Recharge Based Water Supply

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ABSTRACT

The demand for efficient and sustainable water supply systems is ever-increasing due to urbanization and population growth. In response to this challenge, this paper introduces an innovative approach to water supply management by combining the power of the Internet of Things (IoT) and cloud technology. The proposed system is designed to ensure a reliable, efficient, and environmentally sustainable water supply through a recharge-based approach.

This IoT and cloud-based recharge-based water supply system leverages a network of sensors and actuators installed throughout the water distribution infrastructure. These sensors continuously monitor water levels, quality, and pressure, allowing for real-time data collection and analysis. The data is then transmitted to a cloud-based platform, where advanced analytics and algorithms process the information to optimize water distribution.

One of the key features of this system is its recharge-based mechanism, which promotes groundwater replenishment. By monitoring aquifer levels and controlling well pumps, the system helps maintain a balanced water table, preventing over-extraction and ensuring a sustainable source of water in the long term. This environmentally conscious approach aligns with the principles of water conservation and resource management.

Furthermore, the cloud-based platform offers remote monitoring and control, enabling water supply authorities to make informed decisions promptly. Users can access a web-based dashboard to visualize real-time and historical data, track water consumption, and set alerts for any anomalies in the system.

Keyword :- *Cloud Computing, IoT, Machine Learning, Prepaid water supply, monitoring water supply, Automated System, AWS S3, AWS EC2, AWS IOT-Core, AWS Dynamodb, AWS SNS, Paytm Payment Gateway*

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1. INTRODUCTION:

Access to clean and reliable water is a fundamental necessity for human life and economic development. However, the increasing demands on water resources due to rapid urbanization and population growth, coupled with the challenges of climate change and water scarcity, have highlighted the urgent need for innovative and sustainable solutions in water supply management. The integration of cutting-edge technologies, such as the Internet of Things (IoT) and cloud computing, presents a promising avenue to address these challenges effectively.

This introduction sets the stage for a comprehensive exploration of an IoT and cloud-based recharge-based water supply system—a forward-thinking approach designed to transform the way we manage and distribute water resources. In an era where smart cities and digital transformation are becoming prevalent, the convergence of IoT and cloud technology promises to revolutionize water supply systems by providing real-time monitoring, data-driven decision-making, and efficient resource utilization.

Traditional water supply systems often face a range of issues, including inefficient distribution, water losses due to leakages, water quality concerns, and a lack of robust sustainability practices. To combat these problems, the integration of IoT devices allows for the continuous and remote monitoring of critical parameters within the water infrastructure. These parameters may include water levels, pressure, quality, and more. IoT sensors and actuators, strategically placed throughout the distribution network, generate a constant stream of data, enabling a deeper understanding of the system's dynamics.

The heart of this innovative approach lies in the cloud-based infrastructure that processes and manages the vast amounts of data generated by the IoT sensors. Cloud platforms offer the scalability, data storage, and computational power required to analyze this data in real-time, facilitating proactive decision-making. Such advanced analytics can help identify issues like leaks, equipment malfunctions, or deviations in water quality, allowing for immediate responses and enhanced system efficiency.

Moreover, the recharge-based concept within this system takes a holistic approach to water supply management. By monitoring aquifer levels and regulating well pumps, the system seeks to maintain a sustainable balance in groundwater extraction, ensuring the long-term availability of water resources. This approach aligns with the principles of environmental conservation, reducing the ecological impact of water supply practices.

1.1 PROBLEM DEFINATION:

The problem definition for a recharge-based water supply system centers on addressing the challenges associated with sustainable and reliable water sources in the context of increasing demand, environmental concerns, and climate variability. In many regions, traditional water supply systems are grappling with over-extraction from aquifers, declining groundwater levels, and the depletion of natural water reservoirs. Additionally, the impacts of climate change, including altered precipitation patterns and prolonged droughts, further exacerbate the stress on existing water resources.

The need for a recharge-based water supply arises from the imperative to replenish and sustain underground aquifers, which serve as crucial sources of freshwater. Overreliance on conventional water extraction without adequate replenishment leads to long-term environmental degradation and a heightened risk of water scarcity. The problem extends to communities that heavily depend on groundwater for domestic, agricultural, and industrial needs.

1.2 PROPOSED SYSTEM

The proposed system for a recharge-based water supply is designed to address the current challenges in water resource management by introducing a holistic and sustainable approach. Key components of the proposed system include:

Rainwater Harvesting Infrastructure:

Implementation of rainwater harvesting systems to capture and store precipitation effectively. This infrastructure aims to reduce runoff and facilitate the percolation of rainwater into aquifers, contributing to their replenishment.

Aquifer Recharge Mechanisms:

Deployment of targeted recharge mechanisms such as recharge wells, check dams, and infiltration basins strategically located to optimize the natural replenishment of underground aquifers. These mechanisms enhance the groundwater storage capacity and support sustainable water extraction.

Smart Monitoring and Data Analytics:

Integration of smart monitoring devices, sensors, and data analytics tools to continuously assess groundwater levels, water quality, and environmental conditions. Real-time data will enable efficient decision-making and adaptive management strategies.

Community Awareness Programs:

Implementation of community engagement and awareness programs to educate local residents about the importance of water conservation, responsible usage, and the benefits of recharge-based practices. Community involvement is integral to the success and sustainability of the proposed system.

Policy and Regulatory Framework:

Development of policies and regulations that incentivize and mandate recharge-based water supply practices. This includes guidelines for sustainable groundwater extraction, land-use planning to protect recharge zones, and regulations promoting water-efficient technologies

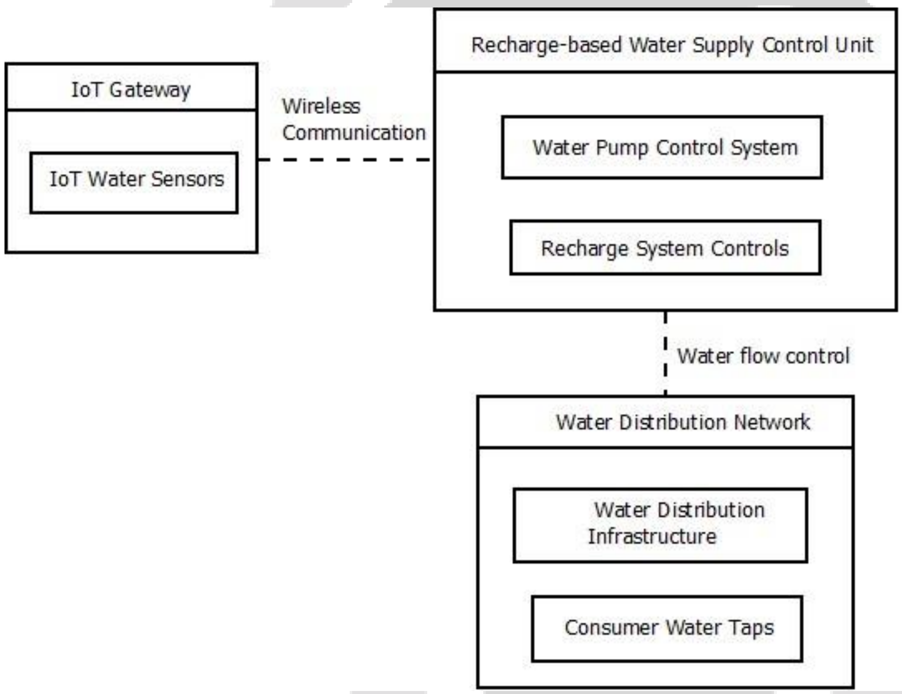

Fig 1.4 Proposed System

2. LITERATURE SURVEY:

- **Paper Title**: Groundwater Artificial Recharge Based on Alternative Sources of Water: Advanced Integrated Technologies and Management
- **Abstract**:
  This research project, conducted within the framework of the Sixth Framework Programme Priority 1.1.6.3 on Global Change and Ecosystems, is dedicated to addressing the pressing challenges associated with sustainable water management in the context of global change. The specific focus of Deliverable D32, titled "Technologies for Efficient Infiltration of Different Quality Waters into Aquifers," underscores the project's commitment to developing advanced technologies and management strategies for recharging aquifers with alternative water sources.
- **Objective**:

The primary objective of the research is to enhance the resilience of aquifer systems amidst changing climate patterns and the escalating demand for water resources. By prioritizing the efficient infiltration of different quality waters into aquifers, the project aims to ensure a sustainable and diverse supply of water for various uses.

- **Approach**:
  The research adopts a comprehensive approach by considering "alternative sources of water," which may encompass treated wastewater, stormwater, or desalinated water. The investigation delves into innovative technologies and management practices, exploring various infiltration methods such as percolation tanks, injection wells, and artificial recharge basins to optimize the recharge process.
- **Technological Integration**:
  Emphasizing advanced integrated technologies, the research leverages cutting-edge tools, including remote sensing, GIS, and real-time monitoring systems. These technologies play a crucial role in mapping and monitoring groundwater recharge zones, assessing water quality, and optimizing the spatial distribution of recharge structures.
- **Contribution to the Sixth Framework Programme:**
  The project significantly contributes to the overarching goals of the Sixth Framework Programme by directly addressing the challenges posed by global change to ecosystems. Specifically, it aligns with the program's objectives of developing innovative solutions for sustainable water management through artificial recharge. Deliverable D32's focus on the efficient infiltration of different quality waters into aquifers showcases the project's commitment to mitigating the impacts of global change on the environment and vital ecosystems.
  This research represents a pivotal step towards advancing knowledge and technologies in groundwater recharge, offering valuable insights for policymakers, water resource managers, and environmental scientists working towards sustainable water solutions in the face of evolving global challenges.

2.1 EXISTING SYSTEM:

The existing systems in the context of the proposed recharge-based water supply are typically characterized by conventional water management practices that often struggle to address the challenges of depleting aquifers, over-extraction, and insufficient groundwater recharge.
Traditional water supply systems may rely heavily on the extraction of groundwater without adequate measures to replenish the aquifers, leading to declining water levels and potential long-term environmental consequences. These systems may lack integrated monitoring and data analytics capabilities, hindering real-time assessment of groundwater conditions.
Additionally, there may be a limited focus on community engagement and awareness regarding sustainable water usage. The absence of comprehensive policies and regulations specifically promoting recharge-based approaches further contributes to the inadequacies of existing systems. In summary, the prevailing water supply systems may face limitations in terms of sustainability, adaptability to changing conditions, and the incorporation of innovative recharge strategies.

2.2 DRAWBACK OF EXISTING SYSTEMS:

The existing water supply systems exhibit several drawbacks that necessitate a shift towards recharge-based approaches. One significant drawback is the over-reliance on conventional extraction methods, leading to the depletion of aquifers and a decline in groundwater levels. These systems often lack sufficient measures for the replenishment of aquifers, resulting in long-term environmental consequences such as land subsidence and the deterioration of water quality.

Additionally, the absence of advanced monitoring technologies and real-time data analytics hinders effective decision-making and adaptive management. Community engagement and awareness about sustainable water usage may be limited, contributing to a lack of participation in conservation efforts. The existing systems also face challenges related to out-dated infrastructure and a dearth of comprehensive policies and regulations promoting sustainable water management practices. The drawbacks collectively underscore the need for a more holistic and innovative recharge-based approach to address the shortcomings of current water supply systems. in big point.

Over-reliance on Conventional Extraction:

Existing systems heavily depend on traditional extraction methods, leading to the depletion of aquifers and a consequent decline in groundwater levels.

Insufficient Aquifer Replenishment Measures:

Inadequate strategies for the replenishment of aquifers result in long-term environmental consequences, including land subsidence and the deterioration of water quality.

Lack of Advanced Monitoring Technologies:

Absence of advanced monitoring technologies and real-time data analytics impairs effective decision-making and adaptive management in water supply systems.

Limited Community Engagement:

Insufficient community engagement and awareness about sustainable water usage contribute to a lack of participation in conservation efforts.

Outdated Infrastructure Challenges:

Existing water supply systems often grapple with challenges related to outdated infrastructure, hindering their ability to adapt to evolving water management needs.

Absence of Comprehensive Policies and Regulations:

A dearth of comprehensive policies and regulations specifically promoting sustainable water management practices adds to the drawbacks of current systems.

3. REQUIREMENT ANALYSIS:

We will see all the requirements used for this project.

3.1 FUNCTIONAL REQUIREMENTS:

The functional requirements for a recharge-based water supply system encompass the essential features and capabilities that the system must possess to effectively address water management challenges and promote sustainability. Key functional requirements include:

Recharge Infrastructure:

The system should facilitate the implementation of various recharge mechanisms such as recharge wells, infiltration basins, and check dams to optimize aquifer replenishment.

Monitoring and Analytics:

Incorporation of advanced monitoring technologies, including sensors and data analytics, to track groundwater levels, water quality, and environmental conditions in real-time.

Rainwater Harvesting:

Integration of rainwater harvesting infrastructure to capture and store precipitation, promoting efficient water utilization and reducing runoff.

Community Engagement Tools:

Tools and features to engage and educate the community on sustainable water usage, conservation practices, and the benefits of recharge-based approaches.

Policy Compliance Module:

A module to ensure compliance with policies and regulations related to sustainable water management, promoting adherence to recharge-based practices.

Smart Decision Support System:

Implementation of a smart decision support system that utilizes data analytics to inform adaptive management strategies and facilitate timely decision-making.

3.2 NON- FUNCTIONAL REQUIREMENTS:

Non-functional requirements are essential characteristics that specify the quality attributes and constraints of a system. For a recharge-based water supply system, these non-functional requirements are crucial to ensure the system's overall effectiveness, reliability, and performance. Key non-functional requirements include:

Reliability:

The system should exhibit a high level of reliability, ensuring consistent and accurate performance in monitoring, data analytics, and aquifer replenishment processes.

Scalability:

The system should be scalable to accommodate changing needs, such as increasing data volume, expanding user base, or incorporating additional recharge infrastructure.

Performance Efficiency:

The system should be designed to operate efficiently, providing quick response times for data retrieval, analytics, and decision support, even during peak usage periods.

Security:

Robust security measures must be implemented to safeguard sensitive data, prevent unauthorized access, and protect against potential cybersecurity threats.

Usability:

The system should have an intuitive and user-friendly interface, ensuring ease of use for stakeholders with varying levels of technical expertise, including community members and administrators.

Accessibility:

The system should be accessible to a diverse range of users, including those with disabilities, ensuring inclusivity and compliance with accessibility standards.

Maintainability:

The system should be designed with ease of maintenance in mind, allowing for updates, modifications, and troubleshooting without causing significant disruptions.

Interoperability:

The system should be interoperable with other water management systems and technologies, facilitating seamless data exchange and collaboration between different entities.

3.3 DESIGN REQUIREMENTS:

Design requirements for a recharge-based water supply system are crucial to ensure that the system is effectively planned, developed, and implemented. These design requirements encompass various aspects, including architecture, functionality, and user experience. Key design requirements include:

Recharge Infrastructure Design:

Design specifications for various recharge mechanisms, including recharge wells, infiltration basins, and check dams, ensuring optimal placement and efficiency in aquifer replenishment.

Monitoring System Architecture:

Architectural specifications for the implementation of advanced monitoring technologies, sensors, and data analytics, detailing the system's structure for real-time groundwater assessment.

Rainwater Harvesting System Design:

Design parameters for rainwater harvesting infrastructure, specifying components such as collection surfaces, storage systems, and distribution mechanisms to maximize water capture.

User Interface Design:

Design guidelines for a user-friendly interface accessible to various stakeholders, emphasizing intuitive navigation, clarity, and responsiveness for an enhanced user experience.

Integration Framework:

Design specifications for the integration of the recharge-based water supply system with existing water supply infrastructure, ensuring compatibility and seamless data exchange.

Adaptive Decision Support System Design:

Designing the architecture of a smart decision support system that leverages data analytics for adaptive management, providing actionable insights for efficient water resource utilization.

Community Engagement Features:

Design requirements for tools and features aimed at community engagement, including educational materials, communication channels, and interactive elements to raise awareness and encourage sustainable practices.

Climate-Resilient Design Principles:

Integration of climate-resilient design principles, specifying measures to address the impacts of climate change on water availability and ensure the system's adaptability.

Security Architecture:

Designing robust security architecture with encryption, authentication, and authorization mechanisms to safeguard sensitive data and protect against potential cyber threats.

SOFTWARE REQUIREMENTS:

- Arduino IDE
- Cloud platform :Think Stick

HARDWARE REQUIREMENTS:

- Arduino UNO
- Flow Sensor
- Relay model
- Water pump
- Esp8266
- RFID receiver
- RFID Card
- Transformer
- Voltage regulator

4. DESIGN:

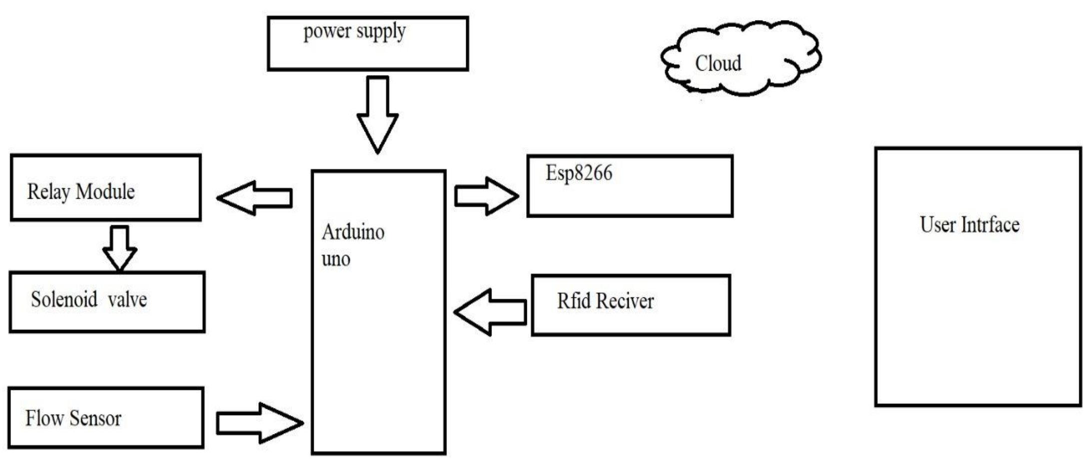

Fig 4.1 System Architecture

Figure 4.1 above depicts the system of the project. It consists of three modules which are Hardware interface ,user interface and cloud. Full system works on the internet. Users will interact with the system using a application. From that application user will first need to make their account after that only it can use that application. When a user wants water then, the user will first pay according to the selected plan. After that users can get their purified water. Payment is done by using paytm API for that user needs to have a paytm account. When recharge is done then this system detects it according to user requirement it will set their counter to that limit i.e if the user wants 5 liter of water supply then this system measures water flow and count till it reaches 5 liter. where according to user consumption it will decrease the counter .This monitoring and measurement of the system is done by using Microcontroller which is NodeMCU . It will send the instruction via the internet from that system will track user consumption of water usage on their daily bases. Through NodeMCU, flow control and solenoid sensor is connected which will be input and output for the system . Which means flow control sensor work as an input device where from that system give feedback for closing water supply to solenoid valve which is nothing but an output device. Both User interface and hardware interface are connected by the help of cloud.

4.2 FLOWCHART:

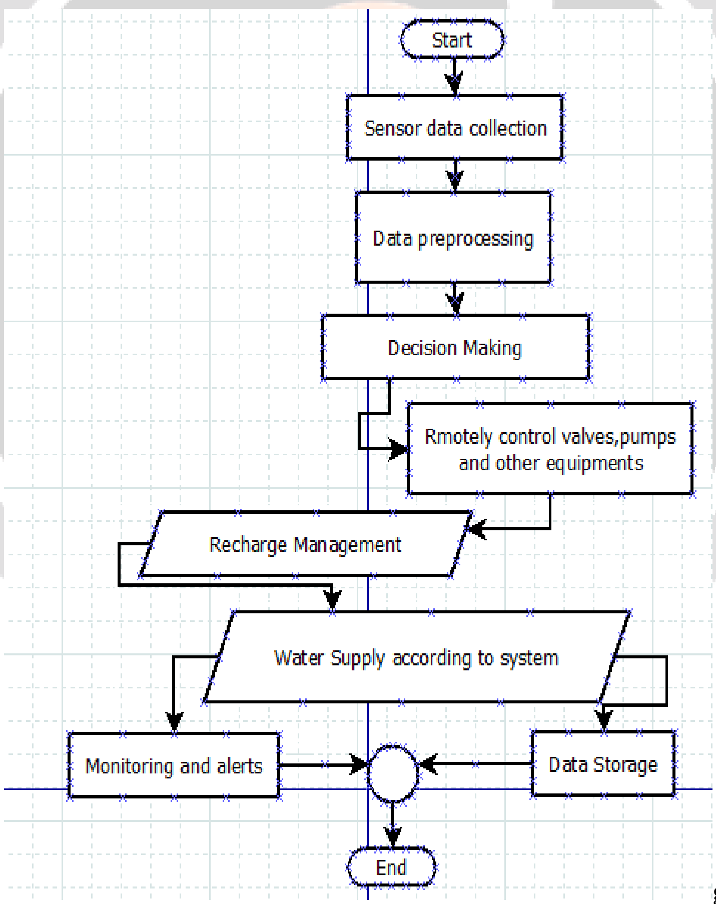

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Fig 4.2 Flowchart of the Project

4.3 ALGORITHM :

- First, making an application which will interact with users should be made by using Spring boot technology which is nothing but an java framework and angular as a front end.
- While form backend which is spring boot we create restful api's, then by using angular framework we are consuming them using http protocol.
- After that in the second phase, we establish mqtt connection with NodeMCU and AWS cloud. where on AWS we are using IOT core service which is useful for mqtt connection, using that we can subscribe topics, where we subscribe two topics one is inTopic and other is outTopic,inTopic is useful for sending instruction from IOT core(AWS cloud) to NodeMCU, where outTopic is useful for sending data from NodeMCU to IOT core(AWS cloud).
- After selecting a plan of recharge amount we use Paytm payment gateway for payment purposes. hence we integrate Paytm Api with our spring boot app, paytm api needed server parameters which we will mention using the backend.
- To store outTopic JSON data we are using DynamoDB which is also an AWS service .DynamoDB is nothing but a NoSQL database. While storing data on DynamoDB we set one partition key which is timestamp and other fields are user_id, recharge_id with their usage amount in liters.
- For alert notification We use SNS service from AWS.
- For security of our application we suses both server side and UI/UX side security. For that we use the JWT form server side for authentication of every user.
- For deployment of our application we use EC2, S3 and RDS services form AWS.

5. CONCLUSION:

The IoT and Cloud-Based Recharge-Based Water Supply System represents a visionary approach to water supply management, offering a transformative solution to the challenges faced by communities, industries, and municipalities worldwide. By integrating the power of IoT sensors, real-time data analytics, and cloud computing, this system has the potential to revolutionize the way we access, manage, and conserve one of our most precious resources: water.

Through this exploration, we have uncovered a series of advantages that this innovative system brings to the table. It offers real-time monitoring capabilities, data-driven decision-making, improved resource utilization, and the promotion of water conservation. The recharge-based mechanism, a cornerstone of this system, ensures the sustainability of our water sources and aligns with environmental conservation efforts.

The applications of this system are diverse, extending to urban water supply systems, agriculture, industrial water management, smart cities, remote areas, and environmental monitoring. It also plays a crucial role in emergency response, ensuring access to clean water during times of crisis. Moreover, by incorporating this system into aquifer recharge programs, it actively participates in maintaining groundwater levels and quality.

Our proposed system can be implemented using dedicated hardware which are mentioned in system requirements which are also cost efficient. As we mention that this system tracks usage details of any user so that we can give notification alerts according to their usage. If a user uses less water per day then we give notification alerts so users can be aware about their health. We are trying to implement this proposed system within a housing society so we can also give health reports to the health department so that it will also be useful for avoiding health issues.

6. FUTURE SCOPE:

The future scope of a recharge-based water supply system holds promising avenues for sustainable water management and environmental conservation. As technological advancements continue to evolve, the system can benefit from integrating cutting-edge innovations such as artificial intelligence, machine learning, and advanced data analytics. These technologies can enhance the system's predictive capabilities, allowing for more accurate forecasting of groundwater levels, precipitation patterns, and aquifer health. The implementation of smart sensors and Internet of Things (IoT) devices can further contribute to real-time monitoring, enabling proactive decision-making and adaptive management.

The future also presents opportunities for increased community engagement and awareness through the utilization of emerging communication platforms and educational tools. Engaging the community in water conservation efforts, promoting sustainable practices, and fostering a sense of shared responsibility can amplify the positive impact of the recharge-based system. Moreover, the integration of blockchain technology may offer transparent and secure data management, addressing concerns related to data integrity and security.

Climate-resilient design principles will play a pivotal role in the future development of the system, considering the ongoing challenges posed by climate change. The system can be adapted to incorporate innovative solutions for mitigating the impacts of extreme weather events, prolonged droughts, and other climate-related challenges on water resources.

Collaborative governance models, involving public-private partnerships and stakeholder participation, can enhance the system's effectiveness. Leveraging the expertise and resources of various entities will contribute to the long-term success and sustainability of recharge-based water supply initiatives.

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