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SMART VILLAGE MONITORING SYSTEM USING IOT SYSTEM

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ABSTRACT

The Smart Village Monitoring System using Internet of Things (IoT) is developed to improve rural infrastructure and provide efficient management of essential village resources through automation and real-time monitoring. The system integrates multiple smart modules including automatic irrigation pump control, water tank level monitoring, smart street light automation, and intelligent waste management into a single IoT-based platform. Soil moisture sensors are used to monitor soil conditions and automatically control irrigation pumps, helping in water conservation and improving agricultural efficiency. Ultrasonic sensors continuously monitor water tank levels to prevent overflow and dry-run situations, ensuring effective water management with minimal manual intervention. The street lighting system uses LDR and IR sensors to automatically control lights based on surrounding light intensity and human or vehicle movement, thereby reducing unnecessary energy consumption. In addition, the smart waste management module monitors garbage bin levels and sends alerts for timely waste collection, improving cleanliness and hygiene in rural areas. All modules are connected and controlled using the ESP32 microcontroller with IoT connectivity, enabling wireless communication, remote access, and real-time data monitoring through mobile or web applications. The proposed system is cost-effective, energy-efficient, scalable, and suitable for smart rural development. By integrating automation and IoT technologies, the system enhances sustainability, optimizes resource utilization, reduces human effort, and contributes to the development of smarter and eco-friendly villages.

KEYWORDS: Smart Village, Internet of Things (IoT), ESP32, Smart Street Lighting, Water Level Monitoring, Soil Moisture Sensor, Automatic Irrigation System, Smart Waste Management, Ultrasonic Sensor, Relay Control, Energy Management, Real-Time Monitoring, Automation, Wireless Sensor Network, Sustainable Development

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INTRODUCTION

In many developing countries, villages play a crucial role in supporting agriculture, food production, and cultural heritage. However, despite technological progress in urban areas, rural regions still suffer from outdated methods of irrigation, water storage monitoring, public lighting, and waste disposal. Traditional systems demand manual supervision, which is not only time consuming but also inefficient and prone to human error. Water is often wasted due to over-irrigation, street lights remain turned ON even when not needed, water tanks overflow unnoticed, and waste bins are emptied irregularly, leading to unhygienic surroundings. These issues collectively affect productivity, energy consumption, environmental cleanliness, and quality of life in villages.

With the rapid evolution of Internet of Things (IoT) technology, it is now possible to build automation systems that can sense, process, communicate, and act intelligently without human involvement. IoT allows real-world devices—such as sensors, pumps, lights and controllers—

Research Paper

to connect to the internet, share data, and make real time decisions. When this technology is applied to rural environments, it transforms traditional villages into Smart Villages, where essential services are optimized using automated monitoring and control mechanisms. The proposed Smart Village Monitoring System using IoT aims to modernize key village operations by integrating four essential modules into a single platform:

1. Soil Moisture-Based Irrigation with Automatic Water Pump Control
2. Water Level Monitoring in Storage Tanks using Ultrasonic Sensors
3. Smart Street Light Automation using LDR and Motion Detection
4. Basic Waste Management through Level Detection Sensors

The system is designed to be low-cost, modular, scalable, and easy to install, making it ideal for small villages as well as large rural communities. Future extensions such as solar integration, GSM alert systems, or machine learning-based prediction models can further enhance its functionality. By reducing manual effort, optimizing water and electricity consumption, and improving hygiene and safety, this project contributes significantly to sustainable rural development. Thus, the Smart Village Monitoring System using IoT is not just an automation project—it is a step toward digital transformation, self reliance, and environmental conservation in rural areas, aligning with national initiatives such as Digital India, Smart Village Mission, and Atma nirbhar Bharat.

LITERATURE SURVEY

[1] "IoT-Based Smart Garbage and Waste Collection" (Navghane et al., 2016)
This paper proposed an innovative IoTbased system to address a common problem in many communities: inefficient waste management. The system used ultrasonic sensors placed in garbage bins to continuously monitor the waste level. When a bin reached a certain fill capacity, the system would automatically send an alert to sanitation authorities, allowing for timely collection. This approach was designed to minimize the need for manual checks, reduce the number of unnecessary trips by collection vehicles, and ultimately improve overall hygiene and public health.

[2] "Smart Irrigation Management System Using IoT" (ResearchGate, 2022)
Focusing on the agricultural sector, this research paper highlighted the use of IoT to create a smart irrigation management system. The system utilized sensors to monitor critical parameters like soil moisture and local weather conditions. Based on this real-time data, the irrigation process could be automated, ensuring that crops received the optimal amount of water precisely when needed. The primary goal of this system was to prevent water wastage, a significant issue in agriculture, and simultaneously maximize crop productivity by maintaining ideal growing conditions.

[3] "IoT Based Smart Village using Raspberry Pi" (Naveen et al., 2019)
This study explored a more comprehensive approach to smart villages by presenting a model that incorporated multiple IoT applications within a single framework. The system was built around a Raspberry Pi, a popular and versatile single-board computer, and integrated solutions for smart garbage management, E-learning platforms to improve education access, and soil monitoring for agriculture. The paper demonstrated the potential for using a centralized, low-cost computing platform to manage various aspects of a smart village ecosystem.

[4] "Implementation of IoT based smart village for the rural development" (ResearchGate,2017)
This research discussed various technical solutions for applying IoT to rural development. The paper detailed the implementation of systems for energy management, aiming to optimize power consumption and distribution; smart irrigation, to conserve water; and waste management, to improve sanitation. The study's focus was on how these technical solutions could be practically deployed to advance rural areas and enhance the quality of life for their residents.

[5] "IoT and Cloud Based Sustainable Smart Irrigation System" (E3S Conferences, 2024)
Taking a step further, this paper reviewed sustainable irrigation systems that combined IoT with cloud technology. It described how IoT sensors collect data on environmental conditions, while cloudbased

platforms store and analyze this information to makeintelligent decisions about irrigation schedules. This approach was particularly focused on optimizing water usage to a high degree of precision and promoting long-term water conservation practices, which is crucial for addressing climate change and resource scarcity.

[6] "Smart Water Resource Management Using Artificial Intelligence" (MDPI, 2022)
This paper went beyond basic IoT to incorporate Artificial Intelligence (AI) into its framework for smart water management. The research focused on developing an efficient and comprehensive framework that used IoT sensors to monitor both water quality and distribution across a network. The AI component was then used to analyze this data to predict demand, detect leaks, and optimize the flow of water, ensuring that a community's water resources were managed sustainably and intelligently.

[7] "Review of IoT based Smart Village for the Rural Development" (IJERT, 2018)
This review paper provided a broad overview of the different IoT-based approaches being used for smart villages. It examined a variety of systems, including smart irrigation, automated street lighting to save energy, and safety systems to enhance security. The review summarized the current state of technology in this field and identified the benefits and challenges of deploying such systems in a rural context.

[8] "Smart Village: An IoT Based Digital Transformation" (ResearchGate, 2021)
This paper outlined the potential of IoT to drive a digital transformation in smart villages. It provided a detailed categorization of how IoT applications could be integrated into various aspects of village life, such as agriculture, social services (like education and healthcare), and essential utilities (such as water and power). The paper served as a guide for researchers and developers on how to holistically approach smart village initiatives.

[9] "Smart village | PPTX - Slideshare" (2016)
This presentation material outlined a vision for smart villages, specifically in the Indian context. It highlighted the importance of using technology, such as various sensors and mobile applications, to monitor and manage local conditions. The presentation served as an early framework for how technology could be leveraged to address specific challenges faced by rural communities in the country.

[10] "SMART VILLAGE USING IoT" (IRJET, 2019)
This study provided a concrete demonstration of a working system for a smart village. The research detailed a prototype that utilized an Arduino microcontroller and a Raspberry Pi for its core operations. The system was designed to implement smart drip irrigation, a watersaving technique, and to perform general environmental monitoring, showcasing a practical application of IoT in a rural setting

PROBLEM STATEMENT

Villages in developing countries like India face multiple challenges in managing agricultural practices, water resources, waste disposal, and energy consumption due to a lack of modern technological infrastructure. Agricultural irrigation is often performed manually or based on traditional assumptions rather than realtime data, leading to either over-irrigation or insufficient watering. Both situations negatively affect crop productivity and waste valuable water resources. Similarly, water storage tanks in villages are rarely monitored, causing issues such as overflow, dry tanks, or inefficient utilization of stored water. Street lighting systems in many rural areas remain active throughout the night regardless of actual usage, leading to unnecessary energy consumption and higher electricity expenses for local governing bodies. Furthermore, improper waste disposal practices result in unhygienic surroundings, blocked drainage, foul odor, and an increase in vector-borne diseases, affecting public health. The Smart Village Monitoring System using IoT aims to address these challenges by introducing automation and real-time monitoring through a centralized platform with four key modules:

1. Smart Irrigation using soil moisture sensing and automatic water pump control.
2. Water Level Monitoring in storage tanks using ultrasonic sensors with real-time alerts.
3. Smart Street Lighting using LDR and motion sensors to reduce unnecessary power consumption.

4. Waste Management System using sensorbased dustbins that notify authorities when bins are full, ensuring timely collection and maintaining hygiene.

This project promotes sustainability, improves resource utilization, and reduces dependency on manual labor contributing to a smarter, cleaner, and more efficient rural lifestyle.

METHODOLOGY

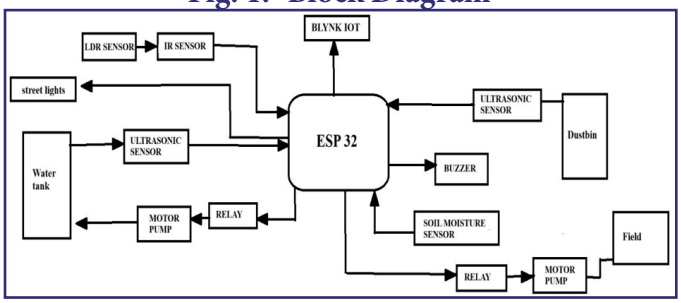
Components

1. ESP32: Acts as the main controller of the system. It collects data from all sensors, processes it, and sends the information to the IoT cloud using Wi-Fi.
2. LDR Sensor: Placed near the streetlight setup to detect ambient light intensity and automatically control street lighting based on day and night conditions.
3. Ultrasonic Sensor: Mounted on the water tank to measure the water level continuously and send real-time level data to the ESP32.
4. Ultrasonic Sensor: Placed inside the dustbin to detect the fill level of waste and trigger alerts when the bin is full.
5. IR Sensor: Used near the dustbin to detect object presence and improve accuracy in waste monitoring.
6. Soil Moisture Sensor: Inserted into the soil to measure moisture content and determine whether irrigation is required.
7. Relay Module: Acts as a switch between the ESP32 and the motor pump, allowing safe control of high-voltage devices.
8. Motor Pump: Used for irrigation; it automatically turns ON or OFF based on soil moisture levels.
9. LEDs: Represent streetlights and indicate system status such as ON/OFF conditions.
10. 1Connecting Wires: Used to establish electrical connections between the ESP32, sensors, and output devices.

Block diagram

The Smart Village Monitoring System is an automation-based technological solution designed to enhance the lifestyle and infrastructure management in rural areas. By utilizing low-cost IoT components such as sensors, ESP32 microcontroller, relay, and actuators, the system enables intelligent monitoring and control of four major public utilities: street lighting, water tank management, smart irrigation, and waste collection. The ESP32, being Wi-Fi enabled and capable of continuous processing, acts as the central hub that collects sensor inputs, processes the data, and performs automated actions without human intervention.

Fig. 1:- Block Diagram



IMPLEMENTATION

The Smart Village Monitoring System is implemented using an ESP32 microcontroller integrated with LDR, ultrasonic, soil moisture, and IR sensors. The ESP32 collects sensor data, processes it, and controls LEDs for street lighting and a motor pump through a relay based on predefined conditions. Two ultrasonic sensors monitor water level and waste bin status. All sensor data and system status are transmitted to an IoT platform via Wi-Fi for real-time monitoring and alerts, ensuring efficient and automated village management effectively. Overall, the project achieved its objectives and proved to be a reliable, costeffective IoT-based smart village solution.

Fig. 2: Full View of Prototype

RESULT

The Smart Village Monitoring System using IoT was successfully designed and implemented using the ESP32 microcontroller and various sensors. The Smart Street Lighting System operated automatically by switching LEDs ON and OFF based on ambient light detected by the LDR sensor, resulting in effective energy savings. The Water Level Monitoring System accurately measured tank water levels using an ultrasonic sensor and displayed real-time data on the IoT platform. The Soil Moisture Monitoring System efficiently controlled the motor pump through a relay by automatically activating irrigation when soil moisture dropped below the threshold. The Smart Waste Management System correctly detected dustbin fill levels using ultrasonic and IR sensors and generated alerts when the bin was full. All sensor data was transmitted wirelessly to the IoT dashboard with minimal delay.The system demonstrated fast response time and reliable operation during testing. Manual intervention was significantly reduced through automation. Resource utilization such as electricity and water was optimized effectively. Overall, the project achieved its objectives and proved to be a reliable, costeffective IoT-based smart village solution.

FUTURE SCOPE AND CONCLUSION

The Smart Village Monitoring System using IoT was successfully designed and implemented using the ESP32 microcontroller and various sensors to automate essential village utilities. The system efficiently controlled street lighting, monitored water levels, managed irrigation through soil moisture sensing, and improved waste management. Real-time monitoring through an IoT platform reduced manual effort and optimized energy and water usage, making the system cost-effective, reliable, and suitable for rural development. In the future, the system can be enhanced by integrating solar power for sustainable operation and using GSM or LoRa communication for wider coverage. Additional sensors for weather, air quality, and water quality monitoring can be added. Advanced mobile applications and AIbased data analysis can further improve automation, prediction, and efficiency, enabling the system to evolve into a complete smart village solution.

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