IoT – BASED SMART GARDENING SYSTEM

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ABSTRACT

Implementation of gardening system with IoT technology has several advantages over conventional methods of farming, which is the reason it proves to be an effective solution for urban farming. With the development of IoT technology, smart gardening systems have been widely popular for effective and automated plant care. This project offers an IoT-Based Smart Gardening System that regularly monitors and controls vital environmental parameters for the maximum growth of plants. The system has different sensors integrated to acquire real-time data: an LDR sensor to measure the intensity of sunlight, a DHT11 sensor to calculate temperature and humidity levels, a pH sensor to check the water's acid level, a TDS sensor to evaluate the total dissolved solids in water, and a soil moisture sensor to find soil moisture levels. According to the readings of soil moisture, an automatic water pump is triggered to keep the soil hydrated at the best level. The ESP32 microcontroller is the heart of the system, and it is responsible for acquiring, processing, and communicating sensor data. The data acquired is uploaded to an IoT platform for remote monitoring and analysis, and the critical readings are also shown on an LCD screen for local monitoring. This system increases gardening effectiveness by giving real-time information and automation, minimizing manual intervention while maintaining adequate plant health and resource utilization.

Keywords: *IoT technology, Wi-Fi Module(ESP32), IoT (Internet of Things), smart gardening, soil moisture sensor, temperature sensor, humidity sensor, light intensity sensor, automatic watering system, water pump, relay module, power supply, smartphone application, web dashboard, online database, real-time data, manual control, water conservation, automation, environmental monitoring, access.*

1.INTRODUCTION

Internet of Things (IoT) has transformed numerous sectors by facilitating ubiquitous connectivity and automation.One example of IoT is in smart garden systems, where there are automatic monitoring and controlling mechanisms for optimizing plant care. Conventional methods of gardening can involve considerable labor to monitor external parameters like solar intensity, temperature, humidity, soil moisture content, and quality of water. Poor handling of these factors can result in unhealthy plants, low yield, and wastage of resources like water and fertilizers. The system interprets sensor readings through an ESP32 microcontroller, also responsible for communication with an IoT platform for remote monitoring. The system supports real-time monitoring, automatic control, and remote access to sensor readings and system performance. The system offers information on plant health and resource utilization, allowing for better plant health, enhanced efficiency, water savings, and higher yield.

The system has various benefits, including improved plant health due to optimal environmental conditions, increased efficiency due to automated monitoring and control, water conservation due to optimized watering schedule, and enhanced yield due to improved plant health and resource management.

2.OBJECTIVES

Future plans for the system are to integrate it with other IoT devices to further extend system capabilities and functionality, sophisticated data analytics to better inform plant health and resource consumption, machine learning to allow the system to learn and adjust to fluctuating environmental factors, and to more crops to utilize the system in other gardening endeavors.

The goals of the IoT-Based Smart Gardening System are to make the irrigation process automatic with real-time soil moisture levels, decreasing human labor and water wastage.

The system is designed to monitor environmental factors like temperature, humidity, and light intensity continuously to facilitate healthier plant growth. It provides remote monitoring and control via an IoT platform, enabling users to view garden data and control the system remotely. Also, it aims at maximizing the utilization of resources such as water and power by turning components on when required. The system also aims to record environment data in the long run for analysis and future enhancement purposes, while having a cost-effective and scalable approach adequate for small-scale and large-scale garden applications

3.RELATED WORK

IoT-enabled intelligent gardening systems incorporate sensors and automation to maximize care for plants. The systems monitor soil moisture, temperature, humidity, and light intensity in real-time, triggering automated watering and accurate plant care. Gardeners can remotely check and manage gardens via mobile applications or web pages.
The advantages of IoT-based smart gardening systems are water conservation, enhanced plant health, enhanced efficiency, and sustainability. The systems are capable of saving more than 50% of water consumption and supporting healthier plant growth. Automation reduces mundane work, allowing gardeners to have more time to relax in their own little green heaven.
The technologies employed by IoT-based intelligent gardening systems are microcontrollers such as Node MCU ESP8266, Raspberry Pi, and Arduino, sensors, and IoT platforms. Mobile apps allow gardeners to receive notifications, monitor, and control gardens remotely.
These systems are utilized for different applications such as home gardening, commercial gardening, and urban gardening. They are more practical in urban development areas where resources and space are limited. Through the use of IoT technology, gardeners can make more efficient, sustainable, and productive gardens.

4.METHODOLOGY

4.1 Hardware Description

• Microcontroller

A microcontroller is a small integrated circuit that is made to control particular operations in an embedded system.It contains a processor core, memory (e.g., Ferroelectric RAM, flash, or ROM), and programmable input/output peripherals all on one chip. Microcontrollers are designed to be optimized for embedded application tasks like home appliances, medical devices, cars, toys, and tools, where cost and size efficiency are the most important considerations. Hey are power-efficient and can run on very low power, which makes them suitable for battery-powered systems. Some microcontrollers execute simple tasks at low clock rates (e.g., 4 kHz) to conserve power, while others execute performance-hungry operations such as digital signal processors.

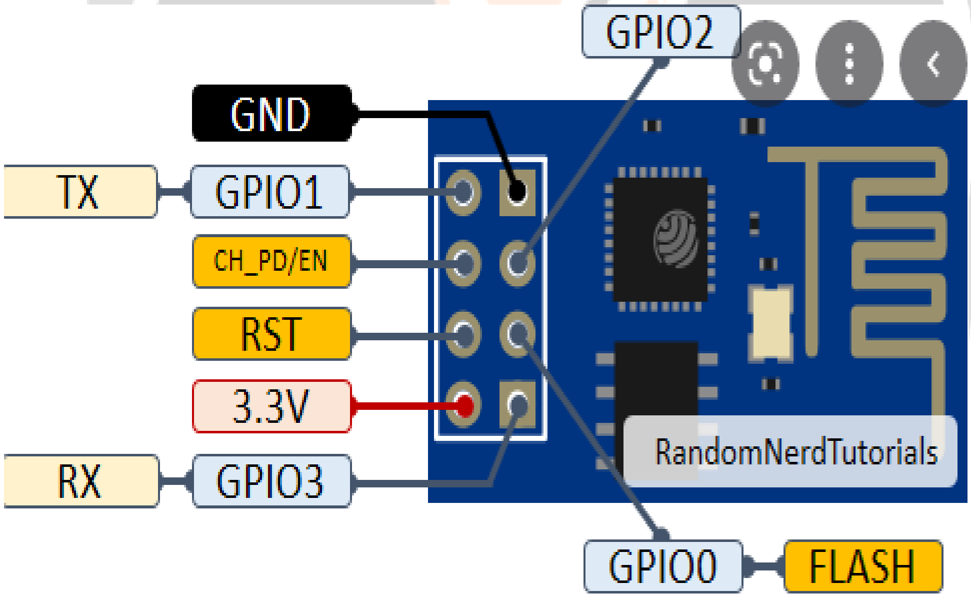

Fig 1 SPI Control

•Temperature and Humidity Monitoring

The entails taking measurements of the ambient conditions around the plants via sensors such as the DHT11 or DHT22.These sensors are able to measure and report actual temperature and relative humidity levels in real-time, which are paramount in ensuring a healthy growing environment. Monitoring these parameters prevents plants from being subjected to extreme heat, cold, or wetness or dryness. Data obtained can be utilized to initiate automated responses, like a fan, sprinkler, or alarm, to preserve ideal growing conditions. This monitoring is critical in smart gardening systems for enhancing plant growth and minimizing manual intervention

•Soil Moisture Analysis

This is one of the main advantages of IoT-based smart gardening systems. It makes use of a soil moisture sensor to determine in real-time the amount of water in the ground. The sensor transmits this information to a microcontroller, which determines if the soil is too dry and must be watered. If the moisture content falls below a threshold, the system can automatically switch on a water pump to water the plants. This eliminates overwatering or underwatering and ensures optimal use of water, leading to healthier plant growth with minimal human intervention.

• pH sensor

pH Sensor is employed to check the alkalinity or acidity of the soil, which is essential for plant well-being.
Plants need varied pH levels to grow optimally.In a smart gardening system, the pH sensor gathers data from the soil and transmits it to the microcontroller. The system can then notify the user if the pH level is beyond the desired range, enabling timely adjustment with fertilizers or soil additives. Incorporating a pH sensor ensures the ideal soil condition and facilitates improved nutrient uptake by plants. •\tLight Detection This is utilized to measure the light intensity of sunlight or artificial light to which the plants are exposed. A light sensor, like an LDR (Light Dependent Resistor), senses the brightness and provides the information to the microcontroller. This data ensures that plants connect to the internet. This facilitates remote monitoring and control via a smartphone or web interface.

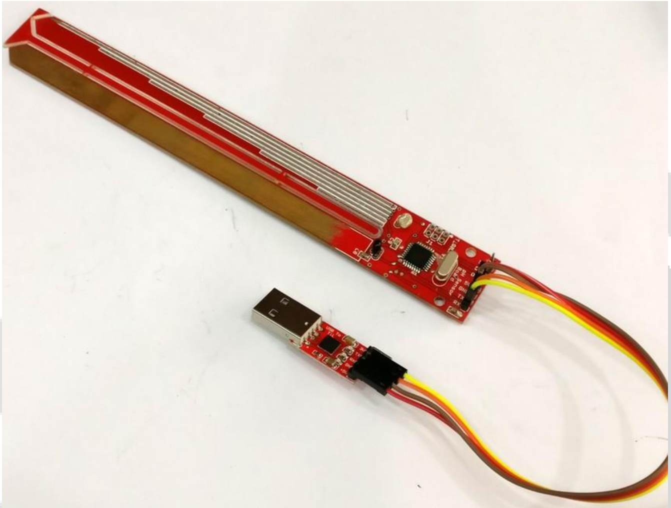

Fig 2 Ph Sensor

•Relay

A Relay is an electrically controlled switch utilized to drive high-power devices such as water pumps, fans, or grow lights within an IoT-based smart gardening system.
The microcontroller sends a low-power command to the relay, and it switches the high-power devices on or off.This enables the system to drive equipment that would otherwise need more power than the microcontroller can supply directly.Relays support safe operation as they separate the microcontroller from high-voltage circuits and permit automated action against sensor input (e.g., turning on water pump if there is low moisture in soil).

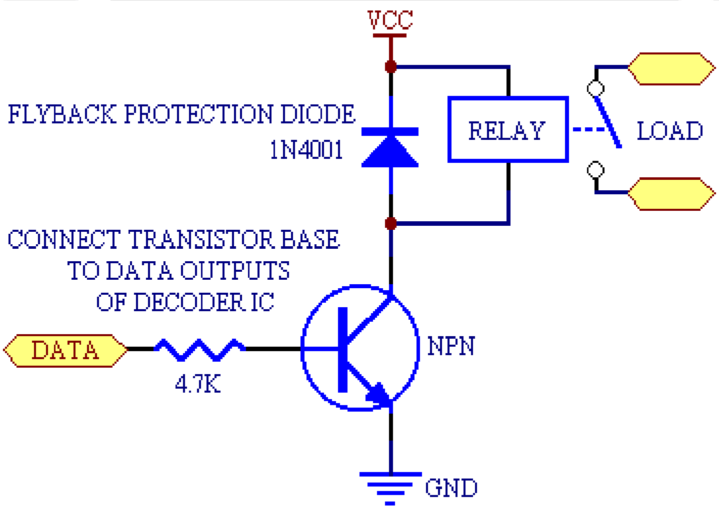

Fig 3 Relay

•LCD

An LCD or Liquid Crystal Display is utilized within an IoT-based smart garden setup to show graphical feedback on real-time information pertaining to the state of the system. It displays critical data including soil moisture percentage, temperature, humidity, as well as warnings from the system. This enables quick observation of the garden conditions without remotely accessing the system.The LCD improves the user interface by presenting real-time data on location, which makes it easier to monitor the well-being of the plants and the system's performance.

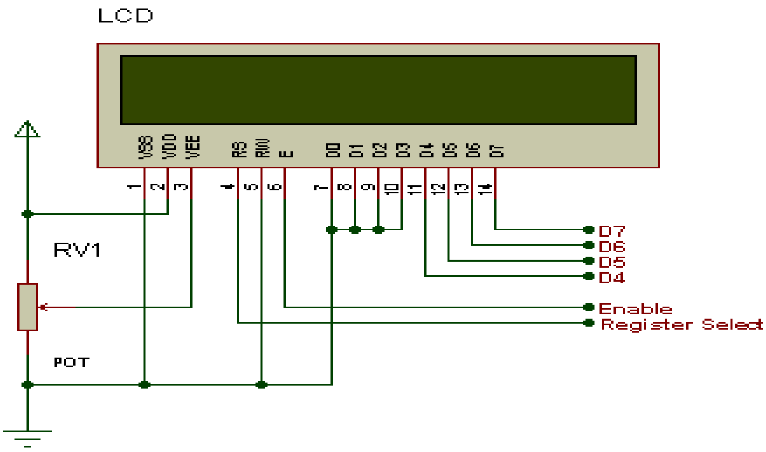

Fig 4 LCD Pin diagram

4.2 Block Diagram of Project

The smart garden system based on IoT works through the continuous sensing of important environmental parameters and autonomous irrigation based on sensor readings. The ESP32 microcontroller works as the control unit, sensing real-time conditions from different sensors and taking action accordingly. The system uses several sensors such as an LDR to sense the intensity of sunlight, a DHT11 sensor to sense temperature and humidity, a pH sensor to determine water acidity level, a TDS sensor to determine the level of total dissolved solids in water, and a soil moisture sensor to determine the moisture level in the soil. The sensors help gather important data regarding plant condition and environmental parameters.

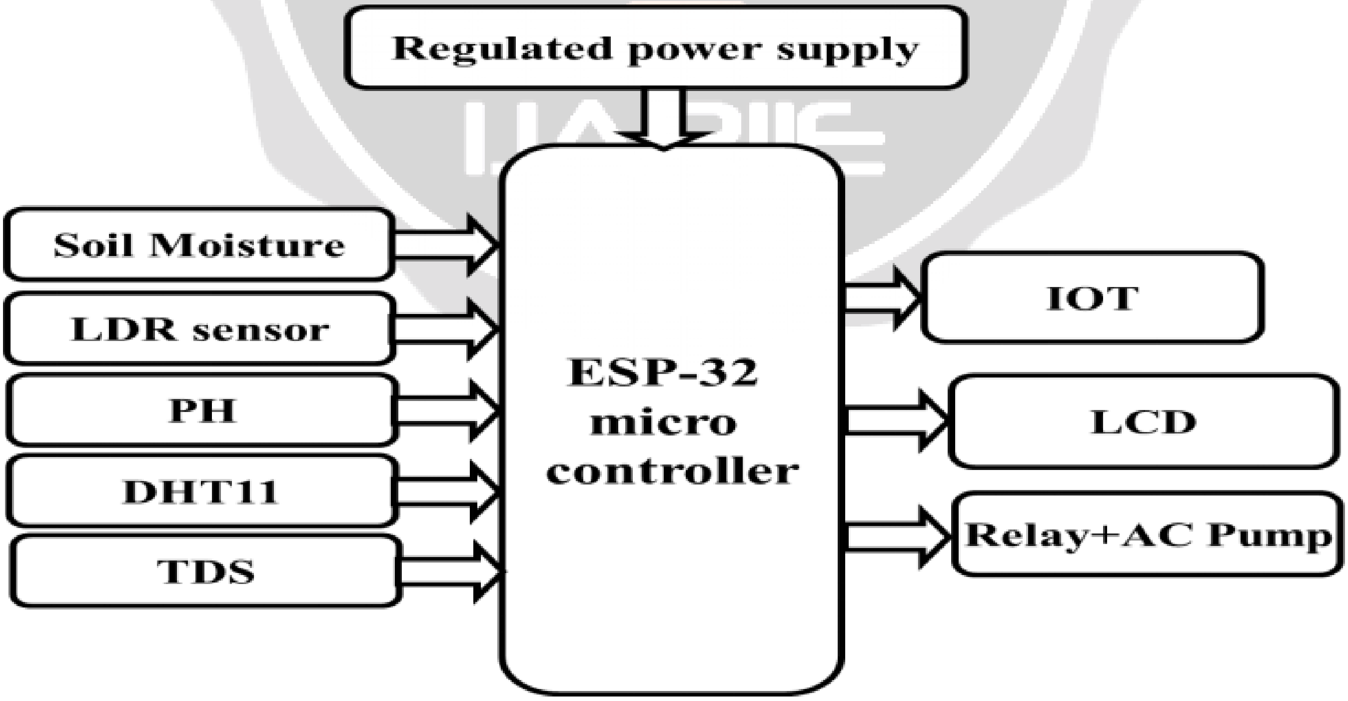

Fig 5 Block Diagram

4.3 Description of Software

The software for the IoT-based smart gardening system is intended to control and regulate the different subsystems of the

system to achieve maximum growth of the plants with minimal intervention by humans. The software is usually coded with an IDE such as Arduino, where the microcontroller (e.g., Node MCU, ESP32, or Arduino Uno) is programmed to read sensor data and make decisions based on set thresholds. The sensors in the system, such as soil moisture, temperature, humidity, and light sensors, continuously collect data regarding the plant environment.
This information is then analyzed by the microcontroller, who will use it to drive devices like water pumps, fans, or grow lights.The system is in a continuous loop, scanning the sensors at all times and making decisions instantaneously.When the soil moisture level goes below a level that is determined in advance, the microcontroller will activate the water pump to water the plants. In a similar way, if the temperature crosses a predetermined limit or humidity becomes too low, the system can turn on fans or misters to control the weather. Light intensity is also tracked, and when it is low, the system can turn on artificial lighting so plants receive the appropriate level of exposure. For remote monitoring and control, the system communicates with cloud platforms such as Thing Speak or utilizes communication protocols such as MQTT to transmit data to the cloud. This provides the user with the ability to monitor garden conditions remotely through a web or mobile interface, getting real-time information and notifications.
There is also an optional LCD display capable of displaying local data on the status of the garden, including soil water levels, temperature, humidity, and light levels.
In total, the software integrates sensor information, control algorithms, and cloud connectivity to provide a smooth, automated gardening experience that promotes plant growth and minimizes manual intervention.

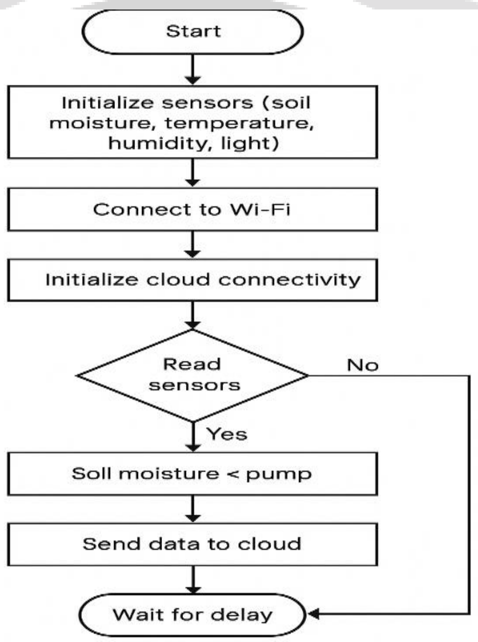

Fig 6 Flow chart demonstrating

5. BENEFITS

An IoT smart gardening system is engineered to maximize the care of plants by combining Internet of Things (IoT) devices, sensors, and automation to enhance plant health, conserve water, and increase overall efficiency. The outcome of using such a system could be

1. Optimized Watering: Sensors such as soil moisture sensors can offer real-time feedback to the system, and the plants are watered exactly when required, saving water and ensuring healthy growth.

2. Improved Plant Health: With the ability to track environmental conditions like temperature, humidity, soil pH, and light intensity, the system can maintain the plants in ideal conditions. Any parameter exceeding the desired range can trigger alerts to the user for remedial action.

3. Energy Efficiency: The system can automatically optimize the lighting, watering, and temperature conditions using real-time data, minimizing energy usage and making sure that resources are optimally utilized
4. Remote Monitoring and Control: Using IoT, the gardening system can be remotely accessed and controlled using mobile apps or websites. Users can be alerted, track their plants, and even tweak settings remotely, improving convenience.

5.Data Insights and Analytics: The system may gather data over time, allowing for useful insights on the patterns of growth, usage of water, and other variables. These details can assist gardeners in making better decisions towards improving and maintaining future gardening practices.

6.Automation: Automated watering, fertilizing, and even pest management systems can be time and effort savers for the gardener while providing regular care to the plants.

7. Sustainability: Through minimizing resource usage (water, energy) and enhancing plant health, an IoT-based smart gardening system encourages more sustainable gardening.

6. CONCLUSION AND RESULTS

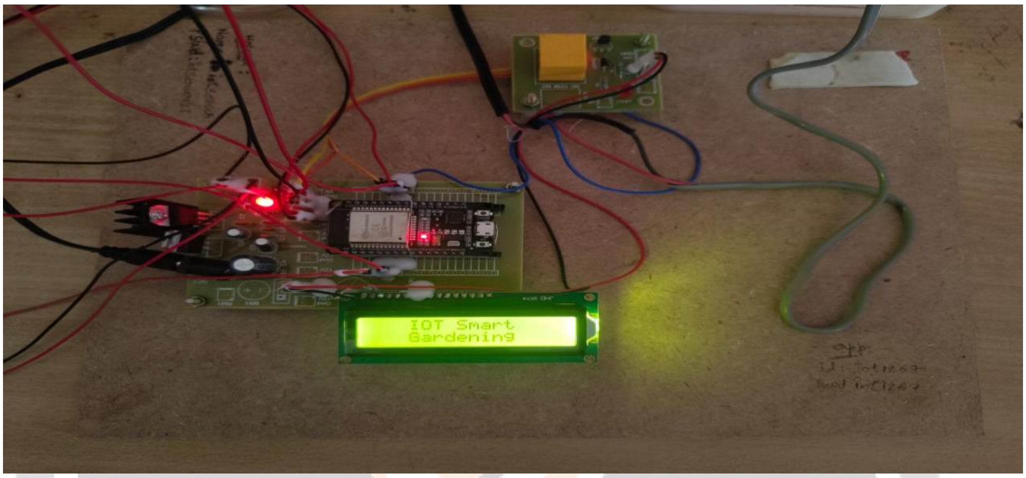

Fig 7 IoT based smart gardening system

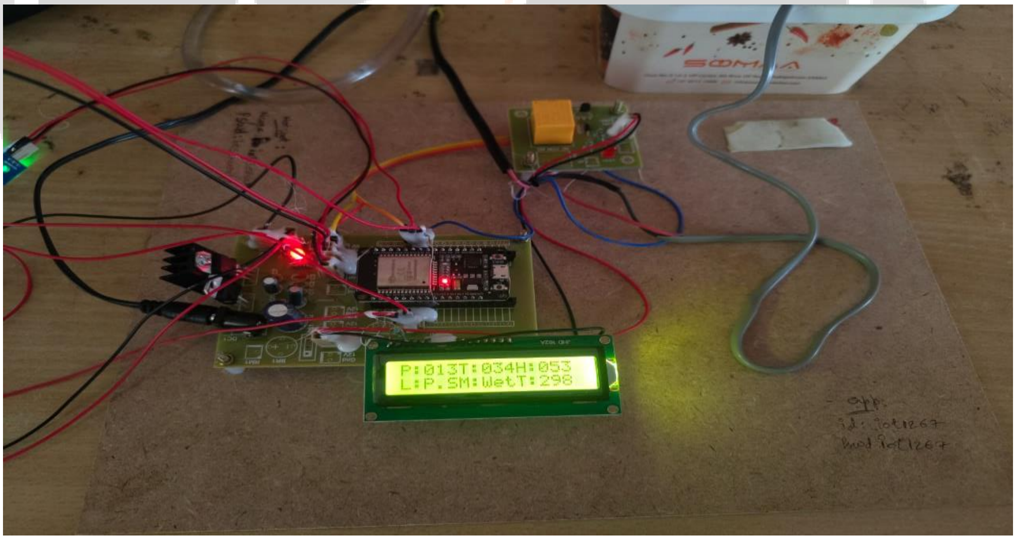

Fig 8 Sensors Results in display

Fig 9 Hardware Implementation

An IoT-based smart gardening system maximizes plant care through the use of sensors and automation.
It provides accurate watering through the utilization of soil moisture sensors, minimizing water wastage and enhancing plant health.
Environmental parameters like temperature, humidity, soil pH, and light intensity are measured to keep the conditions for healthy plant growth in check.
In case any parameter drops out of the preferred range, the system can alert the user for timely action.
The system also improves energy efficiency by adjusting conditions such as temperature and lighting automatically using real-time data to save resources.
Remote monitoring and management via mobile applications or websites are convenient, and users can check on their plants and make the necessary adjustments remotely. Information that is gathered over time is incredibly useful in gaining insights into plant growth patterns, water consumption, and other considerations, and makes gardeners make more informed choices. Automation of watering, fertilization, and pest control reduces time and delivers consistent care. This system ensures sustainability by conserving resources and improving plant health, leading to a more efficient, sustainable, and low-maintenance gardening experience.

7. FUTURESCOPE

The IoT-based Smart Gardening System has tremendous scope for future development. It can be further improved by incorporating Artificial Intelligence and Machine Learning to study plant health, forecast watering requirements, and maximize resource utilization. Adding weather forecasting features will enable the system to modulate irrigation timetables with real-time climatic information, enhancing efficiency. Adding voice assistant compatibility, including Google Assistant or Alexa, will make it possible to control gardening operations hands-free.
A custom mobile app will also increase the level of user interaction by making remote monitoring, control, and access to historical data possible.
The system is also scalable for use in agriculture, helping farmers automate the watering and observation of vast fields. These advancements render the system extremely versatile, efficient, and effective for both home and business use in gardening.

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