Leakage Reporting and Management Using GIS: A Case Study of the Tema Region

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Key words: Leakage Management, Dashboards, GIS

SUMMARY

Water leakages represent a significant challenge for water utilities, leading to substantial water losses, increased operational costs, and potential environmental impacts. Effective leakage reporting and management are crucial for ensuring the efficient distribution and preservation of water resources. This paper presents a case study of how the Ghana Water Limited (GWL) has leveraged on Geospatial Technology to enhance leakage reporting and management in the Tema Region, highlighting the benefits, challenges, and potential for replication across other regions in Ghana.

1. INTRODUCTION

The Tema Region, located in southeastern Ghana, is a major industrial hub and a densely populated area served by GWL. With an extensive water distribution network, the region is faced with challenges in detecting and mitigating water leakages, which can result in significant water losses and disruptions in supply. According to GWL annual reports (2023), water loss or Non-Revenue Water (NRW) stands at 49.4% January 2024. Physical loss (leakages) is considered a major component of water loss (Non-Revenue Water). Various methods have been used in managing physical loss and these include 1. Leak detection and replacement of pipes: this may be accomplished by combining targeted pipe replacements, proactive leak monitoring, control and prompt repairs, and pipeline rehabilitation techniques (Ong et al., 2023). In some situations, appropriate leakage control can reduce the need for expanding water sources and assist recouping money from water losses (Environmental Protection Agency, 2016). 2. Using technology to find and fix leaks: These days, leak detection solutions come in the form of software and hardware equipment (Zhou et al., 2018). With the use of these tools, distribution network leaks and trouble spots can be promptly located, their effects on water loss volumes may be more accurately assessed, and service providers' capacity to react swiftly and fix leaks is enhanced (Cassidy et al., 2021). 3. District Metered Areas (DMAs): A zone-by-zone or smaller-scale segmentation of the water distribution network with clearly defined borders. Water service providers may more easily identify issue locations, analyze water-flow patterns, and locate leaks faster thanks to this methodical approach to operational management (Al-Washali et al., 2019). 4. Monitoring, controlling, and preserving appropriate pressure in water distribution systems is known as pressure management. It lowers the frequency of fresh bursts, lowers leakage, and uses less water (Vicente et al., 2015). Traditional leakage reporting methods, such as manual inspections and customer complaints, have proven inefficient and time-consuming, leading GWL to explore the integration of Geospatial technology for improved leakage reporting and management (Yussof & Ho, 2022).

GWL, under a pilot project has implemented a web-based GIS platform that allows field personnel and customers to report leakages through a user-friendly geolocation-based interface. The system leverages GNSS-enabled smartphones and tablets to capture precise location data, along with photographs and descriptions of the reported leakages. This information is then seamlessly integrated into the GIS platform, creating a comprehensive spatial database of leakage incidents.

The GIS-based leakage reporting system provides GWL with powerful analytical capabilities for effective leakage management. Through spatial analysis and visualization tools, GWL can identify leakage hotspots, prioritize repair efforts, and allocate resources more efficiently. The system also enables the tracking of leakage repair progress, ensuring timely resolution and minimizing water losses.

Additionally, the GIS platform allows for the integration of ancillary data, such as water distribution network maps, demographic information, and historical leakage records. This integration facilitates a more comprehensive understanding of leakage patterns and potential risk factors, enabling proactive maintenance strategies and targeted infrastructure improvements.

1.1 Benefits of the GIS-Based Leakage Reporting and Management System

The system enables prompt detection and reporting of leakages, allowing GWL to respond quickly and minimize water losses. By identifying leakage hotspots and prioritizing repair efforts, GWL can optimize the allocation of personnel and resources for leakage management.

The spatial analysis and visualization capabilities of the GIS platform provide GWL decision-makers with valuable insights for informed decision-making and strategic planning. The user-friendly reporting interface encourages customer participation in leakage reporting, fostering a collaborative approach to water resource management.

Effective leakage management through the GIS-based system can result in significant cost savings by reducing water losses and minimizing the need for costly infrastructure repairs.

1.2 Challenges and Considerations

Ensuring the accuracy and reliability of leakage reports and location data is crucial for effective leakage management.

Proper training and user adoption among GWL personnel and customers are essential for the successful implementation and utilization of the GIS-based system.

Seamless integration of the GIS platform with GWL's existing information systems and databases is necessary for efficient data management and decision-making.

Reliable internet connectivity and ICT infrastructure across the Tema Region are required for the smooth operation of the web-based GIS platform and data collection through GNSS-enabled devices.

2.0 STUDY AREA

Figure 1.0 Map of study area

3.0 DATA AND METHODS

For the successful implementation of the project, one key requirement was to ensure mapping and validation of water transmission and distribution assets, as well as customer locations have already been undertaken to at least 90 to 95% in the study area.

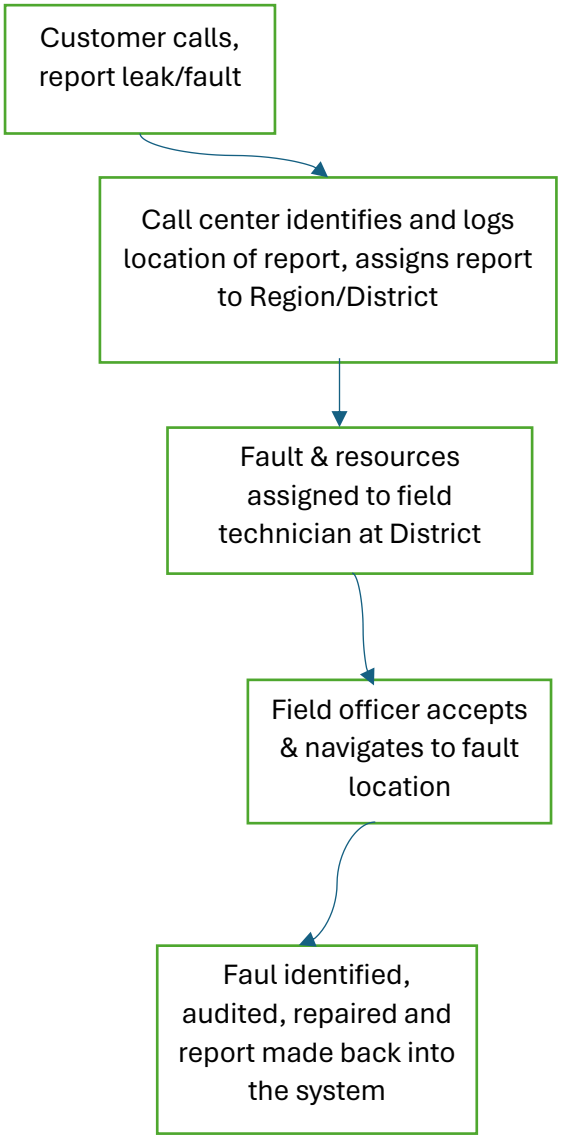

Figure 2.0 Process flow diagram of methodology

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	Microsoft Excel	GWL
9	Microsoft Word	GWL
10	Mobile phones	GWL
11	Laptop Computers	GWL
12	4X4 Pickup vehicle	GWL

Table 1.0 Data & Other Resources

4.0 RESULTS AND DISCUSSIONS

The primary outcome of this study was the design and implementation of a comprehensive dashboard for leakage reporting and management. The dashboard consists of a web-based platform and a mobile field version, both built within the ArcGIS Enterprise environment. Due to the sensitive nature of the work processes and tasks involved, access to the dashboard is restricted and not available to the general public.

4.1 Web-Based Platform

The web-based platform allows customers and the general public to report leaks and other faults related to water supply infrastructure. Figure 4.0 illustrates the leakage reporting interface, providing a user-friendly way for customers to log reports.

Figure 4.1 demonstrates the detailed information required when submitting a leak report. It guides users through the process of accurately logging reports, ensuring that all necessary details are captured.

Once a leak is reported, the dashboard provides a real-time view of the progress of work on each reported leak. Figure 4.2 displays a color-coded representation of the reported leakages, allowing users to quickly identify the status of each reported incident.

4.2 Mobile Field Version

The mobile field version of the dashboard is designed to assist pipe fitters and leak technicians in their field operations. Figure 4.3 shows the detailed information available to field personnel when they receive an assigned leak task. It outlines the various actions and tasks that a leak technician can undertake upon initial assignment, ensuring efficient and standardized field operations.

4.3 Reporting and Analytics

The dashboard incorporates comprehensive reporting and analytical capabilities, enabling data-driven decision-making and performance monitoring. Figure 4.4 illustrates the reports and analytics available, which can be accessed by clicking on the respective buttons. These reports and analytics provide valuable insights into the leakage management process, allowing for continuous improvement and optimization.

By integrating GIS technology, the dashboard offers a seamless and efficient solution for leakage reporting and management within the Tema Region of Ghana Water Limited. The combination of the web-based platform and mobile field version ensures that all stakeholders, from customers to field personnel, have access to the necessary tools and information to effectively address leakage issues and improve water supply infrastructure management.

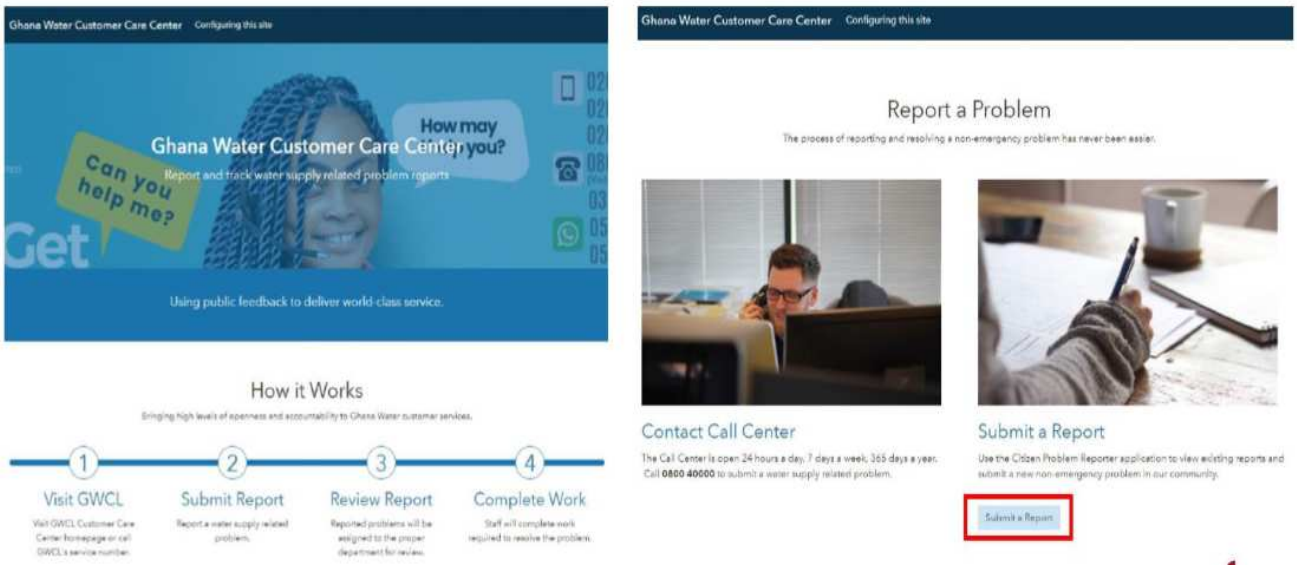

Figure 4.0 Leakage Reporting platform for customers

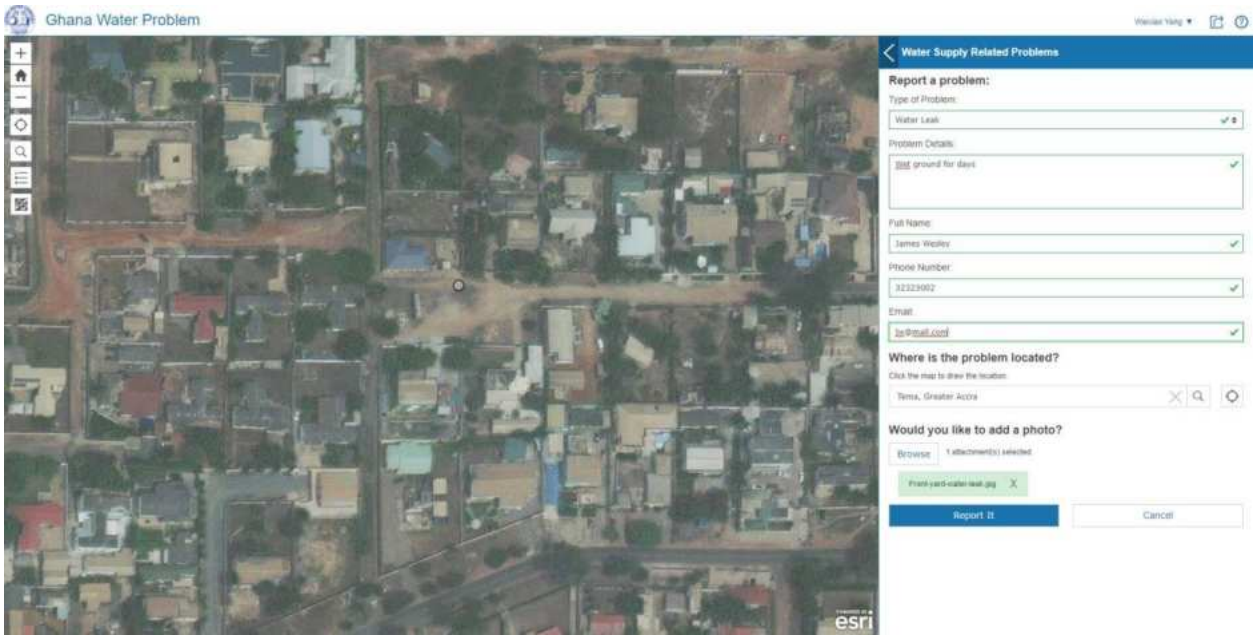

Figure 4.1 How leak reporting is done on the platform.

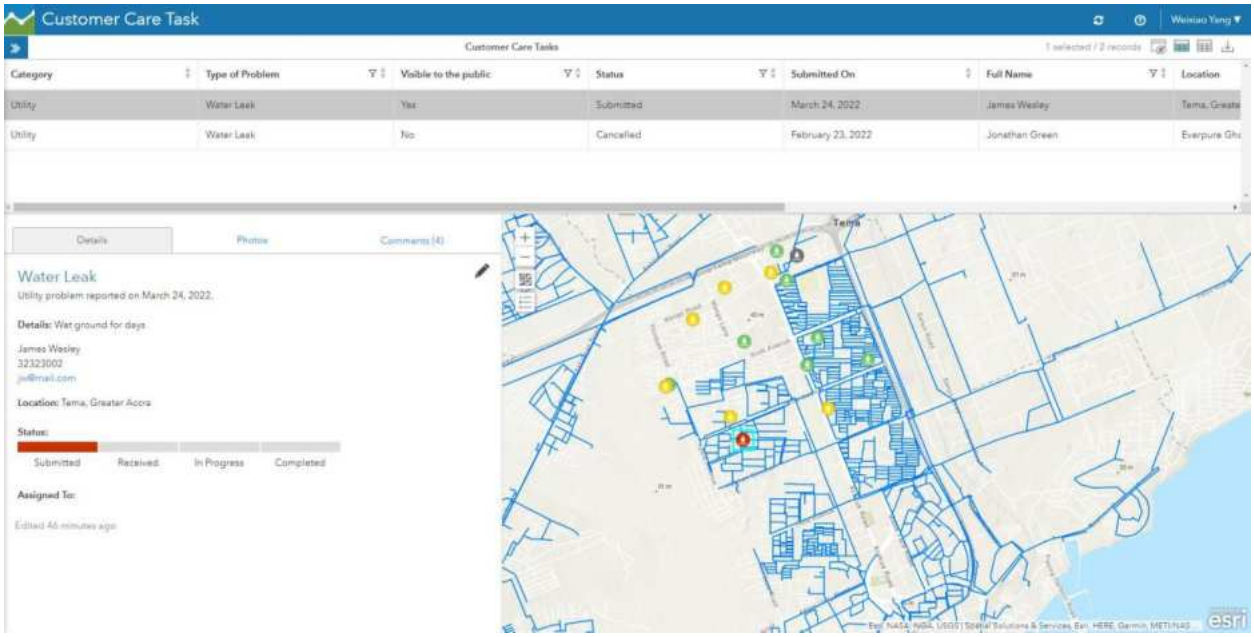

Figure 4.2 Reported leaks with status indicating progress of work.

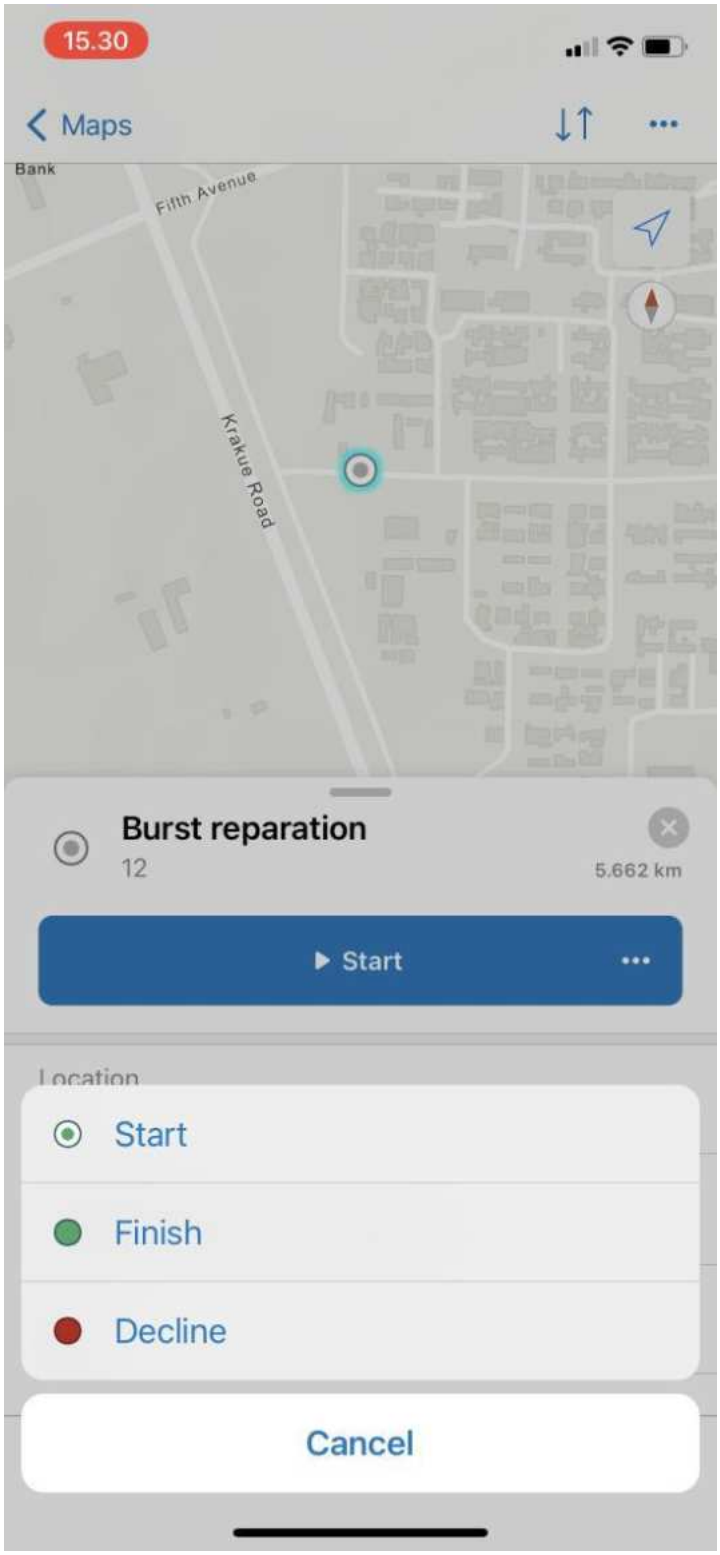

Figure 4.3 Reported and assigned leak received by pipe fitter for action.

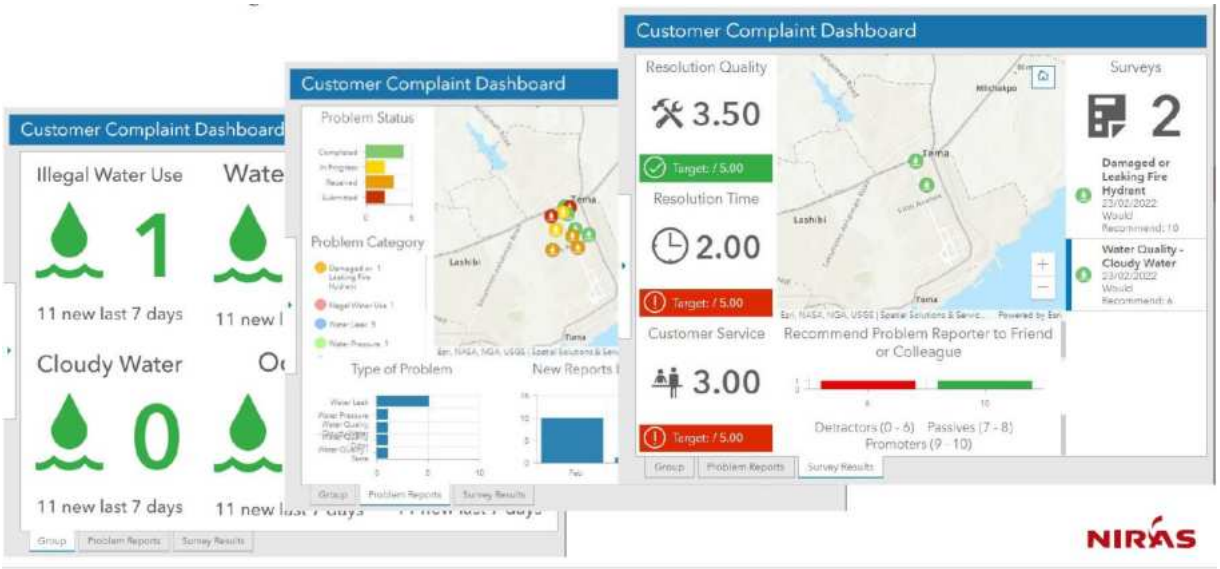

Figure 4.4 Analytics from actions taken on reported leaks.

5.0 CONCLUSION

The implementation of a GIS-based leakage reporting and management system by GWL in the Tema Region has demonstrated the potential of geospatial technologies in addressing water leakage challenges. By leveraging the power of spatial data, analysis, and visualization, GWL has enhanced its ability to detect, report, and manage leakages promptly and efficiently. The system has provided valuable insights for decision-making, optimized resource allocation, and fostered customer engagement in water resource management.

While challenges related to data quality, user adoption, and infrastructure exist, the benefits of the GIS-based approach highlight its potential for replication across other regions served by GWL and other water utilities beyond Ghana. By embracing geospatial technologies, water utilities can take proactive steps towards sustainable water resource management, reducing water losses, and ensuring a reliable and efficient water supply for communities across the country.

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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 a 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. Christina Betty Taylor is a water engineering professional and serves as a Non-Revenue Water Officer at the Technology and Innovation Department of the Ghana Water Limited. Holding a Bachelor of Science Degree in Civil Engineering and a Master of Science Degree in Water Supply and Environmental Sanitation, she specializes in water, sanitation and hygiene. With a focus on designing water supply systems and managing water loss, she actively contributes to projects aimed at enhancing operational efficiency and minimizing water losses through innovative technological solutions. Her role as a young expert with the Waterworx project underscores her commitment to leveraging technology for sustainable water management. She is a Professional Member of Ghana Institution of Engineering (GhIE).

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. Ing. Surv. Jeff Opoku-Gyambibi is a GIS professional with over sixteen years of experience. He manages the Technology and Innovation Department in the Tema Region of Ghana Water Limited, where he leads in leveraging technology to enhance daily operations at the regional level. He is adept in the use of various GIS applications and executed many GIS projects in Ghana. He has played a key role in establishing the GIS unit in Ghana Water Limited. He is member of the Ghana Institution of Surveyors (GhIS), Ghana Geospatial Society (GGS) and Ghana Institution of Engineering (GhIE).

Ing. Kwaku Nyarko-Dokyi has obtained relevant experience working on water supply and land surveying related projects in Ghana over the last fifteen years. His areas of expertise are land surveying, GIS and mapping, as well as design of water supply systems. He holds a Master of Science degree in Water and Environmental Engineering and a Bachelor of Science degree in Geomatic Engineering. He has since participated in various courses relevant to his profession

including Certification in Water Transport and Distribution. He is a Corporate Member of the Ghana Institution of Engineering as well as a Professional Member of the Ghana Institution of Surveyors and Ghana Geospatial Society. He has previously published and presented a similar article during FIG Working Week 2023. He presently works as an Engineer with Ghana Water Limited and is currently the Regional Manager in charge of Technology & Innovations Department in the Ashanti South Region.

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 on the 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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