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Automated Urban Garden System: Real-Time Data Acquisition and Remote Monitoring

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Abstract: — Urban gardening plays a crucial role in enhancing sustainability and green infrastructure in smart cities. However, maintaining optimal plant health requires. This paper introduces an Automated Urban Garden System that uses IoT and real-time data to monitor environmental conditions and automate irrigation. It integrates Arduino with sensors like LDR, soil moisture, and DHT11, controlling a water pump based on moisture levels. Data is uploaded to Thing Speak via the ESP8266, enabling remote monitoring, while a 16x2 LCD displays readings on-site. The system also supports real-time alerts for critical parameters. Experimental results show that it reduces water waste, ensures optimal plant growth, and minimizes manual work. This solution enhances sustainability, resource efficiency, and scalability, making it ideal for smart city applications.

Index Terms — IoT, Arduino, Automated Irrigation, Thing Speak, ESP8266.

I. INTRODUCTION

Urban gardening is becoming a crucial component of smart city infrastructure, promoting sustainability, reducing carbon footprints, and improving urban resilience. However, maintaining urban gardens requires continuous monitoring of environmental conditions such as soil moisture, temperature, humidity, and light intensity to optimize plant .and water usage. Traditional irrigation methods are often inefficient, leading to water wastage or plant stress, which necessitates automated, data-driven solutions.

Fig. 1. Smart Garden System.

Urban gardening is becoming more popular, but several obstacles affect its effectiveness: Poor water management often leads to either excessive or insufficient watering, primarily due to the absence of immediate soil moisture monitoring. Traditional gardening methods necessitate manual labor for watering, making them less efficient in terms of resources. Many urban gardens lack the ability to monitor environmental conditions in real-time, which limits their smart monitoring features Various environmental factors, like changes in temperature, humidity, and sunlight, can influence plant health, highlighting the need for flexible irrigation methods. Recent developments in Internet of Things (IoT) technology have facilitated the creation of intelligent irrigation and monitoring systems that leverage wireless sensor networks (WSN), cloud computing, and real-time data analysis. Urban gardens equipped with IoT capabilities minimize water waste, enhance efficiency, and allow for remote monitoring, making them more sustainable and adaptable for use in smart city initiatives. This paper introduces an Automated Urban Garden System that utilizes IoT, Arduino, and cloud-based data monitoring to enhance urban gardening practices.

The main components of the proposed system include environmental sensors for data collection, such as a soil moisture sensor that monitors water content to automate irrigation, a DHT11 sensor that measures temperature and humidity for environmental assessment, and an LDR sensor that detects light intensity to optimize plant growth. Additionally, the system features an automated irrigation mechanism where water pump activation is controlled based on real-time soil moisture levels. For cloud-based remote monitoring, an ESP8266 Wi-Fi module transmits data to Thing Speak for real-time visualization, while a 16x2 LCD module provides on-site display of environmental readings.

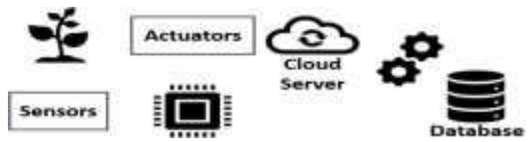

Fig. 2. System architecture of the Automated Urban Garden System.

I. METHODOLOGY

This section describes the hardware, software, and communication architecture of the proposed Automated Urban Garden System. The system integrates IoT sensors, real-time data acquisition, and cloud-based monitoring to automate irrigation and enhance urban gardening efficiency. The proposed system is composed of three key components the first is the Data Acquisition Layer, which collects real-time environmental data using various sensors. The second component is the Processing and Control Layer, where an Arduino microcontroller processes the data and makes decisions for automated irrigation. Lastly, the Communication and Monitoring Layer transmits the sensor data to the Thing Speak cloud via an ESP8266 Wi-Fi module and displays the readings on a 16x2 LCD module.

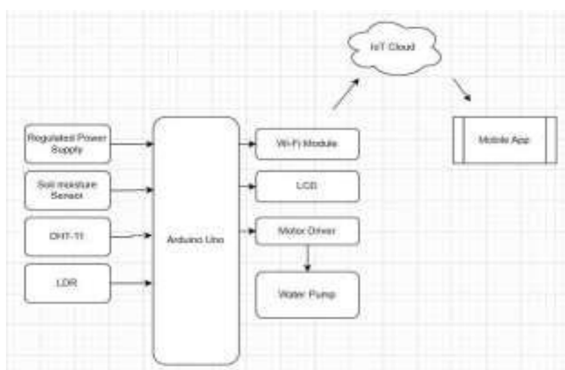

Fig. 3. Block Diagram of the Automated Urban Garden System.

The system integrates multiple IoT sensors and actuators to facilitate real-time environmental monitoring and automated irrigation. It includes a Soil Moisture Sensor that measures the water content in the soil to determine irrigation needs, and a DHT11 Sensor that captures temperature and humidity data to assess environmental conditions. Additionally, an LDR Sensor monitors light intensity to support plant growth analysis. The Water Pump and Relay Module control irrigation based on soil moisture levels, while the ESP8266 Wi-Fi Module transmits sensor data to the Thing Speak cloud for remote monitoring. Finally, a 16x2 LCD Module displays real-time sensor values for on-site monitoring.

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The workflow of communication between components begins with the Arduino microcontroller collecting and processing sensor data. Subsequently, the ESP8266 module transmits these sensor readings to the Thing Speak cloud for visualization purposes, while the LCD module provides time display of readings for local monitoring. Additionally, the system is designed to control the water pump based on soil moisture levels, activating or deactivating it as needed. The decision-making algorithm follows a systematic approach: it starts by reading data from sensors that measure soil moisture, temperature, humidity, and light intensity. When the soil moisture falls below a certain threshold, the algorithm triggers the activation of the water pump. Conversely, if the moisture levels rise above the optimal range, the pump is turned off. This process is complemented by continuous updates of sensor values to Thing Speak, ensuring remote access to the data. To evaluate the system's performance, several key metrics are taken into account. Water Usage Efficiency (WUE) assesses the effectiveness of the automated irrigation in reducing water wastage, while Sensor Accuracy evaluates the dependability of the readings from the soil moisture, temperature, and humidity sensors. Furthermore, Response Time measures the system's responsiveness in activating or deactivating irrigation based on real-time data, and Cloud Communication Latency gauges the delay in data updates to Thing Speak. To improve the security of the proposed Automated Urban Garden System, several measures are implemented. First, data encryption techniques are employed to ensure that the transmission of sensor values remains secure, protecting against potential interception. Additionally, access control mechanisms are established to restrict unauthorized access to the Thing Speak dashboards, safeguarding sensitive information. Error-handling routines are also integrated into the system to prevent sensor failures from causing disruptions, ensuring continuous operation. In summary, the Automated Urban Garden System offers a scalable and cost-effective solution for smart irrigation in urban settings. By optimizing water usage and minimizing the need for manual intervention, the system supports real-time remote monitoring, making it a significant contribution to smart city initiatives.

IV.RESULTS

A real-time flash flood monitoring and forecasting system using IoT and ESP32 provides continuous monitoring of water levels and environmental conditions to predict and mitigate flood risks. The system integrates various sensors to measure parameters such as water level, rainfall intensity, flow rate, and temperature. These sensors are connected to the ESP32 microcontroller, which processes the data and transmits it wirelessly to a cloud-based IoT platform. This ensures real-time data collection and remote access for authorities and disaster management teams. Flood forecasting in this system is achieved using either machine learning models or predefined threshold-based algorithms. When sensor readings indicate a potential flash flood, the system generates alerts through SMS, mobile applications, or sirens, notifying local residents and officials. This early warning mechanism helps in timely evacuation and response, reducing the risk to life and property. Additionally, the system logs data in cloud platforms such as ThingSpeak, Firebase, or AWS, allowing continuous analysis of water level trends. These insights enable better flood prediction and preparedness for future events. The ESP32 microcontroller ensures low power consumption and reliable wireless communication via Wi-Fi or Bluetooth, making the system suitable for remote and flood-prone areas. By implementing this IoT-based flood monitoring system, communities can benefit from real-time data access, improved forecasting accuracy, and scalable deployment across multiple regions.

Fig 3.Water flow sensor parameters
Parameters

Fig 4.Ultra sonic sensor parameters

Fig 5.Rainfall sensor

V.CONCLUSION

This research presents an innovative IoT-based flood management system designed to monitor, predict, and mitigate the impact of floods in real time, focusing on Uttarakhand, India. By collecting vital hydrological and meteorological data such as water discharge, rainfall, temperature, and wind speed, the system generates early warnings when thresholds are exceeded, providing critical information to authorities and local communities. The system's success in remote areas with poor network connectivity demonstrates its effectiveness in flood-prone regions. The mobile application "FLOODWALL" facilitates access to real-time data and alerts, ensuring timely action. Utilizing low-cost, energy-efficient IoT sensor units, the system collects data every 30 seconds from three for timely intervention, Since its implementation in July 2021, the system has proven valuable in flood monitoring. Future improvements can enhance prediction accuracy through the integration of Geographic Information Systems (GIS) and remote sensing technologies, facilitating better decision-making and flood forecasting. Additionally, the study introduces a Flash Flood Management Model (FFMM) that applies advanced learning algorithms for real-time flood management, especially in urban areas prone to flash floods. Although initial results were slower compared to traditional methods, the FFMM showed improved efficiency after multiple iterations. The research also highlights the importance of IoT-based flood management systems in mitigating flood impacts through accurate data collection, datadriven decision-making, and predictive analytics. A key innovation in this study is the use of a contentbased recommendation system for data filtering and the application of reinforcement learning for optimized decisionmaking during flood events. This approach demonstrated significant improvements in efficiency compared to conventional flood evacuation systems. Overall, the research underscores the potential of IoT and AI to enhance flood resilience, optimize resource allocation, and protect communities from the devastating effects of floods strategy.

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