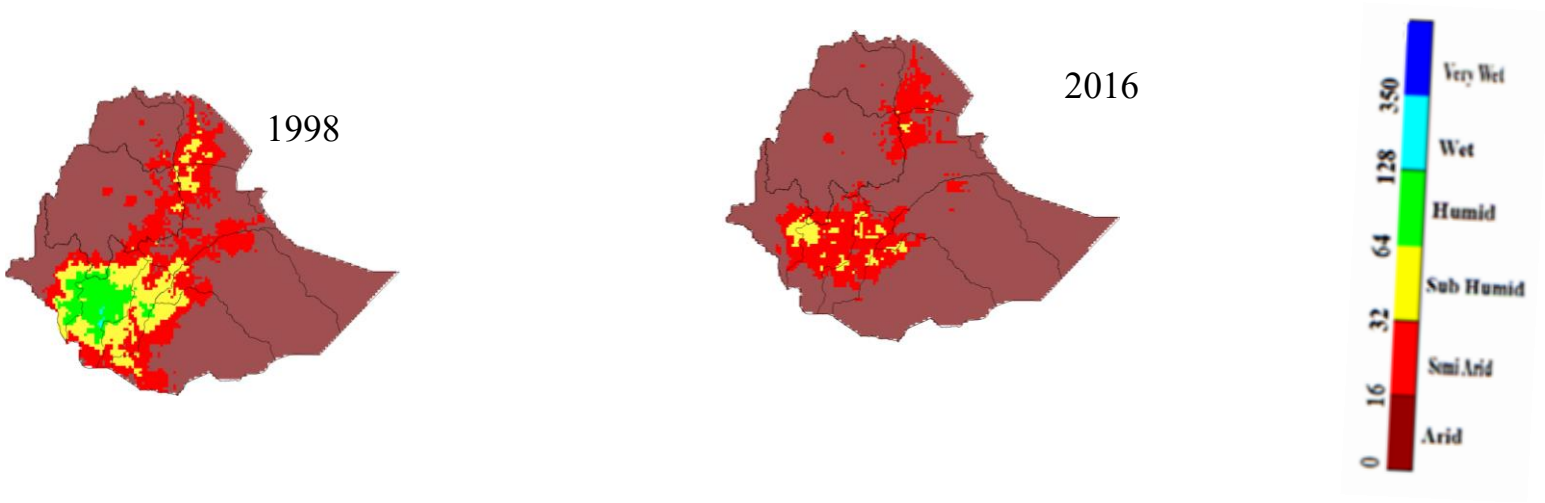


Figure 3. January month aridity index for 1997 and 2015

5. Tercile rainfall probability for Bega, 2023_24season

According to the Tercile probability, the south Western, Southern and South Eastern catchments such as lower Tekeze, central and lower Abay, OmoGibe, central and lower Baro Akobo, Rift Valley, most part of Genale Dawa, Ogaden, and Wabishebele Basins are expected to have Normal to Above Normal Rainfall.

The Eastern and North Eastern catchments such as Upper part of Tekeze, Abay, Rift valley and Wabishebele, Awash and Afar Denakil basins are anticipated to have Normal Rainfall

Unseasonal rainfall is expected over North Western and north eastern catchments of the country. This situation would benefit by providing water for irrigation schemes, drinking water and ground water recharging as shown below in figure (6a).

6a.

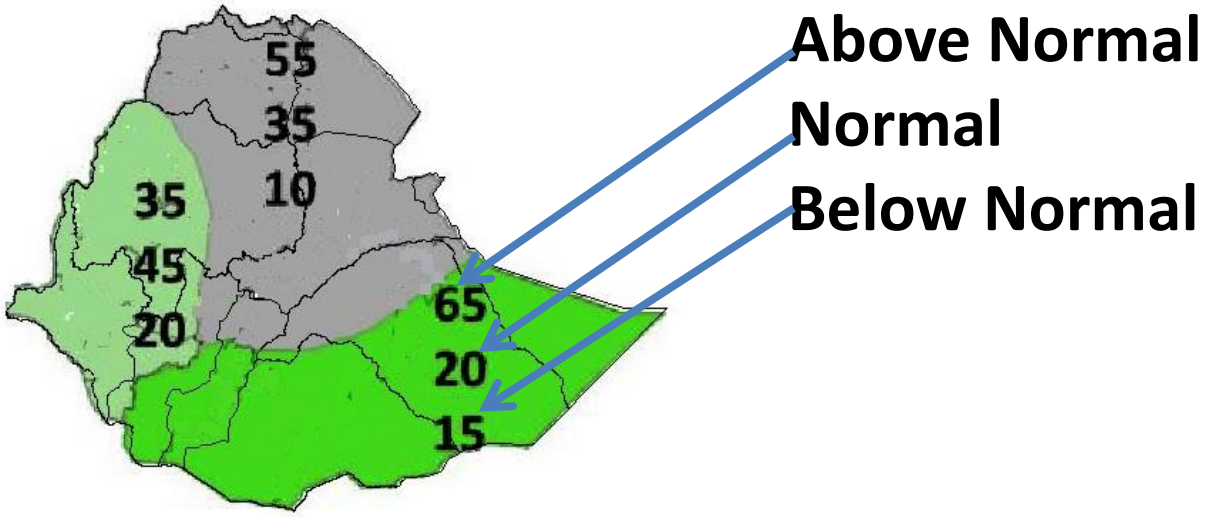


Figure 6a Tercile rainfall probability for Bega, 2023_24 season

6. Conclusion and Recommendation

Based on the rainfall Tercile probability, most parts of Bega benefiting river basins are expected to be under normal and tending to above normal condition. The Western catchments such as middle and lower Tekeze, most part of Abay, upper OmoGibe and some part of BaroAkobo are anticipated to get Normal Rainfall and unseasonal rainfall is also expected. This will have positive impact over the North Western catchments especially for irrigation schemes and drinking water availability. The Bega 2023_24 season is anticipated to be wet over Bega Benefiting catchments. Flood and flash flood are anticipated across basins which received Bega season rainfall, such as middle and lower OmoGibe, Rift valley, GenaleDawa, Lower Wabishebele and Ogaden Basins. This wet Bega would have positive impact on water availability especially for the Bega Benefiting southern and south Eastern catchments, which were under dry condition during Kiremt 2023 season. Therefore, we recommend the responsible bodies to carry out catchment management activities to control negative impacts such as flood and flash floods especially over Bega benefiting catchment, harvesting of gained water resources for different economic activities is highly recommended. Also it is important to follow EMI's daily, 10 daily and monthly reports and mid-season forecasts through EMI Website and other Medias.