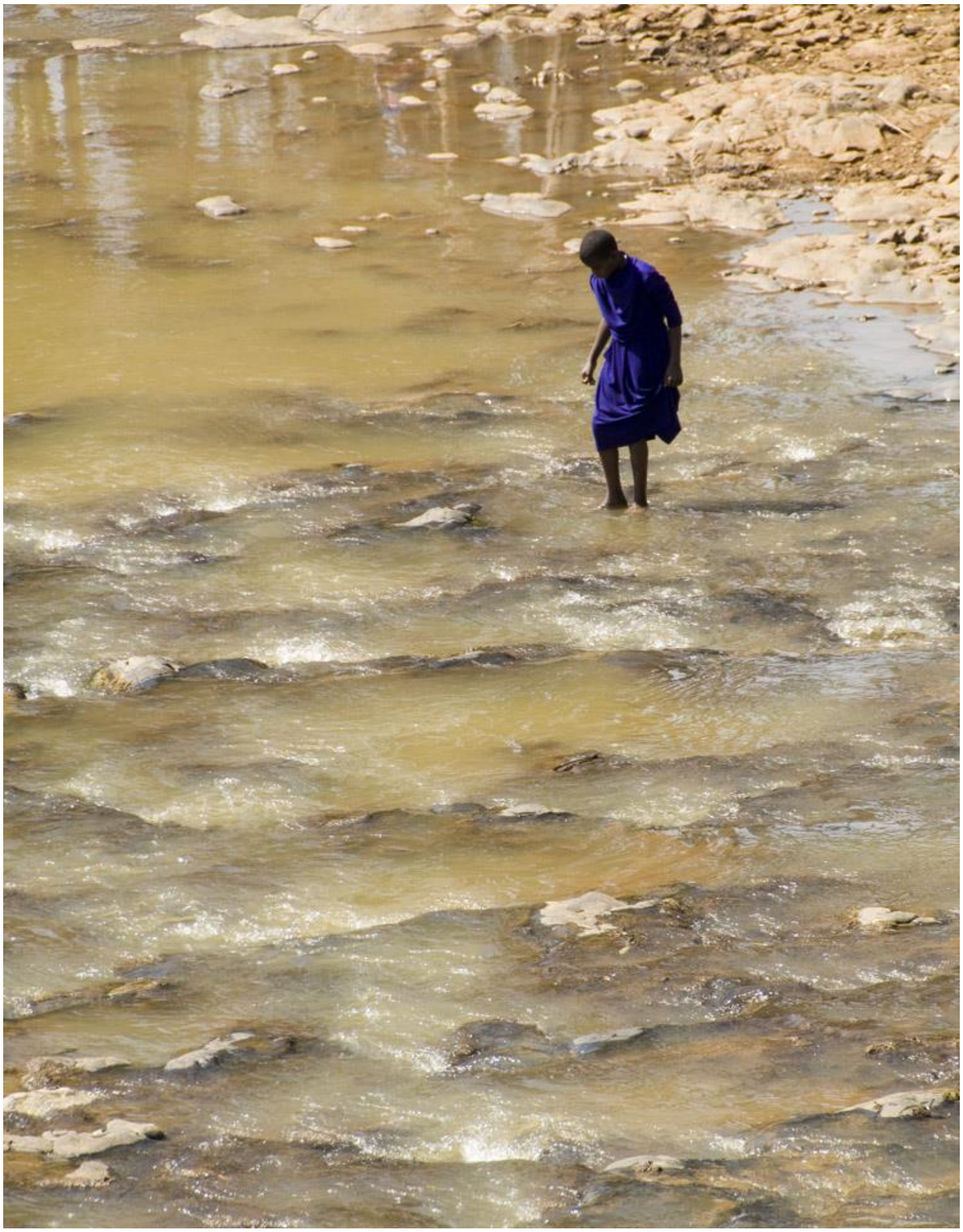
Report No: AUS0001640

Challenges and Opportunities for Water in Development in the Lowlands of Ethiopia



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1.1 General Characteristics of the Ethiopian Lowlands

Ethiopia can be divided into highlands (35 percent) occupying approximately an area of 394,494.5 km^{2}and lowlands (65%) covering roughly an area of 732,632.5 km^2 using 1500-m elevation as a crude threshold. Almost all of Ethiopia's lowlands are located along the periphery with most of the lowlands located along the eastern part of Ethiopia. The Eastern Lowlands start narrowly from top north of Afar covering the entire region, and the northern part of Ethiopia Somali Region before wide stretching to Southeast and Southwest of Ethiopia. The northeastern lowlands of Ethiopia are relatively flat areas interrupted by occasional volcanic landforms, some of which are active. The lowest point of the country is also in these northeastern lowlands of Denakil plain, Dallol depression known as the Kobar Sink, which drops as low as 120 meters below the sea level (m.a.s.l). The Western Lowlands of Ethiopia has an elevation of about 1,000 meters and stretch north-south along Sudan and South Sudan border and include the lower valleys of the Blue Nile, Tekeze, and Baro Rivers.

The lowlands of Ethiopia encompass almost seven million people, more than 500,000 km^2 (61 percent of the area of Ethiopia) and over eleven million animals. The lowlands are generally characterized by dispersed and sparsely populated areas.

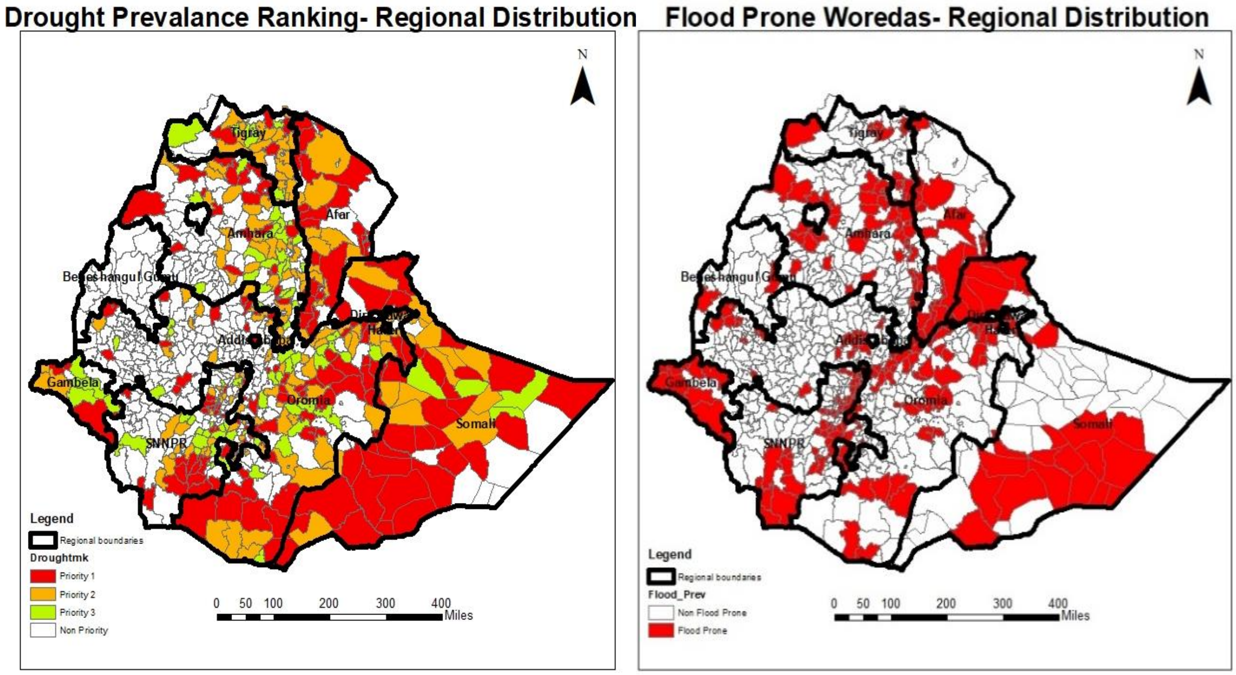
1.2 Climate and Impacts on Water Resources

Average rainfall figures do not capture the large spatial variations in rainfall across different parts of the country. Not only do arid and semiarid or drought-prone areas have lower average annual rainfall, but they also exhibit significantly more considerable inter-annual rainfall variability. Ethiopia's eastern lowlands are hot zones with arid and semiarid climates corresponding to the Ethiopian *bereha* and *kolla* climatic zones with average temperatures between 20°C to 30°C with temperature reaching up to 45°C at the Denakil Depression. The arid zone makes up nearly 64 percent of the lowlands, including territories of the Beni Amer, Afar, and Issa to the north and north-east, the Somali in the eastern half of the Ogaden and the Borena zone to the south. The average rainfall is about 700 mm of precipitation per year. Areas like the Ogaden in Afar receive a mean annual rainfall of 200 mm or less.

The lowlands in the western part of Ethiopia, on the other hand, receive relatively a better rainfall, with flat areas with less than 500 m elevation being moist. The lowlands of Abay basin in the north-west, the west and along the deep valleys have a mean temperature during the coldest month above 18°C and a mean annual rainfall between 680 and 1 200 mm while the western lowlands in Baro-Akobo Basins receive yearly rainfall between 850 to 1,150 mm with temperatures within the basin in the lowlands of Gambella around Akobo ranging from 27.5°C to 40°C.

Most areas in Ethiopia receive one main wet season called "*Kiremt*" from mid-June to mid-September and a secondary wet season of erratic, and considerably lesser, rainfall called "*Belg*" from February to May. Whereas for the south and southeastern parts the primary rainy season is from February to May and the short rains are from October to November having their dry periods from June to September and December to February.

Eighty-seven percent of the identified 450 drought-prone woredas Based on the December 2017 regular report of the Early Warning and Response Directorate (EWRD) of the Disaster Risk Management and Food Security Sector are in lowland regions – 169 of these woredas are also flood prone. Of the 450 identified woreda, 190 are priority 1 hotspots; 169 are vulnerable to both floods and droughts. As depicted in Figure 1 and 2, these hotspot woredas are predominantly located in E. Somali, Oromia (Borena region), Southern Nations, Nationalities and Peoples (SNNP) and Afar.

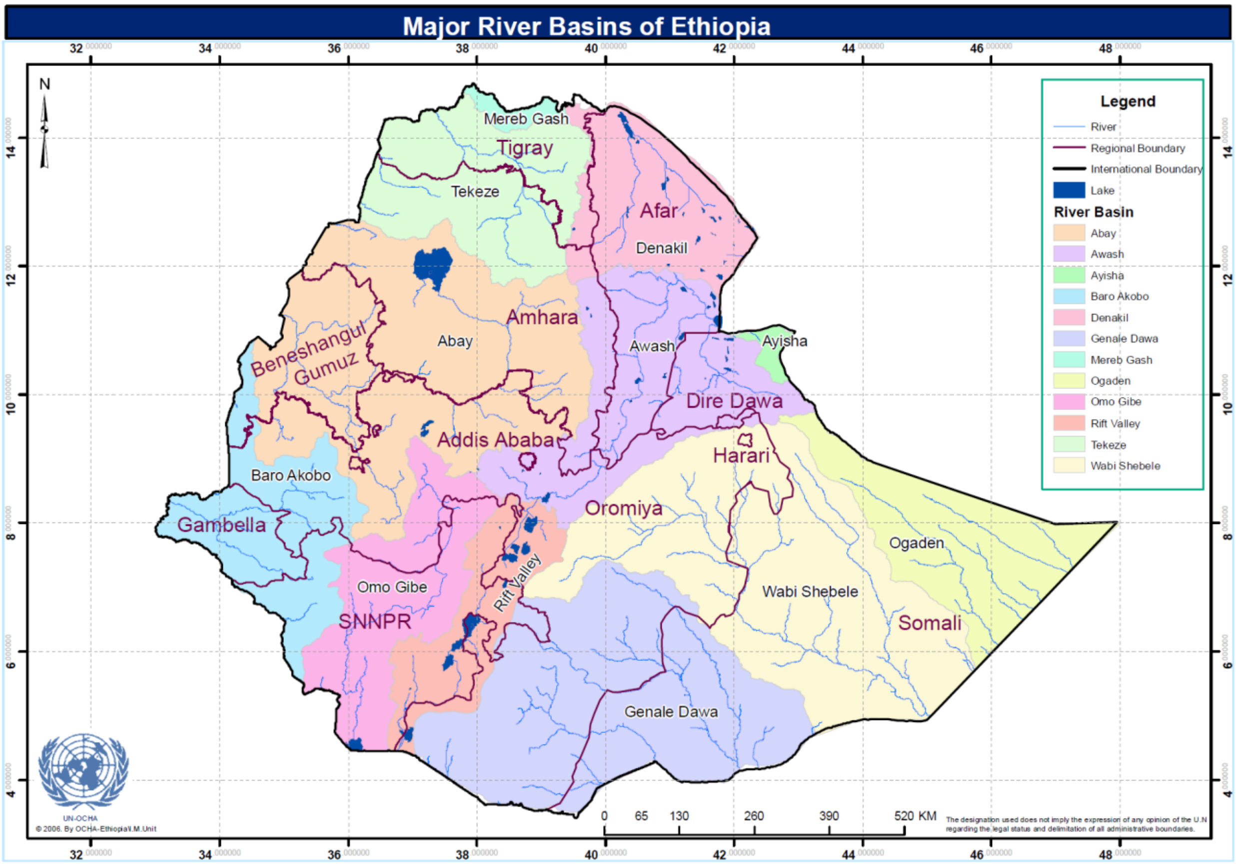


Source: WaSH Baseline Assessment for the One WaSH National Program – Consolidated WaSH Account Phase II, August 2018

Figure 1 Drought prevalence Ranking and Flood Prone Woredas

2 CHARACTERSTICS WATER RESOURCES

At first glance, Ethiopia's water resources endowment appears generous. The country has adequate average annual rainfall, several major rivers and lakes, and significant groundwater resources. The total renewable surface water resources are estimated at 112 billion cubic meters per year from 12 major river basins and 22 lakes. Renewable groundwater resources are estimates range from 12.7 billion cubic meters to 1 BCM (Kebede 2012) but given the large discrepancy between different estimates and limited data, it is difficult to estimate available groundwater resources accurately. Figure 3, highlights the major river basins of Ethiopia



Source: UN OCHA

Figure 2 Major River Basins in Ethiopia

However, the development and management of Ethiopia's water resources face two significant challenges, a natural legacy, and a historical legacy. The natural legacy is one of high hydrological variability. Rainfall across much of the country is exceptionally variable and unpredictable, both in time (within and between years) and space. The historical legacy is depicted by highly vulnerable watersheds and almost no investment in water storage, a consequence of this hydrological variability is endemic and unpredictable drought and flood. There are many gaps in understanding the quality and quantity of water resources. Master plan studies of the different river basins focused on surface water resources potential for hydropower and irrigation use and mainly in the highlands of Ethiopia with limited resource assessment in the lowlands. Information available about groundwater resources in the lowlands of Ethiopia is inadequate.

Ethiopia's highly varied topography greatly influences its hydrology. The heart of the country is a vast highland plateau, lying at an elevation of 1,500–3,000 meters with some peaks rising to more than 4,500 meters. This central massif is divided by the deep Rift Valley, which runs from northeast to southwest. To the west, the plateau slopes gently away to Sudan and the vast plains of the White Nile and Main Nile. To the east, a steep escarpment drops to the into the vast stretch of the Ogaden Desert.

There is a wide variety of conditions in Ethiopian lowlands, particularly in relation with geology, hydrogeology and groundwater presence and availability. All sorts of geological conditions are found, with volcanic, karstic, sedimentary and basement formations. However, one common parameter is that rainfall is always lower than 600 mm per year, usually under 400 mm, and sometimes lower than 200 mm. Large areas have brackish or salty groundwater, with mineral contents of 1.5 g/l and above that makes it unsuitable for drinking water and most other purposes. As a result, water resources in pastoralist areas, particularly in the two regional states of Afar and Somali, are usually scarce, and uneasy and costly to access for rural water supply.

Although the potential for surface and groundwater is higher than the demand for water supply services, Ethiopia still has one of Africa's lowest rates of access to freshwater. Ethiopia has 12 major river basins, of which three are considered dry(the Ogaden, Aysaha, and Danakil). The northern and central highlands drain westward into Ethiopia's most extensive river system, the Abbay, or the Blue Nile, into the Tekeze River, a tributary of the main Nile, and the Baro River, a branch of the White Nile. The eastern highlands drain into the Awash, WabiShebele and Genale-Dawa Rivers. The Awash River never reaches the sea but is ultimately absorbed into a succession of lakes and marshes near the Djibouti border. The WabiShebele and Genale-Dawa Rivers cross that eventually cross the eastern lowlands, moderate the desert ecology. In the south, the Omo River drains into Lake Turkana, and several streams flow into the other Rift Valley lakes. In the southeast, the mountains of Arsi, Bale, and Sidamo drain toward Somalia and the Indian Ocean, but only the Genale or Juba River permanently flows into the sea. Apart from the larger rivers, there are few perennial streams below 1,000 meters. The table below provides a summary of basin characteristics.

River Basins in Ethiopia – Major Characteristics and Exploitable Potential

	Area ‘000 km^2	**Available Water (Annual Runoff)**			**Exploitable Potential**			**Flow Direction & Destination**
		Volume Bm^3	**Depth mm**	**Surface discharge in l/sKm^2**	**Irrigation (1000ha)**	**Hydropower GWh/yr**	**Groundwater Bm^3**	
WabiShebele	202 220	3.4	15.6	0.5	887	5440	0.04	Shebele River, Somalia
GenaleDawa	172 259	5.88	35	1.2	423	1512	0.03	Juba River, Somalia
Abbay	199 912	52.62	265.8	7.8	1,002	78 820	1.8	Blue Nile , Sudan
Tekeze	82350	8.2	94.8	3.2	190	4 230	0.2	Atbara Main Nile, Sudan
Baro-Akobo	75 900	11.89	155.6	9.7	600	13 760	0.31	Sobat/White Nile South, Sudan
Mereb	5 900	0.50	--	3.2	--	--	0.05	Border with Eritrea
Omo-Gibe	79 000	17.96	227.3	6.7	87	22 454	0.1	Lake Turkana, Kenya
Denakil	62,900	0.86	13.7		3	--	--	Lake Asale, Denakil Depression
Awash	112 700	4.60	40.8	1.4	205	4 470	0.14	Lakes Gamari border, Djibouti
Rift valley	52,700	5.63	106.8	3.4	139	800	0.1	Internal Lakes, Kenya border
Ogaden	77 100	0.86	11.2		--	--	--	Ogaden desert
Aysha	2,200	0.02	10		--	--	--	Boarder with Djibuti
Total Ethiopia	1,066,938	112.42			44.2	3,496	4.6	

Source: Genale- Dawa Master Plan Studies

2.1 Surface Water Sources in the Lowlands

2.1.1 Awash Basin

The Awash River originates in Oromia region from Becho west of Addis Ababa, crosses through Ethiopia Somali Region and ultimately terminates in a series of marches and lakes in Afar Region. This basin is the most utilized and developed basin in Ethiopia with enormous human, livestock, irrigation, industrial and agricultural activities and the headwaters of the river. Due to extensive upstream use, the Awash River is heavily polluted from domestic, commercial and industrial discharges. According to Awash Basin Authority (AwBA), the annual demand for water in the basin is 3.411Bm^3 of which 0.298 Bm^3, 0.121 Bm^3 and 0.283 Bm^{3}are utilized for irrigation, domestic, livestock and industrial respectively. Irrigation water use accounts for 83 percent of the total water use of the basin.

The Awash Basin is divided into three distinct zones: Upper Basin, Middle Basin, and Lower Basin based on factors such as altitude, climate, topography, agricultural development, inhabitants, administrative boundaries, etc. Although the basin has surplus water, seasonal water stress exists among the different water users in the basin. Lack of coordinated and integrated water resources management, including water allocation, optimization of existing hydraulic infrastructure and competing demands between sectors and users further exacerbate water conflicts.

Though Middle and Lower Awash were the predominant cotton producing areas of Ethiopia, most of the agricultural lands have been abandoned due to natural soil salinity and shallow saline groundwater over the past few decades. Large scale agriculture remains a principal use in the middle and lower reaches of the basin. In total there are 29 irrigation schemes, of which 20 are medium-scale, and nine are large-scale in Afar. Kessem and Tendaho sugar plantations are two mechanized sugarcane state farms that are widely expanding in the basin.

The Lower Awash comprises the deltaic alluvial plains in the Tendaho, Assaita, DitBehri area and the terminal lakes area. In the eastern catchment of the basin, mainly in Afar and Somali regions, the mean annual rainfall is estimated to be 465 mm. Minor rains commonly occur in March and April and significant rains from July to August. The occurrence of precipitation is highly erratic, varying greatly in the amount from year to year, resulting in severe droughts in some years and flooding in the others.

Frequent droughts coupled with the development of irrigation projects in the upper reaches of the basin complicates water resources management, affecting the socio-economic activity of the people and the diversity of ecosystem especially in the lower reach of the basin. Results from hydrological drought analysis show that drought events of all severity levels are most frequent in the Lower Awash Basin. Most of the existing water use sectors in Afar (agricultural, municipal and industrial) are clustered in Middle Awash Basin. Areas with frequent droughts are found around Hurso and Miesso areas in the Middle Awash Basin and Adaitu, Dubti, Mille and Cheffa areas in the Lower Basin.

2.1.2 WabiSheble Basin

This river originates in the highlands of Oromia Region. Major tributaries to WabiShebele River are Ulul, Robe, Manya, Ungwata, Ramis, Erer, Dakata, and Fafen. Of these tributaries, the flow from Fafen and its tributary Jerer are intermittent. Though WabiShebele River basin has the most extensive area coverage; it is considered water scarce due to the low annual runoff.

The upper reaches of the basin, which account for 25 percent of the basin drainage area, are sub-tropical zones locally known as WeinaDega. This zone is found between an altitude of 1500m and 2500m above sea level in Harari National Regional State and Bale, West Hararge, East Hararge, and Arsi zones of Oromia region. These zones receive an annual rainfall up to 1200 mm and above, and the temperature ranges between 16 to 20°C. Settlements are dense, and it is the most intensively cultivated reach of the basin. Wurch and High Wurch zone covering Arsi and Bale highlands occupies the smallest portion of the total area of the basin. Cultivation is difficult and confined to growing limited types of crops.

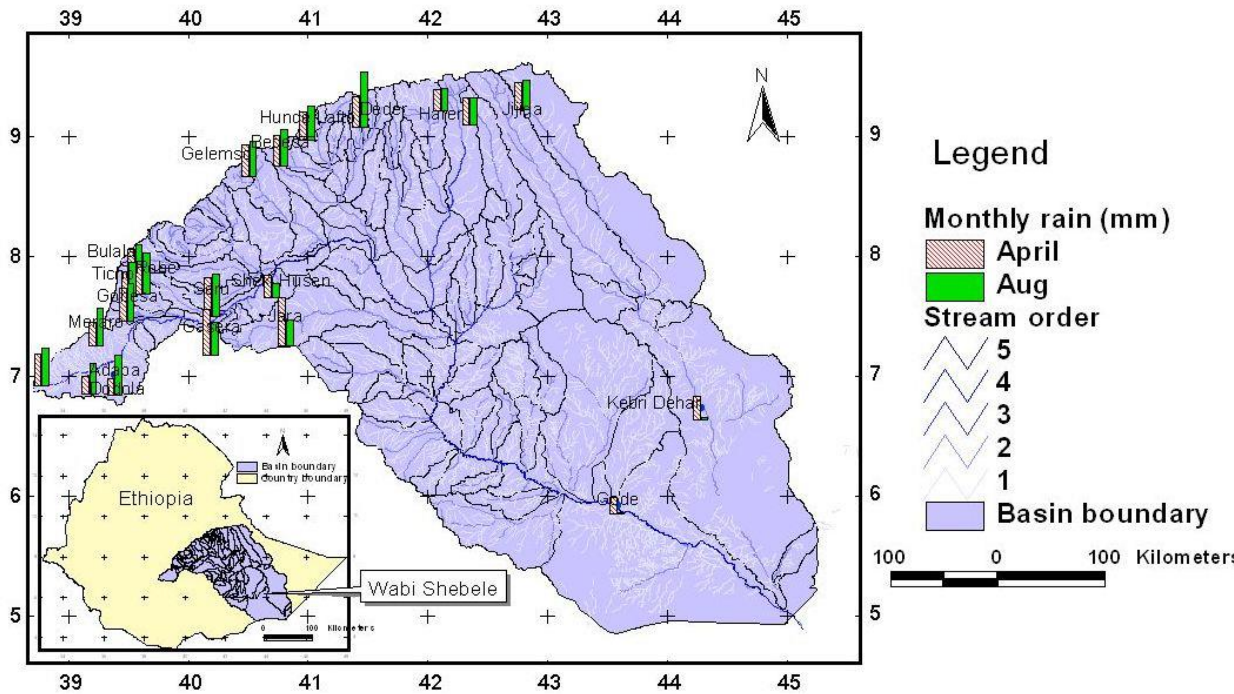


Figure 3 Wabi Shebele River Basin Monthly rain and stream flow

About 75 percent (100 000 km^2) of the basin area located in Somali region has an attitude of less than 550m above sea level, with the lowest in the basin being 220 mm in Kelafo Area of Somali Region. This area is categorized as semi-desert zone having a mean annual rainfall ranging between 150 mm and 500 mm and 25°C as the mean annual temperature. This zone is mainly occupied by semi-nomadic societies with cattle rearing being the main economic activity. The remaining 25percent of the basin area in Somali region is predominantly located at an altitude between 500m, and 1,500m is a tropical zone, which is locally termed as *kolla* area. The area receives an average annual rainfall between 500mm to 1,000mm and temperature ranges between 20° -25°C. The mean annual evaporation reaches to 2800- 3 000 mm in the southeast.

Lower reaches of the basin is sparsely populated. A sizeable area in this zone is under cultivation but due to scarce and unreliable rainfall drought and crop failure frequently occur in this zone. The lowland part along the Somalia border is under small crops and localized all along the WabiShebele River. The shrub vegetation is the source of grazing and browsing of nomadic pastoralism. No assured rainfed agriculture could develop as the annual average rainfall is below 300 mm.

2.1.3 Denakil Basin

The Denakil Basin extends from a plateau from west to east, with all runoff, rivers, and streams flowing towards and ending in the Danakil Depression. This Basin is located solely within the Afar Region. An irregular rainfall pattern characterizes Denakil region. Though erratic rainfall occurs through the periods of August - September, and January -February, the pattern is diffused and not well defined. Annual runoff depth is a little more than 10 mm in the eastern, northern part of the basin with low intermittent flows eastwards. The climate of the Danakil region is hot and dry with desert to semi-desert conditions. Average daily temperatures vary between 20-28 °C in winter and reach up to 50 °C in summer.

The rivers and streams in Denakil Basin are non-perennial or sub-surface flows within the plateau and meandering flows within the lower lying areas of the depression. The depression is bordered by the tributaries of the Ragali River in the west. The Ragali River flows in a northerly then easterly direction towards the village of Badah, where it flows out onto a salt plain. This River flows at the subsurface as base flow or as sheet wash within the depression. Lelegheddi River is one of the tributaries for Ragali River. The Alluvium and the underlying limestone of Lelegheddi River is a potential source for freshwater, but this has not been adequately explored. To the south, the Seba River flows east into Lake Assale.

Locally groundwater is channeled along the dominant faults within the plateau north towards the Ragali River. Spring, though rare, also occur along regional fractures. Groundwater exploitation within basement rocks occurs on a small scale in the form of dug wells and occasional boreholes. Boreholes drilled in Denakil zone have an average depth of 50m, or shallower and yields are reported to be approximately 2.7 liters per second (l/s). The alluvial fan aquifer including alluvium and excluding the clays and saline material at the base of the Danakil depression is of moderate to possibly high groundwater potential. The water quality in these alluvial fans will be fresh to brackish water quality as is seen through the testing of some of the boreholes.

2.1.4 Genale -Dawa Basin

The Genale-Dawa Basin has the third largest basin in Ethiopia with an area of 170,000km^2 with about 80 percent of the basin area considered as lowlands (below 1 500 m.a.s.l.). Genale-Dawa has five sub-basins with Genale-Dawa and Weyb and their respective sub-catchments being the principal rivers that define Genale-Dawa Basin; while the other two sub-basins Lege-Sure and Bare are devoid of perennial water courses with Bare sub-basin being entirely in Somali region. The individual sub-basins of the Genale, Dawa and Weyb Rivers occupy 33, 28 and 14 percent respectively of the total basin area. The remaining 25 percent of the basin are intermittent streams that do not enter the main streams. The Genale and Dawa Rivers and their respective tributaries flow in deep valleys until reaching broader areas in their respective floodplains below 400 m while Weyb River flows in a wide valley. Surface water in terms of annual yield has been estimated to be about 6Bm^3. The basin includes three regional states: 53 percent is in Oromia (91,901 km^2), 45 percent in in Somali Region (77,901km^2) and 1.8 percent is in the Southern Nations, Nationalities and Peoples (SNNP) (3,067km^2). The Oromia region of the basin has the highest peak Mount Dimtu (4 377 m.a.s.l.) on the northern side of the basin with attitude decreasing north to south. The elevation in Bale zone varies considerably from 298 m to 4 385 m. About 68% of Bale zone of the basin has flat topography. The area has bimodal rainfall ranging from 425 mm to 1 429 mm with a mean rainfall of 772. The Borena region of Oromia is considered drought-prone lowlands.

The Lowland area of Genale-Dawa is characterized by a semi-bimodal rainfall pattern with a small peak in April and a maximum peak in August. There is chronic water shortage limiting development in the lower part of the basin.

The groundwater potential and quality in the Oromia region of the basin is better in comparison to the Somali region. Borena and Guji landscape varies from lowland plain to undulating hill area with a highland area in the north. The average annual rainfall is 546 mm but with high evapotranspiration rate limiting agricultural production. Annual runoff in Borena and Guji zone is 8.4 mm to 303.6 mm

2.1.5 Ayisha Basin

The Ayisha Basin is considered a dry basin due to its non-perennial, seasonal flow. The topography of Ayisha basin can be broadly categorized into highlands and lowlands. The highlands cover the western part of the basin between 900m to 4000m elevations whereas the lowlands range between 200m to 900m elevations above mean sea level. About 50 percent of the basin area has an attitude of less than 550m above sea level and is categorized as the semi-desert zone having a mean annual rainfall ranging between 150 and 500mm and 25oc as the annual mean temperature. Sizeable parts of Somali region being sparsely populated and having no settled farming activity are included in this zone. The area is mainly occupied by semi-nomadic societies with cattle rearing being the main economic activity.

2.1.6 Ogaden Basin

The Ogaden Basin is located in the southeastern part of the country in the Somali region. Average annual daytime temperature is more than 40°C in the arid Ogaden. The most prominent bimodal system occurs in the Ogaden with a total annual rainfall of about 250mm with 50 to 60% occurring in March through May and 25 to 35% in September through November. Annual runoff depth is a little more than 10mm in the southeastern Ogaden Basin.

2.1.7 Rift Valley Lakes Basin

The Rift Valley Lakes Basin (RVLB) can be considered to have four main surface water sub-basins that cover a total area of approximately 53,000 Km^2: (i) the Ziway-Shala sub-basin (14,477 km^2), which includes the catchments of Lake Ziway, Lake Langano, Lake Abiyata and Lake Shala; (ii) the Awasa sub-basin (1,403 km^2) which is hydrologically separate from the others and includes the former Lake Cheleleka, which is now mainly wetland with grazing and agriculture; (iii) the Abaya-Chamo sub-basin (18,118 km^2) which includes the catchments of Lake Abaya and Lake Chamo; and (iv) the Chew Bahir sub-basin (19,029 km^2) which is the catchment of Chew Bahir, mostly comprising the Weito and Segen Rivers. The total surface water resource of the RVLB is estimated at 5.3Bm^3/year, flowing into the lake systems under 'natural' conditions without human abstractions. This amounts to a current per capita water availability of 597m^3, which is well below the threshold of 'water scarcity,' defined as 1000m^3 per person per annum.

The RVLB's northern limit is near to Addis Ababa and runs south from there to the Kenyan border. The highest elevations of the highlands form its eastern and western boundaries. The basin has typical rift valley topography with a full, steep-sided valley and a broad, flat bottom. About 40 percent (20 632 km^2) of the land cover for the rift valley basin is in Oromia regional state. The remaining 60 percent (31,538 Km^2) of the Rift valley land cover is in SNNP regional state. 74 percent of the basin's population lives in SNNP.

About 48 percent of the basin area is in the lowlands of which about 90% is warm, humid lowlands and about 10% hot to warm semi-arid lowlands. The valley-wide elevation range from 485m at Chew Bahir in the southern pastoral zone of the rift valley to 4,170 min the northeast highland at Mount Ketcha. Water is a significant constraint in the RVLB with a series of terminal lakes that are either saline or alkaline with no surface water outlet. In terms of rainfall, the basin receives a decent amount of rainfall. The pastoralist zone with semi-arid lowlands receives rainfall ranging from 450mm to 1,300 with a mean annual rainfall of 874mm, but surface water runoff in the basin is low. Groundwater resources are an essential element particularly in the development of water supplies for urban and rural settings. Borehole sources in the basin provide over 50 percent of water supply for human consumption.

2.1.8 Omo-Gibe Basin

The Omo-Gibe River Basin, situated in the southwestern part of Ethiopia, flows from the northern highlands (2,800m) through the lowland zone in the south to discharge to Lake Turkana on the Kenyan border. It is Ethiopia's second largest river system, accounting for 14 percent of annual Ethiopian Runoff. The basin is divided sharply into the highlands (1,500 – 2,800m) in the northern half of the area and lowlands (500 - 900m) in the southern half. The lowlands, below 1500m, can be divided into the lowlands of the north, with rolling to steep topography and steep slopes; with almost 38 percent of the lowlands having slopes of less than 2 percent while 20 percentof the area falls between 2-10 percent slopes (Mays and Yung, 1992).

2.2 Groundwater Resources in Eastern lowlands

The hydro-geological data from drilled boreholes in the lowland areas have not been collected systematically and analyzed to assess groundwater potential. Efforts are underway to map remaining groundwater resources.

Afar regional state: Regardless of its aridity the Afar regional state is underlain by several deep and prolific aquifers of regional socio-economic importance. Some of the aquifers have been extensively explored for their suitability for large scale water supply, for irrigation water use and for use in mining. The major aquifers include: (i) the TeruDigdiga plan alluvial and volcanic aquifer; (ii) the Afar stratoid basalt in western Afar escarpment; (iii) the Museley fan and other alluvial fans adjoining the Dalol salt plain; and (iv) the Alidegie plan volcanic/alluvial aquifer in southern Afar. Other aquifers exist along the lower Awash plain and adjoining the Awash river (e.g. be Tendaho and Afambo, along the banks of the Awash River). However, high salinity of the waters limit use of the aquifer for irrigation and drinking water sources. Fresh groundwater bodies can be found in association with alluvial materials and basalts. There are hundreds of deep productive boreholes of substantial yield (>10 lps) encountered in the western Afar. The aquifers have been targets for groundwater-based irrigation development, though no irrigation has started yet.

Data from well completion reports of deep boreholes in the Middle Awash basin of Afar region in Allaidege Plain indicate that average depth of drilling is about 465 m and yield 80 l/s and temperature 42ºC. Data from drilled boreholes in the Middle Awash Basin of Somalia region show that average drilling depth 320 m, yield 62 l/s, and electrical conductivity value of 9470 µS/cm. Average drilling depth in the Lower Awash area is 490 m, average yield of 35 l/s and electrical conductivity value of 4 700 µS/cm. The high electrical conductivity values indicate the high amount of total dissolved salts in the groundwater.

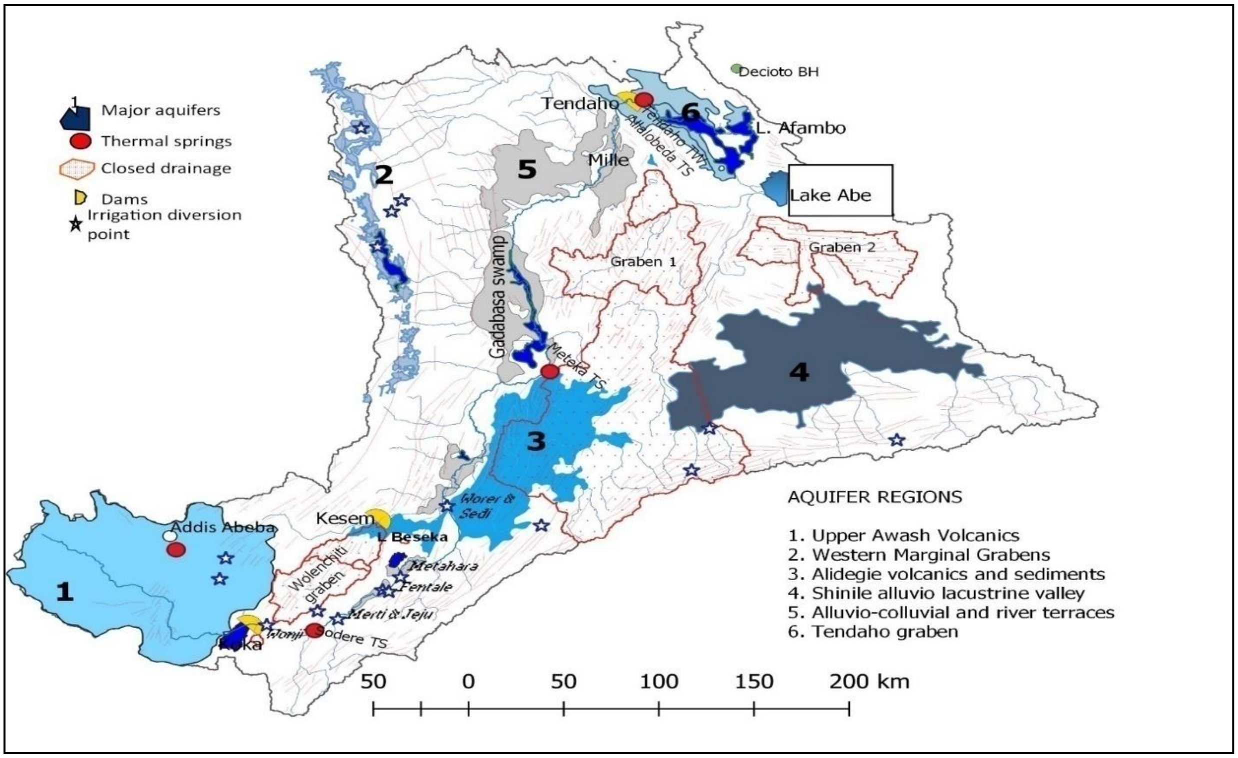


Figure 4 Location of Major aquifers in the Awash river basin (Kebede et al. 2018)

Somali regional state: The Somali regional state is characterized by difficult hydrogeology- deep water tables, high salinity groundwater, and low yielding aquifers. Notable areas for better groundwater potential areas include: (i)) the Shinile Aquifer in northern Somali regional state (see figure 1); (ii) the Jarer valley multilayered sedimentary aquifer, and (iii) the shallow groundwaters in the Fafam valley in northern part of the Somali regional state. Elsewhere in the region, groundwater of limited areal extent can be encountered along the banks of the major rivers. Shallow groundwater also occurs in the Ogaden zone. Elsewhere water table is deep, salinity is high, and yields are low. Data from drilled boreholes in the Middle Awash Basin of Somalia region show that average drilling depth 320 m, yield 62 l/s, and electrical conductivity value of 9,470 µS/cm.

The Borena lowlands,Oromia: In Borena at least two aquifer areas can be recognized: (i) the extensive network of wadi bed alluvial sediments; and(ii) the Bulal basalt aquifer of major regional significance. With proper management and development

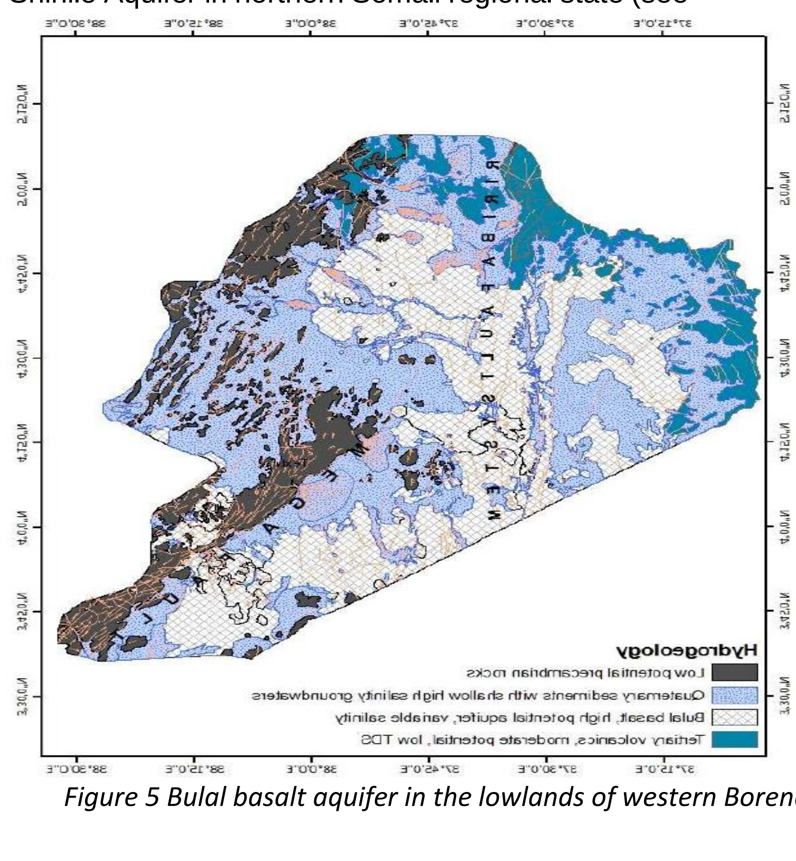


Figure 5 Bulal basalt aquifer in the lowlands of western Borena

approaches the wadi bed sediments can utilized for livestock watering and drinking water uses. The Bulal basalt aquifer is one of the prolific aquifer in the region with borehole yields in this aquifer exceeding 10 lps in many localities.

Figure 5. Figure showing the extent of the Bulal basalt aquifer in the lowlands of western Borena

The Omo valley: Two aquifer are recognized in the southern Omo region. In the eastern highlands that run between the town of Jinka and the Ethiopia Kenya border, limited groundwater occurs in shallow and thin alluvial sediments that mantle the basement rocks. Groundwater potential is limited for any major productive use. The second aquifer system is the Omo valley, which adjoins the Omo River and the Lake Turkana. This area is underlain by thick (up to 3 km) inter bedding of alluvial and lacustrine sediments. Groundwater occurrence is not a problem. The main challenge in the Omo Valley is the high salinity of groundwater limiting major groundwater development. With proper well sighting, areas with less saline groundwater can be further developed. Simplified geological map of the Omo valley is shown in Figure 6.

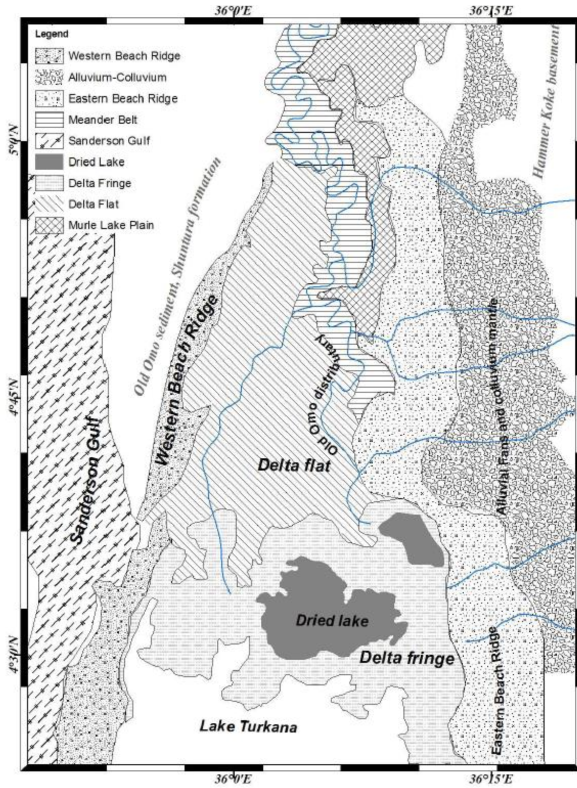


Figure 6 Detailed Geomorphologic map of the Omo delta area (Kebede 2013)

3 SETTLEMENT PATTERNS – WATER USE IN THE LOWLANDS

In lowland resources (water and Pasture) and security is primary factors that shape the settlement of Somalia pastoralist. Settled villages are in areas that are suitable for agriculture; otherwise, there is scattered settlement by clans/sub-clans. Settlement and movement patterns imply water resources and water service delivery.

Settlements in these lowlands are disbursed as the climate is also too hot to attract dense settlement. Over 90 percent of the lowlands of Ethiopia are estimated to be pastoralists or agro-pastoralist. Limited access to water and uncertainties of rainfall promote an animal-based lifestyle in these lowlands thus enabling those people to be mobile. The movement of the pastoralist communities in search of water for their livestock has usually been one of the common causes of conflict amongst the pastoralist communities.

Livestock production, which requires considerable water resources, has significant contributions to the economy and livelihood of people living in the lowlands of Ethiopia. Pastoralists rely on milk for food and use animals to store and generate wealth. Thus, animals are essential elements in their social value systems. Pastoral, social networks also commonly decentralized emphasis leadership that promotes flexibility in resource use.

Afar:

Land use in Afar like many rural particularly lowland areas is based on traditional ownership. The social organization is governed by customary law and social structure that unites several tribes. Land use and water rights are specifically tailored to the size and kind of livestock such as cattle, goats, sheep, and camels; the delineation and non-utilization of lands usually being reserved for livestock grazing and regeneration purposes. Many pastoralists were evicted from their wet grazing lands for dam construction and irrigation development for sugar cane, horticultural crops and cotton (Fiona Flintan and Imeru Tamrat 2002; François Piguet, 2001).

The Awash valley in Afar has historically been a central gateway for the caravan trade between the coast and the highlands of Ethiopia to Djibouti. Currently, official import and export trade activities of the country also take place through the pastoral areas of the Afar region. Cross-border trade with neighboring countries is also an essential aspect of the economic life in these pastoral areas of the country.

Somali Region:

Settled villages are in areas where it is suitable to agriculture otherwise scattered settlement by clans/sub-clans. In areas more suited to settled agriculture, the Somalis are settled in permanent villages, which are composed of families who are either from distantly related lineages of the same tribe or different tribes. The settlements contain from four to twenty huts and nuclear families. Most of the houses in such villages are different from the nomadic shelters (Dasa).

Permanency of settlement is dependent on availability and distribution of critical resources such as pasture and water. In areas where resources are scarce, the Somalis live in a cluster of 3 to 50 huts (Dasa) in one place. Generally, the settlements are small, temporary and short unless it is around water points where settlements are for more extended period and relatively larger settlements. Mobility pattern of Somali pastoralists is based on the availability of rainfall and the resulting availability of pasture for grazing. The seasonal availability of water and pasture, as well as rapid exhaustion of pasture owing to heavy grazing, is the main reasons for mobility of the Somali pastoralists. The time, direction and extent of their movement mainly depend on rainfall.

Somalia region food insecurity is a widespread and significant proportion of population relies on relief assistance, and pastoral areas are affected by frequent drought requiring emergency intervention. Lack of water, food and livestock feed resulting in catastrophic loss more than 70 percent of goats and sheep populations.

Borena, Oromia lowlands:

The Borena population is mainly pastoral. Major Livestock in this area are cattle and goats. Food insecurity is a widespread and significant proportion of people rely on relief assistance in the Borena zone. Pastoral areas are affected by frequent drought requiring emergency intervention: lack of water, food and livestock feed resulting in catastrophic loss >70% of goats and sheep

4 CHALLENGES IN WATER SUPPLY SERVICE DELIVERY

While progress on water and sanitation coverage has been made in the predominantly pastoralist and agro-pastoralist regions and areas (Afar, Somali, and pockets of Oromia and SNNPR) the coverage level is still low compared to other agrarian areas of the country.

Access to improved water supply and sanitation facilities in pastoralist areas of Afar, Somali, and pockets of pastoralist areas in Oromia and SNNPR are relatively low compared to other regions and the national average. Access levels for water and sanitation in pastoralist regions and woredas ranges from 39.5 – 61 percent and sanitation coverage ranges from 6.5- 21 percent respectively. In the other parts of the country water coverage ranges from 62-95 percent and 41% to 76 percent for sanitation (OWNP Phase II program document November 2018). According to Ethiopian WaSH Poverty Diagnostic study, agrarian woredas were significantly more likely to have access to improved water than agro/pastoralist woredas – by about 10 percentage points. Figure 7 highlights regional coverage rates by woreda.

According to a survey conducted in lowland Woredas of Somali, Afar and South Omo zone of SNNP regions (USAID May 2016) 48 percent did not have access to the improved drinking water sources of which 48 percent were in Afar, 81 percent in Somali and 15 percent in SNNP. The same survey highlighted, of the 51% that are having access to water in Afar, 86% of the households use protected sources from drilled boreholes. Baseline data collected in 366 Woredas in 2018 also indicated that 80 percent of the Woredas in SNNP, Somali and Afar are below the national access coverage (53%). Similarly, USAID survey also suggests that there is very low sanitation coverage in Afar (23%) and Somali (5%) regions while SNNP has (89%) but these are mostly latrines with no superstructure and as surveyed with only 34% of utilization.

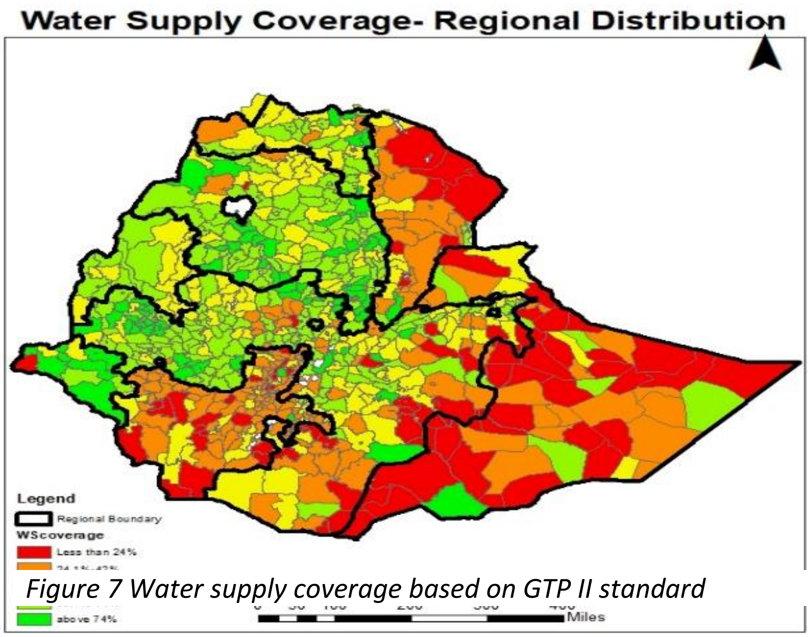


Figure 7 Water supply coverage based on GTP II standard

Several factors have contributed to the challenges and disparities highlighted in water service delivery. These challenges include:

Pastoralist and agro-pastoralist areas receive less rainfall than other regions (ranging between 600 mm-200 mm/year), potential water sources are usually scarce; groundwater sources are costly to access. While there are shallow aquifers in the alluvial beds of many rivers, they are not perineal and may last a few weeks to a few months after the rainy season. There are also areas that have sedimentary or volcanic formations, with deep to very deep aquifers. However, some of the deep aquifers could have a meager yield (<1lps) or may have poor water quality often with high mineral contents of 1.5 g/l and more, or high temperature, which may make the water unsuitable for drinking, small-scale irrigation, and sometimes even for animal watering.

The scattered settlement patterns of pastoralist and agro-pastoralist areas have made water service schemes too expensive to maintain. Given the transient nature of some communities, considerations for operation and maintenance of these systems have not been adequately put in place. Systems that require extensive pumping of deep groundwater sources, for example require diesel to operate pumps, replacement of spare parts that are often imported (electro-mechanical equipment, steel casing, etc). Consequently, investments in sparsely populated areas have fallen into disrepair due to lack of accountability, community engagement and capacity for repairs. Consideration of appropriate technology options that factor in a limited role for O&M has not been adequately scaled up.

The hydrology and geology in the lowland of Ethiopia are complex and little is known about the quality and quantity of water resources making the cost of reconnaissance before drilling expensive. Master plans studies of the different river basins focus only on significant tributaries and detail the surface water resources potential for hydropower and irrigation use. Information available about groundwater resources in the lowlands of Ethiopia fragmented. The hydro-geological data from drilled boreholes in the lowland areas have not been collected systematically and analyzed to assess groundwater potential to orient design and management of water service delivery. There are current fragmented initiatives to better understand groundwater quantity and quality of selected aquifer systems in the lowlands.

Water quality issue in groundwater resources. Studies and water quality data from most drilled deep boreholes in the arid and semi-arid lowlands indicate saline water with high mineral content (fluoride, iron, nitrate) and high temperature, an index to geothermal activity and instability calling for additional treatment. Expensive water treatment technologies such as de-fluoridation plants may be required to remove fluoride or reverse osmosis to remove salinity.

Cost of drilling and groundwater exploitation in most of the pastoralist regions is getting more expensive with a technological shift towards deep boreholes and limited drilling capacities in lowland regions. Although the knowledge base to orient investment in groundwater is fragmented, the reliance in groundwater is increasing. To reverse the high rate of drilling failure or lower than average water yield or chances of boreholes "drying up" the resolution made was drilling deeper. Borehole drilling in lowlands is significantly high and can be as high as US$291 000 per borehole; national median is US $128 000. Review of actual drilling contracts in Oromia, SNNPR, Somali and Afar regions have revealed that average cost of drilling a borehole ranges from ETB 4.69 million in Somali to ETB 0.44 million in Oromia. Besides the high price in drilling, there is also a higher rate of non-functionality – national average per reports from the Ministry of Water, Irrigation and Electricity (MoWIE) is 11 percent while in some lowland regions this rate is three times higher.

There are also logistical challenges for water service delivery in lowlands of Ethiopia. These challenges include: (i) poor security; (ii) accessibility; (iii) unfavorable weather conditions of sites; (iv) difficulty finding competent contractors willing to work in these areas; (v) disbursed settlement patterns that contribute to problems to gain economies of scale; and (vi) limited use of technology options suitable for lowland contexts.

Affordability. Water tariffs are extremely low (0.5 birr per 20 litters) in rural Ethiopia except for motorized piped schemes. Motorized piped schemes, which are common in pastoralist and agro-pastoralist areas, use diesel engines to pump water from borehole to distribution points making operational cost expensive and unaffordable for some households. The cost of diesel is compounded by high transport fees. As a result of high operating costs, communities in the lowlands pay on average25 ETB per m^3. Water from motorized schemes is over five-times the average urban tariff per m^3 and 25 times higher than the lowest municipal tariff band. Consuming just 20 liters per person per day would be equivalent to just under ETB 200 per person per year, which is more than the 5 percent affordability threshold commonly used to gauge affordability.

Higher vulnerability to climate shocks (droughts and floods) significantly affecting the availability and reliability of water supply systems. Lowland areas such as the downstream plains of Awash River in Afar, part of Somali region along WabeShebele, Genale and Dawa Rivers, and down steam areas along the Omo River in SNNPR are among the drought-prone areas in Ethiopia. There have been recurrent droughts in pastoral Ethiopia, with six drought episode being registered between 2000 and 2016 with the latest two (in 2011 and 2016-17) devastating pastoral and agro-pastoral livelihoods. The 2016 drought has been the most severe drought ever in its intensity, duration, and coverage. In the three pastoral eco-systems of Somali, Borena in Oromia, SNNPR and Afar Regions, nine consecutive dry months have been recorded and the amount of rain received in the preceding months was insufficient to make a difference. Many of these areas are also adversely impacted by localized flash floods.

Design Limitations. Technical designs of water supply schemes often do not adequately address: (i) the social and cultural considerations like traditional water rights and community leadership structures; (ii) fail to sufficiently dimension influx of mobile communities; (iii) implications of using the limited natural resources; (iv) lack of awareness about benefits of clean water; and (v) do not explore usage of appropriate technology options such as renewable energy sources, low cost water harvesting, groundwater recharge etc. There are also limitations at the local level in capacity to design, implement and manage water service delivery.

Limited capacity at the local level. Water supply design and implementation is a mandate of woreda, but the capacity at the local level to design, implement and manage water service delivery is limited particularly in the lowland areas. There are a limited number of qualified professionals at regional and woreda levels to provide adequate oversight for the design and implementation of water supply service delivery. Further, in many cases, the hydrological boundaries where water is available do not coincide with the administrative woreda boundaries.

Weak vertical and horizontal coordination. The decentralization in the government structure has created vague accountability structures, inadequate coordination and communication gap among the different level of actors in the same sector at regional, zonal and woreda level. There is also very weak coordination among sectoral offices at all level horizontally.

5 OPPORTUNITIES FOR WATER DEVELOPMENT

There are several opportunities to enhance management of water resources in the lowlands to better sustain service delivery, livelihoods and contribute to economic growth. While there has been a substantial improvement in access to water supply services several vital areas can be strengthened to ensure sustainability of water use and alignment with other productive sectors (e.g., agriculture, pastoralism, industry, etc.). Opportunities and way forward include:

a. Expand the spectrum of storage
b. Linkage of water infrastructure development with pastoralists livelihood systems – rangeland management approach
c. Investing in water M&E – as a tool to enhance functionality and accountability
d. Consider financing mechanisms that incentivize performance and local government participation
e. Tailored technical assistance to address capacity gaps
f. Provision of water must be coupled with sanitation interventions

5.1 Expand the spectrum of storage

To enhance the resilience of livelihoods and economic activities in the lowlands, an increase in water storage is needed. A broader spectrum of storage should be ideally explored to include a strategic mix of "blue" and "green" options. Blue storage refers to varying sizes and combinations of surface retention structures from traditional birkas, haffirs, and dams of varying sizes whereas "green" storage considers options of storage in soil retention. "Green" storage is ideally suited to expand livelihood activities such as small-scale spate irrigation. Increasing storage will allow for sustainable water resources that can mitigate against climate variabilities and enable communities to better cope with climatic shocks.

Although water resources are highly variable, even within "dry basins" there is a significant amount of runoff in the form of rainfall and flash floods that can be strategically harnessed. Figure 8 highlights the streams that contribute to surface water hydrology. Many of these streams are ungauged, with limited information regarding seasonal flows. Assessment of the three "dry basins," Aysha, Ogaden, and Denakil indicate that on average each basin receives rainfall that can be strategically considered for water harvesting. The basin-wide the rainfall characteristics are summarized in the following table.

Table 2. Mean rainfall values in the three 'dry' river basins of Ethiopia

Rainfall Characteristics	**River Basin**		
	Ayisha	Denakil	Ogden
Mean Rainfall	242.1	367.1	351.4
Median Rainfall	243.1	372.5	330.7
Standard Deviation	48.7	53.9	71
Coefficient of Variation	20.2	14.7	29.3

As shown in Figure 8, Denakil River Basin looks to have a series of river networks showing the presence of runoff from high lands indicating some opportunities for runoff water harvesting. For Ogden, the river networks are not well developed; hence the runoff harvesting of large volume for flood irrigation may not be high. Aysha has some river networks, and opportunities are water harvesting may be sought. Assuming about 20% of the rain is converted to runoff, are the mean runoff that can be harvested could be estimated at 48, 72, and 35 mm for Aysha, Denakil, and Ogaden river basins, respectively. If a drought tolerant crop such as sorghum (450 -650 mm) is to be grown, this would require at least a command area to command: catchment ratio of at least 1:10.

Experiences from other countries with similar dryland climates have been able to harvest rainfall that is lower than 200 mm to sustain water supply service delivery and to produce crops. The rainfall available in what are generally considered as dry basins has the potential to support lives and livelihoods provided that improved water harvesting techniques are employed that consider a strategic mix of storage options.

Beyond harnessing the potential of surface water hydrology, exploitation of groundwater and conjunctive use present critical opportunities for water resources development. In arid environments where evaporation rates are high due to high temperatures, consideration of groundwater exploitation is vital. The current knowledge base of groundwater potential is fragmented and requires investments in mapping to better understand groundwater potential. Groundwater resources can be jointly and strategically used with seasonal surface water from streams, wadis, and rivers. Shallow aquifers that are present near the banks of surface water bodies, current low-cost opportunities for water supply. Managed recharge through the use of structures such as sub-surface and sand dams can potentially increase storage potential in shallow aquifers and reduce water losses due to evaporation from surface water storage structures. Recharge requires further study, and localized assessments as local groundwater sources may be contaminated (saline, brackish, high mineral content, etc.) and it would not be prudent to mix potable harvested surface water with contaminated groundwater.

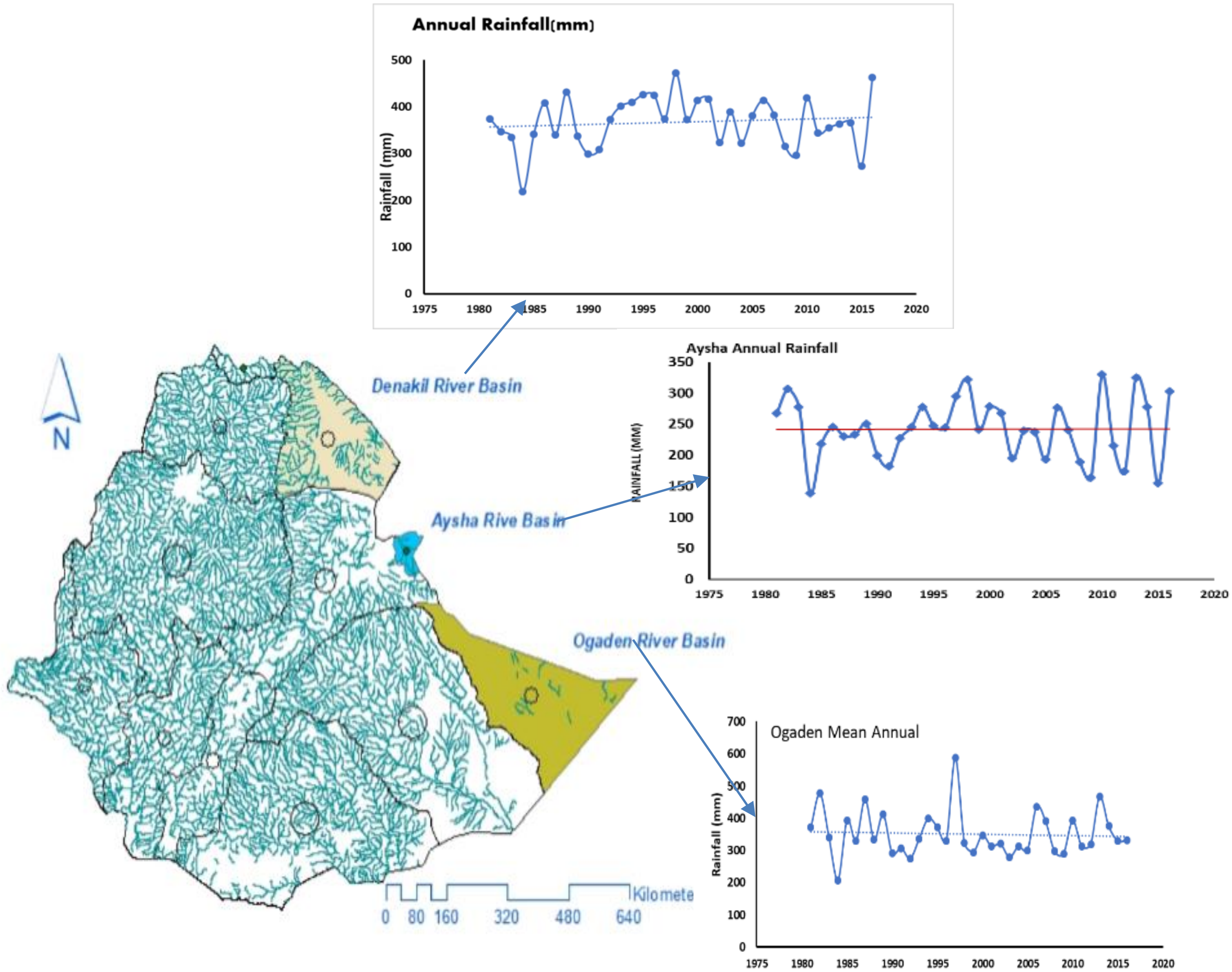


Figure 8 River networks and the three dry river basins along with rainfall time series.

Optimization of operations of existing hydraulic infrastructure can reduce impacts of climate shocks to vulnerable communities. For example, existing hydraulic infrastructure such as single-purpose dams for irrigation can be revised to address water stress. Revising operation rules of existing water storage infrastructure to release additional flow during drought periods can alleviate downstream impacts.

5.2 Linkage of water infrastructure development with pastoralists livelihood systems – rangeland management approach

Multi-use water infrastructure that can provide multiple benefits reduces the high costs of investments. Fragmented investments in water supply, irrigation, hydropower, and water for industrial use do not offer economies of scale for investment planning**.** Costs of groundwater exploitation and water harvesting infrastructure are considerably high in Ethiopia.

Develop water systems that are linked to movement (e.g. pastoralists routes) to dimension potential needs and promote movement that is in tandem with the availability of water and other natural resources. Provision of localized water supply for human consumption that fails to consider the movement of transient communities with large herds of livestock can be potentially detrimental and lead to environmental degradation. Water supply infrastructure should be designed to recognize natural herd movements and provide services at localized points that promote movement and replenishment of natural resources. This approach will serve to sustain the predominant economic activity of livestock rearing and reduce localized social tension that arises from competition for limited water and pasture. As such, the need for multi-woreda or multi-regional solutions that require intervention and planning and design of water supply systems at higher spatial and landscape planning units is critical.

5.3 Water resources mapping, monitoring and planning

Investments in enhancing capacities for mapping, monitoring and planning are critical to ensuring sustainability of water infrastructure. As noted above, the costs of investments in lowlands are prohibitive due to lack of reliable data and information to guide citing of borehole drilling as well as the design of water infrastructure. Investments in mapping existing water resources and potential can better guide the dimension of proposed infrastructure developments. Investments in water resources monitoring, such as gauging of critical surface water streams and groundwater levels in critical areas can provide additional information that can support management of water infrastructure, particularly in isolated areas where frequent monitoring cannot be carried out by government officials. Use of remote sensing and earth observation tools can be useful in filling in key knowledge gaps.

Shift towards proactive management – contingency planning and preparedness. With investments in the monitoring of water resources, active management can help reduce costs of emergency response. Strategic use of triggers that can signal signs of multi-indices drought (hydrological, meteorological, agricultural, ecological, etc.) that are conclusively linked to localized action plans can be useful tools to quickly mobilize resources for mitigation activities to reduce the impact of climate shocks.

5.4 Investing in water M&E – as a tool to enhance functionality and accountability

Monitoring and evaluation tools can be useful in promoting the functionality of water supply infrastructure and enhancing accountability for operation and maintenance. In lowland regions, particularly for water supply infrastructure, functionality is a crucial challenge. Given the dispersed nature and location of schemes, oversight and technical assistance by local governments can be difficult. Implementation of M&E tools such as sensors or introduction of community-based monitoring via sms applications have proven to be very useful at pilot scale and demonstrate considerable potential for scale-up. Availability of information about the schemes, their functionality, revenue collection, management etc. is essential especially for complex schemes where the local technical capacity is limited, and the demand for regional level intervention for maintenance is high. Improvement in the monitoring and evaluation (M&E) can also be a tool to increase accountability.

5.5 Consider financing mechanisms that incentivize performance and local government participation

Introduction of conditionalities with fiscal transfers to incentivize improvement in service delivery is essential. In many instances, there has been a narrow focus on construction of water supply infrastructure without due attention for operation and maintenance. In areas where access to schemes by local government is difficult, functionality rates are higher. Financing mechanisms that consider increased capital costs for investments are needed. Further, incentive mechanisms to motivate due attention of O&M by local government and communities is necessary to ensure the sustainability of service delivery.

5.6 Tailored technical assistance to address capacity gaps

Building institutional capacity. Capacity to design and implement should be an integrated part of any investment in resilient water supply developments at all levels. In the case of lowlands where water schemes are complex, there is a need for tailored technical assistance (design, contract management, coordination (vertical and horizontal), etc.).

Leverage the presence of local organizations to provide support and enhance accountability. Local NGOs and CSOs can be useful mechanisms to offer targeted support at community levels. Engagement of local actors, where access and capacities are limited at woreda level can strengthen the implementation and management of localized water service delivery.

Provision of water must be coupled with sanitation interventions. Inadequate attention to sanitation may not yield expected impacts for the provision of water. To ensure that communities lives and livelihoods are enhanced, the provision of water supply should be adequately dimensioned with sanitation to the proliferation of water-borne diseases.

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