

Water & Sanitation in Ghana- Review

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Water Resources and Rainfall Pattern

Ghana is abundant in water resources with seasonal but plenty rainfall. Ghana has two expansive river basins and Lake Volta, one of the world's largest artificial lakes. These are available as water reservoirs. In addition, there are large groundwater resources underneath the Volta Basin replenished by seasonal rains. Ghana's estimated renewable water volume is 53 billion cubic meters annually with a renewable water resources per capita of 1,949 cubic meters. Ghana's water resources potential is divided into surface and groundwater sources.

Surface water resources are mainly from three river systems (Figure 1) that drain Ghana, namely: the Volta, South Western and Coastal river systems. The Volta system is made up of the Red, Black and White Volta Rivers as well as the Oti River. The South-Western river system is made up of the Bia Tano, Ankobra and Pra rivers. The Tordzie/ Aka, Densu, Ayensu, Ochi-Nakwa and OchiAmisshah comprise the Coastal river systems.

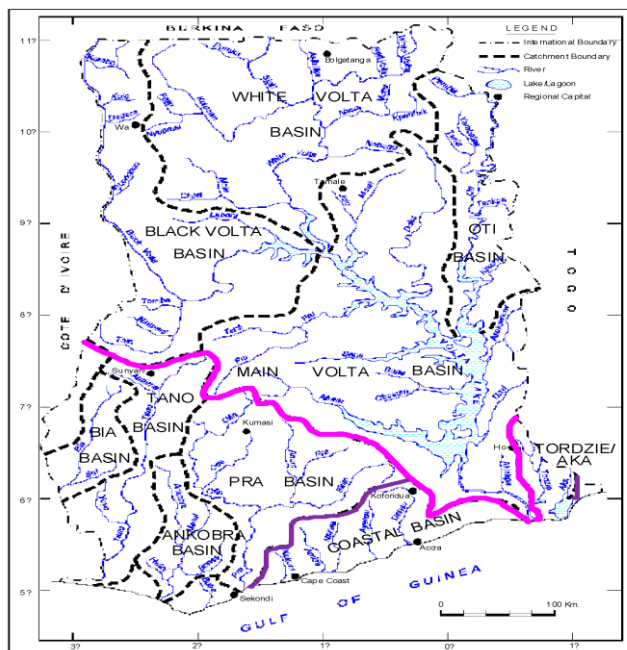


Figure 1. – Ghana's River Systems

These river systems make up 70%, 22% and 8% (Figure 2) respectively of Ghana's total land area of about 240,000 km². In addition to these, the only significant natural freshwater lake in Ghana is Lake Bosumtwi. This is a meteoritic crater lake located in the forest zone.

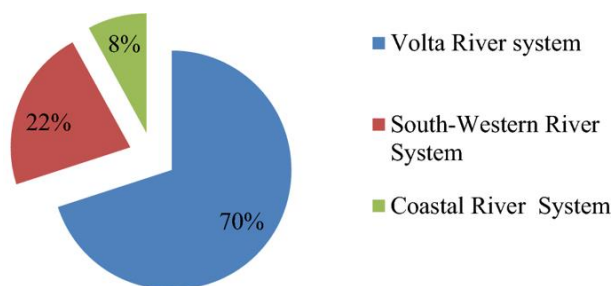


Figure 2. – Numerical composition of Ghana's River Systems

Surface water resources in Ghana

Groundwater – The occurrence of groundwater in Ghana is associated with 3 main geological formations. These are the basement complex, comprising crystalline igneous and metamorphic rocks; the consolidated sedimentary formations underlying the Volta basin (including the limestone horizon); and the Mesozoic and Cenozoic sedimentary rocks.

Ghana has over 56,000 groundwater abstraction systems comprising boreholes, hand-dug wells and dugouts. The yields of aquifers which these systems tap are generally low. There are about 10,500 boreholes, 45,000 hand dug wells and some dug outs in Ghana. The regional distribution of borehole and the estimated annual abstraction of groundwater based on 12 h of pumping per day is given in figure 3.

Region	Number of boreholes	Abstraction (m ³ a ⁻¹)	Region	Number of boreholes	Abstraction (m ³ a ⁻¹)
Upper east	1680	17.0 × 10 ⁶	western	700	6.8 × 10 ⁶
Upper west	1350	11.2 × 10 ⁶	eastern	950	22.1 × 10 ⁶
Northern	1340	21.0 × 10 ⁶	central	925	11.4 × 10 ⁶
Brong-Ahafo	855	13.0 × 10 ⁶	Volta	1140	22.4 × 10 ⁶
Ashanti	1310	13.1 × 10 ⁶	Greater Accra	210	2.5 × 10 ⁶

Figure 3. Regional distribution of boreholes

Ghana has a tropical climate with two main seasons, which are the dry and wet seasons, which defines the rainfall pattern. The North of Ghana experiences its rainy season from April to mid-October while the south experiences from March to mid-November. Generally, rainfall decreases from the south-west of the country (2,000 mm/year) towards the north (950 mm/year) and the south- east (800 mm/year) (Figure 4). Mean annual rainfall of the country is estimated at 1200 mm.

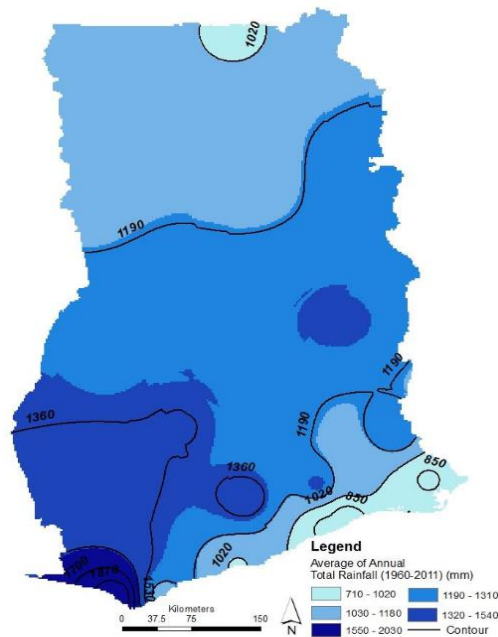


Figure 4. – Rainfall pattern of regions in mm.

Water Supply in Ghana

Ghana halved the proportion of the population without sustainable access to [safe drinking water](#) by 2015, in line with targets for water outlined in the Millennium Development Goals (MDGs). In 2015, [89% of the population in Ghana](#) has access to improved sources of drinking water (Figure 5).

	Ghana (Total)	Ghana (Urban)	Ghana (Rural)
1990	56 %	84 %	39 %
2015	89 %	93 %	84 %

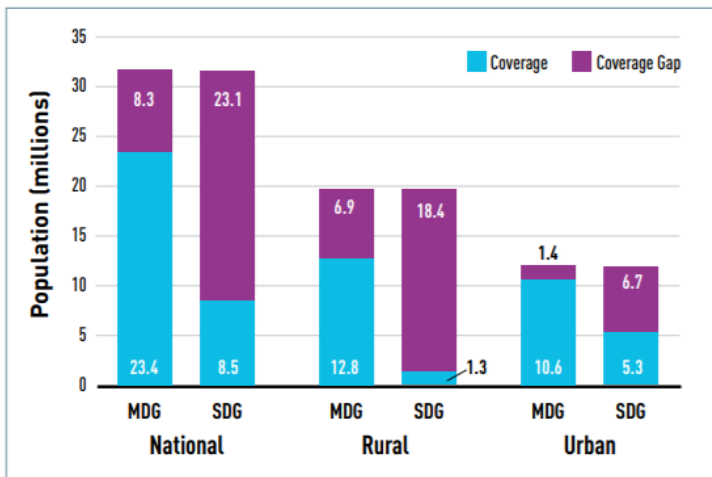
Figure 5. - Estimates of access to improved sources of drinking water. Source: UNICEF and (WHO), 2015



According to [Ghana Safe Water Network](#) 8.3 million people lack access to a basic drinking water service (Figure 6), while 23.1 million people (73% of Ghana’s population) lack access to a safely managed service that provides on-premises, reliable, and contaminant-free drinking water. Most of those without access to basic or safely managed drinking water live in rural areas. 18.4 million people living in rural areas and 6.7 million people living in urban areas lack access to safely managed drinking water. About 38% of the population in rural communities and small towns are yet to be served with potable water supplies.

Figure 6. - Drinking Water Coverage in Ghana in 2015

Although Ghana has witnessed significant progress in the water sector, water access, affordability, and quality continue to be predominant concerns, in both rural and urban areas, including the Greater Accra Metropolitan Area (GAMA). Only about 30% of the population in Accra has access



to clean drinking water for at least 12 days in a month, 35% on 2 days in a week, while 10% have no access to safe drinking water. 1.4 million people in urban areas still lack access to basic drinking water services, and 6.7 million lack access to safely managed drinking water (Figure 7).

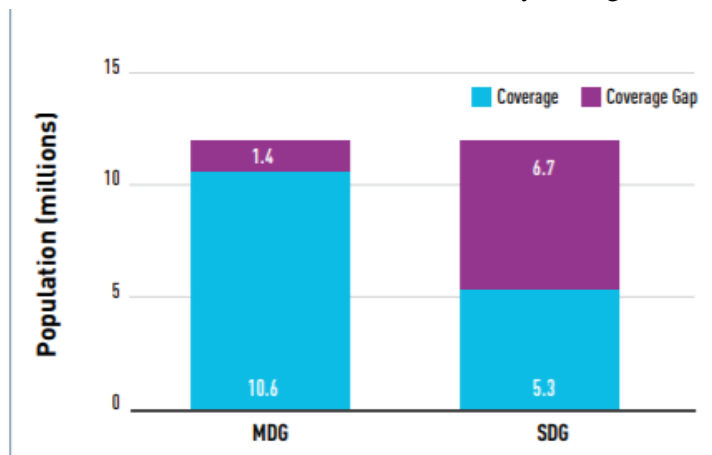


Figure 7. - Urban Access to Drinking Water Services in 2015

The national water coverage rate was estimated at 63.15% in 2012. Based on the provider-based estimates for the national water coverage for 2012, about 36.85% of Ghana's population were yet to be served with potable water as at the end of 2012. These are mainly residents of rural areas, low-income urban communities and peri-urban areas. Coverage in rural areas remained steady at 64% from 2012 to 2014, with a slight increase to 65% in 2015. The number of people within coverage is expected to remain about the same in the coming years, which would mean 6.9 million people in rural areas (Figure 8) would be without access to basic drinking water services, and 18.4 million people in rural areas without access to safely managed drinking water.

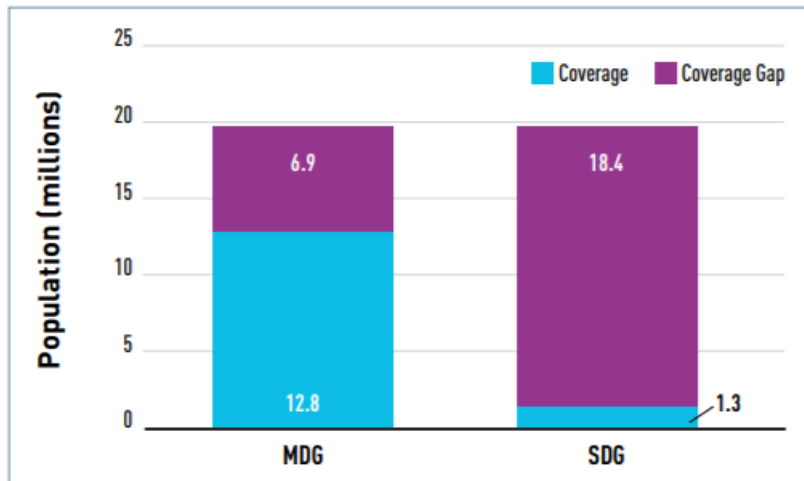


Figure 8. - Rural Access to drinking water in 2015

Almost 20 million Ghanaians (predominantly those in rural areas and small towns) are within the operational area of Ghana's Community Water and Sanitation Agency (CWSA) while 12 million (predominantly urban) are within the Ghana Water Company Limited's (GWCL) operational area. In the majority of urban areas, water is rationed due to a combination of high demand and inadequate supply. It is significant to note that there is lack of proper metering of urban water production and consumption by the Ghana Water Company Limited (GWCL) and therefore data available are largely anecdotal estimates by GWCL. GWCL estimates it is able to produce 62.65% of the total daily demand.

It is estimated that between 12% and 20% of water facilities in rural communities and small towns are either non-functional or functioning below the expected standards at any given time. In the rural water sub-sector, there is currently no system in place for monitoring water quality at point sources, beyond the initial water quality tests that are conducted prior to handing over these facilities to communities.

Ghana Water Company Limited (GWCL) records reveal extremely high losses because of non-revenue water, reckoned to average around 50%. Its bill collection ratio is also at about 95%. The proportion of non-revenue water i.e. water that is lost before reaching the consumer, is more than twice the international best practice level of 20% and even the benchmark of 33% for the low-income country peer group. The average bill collection ratio for is also lower than the benchmark of 96% and 99.2% for low and middle-income country peer groups. The ageing and poorly maintained distribution infrastructure, which is riddled with leaks and high level of theft from the distribution network, sometimes for the purposes of secondary retailing to sachet (commercial) water producers are the main reasons for the losses. The unit cost of delivering water services is higher for Ghana than in other countries in the Sub-Saharan Africa region.

In Ghana, the purpose of groundwater use is largely determined by the quantity of groundwater available, its quality and the unavailability of other alternatives. Due to the low yield of boreholes and the relatively good quality of the groundwater compared to surface sources, boreholes in almost all regions with the exception of the Greater Accra regions are exclusively used to supply water for drinking and other domestic purposes. The estimated total annual abstraction of groundwater for drinking and other domestic purposes by means of borehole is $1.38 \times 10^8 \text{ m}^3$. In the Greater Accra

region, the groundwater quality is poor due to high level of salinization of water in the gneiss which underlies most part of the region and there is a good coverage of pipe-borne water supply system. As a result, the use of borehole for drinking water supply is limited to only small farming communities. Due to the high level of pollution of hand dug wells only about 50% of the total are used for drinking purposes while about 66% are used for both drinking and other domestic purposes. The estimated annual abstraction by hand dug wells for domestic purposes is therefore $7.3 \times 10^7 \text{ m}^3$. The total estimated groundwater abstracted for domestic purposes including drinking is $2.11 \times 10^8 \text{ m}^3 \text{ a}^{-1}$. This forms 84% of the total annual groundwater abstraction.

Packaged Water Consumption

Packaged water comprises bottled, sachet and cooler water, sealed in plastic containers. In Ghana, sachet water is by consumed by 63% of the population and 4.1% of the population consume bottle water. The reason for high consumption of sachet water by households (Figure 9) is the cheap pricing of GHS 0.20 per sachet. This is easy on the pocket for most low income earners while the middle class to upper class stick to bottled and glassed drinking water. There are many brands of sachet and bottled water on the market. Each has to be permitted by the FDA before they are allowed to sell. It is believed most sachet water producers use water from the tap with little or no further filtration before packaging them in sachets. Most bottle water producers obtain their water from natural sources such as deep mountain wells. Bottle water producers pass the water through a number of filtration process before packaging them since they are considered premium brands as compared to sachet water.

Main source of drinking-water	Consumed packaged water	
	%	Households
Piped to premises	71.2%	421 394
Piped-neighbour	68.4%	331 947
Public tap, standpipe or tanker	67.8%	577 188
Borehole, pump, or tube well	44.5%	785 315
Protected well or spring	62.5%	149 612
Unprotected well or spring	30.8%	59 516
Surface water or other	30.9%	177 699
Rainwater	43.5%	12 183
Bottled or sachet water	91.5%	1 710 000
Total	64.1%	4 230 000

Figure 9. - % of Ghanaian Households consuming packaged water

Waste Water

The actual annual total waste production in Ghana has not been estimated yet. This is due to fact that little or no data exist on commercial and industrial wastewater production, except on domestic wastewater. In 2006, the estimated total amount of wastewater (domestic- grey and black waters, produced in urban Ghana was estimated to be approximately 280 million m^3 . With increasing spread of processing facilities into inland areas future increases in the percentage of wastewater from industrial sources could be expected. It is estimated that urban wastewater generation in Ghana will increase from about 530, 346 m^3 /day (36%) in 2000 to about 1,452,383 m^3 /day (45%) in 2020 (Agodzo, 2003). Wastewater treatment in the ten regions of Ghana is very abysmal, only less than 8% of wastewaters (domestic) in Ghana undergo some form of treatment. Most industries are located along the coast discharge their effluent directly into the ocean without any form of treatment, while those located in land discharge their effluent into major streams and urban storm drains. Thus, existing wastewater treatment facilities are used for treating domestic wastewater. The most dominant wastewater treatment

plant is the stabilization ponds, which exist in almost all the regional capital cities, followed by the trickling filter and activated sludge respectively

Ghana has a very low coverage for wastewater and faecal sludge treatment, which is mostly sewage systems. The national average for sewage coverage is as low as 4.5%. Only about 10% of urban wastewater emanating from domestic and municipal sources is disposed off through sewage networks connected to treatment plants. Tema is the only municipality with a comprehensive sewerage system. Accra has a sewerage system covering the State House and ministries area and parts of the Central Business District with low property connections. There are also several satellite sewerage systems for Dansoman, Teshie-Nungua, Burma Camp, University of Ghana, Legon, Achimota School, 37 Military Hospital and Ridge areas. The treatment facilities for both the Accra and Tema systems have broken down and not in use (Figure 10). Currently operational treatment plants are Lavender Hill, Mudor Plant and Kotoku Plant which are managed by Sewerage Systems Ghana Ltd a private Ghanaian owned firm.

A 13 million Euro water treatment plant is to be completed by the end of 2020 by the Jospong Group of Companies. This facility would a capacity of 1000 m³ per day. Other water treatment facilities are to be rehabilitated soon but no clear dates have been provided.

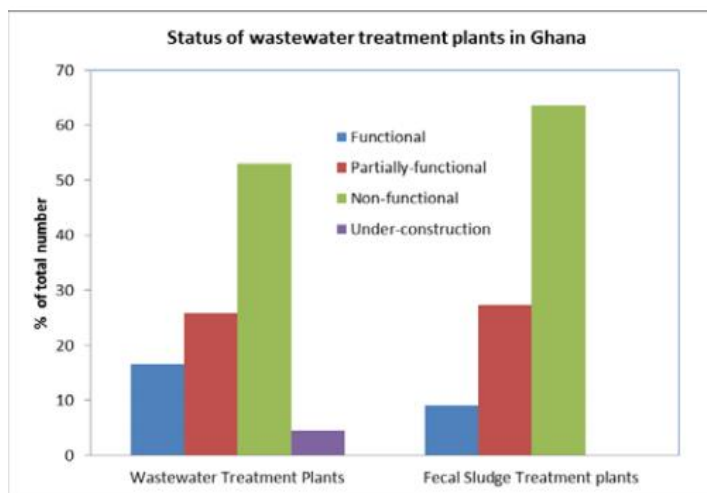


Figure 10. - Status of wastewater and fecal sludge treatment facilities in Ghana in 2013

Water for Agriculture Irrigation

At present, Ghana is endowed with adequate water resources given the country's demographic situation. The total water withdrawal as a percentage of total renewable water resources is 1.8% and an estimated 66.4% of this minuscule withdrawal is used for irrigation. In 2000, about 652 Million Cubic Meters of water was withdrawn for irrigation. The Government of Ghana is currently appraising a large-scale commercial irrigation project known as the 'Accra Plains Irrigation Development Project' to develop the Accra Plains using water from the Volta River. Crops grown under irrigation include rice and vegetables such as tomatoes, okra and exotic vegetables (cabbage and spring onions). Rice area under formal irrigation is about 40% of the total area, with vegetables making up the rest.

The use of groundwater for irrigation is limited to mainly the southern Volta region, the upper regions and the Accra Plains. Groundwater is used to mainly irrigate large hectares of vegetable farms for all the year round farming. In the Northern part of the country, groundwater is also used for livestock farming.

Basic Sanitation and Hygiene

About 20% of the entire country's population practice open defecation. The practice is much more widespread in the Northern part of Ghana where more than 70% of the population practice open defecation. There is also a weak culture (especially in the rural areas) of individual household latrine ownership in Ghana. A high proportion (almost 51%) of Ghanaians uses communal latrines, which, according to the Joint Monitoring Program of WHO/UNICEF, are classified as unimproved. 81 % of Ghanaians lack access to improved sanitation or are entirely without toilet facilities. The national sanitation coverage rate was estimated at about 14% in 2010.

Major challenges affecting basic rural sanitation delivery includes lack of planning and coordination of programmes aimed at improving sanitation and this is due to limited staffing in the various institutions and limited resources for capacity building and implementation of programmes. There is no clear urban basic sanitation strategy and plan in Ghana. Various approaches and interventions in urban basic sanitation are not effectively coordinated and monitored. Unlike rural communities, social mobilization for sanitation and hygiene promotion in urban settlements is quite complicated due to its cosmopolitan and multi-cultural nature.

In terms of hygiene, The Ghana Demographic and Health Survey reveals that while more than half of Ghanaian households have a designated place for washing hands, only about one household out of every five has water or other cleansing agents available at home.

Government Agencies in Charge of Water & Sanitation

Ministry of Sanitation & Water Resources - Through its Water Directorate (WD), is responsible for providing leadership for sector activities in policy development, implementation, coordination, monitoring and evaluation.

Ministry of Local Government and Rural Development - The Ministry of Local Government and Rural Development, through its Environmental Health and Sanitation Directorate (EHSD), has oversight responsibility for sanitation.

Public Utilities Regulatory Commission (PURC) – It regulates the urban water sector. Its responsibilities include reviewing and approving tariffs as well as monitoring the GWCL and other secondary and tertiary water suppliers. In addition to working to ensure that tariffs and rate hikes are reasonable, PURC also works to ensure financial sustainability of the urban water system

Ghana Water Company Limited (GWCL) – GWCL is a utility company which is fully owned by the state and it is responsible for potable water supply to all urban communities in Ghana.

Community Water & Sanitation Agency (CWSA) - CWSA is committed to effective facilitation of the provision of sustainable potable water and related sanitation services as well as hygiene promotion to rural communities and small towns through resource mobilization, capacity building and standards setting with the active participation of major stakeholders.

The Water Resources Commission (WRC) - WRC is responsible for water resources regulation and management, implementing the Integrated Water Resource Management Strategic Plan and granting water rights.

Water Research Institute - WRI has a mandate to conduct research into water and related resources. WRI generates and provides scientific information, strategies and services toward the rational development, utilization and management of the water resources of Ghana in support of the socio-economic advancement of the country.

The Environmental Protection Agency (EPA) - The mission of the EPA of Ghana is to co-manage, protect and enhance the country's environment as well as seek common solutions to global environmental problems. The accomplishment of the mission is to be achieved inter alia through research, scientific, technological and innovative approaches, good governance and partnerships.

Metropolitan, Municipal and District Assemblies (MMDAs) - The Metropolitan, Municipal and District Assemblies (MMDAs) are the highest local political authorities mandated to provide basic infrastructure and services to support social and economic development.

Food and Drugs Authority (FDA) - FDA is the regulatory body mandated by the Public Health Act to regulate the safety of food and drugs. Their duty is to regulate the import, export, manufacture, distribution and sale of food, drugs, cosmetics, medical devices and chemicals which included packaged and bottled water. They provide the license for bottled and sachet water companies to sell to the general public.

Government of Ghana Interventions in the Water Sector

National Water Policy (2008) - The policy addressed issues on integrated water resources management (including water for energy, food security and transportation), urban and community/small town water delivery. The policy also highlighted the international legal framework for the domestic and trans-boundary utilisation of water resources.

Water Sector Strategic Development Plan (2012 – 2025) - WSSDP sets out Ghana's commitment to and provides the framework for achieving the vision in respect of water, which is "sustainable water and basic sanitation for all by 2025." The WSSDP identifies and addresses existing and emerging challenges in delivering water and basic sanitation services in the country and proposes strategies towards ensuring that all people in Ghana have access to basic levels of water and sanitation services by 2025.

Community Water & Sanitation Agency (CWSA) - CWSA has been able to establish a private sector managed distribution system of hand pump spare parts for the four recognized hand pumps in Ghana. Sales outlets have been opened in all of the regions and the private operator has completed the repayment of the seed funds provided to kick-start the network. According to CWSA, the privatized network is becoming financially sustainable and will stay operational when subsidies to the private operator end in the near future.

National Environmental Sanitation Strategy and Action Plan (NESSAP) - NESSAP seeks to adopt Community Led Total Sanitation – an innovative methodology for mobilizing communities to completely eliminate open defecation. Communities are facilitated to conduct their own appraisal and analysis of open defecation and take their own action to become open defecation free. This serves as a means of accelerating the population's access and use of basic sanitation.

Developmental Agencies Interventions in the Water Sector

GAMA Sanitation & WASH Project by the World Bank (2013 – 2020) - The development objective of the Greater Accra Metropolitan Area (GAMA) Sanitation and Water Project for Ghana is to increase access to improved sanitation and improved water supply in the GAMA, with emphasis on low-income communities and to strengthen management of environmental sanitation in the GAMA.

Water Aid Ghana - The Ghana program was established in 1985 and it has since been operating through partnerships with local NGOs. These NGOs, eight of them now, perform the day-to-day implementation and project management functions while Water Aid provides financial and technical support.

Safe Water Network - Operating at scale in both Ghana and India, Safe Water Network is demonstrating a cost-effective approach for locally owned and operating small water enterprises to reach millions in need of safe water around the world. Working with other implementers and agencies, they are developing the tools and resources for replication and advancing the case for funding and policy reforms that will enable scale-up.

Water & Sanitation for the Urban Poor (WSUP) - WSUP is a non-profit partnership between the private sector, NGOs and research institutions focused on solving the global problem of inadequate water and sanitation in low income urban communities. WSUP brings lasting solution to low income areas by working in partnership with service providers including water utilities, local authorities and businesses.

IRC Wash - IRC and the Government of Ghana have agreed to step up moves to strengthen WASH systems in the country over the next four years through the IRC Ghana Strategy 2017-2021.

CONIWAS - The Coalition of NGOs in Water and Sanitation (CONIWAS) was formed to act as a body with a unified voice, capable of mobilizing sector actors for actions that are non-confrontational but capable of resolving sector concerns. Giving the NGOs one voice for advocacy and lobbying has been one major benefit to the coalition.

Water Health Ghana - Water Health Ghana (WHG), which is a wholly owned subsidiary of Water Health International, was established in 2008 with a vision to provide safe, scalable and affordable drinking water to the underserved communities across Ghana. Since then, WHG has successfully installed over 50 Water Health Centers (WHCs) across seven regions of Ghana. The organization has also collaborated with RVO (Netherlands Enterprise Agency) for 85 WHCs under Ghana Wash Window (GWW) program.

UNICEF - UNICEF's on-ground interventions include the installation of water wells and implementing behavioral change strategies to improve uptake of sanitation and hand washing behaviors, based on Community Led Total Sanitation (CLTS) as the primary strategy in Ghana.

International Water Management Institute (IWMI) - The International Water Management Institute (IWMI) conducts research for development through programs whose purpose is to build an evidence base for new approaches that address key water-related challenges.

Main Events for Water Sector in Ghana

Ghana beyond the pipe forum by Safe Water Network - The objective of the "Beyond the Pipe" is to make the financial case for the scaling up of small water enterprises as a vital component in addressing the 8.2 million Ghanaians (or 30 percent of the country's population) who lack access to safe, affordable, reliable water. <https://www.safewaternetwork.org/engagement/2019-ghana-beyond-pipe-forum>

Water Africa Ghana - Water Africa Exhibits the latest equipment and services in the field of water and wastewater engineering for commercial, industrial use and public use. <https://www.tradefairdates.com/Water-Africa-Ghana-M13252/Accra.html>

Water Security Validation Workshop - The Ghana Country Water Partnership (CWP-Ghana) has held the validation meeting for the report on the study entitled "Review of National Policies, Strategies and Program in the context of Water Security and Climate Resilience in Ghana". <https://www.gwp.org/en/GWP-West-Africa/WE-ACT/themes2/Water-Climate-and-Development---WACDEP/News-Activities/Ghana-Water-Security-validation-workshop-held-at-Accra/>

WEDC International Conference - The Water, Engineering and Development Centre (WEDC) International Conference is a global partnership bringing together a wide range of sector professionals from many continents, providing a forum for practitioners, policy makers, academics and researchers from a wide range of disciplines who are working in the water and environmental sanitation sectors. <http://sdg.iisd.org/events/33rd-wedc-international-conference-access-to-sanitation-and-safe-water-global-partnerships-and-local-actions/>

Challenges in the Water Sector

Irregular supply of drinking water in both urban and rural areas - Drinking water supply is a major challenge for the Ghanaian authorities and the entire population. This challenge is caused by multifaceted structural problems such no infrastructure or poor maintenance of the infrastructure, low water pressure, large water loss, unstable electricity and mismanagement of funds by agencies responsible for the water sector.

Lack of proper metering for water production and distribution - Ghana does not have modern metering systems to aid the efficient production and distribution of water. We still rely on old systems, which cannot contain the ever-increasing population.

Illegal small-scale mining activities ("galamsey") - Illegal mining in water bodies is destroying them and making it difficult to treat these water bodies. These destroyed water bodies cannot be treated for drinking water hence reducing the amount of water available to be treated for households.

Finance - The financing deficit affects the performance of sector institutions adversely, creating delays in implementing planned interventions, undermining maintenance and fueling non-functionality. Limited financing for investments and renewal of assets likewise hampers GWCL operations. As a result, GWCL has been unable to provide satisfactory service to its customers. With GoG lacking the political will to pass on the full production costs of urban water to consumers, water tariffs have been kept artificially low, starving GWCL of the financial resources required to operate and maintain existing

facilities effectively and to expand the network. Meanwhile, urban water consumers who are not directly served by GWCL pay considerably higher tariffs for water services.

Coordination between Government Agencies - There are significant overlaps in service delivery owing to the blurred boundaries in the mandates of CWSA and GWCL especially regarding peri-urban areas and small towns. Within the peri-urban and small-towns arena, there are currently no guidelines for communities who may wish to exit from GWCL management and enter into community management arrangements or vice versa.

Opportunities for Israeli Businesses

Rainwater Harvesting Technologies- Households and farms portable units for harvesting, treating and storing significant amount of rainwater would be very useful in tackling the water issues the country faces.

Water Supply Technologies- Low budget affordable water supply technologies especially for rural and peri-urban areas are much needed.

Disability friendly technologies to access water in rural areas- Technologies that are also disability friendly are needed to help folks in very remote places access water.

Private Public Partnership- The Government of Ghana is willing to involve private sector in water management, treatment and distribution.

Water metering systems – New technologies in water metering systems especially for companies like GWCL is needed.

Spare parts- Setting up of sales points in Ghana for spare parts for water pumps and other mechanical parts of any water related technologies. All water agencies import any spare parts needed for their operations.

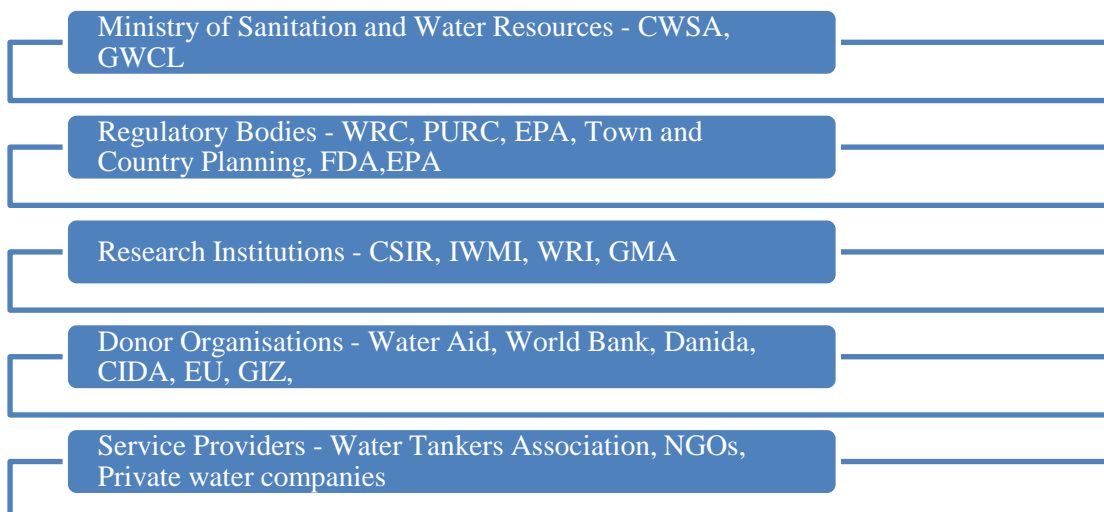
Water quality monitoring technologies – Technologies to continuously monitor water quality for all purposes are needed by the various users of water.

Technologies to support Small Water Enterprises – SWEs best serve the rural and peri-urban areas hence technologies to make their operations and water delivery efficient is needed.

Barriers to market entry

- High interest rates from bank makes investment in water sector very difficult.
- Lack of reliable data.
- Low adoption rates of new technologies.
- Poor adherence to regulations.
- Lack of critical infrastructure in the sector

Key Players



Appendix

https://www.who.int/water_sanitation_health/dwq/gdwq0506.pdf

https://www.safewaternetwork.org/sites/default/files/Sector_Review_2017_Ghana_FullReport_Web.pdf

https://www.ghana.ahk.de/fileadmin/AHK_Ghana/Access_to_Clean_Drinking_Water_Sustainable_Water_Management_in_Ghana.pdf

<http://ugspace.ug.edu.gh/bitstream/handle/123456789/27329/Estimation%20of%20packaged%20water%20consumption%20and%20associated%20plastic%20waste%20production%20from%20household%20budget%20surveys.pdf?sequence=1&isAllowed=y>

http://hydrologie.org/redbooks/a222/iahs_222_0149.pdf

https://www.ais.unwater.org/ais/pluginfile.php/231/mod_page/content/188/wastewater_use_for_agriculture_in_ghana_editable_max.pdf

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