Smart Water Management System's Techniques Analysis

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***Abstract*—The ever-growing demand for water coupled with concerns about resource depletion necessitates innovative solutions for efficient water management. This is where IoT-based water management systems emerge as game-changers. These intelligent systems leverage the power of the Internet of Things (IoT), integrating sensors, software, and connectivity to monitor, analyze, and control water resources in real-time. An IoT-based water management system is a smart and connected infrastructure involving both hardware as well as software aspects of recent technology that allows for the efficient monitoring and management of water resources. Leveraging Internet of Things (IoT) technology, these systems intelligently monitor, analyze, and control water resources. This review aims to provide insights into the evolution, challenges, and advancements in IoT-driven water management solutions. These insights can help users to optimize water usage, reduce waste and costs, and ensure the sustainability of water resources. The synthesis of diverse findings will contribute to a comprehensive understanding of the current state-of-the-art technologies and potential avenues for future research in this critical domain. In future integrating artificial intelligence (AI) could enable predictive maintenance and proactive leak prevention, furthering the efficiency and sustainability of water resources.**

***Index Terms*—Water supply system, water level sensor, pressure sensor, internet of things, water flow sensor, cloud computing, Raspberry pi, GSM, WSN**

I. Introduction

Water plays an indispensable role in sustaining human life, supporting growth, and catering to the demands of a burgeoning population, urban expansion, and economic development. Water scarcity and the imperative to enhance water use efficiency have become pressing global challenges. In response to these challenges, the integration of Internet of Things (IoT) technology into water management systems has emerged as a trans-formative solution. IoT facilitates real-time monitoring, data analytics, and intelligent decision-making, offering unprecedented opportunities to optimize water distribution, reduce wastage, and ensure sustainable practices, offering a dynamic solution to optimize water usage. This review comprehensively explores the landscape of IoT-based water management, encompassing its technological foundations, applications, and implications. By synthesizing existing knowledge, we aim to provide a holistic perspective on the role of IoT in revolutionizing water management strategies for a more sustainable future. Harnessing the power of Internet of Things (IoT) technology along with data-driven decision-making, the smart irrigation and water management system aspires to elevate the efficiency and effectiveness of the irrigation process.

II. Literature Survey

An essential natural resource for maintaining the environment and life is water. To ensure sustainable development, water resources must be managed sustainably and effectively. The planning and management of water resources, as well as their optimal, cost-effective, and equitable use, have become extremely urgent due to the critical importance of water for human and animal life, ecological balance, economic and developmental activities of all kinds, and its growing scarcity.

A. Globalization

The adoption of new regulations and guidelines for international trade in products and services is being driven by the growing power of multinational corporations that are indirectly involved in the use and transport of water. Trade globalization affects consumers, governments, and the environment in a variety of ways. Although virtual water—the water used to create the items that are exchanged across borders—is not frequently traded, with the exception of very small amounts in bottles, it can significantly affect the water balances in basins and regions [12]. One of the main issues the nation is currently facing is the scarcity of water. This issue is largely the result of inadequate resource management. We allow huge quantities of water to run off into the sea unutilized while also overusing our rivers, lakes, groundwater, and other water supplies. When tackling the issue of water shortage in the nation, the importance of public water management cannot be overstated [13].

In the referenced paper [2], the document addresses critical local-level concerns, encompassing agriculture, health, sanitation, and related industries. It underscores the profound link between water security and various facets of human livelihood and well-being. The jeopardy posed to water security by climatic variations and prolonged dry spells, leading to droughts and famines, is a recurring historical theme globally and notably in India. The paper delves into the exploration of Indian Traditional Water Harvesting Systems across diverse regions and states, shedding light on their unique characteristics and contributions to addressing these challenges.

In this paper [1] the author has shown the importance of demand for water. Paper shows rapidly growing cities and supply of clean and uncontaminated water has reduced due to low water resources and high contamination. The availability of freshwater is highly seasonal and both flood and drought in a yearly cycle affects river morphology. Paper also focused on the need for water management: Poverty alleviation, Employment generation, Food security, Fisheries, Improvement of quality of life, Protection and preservation of the environment, etc. to preserve water for daily usage. This paper identifies various geographic, socioeconomic and environmental factors that shape the water management issues. Paper also shows solutions for water management during the dry season on shortage of water, Flood and drainage congestion, Waterborne diseases, Sedimentation, Land erosion Arsenic contamination, Groundwater availability and quality, etc.

In general water management need to take control of risk management, water security and fulfilling the need of water

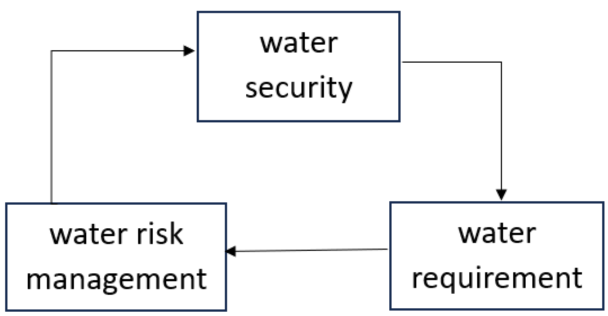

Fig. 1. Need for water management

B. Research on Water Management

This paper [3] describes the use of ultrasonic transducers under the tank lid to measure water level. The distance between the top of the tank and the water surface is obtained by measuring the time between transmitted and received ultrasound pulses. The volume of water is calculated based on the dimensions of the tank. The paper also discusses the development of a sensor with optimized circuitry and algorithms that can achieve a range of up to 10m with an accuracy within ±1.5% of full scale, using low-cost transducers. However the model needs to include control valves and a micro-controller so that we can create a smart distribution system which distributes just enough water to each of the tanks to satisfy the required local demands.

Paper [4] by Mrs. S. Porkodi, Mrs. K.M. Annammal, J. Thesai Jebas, S. Karuppasamy, S.Aron, proposes a system that includes water tank overflow switches that use sensors to detect water level in the tank and can automate the water pump process. The fully automatic water overflow controller switches on the water pump when the water level is low and switches it off when the tank is full. It also has a manual mode that allows users to control the water level manually. The ultrasonic sensor detects the water surface distance, and the ESP uploads the value to a cloud database. The motor function depends on the current water level and maximum-minimum values set by the user respectively in the Android app. This system aims to save manpower and makes efficient use of available water resources, resulting in higher profits. But this system can't detect water quality or find leakages.

Pranita Vijaykumar Kulkarni along with Mrs.M.S.Joshi in their paper [5] describe a system that involves the use of Raspberry Pi as the core controller. Multiple sensors are used to measure water quality, and Python is used to read their values at set intervals. Raspberry pi sends data to the IoT module, which transmits it to the internet through cloud computing. The monitoring parameters of water are transmitted through the IoT module to the gateway, where data analysis takes place. A water sensing component is fitted to the tap, so that if water isn't available, a message is triggered. The system offers secure and continuous monitoring, reducing manual work and making the system more efficient and reliable at a low cost. The system has not been implemented practically therefore many factors are neglected.

This research [6] introduces a water management system employing motors for water pumping, complemented by pressure sensors of range 0-10 bars, flow meters with range min 0.45 m^3/h - max 30 m^3/h range, and ultrasonic sensors for leakage detection in the water distribution network. The implementation includes an actuation system with electronic valves and solid-state relays, enabling automated water management. Real-time data from sensors is relayed to a central system via IoT networks, facilitating comprehensive monitoring of the water distribution system. But, the system lacks water quality sensors to monitor parameters such as pH level and turbidity. This paper's results are based on the 2011 Census report. Today's ground-level present situation is undoubtedly different.

In paper [7] the system consists of three layers: WSN (Wireless Sensor Networks), IoT, and Cloud. The WSN layer includes continuous level sensors and water flow meter sensors that transmit data to a base station, which in turn transmits to the Cloud. The IoT layer provides connectivity that allows sensors to connect to the Cloud, and the Cloud layer includes awareness, control, and management applications as well as big data analytic tools. The water distribution architecture is suitable for intermittent water supply and detection of leakage. No practical step has been taken towards any phase, and localization of leakage remains a problem. The implementation of such a system will be economically high-priced and inconvenient.

The presented water quality monitoring system in paper [8] includes two solenoid valves that open or close based on the detected water quality. If the water quality sensors give a good acceptable reading, the first solenoid valve is opened while the second is kept closed. In contrast, if the sensors detect poor water quality, the first valve is kept closed, and the second valve leading to a water filter is now opened. Users receive a notification message regarding the closure of the solenoid valve and detected water quality readings. This model is made using NASAs' six main phase engineering design process (EDP) model. The pH of the water cannot be raised by water filters; they can only lower the amount of dissolved particles in the water.

The system presented in paper [9] uses different types of sensors, Arduino UNO, GSM module, 220V AC 2-way motorized electric ball valve, and 240V AC relay switch to monitor and control water levels in tanks. The ultrasonic sensor detects water levels, and if the tank needs filling, the Arduino sends a signal to turn on the solid-state relay switch for the water pump. The water pressure sensor ensures that the water pressure remains acceptable to avoid rupture or any kind of damage to the pipes, and the micro controller sends a message to the solid-state relay switch to close or open the motorized electric valve. The GSM module sends data to the server to report the status of the reservoir and current activities of the pumping station. The web server component includes a Raspberry Pi configured as a web server to view status or activities and control different reservoirs and pumping stations. The web application is designed to control the monitoring and controlling system of the different stations and reservoirs by sending an SMS with predefined keyword messages.

The main objective of this project paper [10] is to enhance farming practices by implementing a smart irrigation monitoring system using Arduino. The system checks temperature, humidity, and soil moisture, enabling automated control of the water pump based on predefined soil conditions. Arduino serves as the central controller, managing sensors and actuators. The proposed system offers real-time information on field irrigation, reducing water consumption and optimizing resources. It employs a wireless sensor network for remote monitoring via GSM and Bluetooth. The architecture involves a micro controller, sensors, water pump, and servo motor. The system's advantages include cost reduction, resource optimization, and improved environmental quality. Evaluation demonstrates the efficient functioning of the system in maintaining optimal soil moisture levels, contributing to sustainable agriculture. Future work may include incorporating a water meter for usage estimation and exploring additional features such as valve control and wireless sensors.

This paper [11] discusses an IoT and cloud-based sustainable smart irrigation system. It employs sensors placed in the field to monitor soil moisture, temperature and humidity levels in real-time. The NodeMCU is used to process and relay this information, considering standard deviations and crop-specific parameters. This system uses local weather data to optimize watering schedules based on weather patterns, humidity and soil moisture rates, and crop water needs. Cloud-based platforms improve scalability and accessibility, allowing farmers to remotely monitor and adjust the irrigation system. The paper emphasizes water conservation, cost effective, time efficiency, enhance plant health, and environmental sustainability as potential outcomes of the smart irrigation system. The implementation involves hardware components like NodeMCU, soil moisture sensors and DHT11 sensor, along with a cloud-based system for data processing and analysis. The system aims to revolutionize water management practices and also promote sustainable agriculture and landscaping.

The project [14] introduces an IoT-based remote control water distribution system designed to address water leakage and waste in distribution systems. Utilizing components like ESP8266, DTMF, and a mobile application, the system allows operators to control valves remotely, enhancing response times to leaks. The DTMF calling system serves as a backup in the absence of internet connectivity. This paper focuses more on leakage detection and fast response during leakage situations. The Blynk server dashboard provides a user-friendly interface for monitoring and controlling valves. In case of no internet connectivity the DTMF module can be used but if there's sufficient connectivity then the DTMF module adds redundancy to the system also the leakage should be detected manually and informed to the respective person who has control of the system in order to switch off the valves. Successful testing demonstrated reduced water wastage and improved system efficiency. The project suggests potential extensions for incorporating machine learning algorithms and water quality monitoring. Overall, it offers a promising solution to enhance water distribution system sustainability.

C. Analysis of Tabular Information

Unlike traditional, often manual methods, IoT systems offer several advantages like Real-time data collection where sensors gather detailed information on water flow, water pressure, and quality, enabling proactive leak detection and efficient resource allocation. Next is data-driven insights which provides advanced analytics reveal consumption patterns, allowing users to identify areas for improvement and optimize usage. Automated control of irrigation systems, for example, one can adjust watering based on real-time soil moisture levels, preventing overwatering and saving precious water resources. It also helps in improved decision-making with the use of data visualization and analytics to empower users, ranging from

TABLE I
OVERVIEW OF THE STUDY

Paper Id	IoT Tools Used	Advantages	Problems	Remarks
1	-	Study of various traditional water management practices.	Not very effective and susceptible to more losses.	Tells the need to implement more technologically advanced systems.
2	Ultrasound transducer, 32-bit ARM core M4 with 64 kB RAM.	Achieve a range of up to 10m with an accuracy within ±1.5% of full scale, using low-cost transducers.	Model needs to include control valves and a micro-controller.	As per dimension optimization is carried out and the transducer has good accuracy.
3	Ultrasonic sensor, ESP 8266, cloud database,WSN.	Installation of this system is less expensive, and makes efficient use of available water resources.	No leakage detection. Proposed system's full circuit diagram is not given.	Additional sensors can be used for better management systems.
4	Raspberry pi, GSM ,Water flow Sensor, water level sensors, chlorine detection sensors, pressure sensor, WSN.	It considers multiple parameters for water supply monitoring.	The system has not been implemented practically.	With practical implementation, neglected parameters can be addressed appropriately.
5	Pressure sensors, Flow meter, Ultrasonic water level sensor, Motor pumps, Solid-state relays, Electronic valves	Real-time information from sensors is communicated to a central system with IoT networks. Helps with leakage detection.	Lacks a water quality monitoring system.	By implementing the proposed system, significant losses in supply can be avoided.
6	Water level sensors, Water flows meters, Electric valves , WSN, IoT and Cloud.	Leakage within the zone could be detected. Access real-time information.	No practical step has been taken towards any phase, and localization of leakage remains a problem.	Help to understand layered architecture technologies.
7	NodeMCU ESP32, automatic shut-off valves, Water pH sensor, total dissolved solids sensor, solenoid valve, WSN.	Users can know their daily water consumption at home.	No leakage detection feature.	Initially used Fritzing software was changed to Proteus software due to the components not available in the Fritzing library.
8	Arduino UNO, Raspberry Pi, Ultrasonic sensor, pressure sensor, GSM, WSN, 220V AC 2-way motorized electric ball valve, and 240V AC relay switch.	Fuzzy logic algorithm was implemented. Maintains acceptable pressure in the system. Web application is designed to control the system by sending an SMS with predefined keyword messages.	Leakage cannot be detected.	Ease of user operation is kept in mind while designing the system.
9	Arduino ATmega328, GSM, WSN, Bluetooth, soil pH sensor, moisture and temperature sensors.	Real-time field irrigation information. Cost reduction and resource optimization. Mitigation of water logging and shortages.	Water quality is not monitored.	System saves time and ensures judicious usage of water.
10	NodeMCU, WSN, DHT11 sensor, solenoid valves and soil moisture sensor.	Data driven system decisions.	Leakage and water quality remains a problem.	The system aims to improve water management practices and promote sustainable agriculture.
13	ESP8266, DTMF, GSM, solenoid valves, WSN.	Valve control possible in both with or without internet connectivity conditions	Manual leakage detection is required and if internet connectivity is available then DTMF module is redundant	More sensors may be added to increase autonomy of the circuit and reduce human reliance to detect leakage.

individual consumers to large enterprises, to make informed decisions for sustainable water management.

This technology holds immense potential for the future. As sensor technology advances and data analytics capabilities further improve, we can expect even more sophisticated and personalized water management solutions. Additionally, integrating artificial intelligence (AI) could enable predictive maintenance and proactive leak prevention, furthering the efficiency and sustainability of water resources. By embracing IoT-based water management systems, we can navigate towards a future with secure and sustainable water supplies for generations to come.

Based on the studied research paper, a tabular information is made. following points are need to be considered for proposing methodology to build a new system.

- As per the technology details, Most of the researchers used ultrasonic sensor in the circuit to read the water level values.
- Researchers also used basic electronic component like transducer for micro controlling operation. i.e. to control the valves or motors operation.
- Technical studies IoT and Cloud combination can be used to generate databases for water management system.
- Prediction system can be developed considering Artificial tools like Fuzzy logic, Neural network, Genetic algorithm can be used to predict the water consumption.

- Electronic system is the more useful for learning water logging problem, water quality problem or any risk related to water management.
- If the methodology includes AI based techniques, it will be useful for data driven decision making

III. Conclusion

In conclusion, the reviewed papers collectively underscore the multifaceted approaches and technological innovations in water management systems. While some papers focus on real-time monitoring and automation of water distribution, such as the utilization of ultrasonic transducers and overflow switches, others delve into comprehensive systems involving Raspberry Pi controllers for water quality monitoring or IoT, Cloud, and Wireless Sensor Networks (WSN) integration for intelligent water distribution. Each system exhibits unique strengths and limitations, addressing specific aspects of water security, quality, or distribution. Challenges such as the lack of practical implementation and oversight of factors in theoretical models should be addressed for effective real-world applicability. The integration of IoT, cloud computing, and sensor technologies collectively promises a paradigm shift in water resource management, offering potential solutions to critical global challenges such as droughts, famines, and sustainable agriculture.

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Compliance with Ethical Standards

1. There is no potential conflicts of interest of any author in writing this paper

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My data availability statement

In the capacity of author, we have not used any public or private data related to health, or environment in this review paper.