Food and Agriculture Organization
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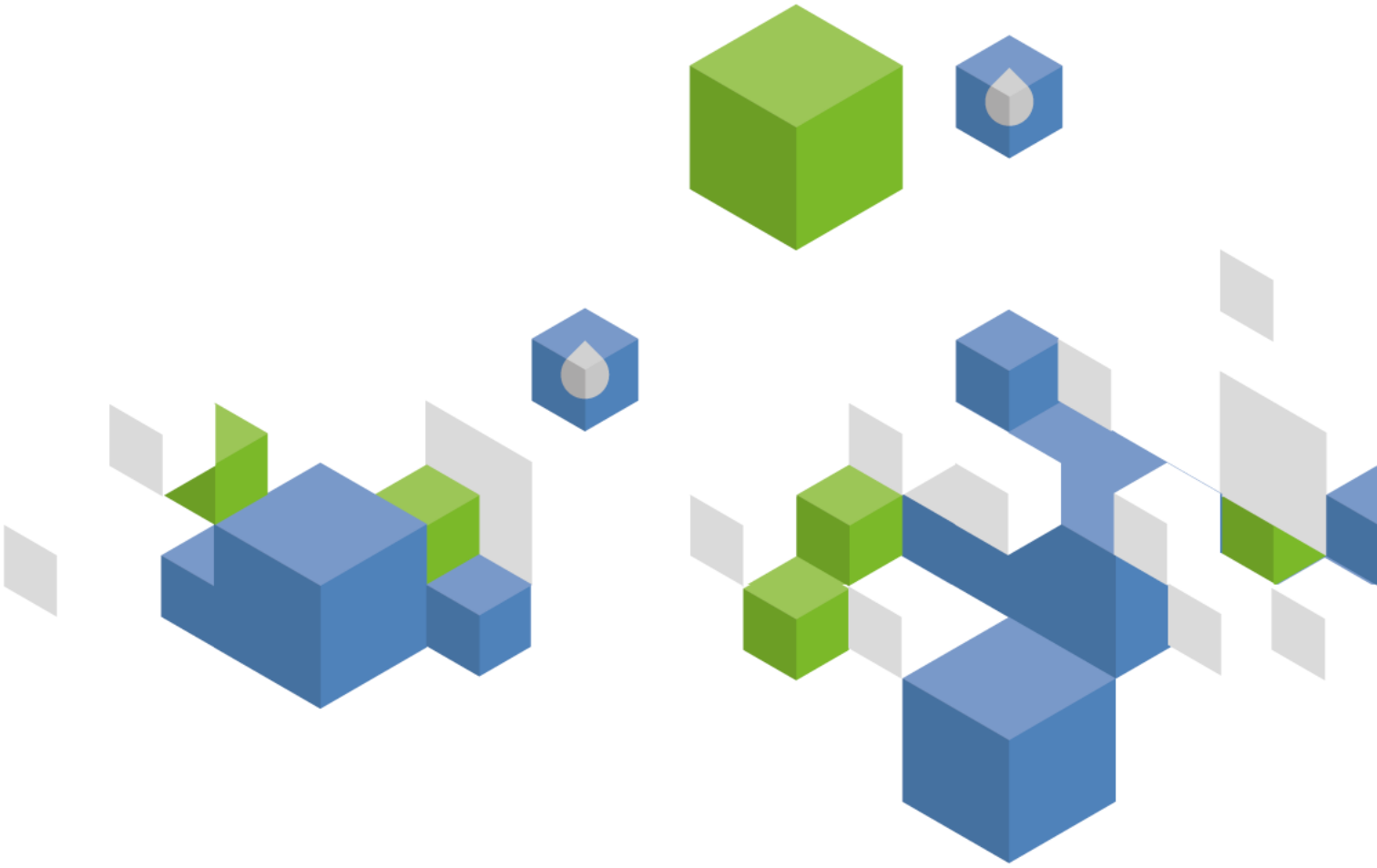
Country profile – Ethiopia

Version 2016



Recommended citation: FAO. 2016. AQUASTAT Country Profile – Ethiopia. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy

Ethiopia

GEOGRAPHY, CLIMATE AND POPULATION

Geography

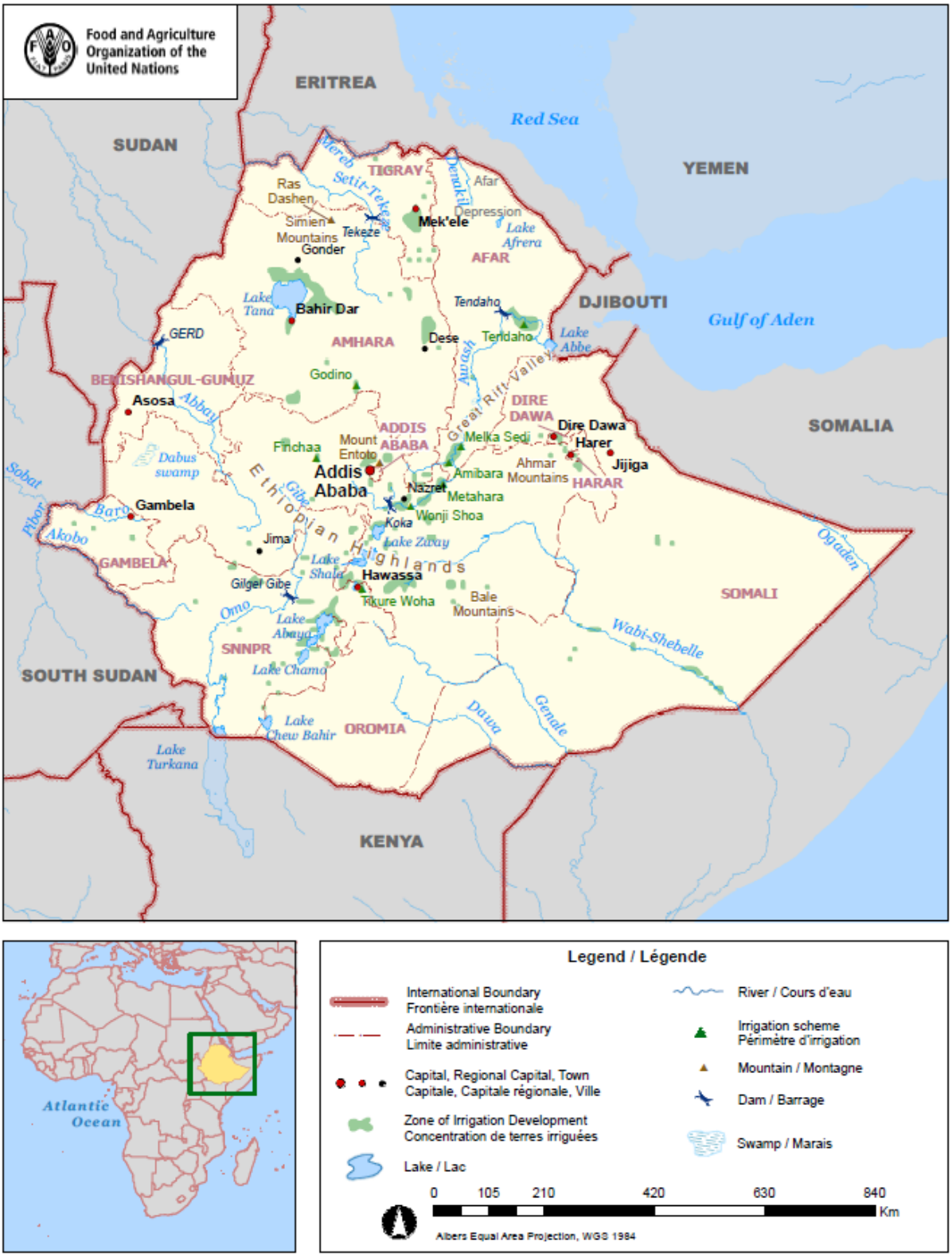
Ethiopia, with a total area of 1.1 million km^2, lies in the northeastern part of the Horn of Africa. The country is landlocked, sharing frontiers with Eritrea to the north and northeast, Djibouti to the east, Somalia to the east and southeast, Kenya to the south, and South Sudan and Sudan to the west. Ethiopia's topographical diversity encompasses high mountains and flat-topped plateaux, surrounded by lowlands, and dissected by deep gorges with rivers and rolling plains with altitudes ranging from 110 m below sea level at the Denakil Depression in the northeast to over 4 600 m above sea level in the Simien Mountains in the north. The Great East African Rift Valley divides the country.

It is estimated that 16 million ha is cultivated and 20 million ha are permanent pastures (Table 1). Water bodies cover around 744 400 ha (IUCN, 2010), forest and woodland about 4 million ha and 29 million ha respectively, while over 26 million ha are protected (EPA and UNEP, 2008).

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	2013	110 430 000	ha
Agricultural land (permanent meadows and pasture + cultivated land)	2013	36 259 000	ha
• As % of the total area of the country	2013	33	%
• Permanent meadows and pasture	2013	20 000 000	ha
• Cultivated area (arable land + area under permanent crops)	2013	16 259 000	ha
- As % of the total area of the country	2013	15	%
- Arable land (temp. crops + temp. fallow + temp. meadows)	2013	15 119 000	ha
- Area under permanent crops	2013	1 140 000	ha
Population:			
Total population	2015	99 391 000	inhabitants
- Of which rural	2015	81	%
Population density	2015	90	inhabitants/km^2
Economy and development:			
Gross Domestic Product (GDP) (current US$)	2014	54 798	million US$/year
• Value added in agriculture (% of GDP)	2014	42	%
• GDP per capita	2014	551	US$/year
Human Development Index (highest = 1)	2014	0.442	-
Gender Inequality Index (equality = 0, inequality = 1)	2014	0.558	-
Access to improved drinking water sources:			
Total population	2015	57.3	%
Urban population	2015	93.1	%
Rural population	2015	48.6	%

FIGURE 1
Map of Ethiopia



ETHIOPIA FAO - AQUASTAT, 2016

Climate

Ethiopia has a tropical monsoon climate with wide topographic-induced variation. Three climatic zones can be distinguished: a cool zone consisting of the central parts of the western and eastern section of the high plateaus, a temperate zone between 1 500 m and 2 400 m above sea level, and the hot lowlands below 1 500 m. Mean annual temperature varies from less than 7-12ºC in the cool zone to over 25ºC in the hot lowlands. Mean annual potential evapotranspiration varies between 1 700-2 600 mm in arid and semi-arid areas and 1 600-2 100 mm in dry sub-humid areas. Average annual rainfall for the country is 848 mm due to its proximity to the equator and high altitude, varying from about 2 000 mm in some pocket areas in southwest Ethiopia to less than 100 mm in the Afar Lowlands in the northeast. Rainfall in Ethiopia is highly erratic, resulting in a very high risk of intra-seasonal dry spells and annual droughts, of which the 1973-74, 1983-84, 1987-88, 1990-91, 1993-94 and 2015-16 are the major ones in the last decades. The drought in 2015-16 is even considered to be the worst drought for over 30 years.

Considering the water balance and the length of the growing period, Ethiopia can be divided into three major agroclimatic zones:

- Areas without a significant growing period, with little or no rainfall (eastern, northeastern, southeastern, southern and northern lowlands);
- Areas with a single growing period and one rainy season from February/March to October/November, covering the western half of the country, with the duration of the wet period decreasing from south to north;
- Areas with a double growing period and two rainy seasons (Meher and Belg) which are of two types: i) in the east of the country: there are a small rainfall peak in April and a major one in August; ii) most of the lowlands of the south and southeast have two distinct wet periods, February-April and June-September, interrupted by two clear-cut dry periods. The peak rainfall months are April and September.

Population

The total population of the country is estimated at 99 million (2015), of which 81 percent is rural (Table 1). The annual population growth rate is 2.6 percent over the period 2005-2015 and the average population density is 90 inhabitants/km², but varies from 7 inhabitants per km^2 in Afar in the northeast to 114 inhabitants per km^2 in Southern Region in the southwest of the country. The urban population is growing rapidly as a result of both population increase and high rural-urban migration.

In 2014, the Human Development Index ranks Ethiopia 174 among 188 countries and the Gender Inequality Index ranks it 129 among 152 countries for which data are available. Life expectancy in Ethiopia is 64 years and the under-five mortality is 62 per 1000 births in 2014, both progressing from 51 years and over 150 per 1000 at the end of the 1990s. Around 80 percent of the children in 2010 are enrolled in primary education, thus almost doubling the 2000 rate, and with a reduced gap between boys (82 percent) and girls (78 percent) compared to that period (50 percent of boys against 39 percent of girls). Adult literacy is 39 percent for the 2005-2012 period (UNDP, 2016), with a gap between female literacy (29 percent) and male literacy (49 percent). Poverty is still widely spread as it concerns almost a third of the population (30 percent) and is more concentrated in rural areas. In 2015, 93 percent of the urban and 49 percent of the rural population were using improved drinking water sources, that is 57 percent of the total population This represents a major improvement since 2002 when only 33 percent of the population had access to an improved drinking water source (JMP, 2015). Sanitation coverage also increased from 10 percent in 2001 to 28 percent in 2015 and almost no difference in coverage between rural and urban areas.

ECONOMY, AGRICULTURE AND FOOD SECURITY

The Ethiopian economy is mostly based on agriculture, with industry and services slightly increasing recently. The country's Gross Domestic Product (GDP) is US$54 798 million in 2014 with an annual growth of around 10 percent since 2004, placing Ethiopia among the fastest growing non-oil producing economies in Africa. Agriculture accounts for 42 percent of GDP in 2014 and about 85 percent of exports earnings in 2010. It also employs 83 percent of the active population (MoA, 2011). Agriculture is primarily rainfed and thus highly dependent on rainfall. Smallholders dominate the sector and the land holding is increasingly fragmented. In 2015, there were 15.6 million agricultural households with an average farm size of 0.95 ha (CSA, 2015). It however benefits from a liberalized economy since the 1990s. The Ethiopian livestock is also significant with over 50 million cattle, 50 million poultry, 20 million sheep and 20 million goats in 2015 (CSA, 2015).

The main agricultural exports are coffee, oil seeds, cereals, cotton, sugarcane, khat, spices, natural gum, incense and cut flowers among others. Coffee is the largest export commodity responsible for a third of the agricultural exports earnings. Ethiopia is the largest African coffee producer and the country where coffee is believed to have been discovered in the eponym Kaffa region. Wheat, palm oil and raw sugar are the main agricultural imports of the country.

The following five main agricultural production systems can be distinguished in the country:

- The highland mixed farming system (1 500 m above sea level) is practiced in most regions of the south and southwest with prolonged humid periods
- The lowland mixed agricultural production system (below 1 500 m) is practiced in low-lying plains, valleys and mountain foothills, which include the northern parts of the Awash and the rift valley
- The pastoral complex supports the livelihood of only 10 percent of the total population living in the Afar and Somali regions and the Borena zone
- Shifting cultivation is practiced in the southern and western part of the country
- Commercial agriculture is a farming system that has only emerged very recently

Food insecurity, as a result of frequent drought among other reasons, is very high. The prevalence of undernourishment is still significant with 35 percent in 2014, but improved a lot falling from 55 percent in 2002 (FAO, 2015). About 10 percent of the households are considered food insecure and partly rely on food aid even without dry spell (ODI, 2015).

WATER RESOURCES

Ethiopia is endowed with a substantial amount of water resources but very high hydrological variability. The surface water resource potential is impressive, but little developed. The country possesses twelve major river basins, which form four major drainage systems (Table 2):

- The Nile basin (including Abbay or Blue Nile, Baro-Akobo, Setit-Tekeze/Atbara and Mereb) covers 33 percent of the country and drains the northern and central parts westwards;
- The Rift Valley (including Awash, Denakil, Omo-Gibe and Central Lakes) covers 28 percent of the country and consists of a group of independent interior basins extending from Djibouti in the north to the United Republic of Tanzania in the south, with nearly half of its total area being located in Ethiopia;
- The Shebelli-Juba basin (including Wabi-Shebelle and Genale-Dawa) covers 33 percent of the country and drains the southeastern mountains towards Somalia and the Indian Ocean;
- The North-East Coast (including the Ogaden and Gulf of Aden basins) covers 6 percent of the country.

All river basins except the Nile basin face water shortages (EU, 2011). Most of the rivers in Ethiopia are seasonal and there are almost no perennial rivers below 1 500 m altitude. About 70 percent of the total runoff takes place during the period June-September. Dry season flow originates from springs which provide base flows for small-scale irrigation.

Table 2 presents the internal runoff in each basin. Due to evaporative losses, not all flow reaches adjoining countries. For example, out of the 17 960 million m^3/year of the Omo-Gibe in the Rift valley only 10 000 million m^3/year arrive at the border with Kenya. Also, out of the 23 600 million m^3/year of the Baro-Akobo in the Nile basin, only 13 000 million m^3/year are seen at the border with South Sudan.

TABLE 2
Area and annual runoff by river basin (Source: EPA and UNEP, 2008)

Major drainage system	River basin	Area (ha)	As % of total area	Annual runoff (million m^3/yr)	As % of total runoff
Nile Basin		**36 881 200**	**32.4**	**84 550**	**69**
	Abbay (Blue Nile)	19 981 200	17.6	52 600	42.9
	Baro-Akobo	7 410 000	6.5	23 600	19.3
	Setit-Tekeze/Atbara	8 900 000	7.8	7 630	6.2
	Mereb	570 000	0.5	260	0.6
Rift Valley		**31 764 000**	**27.9**	**29 020**	**23.7**
	Awash	11 270 000	9.9	4 600	3.7
	Afar-Denakil	7 400 000	6.5	860	0.7
	Omo-Gibe	7 820 000	6.9	17 960	14.7
	Central Lake	5 274 000	4.6	5 600	4.6
Shebelli-Juba		**37 126 400**	**32.7**	**8 950**	**7.3**
	Wabi-Shebelle	20 021 400	17.6	3 150	2.6
	Genale-Dawa	17 105 000	15.1	5 800	4.7
North-East Coast		**7 930 000**	**7**	**0**	**0**
	Ogaden	7 710 000	6.8	0	0
	Golf of Aden/Aysha	220 000	0.2	0	0
TOTAL		**113 681 600**	**100**	**122 000**	**100**

Note: The areas are estimated and the total area is slightly different from the total area of the country, which is 110 430 000 ha. This last figure should be considered as being the correct one nationally.

Intense rainfall sometimes causes flooding particularly along the Awash river and in the lower Baro-Akobo and Wabe-Shebelle river basins, causing damage to standing crops and infrastructures. The construction of dykes mitigated the problem but has not provided a long-lasting solution.

Ethiopia has 11 freshwater lakes and 9 saline lakes, 4 crater lakes as well as over 12 major wetland areas. Most of the largest lakes are found in the Rift Valley, except Lake Tana which is the source of Abbay River in the Nile Basin. Most Rift Valley lakes have no surface water outlets, i.e. they are endorheic, hence extremely saline. Lakes Langano, Abbaya and Chamo are freshwater lakes and not endorheic, but because of diminishing outflow, they are becoming increasingly saline. Most of the lakes are rich in fish. Lakes Shala and Abiyata have naturally high concentrations of chemicals and a soda ash operation is located on the shore of the latter for the production of sodium carbonate (IWMI, 2007). The total area of wetlands in Ethiopia is estimated between 1.4 and 1.8 million ha (EPA, 2003; IUCN, 2010). Floodplains are mostly found in the north-western and western highlands, the Rift Valley and the eastern highlands but some are also located in lowlands.

The groundwater potential of the country is not known with any certainty, but so far only a small fraction of the groundwater has been developed. It is however more easily available than surface water in the arid areas and supplies about 80 percent of the existing drinking water sources (EPA and UNEP, 2008). Traditional wells are widely used by nomads.

Internal renewable surface water resources are estimated at 120 000 million m^3/year and renewable groundwater resources at around 20 000 million m^3/year, but 18 000 million m^3/year is considered to be overlap between surface water and groundwater, which gives a value of total internal renewable water resources (IRWR) of 122 000 million m^3/year (Table 2). External water resources are null and the surface water leaving the country is estimated at 96 500 million m^3/year, of which:

- 64 600 million m³/year flow into Sudan through the Blue Nile and its tributaries (52 600 million m³/year), the Atbara rive (4 370 million m³) and the Setit-Tekeze river (7 630 million m³/year);
- 13 000 million m³/year flow into South Sudan through the Baro and Akobo rivers forming the Sobat river;
- 8 200 million m³/year flow into Somalia through the Genale and Dawa rivers forming the Juba river (5 900 million m³/year) and the Shebelle river (2 300 million m³/year);
- 10 000 million m³/year flow into Kenya through the Omo river into Lake Turkana; and
- 700 million m³/year flow into Eritrea.

TABLE 3
Water resources

Renewable freshwater resources:			
Precipitation (long-term average)	-	848	mm/yr
	-	936 400	million m³/yr
Internal renewable water resources (Long-term average)	-	122 000	million m³/yr
Total renewable water resources	-	122 000	million m³/yr
Dependency ratio	-	0	%
Total renewable water resources per inhabitant	2015	1 227	m³/yr
Total dam capacity	2015	31 484	million m³

Ethiopia has many small, medium and large reservoir dams constructed for hydropower generation, irrigation and drinking water supply. There are currently 12 hydropower plants cumulating a total installed capacity of 1 945 MW (ODI, 2015). Micro-dams, i.e. dams with a water storage capacity of less than 0.15 million m³, have been constructed for small-scale irrigation, especially around 1999 and 2000 in the Amhara and Tigray regional states. Total dam capacity was estimated at 6 540 million m³ in 2008, and increased tremendously in recent years to reach about 31 484 million m³ in 2015. The new Tekeze dam, built on the eponym river in the Nile basin and completed in 2009, has a storage capacity of 9 000 million m³ and thus largely exceeds the previous largest Koka dam (1 900 million m³). The new Gilgel Gibe III dam, built on the Omo river, has a storage capacity of 14 000 million m³ and started to generate electricity after its completion in 2015. It will soon be supplanted by the controversial Grand Ethiopian Renaissance Dam (GERD) started in 2011 on the Abbay (Blue Nile) river close to the Sudanese border mostly for hydropower generation. The GERD dam, expected to create a huge reservoir of 79 000 million m³, is as of May 2016 almost 70 percent completed.

Desalinization is not practiced in Ethiopia, being a landlocked country, and treatment of wastewater is still marginal. The lack of wastewater treatment is partly explained by the way wastewater is collected since the major wastewater disposal system in Addis Ababa, but also in most large and medium cities of the country, is by vacuum trucks. Only 7.5 percent of the collected wastewater is collected by the sewerage system. The Kalitiy and Kotebe wastewater treatment plants are the only two in the capital. The produced municipal wastewater in the 9 main cities–Addis Ababa, Dire Dawa, Hawassa, Mekelle, Bahir dar, Adama,Gondar, Jimna ad Hara–is estimated in 2014 at 226 million m³, out of which only 0.8 million m³ is collected, mostly by trucks (MoWIE, 2015).

INTERNATIONAL WATER ISSUES

Ethiopia has seven transboundary rivers (Table 4), of which the Abbay river, part of the Nile basin, is the most important (Table 2). These important run-off flows to surrounding countries make Ethiopia the "Water Tower of East Africa".

TABLE 4
Transboundary rivers

River	Total basin area (km^2)	% of basin within Ethiopia	Sharing countries
Nile basin	**3 112 369**	**12**	**Burundi, Democratic Republic of Congo, Egypt, Eritrea, Kenya, Rwanda, South Sudan, Sudan, Uganda, United Republic of Tanzania,**
• Abbay			Sudan
• Baro-Akobo			South Sudan
• Tekeze			Sudan
• Mereb			Eritrea
Rift Valley basin	**637 593**	**49**	**Djibouti, Eritrea, Kenya, South Sudan, Uganda, United Republic of Tanzania**
• Gibe-Omo			Kenya
Shebelle-Juba basin	**810 427**	**46**	**Kenya, Somalia**
• Shebelle			Somalia
• Genale-Dawa			Kenya, Somalia

Ethiopia is a member of the Nile Basin Initiative (NBI), an inter-governmental partnership launched in 1999, together with ten other Nile riparian countries. Because both the 1929 and 1959 Nile Water Agreement assigned the Nile's water to Egypt and Sudan without including Ethiopia and the other riverside nations, the NBI was intended to strengthen the cooperation within the basin. The NBI, the headquarters of which are in Entebbe, Uganda, prepared a Strategic Action Programme, which consists of two sub-programmes: the Shared Vision Programme (SVP) and the Subsidiary Action Programme (SAP). The SVP is to help create an enabling environment for action on the ground through building trust and skill, while the SAP is aimed at the delivery of actual development projects involving two or more countries. Projects are selected by individual riparian countries for implementation and submitted to the Council of Ministers of the NBI for approval.

The NBI is intended to be a transitional institution until the Cooperative Framework Agreement (CFA) negotiations are finalized and a permanent institution created. This new Nile CFA was signed in 2010 by Ethiopia and four other countries–Kenya, Rwanda, Uganda and United Republic of Tanzania–and in 2011 by Burundi. Egypt strongly opposed this agreement which gives deciding power over large-scale hydraulic projects to a commission representing all the signatories, hence cancelling Egypt's historical right of veto. Pre-2011 Sudan, a traditional ally of Egypt, initially also rejected the agreement, but the new Sudan is now considering its signature due to increasing awareness of the unequal sharing and also hoping for benefits, in particular from the Ethiopian Renaissance dam, expected to be completed in 2017. Due to its proximity to the Sudanese border, the dam could provide water for vast areas of irrigable land in Sudan, as well as mitigate floods in the agricultural El-Gezira region and greater Khartoum. The Democratic Republic of the Congo is also still to decide upon the CFA signature, as well as South Sudan, moreover so since the water contribution of the latter is considerable. The CFA was ratified by Ethiopia and Rwanda in 2013 and by United Republic of Tanzania in 2015. Signature of all countries would help organize a comprehensive management of the water resources between the basin countries and find an agreed solution to multiple projects of dams on the Nile for hydroelectricity generation in Uganda (see also the country profile for Uganda). Despite there is no progress yet on the CFA, Egypt, Sudan and Ethiopia have signed in 2015 the Agreement on Declaration of Principles on the GERD, on which Egypt and Sudan accept the GERD project and Ethiopia agreed on two studies on the impacts of the dam on the two downstream countries.

The Genale, Dawa and Shebelle rivers are part of the larger Shebelle-Juba basin, of which almost half lies within Ethiopia. No framework of cooperation between riparian countries exists for this basin.

The only significant transboundary lake is Lake Abbe, shared with Djibouti. It receives water mostly by the Awash river.

Table 5 below summarizes the transboundary aquifers shared with other countries.

TABLE 5
Transboundary aquifers (Source: IGRAC, 2014)

Aquifer	Total aquifer area (km²)	Sharing countries
Dawa	24 173	Kenya, Somalia
Juba	34 587	Somalia
Shebelle	30 985	Kenya, Somalia
Sudd Basin	331 661	Kenya, South Sudan
African Rift Valley Aquifer	46 856	Djibouti
Mereb Aquifer	22 786	Eritrea
Gedaref (Upper Nile Basin)	36 491	Sudan

WATER USE

Agriculture is by far the main water-withdrawing sector. Based on the total irrigated area, cropping pattern and calendar, annual agricultural water withdrawal was estimated to be in the order of 5 200 million m^3 in 2002, while municipal and industrial water withdrawals were estimated to be about 330 and 20 million m^3 respectively (Table 4 and Figure 2). Agricultural water withdrawal in 2016 is estimated at around 9 000 million m^3. This figure, however, seems to be a low estimate considering both the large increase in irrigated areas and the changing pattern in irrigated crops. The huge livestock population withdraws an estimated 687 million m^3 in 2010 (EU, 2011). Industrial demand is estimated at 51 million m^3 level and municipal water withdrawal at 810 million m^3 in 2005.

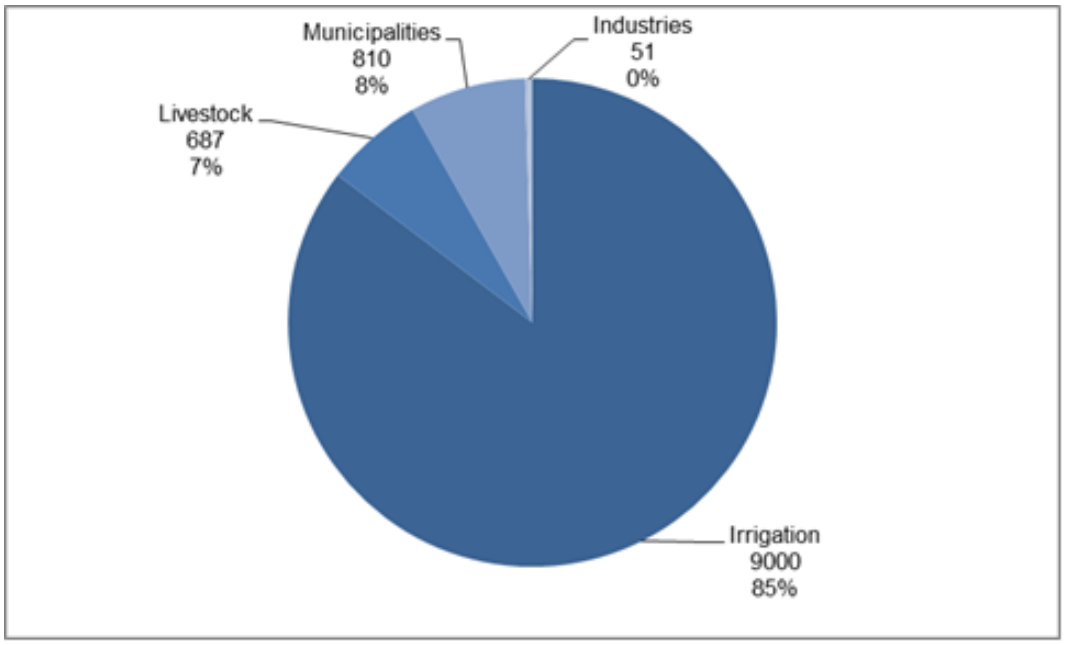
Groundwater is mostly used for drinking supply. It represents about 70 percent of rural water supply and a major role in several of the largest cities (Addis Ababa, Dire Dawa, Mekelle, Harar) and a number of medium sized towns. Groundwater use in irrigation is only at pilot scale for now, but plans to develop it are studied and shallow groundwater wells are constructed by farmers in some areas (MoWR, 2011).

TABLE 6
Water use

Water withdrawal:			
Total water withdrawal	2016	10 548	million m^3/year
- Irrigation	2016	9 000	million m^3/year
- Livestock	2010	687	
- Municipalities	2005	810	million m^3/year
- Industry	2005	51	million m^3/year
• Per inhabitant	2015	106	m^3/year
Surface water and groundwater withdrawal (primary and secondary)	2016	10 548	million m^3/year
• As % of total renewable water resources	2016	8.6	%
Non-conventional sources of water:			
Produced municipal wastewater	2014	226*	million m^3/year
Treated municipal wastewater	2014	0.8*	million m^3/year
Direct use of treated municipal wastewater		-	million m^3/year
Direct use of agricultural drainage water		-	million m^3/year
Desalinated water produced		-	million m^3/year

* *This refers to the nine main cities only*

FIGURE 2
Water withdrawal by sector
Total 10 548 million m^3 in 2016



IRRIGATION AND DRAINAGE

Evolution of irrigation development

River basin master plan studies and related surveys indicate a maximum irrigation potential of about 5.7 million ha, but about 3.7 million ha is commonly quoted. The irrigation potential of Ethiopia is at present estimated at about 2.7 million ha, considering the availability of water and land resources, technology and finance (Table 7).

TABLE 7
Economical irrigation potential by river basin

Major drainage system	River basin	Economical irrigation potential (ha)	As % of total potential
Nile Basin	**Total**	**1 312 500**	**49.1**
	Abbay (Blue Nile)	523 000	19.6
	Baro-Akobo	600 000	22.4
	Setit-Takaze/Atbara	189 000	7.1
	Mereb	500	0.02
Rift Valley		**731 700**	**27.4**
	Awash	205 400	7.7
	Denakil	3 000	0.1
	Omo-Gibe	384 000	14.4
	Central Lake	139 300	5.2
Shebelli-Juba		**627 300**	**23.5**
	Wabi-Shebelle	204 000	7.6
	Genale-Dawa	423 300	15.9
North East Coast		0	0.0
	Oogaden	0	0.0
	Gulf of Aden	0	0.0
Total		**2 671 500**	**100**

Traditional irrigation in Ethiopia dates back several centuries, especially in the highlands for subsistence food crops, while "modern" irrigation was started by the commercial irrigated sugar estate established in the early 1950s by the Imperial Government of Ethiopia and the Dutch company known as HVA-Ethiopia in the upper Awash basin for industrial crops such as sugarcane and cotton. In the 1960s, large-scale irrigation was developed by private companies in the whole Awash basin, thanks to the Koka dam, as well as in the Lower Rift Valley. Modern small-scale irrigation through communal schemes started

only in the 1970s to fight major droughts and famines, especially the 1973 one. In the mid-1970s, state farms were created through the nationalization of private property. Modern private irrigation re-emerged with the liberalization of the economy in the 1990s.

Estimates of irrigated areas vary widely. In 1994, the water managed area was estimated at about 190 000 ha, in 2001 at nearly 290 000 ha (Table 8). The actually irrigated area was then estimated to be equal to the area equipped for irrigation with the following reasoning: on the one hand some irrigation schemes were not operating to their full potential or were not functional at all due to factors related to shortage of water, damaged structures and poor water management; on the other hand, farmers were extending canal networks in some modern irrigation projects and therefore irrigating more land than was reportedly equipped for irrigation.

TABLE 8
Evolution of irrigation and water managed area (in ha)

Schemes	1994	1998	2001	2004	2006	2010	2015
Equipped for full-control irrigation			151 191	175 300	197 250	487 427	658 340
Equipped for spate irrigation						200 000	200 000
Small temporary water managed			138 339	334 700	428 570	853 100	1 100 000
Total water managed	189 560	197 260	289 530	510 000	625 820	**1 540527**	**1 958 340**

Note: Estimated by AQUASTAT, based on MoADR, 2006; IWMI, 2009; IWMI, 2010; MoFED, 2010; NPC, 2015

In 2004, the water managed area was estimated at 510 000 ha, of which 175 300 ha estimated to be full-control irrigation. However, a research estimated that about 30 percent of the command area was not operating at that time (IWMI, 2010). In 2015, the area equipped for full-control irrigation is estimated at 658 340 ha. The area equipped for community spate irrigation is estimated at around 200 000 ha, giving a total area equipped for irrigation of 858 340 ha. In addition around 1 100 000 ha was estimated to be cultivated by small farmers using temporary structures. Thus, in total around 1 958 000 ha (Table 9 and Figure 3) is considered to be water managed in 2014/15 (NPC, 2015).

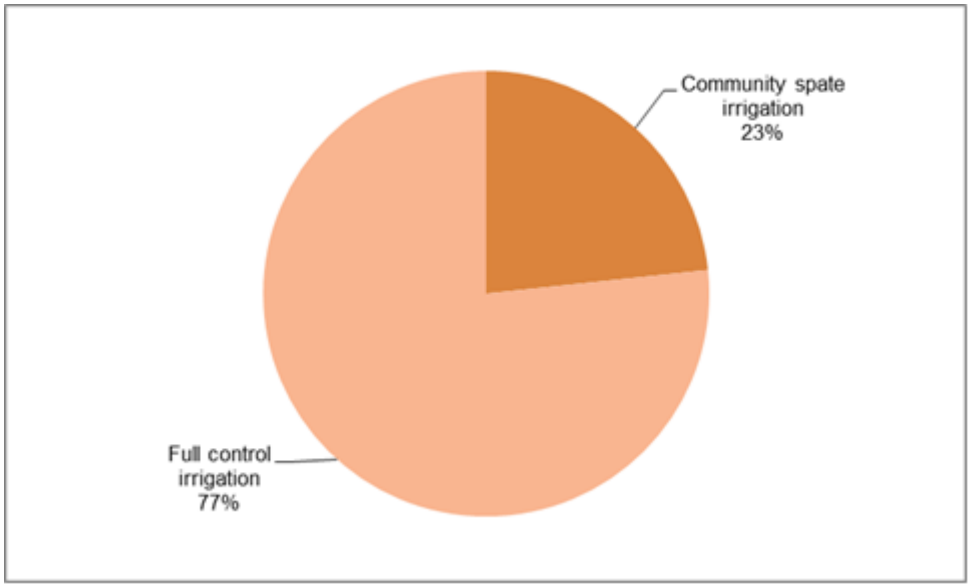
TABLE 9
Irrigation and drainage

Irrigation potential		2 700 000	ha
Irrigation:			
1. Full control irrigation: equipped area	2015	658 340	ha
- Surface irrigation		-	ha
- Sprinkler irrigation	2015	10 000	ha
- Localized irrigation		-	ha
• Area equipped for full control irrigation actually irrigated			ha
- As % of area equipped for full control irrigation	2010	70	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)		-	ha
3. Spate irrigation	2015	200 000	ha
Total area equipped for irrigation (1+2+3)	**2015**	**858 340**	**ha**
• As % of cultivated area	2015	5	%
• % of area irrigated from surface water		-	%
• % of area irrigated from groundwater		-	%
• % of area irrigated from mixed surface water and groundwater		-	%
• % of area irrigated from non-conventional sources of water		-	%
• Area equipped for irrigation actually irrigated		-	ha
- As % of total area equipped for irrigation		-	%
• Average increase per year	2001-2015	11	%
• Power irrigated area as % of total area equipped for irrigation		-	%
4. Non-equipped cultivated wetlands and inland valley bottoms		1 100 000	ha
5. Non-equipped flood recession cropping area		-	ha
Total water-managed area (1+2+3+4+5)	**2015**	**1 958 340**	**ha**
• As % of cultivated area	2015	12	%

TABLE 9 (Continued)
Irrigation and drainage

Size of full control irrigation schemes:	**Criteria**:			
Small schemes	< 200 ha	2015	200 000	ha
Medium and large schemes	> 200 ha	2015	658 340	ha
Total number of households in irrigation			-	
Irrigated crops in full control irrigation schemes:				
Total irrigated grain production			-	metric tons
• As % of total grain production			-	%
Harvested crops:			-	
Total harvested irrigated cropped area			-	ha
• Temporary crops: total			-	ha
• Permanent crops: total			-	ha
Irrigated cropping intensity (on full control area actually irrigated)			-	%
Drainage - Environment:				
Total cultivated area drained			-	ha
• Non-irrigated cultivated area drained			-	ha
• Area equipped for irrigation drained			-	ha
- As % of total area equipped for irrigation			-	%
Area salinized by irrigation			-	ha
Area waterlogged by irrigation			-	ha

FIGURE 3
Area equipped for irrigation
Total 858 340 ha equipped for irrigation in 2015



Harvested irrigated crops reported by the Central Statistics Agency (CSA) cover 327 036 ha for private holdings in 2014/15 (148 132 ha in Belg season and 178 904 ha in Meher season) (CSA, 2015b and 2015c) and there is no precision of the irrigated crops area in the census dedicated to medium and large commercial farms, although most of them seem to practice it.

Spate irrigation is practiced both in the midlands and lowlands. Despite few patches practised for some decades, most of the spate irrigation has been developed relatively recently, especially in arid areas, such as in East Tigray, Somali, Oromia, Dire Dawa, SNNP (Southern Nations, nationalities and Peoples), Afar and Amhara regions. Spate irrigation development concerns between 100 000 and 200 000 ha. Spate irrigation was actually done on 140 000 ha in 2008 (Spate Irrigation Network, 2011).

About 1 240 ha of vegetables are irrigated around Addis Ababa using wastewater or the Akaki river receiving most of the wastewater produced in the city (WeldeSilassie, 2011; UNEP, 2014).

Irrigation schemes in Ethiopia are distinguished by:

- Irrigation technologies:
  - Traditional: often small-scale and community-based, carried out by farmers on their own initiative, including in peri-urban areas particularly in Addis Ababa and Bahir Dar, for the production of vegetables for the local market. Traditional river diversions are physical structures built with local materials. The diversion structures are normally destroyed by floods during the rainy seasons and have to be built each year.
  - Modern: any size or ownership.
- Size:
  - Small: less than 200 ha, often community-based and traditional, but can be modern. Includes wells, spate, river diversion.
  - Medium: between 200 and 3 000 ha, community-based or public. Examples include Sille, Hare and Ziway irrigation schemes.
  - Large: more than 3 000 ha, commercial or public, such as Wonji-Shoa sugarcane plantation, Methara, Nura Era and Fincha. Similarly to medium, they are mainly supplied by surface water stored in dams, with some pilot areas using groundwater.
- Ownership 1:
  - Smallholders, for subsistence or local market.
  - Commercial.
- Ownership 2:
  - Community-based.
  - Private.
  - Public: constructed in the 1960-70s either as private farms or joint venture, owned and operated by public enterprises. About 73 percent of the public irrigation schemes are located along the Awash river. Public schemes are medium or large.

For census purposes, the CSA only distinguishes between small private holdings on the one hand and medium and large commercial farms on the other hand.

Most of the water used for irrigation is surface water, while groundwater use just started on pilot basis in East Amhara. Surface irrigation methods dominate throughout, predominantly furrow irrigation for cotton and wheat and basin irrigation for commercial fruits such as bananas. Sprinkler irrigation is being practiced on about 10 000 ha area for sugarcane on Fincha State Farm. Similarly, it is being used in limited areas of eastern Amhara and southern Tigray in some smallholders' schemes and some private farms in the Rift Valley. Most of the earlier schemes were pump-irrigation projects, but later gravity irrigation schemes were introduced. Some private farms had installed hydraulic rams on the banks of the Awash river to lift up water (MoA, 2011).

Finally, rainwater harvesting, also sometimes named micro-irrigation in national documents, is well developed in the country, although estimates vary again widely: from 40 000 to 800 000 ha, certainly encompassing the basin catchment for the latter figure. A recurrent estimate of 128 000 ha seems more probable.

Role of irrigation in agricultural production, the economy and society

Irrigated agriculture contributed less than 3 percent of the total cereal production in the early 2000s. By 2010, it contributed 9 percent of the agricultural GDP and 3.7 percent of the overall GDP. Over 1.2 million private holders practiced irrigated agriculture in 2014/15 in the Meher season–main rainy season–and over 0.8 million in the Belg season–small rainy season.

Irrigated crops in medium and large scale commercial farms are mostly cash crops, in particular cotton and sugarcane, but fruits and vegetables were also introduced. The Wonji/Shoa, Metehara and Finchaa schemes grow sugarcane (total 21 425 ha in 2005/06), the Amibara scheme cotton (6 448 ha in 2005/06),

and Upper Awash scheme fruits and vegetables (6 017 ha in 2005/06) (MoA, 2011). Large-scale irrigation schemes are under full irrigation throughout the year (IWMI, 2009).

In small-scale irrigation schemes, irrigated crops are more diversified, but for the country as a whole the main irrigated crops are cereals–maize, wheat, barley or teff–, pulses, vegetables, root crops, fruits and fiber crops (cotton). Smallholder irrigators generally prefer subsistence crops rather than cash crops (MoA, 2011) and use irrigation to complement rainfed agriculture, i.e. supplementary irrigation. However, during the dry season, they use full irrigation to get additional income (IWMI, 2009).

Status and evolution of drainage systems

Drainage is as important as irrigation, particularly in the highlands of Ethiopia. However, except in irrigated lands, drainage is not given the required attention in rainfed agriculture where farmers construct traditional drain ditches commonly diagonal to the main slope of the farmlands. Because of irregularity in cross-sections and longitudinal slopes as well as inadequate capacities, the drains are usually converted to gullies if the same drains are adopted year after year. To avoid this happening, drain lines are changed every year. Designs of small-scale irrigation schemes incorporate drainage systems but these are not properly implemented. The drainage system used in the country is the surface drainage system (gravity drainage). The construction of subsurface drainage systems was started for one large-scale irrigation scheme in the Awash Valley for salinity control, but was discontinued.

Women and irrigation

Women and children are the main responsible for fetching water, even when it requires traveling long distances, up to half a day (UNESCO-WWAP, 2004). In agriculture, out of the 15 million farm holders in 2011, only 2.7 million were women (CSA, 2011). Both women and men can register for land ownership, but women do not equally get access to farm plots despite the fact that they undertake up to 75 percent of farm labour and produce 70 percent of the households' food (USAID, 2016). Women also have less access to extension services and agricultural inputs, including irrigation, as well as a lower bargaining power for changing water schedules. Hence, even with water rights, their crops fail more often just because water was not available on time (CDR, 2011). As a result, both in rainfed and irrigated agriculture, they produce up to 35 percent less than men (USAID, 2016) and female-headed households have a weaker position. Finally, the cultural perception that women are unable to plough in some communities may explain partly their lower access to land and inputs (CDR, 2011).

WATER MANAGEMENT, POLICIES AND LEGISLATION RELATED TO WATER USE IN AGRICULTURE

Institutions

At the federal level, the public institutions involved in water resources development include:

- The Ministry of Water, Irrigation and Energy (MoWIE) replacing the Ministry of Water Resources (MoWR), responsible for the overall planning, development, management, utilization and protection of the country's water resources, as well for the supervision all medium and large irrigation schemes. The following six directorates in particular are dedicated to water:
    - Irrigation and Drainage
    - Water Use Permit and Administration
    - Hydrology and Water Quality
    - Groundwater
    - Basin Administration
    - Water Supply and Sanitation

- The Ministry of Agriculture (MoA), in charge of water management (irrigation extension), including water harvesting for smallholder irrigated and rainfed agriculture.
- The Ministry of Environment and Forestry (MoEF), formerly the Environmental Protection Authority (EPA), responsible for the preparation of environmental protection policy, laws and directives. It is also in charge of evaluating the impact of social and economic development projects, particularly irrigation and hydropower projects, on the environment and is further responsible for follow-up work.
- The Water Resources Development Fund (WRDF)

At sub-national level, three River Basin Organisations have been established since 2008, comprising a Basin High Council and River Basin Authorities to ensure integrated water resources management at basin level:

- Awash Basin Authority (AwBA), replacing the former only basin-level institution the Awash Basin Water Resources Management Agency (ABWRMA). Most of the medium- and large-scale irrigation projects and salinity and flooding problems are concentrated in this basin;
- Abbay River Basin Authority (ARBA);
- Rift Valley Lakes Basin Authority (RVLBA).

Finally, the regions are the major operational unit for projects through their:

- Bureau of Water, Mines and Energy (BoWME) and/or Bureau of Water Resources Development (BoWRD), which are responsible for small-scale irrigation and rural water supply as well as small-scale hydropower development.
- State's Irrigation Development Authorities, which undertake operational activities in line with their mandates (study, design and construction of small-scale irrigation schemes).

Water management

Basin Master Plans are expected to rule and detail water allocation, but since most of them are outdated, they do not reflect the actual water needs. In addition, formal water rights are not yet in place, so customary water rights dominate, such as for example the rights associated to communal land tenure in pastoralist areas. However, but these traditional institutions are not always adapted to increasing water scarcity and mobility (EU, 2011).

Almost all traditional irrigation schemes have a corresponding traditional water management organization, but they do not receive any formal support. These traditional water committees, locally known as 'water fathers', administer the water distribution and coordinate the maintenance activities of the schemes. Some Water Users Associations (WUA) have been established. However, WUAs have no legal status and are to be converted into irrigation cooperatives. There are nonetheless differences, in particular in membership and focus, between the two types of association. Membership is compulsory in WUA, but voluntary in cooperative. Marketing is also the main focus of irrigation cooperatives, while WUAs mostly concentrate on water distribution and management (MoA, 2011).

The water management of small-scale irrigation schemes is the responsibility of the farmers themselves, mainly through informal/traditional community groups. Apart from the provision of extension and training services to the WUAs from the MoA, no institution is directly involved in water management in smallholder-irrigated agriculture. Once the construction of irrigation schemes is completed, they are handed over to the beneficiaries but maintenance remains within the responsibility of the regional governments. The absence of any appropriate local-level organs to cater for small-scale irrigation has resulted in a lack of guidance in irrigation operation and maintenance at a community level. With an increase in irrigated areas and more users, irrigation water management and rules for water allocation are becoming more complex and problematic.

Finances

Funding for water development activities is mainly provided by the federal or regional government. The WRDF provide small credits to WUAs. Private investment is increasing but remains low. The States' irrigation authorities have financial autonomy only over their approved and allocated budget. So far, neither cost recovery nor irrigation charges have been considered in irrigation development. However, in some cases beneficiaries have been contributing to the development of some small-scale irrigation schemes by providing free labour for up to 10 percent of the investment. Most beneficiaries have not even contributed to the operation and management of the existing schemes let alone to construction costs. In some small-scale irrigation schemes, though, beneficiary communities collect irrigation charges for covering minor maintenance costs, each beneficiary paying the same amount irrespective of farm size or quantity of water withdrawn.

Irrigation development costs between US$5 000 and US$20 000 per hectare (MoA, 2011).

Policies and legislation

The 1995 Ethiopian Constitution states in its article 44 that all natural resources (including water) are the common property of the Ethiopian people and the state (MoA, 2011). The *Ethiopian Water Resources Management Policy (WRMP) Proclamation 2000* (No 197) sets out the basis for contemporary integrated water management in the country. Its guiding principles are: i) recognition of water as a scarce and vital socio-economic resource to be managed and planned strategically; ii) recognition of water as an economic good; iii) stakeholders to be involved in water resources management. It allocates water to all regional states regardless of the source and location of the resource, and provisions for water rights. In 2001, the Ethiopian Water Strategy translated the policy into action. More recently, additional legislation completed the *2000 WRMP Proclamation*:

- *Water Resources Management Regulation 2005* (No 115) makes provision for maintaining environmental flows, protecting or restoring ecosystem services and addressing the water needs of marginalized groups but its enforcement is not rigorous (ODI, 2015).
- *River Basin Councils and Authorities Proclamation 2007* (No 534) authorizes RBHCs and RBAs for each major river basins.

One chapter of the 2000 Water Resources Management Policy is dedicated to irrigation, the Irrigation Policy, to develop the huge irrigated agriculture potential for the production of the food crops and raw materials needed for agro-industries in a sustainable way. It emphasizes decentralization and user-based management of irrigation systems, development of priority schemes, support and enhancement of traditional irrigation schemes, establishment of water allocation, as well as integration of appropriate drainage facilities.

The Water Sector Development Programme (WSDP) was launched in 2002 for a 15-year period (2002 to 2016). It includes the financing of water resources management and development; the creation of an enabling environment; transboundary rivers management; stakeholder participation and gender mainstreaming; disaster-prevention and public safety, and environmental health standards. The WSDP requested Master Plans for the seven river basins to form a comprehensive "national river basin master plan". Most of these plans were completed by 2014 but used 1990s data and thus needed updates, which started only in the three basins with functioning RBAs (Awash, Abbay and Rift Valley).

Finally, the Growth and Transformation Plan (GTP) replaced the Plan for Accelerated and Sustained Development to End Poverty (PASDEP) in 2010 as Ethiopia's overarching five-year poverty reduction plan (MoA, 2011).

ENVIRONMENT AND HEALTH

The main environmental issues related to water management are erosion and siltation of water infrastructures. Water pollution is still mostly limited to urban and industrial areas, but soil salinization is directly linked to irrigated agriculture.

Erosion and sedimentation

Erosion is caused by natural factors, such as topography, torrential rains and wind. It is also caused by human activities, in particular deforestation for agriculture, charcoal, construction, mining, or by grazing, all due to unsustainable utilization and rapidly expanding human and livestock populations. Annual soil erosion amounts to about 1 900 million tons/year, impacting water, land and agricultural productivity (IWMI, 2010). Since the majority of the main rivers have their headwaters in the highlands parts of the country, their silt content is high. As a result, water bodies are silting up, especially in the Abbay basin (ODI, 2015). Sedimentation in dams, such as the Koka, Aba Samuel, Borkena and Gondar, reduced their storage capacity. Water levels of natural lakes have decreased, in particular Awasa, Abaya, Alemaya, Lange, Rudolf, Chew Bahir, Adele and Zway, and some show signs of drying up. Finally, a number of rivers change their courses due to siltation, particularly during the rainy season, resulting in yearly flooding in the areas near the riverbanks. This is particularly the case of the Lower Awash river (EPA, 2003 and EPA and UNEP, 2008).

Water pollution

Water pollution is still limited to industrial, mining and urban areas (EPA, 2012), but is a growing problem in the Awash river basin, due to major cities and industries in the Upper basin. In early 2000s, about 80 percent of industries around Addis Ababa discharged their waste into nearby water bodies without any treatment. Tributaries of the Awash river around Addis Ababa and Nazareth are polluted (EPA, 2003). Pollution causes water hyacinth infestation in Lake Koka, algal bloom in Lake Aba Samuel, industrial pollution of the Akaki river and nitrate pollution of the Awash river (ODI, 2015).

Salinization

Salinity problems due to waterlogging were observed in irrigated lands along the Awash river. In the 1980s, thousands of hectares of the Amibara plantation for cotton, in the middle Awash basin, had to be abandoned after less than five years of irrigation farming due to faulty drains (WB, 2007).

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

Recurring droughts and growing population pressure drove Ethiopian government to prioritize irrigated agriculture in the country's development agenda in order to reduce the food deficit. Targets of the 2006-2010 PASDEP, 487 000 ha of small-scale irrigation and 323 000 ha of medium- and large-scale irrigation by the end of the period (PASDEP), were mostly achieved. Ethiopia's first Growth and Transformation Plan (GTP) targeted again a colossal increase in irrigated land area for the period 2010-2015, for a total of 1.85 million ha in small irrigation and an additional 785 583 ha in medium and large irrigation schemes by 2015 (GTP, 2010). Anew these were almost reached but mostly through traditional water management often with temporary structures not full-control irrigation schemes. The second GTP set once more for the period 2015-2020 a vast increase, although this small scale irrigation target is lower than in the 2010-2015 GTP, with 1.7 million ha under small irrigation schemes and 954 000 ha under medium and large scale by 2019/2020 to develop 98 percent of the irrigation potential (GTP2). Area under irrigation is mostly expanded with small irrigation schemes requiring lower capital and technical investments and reaching small communities.

However, despite the immense increases mentioned above, the harvested irrigated crops were in 2014/2015 not yet using this new potential fully. In addition, the rapid infrastructure development should

be quickly followed by institutional development and in particular creation of WUAs for local irrigation management to ensure these new irrigation schemes are properly managed, operated and maintained.

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