

IoT Enabled Smart Water Monitoring System for Sustainable Urban Water Conservation

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Abstract— With the rise in urban population and growing need for water, efficient management of the resources is necessary in smart cities. This paper discusses about the design and development of IoT enabled Smart Water Monitoring System for urban water conservation. Comparative Analysis was made between water consumption with/without implementation of SWM technology. Monthly consumption pattern and savings achieved along with monitoring efficiency were evaluated through monthly water consumption of residential areas. Comparative analysis based on daily consumption patterns, average water usage, consumption per day and estimated cost was made. It can be concluded that implementation of SWM technology will help in reducing unnecessary consumption of water and achieve better monitoring and water management.

Keywords— Smart Water Meter (SWM), Internet of Things (IoT), Water Conservation, Smart City Infrastructure, Water Consumption Monitoring

I. INTRODUCTION

Water is among the crucial natural resources essential for human survival and development in the urban environment. Rapid urbanization, rising populations, and high demand for water have caused a significant problem in water management within smart cities. Traditional water supply and monitoring systems cause water wastage due to inefficiencies that include excessive consumption, leakages, incorrect billing, and poor monitoring capabilities. For this reason, there is a need to create intelligent and sustainable water management systems due to recent advancements in IoT technologies.

The development of IoT technology has provided an opportunity for effective real-time monitoring of water resources. SWM systems incorporate IoT technology to enable the continuous monitoring of water consumption and data collection. It helps consumers and authorities to monitor their water consumption to minimize unnecessary wastage.

This study aims to conduct a comparative analysis of water consumption before and after the application of Smart Water Meters technology within residential zones. Daily consumption patterns, total water usage, cost saving from using the smart meters, and water savings

are some of the key factors to be examined during this research.

1.1. INTRODUCTION TO IOT

Internet of Things (IoT) involves a network of interconnected physical objects which have the capability to communicate among themselves using the internet without requiring any human intervention. The devices feature software and sensors that enable real-time data analysis and monitoring. As a result of its capacity to increase efficiency levels and minimize wastage of resources, along with the data-driven nature of decision making, IoT technology has emerged as a significant element of modern smart infrastructures.

In the recent past, the use of IoT has found application in several domains including health care, transportation, agriculture, energy management, and water management. The role played by IoT in smart cities has been crucial in terms of enabling monitoring of public utilities and efficient utilization of resources. One of the important uses of IoT technology has been realized in the field of Smart Water Meters.

1.2. SMART WATER METER

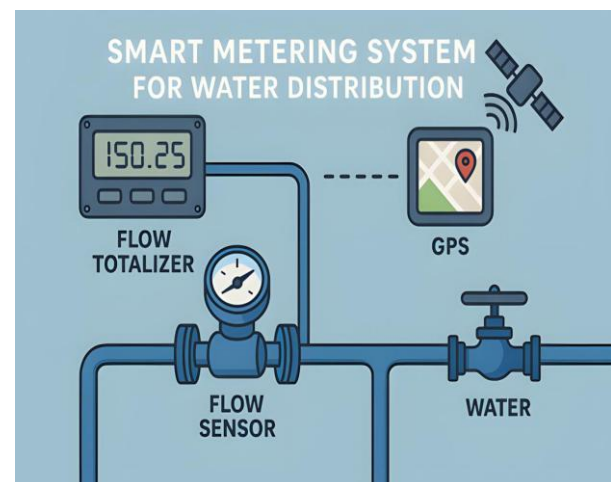


Figure 1: Smart water meter

A smart water meter (SWM) is a smart water monitoring system based on IoT technology, used for collecting and recording data concerning the quantity of

water consumed by various facilities. Contrary to traditional water meters, which require a periodic inspection to collect consumption data manually, a SWM automatically collects and sends the required data by means of the available communication channels.

Smart water meters typically comprise flow sensors, microcontrollers, wireless communication modules, and cloud-based monitoring systems, which collect information about water consumption. As flow sensors measure the consumption continuously, the collected data is sent to a remote monitoring system.

The primary reason for using SWM systems is improving water consumption monitoring, which would result in more efficient use of water resources. Modern cities grow at such a pace that their infrastructure needs constant improvement, especially concerning water supplies. Traditional systems of water consumption monitoring fail to detect any leakage, overconsumption, and other related issues because they do not provide round-the-clock monitoring.

Another key benefit of the SWM system is that it enhances user consciousness concerning water usage. Users who can monitor their water usage will be more conscious in using it, thus ensuring its efficient conservation. SWM systems can ensure efficient billing by eliminating potential human errors due to manual monitoring.

In the context of smart cities, the use of SWM systems can help sustain water usage and prevent any wastage. As discussed above, integrating IoT technology with water monitoring systems can ensure that water is used in a sustainable manner. Authorities will be able to take better-informed decisions about water usage. Thus, the SWM technology contributes to sustainable development and efficient water usage.

1.3. AIM AND OBJECTIVES

Aim- To compare water consumption with and without Smart Water Meter (SWM) technology and evaluate its effectiveness in reducing water wastage through IoT-based monitoring.

Objectives:

1. To compare water consumption with and without Smart Water Meter (SWM) technology.
2. To analyse the effectiveness of IoT-based monitoring in reducing water wastage.
3. To evaluate water usage patterns and monitoring efficiency in residential areas.

1.4. PROBLEM STATEMENT

The conventional way of measuring water usage may lead to wastage of water due to its inability to monitor water consumption on a real-time basis. This issue has been exacerbated by an increase in the number of people living in the cities and thus the rising requirement for water. It has therefore become mandatory to use IoT Smart Water Meter (SWM) systems to save water unnecessarily used in residential areas.

II. LITERATURE SURVEY

Massoud et al., (2025), analyzed the impediments hindering the adoption of Internet of Things (IoT) into sustainable buildings. It was found that the lack of standardization, non-interoperability, traditional methods of construction, and non-adaptability to change are the main obstacles to IoT application. The conclusion of the research is that IoT adoption increases building performance, energy efficiency, monitoring systems, and sustainable building project management.

Hajibabaei et al., (2025) conducted a study examining the sustainability performance of Smart Water Meter adoption within urban water networks through a life cycle assessment approach. It was found that the adoption of such meters increases awareness among users, reduces water consumption by households, and promotes effective leakage management due to the higher resolution of collected data. It can be stated that smart metering solutions help conserve water and energy sustainably.

Kineber, (2024), the advantages associated with the use of IoT technologies for sustainable construction activities were considered. It was revealed that IoT can be applied to enhance monitoring processes, resource utilization, safety, teleoperation, and effective construction process management. In particular, the importance of IoT for efficient sustainable construction was highlighted.

Althoey et al., (2024) assessed the effect of integrating Internet of Things on resource management in the construction industry. It was revealed that the application of Internet of Things facilitates the tracking, effective distribution, and predictive maintenance of resources in construction sites. It was observed that the use of IoT technology improves the management of various resources.

Alves et al., (2024) investigated the design and implementation of Smart Water Meters through an open design strategy. Their work addressed sustainability in water management and emphasized the significance of involving stakeholders in the design of smart water metering systems. According to their findings, Smart Water Meter technology can contribute to better water conservation, efficient monitoring, and sustainable resources management in smart cities.

Silva dos Santos et al., (2022) carried out a systematic review concerning the use of Internet of Things in construction projects. The authors established that Internet of Things technologies enhance construction projects' management, monitoring, productivity, and communication.

Maqbool et al., (2022) explored the usage of Industry 4.0 and IoT technologies in the construction sector. This research showed that IoT technology is useful for improving monitoring, communication, automation, and sustainability within construction projects. The study further revealed difficulties associated with technological knowledge, costs, and awareness about IoT technology among stakeholders in developing sectors.

Aivazidou et al., (2021) discussed the usage of smart technologies in sustainable urban water management systems. The findings from the research showed that technologies such as IoT, sensors, machine learning, and big data can be used to monitor and predict water consumption within urban areas. These findings emphasize the importance of using smart technologies to ensure the sustainable use of water resources in urban areas.

AL-Madhrabi et al., (2021) developed the Smart Water Meter System based on IoT technology. This study was focused on the development of the water consumption monitoring system based on Arduino technology, Wi-Fi and flow sensors, which made it possible to monitor in real-time water usage of households. The results revealed that the introduced algorithm provided higher energy efficiency and decreased unnecessary data transmissions, allowing the effective monitoring of water usage and prevention of leakage.

Davies et al., (2014) conducted research on the long-term effects of using the technology of Smart Water Meters on the water consumption of residential consumers. It is stated that households that used the Smart Water Meters system used 6.4% less water than those households which used conventional systems. It is concluded that such technologies contribute to the effective use of water.

III. METHODOLOGY

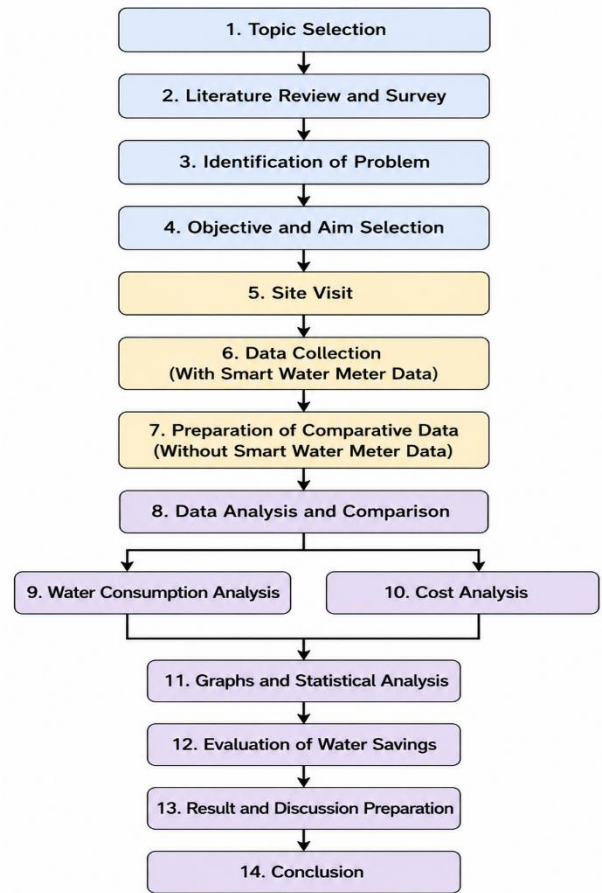


Figure 2: Flowchart of Methodology

Selection of Topic

The selection of this project topic is done considering the growing significance of water management with the help of internet of things technology. It highlights the use of Smart Water Meters for monitoring and analysing the waste of water through various means. The selection of the topic is done with an objective to understand the impact of the Smart monitoring system in reducing water wastage.

Literature Review & Survey

In-depth literature survey has been performed by referring to some research papers and other technical literature on IoT, Smart Water Meter systems and sustainable water management practices. Literature survey has helped in gathering relevant information about how IoT works and what is the impact of smart meters on sustainable water management practices.

Problem Identification

Major problem which led to this project is that of excessive waste of water in case of conventional water metering system. Conventional manual water monitoring systems failed to identify the leaks, irregularities, and wastage of water. There was an urgent need for developing an advanced and smart monitoring system to check wastage of water and monitor the consumption.

Selection of Aim and Objectives of the Project

The objectives and aim of the project have been determined according to the problem and need for the research. The main objective of the project is to conduct comparison between water usage before and after implementing the smart water meter and see how effective this system is for water conservation. Moreover, another aspect that will be examined during the project is the analysis of water consumption and monitoring through IoT-based systems.

Site Visit

To determine the process of water consumption and distribution through smart meters in the selected residential area, a visit to the place has been conducted. This site visit helped understand the whole process of installation, consumption and monitoring of water.

Data Collection (With Smart Water Meter Data)

For this part of the project, data regarding water consumption with the use of the smart water meter has been collected. This data included information about water consumption, present and last meter reading, etc. This information has been collected for the month of March.

Preparing Data for Comparison (Not Considering Smart Water Meter Data)

Data was prepared for comparison, which reflects the condition of conventional water metering and without using Smart Water Meter technology. Comparative data sets were designed with realistic domestic water consumption patterns, along with consumption differences. This was helpful for comparing the efficiency difference of smart meter systems and conventional water metering.

Comparative Analysis of the Datasets

The collected datasets were subjected to analysis, and comparative analysis was performed to compare the usage of water with and without Smart Water Meter technology. Several metrics such as daily consumption pattern, average consumption of water, monthly consumption of water, and associated cost estimates were compared.

Analysis of Water Consumption

Water consumption was analyzed to study the patterns of water usage in daily and monthly terms of the two different approaches mentioned above. With comparative analysis, consumption differences were found in the use of conventional water metering methods and smart metering.

Cost Analysis

A cost analysis approach was used to determine the monthly cost of water use based on overall water consumption. The analysis showed that there is an estimated cost of using water in systems without or with the application of Smart Water Meter.

Charts and Statistical Analysis

Various types of charts like bar, line, pie, and comparison charts were created for the visualization of collected data. Methods of statistical analysis were used to find out consumption rates and the effectiveness of savings. With the help of these charts, a comparative analysis was possible.

Analysis of Water Savings

The water savings analysis was carried out with the calculation of total water consumption of both systems. To estimate the amount of water saved, the difference between conventional and Smart Water Meter consumptions were calculated. It was found that Smart Water Meter technology plays a significant role in decreasing water wastage.

Result & Discussion Preparation

The results of the data analysis and interpretation were presented systematically for discussion. In the discussion part, emphasis was laid on elucidating how the IoT enabled Smart Water Meter system would have an effect on conserving the water resources. The observed results of the study were contrasted with those reported in earlier research papers.

Conclusion

The concluding part of this study includes a brief summary of all its outcomes and emphasizes the significance of Smart Water Meter systems in smart urban water management. The conclusion states that by deploying such monitoring tools, wastage of water can be prevented.

IV. RESULT AND DISCUSSION

This section of the paper discusses the comparative study of water consumption before and after the application of SWM using the collected monthly data. The different aspects, such as daily water consumption, average water consumption, savings of water, and estimated costs were analyzed using graphs and statistical approaches. The findings from the analyses were then used to determine the effectiveness of IoT-enabled Smart Water Monitoring Systems in minimizing water wastage.

Table 1: Comparison of the water used and (%) saved

Date	With SW M (KL)	Without SWM (KL)	Water Saved (KL)	Savings Percentage (%)
01-03-2026	422	503	81	16.1
02-03-2026	0	15	15	100.0
03-03-2026	537	675	138	20.44
04-03-2026	525	652	127	19.48
05-03-2026	66	89	23	25.84
06-03-2026	480	572	92	16.08
07-03-2026	0	15	15	100.0
08-03-2026	559	657	98	14.92
09-03-2026	0	15	15	100.0
10-03-2026	521	675	154	22.81
11-03-2026	0	15	15	100.0
12-03-2026	460	582	122	20.96
13-03-2026	473	627	154	24.56
14-03-2026	0	17	17	100.0
15-03-2026	457	593	136	22.93
16-03-2026	497	584	87	14.9
17-03-2026	37	64	27	42.19
18-03-2026	521	663	142	21.42
19-03-2026	533	687	154	22.42

20-03-2026	1	16	15	93.75
21-03-2026	518	614	96	15.64
22-03-2026	0	15	15	100.0
23-03-2026	364	449	85	18.93
24-03-2026	583	766	183	23.89
25-03-2026	540	651	111	17.05
26-03-2026	0	15	15	100.0
27-03-2026	609	773	164	21.22
28-03-2026	0	15	15	100.0
29-03-2026	535	628	93	14.81
30-03-2026	0	15	15	100.0
31-03-2026	587	731	144	19.7

A comparative analysis of water consumption in terms of implementation and non-implementation of Smart Water Meter (SWM) shows high effectiveness of IoT-enabled monitoring systems in water saving and increasing efficiency of water consumption monitoring. The water consumption of residents was examined on the basis of monthly residential water consumption for March 2026 based on various indicators of water consumption such as daily water consumption, average water consumption, water saved, and cost savings.

From the analysis, water consumption without using SWM technology was relatively higher and varied because there was no continuous monitoring and consciousness about water consumption. The system that uses the SWM technology showed controlled and consistent patterns of water consumption. It is evident from the analysis that the real-time monitoring of the system enabled reduction in unnecessary water consumption.

According to the percentage of savings analysis, 2563 KL of water consumption was saved and the percentage of savings efficiency came out to be nearly 20.69%.

V. CONCLUSION

1. Comparative analysis showed that the Smart Water Meter (SWM) system is useful for achieving a reduction in total water usage.

2. The IoT-based monitoring system helped in improving the efficiency of water management by providing continuous monitoring and increased consumption awareness.

3. It was found that systems that used Smart Water Meter technology had more steady and consistent water usage practices.

4. The use of the Smart Water Meter system can help in sustainable water conservation and efficient urban management.

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