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Smart Water Management for Sustainability in Urban Infrastructure: A Case Study for Denpasar, Indonesia

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Abstract

Water is a critical resource that must be managed efficiently to ensure sustainability in urban infrastructure. Denpasar PDAM, the primary water utility in Denpasar, Indonesia, faced significant challenges in monitoring water consumption, reducing non-revenue water (NRW), and executing an effective billing system. To address these issues, a Smart Water Management System pilot was implemented in collaboration with SES Electronic Water meters South Korea using the DropByDrop (DBD) Smart Water Management Platform from India. The project introduced wireless smart meters, automated data collection, and real-time monitoring, improving operational efficiency and reducing water losses. This case study examines the project's execution, challenges, and outcomes, offering insights into the function of digital technology in sustainable water management.

Keywords: Smart Water Management, Internet of Things (IoT), Smart City, Smart Meters, Bluetooth Low Energy (BLE), Water Conservation, Urban Water Sustainability.

1. Introduction

Water is a vital resource that demands efficient governance to ensure sustainability. In urban areas, inefficient water utilisation, high NRW, and outdated infrastructure lead to significant losses. Denpasar PDAM faced similar challenges, with limited capabilities to track near real-time consumption and losses. The adoption of smart water technologies offers a data-driven approach to improving efficiency, reducing NRW, and enhancing consumer engagement.

This case study explores the deployment of the Smart Water Management System in Denpasar, Indonesia, as part of a collaboration between K-Water and SES South Korea. The project utilized the DropByDrop (DBD) India platform to integrate wireless smart meters, automate data collection, and enhance water consumption management.

1.1 Project aim:

To assess the benefits of using of IOT enabled Smart Electronic over traditionally used Mechanical Water meter to measure hourly consumption by the household at three locations in Denpasar area.

1.2. City Context and Challenges

Denpasar, the capital of Bali, is a rapidly growing urban centre with touristic inflow with increasing demand for potable water. Denpasar PDAM, responsible for water distribution in the city, faces several operational challenges, including:

1. Inadequate metering coverage and outdated meters with manual reading operation.
2. Difficulty in monitoring consumption patterns across different consumer categories and demand planning.
3. Delays in billing and revenue collection due to manual processes.
4. Lack of consumer awareness regarding their water consumption patterns, limiting efforts toward conservation and efficient usage.

To address these issues, the Smart Water Management System was implemented as a pilot project to evaluate new technologies and their impact on water conservation and efficiency.

2. Problem Definition

Denpasar PDAM encountered the following key challenges:

1. Lack of an effective system to track near real-time water consumption at a granular level.
2. High NRW due to leaks, theft, and inaccurate metering.
3. Inefficient billing processes lead to revenue loss.
4. Limited visibility into consumer water usage, affecting demand planning and sustainability.
5. Need for an automated, contactless metering system to ensure uninterrupted operations, especially during emergencies like COVID-19.

3. Solution Brief

3.1 Introduction to the Solution

The Smart Water Management System was designed to address Denpasar PDAM's challenges by leveraging IoT-based solutions. The DropByDrop (DBD) platform was selected for its:

1. Hardware Vendor Neutrality – Compatible with multiple smart metering devices.
2. Multi-Protocol Support – Integration with various communication technologies (LoRaWAN, NB-IoT, SIGFOX, BLE, WMBUS and GSM).
3. Cloud-Based Data Management – Secure storage, analysis, and billing integration.
4. Automated Alerts and Consumption Monitoring – Real-time tracking for improved operational efficiency.

3.2 Unique Features and Innovation

1. Deployment of BLE smart meters from local company Water Point, in collaboration with SES, South Korea.
2. Use of BLE GSM gateways for Automatic Metering Infrastructure (AMI), ensuring seamless data transmission.

3. Integration with the DBD platform for automated data collection, monitoring, and billing.
4. Real-time alerts on leaks, anomalies, and water consumption trends.
5. Consumer engagement via the myDBD app, allowing users to track personal water usage.
6. Operational efficiency for field staff through the DBD Walk app, enabling issue resolution.
7. Automated water balance assessments in Distribution Management Areas (DMA) for loss detection and reduction.

4. Scope of the Pilot Project

4.1 Objectives

1. Evaluate the performance of smart meters in Denpasar area in an urban setting.
2. Identify high water consumption users and assess demand patterns.
3. Assess cost-effective BLE (Bluetooth Low Energy) communication technologies for near real-time data transmission with automatic cloud updates.
4. Determine budget requirements for large-scale implementation.
5. Compare smart meters with existing mechanical meters.
6. Low communication infrastructure planning using android mobile and GSM technology.

4.2 Deliverables

1. Installation of new-generation smart water meters with wireless communication.
2. Integration of the DBD Smart Water Management platform for centralized monitoring.
3. API-based integration with the cloud server and export of meter reading data.
4. Evaluation of Automatic Meter Reading (AMR) and Automatic Metering Infrastructure (AMI) performance.

4.3 Expected Outcomes

1. Automated data collection and near real-time monitoring of water consumption.
2. Alert management, including leak detection, empty pipe alerts, meter malfunction notifications, and reverse flow detection.

3. Improved accuracy and time in billing and revenue generation with timely meter reading data.
4. Selection of the cost-effective wireless communication technology for large-scale deployment.

5. Implementation Plan

5.1 Key Steps

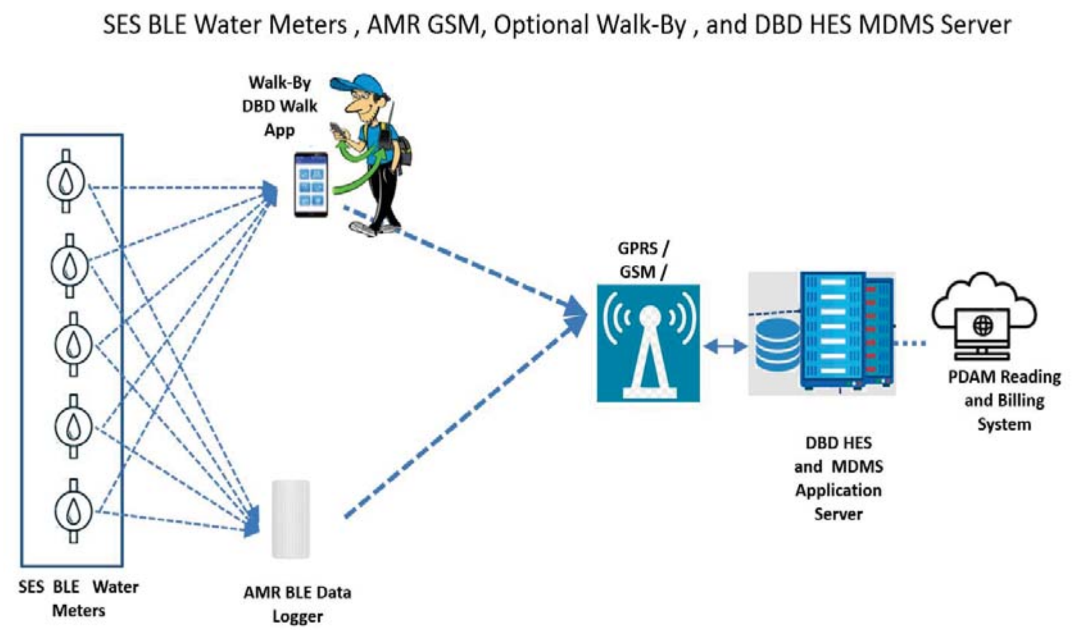

Figure 1: AMR and AMI architecture (Source: DBD Water Systems)

1. Data Collection – Gathering information on existing meters, water consumption, and infrastructure.
2. Smart Meter Selection – Choosing meters with electronic static BLE communication meters for accuracy.

Table 1: Comparison between Smart Meter and Electronic Meter (Source: DBD Water Systems)

	Mechanical	Electronics
Standard	IS-779	ISO-4064 and OIML R49
Communication	Not Possible	Wireless and Wired
Accuracy	1 Liter	1/100 Liter = 10 ml
Remote Reading	Not Possible	Possible
Product Life	5 Years	10 Years
Battery Inbuilt	No	Yes, life 10 years
Vertical Installation	Not Possible	Possible
NRW calculation	Not Possible	Possible
Automatic Billing	Not Possible	Possible

3. Wireless Communication Setup – Deploying BLE-based smart meters and BLE GSM-based gateways at the deployment area.
4. Integration with DBD Platform – Connecting gateway to Head End System with REST APIs. Downlink API integration for Gateway interval setup. Set up geo location of meters and consumer details at Meter Data Management Systems. Consumer service App Integration.
5. Field Deployment – Installing smart meters at consumer connections and gateways.

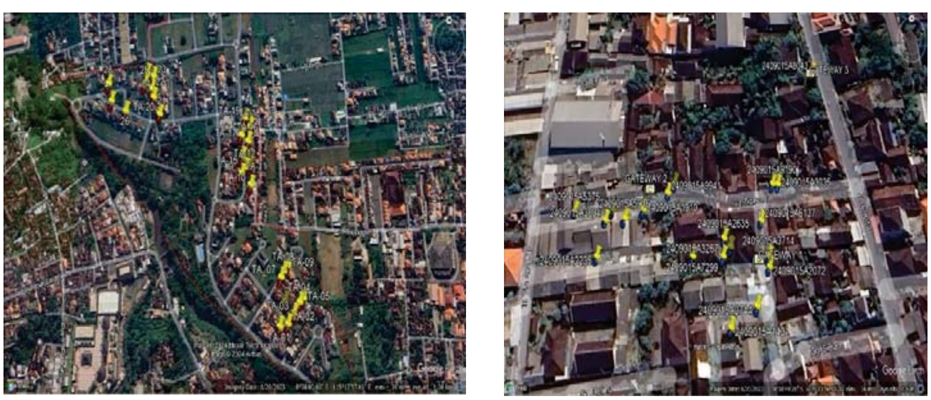

Figure 2: Smart meters Installation Location (Source: DBD Water Systems)

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Figure 3: Smart meter installed along with existing meter (Source: DBD Water Systems)

Figure 4: BLE GSM Gateway (Source: DBD Water Systems)

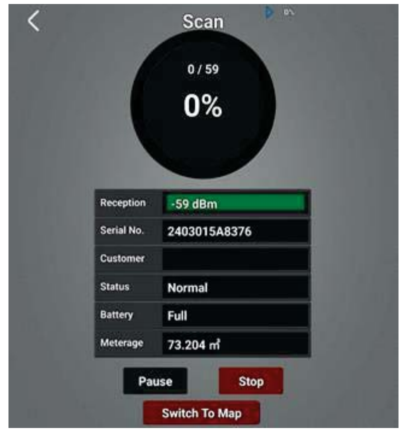

Figure 5: App for field staff (Source: DBD Walk Application)

6. Monitoring and Data Analysis – Assessing system performance and optimizing communication networks.

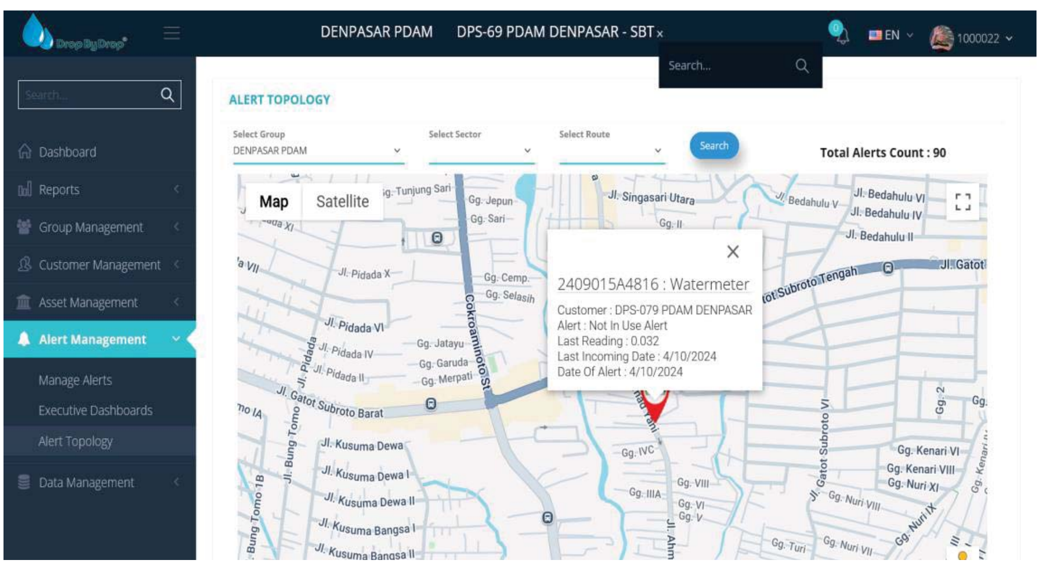

Figure 6: Alert Management (Source: www.dbdwater.com)

7. Consumer Engagement – Enabling consumer tracking through the consumer dashboard.

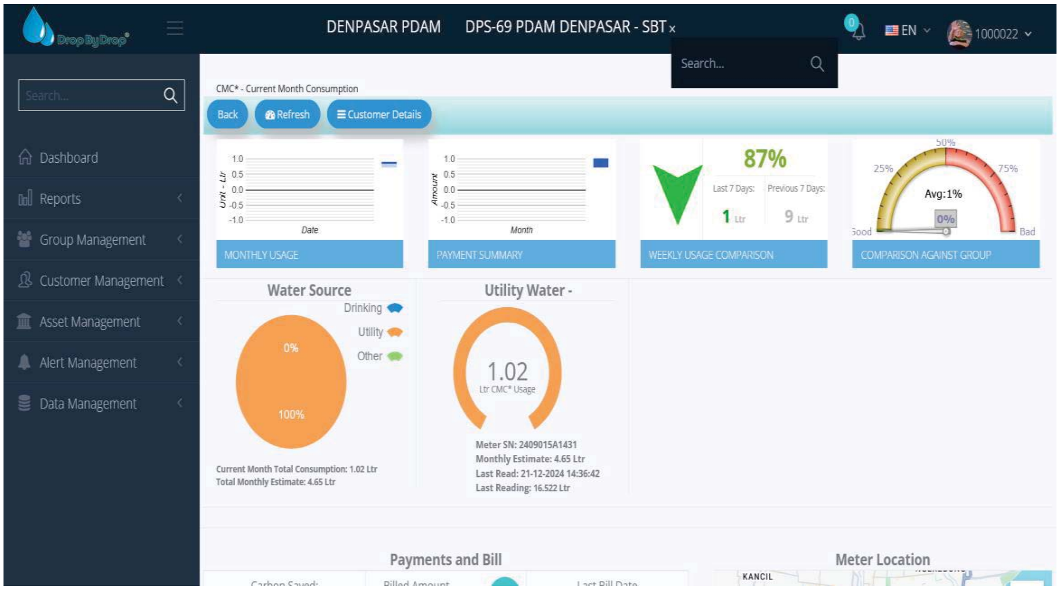

Figure 7: Consumer interface (Source: www.dbdwater.com)

8. Consumer App – Enabling consumer usage management alert and complaint management through android App.

Figure 8: Consumer app (Source: myDBD Application)

5.2 Key Technologies Used

1. Smart Meters – Smart BLE electronic static water meters with IP68 certification.
2. Communication Technologies – BLE and GSM for data transmission.
3. DBD Platform – Cloud-based analytics, alerts, and API-based integration with HES and MDMS.

6. Results and Findings

6.1 Meter Performance

1. The majority of the installed smart meters functioned efficiently, providing accurate near real-time data.
2. Some meters experienced technical issues in communication with AMI due to the range of gateway from them.
3. Smart meters successfully recorded and calculated water consumption with high accuracy.

6.2 Communication Effectiveness

1. BLE meters had a scanning range of up to 50 meters in congested areas and 150 meters in open spaces from the installed gateway.
2. BLE meters allowed manual scanning as a backup in case of communication failure to ensure continuous data collection.

6.3 HES (Head End System) and MDMS (Meter Data Management System) Performance

1. Accurate data collection was achieved through REST API integration with the cloud-based Head-End System (HES).
2. Smart meters provide real-time consumption trends, enabling better demand forecasting.
3. Hourly consumption pattern for each consumer.
4. Monthly meter readings ensured timely and accurate billing for consumers.

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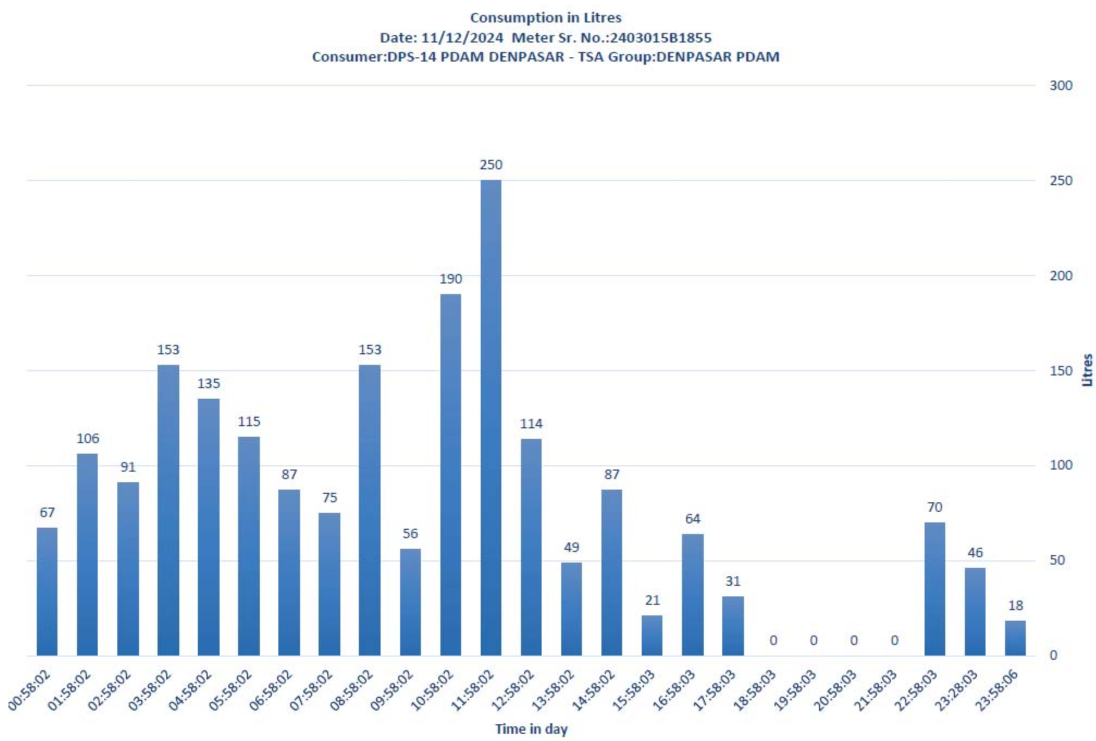

Figure 9: Graph showing Consumption in Litres (Source: www.dbdwater.com)

7. Discussion

7.1 Benefits of Smart Water Management Implementation

7.1.1. Operational Efficiency for the Utility

1. Smart meters enabled reverse flow and near real-time leak detection, leading to faster repairs and reduced Non-Revenue Water (NRW) losses.
2. Automated and accurate billing eliminated human errors, ensuring fair and precise billing.
3. Smart meters help detect and prevention of unauthorized water connections and tampering.
4. Data analytics supported predictive maintenance, which minimized unexpected failures and repair costs.

5. Automated meter readings **reduced labor expenses**, eliminating the need for manual readings.

6. Wireless communication (NB-IoT, LoRa, BLE) enabled **remote monitoring** and potential **valve control integration** for efficient water distribution.

7. Permanent data storage enabled long-term analysis of consumption patterns and system performance.

7.2.2. Consumer Benefits

1. Accurate and transparent billing ensured they were charged fairly for their actual consumption, reducing disputes over incorrect readings.

2. Early leak detection helped users prevent property damage and avoid excessive bills.

3. Access to near real-time water usage data through apps like myDBD encouraged consumption awareness and conservation for better water management habits.

7.2. Performance Comparison: Manual vs. Smart Meter Readings

1. Smart meters captured higher and more accurate consumption data compared to manual readings.

2. Immediate notifications for leaks, malfunctions, and meter failures allowed for quicker issue resolution.

3. Smart meters identified faulty mechanical meters, leading to timely replacements and better resource management.

4. Smart meters can be installed in any orientation—horizontal, vertical, or sloping—without affecting accuracy.

5. Eliminated air count errors common in manual meters, ensuring precise readings.

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Table 2: Performance Comparison: Manual vs. Smart Meter Readings (Source: DBD Water Systems)

Date of Reading	Mechanical Meter	Electronic meter
		
11.06.2024	2271.660 m3	7.370 m3
		
30.05.2024	2267.913 m3	3.928 m3
Consumption in m3	3.747 m3	3.442 m3
23.06.2024	2274.621 m3	10.076 m3
Consumption in m3	2.961 m3	2.706 m3

7.3 Challenges and Limitation

1. High Initial Costs – The cost of smart meter deployment and supporting infrastructure was substantial, requiring significant investment.
2. Data Security Concerns – The use of IoT and cloud-based systems raised concerns regarding cybersecurity and data privacy.
3. Integration with Existing Infrastructure – Many areas had ageing pipeline networks that required modifications to accommodate smart meters.
4. Technical Issues – Some smart meters faced battery drain and water damage, especially in flood-prone areas.

8. Conclusion

The Smart Water Management System successfully improved water tracking, billing accuracy, and operational efficiency. Wireless communication technologies enable real-time monitoring and automation. The project demonstrated a scalable solution for reducing NRW and optimizing water distribution. The pilot project showcased key benefits such as automated consumption tracking, predictive maintenance, improved demand planning, and cost savings by eliminating manual meter readings. Additionally, consumers gained better control over their water usage through real-time monitoring via mobile apps, leading to more conscious water conservation habits. Despite challenges such as high initial costs, infrastructure compatibility issues, and cybersecurity concerns, the overall findings highlight the effectiveness of smart metering in urban water management. The results from this pilot provide a strong foundation for large-scale implementation, enabling sustainable water distribution, reduced losses, and improved service delivery.

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