The Fedral Democratic Republic of Ethiopia Abbay Basin Development Office

State of the Abbay Basin

By; Biazen Ferede
Eskalehu Abeje
Zemenu Degie

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Acronyms

ABDO - Abbay Basin Development Office

HIS – Hydrological Information System

BIS – Basin Information System

BMC - Billion Metere Qubic

ANRS - Amhara National Regional State

BoFED - Beuro of Finance and Economi Development

CSA – Central Stistics Agency

1. Intorduction

Abbay Basin Development Office is established to contribute in creating efficient and stable mechanisms for the implementation of Ethiopian Water Resources Management Policy through basin plans and sustainable management by relevant stakeholders of the water resources of the basin.

Thus, Abbay Basin Development office is operating having the mission; to contribute to the overall sustainable development in the basin by ensuring integrated, participatory, equitable and sustainable water resource management, by creating favorable conditions for the better protection and conservation of the ecosystem, and through knowledge building and being the center of information. The BDO also envisions ensuring the socioeconomic welfare of the people as a result of the integrated development and sustainable management of the water, land and other related resources of the river basin.

It is obvious that among the powers and duties of ABDO is to collect, compile, analyze and disseminate information for proper planning, administration and steering of water resources in the basin.

Compiling and producing a ***'state of the basin***' is believed to be one mechanism to put to effect the above mentioned duty of the BDO. Thus, this document is compiled for the purpose of providing information about the entire feature of the river basin. It aims at presenting relevant information about the socioeconomic aspects of the basin,the biophysical environment, the agro-ecology and topography of the basin.

2. Physiographic Characteristics of the Abbay Basin

2.1. Geographical Location

Abbay Basin in Ethiopia is located in the northwestern region between 7^0 40’ N and 12^0 51’ N latitude, and 34^0 25’ E and 39^0 49’ E longitude. The basin is the second largest basin with an area of 199,812 sq km.The river basin is deemed to be the most significant river basin in Ethiopia in terms of a wide range of natural resources.It occupies 20% of the country’s territory and it covers an area of 60% of Amhara, 40% of Oromiya and 95% of Benishangul-Gumuz regional states. It shares a boundary with the Tekeze basin to the north, the Awash basin to the east and southeast, the Omo-Gibe basin to the south, and the Baro-Akobo basin to the southwest. From its source

Gish Abbay in West Gojam, Abbay flows northward as the Gilgel Abbay into Lake Tana. The Blue Nile River (also called Abbay River in Ethiopia) exits from the south east of Lake Tana and flows south and then westwards cutting a deep gorge towards the western part of Ethiopia. A number of tributaries joined Abbay river in Ethiopia: Beshilo, Jema, Muger, Finchaa, Didessa and Dabus from the east and south; and the Suha, Chemoga, Keshem, Dera and Beles from the north. The Dinder and Rahad rise to the west of Lake Tana and flow westwards across the border joining the Blue Nile below Sennar. In the Sudan, the Blue Nile flows in the plain desert until it reaches the confluence, where it meets with White Nile in Khartoum.

The basin is subdivided into 16 sub basins based on the major rivers in the basin, the Abbay River and its tributaries (See Fig.1 below).

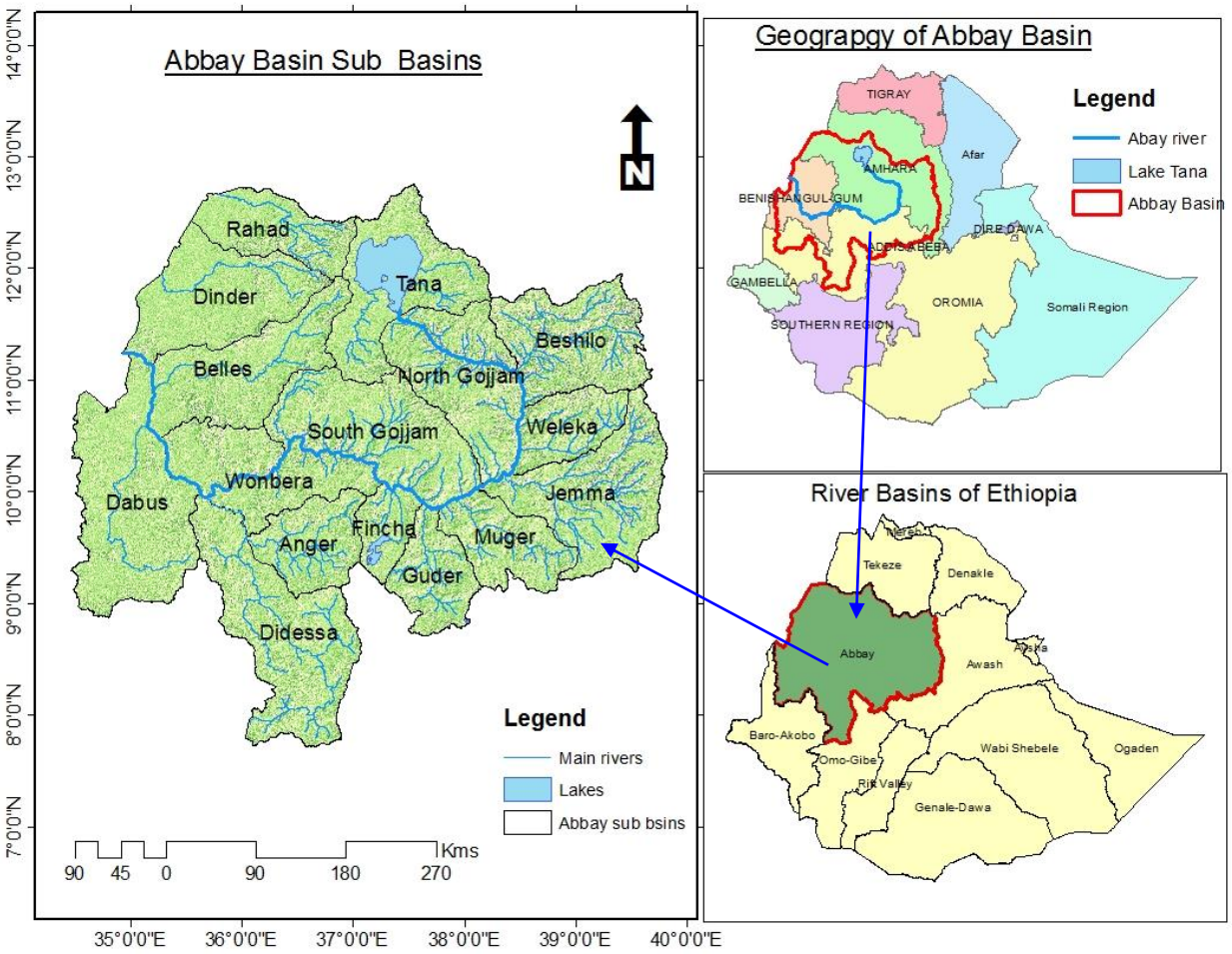


Figure 1:Geographical Location of Abbay Basin

2.2. Topography

The topography of the Abbay basin signifies two distinct features; the ***highlands***, rugged mountainous areas in the middle and eastern portion of the basin and the ***lowlands*** in the western part of the basin. The altitude in the basin ranges from 480masl in the lowlands at Sudanese border up to 4261 masl in the highlands. The gradient of the basin can be grouped into three as it indicated in the pattern below. 85% of the basin areas have a slope percentage of less than 30%, 15% of the basin areas have steep slope having a slope percentage greater than 30%. The Abbay leaves the lake close to the city of Bahir Dar at the southeastern corner of the lake and cuts a deep gorge first south then westwards, through a series of cataracts. Approximately 40 km downstream it drops 50 m over the TeesIssat Falls into the Blue Nile gorge.

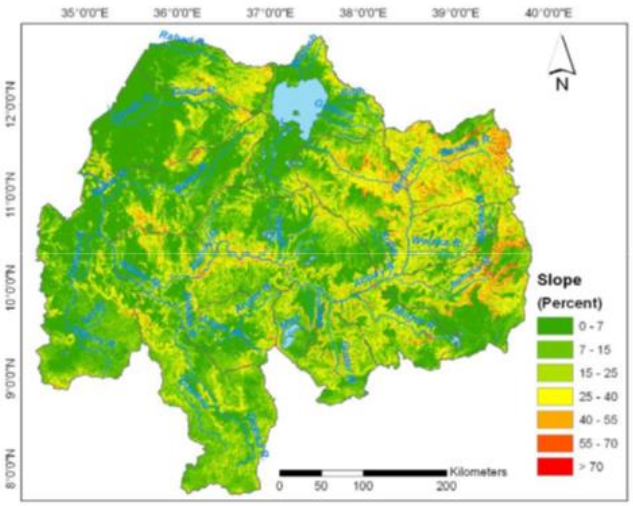


Figure 2: Slope map of the Abbay Basin

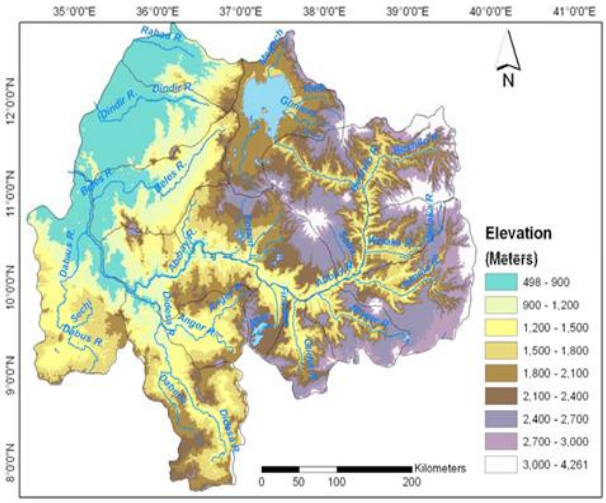


Figure 3: Elevation Map of the Abbay Basin

2.3. Climate

2.3.1. Rainfall

Rainfall provides suitable conditions for many types of ecosystems, as well as water for hydroelectric power, plants and crop irrigation.Within the basin, rainfall varies significantly with altitude and is, to a large extent, controlled by movement of air masses associated with the Inter-Tropical Convergence Zone (ITCZ). There is considerable inter-annual variability, it increases from about 1000 mm near the Sudan border to between 1400 and 1800 mm over parts of the upper basin, and exceeds 2200 mm in some places in the south with a mean of about 1,420mm

yr^{-1} (Awulachew*et al.*, 2008). This proportion generally increases with altitude. There are three main rainy seasons in the basin: the dry season from October to February (Bega), the small rainy season from March to May (Belg) and the main rainy season, usually from June to September (Kiremt) which account for a large portion of mean annual rainfall: roughly 60- 80% occur between June and September with the greatest rainfall occurring in July and August.

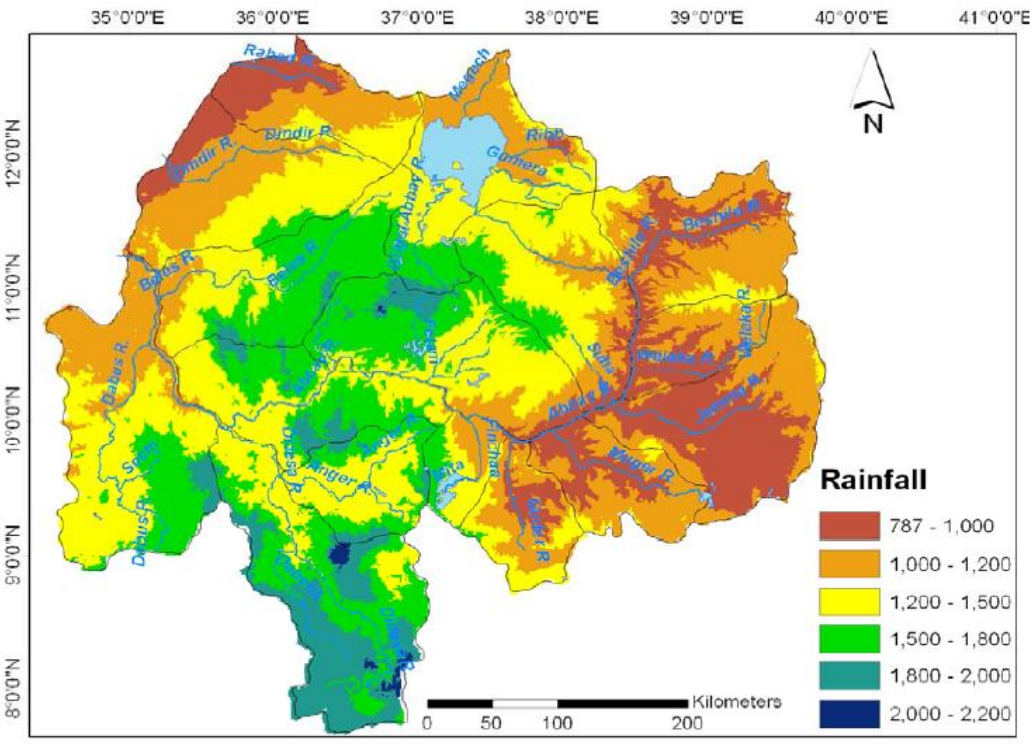


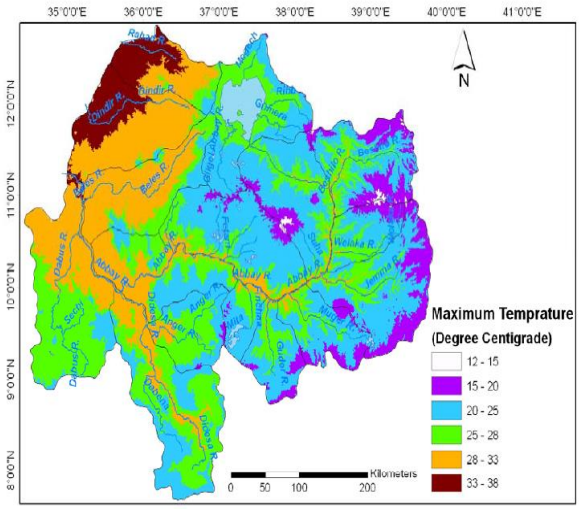
Figure 4:Rainfall distribution in the Basin

2.3.2. Temperature

Abbay basin is found in the tropics, where it expriences warm to hot and moist year-round. The spatial distribution of temperature is strongly related to altitude. The altitude of the Abbay basin ranges from 480masl on the Sudanese border to 4,261 masl at the summit of Mt. Guna. The highest temperature observed in the northwestern part of the basin, in parts of Rihad, Dinder, Beles and Dabus, the maximum temperature being 28^{o}C–38^{o}C and minimum temperature 15^{o}C–20^{o}C (fig. 5). In the eastern part of the basin the maximum and minimum temperature ranges from 12^{o}C – 20^{o}C and -1^{o}C – 8^{o}C respectively as displayed in the figure below.

Minimum temperatures significantly increased in northern, central, southern and southeastern parts of the Basin in all seasons(fig. 6). The minimum temperatures increased at a higher rate than the maximum temperatures during winter, summer, autumn and also at the annual time

scale. Mean annual minimum and maximum temperatures increased from 12.69 to 13.32 °C and 26.43 to 26.91 °C from 1981 to 2010, respectively (Woldeamlak,*et al*, 2014).



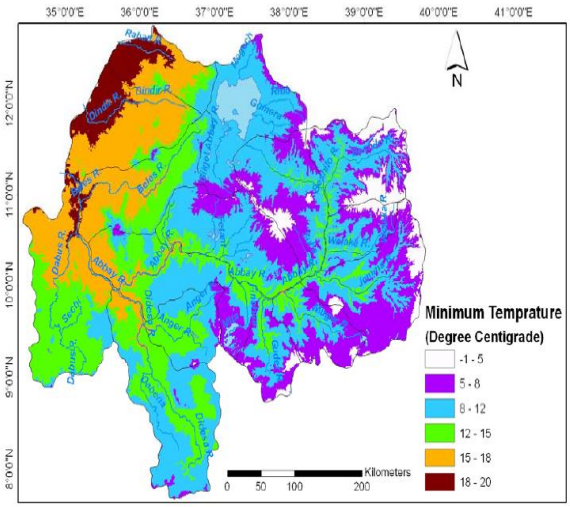


Figure 5.Maximum temperature distribution in the basinFigure.6.Minimum temperature distribution in the basin

2.3.3. Evapotranspiration

Due to its equatorial positioning, the Abbay River is ripe for evaporation in its channels and reservoirs, and evapotranspiration through irrigation practices. Potential Evapotranspiration (PET) in the basin ranges between 1056 mm and 2232 mm per year. High PET is observed between 1800 mm and 2232 mm per year in the North Western parts of the basin, in Dinder, Rahad, and parts of Beles and Didessa sub basins (fig. 7). The Eastern and southern parts having lower PET ranging between 1200 and 1800 mm per year and the lowest PET below 1200 mm per year observed in the parts of the highlands (AbbayBasin atlas, 2015) and, in many places, is less than rainfall in the rainy season.

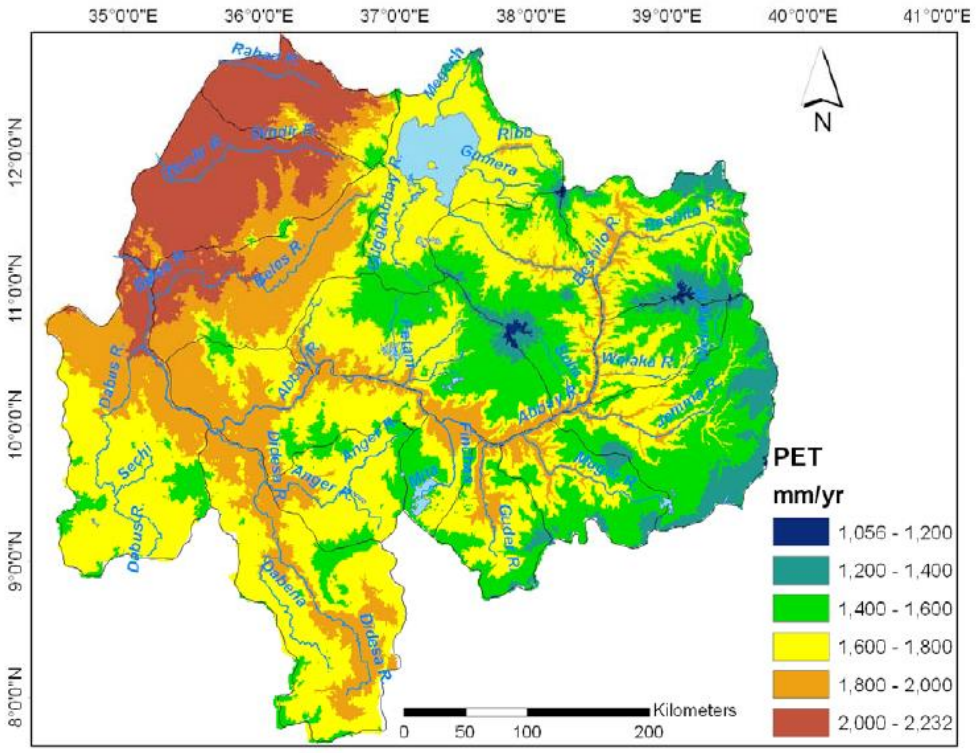


Figure 7:Potential Evapotranspiration of Abbay Basin

2.3.4. Climate Monitoring Stations

There are 349 identified meteorological stations, of which 30 are class I or principal, 28 are Class II, 112 are class III and 176 are class IV. The climatic data network shows there is uneven scattering of the stations over the basin and insufficient coverage of low and highland areas.

The Tana, Dedissa, South Gojjam, Beshilo and Jemma sub basins have intense data coverage. The rest of the sub basins have a very low station density. The catchments of Welaka, Dinder, Wombera, Dabus and Guder, have a very poor coverage of meteorological stations (Fig. 8).

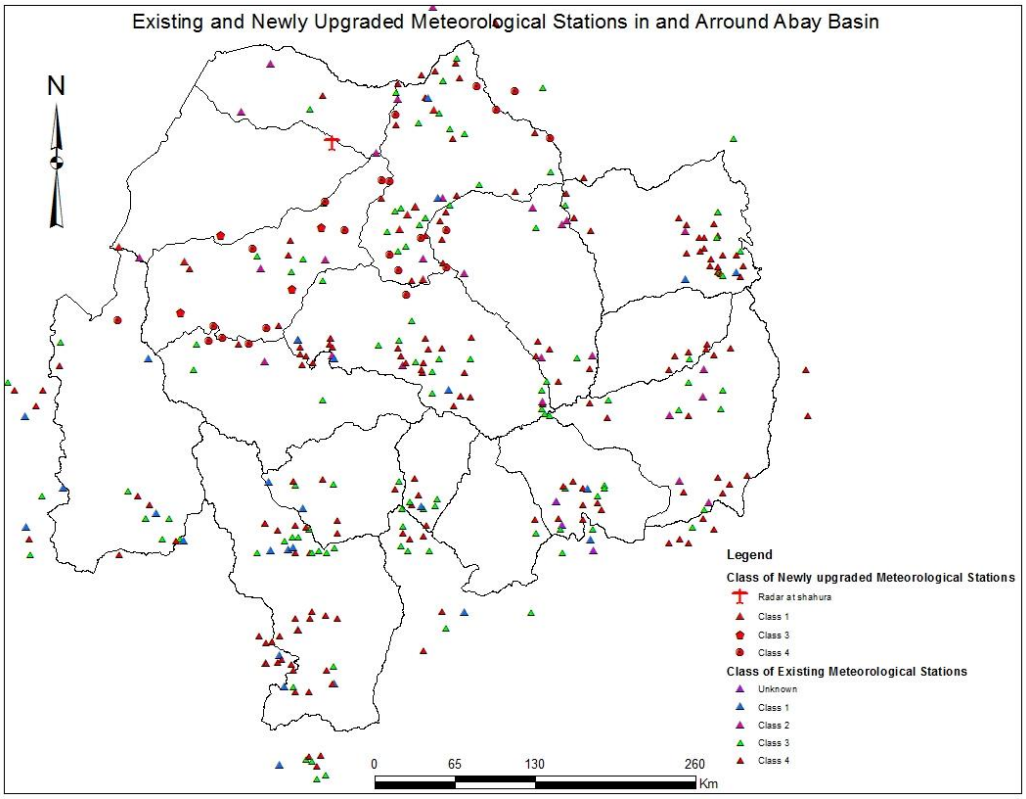


Figure 8:The Distribution of Meteorological Stations in AbbayBasin

Apart from this, 168 hydrological stations are found in the basin in which 43 of them are newly installed, advanced and upgraded HIS/BIS stations established through the HIS/BIS project in addition to the manual recording staff gauges (fig. 9). All data from the monitoring network is collected from the Hydrological Branch Offices of the basin at regular. The data collection activities are mainly engaged in surface water resources assessment which currently comprises a collection of stream flow data, lake level, recording of suspended sediment sampling and water quality data. Like the meteorological station, the basin has not been fully covered by the hydrological stations because of several constraints. The Tana basin is well covered while the Wombera sub basin is poorly addressed.

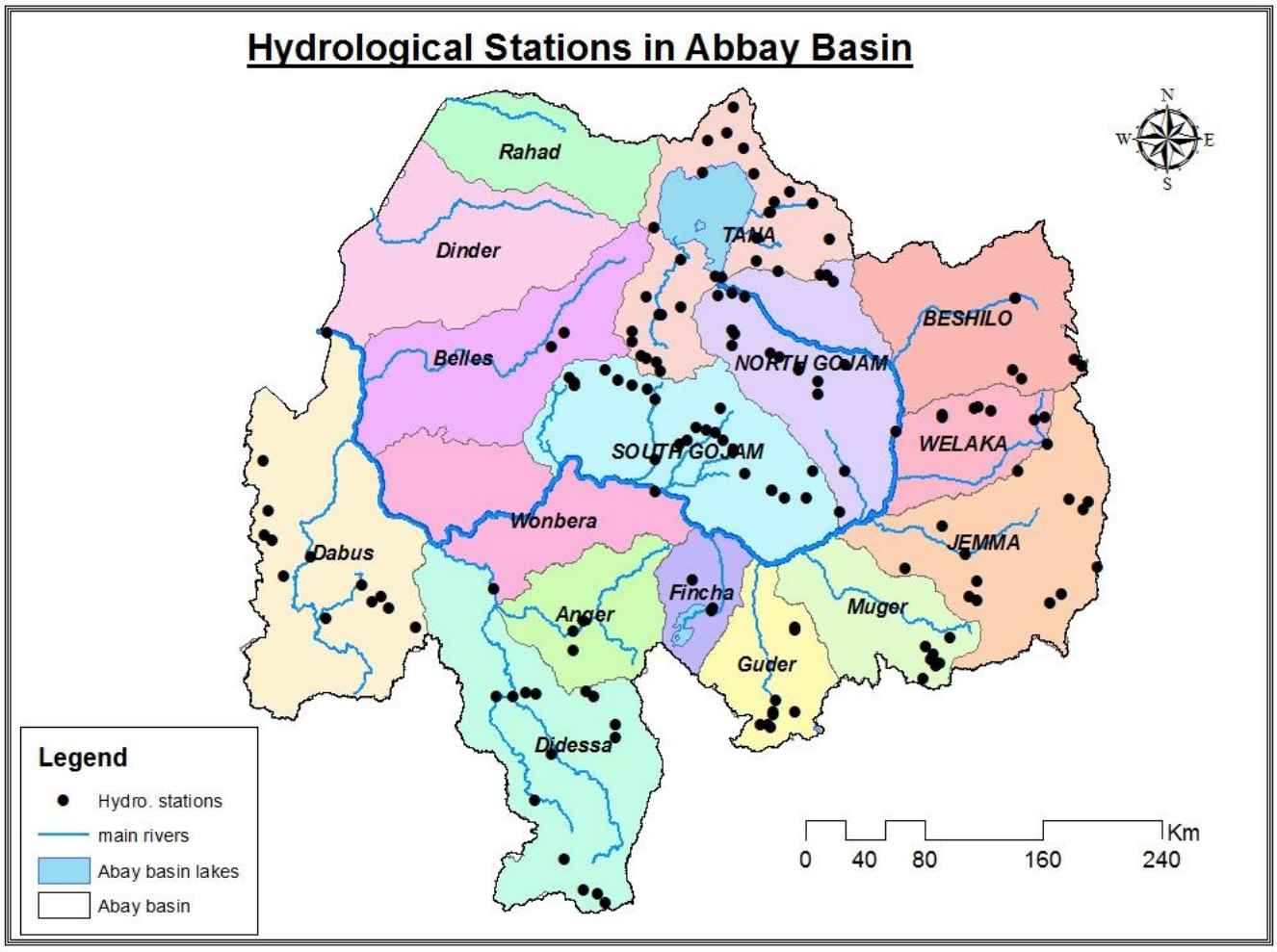


Figure 9 : Hydrological stations in Abbay river basin

2.4. Hydrology of Abbay Basin

The hydrology of the River Abbay is regulated by the interaction between climate and geography throughout the basin. The timing and volume of discharge in the main River Abbay depend on the flow patterns of its tributaries. In turn, water flow and balance within these tributaries and other water bodies within the basin depend on rainfall and temperature patterns; physical characteristics of river channels, lakes, and wetlands; vegetation; and human influences such as dams.

2.4.1. Surface flow

The Abbay River Basin with an area of 199,812 Sq. km is the second largest basin in Ethiopia in terms of runoff estimated to be 54.4 BCM. The Abbay River basin drains to Sudan through three main outlets: (i) the main channel of the Abbay River with a mean annual discharge of 49 BCM at the border. This contributes 94 percent of the basin flow from a drainage area of 172,254 Sq. km; and (ii) the channel of the Dinder and (iii) the channel of Rahad rivers which drain to Sudan to the north of the Abbay channel and join the Abbay. Both the Dinder and Rahad have a mean annual discharge of approximately 5 BCM and which contributes 6% of the Abbay River basin flow from a combined catchment area of about 23,160Sq. Km. The remainder of the catchment is distributed within smaller water courses on both banks of the Abbay River. The rivers joined in the left bank in descending order of entry; the Beshilo, Welaka, Jemma, Muger, Finchaa and Didessa rivers. On the right bank the rivers rising from the Gojam area of the Ethiopian Highlands have smaller, more limited catchments and these rivers include; Abeya, Suha, Chemoga, Birr, Fettam and Dura. Two major tributaries join the Abbay in the lowlands the Dabus on the left bank and the Beles on the right bank.

Table1. Runoff in each sub basin

No.	Name	Area (Km^2)	Runoff depth in mm
1	Lake Tana	15 054	514
2	North Gojam RB	14 389	486
3	Beshilo RB	13 242	455
4	Welaka RB	6 415	410
5	Jemma RB	15 762	422
6	South Gojam RB	16 762	543
7	Mougr RB	8 188	423
8	Guder RB	7 011	537
9	Finchaa RB	4 089	450
10	Dedessa RB	19 630	651
11	Anger RB	7 901	527
12	Wombera RB	12 957	410
13	Dabus RB	21 032	466
14	Beles RB	14 200	378
15	Dinder RB	14 891	279
16	Rahad RB	8 269	339
	TOTAL	199 812	7290

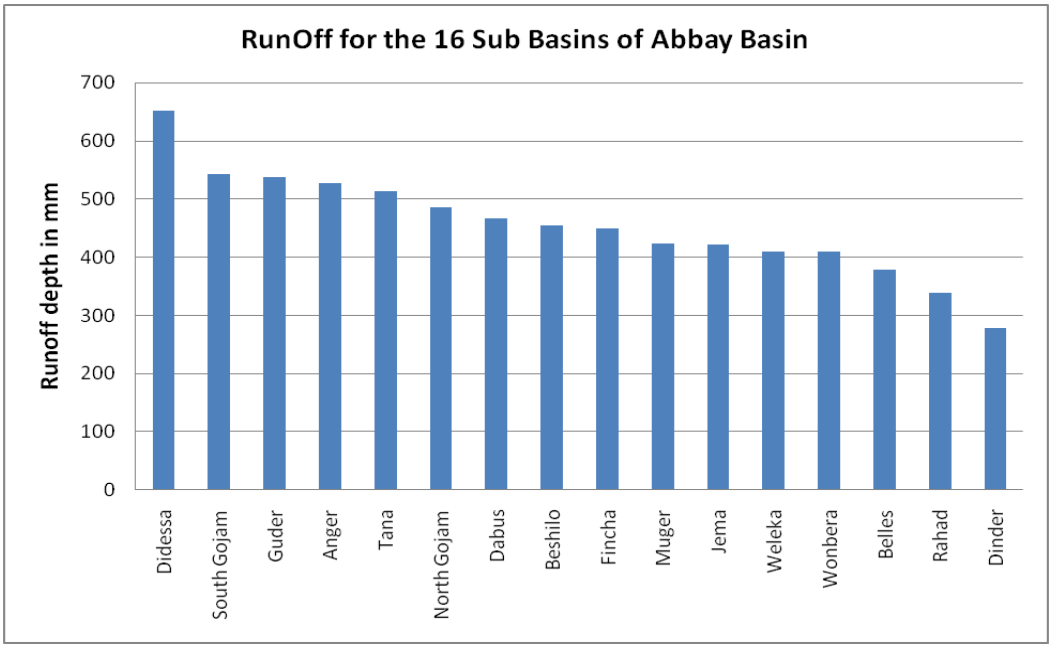


Figure 10: Runoff depth of the 16 sub basins of Abbay

2.4.2. Ground Water Resources

Groundwater resource is almost exclusively included in consolidated rocks: basalts, limestone and sandstone, and metamorphic basement. The retention capacity of these rocks is low. Thus, water flow is linked to the presence of fractures. However, it is anticipated that the porosity of some geological formations may make a significant contribution to the groundwater storage.

Most of the water accessible through 60 to 100 m deep boreholes is found in volcanic rocks. Although Adigrat sandstone outcrops in the southern part of the basin, most of this geological series as well as the other sedimentary formations such as hintalo limestone and Amba Aradam sandstones are generally overlain by thick basaltic rocks that impede infiltration (Geograpgy of Ethiopia, 2008).

The mean borehole discharge ranges between 3 and 4 litres/second except for the Kombolcha area colluvium. In which, the mean discharge is 10 litres/second (water resource document of ABDO, 2019).Groundwater recharge results mainly from infiltration of rainfall. Rainfall infiltration coefficients per geological series have been derived from the groundwater contribution to surface water; they range between 3 % and 20%.

Recharge, expressed as average continuous flow, ranges between 250 and 300m^3/s. The aquifers drain relatively freely to rivers as the storage capacity of the water bearing formations is low due to their lithological characteristics, while frequent and deep canyons provide numerous outlets. Even so, the dry season flow of the Abbay is still largely dependent on groundwater. At the end of the dry season, the Abbay River at the Sudan border still flows at an average of 100m^3/s.

However, in the valley escarpments or in the highlands, the storage capacity of the perched aquifers is generally not able to ensure a continuous flow to the springs. In the highland plateau areas most springs dry up during the dry season. Studies showed that almost twice as many households (37%) on the Abbay valley escarpment reported groundwater shortages than those in lowland areas (23%), with the majority of shortages occurring from February to beginning of May. The least affected area was the plateau area which is remote to the groundwater drawdown area of the escarpments, while benefiting more from the recharge areas.

2.4.3. Drainage Networks

The whole area of the Basin is intersected by streams, many of which are perennial though highly seasonal in their flow. The primary tributaries of the Abbay Basin are theBeshilo, Jema, Muger, Finchaa, Didessa and Dabus from the east and south; and the Suha, Chemoga, Keshem, Dera and Beles from the north. From which the main tributaries of the Abbay,Dabus and Didessa Rivers accounts with 10% and 8.5% of the total flow at the border respectively.

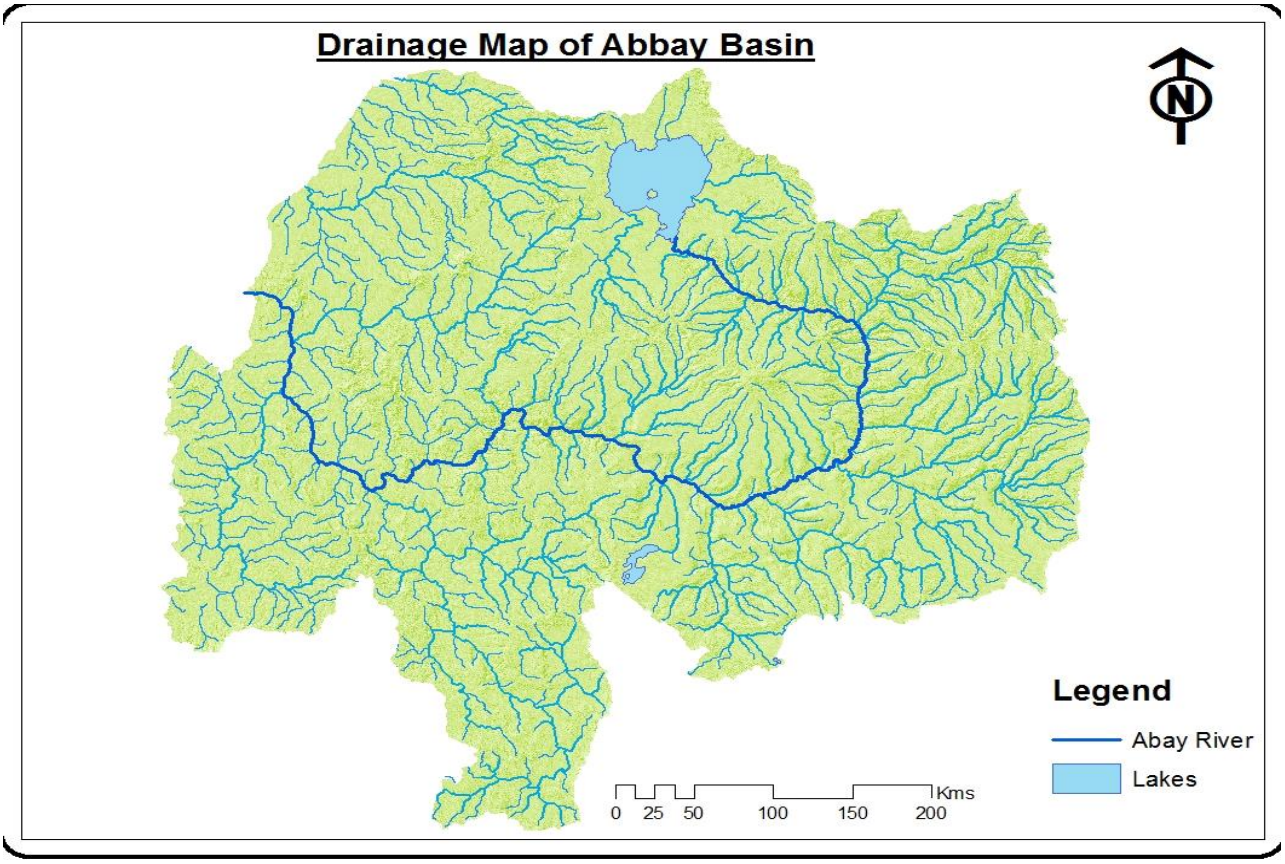


Figure 61:Drainage networks of Abbay Basin

Table 2.Sub basin hydro-climatic characteristics in Abbay basin

Summary statistics for the major sub-basins of the Abbay Basin.						
Sub-basin	Catchment area (km^2)	Mean annual rainfall (mm)	Mean annual evapotranspiration (mm)	Mean annual runoff (mm)	Mean annual flow (Mm^3)	Coefficient of runoff
Guder	7,011	910	1,307	312	2,187	0.34
Dabus	21,030	2276	1,112	297	6,246	0.13
Finchaa	4,089	1766	1,290	438	1,719	0.25
South Gojam	16,762	1633	1,183	299	5,012	0.18
Anger	7,901	1813	1,318	298	2,355	0.16
Beles	14,200	1655	1,274	306	4,345	0.18
Didessa	19,630	1816	1,308	289	5,673	0.16
Muger	8,188	1347	1,210	298	2,440	0.22
North Gojam	14,389	1336	1,242	305	4,389	0.23
Jemma	15,782	1105	1,059	304	4,798	0.28
Tana	15,054	1313	1,136	253	3,809	0.19
Welaka	6,415	1072	1,263	323	2,072	0.3
Beshilo	13,242	982	1,140	296	3,920	0.3
Wombera	12,957	1660	N/A	299	3,874	0.18
Dinder*	14,891	N/A	N/A	188	2,797	N/A
Rihad*	8,269	N/A	N/A	133	1,102	N/A

Source: Modified from Gupta and Van der Zaag, 2007N/A -Not available, * Joins Nile in Sudan

2.5. Agro Ecological Zones of Abbay Basin

Agro ecological zones are geographical areas exhibiting similar climatic conditions, and influenced by latitude, elevation, and temperature, as well as seasonality, and rainfall amounts and distribution during the growing season.The agro-ecology of the basin is divided into three major climatic zones, cold to very cold, tepid to cold, and hot to warm, and further divided into moist, sub moist, humid and sub humid. The agro-climatic zones of the basin are considered based on the topographic nature that ranging from about 475 masl to the highest elevation about 4261 masl. There are five traditional agro ecological zones as described in the table below.

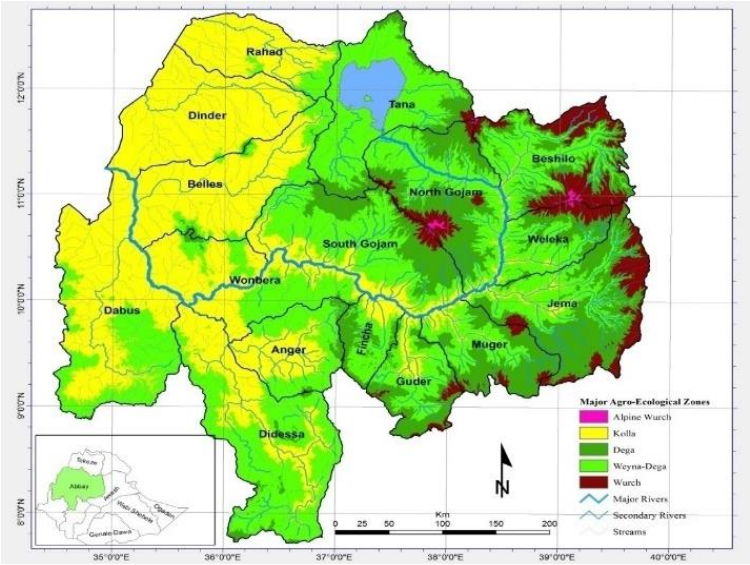


Figure 72: Traditional agro-ecological zone in the Abbay Basin

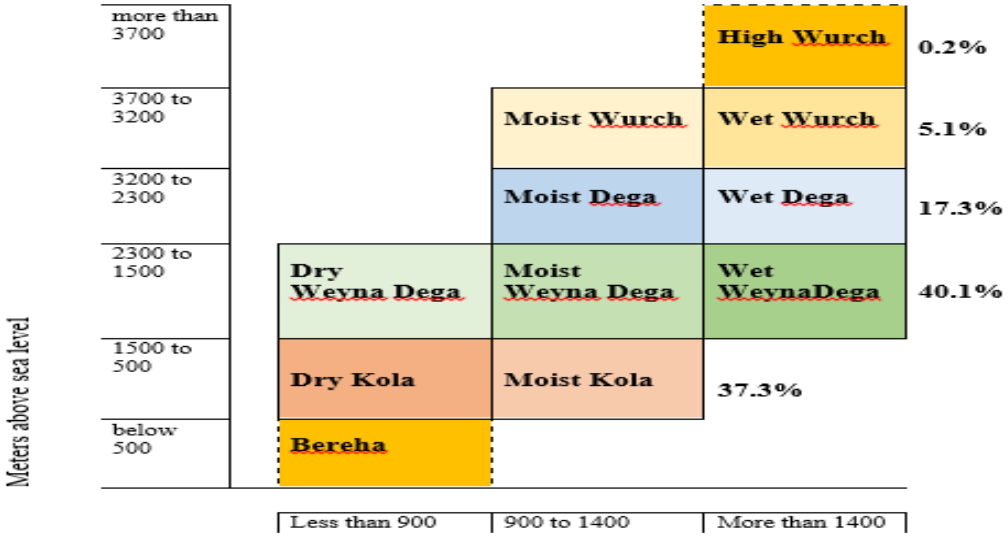


Figure 83: Tabular representation of Traditional agro-ecological zone in the Abbay Basin

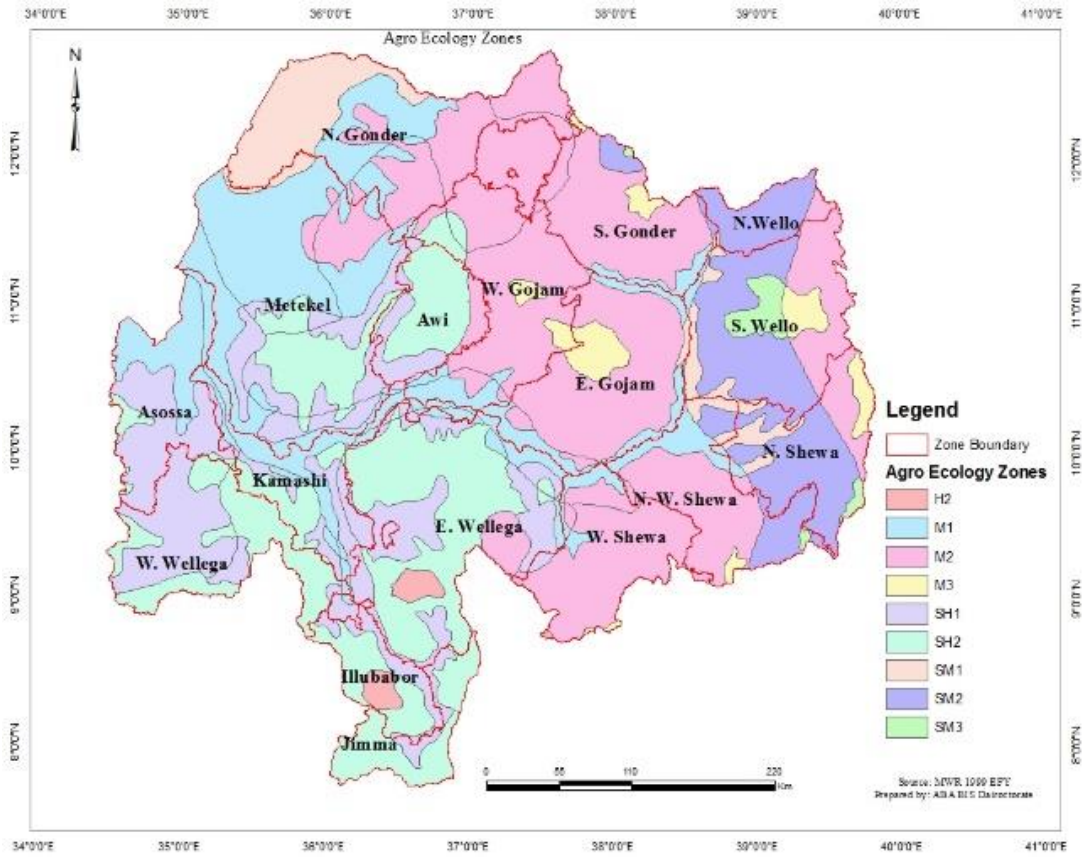


Figure 94: Major agro-ecological zone in the Abbay Basin

H2: Tepid to cool, humid mid to high altitude

M1: Hot to worm moist lowlands and highlands

M2: Tepid to cool, moist mid to high altitude

M3: Cold to Verycold, moist sub-Afro alpine to Afro alpine

SH1: Hot to worm Sub humid low land to the mid altitude

SH2: Tepid to cool Sub-humid low to high altitude

SM1: Hot to Worm sub moist lowlands and plateau ruminants

SM2: Tepid to cool Sub moist low to high altitude.

SM3: Cold to very cold Sub moist sub Afro alpine to Afro alpine

2.6. Land use/land cover

Land cover is what covers the surface of the earth, and land use describes how land is used. Studies of the basin revealed that the basin is mainly characterized by dominantly cultivated, in theeastern part, and grassland, woodlands, and forest to the west part according to the master plan land cover classification.

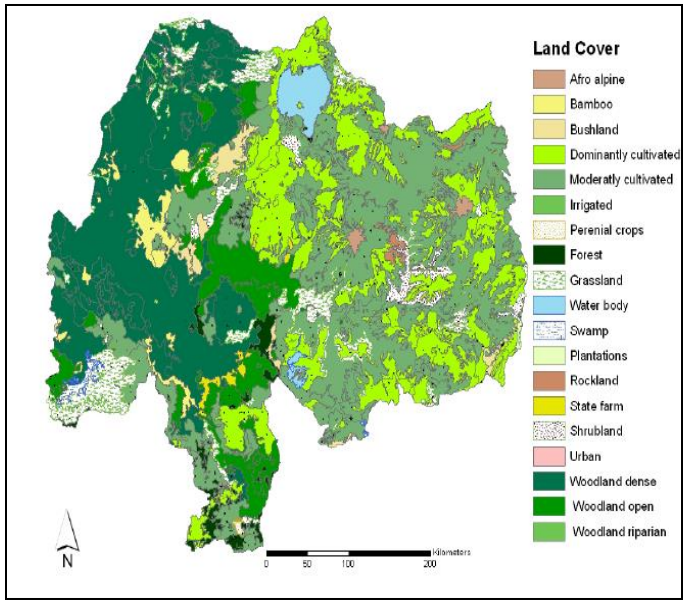
Table 3: Land cover of the Abbay basin

Land cover	Amhara	Oromia	Beni-Gumuz	Total km^2	Total %
Use Category					
Cultivated	42,736	22,349	2,805	67,890	34%
Tree Crops	-	260	-	260	0.13%
Plantation	301	228	8	537	0.27%
Afro-alpine	927	174	2	1,103	1%
Disturbed forest	65	2,128	83	2,276	1%
Bamboo	918	872	5,536	7,326	4%
Woodland, bushland& shrub land	20,598	16,549	23,291	60,438	30%
Grassland	17,797	15,387	12,959	46,143	23%
Wetland	1,110	1,274	-	2,384	1%
Water body	3,045	370	-	3,415	2%
Rock	5,085	2,833	14	7,932	4%
Urban areas	58	50	-	108	0.054%
Total	92,640	62,474	44,698	199,812	100%

Source: Abbay basin Master plan

Table 4: Land use of the Abbay basin

Land Use type	Use in Hectare
Agricultural(A)	3987834.06
Agro-past(AP)	5561400.55
Agro-sylvic(AS)	1559728.84
State Farm(SF)	96832.99
Pastoral(P)	1458909.63
Sylvo-past.(SP)	1741791.59
Sylvi-cultural(S)	729763.19
Traditional(T)	4349205.46
Water(W)	46119.38
Marsh(M)	64829.28
Un useable(N)	70083.48
Urban(U)	10410.57
Lake tana	304162.64
Total	**19,981,071.66**



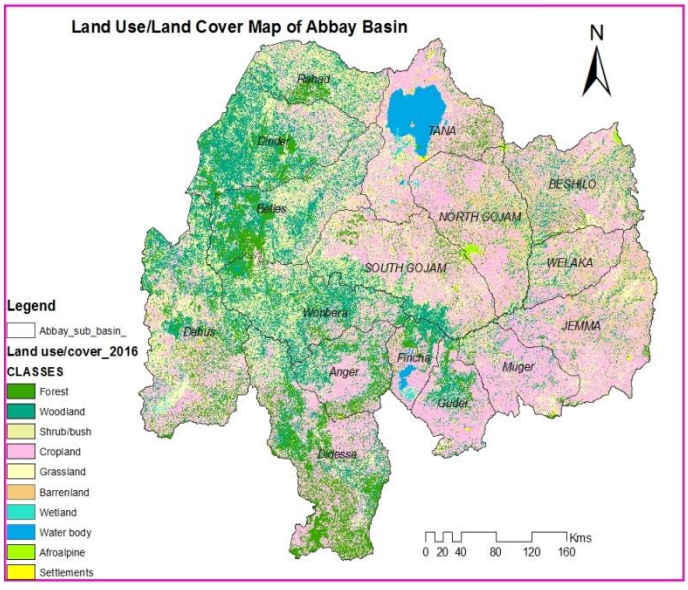


Figure 15: Land Cover of Abbay Basin **Figure 10: Land Use type of Abbay Basin**

2.6.1. Different Land Use/Cover Types in Brief

***Cultivation*:**67,890 Sq. km; 34% of basin; 46 % of Amhara Region; 36% of Oromiya Region and 6% of Benishangul-Gumuz Region.

***Tree Crops*:** (260Sq. km; < 1% of basin). Coffee production in Jimma, Illubabor and some parts of Welega in Oromiya; Mango tree in Benshangul -Gumuze region is the only occurrence of this land use classification.

Plantations (537 Sq. km; <1% of the basin): This mainly includes *Eucalyptus* spp. together with *Cupressuslusitanica*which have been planted for wood and fuel wood.

Afro-alpine vegetation (1,103Sq. km; 1% of the basin; Amhara 1 %). This includes areas above 3,200 masl such as Mt Guna and Mt Choke. These areas are characterized almost devoid of any forest and this is replaced by moist moorland. At its lower extremity the afro-alpine vegetation consists of shrubs, sedges, short woody bushes and occasional trees. Cultivation may now extend up to 3,000 masl on many of these areas, which is now posing a threat to the stability of these extremely fragile areas. Other areas of afro-alpine vegetation occur in limited areas in Oromiya, while 2 km^2 has been reported for Benishangul- Gumuz Region.

DisturbedForest(2,276 Sq. km; 1 % of basin). No areas of undisturbed forest remain anywhere within the abbey basin. The original forest remains in a few places, but the overall effect is one of a seriously disturbed environment. The greatest conversion has occurred in the Amhara and then in the Oromiya Region where areas of forest have been cleared for coffee planting. Disturbed forest areas remain in; Gera, Setema, Jimma, Komto, Chato and Guangua. All of these areas have been classified as National Priority Forest Areas (NPFA's).

Bamboo (7,326Sq. km; 4 % of basin; 1 % of Amhara and Oromiya areas; 12 % of Benishangul-Gumuz Region). Extensive stands of *Oxytenantheraabyssinica* and occasionally *O. borzii*, occur in the lower areas of the western part of the basin.

Woodland, Bush land and Shrub land (60,438Sq. km; 30 % of basin; 22 % Amhara; 26 % Oromiya and 52 % of the Benishangul-Gumuz Regions). These areas occur mainly in the lower western slopes of the basin and are normally always associated with grassed areas between areas of low woody vegetation. These areas support pastoralism, while a major traditional economic activity has been the collection of *Gumarabic* and *frankincense*. Both Guba and Asosa are noted centers for the supply of aromatic gums to wider markets within Ethiopia and elsewhere. *Gumarabic* is also collected within the basin from; Mankush, Bambudi, Almahal, Gizen, Kurmuk, AmuruGarte, Delias and Ginde Beret.

The Grasslands (46,143Sq. km^2; 23 % of basin; 19 % of Amhara; 25 % of Oromiya and 29 % of Benishangul-Gumuz Regions). Two types of grassland occur within the basin; lowland tall grasslands and highland temperate grasslands.

Lowland Tall Grasslands:occur in low rainfall areas and are dominantly grassland interspersed with a few trees, shrubs, and other woody vegetation. The main grasses that occur within these areas are *Hyparrhenia*spp. *Digitaria spp*and *Panicumspp*often in association with *Acacia* shrub lands. These grasses often occur together with gourds, wild squashes and *Acanathaceae* and *Convolvulacea*. Grasslands mainly occupy the lower humid valleys of the Beles, Anger and Didessa valleys where they are maintained as a fire deflected succession by repeated burning.

Highland Temperate Grasslands: occur above 2,000 masl and include palatable grass species such as *Pennisetum, Andropogon, Eragrostis* and *Cynadon.* Better areas may be interspersed with clovers such as *Trifolium*spp. (Low grazing pressure) while herbs consisting of *Haplocarphaschimperi,* chickweed (*Cerastium*s pp.) and sedges (*Cupressus*spp.) occur in wetter areas. Due to an increasing shortage of grazing areas, especially in the Amhara Region many of these areas are intensively grazed, by cattle, sheep and goats. Consequently, many of these areas are now suffering from overgrazing, loss of fertility from the gathering of cattle dung for fuel. These areas are now actively degrading.

Wetlandareas (2,384 Sq. km; 1 % of basin; 1 % Amhara; 2 % Oromia). These areas can be either permanent swamps such as the Dabus swamp or, else they may seasonally recede as

around Lake Tana. This gives rise to recessional agricultural use during the dry season where plantings follow the water level down as the lake level drops.

WaterBodies (3,415Sq. km, 2 % of the basin; 3 % of Amhara; 1 % Oromia); these areas include inland lakes and waterways. Lake Tana at 3,042 km^2 is the largest inland lake in Ethiopia and is an important regulating feature of the Abbay River. It is also an important fishery resource and wildlife area with regard to its aquatic and wetland habitats. Other important water bodies are the Dabus, Finchaa and Chomen swamps. These areas are much shallower and have greater affinity as swamp and wetland areas rather than lacustrine environments. Other smaller lakes occur throughout the basin as crater lakes within extinct volcanoes, e.g. Lakes Zengena and Dendi.

Rock (7,932 Sq. km; 4 % of the basin; 5 % of Amhara; 5 % of Oromia); this is mostly accounted for by large areas of exposed rock on ridges, escarpment sides and valley bottoms e.g. the Abbaygorge. Other areas occur as exposed rocky ridges in hilly areas to the west of Gondar. There is very little of this unit in Benishangul-Gumuz as the area is mainly composed of lowlands with few steep rocky areas.

UrbanAreas (108Sq. km; < 1 % of basin). This is accounted for by land take required for towns, e.g. Gondar, Bahir Dar, Nekemte, etc.

2.7. Geology

The geology of the basin signifies, the Abbay Basin, contains ∼1400 m thick Mesozoic sedimentary section underlain by Neoproterozoic basement rocks and overlain by Early–Late Oligocene and Quaternary volcanic rocks (Gani *et. al*, 2009). The Abbay Basin has evolved in three main phases: (1) pre-sedimentation phase, include pre-rift peneplanation of the Neoproterozoic basement rocks, possibly during Palaeozoic time; (2) sedimentation phase from Triassic to Early Cretaceous (3) the post-sedimentation phase, including Early–Late Oligocene eruption of 500–2000 m thick Lower volcanic rocks. The dominant rock is Basalt (Tarmaber basalt, followed by Ashange basalt, and Amba Aiba basalt).

The Highlands of the basin is composed of basic rocks, mainly basalts, while the lowlands are mainly composed of Basement Complex rocks as well as metamorphic rocks, such as gneisses and marble. Where the Abbay has cut through the basalts there are restricted areas of limestone and then sandstone before the Basement Complex is reached.

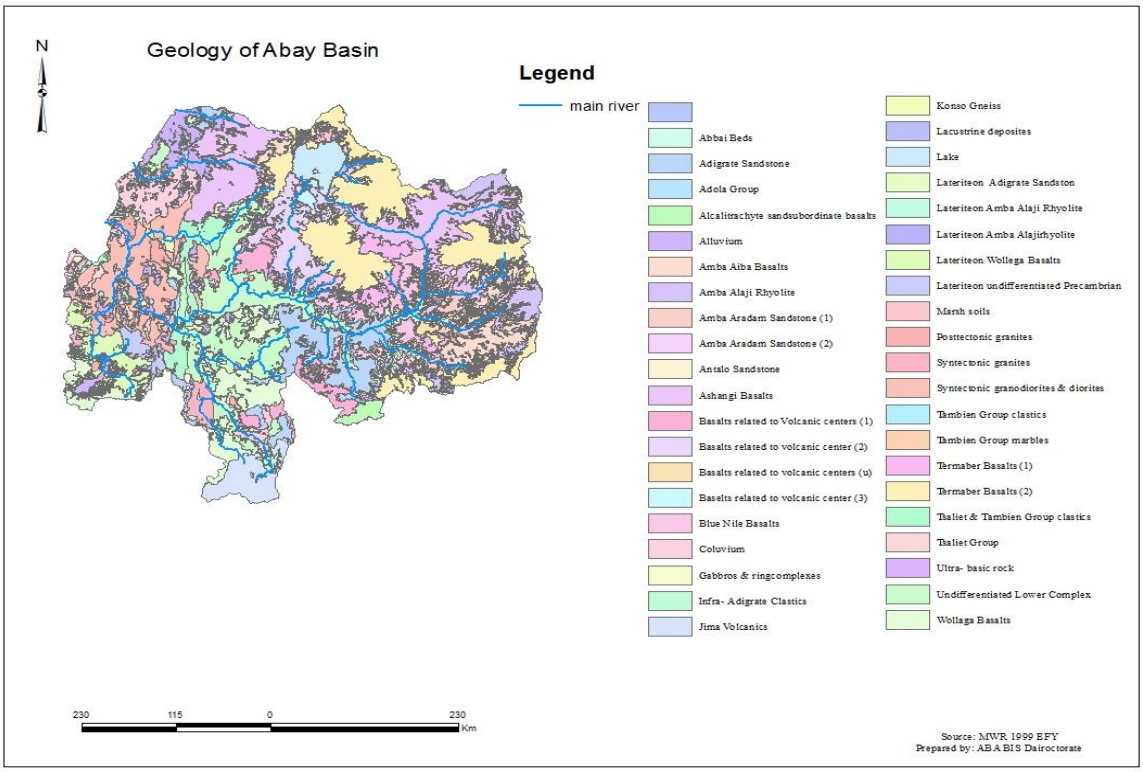


Figure 11.Geological map of Abbay Basin

2.8. Soils

Soil acts as an engineering medium, a habitat for soil organisms, a recycling system for nutrients and organic wastes, a regulator of water quality, a modifier of atmospheric composition, and a medium for plant growth, making it a critically important provider of ecosystem services.The major soils of the basin are Leptosols, Alisols, Nitisols, Vertisols, Cambisols, and Luvisols, in orderof decreasing areal coverage (BCEOM, 1998b). Leptosols (22%) represent the mostwidely occurring soils within the basin, mostly along the course of the BlueNile/Abbay River and its main tributaries. They are shallow soils with limited profiledevelopment and are usually prone to drought. Alisols (21%) are the second mostimportant soils in terms of area coverage. These soils are reddish brown in color andhave deep profiles (>100 cm). Alisols are mainly derived from basalts, granites andgranodiorites and possess favorable drainage, structure and workability. Nitisols(16%) are the third most important soil group within the basin in terms of area.Nitisols are derived from basalts/tuffs and granites/associated felsic materials. On the flat plateaus in the Ethiopian Highlands are extensive areas of Vertisols (15%). Thesesoils are reddish brown in color, clay to clay loam in texture, well drained and verydeep (>200 cm).

Table 5:Major Soils Located in the Abbay Basin

Major Soil Type	**Area %**
Leptosols	21.46
Alisols	20.71
Nitisols	15.9
Vertisols	15.18
Cambisols	9.46
Luvisols	9.05
Acrisols	4.46
Regosols	0.71
Arenosols	0.66
Fluvisols	0.31
Phaeozems	0.05
Total	97.95
Miscellaneous Units/other	
Marshes	0.39
Urban Areas	0.03
Water Body	1.62
Total	2.04
Grand Total	99.99

Corresponding to the variation in landscape and other soil forming factors such as climate and vegetation, the soils of the basin are also highly variable. However, only four soil types, Leptosols (22%), Alisols(21%), Nitisols (16%) and Vertisols(15%). cover over 74% of the area.

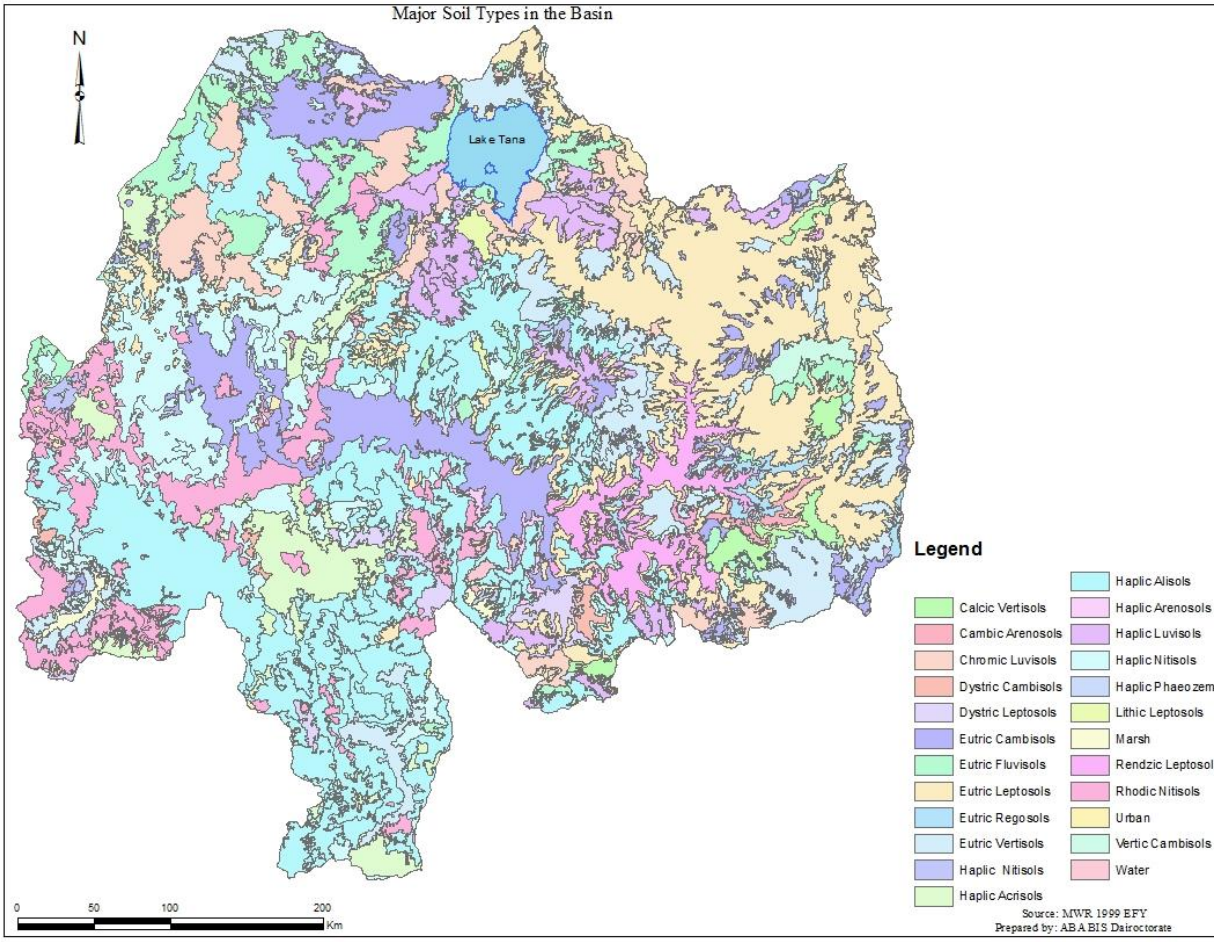


Figure 12:Major Soil Types in the Abbay Basin

3. Socio Economic Aspect of the Basin

3.1. Administrative structure of the basin

According to the current regional structure, the basin covers three regional states, namely Amhara regional state, Oromia regional state, and Benishangul-Gumus regional state.

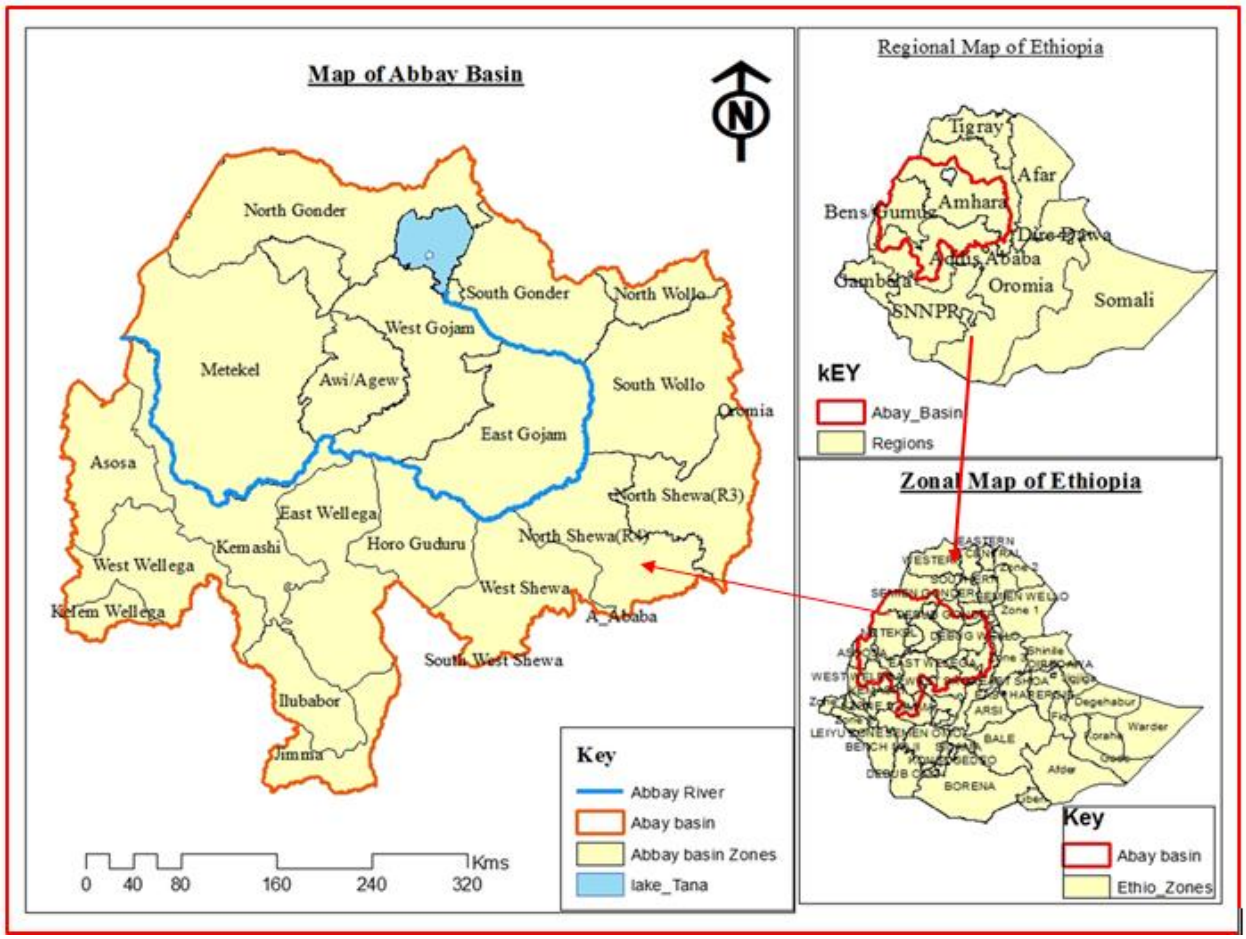


Figure 13: Administrative structure of Abbay Basin

There are 21 administrative zones within the three regions and 194 woredas.

3.2. Population

3.2. 1. Population size

According to CSA and ANRS BoFED, in 2014 the entire population of the basin was about 28,590,000, (Abbay basin atlas, 2015) and in 2030, the population will be expected to increase 40,300,989. This number is expected to share approximately 32 percent of the entire population

of the country. From the total population of the basin, Amhara region has the population of 60%,Oromia region,36% and Benishangul-Gumuz has the population share of 4 % in the basin.Of the total basin population on average 80% of the inhabitants live in rural areas of the basin while the rest 20 % populations dwell in urban areas.

3.2. 2. Population growth trend (2017-2030)

Table 6: Population growth trend in the Basin

Year	*Growth rate*	*Male*	*Female*	*Total*	*Urban*	*Rural*
2017	0.0245	15,465,081	15,300,721	30,765,802	5,846,353	24,919,449
2018	0.0226	15,814,592	15,646,518	31,461,109	5,978,481	25,482,628
2019	0.0226	16,172,002	16,000,129	32,172,130	6,113,595	26,058,536
2020	0.0226	16,537,489	16,361,732	32,899,221	6,251,762	26,647,459
2021	0.0205	16,876,507	16,697,147	33,573,655	6,379,923	27,193,732
2022	0.0205	17,222,476	17,039,439	34,261,915	6,510,712	27,751,203
2022	0.0205	17,575,537	17,388,747	34,964,284	6,644,181	28,320,103
2024	0.0205	17,935,835	17,745,217	35,681,052	6,780,387	28,900,665
2025	0.0205	18,303,520	18,108,994	36,412,513	6,919,385	29,493,128
2026	0.0205	18,678,742	18,480,228	37,158,970	7,061,232	30,097,738
2027	0.0205	19,061,656	18,859,073	37,920,729	7,205,987	30,714,741
2028	0.0205	19,452,420	19,245,684	38,698,104	7,353,710	31,344,393
2029	0.0205	19,851,195	19,640,220	39,491,415	7,504,461	31,986,953
2030	0.0205	20,258,144	20,042,845	40,300,989	7,658,303	32,642,686

Source; Abbay basin atlas, 2015 and CSA projection, 2017-2030

The table shows how many people have been living in the basin from 2017 to 2030. There are several discernable changes in the proportion of people in urban and rural areas. As can be seen apparently the basin population has swelled considerably from 30.76 million to 40.3 million from 2017-2030. This indicates that, fertility manifests itself for the increment of the basin's population.

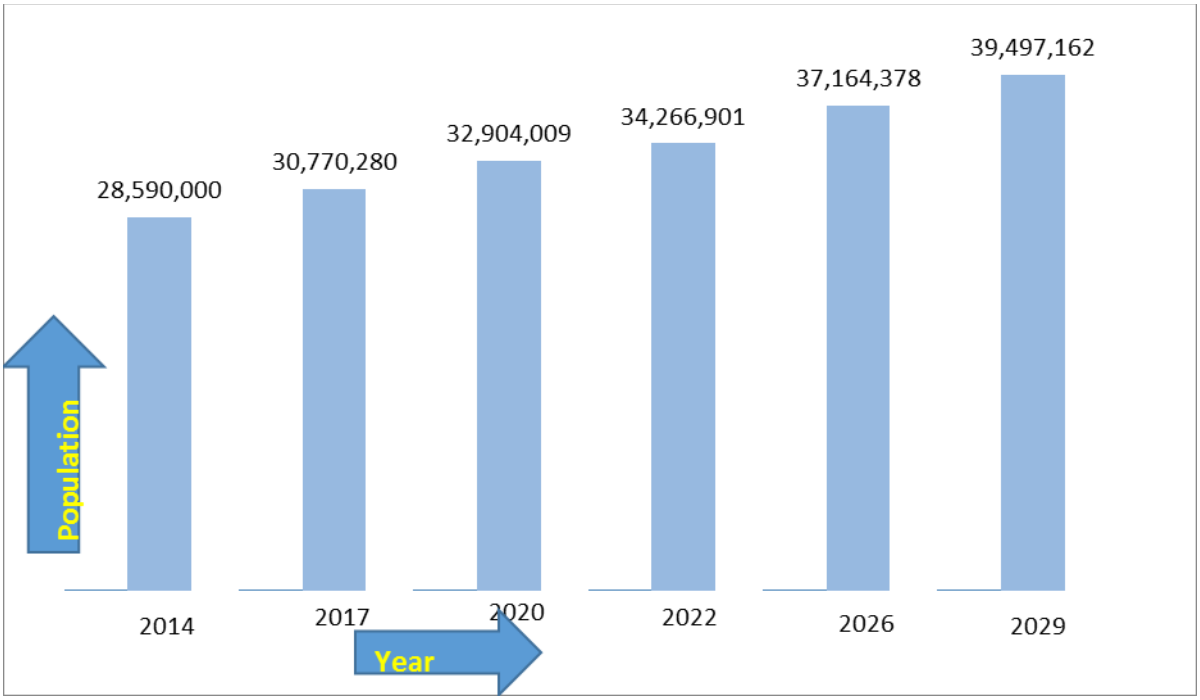


Figure 20 : Graphical Representation

The graph shows the basin population is increasingly growing from 2014 to 2029 mostly.

3.2. 3. Population Distribution

According to CSA, 2007 highly populated areas of the basin include the northern part of Lake Tana, the central part of the basin and the southern ends of Didessa sub-basin but there may be variation among the rural and urban areas. The distribution of basin population as shown in the figure below depicts that, the northern, central and some southern end of the area (Tana, South & North Gojjam and Didessa sub-basins) are densely populated areas.

Moderately populated area of the basin, covers the majority of the central parts and Eastern parts of the basin, (Jemma, Woleka, Beshilo, Anger, Muger, Guder,and Fincha), on the other hand, most of the Western parts of the basin (Belese, Dinder, Rahad, Dabus and Wonbera) are characterized by sparsely populated area.

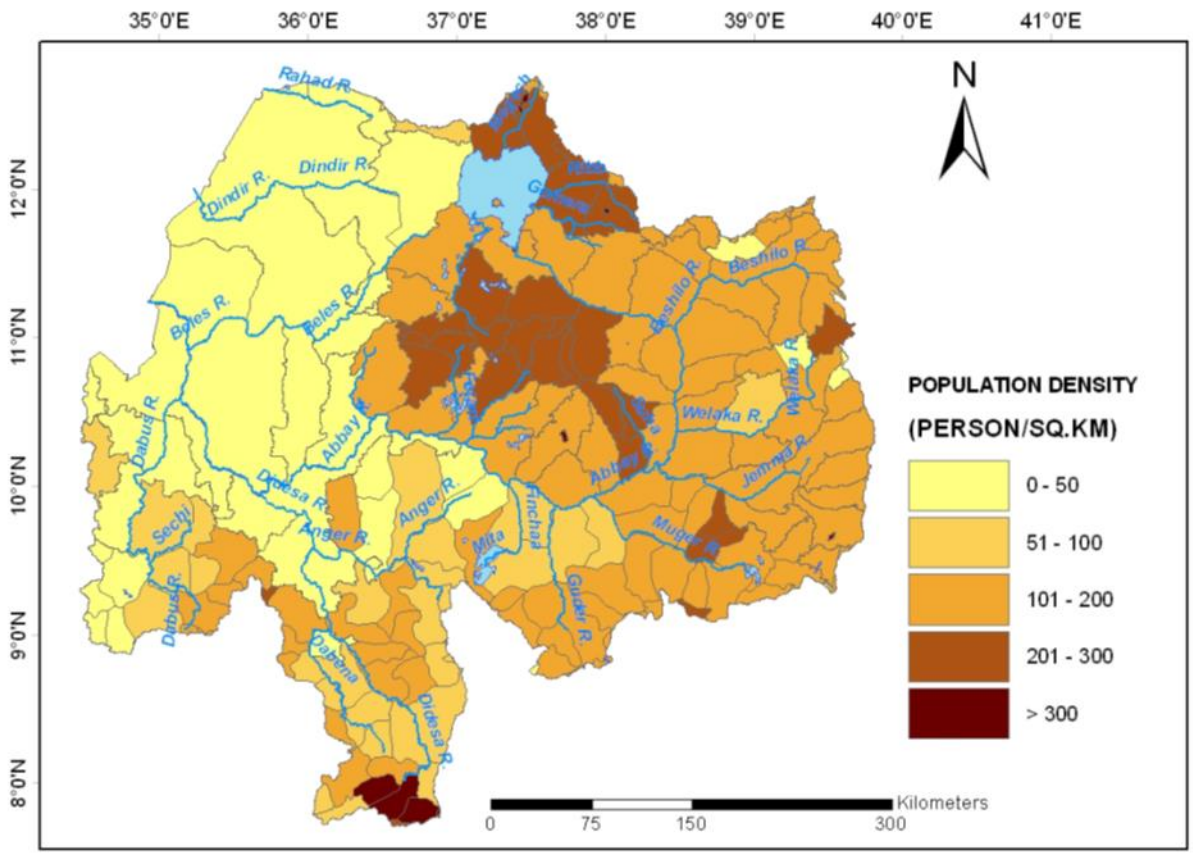


Figure 14: population distribution of the basin

3.2. 4. Sex structure and its trend in the Basin (2017-2030)

Sex structure is the most important demographic characteristics that are captured by a census of a population. It attributes that largely determine an individual's role in society. The following table shows the sex composition of the population of Abbay basin using data obtained from CSA, 2017-2030 and other relevant literatures.

Table 7: Sex Structure

Year	*Total population*	*Male*	*% of Male*	*Female*	*% of female*
2017	30,765,802	15,465,081	50.26711477	15,300,721	49.73288523
2018	31,461,109	15,814,592	50.26711233	15,646,518	49.73288767
2019	32,172,130	16,172,002	50.26711318	16,000,129	49.73288682
2020	32,899,221	16,537,489	50.26711423	16,361,732	49.73288577
2021	33,573,655	16,876,507	50.26711569	16,697,147	49.73288431
2022	34,261,915	17,222,476	50.26711437	17,039,439	49.73288563
2022	34,964,284	17,575,537	50.26711544	17,388,747	49.73288456
2024	35,681,052	17,935,835	50.26711376	17,745,217	49.73288624
2025	36,412,513	18,303,520	50.26711285	18,108,994	49.73288715
2026	37,158,970	18,678,742	50.26711451	18,480,228	49.73288549
2027	37,920,729	19,061,656	50.26711380	18,859,073	49.7328862
2028	38,698,104	19,452,420	50.26711386	19,245,684	49.73288614
2029	39,491,415	19,851,195	50.26711502	19,640,220	49.73288498
2030	40,300,989	20,258,144	50.26711379	20,042,845	49.73288621

Source; Abbay basin atlas, 2015 and CSA projection, 2017-2030

As shown in the above table, the basin female population constitute 15,300,721 in 2017 which was 49.73 percent of the total population of the basin while males constitute 15,465,081 and covers 50.26 percent of the total population of the basin, and in 2030 the size of the female population is projected to be 20,042,845 (49.73%) while males are expected to be 20,258,144 which accounting for 50.27 percent. In each consecutive year (2017-2030), the basin has almost proportional distribution of population in sex, is an important social factor for different governmental, non-governmental and community based organizational intervention to bring equity between males and females in the basin.

3.2. 5. Age Structure

Age structure indicates the number of people in different age group within a given population at a time. It is one of the most basic characteristics of the population of a given territory. Below are the age characteristics of the basin population of the major age categories 0-14, 15-24, 25-54, 55-64, and 65+. The data and discussions are presented based upon the projected population of 2017 CSA data and CIA world fact book, 2020.

Table 8: Age structure of the basin population

No.	Age Structure	Number of population	Coverage in %
1	0-14 years	13,092,874.9	39.8
2	15-24 years	6,403,118.12	19.5
3	25-54 years	10,826,215.6	32.9
4	55-64 years	1,455,323.12	4.4
5	65+ years	1,111,689.29	3.4

Source; CIA world fact book, 2020

3.2. 6. Dependency Ratio

The age dependency ratio is the ratio of persons between the ages defined as a dependent (under 15 and over 64 years) to persons in the ages defined as economically productive (15-64 years) in a population. It shows the proportion of the basin's population not in the workforce who are 'dependent' on those of working-age. According CIA World Factbook,2020 data realizes that, economically active population of the basin consists of 18,684,656.8 (accounting for 56.8 percent of the total basin population) in 2020,while economically inactive population accounts for 14,204,564 (43.2%). The basin has a dominant working age structure that indicates the basin is endowed with potential labor resources for socioeconomic development.

3.2.7. Ethnic, Language and Religion Composition

The population of the Abay River basin consists of Amhara, Oromo, Gumuz, Agew, Berta, Shinasha, Mao, Koma and other ethnic groups. The major spoken language in the basin also includes Amharic, Afanoromo, Agew, Gumuz, etc. Orthodox, Protestant, Catholic, Islam, traditional beliefs, and others are the most common religions found in the basin respectively (ABMP, 1998).

3.3. Educational Institutions

Table 9: number of schools (Governmental and Non-Governmental)

No	Types of educational institution	Number of institutions
1	Primary school (1-8)	12,329
2	Secondary school (9-12)	987
4	Universities	14

Source; (Ministry of Education, 2019)

As shown from the table there is 12,329 primary schools, 987 secondary schools and 14 universities found in the Basin..

3.4. Health Institutions

According to the data collected from Health Minister of Ethiopia in 2019, there are about 80 primary hospitals, 30 general hospitals, 10 referral hospitals. In addition to these higher health institutions, there are also a number of health centers and health posts within the basin which provides necessary health services to the people of the basin.

Common Prevalent disease in the Basin

According to the data collected from different woredas of the basin among the most common prevalent diseases that affect human are: Malaria, Typhoid Fever, Lower respiratory tract infection, ARTI (Acute Respiratory Tract Infection), Helmentitis , Dyspepsia, Diarrhea, Tuber clauses, And Intestinal Parasite, Acute febrile illness /AFI, Trachoma, Intestinal parasite, Acute febrile illness /AFI/, typhoid, skin infection and urinary tract infection, acute febrile illness, tuberculosis /TB, trauma, dyspepsia, rheunmantus, anemia, gasterate and etc.

3.5. Major Economic Activity in the Basin

According to CSA, 2019 the basin's economy comprises:- Agriculture, Industry & Manufacturing, Tourism, Energy, Mining and Minerals, Transport and others.

3.5.1. Agriculture

Like other parts of Ethiopia, agriculture in the basin is the sector where the economy and livelihood of the majority of the people, mainly depends on, it is obvious that agriculture includes both the rearing of animals and the cultivation of crops based on the data collected in woreda agricultural offices of the sub basins. Major agricultural practices in the Basin include;

I. Crop Production -The Basin has diversified agro- ecology (dega, woyna dega and kola) which is suited for the production of different annual as well as perennial crops. These include;

Grain Crops -Refers to the major crop category that includes cereals, pulses and oilseeds which not only constituted the major food crops for the majority of the basin's population.

Cereals- are the major food crops both in terms of the area they are planted and volume of production obtained. They are produced in larger volume compared with other crops because they are the principal staple crops (Teff,Barley, Wheat, Maize, Sorghum, Finger-millet, Oats/'Aja') and Rice.

Pluses:- are also among the various crops produced in all areas of the basin after cereals (Faba beans, Field peas, White Haricot beans, Red Haricot beans, Chick-peas, Lentils, Grass, peas, Soya beans, Fenugreek., Mung bean and /"Masho", Gibto.)

Oilseeds- refer to crops which are also classified within grain crops category**,** nonetheless**.** Oilseeds are grown to flavor the food consumed at home and earn some cash for peasant holders in the area (Neug,Linseed,Groundnuts,Sunflower,Sesame,and Rapeseed)

Vegetables-Holders living near to urban centers largely practice vegetable farming. Most vegetables are not commonly practiced by the rural private peasant holders. (Lettuce,Head Cabbage,Ethiopian Cabbage,Tomatoes,Green peppers,Red peppers, and Swiss chard)

Root Crops-Some root crops like onion and garlic are indispensable to improve the taste and scent of the food we eat. Others like potatoes, sweet potatoes and taro/ godere are among the list of major food crops that are consumed across the basin.

These and other economic importance prompt the peasant holders to grow many of the root crops (beetroot,carrot,onion,potatoes,yam/'boye',garlic,taro/'godere', and sweet potatoes).

Fruit Crops-Fruit crops grown by the private peasant holders cover only a small token area and production in the basin. The number of holders practicing fruit farming is much less than that of grains or cereals (avocados, bananas, guavas,lemons,mangoes,oranges,papayas, and pineapples)

Stimulant crops-Farmers engaged in growing and producing stimulant crops such as coffee and Chat are greater in number than those growing fruits. In agricultural products, coffee is the largest export production, which earns the majority of the export income.

II. **Irrigation-** The Abbay basin has abundant irrigation potential in terms of available water resources and suitable irrigable land. The Master Plan identified that it has a potential of about 2.5 million ha of which 526,000 ha were deemed to be economically feasible. A total of 815,581 hectares of potential irrigable land is estimated, out of which 45,856 ha are for small scale, 130,395 hectares for medium-scale and 639,330 hectares for large-scale development this are with the exclusion of traditional schemes (master plan*1998*).

There are currently three large reservoirs in the Abbay Basin, built for hydropower and irrigation. Around 20,145 ha of sugarcane are irrigated from the Finchaa Reservoir, approximately 7,000 ha of mixed crops irrigated from the Koga Reservoir from which became operational in 2008 and Tana Beles transfer multipurpose project irrigates more than 75,000 ha after generating 460 MW of power. The current large projects irrigate a total of approximately 125,892 ha with a total annual irrigation water demand estimated about 998.31MCM and medium and small scale irrigated land is 654420ha with a total annual irrigation water consumption of 5549.9MCM, so that estimated total irrigation water consumption in Abbay basin is about 6548.21 MCM /yr to irrigate total agricultural area of 780294 ha.

The total estimated irrigation water demand for the basin is 6.617 BCM. This is more than 75% of the total water demand in the basin, which is the highest water demand over all water user sectorser Basin Irrigation Potential

Irrigation Potential of the Basin				
No	**Location**	**Volume (Mm^3)**	**Irrigated area (ha)**	**Level of Study**
1	Finchaa	477	20000	Implemented
2	Koga	83.1	7004	Implemented
3	Beless	1692	80000	Under construction
4	Didessa	2200	80000	Under construction

5	Rija	10	3492.59	Implemented
6	Rib Dam	234	17200	Under construction
7	MegechRobit /gravity	185	16700	Under construction
8	Megech Guramba	No Dam	6500	Feasibility study
9	Megech Jajer	No Dam	6500	Feasibility study
10	Megech Serba pump	No Dam	10000	Under construction
11	Gumara	307	13800	Feasibility study
12	Jemma	173	7800	Feasibility study
13	GilgelAbbay1&2	563	11500	Feasibility study
14	Angar		18000	Detail design
15	Negesso		21315	Detail design
16	Birr		14000	Feasibility study
17	Upper Guder		6282	Reconnaissance
18	Dabus		9661	Pre-Feasibility
19	Gelagu		9860	Reconnaissance
20	Rahad		45135	Reconnaissance
21	Nekemt		11220	Reconnaissance
	Total		**415,969.6**	

Source: Abbay Basin Water Resource Assessment, 2018

III. Livestock

According CSA, 2015 the population of animals found in the basin, are about (71.48 million heads) from which cattle 29 million, sheep 10million, goat 8million, horse more than half million, mule 0.15million, donkey 2.5million, poultry 19million and beehive 2.33million.

3.5.2. Industry

The basin hosts a number of industries as cement factory, beverage industries, milling industries, textile and a number of micro industries found in the basin, these industries create employment opportunities, generate tax revenue, employment, income tax and sales tax revenue. They also have a foreign exchange saving effect to the country by substituting the current imports. According to United Nation Industrial Development Organization (2018), there are 4 industrial parks in the Basin. These include, Bahir Dar industrial park, Arerti industrial park, Debre Berhan Industrial park and Burie Integrated Agro Industrial Park. These industries are planned to produce garment, construction materials and agro processing. Regarding the progress of these industrial park, except Burie Industrial park which is under construction, the rest are at the planning stage. In addition to these industrial parks, the Basin also endowed with the following industries.

- Agro- Processing Industries - Ambo Mineral Water S.C.(Ambo)
- Pulp and Paper:-, D.M.S.K General Trading (Burayu), Huang Shang Cement PLC (Oromia), Main Project) (Derba), Mugher Cement Enterprise(existing) (Muge), Jema Cement PLC (Muketure), Industry PLC.(Holeta), Habesha Cement Sh.Co.(Holeta), Dangote Industrial PLC. (Muger, Ada berga), East Cement PLC. (North Shewa, Feche), C.H Clinker Manufacturing PLC. (Gerba Gurache
- Textile Factories, Bahirdar Textile S.C (Bahir Dar)
- Tanning Industries, Abay Tannery (Bahir Dar), Bahir Dar Tannery (Davimpex) Enterprise, P.l.c Bahir Dar, DebreBerhan Tannery DebreBerhan, Dessie Tannery, P.l.c (Dessie)
- Agro-Processing Industries, Ashraf Agricultural and industrial PLC (Bahir Dar)
- Pharmaceuticals, ElieLaboratoire P.L.C (Gondar)
- Cement, Dejen Project) (Dejen)

3.5.3. Tourism Development

The tourism industry in the Basin contributes a lot to the country's economy. According to ABMP, the specific attractions of the basin divided into four major tourist destination areas.

I.The Northern part; this scenery includes Bahirdar, Lake Tana, Gonder and their surroundings.

II.The Abay Gorge Area and the central part of the basin- These include Abay Gorge,the crossing of the Blue, Muger Sub Basin**,** this circuit is blessed with an abundance of material, non-material cultural resources and historical sites and Debre Libanos Monastery

III. Eastern Edge of Abay Basin; the most promising tourist destination area around this circuit includes Dessie, Debre Birhan and their surroundings.

IV. **The Southern part of Abay Basin / the coffee producing areas.**Known by its coffee production and wealth of wildlife and forest. So that, it is found to be the prominent tourism circuits. Nekemte, Wollega museum and Kumsa Moreda palace.

3.5.4. Mining, Minerals and Energy

Mining-The contribution of the mining sector to export income in the Basin is limited to being generated from gold and gemstone exports with potash exports expected to come on line in the next few years.

Minerals- Production of industrial minerals is limited to domestic consumptions. The current mineral production is small, which in turn explains a low level of existing linkages with the rest of the economy as cement production and construction. According to ABMP The most important metallic minerals found in the basin are; Gold, Platinum, Copper, Nickel, Iron and Molybdenum on the other hand,most abundant nonmetallic minerals are marble deposits, limestone, construction stones, Gypsum, sandstone, Clay and lignite deposits are also found in the Abbay Basin.

Hydropower potential of Abbay river basin

The hydropower potential in the Abby basin is about 17,500 MW different reports estimate, with major power stations on the main stem of the Abbay basin (Karadobi, Beke Abo, Mandaya, Chemogayeda and Border) having potential installed capacities of between 3,643 MW and 7,629 MW. These sites have been identified as priority sites, and feasibility studies are currently being undertaken. The basin has immense hydropower potentials, some scholars believe that the potential may exceed the values estimated if detail and continuous studies undertake. The potential sites are identified by different studies like USBR, BCEOM, and WAPCOS etc.

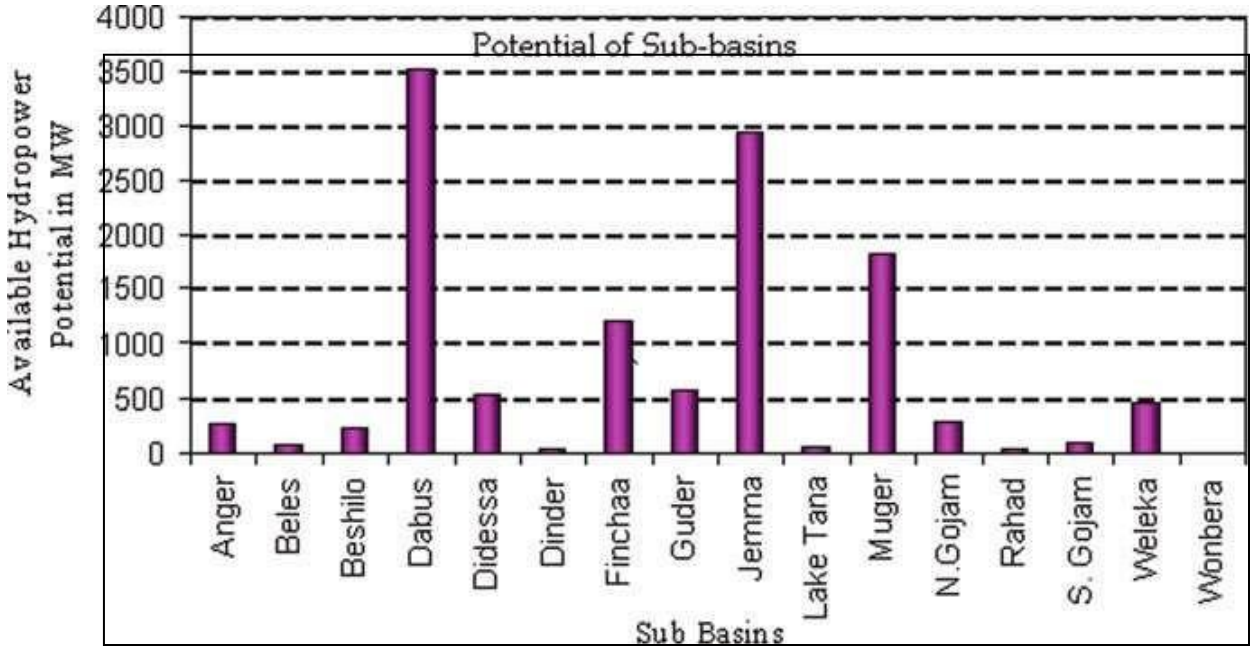
Nile river basin by Assefa M. Meles reports 91 possible hydropower potential sites in the 16 sub-

basins of the Abbay river basin are located with improved accuracy with respect to geo-referencing

and site suitability. The study ranks priority potential hydropower sites taking the prevailing socio-economic conditions in to consideration.

Hydropower generating potential of Abay Basin

No	Hydro power sites and /or sub basins	Installed capacity in (MW)
1	Beshilo site I Beshilo site II	180 75
2	Tana-Beles	460
3	Dabus	326
4	Didessa ➢ Arjo-Didessa ➢ Dabana ➢ Anger ➢ Lower Didessa	 30 85 185 320
5	Dinder-Rehad	40
6	Fincha	134
7	Guder	50
8	Jemma	60
9	Lake Tana	217
10	Muger	24
11	North Gojjam	24
12	South Gojjam	
13	Welaka	20
14	Tis Abbay1(chara chara)	11.4
15	Tis Abbay 2(Tis Issat fall)	73
16	GERD	5250



*Source: Assefa.M. Meles et, al.2012

References

ABA. (2015) Abbay Basin Atlas. Abbay basin Authority, Bahir Dar, Ethiopia.

Abbay Basin Master Plan. (1998).

Aster Denekew Yilma and Seleshi Bekele Awulachew. (2009). *Characterization and Atlas of the Blue Nile Basin and its Sub basins*. International Water Management Institute, Ethiopia

BCEOM, 1998. Abay river basin integrated development master plan project. *Report to Ministry of Water Resources, BCEOM-French Engineering Consultants in association with BRGM and ISL, Addis Ababa, Ethiopia.*

Federal democratic republic of Ethiopia ministry of education. *Education statistics annual abstract 2011 e.c. (2018/19).*

Federal democratic republic of Ethiopia ministry of Health (2019). *Report on Hospital type.*

Gani, Nahid & Abdelsalam, Mohamed & Gera, S. & Gani, M.. (2009). *Stratigraphic and structural evolution of the Blue Nile Basin, Northwestern Ethiopian Plateau. Geological Journal. 44. 30 - 56. 10.1002/gj.1127.*

Mengistu, Daniel & Bewket, Woldeamlak & Lal, Rattan. (2014). *Recent spatiotemporal temperature and rainfall variability and trends over the Upper Blue Nile River Basin, Ethiopia. International Journal of Climatology. 34. 10.1002/joc.3837*.

United Nation Industrial Development Organization. (2018). *Industrial Park Development in Ethiopia: Case Report.*

World fact book. (2020).