Live Water Demand Management Using Geospatial Dashboards and GNSS-Enabled Smartphones

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Key words: Demand Management, Dashboards, GNSS, Smartphone

SUMMARY

Ghana Water Limited (GWL) is responsible for the production, distribution, and management of potable water supply in the urban areas of Ghana. Efficient water demand management is crucial for GWL to ensure sustainable and equitable distribution of this vital resource. This paper explores the integration of geospatial dashboards and GNSS-enabled smartphones into GWCL's operations for real-time monitoring and management of water demand, highlighting the benefits, challenges, and potential applications within the Ghanaian context.

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1. INTRODUCTION

In the world's rapidly urbanizing cities, issues related to water demand management, groundwater depletion, and ensuring a minimum amount of water for daily consumption are common concerns. Addressing and mitigating these primary water problems is particularly difficult in developing nations (Arfanuzzaman & Atiq Rahman, 2017).
As at 2014, 54% of the global population (1.2billion) people have been living in cities and this is projected to increase to 55% of the global population by 2050 (Leeson, 2018).
Water demand management is a critical concern for GWL, particularly in areas where population growth and urbanization have led to demand outstripping supply. Traditional methods of monitoring water demand often rely on feedback or complaints from customers based on rationing programs in use, which can result in delays in responding to changing demand patterns and inefficient resource allocation. The adoption of geospatial technologies, such as geographic information systems (GIS), global navigation satellite systems (GNSS), and web-based dashboards, presents an opportunity for GWL to enhance its water demand management capabilities.
Live water demand management uses Geospatial dashboards which are interactive web-based platforms that integrate spatial data, analytical tools, and visualization capabilities (Piergiorgio P.J. Roveda, 2023).
Jing et al., (2019) undertook a study on Geospatial dashboards for monitoring the performance of smart cities. The objectives of their study was (1) examine the state-of-art geospatial dashboards and key technologies in architecture, design, indicator, visualization, and applications; (2) review the evolution and research on geospatial dashboards to determine if and how geospatial dashboards can be used to monitor the performance of smart cities; and (3) determine the most common design approach to architecture, dashboard design, indicator modeling, and visualization in geospatial dashboards.
Batty, (2015) gave a perspective on city dashboards where he indicates idea of the dashboard and how it evolved over time. He also indicates how it could be used to obtain the maximum benefit.
For GWL, these dashboards can provide a centralized view of water demand data across Ghana, allowing for real-time monitoring and analysis of water rationing patterns within

an area by integrating various data sources, such as customer consumption data and demographic information. Geospatial dashboards can provide valuable insights into water usage trends, identify areas of high demand, and facilitate proactive demand management strategies.
GWL field personnel can leverage GNSS-enabled smartphones to navigate to, locate and report valve operations within the water infrastructure, and report leaks or other issues directly from the field. Mobile applications can be developed or customized for GWL's specific requirements, enabling seamless data collection and integration into geospatial dashboards. This approach enhances the accuracy and timeliness of water demand data, enabling more informed decision-making.

1.1 Benefits of Live Water Demand Management for GWL

Geospatial dashboards and GNSS-enabled smartphones enable real-time monitoring of water demand across Ghana, allowing GWL to respond quickly to changing conditions and mitigate potential issues before they escalate.

By having access to up-to-date water demand data, GWL can optimize its operations, reduce water losses, and allocate resources more effectively across its distribution network. Geospatial dashboards provide GWL decision-makers with a comprehensive view of water demand patterns, enabling data-driven decision-making and informed policy development.

GNSS-enabled smartphones can be used by GWL field personnel to identify and report water leaks promptly, facilitating timely repairs and minimizing water losses.
Web-based dashboards can be leveraged by GWL to educate and engage the public on water conservation efforts, promoting responsible water consumption behavior.

1.2 Challenges and Considerations for GWL

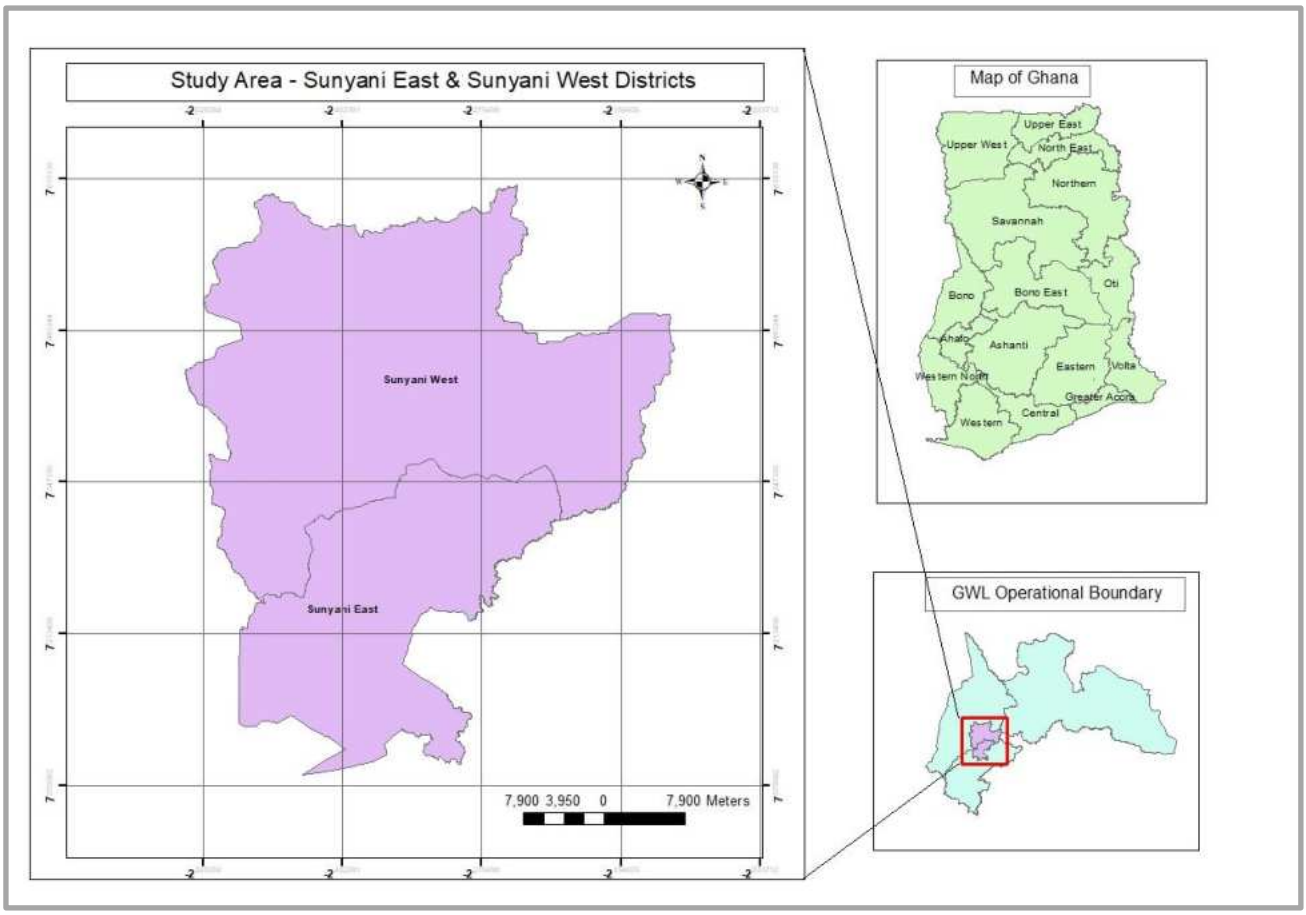
For GWL to make accurate decisions, the quality and accuracy of data gathered using GNSS-enabled smartphones integrated into GIS dashboards must be guaranteed.

The smooth operation of geospatial dashboards and data transmission from GNSS-enabled smartphones used by GWL staff members depends on reliable internet connectivity and a strong IT (information technology) infrastructure across Ghana.

To ensure staff of GWL and decision-makers can leverage the full potential of GIS dashboards and GNSS-enabled smartphones, effective user uptake and training are necessary.

Effective water demand management requires a seamless integration of GNSS-enabled smartphone data and GIS dashboards with GWL's current databases and information systems.

2. STUDY AREA



3. DATA AND METHODS

3.1 Office Reconnaissance

To digitalize the operations of the water demand management, the GIS officers and the Water Distribution officers identify valves that are operated within the areas affected based on the mapped and validated water distribution network and the customer location. This activity was carried out using both web maps and paper maps. The number of valves that were turned to either supply or deny water to an area was then noted, along with the number of days that each of these places had been supplied with water.

3.2 Field Verification

A field verification exercise was carried out to navigate to the various valves as indicated at the desk study stage. The status of these valves was tested, the possible

number of turns each of these valves would be able to attain for opening and closing were also tested and documented.
The field verification also checked the extent of water supply as well to digitize them into the system. See figure 3.0 for the map of rationing valves.

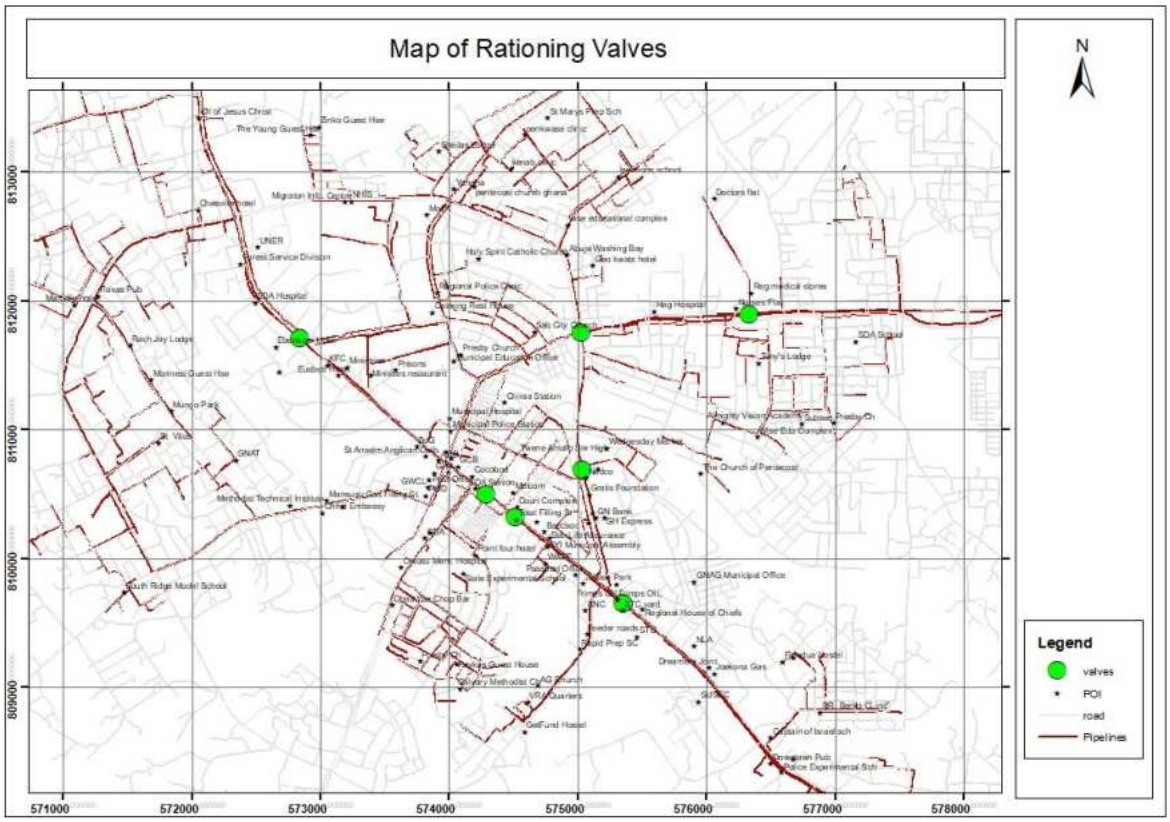


Fig.3.0 Map of Rationing valves

3.3 Database design and development

Based on the Office reconnaissance and field verification, a data structure and then database was designed to hold and manage the various data and operational information to be used. The verified valves and resulting boundaries of water demand management were then loaded into the designed database.

3.4 Design and Development of Dashboard & mobile application

The dashboard and mobile application were designed using Applications on the ESRI ARCGIS Enterprise (survey 123 and Dashboard) after developing and updating the database. Various interfaces were then designed for operational data use and collection of the field data and corresponding analytics on the dashboard were also done.

3.5 Testing of Dashboard & mobile application

The mobile application and the dashboard were both tested with the real data used in the development and the daily operational activities tested on it. The test begun by navigating to each of the water demand valve control locations and the operational activities carried out. When the results obtained were satisfactory, the process was closed.

3.6 Training of users

Field operators and various management staff were then trained on the use of the system and how to interpret the results that are generated in real time.

3.7 Operationalization of system

The system was deployed onto the phones and computers of the various officers to be used for the water demand management. Survey123 interface given to the rationing supervisor.

Table 3.8 Data & other Resources

Item	Resource	Source
1	Mapped & Validated Distribution network	GWL
2	Topo Map	GWL
3	Points of Interest	GWL
4	Customer location data	GWL
5	ESRI Enterprise ArcGIS Software	GWL
6	ESRI Survey123 software	GWL
7	ESRI ArcMap 10.8	GWL
8	Mobile phones	GWL
9	Laptop Computers	GWL
10	4X4 Pickup vehicle	GWL

3.9 Key Requirements

Mapping and validation of water transmission, distribution assets and customer location already undertaken to at least 90 to 95% in study area.

4. RESULTS AND DISCUSSIONS

The result of the study is a dashboard designed and built from the work processes used in rationing water in the study area. The dashboard is a web-based platform built from ArcGIS enterprise environment and a counterpart mobile version. Both the web-based platform and mobile field version do not allow for public access due to the work processes and the task at hand. Figure 4.0 shows the water demand map indicating areas that are receiving water due to the water demand program and those not expected to receive water at that very moment. On this map the valves that are turned on are indicated, the number of turns currently in is operating all stored in the database. Figure 4.1 indicates the history of water supply for the various areas in a histogram on daily basis as a result of opening or closing of the assigned valves to the respective areas. Figure 4.2 shows the affected areas; areas that have been denied water as a result of sending water to some selected areas on daily basis. Similarly, the bars are also indicative of the number of valves that are closed to deny water to those areas. Figure 4.3 gives details of the activities performed on the field. The date and time the valve was operated, the supply and affected areas, who performed the operation, the number of days areas will either be denied or supplied with water, etc. Figure 4.4 indicates the general interface of the dashboard and the relationship between areas receiving water supply and those denied water on daily basis. Figure 4.5 demonstrates the usage of the Survey123 by the field team in the water demand management using GNSS-enabled smart phones.

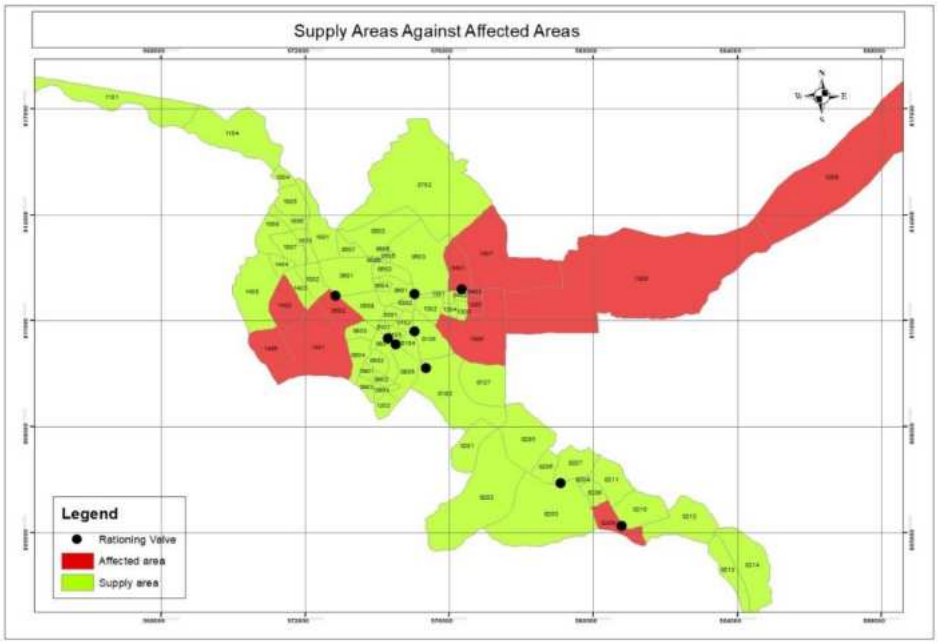


Fig. 4.0 live water demand map

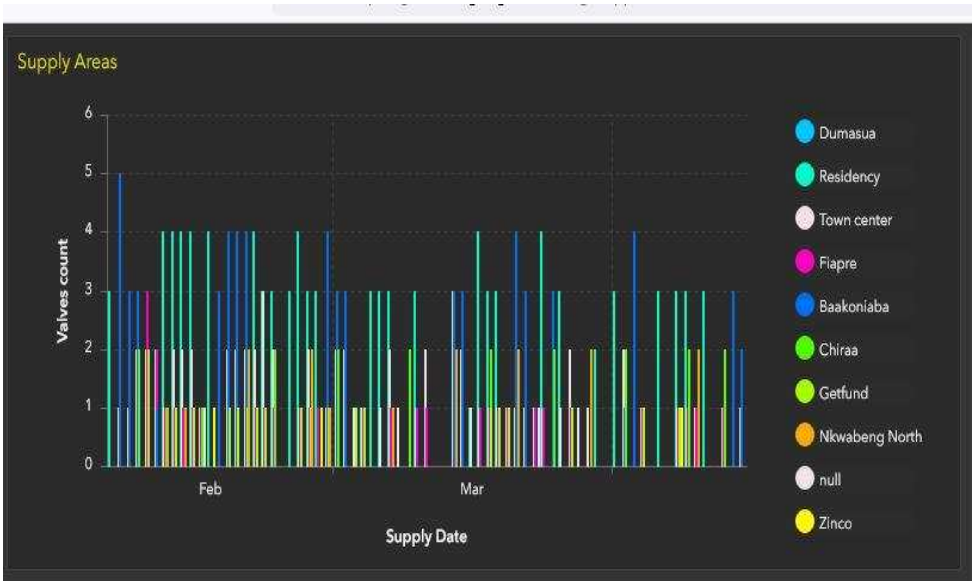


Fig. 4.1 History of supply per area

The length of the bar is indicative of the number of valves that are touched to supply water to the area daily.

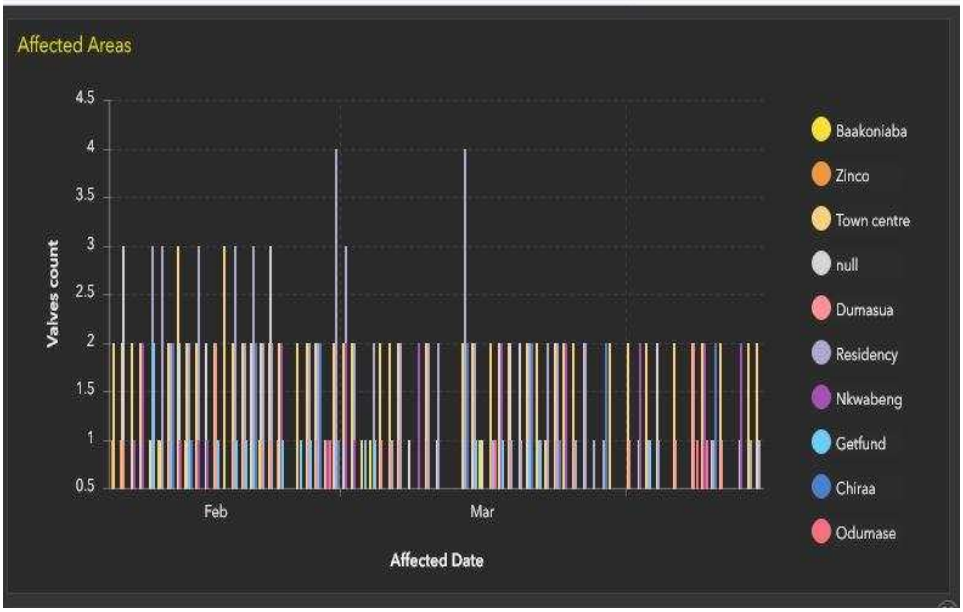


Fig. 4.2 History of no supply per area

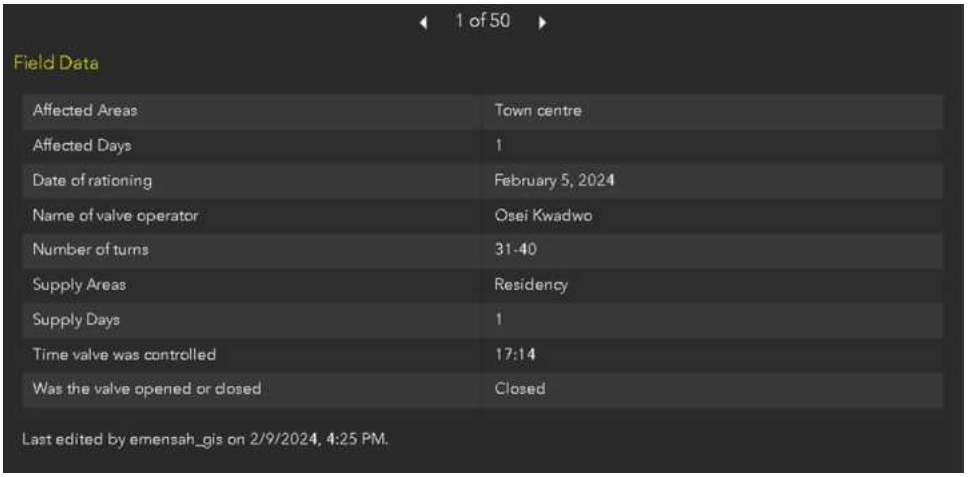


Fig. 4.3 Valve activities details

Fig. 4.4 General interface of dashboard

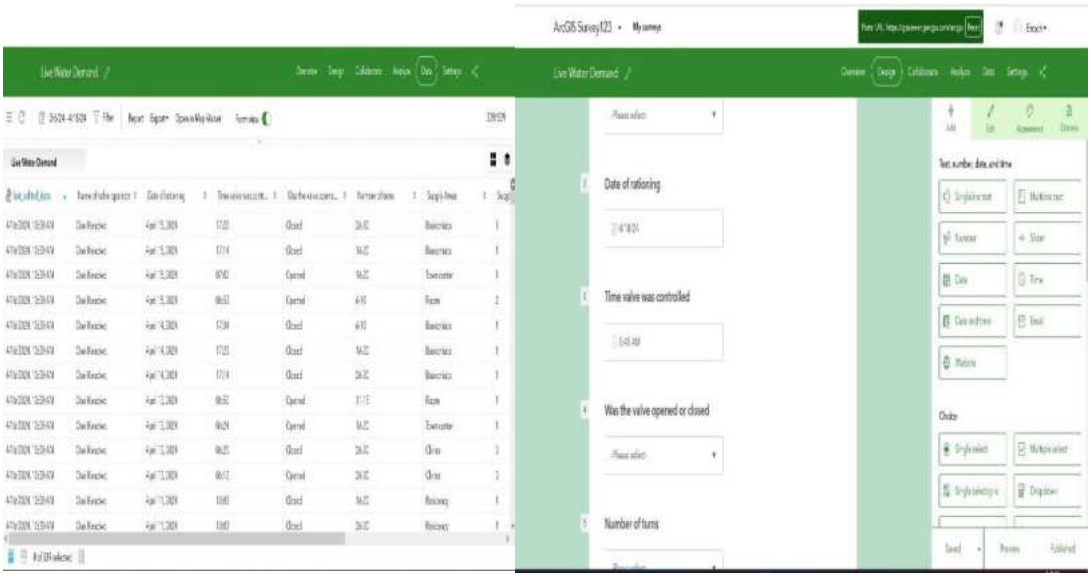


Fig. 4.5 Survey123 usage in water demand management

5. CONCLUSION

Live water demand management using geospatial dashboards and GNSS-enabled smartphones offers a powerful approach for Ghana Water Limited to monitor and manage water resources. more efficiently across the country. By integrating real-time data collection, spatial analysis, and interactive visualization, GWL can gain valuable insights into water demand patterns, revolutionize GWL's water demand management practices, contributing to water conservation efforts and ensuring a more resilient and equitable water supply for communities across Ghana. Identify areas of concern and implement proactive strategies for sustainable water resource management. While challenges exist, this technology-driven approach has the potential to revolutionize GWL’s water demand management practices, contributing to water conservation efforts and more resilient and equitable water supply for communities across Ghana.

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BIOGRAPHICAL NOTES

GS. Ing. Surv. Michael Nyoagbe is a Geospatialist and a Manager at the Ghana Water Limited (GWL) at the Technology and Innovation Department where he works as the head of Research and Innovation Unit. Michael has over 16 years' experience in the Geospatial and Survey industry. He has a career in GIS Consultancies internationally and locally with special interest in application development and artificial intelligence. His research interest focuses on Artificial Intelligence and GIS amongst many other areas. He is the President of the Ghana Geospatial Society (GGS), a member of Ghana Institution of Engineering (GhIE), Licensed Surveyors Association of Ghana (LiSAG), Ghana Institution of Surveyors (GhIS), and the International Federation of Surveyors (FIG).

Ing. Enoch Mensah is the Regional GIS Officer in Brong Ahafo Region in Ghana Water Limited. Ing. Enoch Mensah has been involved in various international and national consultancies on Water Management and Water Loss. He has published many peer-reviewed papers in international journals. He has over 10 years work experience in Engineering survey and GIS. He was the lead Survey Engineer for AECOM on the Tema Port Expansion Project and has also worked on a number of Water Projects across the country. He is a Professional Member of Ghana Institution of Engineering (GhIE) and Ghana Geospatial Society (GGS).

GS. Surv. David N.O Nunoo is a professional with over 14 years of experience in Geographic Information Systems (GIS). He holds a Bachelor of Science degree in Geomatic Engineering and a Master of Philosophy in Geospatial Information System. David possesses a strong academic foundation coupled with extensive practical expertise. He heads the GIS and Hydraulic Network Modelling unit at Ghana Water Limited (GWL). His proficiency in using GIS software and geospatial tools was instrumental in setting up the GIS unit and facilitating informed decision-making based in GIS to drive operational efficiencies for the company. His work spans various disciplines including utilities, urban planning, and engineering surveys. He is a Professional Member of the Ghana Geospatial Society (GGS) and Ghana Institution of Surveyors (GhIS).

GS Francisca Ameley Armah works at the head office of Ghana Water Limited as an assistant GIS officer. She has ten years of experience in remote sensing and geographic information systems (GIS) and was the lead GIS officer for Ghana's Sustainable Management of Wetlands for Strengthening Food Security and Ecosystem Resilience in West Africa (GDZHAO) project under GMES Africa. She also worked at the Centre for Remote Sensing and GIS othe SERVIR project, which monitored artisanal (small-scale) mining using Earth Observation data. She belongs to the Ghana Geospatial Society (GGS) as a professional member and to African Women in GIS.

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