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Zimbabwe

GEOGRAPHY, CLIMATE AND POPULATION

Geography

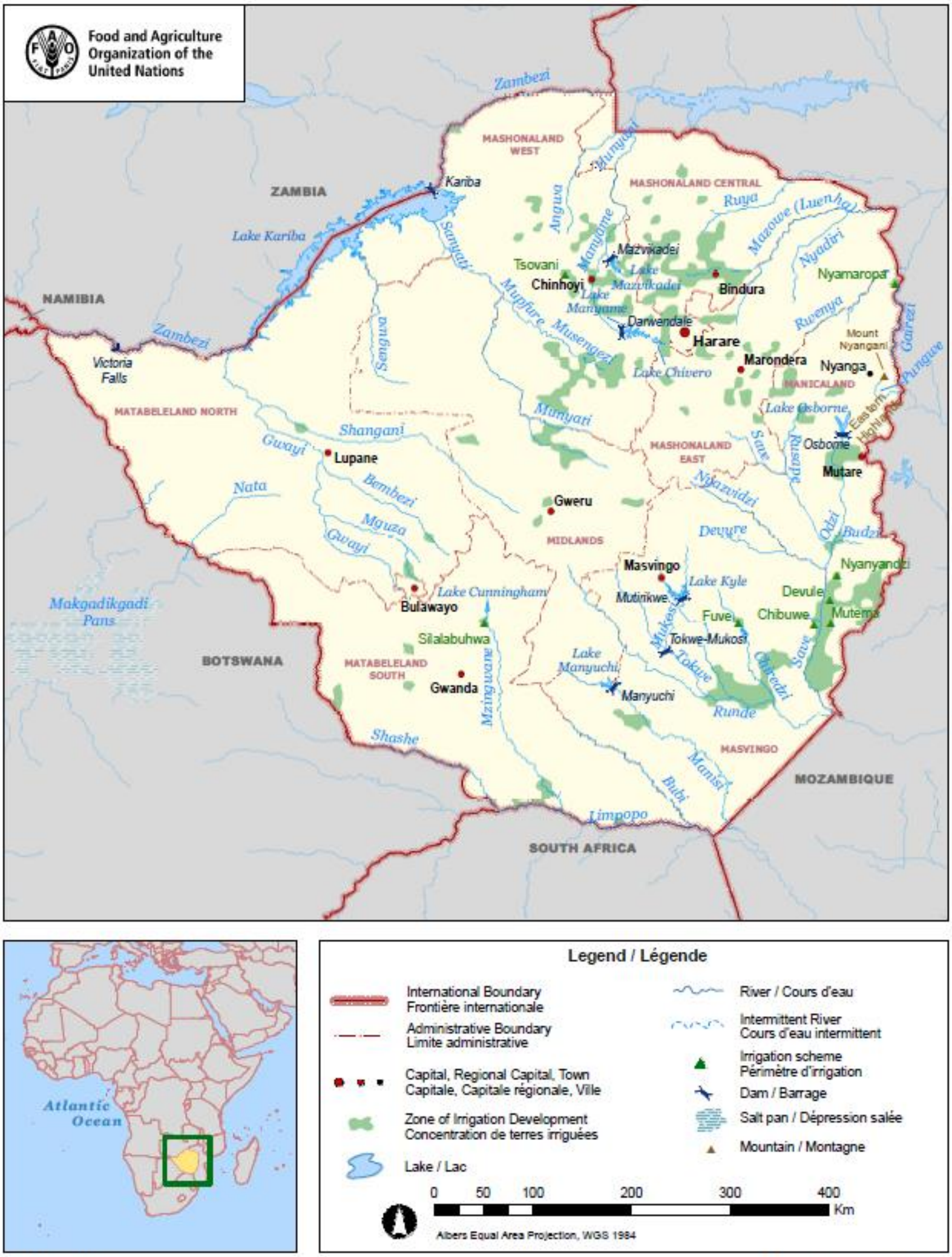
Zimbabwe is a landlocked country, located in southern Africa with a total area of 390 760 km^2. The country is bordered by Zambia in the north, Mozambique in the east, South Africa in the south, and Botswana and Namibia in the west. Four major relief regions are generally recognized on the basis of their elevation: i) the lowveld (< 600 m above mean sea level); ii) the middleveld (600-1 200 m); iii) the highveld (1 200-2 000 m); iv) the Eastern Highlands (2 000-2 400 m). The highest point in the country, Mount Nyangani, lies at 2 592m along the eastern border with Mozambique. Zimbabwean soils are predominantly derived from granite, so 70 percent are sandy and light limiting the cropping potential (MENR, 2010). However soils with significant clay content and of excellent agricultural potential are also found in all regions of the country.

The agricultural area is estimated that 16.2 million ha, of which 4.1 million ha is cultivated and 12.1 million ha are permanent pastures (Table 1). The country's forested area declined from over 22 million ha in 1990 to around 15 million in 2012 (FAOSTAT, 2015). In addition savanna woodland interspersed with open grasslands covers much of the country and the *dambos* (seasonally waterlogged low-lying areas) of the central watershed area (MENR, 2010). As a result, Zimbabwe provides habitats for abundant and diverse flora and fauna.

TABLE 1
Basic statistics and population

Physical areas:			
Area of the country	2012	39 076 000	ha
Agricultural land (permanent meadows and pasture + cultivated land)	2012	16 200 000	ha
• As % of the total area of the country	2012	41	%
• Permanent meadows and pasture	2012	12 100 000	ha
• Cultivated area (arable land + area under permanent crops)	2012	4 100 000	ha
- As % of the total area of the country	2012	10	%
- Arable land (temp. crops + temp. fallow + temp. meadows)	2012	4 000 000	ha
- Area under permanent crops	2012	100 000	ha
Population:			
Total population	2014	14 599 000	inhabitants
- Of which rural	2014	60	%
Population density	2014	37	inhabitants/km^2
Economy and development:			
Gross Domestic Product (GDP) (current US$)	2014	13 663	million US$/year
• Value added in agriculture (% of GDP)	2014	14	%
• GDP per capita	2014	936	US$/year
Human Development Index (highest = 1)	2013	0.492	-
Gender Inequality Index (equality = 0, inequality = 1)	2013	0.516	-
Access to improved drinking water sources:			
Total population	2015	77	%
Urban population	2015	97	%
Rural population	2015	67	%

FIGURE 1
Map of Zimbabwe



ZIMBABWE

FAO - AQUASTAT, 2015

Climate

Climatic conditions in Zimbabwe are largely subtropical with one rainy season from November to March, a cool winter season from April to August and the hottest and driest period from September to mid-November. Average annual rainfall is 657 mm, but ranges from over 1 000 mm in the Eastern Highlands to around 300-450 mm in the lowveld in the south. Rainfall reliability in the country decreases from north to south and also from east to west. Evaporation varies over the country to a much smaller extent than rainfall. Values of net annual pan evaporation range from about 1 400 mm in the Eastern Highlands up to 2 200 mm in the lowveld, generally exceeding precipitations. Erratic rainfall constrains crop farming across at least sixty percent of the country (MENR, 2010).

The country is prone to periodic droughts strongly correlated to El Niño events (warm sea surface temperature in the central and eastern Pacific). In the present millennium the country already experienced devastating droughts in five farming seasons, 2001/02, 2002/03, 2004/05, 2006/07 and 2011/12, directly impacting agriculture (GoZ, 2012).

Population

The total population is estimated at 14.6 million (2014), of which 60 percent is rural (Table 1). The annual population growth rate is 3 percent in 2013 and the average population density is 37 inhabitants/km^2. Around 80 percent of the population is concentrated in areas where rainfall is unreliable. In 2013, the Human Development Index ranks Zimbabwe 156 among 187 countries and the Gender Inequality Index ranks it 110 among 152 countries for which data are available. Life expectancy is 60 years and the under-five mortality is 89 per 1000 births, both progressing from below 45 years and over 100 per 1000 in the 2000s. With no significant distinction between boys and girls, around 94 percent of the children in 2012 are enrolled in primary education, but only 44 percent for secondary education (WB, 2015). Adult literacy is 84 percent for the 2005-2012 period (UNDP, 2015), with a small gap between female literacy (80 percent) and male literacy (88 percent). Poverty concerns 34 percent of the population, mostly in rural areas (43 percent against 16 percent in urban areas). In 2015, 97 percent of the urban and 67 percent of the rural population were using improved drinking water sources, which is 77 percent of the total population. This represents no improvement since 2002 (JMP, 2015). Also the status of improved sanitation facilities, which were already available for only 40 percent of the population in 2002 (52 percent in urban areas and 32 percent in rural areas), remained the same. Even more, due to poor maintenance, urban water and sanitation systems are deteriorating, resulting in 2008 in a large cholera outbreak (100 000 people affected and 4 000 deaths) (GoZ, 2012).

ECONOMY, AGRICULTURE AND FOOD SECURITY

The economy was not performing well with a GDP declining by 50 percent from 1997 to 2008. However, since 2009 it is increasing again and reached 13 663 millions current US$ in 2014 thanks to the establishment of a Government of National Unity in February 2009 and the adoption of macroeconomic stabilization policies, including the multi-currency regime.

Prior to 2000, agriculture contributed to over 20 percent of the GDP depending on the years, but declined similarly to the whole economy due to the “Fast Track Land Reform Program” (FTLRP), droughts, high HIV prevalence (15 percent in 2013) and extremely high unemployment (estimated at 60 percent). However, agriculture production is also recovering and contributes to 14 percent of the GDP in 2014. It remains a cornerstone of the Zimbabwean economy and is, together with the mining sector, leading the economic recovery.

Production of major crops contributing to the national food security increased significantly during the 1980s and 1990s, when Zimbabwe was referred to as a “breadbasket of Southern Africa” (MDT 2011). However there has been a major decline in yields and global production of key crops in the period 2000-2010. Since then, increase in agricultural production, in particular maize, helped address food security and rural poverty, but still 33.5 percent of the population is undernourished in 2015 (FAOSTAT, 2015) and 72 percent of the population lived below the national poverty lines in 2011 (WB, 2015).

Because most of the country receives limited and erratic rainfall, irrigation is a prerequisite for successful crop production in these areas. Access to water through irrigation could both increase agricultural production and stabilize crop yields (AFD, 2012), but it is the main challenge for the sector together with access to the other agricultural inputs (land, fertilizers, pesticides, etc.) (GoZ, 2012).

WATER RESOURCES

Zimbabwe's border to the north with Zambia is the Zambezi river and to the south with South Africa is the Limpopo river, both of which flow into Mozambique. The country is divided into seven river catchments (EMA, 2014): Gwayi, Sanyati, Manyame, Mazowe (or Mazoe), Save (or Sabi), Runde and Mzingwane (Table 2). With the exception of the Save and Runde, which join at the border with Mozambique and then flow as one river to the Indian Ocean, all other main rivers drain into either the Zambezi or Limpopo. However, while the Gwayi river drains into the Zambezi river, the Nata (or Amanzamnyama) river, which is considered to be part of the Gwayi water catchment, drains into the Makgadikgadi Pans in Botswana, which in reality are not part of the Zambezi river basin, but of the South Interior basin. The Zambezi is particularly important to the country as it produces most of its electricity.

TABLE 2
Water catchments

Water Catchments	Major sub-basins	Drainage
Gwayi	Shangani, Bembezi, Mguza, Upper Gwayi and Nata	Zambezi
Sanyati	Zivagwe, Munyati, Muzvezve, and Mupfure	Lake Kariba
Manyame	Angwa, and Musengezi	Zambezi and Lake Kariba
Mazowe	Nyadiri, Ruya, Rwenya, Nyangombe and Gairezi	Zambezi
Save	Devure, Nyazvidzi, Upper Save, Macheke, Rusape, Odzi, Pungwe and Budzi	Indian Ocean (in Mozambique)
Runde	Tokwe, Mutirikwi, and Chiredzi	Save
Mzingwane	Shashe, Bubi, and Mwenzi	Limpopo

Zimbabwe has limited groundwater resources, mainly because the greater part of the country consists of ancient igneous rock formations where groundwater potential is low. Four aquifer systems are an exception with relatively high potential:

- The Lomagundi dolomite aquifer, lying northwest of Chinhoyi, about 120 km northwest of Harare;
- The forest sandstone formation in the Nyamandhlovu area, close to Bulawayo; the formation is part of the Karoo aquifers shared between Botswana, Namibia, South Africa, Zambia and Zimbabwe;
- The Kalahari sands which are widespread in the southwestern part of the country and where exploitable groundwater resources are related to the thickness of the sands;
- Alluvial deposits which mainly occur in the Save valley where they form a local aquifer, along the Zambezi, Manyame (Mushumbi pools area) and Musengezi rivers (Muzarabani areas).

As a result of these scarce groundwater resources, the country relies mainly on surface water resources. Internal renewable surface water resources are estimated at 11 260 million m^3/year and renewable groundwater resources at around 6 000 million m^3/year. About 5 000 million m^3/year is considered to be overlap between surface water and groundwater, thus total internal renewable water resources (IRWR) are 12 260 million m^3/year (Table 3). Total flow in border rivers amounts to 39 900 million m^3/year, corresponding to both the Zambezi from Zambia and Limpopo from Botswana, but their accounted inflow is limited to 7 740 million m^3/year. Total renewable water resources are thus 20 000 million m^3/year, or 1 413 m^3/year per capita in 2014. This per capita value is projected to fall under the absolute water scarcity threshold of 500 m^3/year by 2030, due to population increase. Surface water leaving the country is estimated at 14 140 million m^3/year, of which 14 100 million m^3/year through the Mazowe river to Mozambique and 40 million m^3/year through the Nata river to Botswana.

TABLE 3
Water resources

Renewable freshwater resources:			
Precipitation (long-term average)	-	657	mm/year
	-	256 700	million m^3/year
Internal renewable water resources (Long-term average)	-	12 260	million m^3/year
Total renewable water resources	-	20 000	million m^3/year
Dependency ratio	-	39	%
Total renewable water resources per inhabitant	2014	1 413	m^3/year
Total dam capacity	2015	99 930	million m^3

There are no natural lakes in Zimbabwe but numerous reservoirs thanks to the 2 200 dams, including 260 large ones (WB, 2014). Only 850 of them were constructed by the government, and their permits are owned by the Zimbabwe National Water Authority (ZINWA). The private dams are mostly small ones (AfDB, 2011). The total capacity of dams is estimated at 99 930 million m^3, which includes half of the total reservoir capacity of 188 000 million m^3 of the Kariba dam, shared with Zambia. The Kariba dam, completed in 1959 at the former Kariwa (Kariba) Gorge on the Zambezi river and owned by the Zambezi River Authority (ZRA), is the largest dam worldwide in terms of reservoir capacity. A rehabilitation project of the Kariba dam was approved in 2014. Other major dams in the country include Mutirikwi (or Kyle), Chivero, Manyame (or Darwendale/Robertson), Mazvikadei, Osborne and Manyuchi dams. Dams under construction such as the Tokwe-Mukosi (1 800 million m^3) completed at 80 percent in 2015 and the Kondo dams (1 230 million m^3) will improve water supplies in the Save-Limpopo region, where water for irrigation was previously imported from Lake Mutirikwi in the Central region (MENR, 2010). However, siltation considerably reduces the total dam capacity: by 2003, it was reduced by 29 million m^3 and a large number of medium- and small-sized dams face operational difficulties because of sedimentation. Nonetheless, the ratio of water used compared to the water stored in dams is low (AfDB, 2011).

Some water transfers also take place and the Matabeleland Zambezi Water Project, also called the Bulawayo-Zambezi Water Supply Scheme, will bring water from the Zambezi river to Bulawayo. Its first phase is the Gwayi Shangani dam, commenced in 2004 but stopped in 2007 due to funding problems (SADC, 2012).

Surface water also takes the form of wetlands (IUCN, 1994):

- Floodplains: Mid-Zambezi Valley in Mana Pools area, and around the Save-Runde confluence
- Riverine wetlands: along the Save-Runde, Manyame, Gwayi-Shangani, Mazowe and Sanyati rivers
- *Dambos* or palustrine wetlands: covered 1.28 million ha in 1990s
- Pans: not widespread, in Hwange and Gonarezhou National Parks
- Swamps: limited to Tsamtsa, Kwaluzi and Binga swamps

Seven wetlands are Ramsar sites since 2013: Cleveland Dam, Chinhoyi Caves, Driefontein Grasslands, Lake Chivero and Manyame, Mana Pools, Monavale Wetland and Victoria Falls National Park, covering around 275 000 ha in total.

INTERNATIONAL WATER ISSUES

Zimbabwe shares six major river basins with neighbouring countries: Zambezi, Limpopo, Nata, Save, Shashe (part of the Limpopo river basin) and Pungwe (Table 4). It is cooperating with other members of the Southern Africa Development Community (SADC) on the shared management of the region's river systems. The country is a signatory to the SADC's Shared Water Course Systems Protocol and its revised version, which provides the basis for the management of international rivers in the SADC region, which consists of 14 countries.

TABLE 4
Transboundary rivers

River name	River basin area (km^2)	Sharing countries	Joint management
Zambezi	1 351 365	Angola, Botswana, Malawi, Mozambique, Namibia, United Republic of Tanzania, Zambia	ZAMCOM, ZRA
Limpopo	401 865*	Botswana, South Africa, Mozambique	LIMCOM
Shashe	18 991	Botswana	Joint Technical Committee
Nata	23 000	Botswana	
Save	115 700	Mozambique	Joint Water Commission
Buzi	27 000	Mozambique	
Pungwe	31 151	Mozambique	PRBC

Zimbabwe is hosting the Zambezi Watercourse Commission (ZAMCOM), established according to the Zambezi Watercourse Commission Agreement signed in 2004 between the eight riparian countries (Table 4). More limited in scope, the Zambezi River Authority (ZRA) was established in 1987 between Zambia and Zimbabwe and is only dedicated to the management of the Kariba dam, replacing the previous Central African Power Corporation (CAPCO) of the Rhodesian governments.

Zimbabwe is also member of the Limpopo Watercourse Commission, established in 2003, together with the three other riparian countries: Botswana, South Africa and Mozambique. A Joint Water Commission with Mozambique manages both the Save and Buzi rivers and a similar Joint Technical Committee exists with Botswana for the Shashe river, part of the larger Limpopo basin, and for the Nata river. Finally the Pungwe River Basin Commission (PRBC) was formalized in 2002.

Despite the relatively scarce groundwater resources, some of aquifers are shared with neighbouring countries (Table 5). No agreement rules the sharing of these groundwater resources between the countries.

TABLE 5
Transboundary aquifers (Source: IGRAC, 2014)

Aquifer name	Total aquifer area (km^2)	Sharing countries
Limpopo basin	19 961	Mozambique, South Africa,
Tuli Karoo sub-basin (or Gaborone to Shashe river)	14 330	Botswana, South Africa
Nata Karoo sub-basin	90 982	Angola, Botswana, Namibia, Zambia
Eastern Kalahari Karoo basin	39 603	Botswana
Save Alluvial	11 477	Mozambique
Medium Zambesi aquifer	10 705	Zambia

WATER USE

The total water withdrawal was estimated at 4 205 million m^3 in 2002, with agriculture accounting for 79 percent of total water use. However there has been a significant decrease in water demand in agriculture following the introduction of the FTLRP, as well as in industry and mining due to the subsequent financial crisis. In 2007, the total volume of water allocation was estimated at 3 570 million m^3 (WB, 2014), including 2 930 million m^3 (or 82 percent) for agriculture (Table 6 and Figure 2). Actual water withdrawal is nonetheless much less than the allocated volume. In addition, since 2008 irrigation water withdrawal has declined dramatically. In all catchments, except Runde, less than 30 percent of the potential water available in reservoirs was utilized in 2010 (WB, 2014).

Some estimations consider that water withdrawal in 2010 was half the 2002 level, mainly due to a sharp decline in irrigation. These estimations used the data of 4 205 million m^3 in 2002 from the AQUASTAT database as a starting point, including 3 318 million m^3 for agriculture, and based on that estimated that it is 2 170 million m^3 in 2010, including 1 660 million m^3 for agriculture (AfDB, 2011). In that scenario, the 2002 water use level would be recovered in 2014-2015.

Finally, national data from the ZINWA seven catchment offices declare a total water withdrawal of 887 million m^3 in 2014, including 700 million m^3 for agriculture. These data, however, seem to be too low estimates considering the total population and the total irrigation areas and might partly refer to water consumption rather than water withdrawal.

TABLE 6
Water use

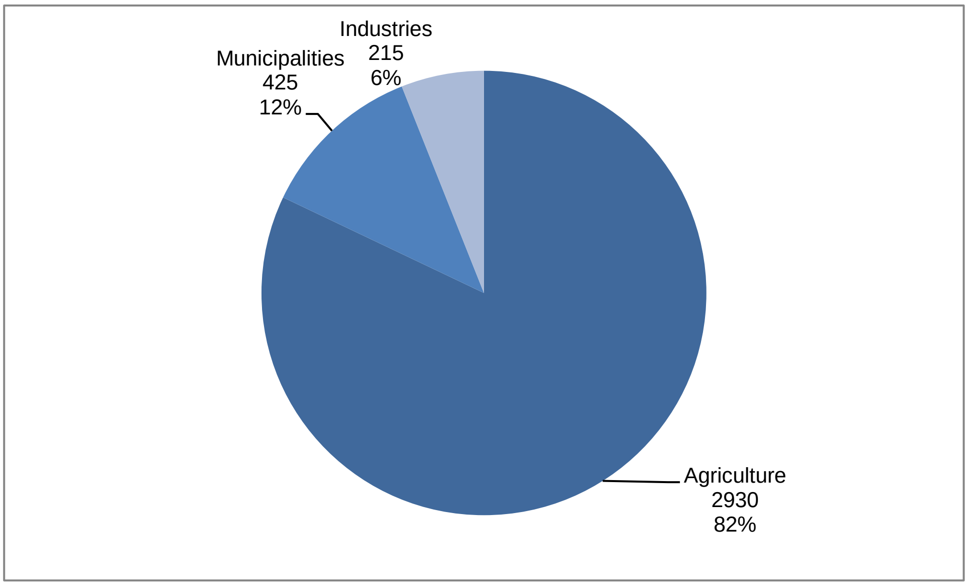
Water withdrawal: *			
Total water withdrawal	2007	3 570	million m^3/year
- Agriculture	2007	2 930	million m^3/year
- Municipalities	2007	425	million m^3/year
- Industry	2007	215	million m^3/year
• Per inhabitant	2007	280	m^3/year
Surface water and groundwater withdrawal (primary and secondary)	2007	3 570	million m^3/year
• As % of total renewable water resources	2007	18	%
Non-conventional sources of water: **			
Produced municipal wastewater	2012	194	million m^3/year
Treated municipal wastewater	2012	95	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

* *The data refer to water allocated and not water withdrawal, which is less but no data available*
** *Wastewater data refer to four major cities only: Harare, Bulawayo, Mutare, Gweru*

Despite the fact that groundwater resources are limited, groundwater is the main source of water for more than 70 percent of the population in particular in rural areas. It's only since the public water supply network systems have become unreliable that groundwater demand is increasing also in urban areas (WB, 2014).

Water shortage, in particular in Bulawayo, the country's second largest city, sometimes restricts industrial activity (GoZ, 2012). So use of non-conventional water is of particular importance.

FIGURE 2
Water withdrawal
Total 3 570 million m^3 water allocated in 2007



Wastewater is collected to semi-centralized wastewater treatment plants using conventional sewerage infrastructure, but storm water drains directly into rivers and reservoirs. It is estimated that about 194 million m^3 of municipal wastewater was generated in 2012 in four major cities (Harare, Bulawayo, Mutare and Gweru) and only 95 million m^3 treated in the 137 existing wastewater treatment plants in Zimbabwe (UNWAIS, 2012). However, these plants are currently operating at maximum 30 percent of the capacity, hence releasing raw or partially treated wastewater into rivers. Harare's wastewater pollution is being detected some 260 km away, while Bulawayo's some 100 km downstream (WB, 2014).

Because the major cities are often upstream of the main basins and water supply is usually installed downstream the city to increase the catchment yields, untreated wastewater returning to the catchments is most probably harmful for the same cities. On the positive side, treated wastewater is a significant potential source of water close to the cities.

IRRIGATION AND DRAINAGE

Evolution of irrigation development

There are traces of an ancient terraced system in Nyanga, Eastern Zimbabwe, with furrows, reservoirs and aqueducts pointing to pre-colonial irrigation techniques, as well as in the Limpopo river catchment, the Lowveld and the Drakensberg escarpment (Tempelhoff, 2009). In the 19th century, *dambo,* or *vlei, mbugas, and fadama* cultivation (lowlands and valley bottoms) was widespread and intensive, despite the fact that it was banned by the colonial authority in early 1900s, and cultivation the those lowlands and inland valley bottoms continues still today (Mabeza *et al.*, 2012). From 1912 onwards smallholders developed their own irrigation schemes, encouraged by missionaries, to fight famine. The Manicaland province schemes were the first ones to be developed. However, from 1928 onwards the colonial government started to assist them and soon took over the schemes' management, imposing crops and forbidding rainfed farming (Rukuni, 1988). After the 2nd World War, new irrigation schemes were developed to settle black farmers displaced from areas designated for white commercial farmers. Due to lack of involvement in management and rising costs to be paid to the government, the smallholders deserted these schemes, which became uneconomic. As a result; from 1960 to 1980 there has been almost no irrigation development for smallholder farmers, but the government invested heavily in dam construction and irrigation infrastructure for the large commercial farmers. But the 1981 and 1984 droughts decided the newly independent government to encourage irrigation and extend the benefits of irrigation to the smallholder farming sector and intensified its efforts in that direction. The trend has been to promote farmer-managed smallholder schemes, although government-managed and jointly-managed schemes were also developed.

The irrigation potential for the country is estimated at 365 624 ha (Table 7), which takes into consideration only the available internal renewable water resources and not water from the Zambezi and Limpopo border rivers. Water is far a greater constraint than land as the overall area of soils classified as irrigable in Zimbabwe is estimated at 600 000 ha. The estimate for irrigation potential does not take into account the economic, technical or social feasibility of further irrigation development.

In 1999, it was estimated that the total equipped area under irrigation was 173 513 ha, of which 49 647 ha or 28.6 percent was equipped but not functional because the equipment was damaged during the ongoing land redistribution exercise. This left 123 866 ha as the operational area under irrigation in the country. In addition, irrigation in *dambos*, either equipped or not, was estimated between 20 000 to about 50 000 ha.

The FTLRP redistributed the previously privately-owned irrigation schemes of large commercial farms to multiple smallholder farmers, many of whom had no prior experience with irrigation (USAID, 2012). In addition to lack of training, some irrigation infrastructures have also been dismantled during the land redistribution, either by those leaving taking the equipment with them or by those arriving who did not believe initially that they would stay on the land in the long term.

TABLE 7
Irrigation and drainage

Irrigation potential		-	365 624	ha
Irrigation:				
1. Full control irrigation: equipped area		2014	150 000	ha
- Surface irrigation		2014	26 550	ha
- Sprinkler irrigation		2014	112 500	ha
- Localized irrigation		2014	10 950	ha
• Area equipped for full control irrigation actually irrigated			-	ha
- As % of area equipped for full control irrigation			-	%
2. Equipped lowlands (wetland, ivb, flood plains, mangroves)		2014	25 000	ha
3. Spate irrigation			-	ha
Total area equipped for irrigation (1+2+3)		**2014**	**175 000**	**ha**
• As % of cultivated area		2014	4.3	%
• % 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		2012	1.5	%
• Area equipped for irrigation actually irrigated			-	ha
- As % of total area equipped for irrigation		2014	< 50	%
• Average increase per year			-	%
• Power irrigated area as % of total area equipped for irrigation			-	%
4. Non-equipped cultivated wetlands and inland valley bottoms		2014	15 000	ha
5. Non-equipped flood recession cropping area			-	ha
Total water-managed area (1+2+3+4+5)		**2014**	**190 000**	**ha**
• As % of cultivated area		2014	4.6	%
Size of full control irrigation schemes:	**Criteria**:			
Small schemes	< - ha		-	ha
Medium schemes	> - ha and < - ha		-	ha
large schemes	> - ha		-	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		2002	46 850	ha
• Non-irrigated cultivated area drained			-	ha
• Area equipped for irrigation drained		2002	46 850	ha
- As % of total area equipped for irrigation		2002	27	%
Area salinized by irrigation			-	ha
Area waterlogged by irrigation			-	ha

An exact inventory of the irrigated areas, either equipped or actually irrigated, is not available. The Department of Irrigation estimates the area equipped for full control irrigation at 150 000 ha in 2014, divided between 26 550 ha surface irrigation, 112 500 ha sprinkler irrigation and 10 950 ha localized irrigation (Table 7 and Figure 3). But the equipped area that is actually functional and the actually irrigated areas seem much lower (Table 8): 38 percent of the sampled wards–administrative subdivision of districts and provinces, surveyed for the annual vulnerability assessment–with irrigation schemes had functional schemes, 30 percent had partially functional ones and 32 percent had not functional ones (FNC, 2012). In 2012, 102 000 ha were equipped for irrigation and operational (GoZ, 2013). Out of this functional area, another estimation based on satellite imagery, indicates that 51 000 ha was actually irrigated in 2012 (WB, 2014). Despite the uncertainty implied with satellite imagery and the very punctual assessment it represents, the figure tends to confirm the low rate of actually irrigated areas. The actually irrigated area seems to be concentrated in the Save and Runde catchments: satellite image shows 40 000 ha out of the total of 51 000 ha are located in the south-east Lowveld (WB, 2014). In addition, Mashonaland West had the highest number of wardswith non-functional irrigation schemes (67 percent), and Matabeleland North the highest number (54 percent) of wards with functional irrigation schemes (FNC, 2013). In addition, equipped dambos are estimated at 25 000 ha (Table 7 and Figure 4).

FIGURE 3
Techniques of irrigation
Total 150 000 ha equipped for full control irrigation in 2014

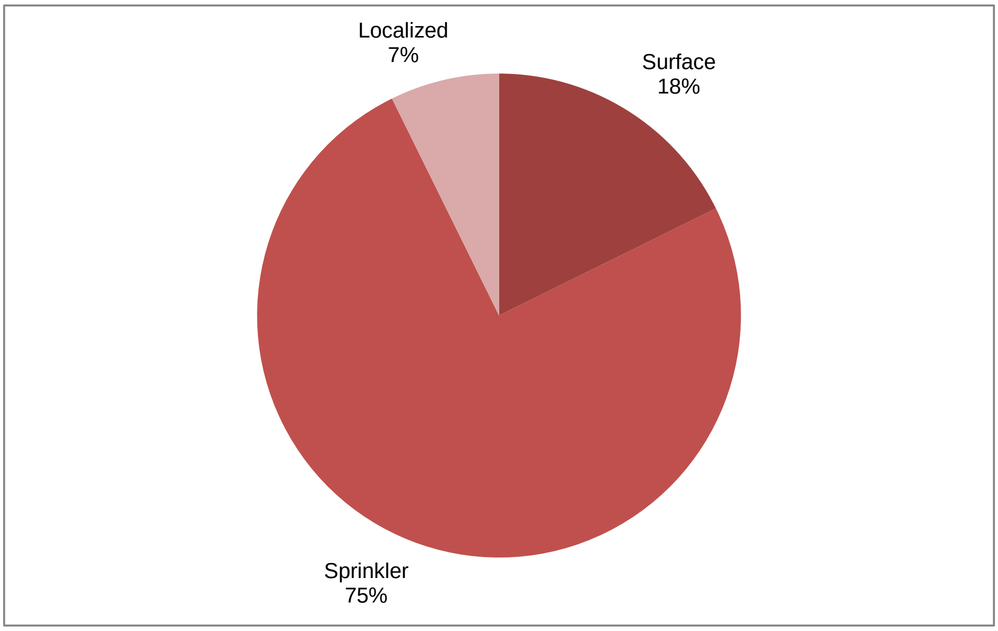
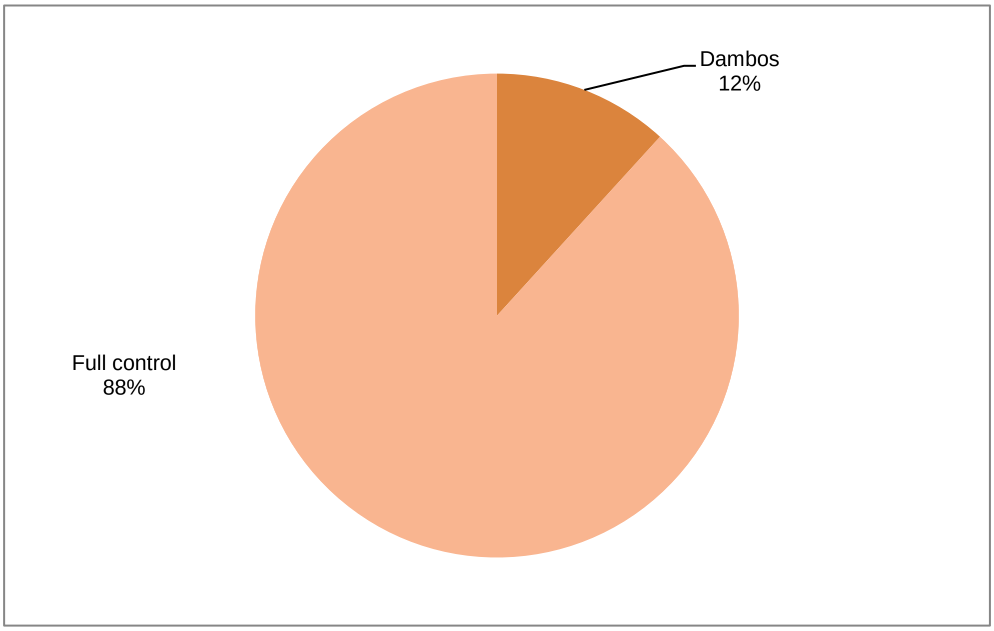


FIGURE 4
Area equipped for irrigation distribution
Total 170 000 ha in 2014



The ratio of wards with functional and partly functional schemes has a positive trend with a strong increase between 2012 and 2014 (Table 8), although it's only a partial estimation as not all wards were surveyed each year. However, some of the 32 percent non-functional schemes in 2012 had been smallholder community irrigation schemes rehabilitated since 2009. Indeed, a double challenge faces the new irrigators: the rehabilitation of the irrigation infrastructure when required, as well as the difficulties associated with the management of common irrigation infrastructures through associations that are sometimes still to be established.

TABLE 8
Estimation of functional irrigation schemes in the Zimbabwe Vulnerability Assessment Committee (ZIMVAC)

%	ZIMVAC 2012	ZIMVAC 2013	ZIMVAC 2014
Functional schemes	38	40	44
Partly functional schemes	30	39	
Non-functional schemes	32	21	
Surveyed wards with irrigation schemes	24	22	22

Four broad categories of irrigation can be identified in the country:

- Large-scale commercial schemes: refers to land owned by private individuals or groups including estates and plantations. Before the FTLRP, all were operated by white farmers. Some "indigenous large-scale commercial schemes" have now emerged (UNESCO, 2008).
- ARDA (Agricultural and Rural Development Authority) schemes: refers to parastatals responsible for running government-owned estates and farms, and for agricultural and rural development in rural areas.
- Smallholder irrigation schemes: refers to a group of farmers irrigating together, even before the FTLRP, and sharing the same water source and main supply line. However there is individual control of irrigation and farming activities by each farmer in his/her plot.
- A1 and A2 irrigation schemes: this new kind of irrigation scheme has emerged as a result of the FTLRP, splitting the commercial schemes and increasing the area under smallholder irrigation. The A1 group of farmers irrigate small areas at times with shared infrastructure and the A2 groups are commercial irrigators. There is sometimes an overlap between A1 and A2 groups.

The extent of each of these categories is unknown after the FTLRP. However, there has been a significant decrease in the extent of large-scale commercial schemes to the benefit of the small farmers in A1 and A2 groups.

Most formal irrigation schemes in the country depend on water stored in small- and medium-sized dams. Other important water sources are boreholes/deep wells, direct river diversion, shallow wells/springs and sand abstraction systems (a technique for extracting water from sand layers in river beds through a network of perforated pipes buried in the river bed which collects water into a sump from which it is pumped).

The traditional cultivation of non-equipped wetlands or *dambos* also still exists. It is estimated that around 15 000 ha are cultivated in 2014 (Table 7).

Irrigated schemes to be operated with treated wastewater have been developed in the main cities over the last 30 years for crop and pasture (Harare/Chitungwiza/Norton, Bulawayo, Gweru, Kwekwe, Kadoma). However, these schemes are mostly not functional anymore (WB, 2014). It is estimated that in 2012 about 2 600 ha was equipped for irrigation using treated municipal wastewater (UNWAIS, 2012).

Water harvesting is another important activity in the country. In-situ techniques are the most commonly practised and are dominant in the drier regions. The most common systems are the use of infiltration pits, strip catchment tillage, earth basins and contour ridges. However, there is no data on the extent of its use in the country. Conservation agriculture was estimated to be practiced on 332 000 ha in 2013, representing over 8 percent of the cultivated area.

Role of irrigation in agricultural production, the economy and society

The number of non-functional irrigation schemes in rural communities evidences the high dependency on rainfed cropping in rural Zimbabwe (FNC, 2013). Before the FTLRP, irrigated agriculture was a major contributor to the agricultural GDP, with almost half of the marketed crops being irrigated, although irrigation was practised on around 5 percent of the cultivated area. The major irrigated crops in the country were wheat, cotton, sugarcane, tobacco, soybeans, fruit, vegetables and maize. A recent irrigated crop calendar is not available. The latest one prepared by AQUASTAT in 2012 dates back to 1999.

All wheat and sugarcane grown in Zimbabwe is under irrigation, while 70 percent of coffee and 55 percent of tea are under irrigation. All commercial wheat produced in Zimbabwe is grown under full irrigation during winter. Traditionally grown by large-scale commercial farmers due to the high level of inputs required, the area under cultivation of wheat has decreased after the FTLRP from 37 to 70 000 ha prior 2008 to 12 000 ha in 2009 (GoZ, 2013). Yields have also decreased significantly (from 5.4 tons/ha in 2001 to only 2 tons/ha in 2009) as a result of the non-functional irrigation equipment and even more frequent electricity shortages (AFD, 2012).

Sugarcane production in Zimbabwe is well below the prior FTLRP level, with 475 000 tons in 2012/2013 and 372 000 tons in 2011/2012. The traditional sugar production estates are adapting to the land reform, for example Tongaat Hullets estate has an ongoing project that aims to allocate 15 880 ha of land to private farmers. Mkwasine estate is farmed by smallholder farmers on 8 200 ha and includes Chapiwa, a resettlement scheme. Another main sugar growing estate is Mpapa, cultivated by a group of 17 farmers with 35 ha each.

Women and irrigation

Women play an important role in agriculture and it is estimated that 70 percent of smallholder farmers are women. A survey indicated that irrigation in smallholder schemes is also dominated by women, although only few are represented in their Irrigation Management Committees (IMCs) constituted by 80 percent men and 20 percent women. Women, who largely provide labour in the surveyed irrigation schemes, also look after children as well as other vulnerable groups, such as orphans and chronically ill persons. The fact that nationally 38 percent of the rural households include one member of these vulnerable groups has therefore a negative impact on the viability of these irrigation schemes (Mutambara *et al.*, 2014).

Status and evolution of drainage systems

Drainage issues have received less prominence and are less documented compared to the development of new irrigation infrastructure. Drainage is seasonal in the country and the most common drainage system found is surface drainage and this is installed in both large-scale commercial and smallholder surface irrigation schemes as part of the water management system. Generally the drainage systems are made up of field drains (open canals) which collect excess irrigation water and rainfall runoff from the fields. The field drains discharge into a network of secondary drains which in turn discharge into the main (primary) drain which delivers drainage water out of the scheme.

The main problem with surface drainage systems in all irrigation schemes is the lack of proper maintenance resulting in below optimum functioning of the systems. In smallholder irrigation schemes farmers have a tendency to plant fruit trees or dump manure in the drains rendering them non- functional.

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

Institutions

Two ministries are mainly involved in irrigation and water management in Zimbabwe, including their respective departments and parastatal agencies:

- The Minister of Environment, Water and Climate (MEWC), replacing the Ministry of Water Resources Development and Management (MWRDM), formulates policies for the utilization of Zimbabwe water mainly through:
  - The Department of Water Resources Planning and Management has the responsibility to plan for the development, use and protection of the country's water resources, including the design and management of the dams.
  - The Zimbabwe National Water Authority (ZINWA) is a parastatal agency working in the framework of the seven water catchments, and with their respective catchment councils. The organization plays an important role in the management of the water permit system and the operationalization of water pricing.
  - The Environmental Management Agency (EMA) controls water pollution.
- The Ministry of Agriculture, Mechanisation and Irrigation Development (MAMID) is responsible for the overall development and implementation of the government's policy on agriculture and irrigation:
  - The Department of Irrigation Development (DID) is mandated with the provision of irrigation services to the farming community to enhance agricultural production and productivity, which include planning, identification of schemes, designing, construction, operation and management of existing irrigation schemes.
  - The Department of Agricultural Technical and Extension Services (Agritex) provides technical and advisory services to farmers.
  - The Agriculture and Rural Development Authority (ARDA) is a parastatal agency responsible for the operation of government-owned irrigated estates and farms. It works closely with the DID.
  - The Zimbabwe Irrigation Technology Centre (ZITC), houses the Research, Testing and Technology Development branch of the DID.

Water supply and sanitation assets in urban areas were transferred to ZINWA in 2006 for centralized management. However, two years later they were returned to local authorities as infrastructure continued to deteriorate leading to a severe decline in services and the 2008 outbreak of cholera. The Institute of Water and Sanitation Development is a non-governmental organization providing a range of technical training for system operators with wide-ranging qualifications

Water management

Although the Zimbabwe government tried to promote farmer-managed schemes as much as possible since independence, the management of the water resources prior to 1998 was still favouring the large commercial farms. The 1998 water sector reform established ZINWA and water catchment councils to enhance an integrated water resource management and stakeholders' participation. The water catchment councils are supposed to represent all stakeholders in a given catchment area. However, involvement is dominated by large water users (commercial farms, estates, mines, cities, etc.) rather than communal farmers (WaterNet, 2005). Hence, water governance remains one of the challenges of the sector (GoZ, 2012).

The FTLRP had a significant impact on water and irrigation management, in particular through the resulting four land tenure systems: i) communal, ii) A1, iii) A2 and iv) estates (SADC, 2012). For example, ZINWA has taken over permits of dams from the former commercial farms to ensure they are maintained (WB, 2014). It also disrupted the local institutions and management entities, resulting in a lack of management at local level such as irrigation schemes boards (AFD, 2012).

In terms of irrigation management, the remaining large-scale commercial schemes including estates and plantations are managed and run by their private owners. ARDA is responsible for managing the schemes under its jurisdiction on behalf of the government.

Within the smallholder irrigation schemes, three broad types of management can be found:

- Government-managed schemes: they are developed and maintained by the government; refers to about 32 percent of the schemes;
- Farmer-managed schemes: they are developed by the government but owned and managed by the farmers with no external assistance; refers to about 50 percent of the schemes;
- Jointly-managed schemes: the farmers and the government share the financial responsibility for operation and maintenance; refers to about 18 percent of the schemes.

In terms of hectares the government is still managing a larger area given that most farmer-managed schemes tend to be small.

In smallholder irrigation schemes, Irrigation Management Committees (IMCs) have been established to help encourage farmer management. However, the IMCs have no legal standing and their effectiveness varies from scheme to scheme.

Regarding groundwater management, changes were introduced in 2012 with the compulsory registration of borehole owners, drilling companies and water bottling to the water catchment councils, as well as the request of permit for drilling a borehole (GoZ, 2012).

Finances

Large-scale commercial irrigators used to source funding for irrigation development privately, while funding for irrigation development for ARDA, smallholder irrigation schemes and dam construction by ZINWA has been traditionally provided by the government. Since the economic crisis, ZINWA funded rehabilitation for few smallholders irrigation schemes (Mutambara *et al.*, 2014). However, irrigation is directly affected by a steep decline in infrastructure funding (AFD, 2012).

ARDA, smallholder farmer-managed schemes and formerly large-scale commercial farmers pay for their operations and maintenance (O&M) costs. On government-managed schemes, farmers pay the annual maintenance fee to the DID and ZINWA for irrigation water. Billing is based either on the volume used or the area irrigated. Irrigation schemes are being supplied with water on the basis of water agreements with ZINWA.

After years without proper budget, in 2011, the government public expenditure for irrigation development raised to almost 12 million US$. The *Zimbabwe's Agriculture Investment Plan (ZAIP) 2013-2017* dedicates the 2nd largest proportion of its budget (22.5 percent) to sustainable land management and irrigation, ie 1 billion US$ including the rehabilitation of the irrigation infrastructure and its adaptation to smallholders irrigation (GoZ, 2013).

Policies and legislation

The first post-independence legislation for the water sector, which still is the main one, is the *1998 Water Act*, which repealed the colonial *1976 Water Act* and even before the *1927 Water Act*. The *1976 Water Act* established perpetual water rights (attached to land), the priority date system of reallocation if water shortages happen and limited stakeholder participation (UNESCO, 2008). But the devastating 1991-92 drought evidenced the need for change, so a Water Resources Management Strategy was initiated in 1995. As a result, the *1998 Water Act* widely reformed the sector with time limited water permits allocated by the newly established catchments councils involving all stakeholders, allocation of water for the environment and both the user-pays and polluter-pays principles. Complementary to the 1998 Water Act, the *2000 Zimbabwe National Water Authority Acts* became operational with the establishment of the parastatal agency ZINWA. More in general on natural resources, the *2002 Environmental Management Act* and its complement the *2003 Environmental Management Agency Act* (EMA) widen the planning and protection scope to all natural resources by requesting environmental impact assessment before undertaking any activity, including irrigation development. It also forbids the cultivation of wetlands and stream banks. In addition, the *1987 Zambezi River Authority Act* (ZRA) established the management entity of the Kariba dam to replace the previous colonial CAPCO. A last legislation, the *2000 Land Acquisition Act* initiating the FTLRP has a strong impact on irrigation by empowering the government to compulsorily acquire any land, in particular commercial farms, for resettlement purposes once split into smaller plots.

The *National Water Policy* and the *National Water Pricing Policy and Strategy* were prepared in 2000. But despite several attempts to formulate an irrigation policy, none was ever endorsed by the government. MEWC is currently reviewing a water policy, in particular regarding water quality and protection, and DID is drafting an irrigation policy (WB, 2014) and a comprehensive irrigation development master plan (MEPIP, 2011).

Some water resources and irrigation objectives were set in the *Zimbabwe's Agricultural Policy Framework 1995-2020*. However, following the changes in the agriculture sector lead by the FTLRP this framework is not valid anymore. The *Zimbabwe's Agricultural Investment Plan 2013-2017* (ZAIP) aims to redesign and rehabilitate irrigation infrastructure so that the total equipped area of 175 000 ha could be under irrigation in 2016 (GoZ, 2013). The *Medium Term Plan* (MTP) 2011-2015 focuses on rehabilitation of existing irrigation infrastructures and completion of projects to "increase and stabilize the agricultural production" (MEPIP, 2011).

ENVIRONMENT AND HEALTH

Water access and quality are the main challenges faced by the water sector in Zimbabwe, in addition to water governance as previously mentioned.

Water access

The frequent and periodic droughts have resulted in serious water shortages in both the rural and urban areas. But other factors also explain water shortages:

- In urban areas, following the disrupted services of water supply systems, there is a rapid increase in groundwater use for domestic purposes, including in Harare. As a result, some boreholes are drying out (GoZ, 2012).
- In former commercial farms, where resettlement occurred, common infrastructures, such as boreholes, have not always been maintained. In these cases, increased demand on local rivers sometimes lead to drying up of these rivers.
- In the late 1990s and early 2000s, before the irrigation decline, abstraction for agriculture resulted in low flows in many of Zimbabwe's rivers, including the Save and Limpopo rivers, which run dry periodically (USAID, 2012).

Erosion also impacts water access as a result of the reduction in storage implied by siltation of dams. Erosion originates from overgrazing, expansion of crop cultivation, deforestation, veld fires and poor soil structures. It is estimated that 10 percent of the soils in Zimbabwe are under high risk of erosion due to the nature of soils, which are sodic (EMA, 2014a). Soil erosion also threatens water quality.

Water quality

Most surface water and groundwater are polluted, limiting the availability of safe water. The contamination of water has various sources, including agricultural activity, discharge of raw municipal sewerage into public streams, as well as industrial activity.

Before the FTLRP, there was a general increase in the use of agrochemicals in the country due to the intensification of crop production. This is however on hold since 2000 with the decline of agricultural production. The decline of maintenance of sewage systems intensified the volume of untreated wastewater discharged into rivers and reservoirs. Food processing, chemical, pulp and paper industries were identified as the major polluters. Despite the fact that most industries treat their effluents, several large- and medium-sized industries do not have adequate treatment facilities (GoZ, 2012). Industries discharge their treated or untreated wastewater into storm drains flowing directly into streams (UNWAIS, 2010).

The most recent concern for water pollution are the illegal artisanal mining activities, which expanded widely since 2000 with around one million persons practising gold panning along the country's rivers (USAID, 2012). Miners not only clear trees to install camps, destroy stream-bank by digging pits in riverbed and divert river to access minerals in riverbeds, they also discharge toxic chemicals, in particular cyanide and mercury, into rivers. The latter ones contaminate the fish consumed by the population, affecting brain development in children and mental functioning in adults (WB, 2014). Mining also spreads minerals from the soil into rivers. As a result, the fish in Lake Kariba, the largest fishing area of the country, contains high concentration of lead and cadmium. The Yellow Jacket river in Mashonaland Central is "dead" due to heavy pollution from the Iron Duke mine, despite the fact that the mine closed in 2009. Until now, its water is unsuitable for domestic and agricultural uses (EMA, 2014b).

Impacts of water pollution have also resulted in increased eutrophication of water bodies, loss of aquatic biodiversity, proliferation of aquatic invasive alien species in water bodies, such as water hyacinth as a result of excessive eutrophication, increased incidences of water borne diseases including diarrhoea and typhoid, as well as cholera such as in 2008 (GoZ, 2012).

FTLRP impacts

Migration and resettlement resulting from the FTLRP have decreased pressure on the most densely populated agricultural zones of the country since 2000. However, the subsequent economic and food crisis created a wave of uncontrolled harvesting of natural resources as rural poor turned to hunting wildlife, harvesting firewood and panning gold. Pressure will remain as long as the high poverty rate continues. In addition, newly resettled and often inexperienced famers practice unsustainable and inappropriate farming by clearing forests causing erosion, which will limit crop productivity and threaten water supplies stored in reservoirs (USAID, 2012).

Wetlands

Wetlands, floodplains and river banks, providing a natural buffer against flood and water pollution as well as acting as groundwater recharge zone, are degraded across most of the country. They have been put under cultivation by farmers attracted by their moisture and relatively fertile soils.

PROSPECTS FOR AGRICULTURAL WATER MANAGEMENT

Despite the government's will since independence to extend the smallholder irrigation sector, up to the FTLRP irrigation was mostly practiced by large commercial farms. After the split of the large commercial irrigated farms, challenges faced by the newly resettled farmers to increase the areas equipped for irrigation that are actually irrigated include the need to:

- rehabilitate the irrigation schemes and, in some cases, convert them from single-user systems to multi-users systems
- be trained in irrigation management for a more efficient and sustainable irrigated agriculture
- rebuild and/or create the institutional capacity for IMCs to organize the use of common irrigation infrastructure

The need for a national irrigation master plan or irrigation policy and strategy is urgent to be able to organize potential and new irrigators, as well as to prioritize rehabilitation of as many non-functional irrigation schemes as possible before they are completely destroyed. Such irrigation strategy should also include a clear policy on *dambo* cultivation in order to both promote their sustainable use and restrict the extent of their cultivation to ensure environmental protection.

Once the area equipped for irrigation is made functional again, the limiting factors for further development will be water availability and capital. Two next steps, which could further enable the expansion of irrigation, are: (i) full utilization of the water available in state dams; it is estimated that between 6 000 ha (GoZ, 2013) to 9 000 ha could be irrigated with the water remaining in the existing reservoirs; (ii) rehabilitation of the schemes dedicated to using treated wastewater. Finally, with larger funding requirements, about 30 000 hectares could be developed to add on to existing irrigation schemes in the communal areas, and another 30 000 hectares of irrigated land could arise from the construction of major dams (FAO *et al.*, 2004), such as the recently completed Tokwe-Mukosi dam. By 2020, an additional 6 million m^3 of dam capacity is required to match the water demand (AfDB, 2011).

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