

Blockchain Based Water Management System using IOT Sensors

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Abstract- This research introduces a Blockchain-Based Water Management System designed to boost transparency, efficiency, and trust in how water is distributed and monitored. The system uses IoT-based water sensors to gather real-time information on how much water is used, how much is flowing, and whether there are leaks. This data is securely stored on a blockchain network. Smart contracts are used to automatically track water use, handle billing, and control access, making sure the data can't be changed or tampered with. A decentralized ledger means we don't rely on a single authority, which stops people from altering data—this ensures a fair share of water for everyone involved. A web-based dashboard gives authorities and consumers real-time data, helping them make better decisions and save water. Testing shows data is sent securely, transactions are validated reliably, and there's more transparency than traditional systems. This system has strong potential for managing water resources sustainably in smart cities and rural areas.

Keywords – Blockchain, Water Management, IoT, Smart Contracts, Decentralized Systems, Smart Cities.

I. INTRODUCTION

As the need for water grows because of population increase and climate change, there's a stronger need for efficient, transparent, and sustainable water management systems [1]. Traditional systems often depend on centralized infrastructure, which can lead to problems like data tampering, inefficient water use, lack of transparency, and slow responses to leaks or misuse. These issues can hurt water conservation and fair sharing, especially in areas with limited monitoring. Combining the Internet of Things (IoT) with blockchain offers a good solution to these problems. IoT sensors and smart meters can track water flow, usage, and leaks in real time [2]. However, IoT systems can be unsafe, data can be changed, and they can fail because they depend on one central point. Blockchain helps by using a decentralized, unchangeable record to store water usage data and system events. It also allows smart contracts to handle water use rules, billing, and access control without needing a middleman. Combining real-time sensor data with analytics helps authorities watch usage patterns, find issues, and manage water more efficiently [3].

This mix improves transparency, trust, and accountability among people like users, water providers, and regulators. This study introduces a Blockchain-Based Water Management System that allows real-time monitoring, transparent data sharing, and automatic water resource management. The system combines IoT sensors with blockchain to protect data, make things run more smoothly, and help people use water more sustainably. The use of blockchain with IoT has seen a lot of interest in improving water resource management by making

it more transparent, real-time, and automated. Many studies point out that blockchain-based water systems can make operations more efficient, data more reliable, and users more confident. By using decentralized storage and smart contracts, these systems make monitoring and management easier for both officials and customers, cutting down on manual work and administrative hassle. Recent studies have looked into how effective and user-friendly blockchain-based resource management can be. Kumar et al. did a review of blockchain applications in smart utilities, categorizing them into water distribution, billing automation, and leak detection systems. Their work found that blockchain makes it easier to access water usage records and reduces disputes because of its unchangeable logs. Sharma and Verma suggested an IoT-powered smart water system using blockchain to automate billing and enforce usage rules, focusing on better user experience with real-time dashboards and open data access.

Using smart contracts greatly improves the system's usability by handling essential tasks like recording water use, billing, and controlling access automatically. These automated steps take away the need for manual work and lower administrative costs, allowing officials to manage water distribution effectively through easy-to-use dashboards. Customers can track real-time water use, billing, and alerts about leaks or unusual usage through a simple web or mobile app. Edge processing also makes things easier by checking and cleaning sensor data before sending it to the blockchain, lowering delays and keeping the system running smoothly. Alerts generated at the edge layer let people respond quickly to leaks or high usage, saving water without needing constant supervision. The decentralized nature of blockchain means it doesn't rely on a

single server, reducing system downtime and making it more reliable. Overall, the system is easier to use because it has automatic processes, clear data access, and simple interfaces. By using IoT, blockchain, and cloud-based analytics, water management is made more efficient, secure, and accessible, making it a practical option for real-world use in smart cities and places with limited resources.

II. LITERATURE REVIEW

Traditional water management systems often have issues like lack of transparency, data being changed, inefficient distribution, and slow discovery of water quality problems. Newer technologies suggest that combining Blockchain, IoT, and AI can greatly improve the way we manage water resources. Blockchain provides a decentralized and unchangeable record system that safely holds water allocation records, billing, and quality reports. Researchers have noted that blockchain builds trust among stakeholders by stopping unauthorized changes to data and enabling clear monitoring of how water is distributed. Several studies have suggested using IoT-based monitoring systems where sensors capture data like pH, cloudiness, how well water conducts electricity, and carbon levels. These factors are important for knowing water quality. The data collected is usually cleaned and checked for accuracy before being stored. When blockchain is used, only confirmed data or data coded with a digital fingerprint is stored on the blockchain, while larger groups of data are stored elsewhere to save space and improve performance. This mix of storing data both on and off the blockchain is often suggested in recent research for better scalability and performance.

Machine learning is becoming more common for predicting water quality and determining if water is safe to drink. Techniques like Random Forest, Support Vector Machines, and Neural Networks have shown good results in predicting whether water is potable. These AI models can help find contamination early, allowing for quick actions to prevent problems. However, experts stress the need for good data preparation, including cleaning the data, normalizing it, and choosing the right features to make the models more accurate and dependable. Smart contracts are important for managing water distribution and billing. They can automatically set limits on water use, calculate how much to charge, update payment statuses, and send alerts when something is wrong. This lowers the need for manual work and makes water sharing fairer. Also, blockchain systems offer a way to track records, which helps regulators check data efficiently. Even with these benefits, there are challenges in using blockchain for water management. These include problems with handling large amounts of data, sensor reliability, keeping data private, and making the system work with older infrastructure. Experts suggest using permissioned blockchain networks to balance transparency and privacy while making transactions faster. Overall, the research shows that combining blockchain, IoT, and AI creates a strong

system for monitoring water quality, sharing water fairly, and securely storing records.

III. METHODOLOGY

The proposed blockchain-based water management system follows a layered and modular approach that combines IoT sensing, edge processing, blockchain technology, and cloud-based analytics to manage water resources securely, transparently, and efficiently. The system is designed to support real-time monitoring, automatic decisions, and reliable data storage while being easy to use and scalable.

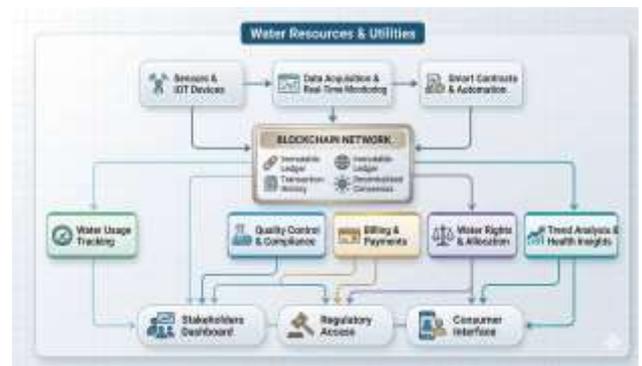


Figure 1. Flow structure of the proposed system

The process starts with IoT-enabled sensors like flow sensors, level sensors, and leak detectors placed at key points in the water network are show in figure 1. These sensors gather real-time data on usage, flow speed, storage levels, and possible leaks. The data is sent to an edge processing unit, such as a microcontroller or Raspberry Pi, for initial checks and filtering. At the edge processing stage, raw data is cleaned to remove noise, spot unusual patterns, and reduce data sent over the network. This reduces delays and data usage, allowing quick local responses. If a problem like leaks or high usage is found, local alerts are triggered to take action. The cleaned data is then securely sent to the blockchain for long-term storage. The blockchain part keeps an unchangeable and shared record of all water usage data. Each entry is stored as a transaction, making the data secure and hard to alter. Smart contracts are used to manage operations like logging usage, controlling access, and handling billing. These contracts follow rules on their own, reducing the need for manual checks and making the system transparent for all users.

To support advanced analysis and user interaction, selected blockchain data is synchronized with a cloud platform for storing and processing data. The cloud allows for data visualization, analysis, and report creation through easy-to-use dashboards for water authorities and consumers. Users can check real-time consumption, receive alerts, and view billing information via secure websites or apostle system also includes strong security features like user verification, data encryption,

and access controls. These ensure only authorized users can see sensitive information and comply with data protection rules. The overall approach ensures the system runs efficiently, is transparent, and helps manage water resources well for both cities and rural areas. To handle data efficiently, the system uses a mix of storing data both on and off the blockchain. Important records, transaction hashes, and access logs are kept on the blockchain for their reliability and traceability, while large sensor data is stored off-chain in the cloud. This lowers the cost and storage needs of the blockchain, improves scalability, and keeps data integrity.

The system also uses real-time analytics and methods to detect unusual water usage and possible system issues. By looking at historical and current data, it can spot leaks, unauthorized use, or changes in water demand. These insights help water authorities make smart decisions, improving distribution and maintenance of their systems. To make the system user-friendly, it uses different interfaces for different users. Water managers have dashboards to track system performance, manage contracts, and control billing, while consumers see simple views of their usage, bills, and alerts. This division of interfaces makes the system clear, easy to use, and less complicated for everyone involved. The proposed approach also focuses on scalability and the ability to work with other systems. The modular design allows the system to connect with existing water systems and expand by adding new sensors or service areas without major changes. Using common communication standards and APIs helps connect with other systems like smart city platforms, ensuring the system can grow and adapt over time.

IV. RESULTS ANALYSIS

The Blockchain-Based Water Management System was tested to see how well it works in real-time monitoring, data security, system speed, and overall performance. The system was tested using simulated water distribution situations that included normal use, leaks, and unusual water use. The results show that using IoT and blockchain together makes the system more transparent, reliable, and automated compared to traditional water management systems. Initially, IoT-enabled water sensors like water flow sensors, water level sensors, and leakage detection sensors are placed at key points in the water supply network. These sensors keep sending real-time information about how much water is being used, how fast it is flowing, how much is stored, and if there are any leaks. The data they collect is then sent to a small computer or a device like a Raspberry Pi for some basic checks and filtering. At this early stage, the raw data is cleaned up to get rid of any unnecessary or wrong information. This helps the system respond quickly and reduces the amount of data sent over the network. If something goes wrong, like a leak or unusual water use, an alert is sent right away so actions can be taken quickly.



Figure 2. Results

The valid data then goes to a blockchain system for permanent storage. The blockchain part of the system keeps a secure and unchangeable record of all the water usage data. Each piece of valid data becomes a transaction in the blockchain, ensuring that the data cannot be altered or faked. Smart contracts are used to handle things like recording water usage, controlling who can access what, and managing billing. These contracts run on their own based on set rules, so there's no need for manual checks. This makes the whole system more transparent for everyone involved. To help with advanced data analysis and user interaction, some of the blockchain data is moved to a cloud-based system for more detailed handling. The cloud layer allows for things like making charts, finding trends, and creating reports that water officials and users can see through easy-to-use dashboards.

Users can check real-time water usage, get alerts, and see their bills through secure websites or an app. The system also has strong security and privacy features, including user login, data encryption, and access based on roles. These help make sure only the right people can see sensitive information and meet data protection rules. The entire system is designed to work efficiently, provide more transparency, and help manage water resources better in both smart cities and rural areas. The system also uses real-time analysis to spot unusual water usage or problems with the system. By looking at past and current data, it can detect leaks, unauthorized use, or unexpected changes in water demand. These insights help water officials make better decisions, plan more efficiently, and maintain the infrastructure regularly. The system is also built to grow and work with other systems easily. It uses a modular design that lets it connect with existing water systems and add new sensors or areas without changing the main structure. Using common communication standards and APIs makes it easier to integrate with other platforms, like smart city systems, ensuring it can expand and change over time.

V. CONCLUSION

This research introduced a Blockchain-Based Water Management System that combines IoT sensors with blockchain technology to improve transparency, security, and efficiency in managing water resources. Using blockchain's ability to store data that can't be changed or tampered with, along with smart contracts, the system ensures accurate tracking of water usage, automatic billing, and safe sharing of data between different groups involved. Real-time data from IoT sensors helps keep a constant watch on water flow, usage, and leaks, allowing quick action and better decisions. The system overcomes major issues found in traditional water management, like data being altered, no clear responsibility, and poor efficiency. By using decentralized control and automated processes, the system makes operations easier and builds more trust between users and providers. The system also includes easy-to-use dashboards that help users understand water usage and system performance clearly. Overall, the study shows that using blockchain in water management can greatly support sustainable water use, better use of resources, and the development of smart cities. Future efforts could include expanding the system to larger areas, adding advanced tools like analytics and machine learning for better predictions, and improving blockchain's ability to handle more data and use less energy.

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