Reducing Non-Revenue Water

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Abstract: Non-Revenue water (NRW) refers to water produced and lost before reaching consumers. The summary focuses on the importance of reducing Non-Revenue water (NRW), as it increases water availability and the revenues of drinking water. This reduction is achieved when we install the flow meters and water pressure devices at water sources or inlets and exits of isolated areas. We can calculate the amount of water supplied to the area, comparing it with the calculated amount and determining the volume of water not subject to accounting. To solve this, actions like leak detection to determine the location of hidden connections and installation of effective water meters.
Supervisory Control and Data Access (SCADA) systems have a role in water management, providing control and real-time monitoring, early problem detection, improved efficiency, and support decision making. When we use Supervisory Control and Data Access (SCADA) technology, we can reduce water losses, ensure reliable water supplies, and contribute to city water management practices.
Reducing inaccurate billing or theft can increase revenue. Also, reducing physical/real losses, like leakages or inefficient distribution systems, engage water and wastewater companies to postpone investment in water resource development. To achieve the challenge, cooperation between departments such as network operations, hydraulic analysis, and geographic information systems is required. The commercial sector is important to evaluate and identify the different components that contribute to reducing water loss (NRW).

Keywords: Non-Revenue water - Geographic Information Systems - Smart Cities - Hydraulic Analysis - Supervisory control and data access systems - Districts Metered Zone), GIS, Hydraulic Modeling

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1. Introduction

The reduction of Non-Revenue Water (NRW) loss stands as a major challenge in the water assiduity and encyclopedically, as minimizing NRW translates to increased water vacuity and fiscal earnings. One of the major issues affecting water serviceability in the developing world is the significant difference between the quantity of water introduced into the distribution system and the quantity of water billed to consumers, it is also called "no-income water" (NRW) [1]. For illustration, abridging marketable losses enhances billing delicacy, a vital source of fresh profit, while the reduction of Physical/ Real Losses allows serviceability to postpone necessary capital investments in water source development enterprises. As for Governance, it regards the successful perpetration of the Strategy. It requires a few ways (1) set up a devoted PWA Non-Revenue Water Team;(2) set up systems and train the Non-Revenue Water (NRW) Team;(3) engage the service providers;(4) set up NRW Practitioner Team to give the specialized advice and help to the lower service providers to apply the Strategy [2]. The importance of reducing Non-Revenue water (NRW), as it increases water availability and the revenues of drinking water [3]. Sustainability includes ensuring that sufficient safes are available for present and unborn generations. Water that does not generate revenue (NRW) creates a precaution for sustainability through loss of energy and water. However, there is still a need for a comprehensive view of non-accounting water reduction strategies [4]. An important problem is the high status of non-income water (NRW) or the difference between the volume of system input and authorized consumption in the invoice [5] which, for example, amounts to 42 in Nairobi, incompletely because of illegal connections and poor conservation of the systems being constructed further than 40 times agone.

, "Assessing non-revenue water and its factors, A practical approach". In India 30 to 60% chance of treated and supplied water is lost during transmission from water service force to client service connections [6]. Given the non-supervisory terrain in which Canadian water agencies operate, some of these benefits - particularly those that are external to the agency or that may return to the agency in periods not yet generated - may not be fully accounted for when agencies decide to detect leakage [7]. Utility Management Specialist works closely with attachment stakeholders and helps to maintain an effective pace of design operations despite the complex, contemporaneous tasks being in each governorate [8]. Multiple Indian metropolitan metropolises face severe water, these metropolises generally have high non-revenue water (NRW) situations [9]. In Balkan countries, half of the water volume is being lost during the distribution process [10]. The high level of non-income water in Malaysia (NRW) reduced the capacity of water service providers to absorb additional water demands and caused considerable financial pressure on their investments in water-related structures as well as operating expenses. - The intention to reduce water revenues in Selangor [11].

The Non-Revenue Water (NRW) level serves as a crucial performance indicator for efficiency. However, many Water Service Companies (WSCs) tend to "underestimate" the actual level of non-potable water due to inaccurate information, insufficient knowledge, and institutional or political pressures. Reporting artificially low NRW levels can mask genuine issues affecting the effectiveness of drinking water operations. Therefore, it is imperative to accurately quantify and size Non-Revenue Water (NRW) components to validate the reported Non-Revenue Water (NRW) level.

Despite reports suggesting a 22% NRW level, the validity of this low figure is questionable. The discussions with senior management, record reviews, and field visits indicate that reported low NRW levels may result from intentional misinformation or a lack of accurate data. An audit of Non-Revenue Water (NRW) components is necessary to establish a more "reliable" standard and detect actual issues impacting the operational efficiency of WSCs. Collaboration among network operations, hydraulics, GIS, and the commercial sector is vital for estimating and quantifying NRW components.

Many reports put the Non-revenue water (NRW) at 20%; However, this low level of non-accountable water is questionable. NRW level is less than 20% as "good," 20% as "accepted," and more than 25% as "unacceptable".

Given that each component has a distinct impact on the Non-Revenue Water (NRW) value, and the size of the component varies for a water utility, conducting an NRW audit is crucial to ascertain the level of each component. The non-revenue water (NRW) has five main components: the volume of system inputs, authorized consumption billed, unauthorized consumption, apparent/commercial losses, and real (material) losses. Networks are divided into restricted areas (DMA) or larger areas known as counter-zones (DMZs).

Current challenges in water management, including water scarcity, old infrastructure, increased demand, and the need for efficient resource allocation, are effectively addressed through SCADA (supervisory control and access to data). SCADA plays a central role in real-time surveillance, control, and automation of water systems. It solves high levels of water loss due to leaks and inefficient water distribution by enabling real-time control of water flow, pressure for early detection, and better system management, which reduces non-income water. Replacement and renovation of the old water network are carried out using SCADA and facilitating maintenance. In the face of increasing population, SCADA can improve water distribution by providing different consumption patterns. SCADA can provide careful control of water treatment and distribution processes, ensuring better resource allocation and effective operation of water treatment plants. Also, SCADA solves the challenges of data management and decision-making through real-time data collection and analysis and the provision of good information to decision-makers. In conclusion, SCADA solves current water management challenges by providing real-time data, control, and automation to enhance the efficiency, reliability, and sustainability of water systems.

2. Implementation

To operationalize the DMZ and Luxor Non-Revenue Water (NRW) initiatives, the collaborative efforts of hydraulic analysis, operation and maintenance, commercial management, and GIS will include the following tasks:

- Conducting the Customer Identification Survey to pinpoint commercial losses among customers.
- Deployment of the Leak Detection staff to install pressure and flow meter sensors for continuous monitoring of the designated zone.
- Implementation of a mobile application for the seamless transfer of GIS links connecting customer meters with the commercial section.
- Using satellite imagery to identify physical features within the region.

The DMZ component will include a limited number of fixed Ultrasonic meters, several sensors of pressure, and a program for receiving readings from meters. Additionally, a monitoring server system, data transfer units, and a software system (SCADA, Fig. 1) will be integral components of the initiative.

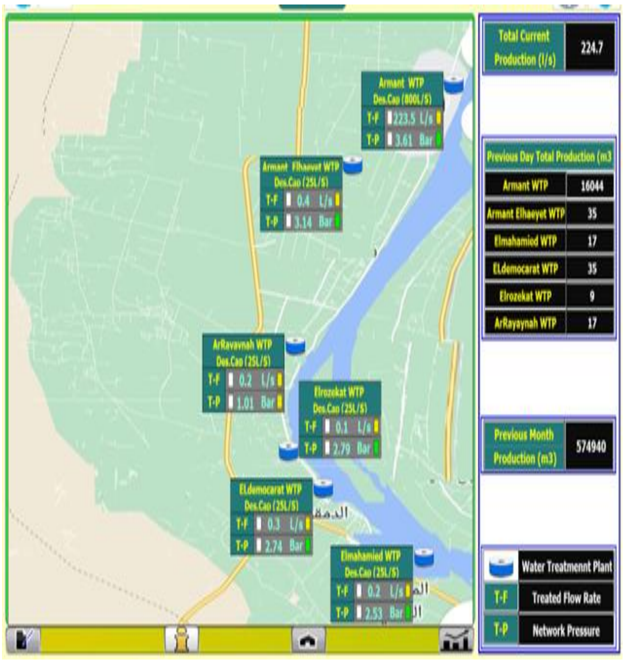

Fig. 1. SCADA monitor program for pressure and water flow.

The main Devices are Pressure devices, Flow meters, RTU (Remote Terminal Unit), Panels and SIM cards.

The presented diagram (fig. 2) illustrates the interconnections among different sections, including the hotline, DMZ (Districts Metered Zone), GIS, Hydraulic Modeling, Operation and Maintenance, Leak Detection departments, and Research and Development.

Fig. 2. Linking different sections.

The diagram illustrates a network setup incorporating devices like Pressure sensors and Flow Meters. These devices are linked to an RTU (Remote Terminal Unit) or a PLC (Programmable Logic Controller), and these, in turn, are connected to a router, fig. 3. On the server, a router is in place to receive data from the devices and transmit it to the server and SCADA program for saving data and analysis.

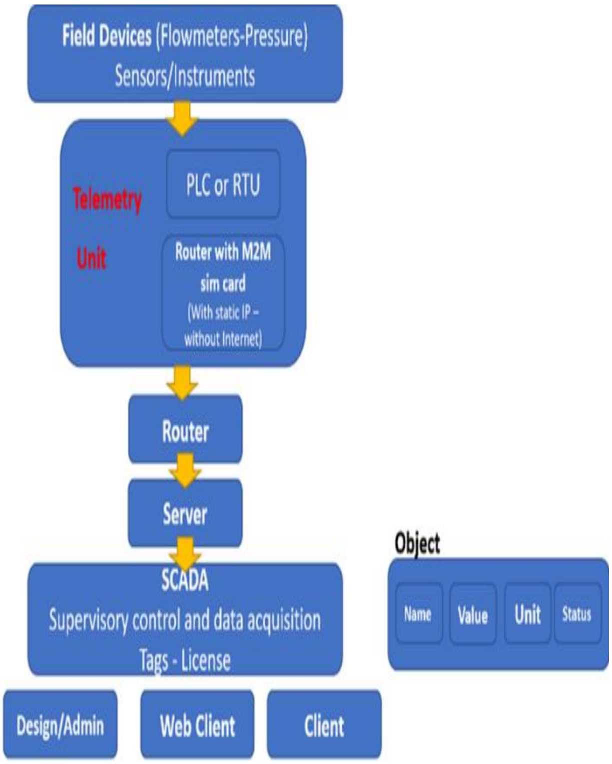

Fig. 3. Flow Chart for SCADA devices.

2.1. Methodology

To aid water companies in implementing DMZ, the methodology will be clarified as follows:

1. Establish criteria for prioritizing DMZs and selecting the Governorate.
2. Use of the geographic information systems mobile telephone application during field surveys to identify clients and meter locations. This information can be combined with hotlines, commercials, and other sections.
3. Define the ultimate GIS maps and hydraulic model of DMZs.
4. Generate maps for water stations, including inlets and outlets of the zone.
5. Conduct field verification to ensure that GIS maps align with and are suitable for the as-built conditions.
6. SCADA staff use templates using the internet to send data.
7. Incorporate satellite images into the process.
8. Provide training for staff on using the mobile program and downloading satellite scenes.

2.2. The Activities

1. Form teams from contributing departments (such as Network O&M, NRW, Hydraulic Analysis, GIS and Commercial).
2. Provide an orientation for the teams on the program's goals, mission, and objectives.
3. Choose a pilot zone of the water balance and GIS mapping based on predefined criteria.
4. Deliver the training for the contributing sections.
5. Develop a database of water networks, GIS, billing, meter readers, and collectors.
6. Update the customer database, integrate comprehensive data on communications, clients, and numbers, and integrate the information collected during field surveys into an updated map. This includes details such as connections, water pipeline tracks, pipeline diameter, materials, customer names and numbers, consumption classification (residential, commercial, and industrial), and meter.
7. Provide technical training for the leak detection crew, focusing on the use of leak detection equipment to obtain readings of flow and pressure measurements.
8. Interference with business losses, addressing problems such as replacing defective meters, dealing with illegal deliveries, updating meter readings, and dealing with government clients.
9. Map the location of leaks on the GIS map.
10. Conduct repairs for the identified leaks with the water network team.

11. Perform pressure and flow measurements in the selected area after repairing the identified leaks in its network.
12. Analyze both commercial and physical data.

3. The Results

3.1. Presentation of Charts and Data

1. Clarification of connection status is very necessary, indicating whether the connection exists or not.
2. Display signal status from flow meters and pressure sensors, indicating malfunctions or lack thereof, or issues with the devices.
3. Inclusion of buttons to directly access reports and charts.
4. Reprogramming of the program interface to feature many screens, where feeders of stations of the branch are plotted on maps instead of table view only.

3.2. Presentation of Historical Data

1. Display of monitored data for the signals (call status and warning signals).
2. Saving and linking data to dedicated data like a MySQL database.
3. Utilization of the displayed monitoring data as a basis for creating various reports, conducting analysis, and charts.

3.3. Presentation of Trends in Data Measured

1. Displaying the changes in values of periods preceding all signals to illustrate variations in measured values during previous periods.
2. Analysis of the curve values based on the duration to be presented to the curve.

3.4. Report Generation

1. Establishment of reports for all signals, including the status of communications, which is a key function.
2. Establishment of various types of reports, including daily reports showing total behavior and average pressure per hour per day, monthly reports reflecting overall behavior and average pressure per day, as well as annual reports.

% NRW	District Metered Zones				
	DMZ 1	***DMZ 2***	***DMZ 3***	***DMZ 4***	***DMZ 5***
FY2020	26%	35%	21%	36%	29%
FY2021	25%	27%	27%	36%	28%
FY2022	21%	22%	24%	29%	27%

Table 1. NRW for District Metered Zones

Table 1 illustrates the decrease in %NRW in district-metered zones after implementing SCADA systems from the year 2020 to 2022.

3.5. SCADA Systems

1. SCADA (Supervisory Control and Data Access) systems are useful for water management in smart cities. The following points highlight their importance:
2. Real-time surveillance and control: SCADA systems allow operators to control and control the various components of the water supply system in real-time.
3. Early detection of problems: SCADA systems facilitate early detection of abnormal cases, such as leaks or malfunctions, allowing for rapid maintenance.
4. Improved efficiency and improved resources: SCADA systems provide insights into water use patterns, helping to improve distribution and implement demand management strategies.
5. Enhancing resilience and disaster response: SCADA systems enhance infrastructure resilience by providing real-time situational awareness during emergencies.
6. Data analysis and decision support: SCADA systems create data for analysis and support informed decision-making for proactive maintenance and long-term planning.

The SCADA application should encompass main functions such as charts, history of data, Alarms, Reports, Trends, and Security, as depicted in the following figure (fig. 4).

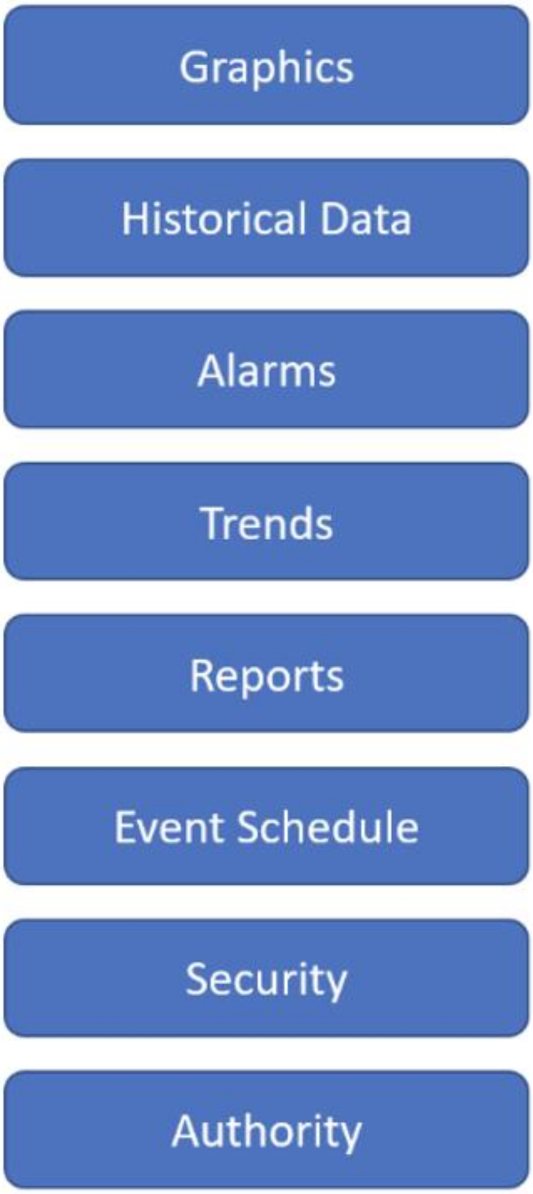

Fig. 4. The functions of the application.

4. Conclusion

A study of the western area of the city of Esna in Luxor governorate was conducted during April and May 2021 before the meter was installed, and in 2022 after the meter was installed, the notes were as follows:

In April 2021, the total water production for the region of Esna was 2,092,181 m^3 (Luxor Water Company). In April 2022, the production of total water was 1,956,020 m^3 (SCADA program). Notably, there was a reduction in productivity of approximately 7% in April.

For May 2021, the total water production in western Esna was 2,120,272 m^3 (Luxor Water program). In May 2022, the total water production decreased to 1,834,355 m^3 (SCADA system). The reduction in productivity for May was around 13%.

These findings highlight the percentage calculation of the losses and non-accountable water, emphasizing that this calculation can be more accurate after the installation of the equipment and improved operation of the SCADA program compared to calculations conducted before these measures were implemented, as in table 2.

May		April	2022	2022	2021	2021
%		%	May	April	May	April
-13%		-7%	1,834,355	1,956,020	2,120,272	2,092,181

Table 2. Results

5. The Recommendations

1. Expanding the operation of SCADA and DMZ to encompass all fresh governorates. 2. It's pivotal to suffer training on SCADA and device conservation to enhance chops. 3. Supplying the needful bias, similar to inflow measures and pressure detectors, to extend the content of DMZ to all the governorates. 4. The objectification of artificial intelligence (AI) is poised to offer enhanced perceptivity in SCADA network exertion, easing further effective responses to implicit pitfalls. 5. The growing application of IoT (Internet of Effects) bias and detectors within SCADA is anticipated to induce substantial quantities of data, which can be anatomized with advanced data.

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