The Ghana Water Company Transformation Journey

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SUMMARY

Operations in Ghana's urban water utility have been enhanced over the past years due to, amongst other reasons the impact of geospatial technology. A robust spatial decision support system has been built to enhance operational efficiency.

A total of 11,340 out of an estimated 13,500 km of pipe network has been mapped. This includes water distribution network appurtenances and fittings. 9,819 valves and 1,349 fire hydrants have also been mapped, with fieldsmen providing updates on operational status of same. Proprietary software is employed in creating dashboards which form the basis upon which live water demand maps are generated for Engineers and Operators. Reported bursts and leakages which affect physical loss of treated water are also consistently mapped. A total of 790,989 customer locations in 3,526 administrative revenue zones have been mapped together with many other commercial assets.

Integrated network modelling, supervisory control and data acquisition (SCADA) systems, drone deployment and smart metering technology represent various technological applications developed based on data obtained from the GIS already highlighted. All the above has resulted in increased efficiency and positive customer feedback. Apart from an 8% decrease in non-revenue water, which is a key performance indicator for water utilities worldwide, a corresponding 34.8% increase in revenue (although tariff adjustments occurred), within the last five years is also reported (GWCL, 2022). Supply to an urban population who have raised expectations of the water utility has been enhanced amidst global challenges of urbanization, climate change and pollution which contributes to depleting water resources required for potable water production.

Hydrographic and bathymetric surveys have also become relevant amidst recent challenges of heavy siltation currently being experienced in virtually all 91 abstraction points.

1 INTRODUCTION

Goal 6.1 of the Sustainable Development Goals (SDG) calls on the global community to commit to ensuring safe and affordable drinking water for all. Ghana's response to this call has been the enactment and implementation of several policies to guarantee universal coverage of water by 2030. Urban water supply in particular has been reformed over the last two decades while recognizing constraints such as limited freshwater resources, rapid urbanization, climate change, and pollution especially due to illegal alluvial mining for both precious minerals and sand. Oboubie et al (2012) has predicted a 50% and 46% water surface volume reduction for the White Volta (106,000 km^2) and Pra River (20,023 km^2) Basins respectively, for the 2050s. These basins supply raw water for some 23 out of the 91 urban water systems in Ghana.

The Ghana Water Company Limited (GWCL) which manages these urban water systems recognizes such dire threats, as well as challenges with managing a huge network of discrete systems for water supply. It has therefore, for the last decade, turned to prevailing industry technology to deal with such teething challenges as high non-revenue water (NRW), operational efficiency in water distribution operations, lack of modern systems to manage the commercial business of the company among others. Most notable solutions deployed are the use of Geospatial Technology for managing water distribution networks and customer data, the use of SCADA systems for hydraulic data acquisition and management, and the development of a custom-made system for managing meter reading, billing, and collection. These directly respond to the challenges enumerated above. The paper will explore GWCL's journey of transformation from a very manual based operations to digital operations at present, it highlights the impact of Geospatial Technology on the operations of Ghana Water Company Limited.

It is worth noting that, the transformation discussed is possible only because significant investments were made in building the capacity of staff and various functional areas to deliver such change. As echoed by Khatri et al (2008), effective change in existing approaches to urban water supply management is possible if institutional development and capacity building are prioritized.

2 URBAN WATER SUPPLY IN GHANA

Public water supplies in Ghana begun before World War I; circa 1912. Since then; the water sector has gone through many reforms leading to the establishment of the Ghana Water Company Limited (GWCL); just at the end of the twentieth century. Today, there are 91 urban water supply systems in Ghana, these are managed by the Ghana Water Company Limited, a limited liability company owned by the Government of Ghana. Altogether, the 91 systems (Shown in Figure 1.0), produce on daily basis, close to 900,000 cubic meters of potable water for distribution to more than 900,000 customers within the urban areas of Ghana. Water distribution is done by some 13,500 kilometers of pipe network infrastructure, and the entire system is managed by about 5,000 permanent staff.

In the late 90s and the early 2000s, software for the management of customer data was introduced into the operations of GWCL. The introduction of application software in managing customer data meant that extraneous efforts that accompanied manual management of such data was a thing of the past. In the last decade, the deployment of technology, especially geospatial technology has been accelerated due to the growing complexity of urban water network management as well as customer demands coupled with the challenges discussed above. Although geospatial professionals represent less than 5% of employees in GWCL, the impact of geospatial activities on the operations of the company is enormous. In recent times, an increase in intake of such professionals, coupled with recent investment in geospatial technology and infrastructure for water management, as well as the creation of a specialized functional area (for Technology and Innovation) with a director demonstrate an appreciation by policy makers in the industry of the relevance of geospatial technology to operational efficiency. Spatial Decision Support System (SDSS) is used to manage water supply and distribution assets such as treatment plants, pipe network infrastructure, floating tanks, booster stations and customer locations to ensure overall customer satisfaction.

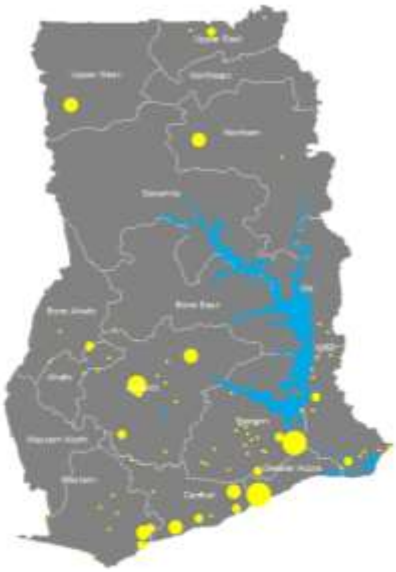


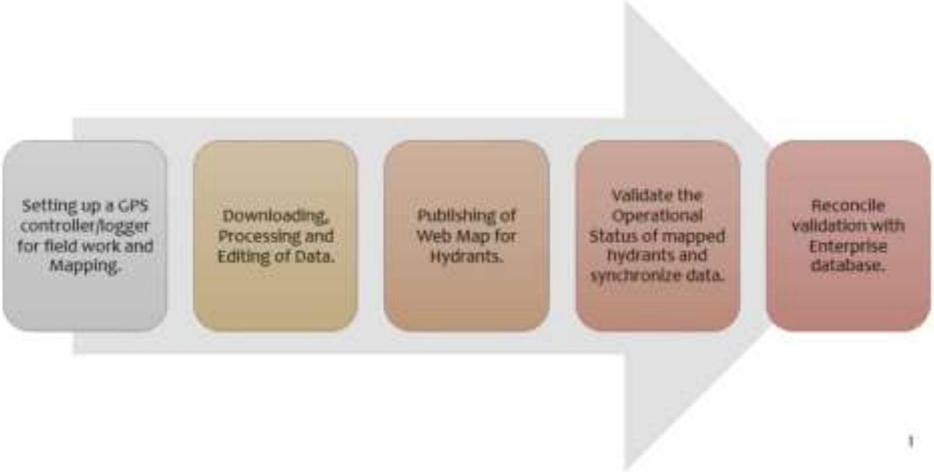
Figure 1.0 Locations of 91 systems in GWCL

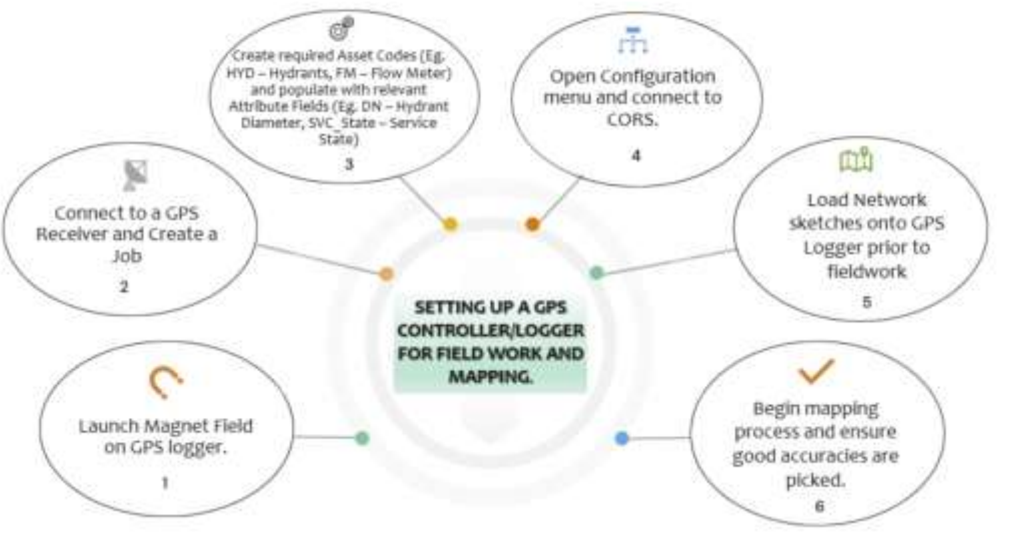
The company in 2018 began an €8 Million Project *"Services for the Enhancement of the Nationwide Water Network Management Project"* funded by an Austrian Government subvention (SFC Umwelttechnik, 2019). As part of project outputs, GWCL's capacity in the deployment of geospatial technology was given a significant boost. Offices were renovated across all regions of Ghana for the deployment of GIS, all these offices were provided with modern GIS Equipment while GIS professionals were given technical training on the application of modern GIS Set ups in water supply management.

3 GEOSPATIAL ACTIVITIES IN GWCL

Geospatial and Land Surveying professionals are relevant within virtually every chain of the potable water supply industry. Drone technology is currently being explored for catchment monitoring, and abstraction points at all 91 systems nationwide have been mapped. Process flow diagrams are constantly being developed for all treatment works after which route surveying is employed in mapping buried pipelines of varying diameter (between 50mm to 1040mm) which transports treated water to various customer locations. Water distribution fittings and appurtenances such as valves, and hydrants are also constantly captured with operational status and conditions constantly being updated by fieldsmen. End user locations and activities relevant to revenue generation are captured and monitored within an integrated spatially referenced system.

Details of geoinformation based technologies application are as follows:


Setting up a GPS controller/logger for field work and Mapping.
Downloading, Processing and Editing of Data.
Publishing of Web Map for Hydrants.
Validate the Operational Status of mapped hydrants and synchronize data.
Reconcile validation with Enterprise database.


SETTING UP A GPS CONTROLLER/LOGGER FOR FIELD WORK AND MAPPING.
Launch Magnet Field on GPS logger.
1
Connect to a GPS Receiver and Create a Job
2
Create required Asset Codes (Eg. HYD – Hydrants, FM – Flow Meter) and populate with relevant Attribute Fields (Eg. DN – Hydrant Diameter, SVC_State – Service State)
3
Open Configuration menu and connect to CORS.
4
Load Network sketches onto GPS Logger prior to fieldwork
5
Begin mapping process and ensure good accuracies are picked.
6

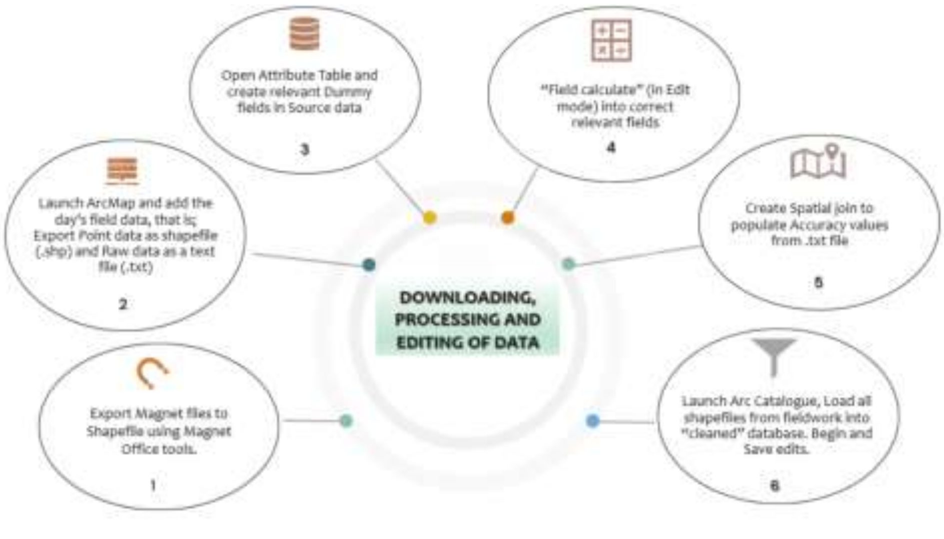


Figure 2.0 Flowchart showing processes for mapping & validating GWCL Water Distribution Assets

3.1 WATER DISTRIBUTION OPERATIONS

The Operations Department of GWCL is responsible for the installation and maintenance of water distribution assets. The location of these assets and the work carried out on them is very crucial for managing its current state and increasing its lifespan. After the GIS Officers map the water production and distribution assets under asset validation, this data needs to be consumed by the Operations Department in their day-to-day activities. To begin using the data captured, deployment is done to this end user by employing dashboards for visualization, and then *Environmental Systems Research Institute's* (*ESRI) Field Maps* and *Survey123 applications* for field data update and collection respectively. Data assignment and job management is executed by using the *Workforce App*. The various users are configured on the system by providing user rights which enables access to various levels of functionalities required for their respective job schedules. Daily activities of the department include water demand management, maintenance of transmission and distribution network, and pressure management. To be able to undertake any of these activities, asset data captured, such as valves and their operational status, will first require validation.

3.1.1 ASSET VALIDATION – DIGITIZATION OF WATER DISTRIBUTION NETWORK

This process involves the retrieval of old as-built maps, which were scanned and digitized to serve as base data for field network validation. Database was designed based upon end user requirements and available software. Personnel of the GIS Unit ensure there are adequate consultations with Operations Staff in this regard. A detailed database data structure is then designed, tested, and implemented for data collection to be undertaken. Water distribution assets are mapped, with spatial and attribute data captured and consolidated onto a standardized geodatabase. Mapping of these assets is done with *Topcon Global Navigation Satellite System*

(*GNSS*) devices connected to a *Continuous Operating Reference System (CORS)* to improve the accuracies of the work done.

This *CORS* is utilized based on a memorandum of understanding (MoU) with GMX and Geotech System Limited who are providing such services in Ghana. Data processing is then carried out using *ESRI's suite of applications* during these validation processes. Figure 2.0 illustrates processes by which personnel of the GIS Unit in GWCL undergo to obtain the robust SDSS. Table 2.0 details a summary of some major assets mapped as at the end of year 2022. The validation of the assets is specifically carried out by the GIS Officers of the Utility based on the level of importance placed on managing this data and its collection.

3.1.2 VALVE OPERATIONAL STATUS MONITORING AND UPDATE

The validation of the valve status is carried out by assigning these valves to the operations technicians using the *Workforce App* from *ArcGIS Enterprise.* This application is initially installed on the field mobile GNSS-enabled devices of the technicians. During the process, the technicians navigate to the location, operate the valves, and update records regarding its status accordingly. This then brings the database to an updated status with the date and time of the update, as well as details of the technician who performed the field verification and update. Supervisors such as Distribution Managers and District Managers, who are responsible for operations and maintenance of these valves within that jurisdiction, closely monitor these updates and actions via a dashboard. Call Center Staff also monitor the dashboards to facilitate customer feedback mechanisms on operations. Figures 2.1a-c further illustrate and summarizes the entire process.

3.1.3 PIPELINE MAINTENANCE

Maintenance of pipes is undertaken by periodically visiting the transmission and distribution assets to check, troubleshoot and update operational status. This process was digitalized with the *ArcGIS Enterprise*. With asset validation in an advanced stage, the assets to be maintained are assigned from the Enterprise software using the *Workforce App*. The technician undertaking the assignment receives the assigned job on his GNSS-enabled mobile device. He or she proceeds to navigate to the location and undertakes the troubleshooting exercise. The system is then updated with the current state of the asset for any repair or replacement work to be undertaken. Details have been illustrated in Figure 2.1d.

Figure 3.1a: Flowchart showing process for Publishing on ESRI's ArcGIS Portal – Valve Operational Status Mapping

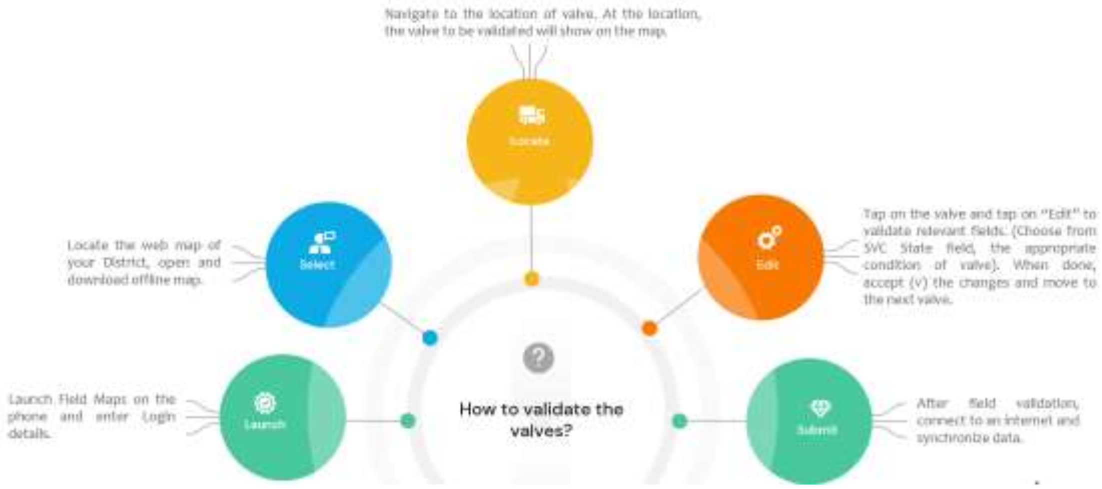


Figure 4.1b: Flowchart showing process for Validation of Valve Operational Status Mapping

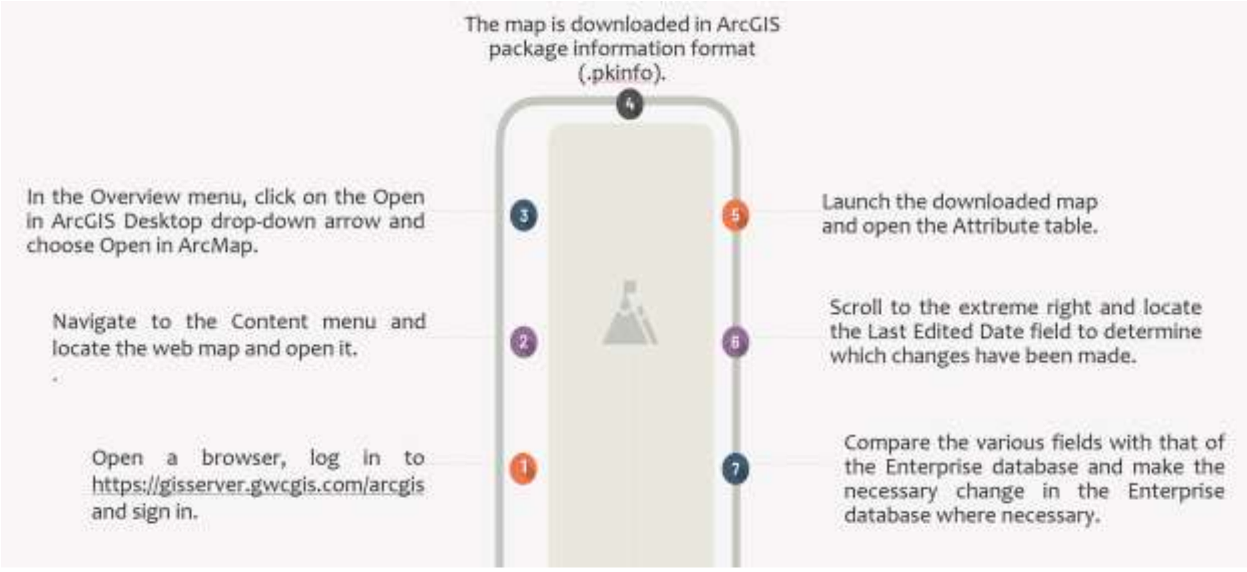


Figure 5.1c: Flowchart showing reconciliation process for both Pipeline Maintenance & Valve Operational Status Mapping

Figure 6.1d: Flowchart showing processes for Pipeline Maintenance Mapping

3.1.4 LEAKAGE REPORTING AND MANAGEMENT

When a leakage occurs, there are two processes through which the utility gets notified, one is by active search usually executed by the leakage technicians, and the other is via reports from the public. Both channels have been spatially digitalized to ensure that details generated are location specific. The resulting data is managed from the reported stage, up to repairs.

When a leakage is identified during an active leakage search exercise, it is initially mapped. Details of the leakage, which include the pipe diameter, are recorded in the database. If the diameter of the leaking pipe is within permissible limits to be handled by the technician, he or she proceeds with repairs. Otherwise, a backup team is immediately informed after pipe isolation is done. The technician ensures the leakage is fixed within the shortest possible time to limit water loss.

The backup team is assigned from the office based on the report submitted by the field technician for the right materials and logistics to be acquired for the work. Once the leakage is repaired, the system is updated to capture the work done. In the other instance where the public reports a leakage, the system automatically assigns it to the appropriate district after confirmation of the location by the Call Center, which is manned by GWCL personnel. A technician is then assigned to the leakage from the district, who then navigates to the location using the GNSS enabled mobile device. After repairing the leakage, the system is duly updated. This update includes pictures of the leakage, when the technician arrived at the scene, and pictures of the repair work, to indicate the completion of the task. Once the repairs are carried out, the data is then migrated into an asset risk management database to monitor the various levels of risk. This then feeds into the decision of replacing the pipe ahead of its economic lifespan. Figure 2.2 shows an example of a burst and leakage dashboard.

Figure 7.2: Dashboard showing Leakage Mapping Activities in Central Region GWCL

3.1.5 INTEGRATED NETWORK MODELING

Owing to the complexities of modern urban water systems, it is not uncommon for utilities to use mathematical models to understand the hydraulic behavior of existing water networks, simulate expected changes on the network as well as make predictions for the future. Designing a water distribution model involves importing the asset data (pipe network, appurtenances, customer, etc.) mapped through processes highlighted above, into a hydraulic network modeling software. Elevation data and demand per area represents other key parameters required to run a successful model or simulation. Developed models are then used for managing the hydraulic behavior of the water network, extending supply to other areas deprived of supply, as well as to troubleshoot distressed areas.

3.2 WATER QUALITY MONITORING

Distribution Water Quality monitoring – The company as part of its core duty ensures that water quality standards are adhered to from catchment to the end user. GIS technology enhances this process by informing management of trends in the distributed water quality. Residual chlorine levels along the water distribution network can for instance be monitored.

ESRI's ArcGIS platforms are used for this exercise. The process involves creating a database in *ArcMap*. The water quality parameters form the main attribute data. This is then published onto the *ArcGIS server* after which a web map is created from the published feature layer. An offline map is added to serve as background, mainly due to network connectivity issues associated with some sampling locations. The entire database is then deployed onto mobile devices using the *ArcGIS FieldMaps Application*. Water Quality Assurance Department field workers then go to the field to map the respective sampling locations, filling in the attributes after analysis.

3.3 COMMERCIAL BUSINESS

Customers of the water utility represent one major asset. Geospatialists are responsible for ensuring commercial assets such as customer pay points, prospective customer locations, and more importantly, registered customer locations are mapped. This includes certifying the integration of these mapped locations with existing and relevant consumer data.

Prospective customer location mapping - New applicants who wish to be connected to the water network in various parts of the country have their premises mapped. This enhances auditing processes associated with material requisitions for the entire new service application process. Internal delays linked with the generation of customer accounts, which represents the final stage a prospective customer undergoes to become a registered customer, are also monitored. Finally, geospatial professionals assist Internal Auditors to track illegal connections which could arise due to possible internal delays through this mapping application process.

Registered customer location mapping – GWCL has through a Software as a Service (SaaS) built an electronic billing system which essentially has the customer database integrated with mapped customer locations. This comprehensive billing system was introduced in October 2016. Due to functionalities associated with the geographic component, it is monitored daily by both geospatial professionals and personnel in the Commercial Department. Some benefits associated with the E-Billing system include an increase in revenue as a result of independent navigation to customers defaulting in payment, for instance. Debtors' maps are usually created for revenue taskforce teams (Figure 3.0). This is done via data obtained from the E-Billing platform which is basically an integration of the customer location and billing data. Both hardcopy maps and *kmz* files are deployed for field revenue taskforce teams. Management had observed an increase in revenue attributable to this change in strategy. The notion created was that Revenue Officers responsible for daily activities within the respective zones had become familiar with customers. Also, regarding general quality of service delivery, GWCL customer feedback monitoring has in recent times tracked evidence of customer satisfaction. Hitherto, whenever complaints are lodged at District Offices by customers, supervisors were required to visit customer premises with assigned Meter Readers. The introduction of the system enables remote monitoring of meter readings in majority of these cases, which provides enough basis for satisfactory customer feedback.

Smart Metering – Digital meters and sensors, as well as SCADA systems are currently being integrated with the company's GIS to facilitate smart metering projects. These are being piloted in selected areas in the country.

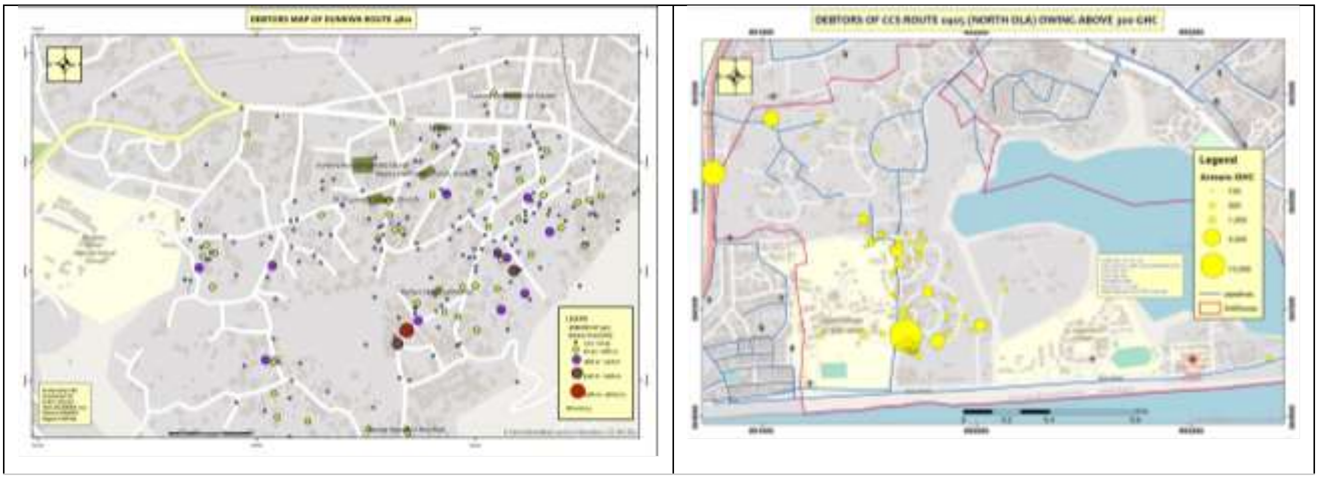


Figure 3.0: Maps showing locations of various debtors in some Revenue Zones in GWCL Central Region

Drone Deployment – Apart from catchment studies, determination of the location of physical losses (major burst and leakages) within transmission and distribution networks is being explored with the assistance of drone technology.

4 GEOSPATIAL OPPORTUNITIES

Opportunities exist for contractors and geospatial professionals in the wide range of areas of operations especially regarding mapping of mains extensions and general water supply infrastructure. From large scale projects such as expansion of treatment systems and distribution works worth millions of dollars to locally contracted surveys which often involve production of both design and as built drawings.

One major area of operation yet to be fully explored is hydrographic and bathymetric surveys which have become relevant due to climate change effects on droughts and flooding as well as anthropogenic activities along catchment of river bodies. Illegal mining activities in River Pra in Ghana which occurs upstream of the Sekyere Hemang Headworks Intake Station in the Central Region has for instance caused heavy siltation of raw water. This is having a negative effect on low lift pumps, affecting volumes available for production.

Inputs of hydrographic surveyors are readily required to assist engineers estimate appropriate volumes of silt required to be dredged. This is currently being deployed by GWCL where a contractor was procured to dredge one of its reservoirs (Owabi) in the Ashanti Region, after a successful bathymetric survey. The outcome of the survey revealed an approximate volume of 1.5 million cubic meters of sediments according to survey reports submitted to the Project Planning & Development Department of GWCL.

5 RESULTS

Activities of geospatialists within the GWCL have immensely affected two key performance criteria employed in assessing water utilities globally. Table 1.0 summarizes general assets mapped as at the end of the year 2022. Processes involved in mapping these key assets have been explained above.

Asset	**Number Mapped**	**Estimated Total**
Pipelines (km)	11,340	13,500
Valves (Nr.)	9,819	
Hydrants (Nr.)	1,349	
Customer Locations (Nr.)	854,496	
Water Quality Sampling Locations (Nr.)	15,596	

Table 5.0: Summary of Mapped GWCL Assets by year ending 2022 (GWCL Operational Report, 2022)

6 CONCLUSION

Geospatial technology has become an indispensable tool in the delivery of water, and in achieving SDG 6, so much so that almost all technologies deployed by GWCL are rooted in GIS. A key technical and financial performance indicator for water utilities is non-revenue water, which from all indications cannot be tackled without the intimate involvement of Geospatial technology. Current GWCL interventions to curtail the problem includes but not limited to the creation of District Metered Areas (DMA), leakage search and control, pressure management, selective pipe replacement, monitoring of illegal connections and activities, and capacity building of all staff. The net effect is an 8% NRW reduction between 2017 to 2022 (GWCL, 2023).

Revenue has also increased by 34.8% within that period although marginal tariff adjustment has occurred. In Ghana, tariff adjustment is the responsibility of the Public Utilities Regulatory Commission (PURC) by an act of Parliament, ACT 538. A study undertaken by Twerefou et al (2015), reveals most end users of potable water are willing to pay more for the service. This study was undertaken in the Greater Accra Metropolitan Area of Ghana where nearly 70% of GWCL's revenue is generated. It is worth pointing out that the study was undertaken prior to major geospatially related interventions highlighted above.

GWCL has improved in all other functional areas of operations such as Water Treatment, Distribution, Water Quality Assurance, Project Planning & Distribution, Business Support, Low Income Consumer Support, Lands & Estate, Human Resource, Finance, Audit, and Procurement. GIS and Geospatial technology continue to play an essential role in GWCL and the management of urban water supply systems in Ghana. The impacts can be observed across all functional areas in the company's operations, and it is recommended that utilities invest in the application of GIS and Geospatial Technology.

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Bibliography Notes

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