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Green-Guardian: Automated Plant Care and Watering System

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Abstract: *Green Guardian is a smart and user-friendly system designed to make plant care easier and more efficient. Built with modern technology, it uses sensors and microcontrollers to track key conditions like soil moisture, temperature, humidity, and light levels. By analysing this data in real time, the system automatically waters plants when they need it, helping them grow well while also saving water. Users can control and monitor Green Guardian through a mobile or web app, which provides real-time updates and remote access. The system also allows for custom watering schedules, sends alerts when something needs attention, and stores past data to help improve plant care over time. This solution is ideal for people who are busy, travel often, or are new to gardening. It's a sustainable way to grow plants without constant manual effort. Green Guardian supports eco-friendly living by reducing water waste and increasing plant survival. Its simple design, low cost, and ability to scale make it perfect for home gardens, greenhouses, or small farms. With Green Guardian, technology meets nature in a smart, practical, and sustainable way.*

Keywords: IoT, Smart Plant Care System, Agriculture

I. INTRODUCTION

In recent years, the integration of advanced technologies in agriculture has significantly transformed traditional practices, particularly in irrigation and plant care. As urbanization accelerates and global water scarcity becomes a more pressing concern, there is a growing demand for efficient and sustainable solutions. Conventional methods of plant maintenance often rely heavily on manual observation and intervention, leading to inconsistent care, overuse of resources, and potential health hazards due to pesticide exposure. These challenges are especially prominent among urban dwellers who face limitations in time, knowledge, or space to care for plants effectively [1].

Recent developments in smart farming have demonstrated that automation using sensor networks and IoT can significantly improve efficiency have shown that IoT-based smart farming systems enable users to remotely monitor and manage irrigation processes via mobile applications. Additionally, explored the use of wireless sensor networks to enhance agricultural automation, laying a strong foundation for intelligent irrigation solutions.

Green Guardian is designed in response to these needs. It is a comprehensive, user-friendly system that leverages ESP32 microcontrollers, environmental sensors, and mobile connectivity to automate plant care. [2] The system not only monitors key conditions like soil moisture, humidity, temperature, and light intensity, but also acts on this data to optimize watering and pesticide application. With built-in remote access through smartphone apps, it is an ideal solution for small- scale farmers, greenhouse operators, and urban gardening enthusiasts seeking a balance between convenience, efficiency, and sustainability.

Green Guardian combines innovation and simplicity to support sustainable gardening in everyday life. [3] By bringing together technology and nature, it offers an accessible way for anyone regardless of experience to care for plants effectively and with minimal effort.

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II. LITERATURE REVIEW

Numerous researchers have contributed to the advancement of smart irrigation and plant monitoring systems using IoT and wireless sensor technologies. Presented a practical IoT-based farming system that enabled real-time monitoring through mobile interfaces, while focused on crop productivity enhancement through remote- controlled irrigation.[4] Blynk and other mobile integration platforms have further simplified user interactionwiththesesystems,asexplored review.

Reviewed intelligent irrigation systems powered by wireless sensor networks and highlighted their potential in improving water efficiency. Emphasized the use of WSNs in automation and real-time data acquisition, critical for smart agriculture. Similarly, [5] showcased how sensor networks canbetunedfor accurateandresponsive irrigation control.

Several studies also focused on sustainability and eco-friendliness. For example, demonstrated the useofsolar-poweredautomatedirrigationsystems. Proposed an IoT-based model that combined soil moisture and temperature monitoring for precise irrigation scheduling. Despite their usefulness, many of these systems still face challenges in affordability, long-term reliability,[6] and ease of deployment.

Green Guardian addresses these limitations by incorporating durable and accurate sensors, enabling real-time alerts and user control, and offering a scalable solution that is both cost- effective and accessible to a wide range of users.

III. SYSTEM DESIGN AND ARCHITECTURE

The Green Guardian system is a smart, fully automated plant care solution built on an Internet of Things (IoT) framework. At the core of the system is the ESP32 microcontroller, a highly capable and energy-efficient board that features built-in Wi-Fi and Bluetooth. [7] This board acts as the system's brain—gathering data from connected sensors, processing commands, and handling communication with a cloud-based platform.

To monitor the plant's environment, the system includes a set of essential sensors. A capacitive soil moisture sensor tracks the water content in the soil continuously. Unlike traditional resistive sensors, capacitive sensors are more durable and provide reliable readings over time, as they are less susceptible to corrosion. For atmospheric monitoring, a DHT11 sensor is used to measure temperature and humidity. This data helps the system make smarter decisions about irrigation by factoring in surrounding weather conditions. Additionally, [8] a Light Dependent Resistor (LDR) measures the level of sunlight reaching the plant. This can inform users whether a plant needs repositioning, or, in more advanced versions, help automate lighting systems for indoor setups.

Watering is managed by a submersible DC pump, which is controlled through a relay module. When the soil moisture level drops below a specific threshold—commonly set between 30% and 45%—the ESP32 triggers the relay, [9] activating the pump for a fixed period to deliver water from a connected reservoir. Users can adjust this threshold based on the type of plant or personal preferences.

The system is designed to operate on dual power sources, supporting both rechargeable batteries and solar panels, making it suitable for both indoor and outdoor use while promoting energy-efficient operation. [10] All sensor readings are transmitted wirelessly to a cloud platform such as Firebase or Blynk using the ESP32's Wi-Fi capabilities.

The mobile app provides users with an intuitive interface to monitor real-time data like soil moisture, temperature, and humidity [11]. It also allows users to control the pump manually if needed and sends push notifications for unusual conditions, such as very dry soil or low water levels in the reservoir.

The system's modular and scalable design allows for the addition of more sensors and pumps to support multiple plants, making it ideal for home gardens, greenhouses, or even small-scale farming operations. Green Guardian blends automation, sustainability, and simplicity to offer a practical solution for modern plant care.[14-115]

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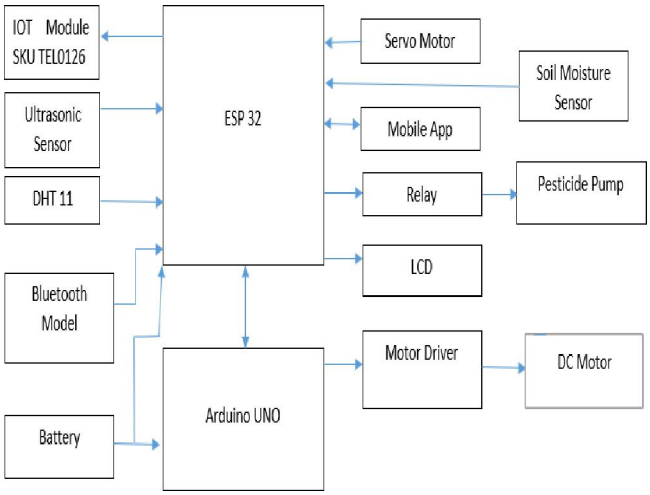

Fig.1Block Diagram of Green Guardian System.

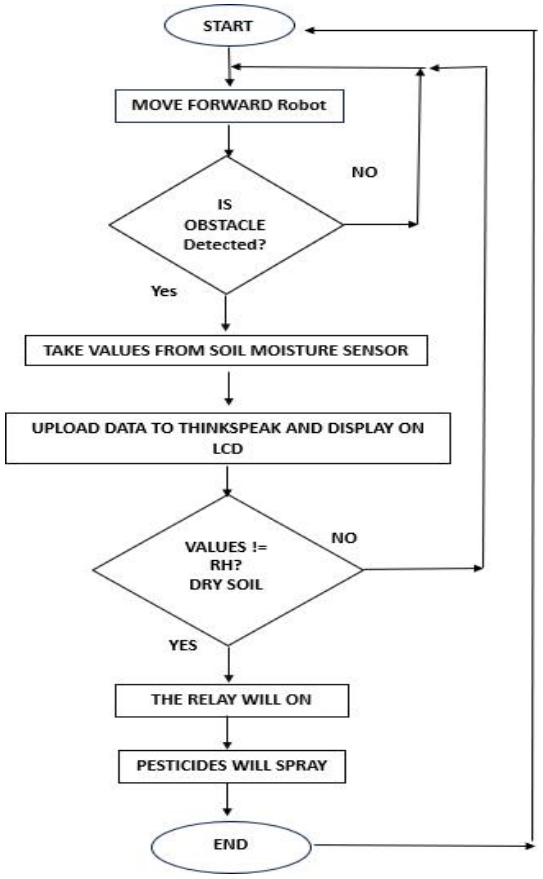

Fig.2 Flow Chart of Green Guardian System.

IV. Result

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When the soil is dry, with moisture levels between 20% and 40%, plants are likely under stress and need water. In this case, watering is a top priority to keep the plants healthy. However, spraying pesticides during dry conditions is not a good idea, because the heat and dryness can cause the chemicals to evaporate quickly. This reduces their effectiveness and can even be harmful to the environment or people nearby.

In medium soil conditions, with 41% to 70% moisture, the soil has a healthy amount of water. You may not need to water right away, but it's a good idea to keep an eye on it. This is also the best time to spray pesticides, since the moisture helps the chemicals stick to the plants better and get absorbed more effectively without risk of evaporation or runoff.

When the soil is wet, with moisture levels between 71% and 90%, there's already plenty of water, so irrigation should be avoided to prevent overwatering, which can lead to root rot or fungus. Pesticide spraying is also not recommended at this stage, because excess water can cause the chemicals to run off the plants and into the soil, reducing their impact and potentially polluting nearby water sources.

Fig.3 Hardware of Green Guardian System.

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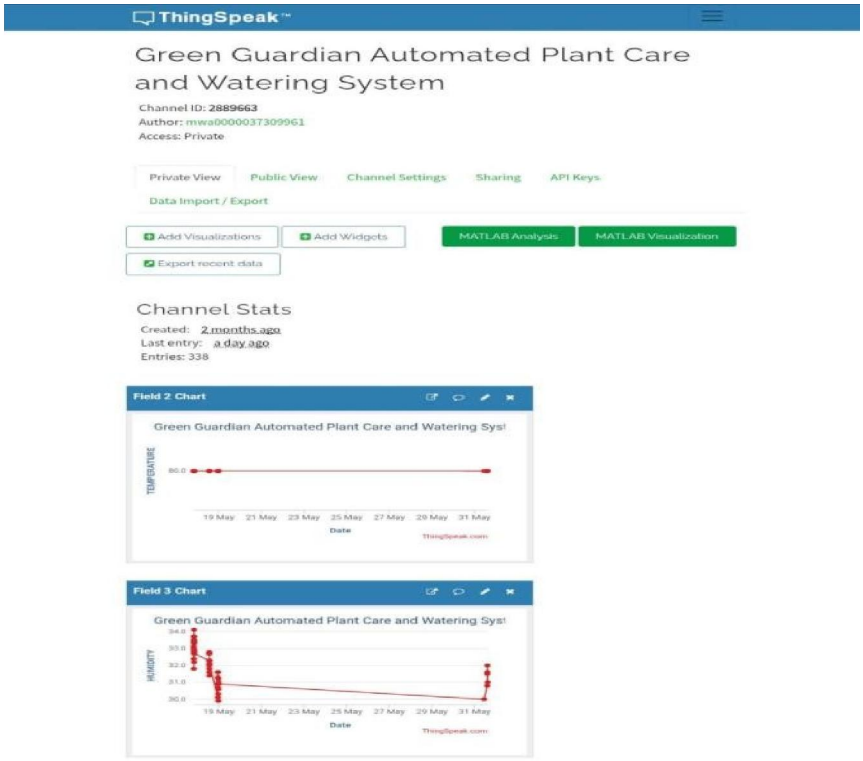

Fig. 4 Gradual Changes in Temp. & Humidity.

TABLE I: Soil Condition with Irrigation and Pesticide Recommendation

Soil Condition	Moisture Range Relative Humidity %)	Water Spraying (Irrigation)	Pesticide Spraying
Dry Soil	20% – 40% RH	Recommended (High priority)	Not Recommended (Evaporation loss likely)
Moist Soil	41% – 70% RH	Moderate (Monitor conditions)	Recommended (Besteffectiveness)
Wet Soil	71% – 90% RH	Not Recommended (Overwatering risk)	Not Recommended(Runoff, low absorption)

V. CONCLUSION

The Green Guardian Automated Plant Care and Watering System has proven to be an effective solution for optimizing plant care through automation. Byintegrating real-time soil moisture monitoring, environmental sensors, and a smart pesticide spraying mechanism, the systemensures that plants receive optimal care with minimal human intervention. Key benefits of the system includewaterconservation,enhancedplanthealth, and precise pesticide application, significantly reducing pesticide overuse and environmental impact. The use of IoT-based remote monitoring provides users with the convenience of managing plant care from anywhere, making it suitable for both residential and commercial use. Overall, GreenGuardianoffersasustainable, efficient, and user-friendly approach to modern gardening and plant care.

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