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Smart Village:Solar Based Agriculture with Iot Enabled for Climate Changes

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***Abstract*—In smart villages, access to sustainable energy services acts as a catalyst for development. Enabling facility of internet connection for the new possibilities of increasing agricultural cultivation with proper information and guidance, access to clean water, sanitation and nutrition, the growth of productive enterprises to boost farmer's income. The development of a country depends on the village's development. Most of the agriculture productivity suffer greatly with unforeseen change in climate. Therefore, farmers need to get appropriate information's if any sudden climatic disruption occur, it should notify on time to avoid any major damage in agricultural field. As part of the smart village concept, an intelligent system is designed that may help a farmer to get basic facilities/infrastructure by agricultural development. Here an intelligent system is proposed on the fact of farmers getting all relevant details about the improvement in fertilization of soil and agriculture by delivering climate change information's through an IoT (Internet of Things) devices. These information's could be handled through website and mobile phones. To ease for farmer understandings all the facts and information related to soil fertilization and climatic alerts are delivered as per their native language / language of their interest. This system may help its members to collaborate and take it to another level of requirement in improving their production capacity. These IoT devices are operated either through solar panel or electric supply appropriately to balance the power requirement across the field.**

***Index Terms*—mart Agriculture, Internet of Things (IoT), ESP32 Microcontroller, Soil Moisture Sensor, Solar-Powered System,Blynk App,Climate Change Adaptation,SmartVillage,PrecisionFarming,Automated Irrigation,Remote Monitoring,Agricultural IoT**

I. INTRODUCTION

Agriculture is a cornerstone of global food production, yet it faces significant challenges due to the impacts of climate change, erratic weather conditions, and soil degradation. Traditional farming methods often struggle to address these challenges effectively, resulting in inefficient resource usage, water wastage, and poor soil quality. As climate change accelerates, farmers need innovative solutions that can help mitigate these issues, optimize water usage, and improve overall agricultural productivity. The integration of Internet of Things (IoT) technologies offers a promising approach, providing real-time data monitoring, automated decision-making, and the ability to adapt to changing environmental conditions. This project presents a Smart Village Solar-Based Smart Agriculture System that leverages IoT to enhance agricultural practices while addressing sustainability concerns. By using an ESP32 microcontroller, soil moisture sensors, climate sensors, and solar power, the system autonomously monitors and manages soil health and irrigation needs. The integration of a Blynk app allows farmers to remotely track environmental conditions and control the system, ensuring efficient resource usage. This system aims to reduce water consumption, improve soil fertility, and ensure sustainable farming practices, ultimately contributing to the fight against climate change and enhancing agricultural productivity in rural areas.

II. LITERATURE SURVEY

A proliferation of literature is available in plant leaf disease detection. We will highlight some of the key configuration. A methodology for detecting plan diseases early and accurately using diverse image processing techniques has been proposed by Anand H. Kulkarni et al., in which Gabor filter has been used for feature extraction and ANN based classifier has been used for classification with recognition rate up to 91%.

Homogenize techniques like canny and sobel filter has been used to identify the edges by P. Revathi et al. Then these extracted edge features have been used in classification to identify disease spots. Proposed homogeneous pixel counting technique for cotton disease detection (HPCCDD) algorithm has been used for categorizing the diseases. They claim the accuracy of 98.1% over existing algorithm.

Asem Khmag, proposed a recognition system for leaf images based on its leaf contour in which the recognition of plants is directly associated to society's life. Leaves from plants is proved to be a feasible source of information used to identify plant species. The recognition system of leaves is accomplished automatically using the experts of experts of human being. The leaf contours of the same plants are computed using support victor machine (SVM) where the similar sequences of the same contours usually carry the same features while different plant sequences have different contours.

Tushare H Jaware et al. proposed a novel, in which improved K-means clustering technique is used to solve the low-level image segmentation. Spatial gray-level dependence matrices (SGDM) method has been used for extracting statistical texture features by Sanjay B. Dhaygude et al. also RGB images has been converted into Hue Saturation Value (HSV) color space representation.

A new technique have been proposed by S.M.Ramesh et al. for enhancement of color images by scaling the discrete cosine transform coefficients which provides better enhancement compared to image capture by digital camera. In order to classify the grape and wheat diseases black propagation networks have been used by Haiguang Wang et al.

A. Menukaewjinda et al. tried back propagation neutral network (BPNN) for efficient grape leaf color extraction and they also explore modified self-organizing feature map (MSOFM) and genetic algorithm (GA) and found that these techniques were providing automatic adjustment in parameters for grape leaf disease color extraction. Support vector machine (SVM) have been found a very promising technique to achieve efficient classification of leaf disease.

III. METHODOLOGY

The methodology of this project revolves around integrating IoT technology with solar-powered systems to create an automated and efficient smart agriculture solution. At the heart of the system is the ESP32 microcontroller, which serves as the central processing unit, handling data acquisition from various sensors and controlling the actuation modules. The ESP32 is programmed using the Arduino IDE to interface with sensors, process inputs, and perform necessary actions such as triggering irrigation or activating alert systems. This microcontroller's connectivity capabilities also enable communication with the Blynk app, which provides a user-friendly interface for farmers to monitor real-time data and control the system remotely.

The hardware components of the system include several key sensors and modules. The soil moisture sensor continuously measures the moisture content of the soil and sends this data to the ESP32. When the soil moisture falls below a predefined threshold, the microcontroller activates the pump module via a relay to irrigate the crops. The LDR (Light Dependent Resistor) sensor monitors light intensity, which helps track the amount of sunlight the crops are receiving, enabling the system to assess the overall health of the plants. Additionally, a fencing sensor is used for security purposes, detecting any unauthorized access to the farm, which is critical in a rural setting where theft or intrusion might be a concern.

To ensure that the system functions efficiently and sustainably, solar power is used to power the entire setup. A solar panel system is used to generate electricity, which is stored in a battery for use during cloudy days or at night. This makes the system self-sufficient, which is crucial for rural areas with limited access to a stable power grid. The use of solar energy also aligns with the goal of promoting sustainable farming practices by reducing reliance on conventional energy sources, minimizing the environmental impact, and lowering operational costs for farmers.

On the software side, Arduino IDE is used to program the ESP32 to handle the sensor data and control the actuators. The system's logic ensures that when the soil moisture is low, the irrigation system is triggered, while the Blynk app allows the farmer to monitor the system remotely, receiving updates on soil moisture, temperature, light intensity, and system status. In case of critical conditions, such as low moisture levels or security breaches, the buzzer provides an audible alert, and LED indicators (red and green) signal the status of the system—green indicating normal conditions and red signaling danger. This combination of hardware and software provides a comprehensive solution to modern farming challenges, enhancing productivity while conserving resources.

SYSTEM DESIGN AND COMPONENTS

The Smart Village Solar-Based Smart Agriculture System uses an ESP32 microcontroller to monitor soil moisture, light intensity, and security with sensors like soil moisture, LDR, and fencing sensors. The system automatically controls irrigation using a pump module and relay, powered by solar energy for sustainability. Data is transmitted to the Blynk app, allowing remote monitoring and control. LED indicators and a buzzer alert the farmer to system status or emergencies. The design ensures efficient resource use, sustainability, and effective agricultural management.

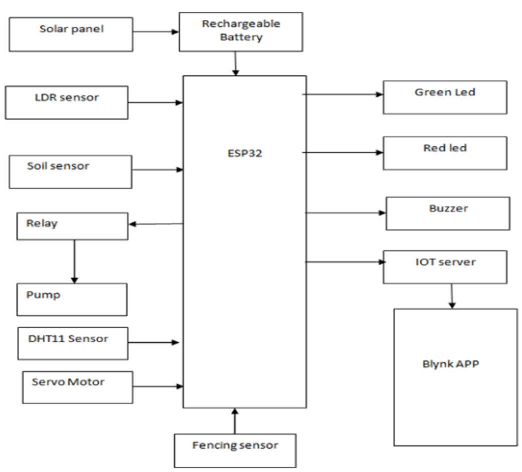

Fig:Block Diagram

ESP32 MICROCONTROLLER:

The ESP32 is a powerful, low-cost, and highly versatile microcontroller developed by Espressif Systems. It is widely used in IoT applications due to its built-in Wi-Fi and Bluetooth connectivity, making it ideal for wireless communication, remote monitoring, and automation tasks. In the context of the Child Rescue System from Borewell, the ESP32 plays a central role as the brain of the entire system, managing sensor inputs, controlling actuators, and enabling real-time data transmission to the cloud through the Blynk IoT platform.

- Dual-core Tensilica LX6 processor (up to 240 MHz)
- Built-in Wi-Fi and Bluetooth (BLE)
- Support for SPI, I2C, UART, PWM, ADC, and DAC
- Low power consumption, ideal for portable and battery-powered devices
- Compact size and low cost

SOIL MOISTURE SENSOR:

A Soil Moisture Sensor is an essential component in the Smart Village Solar-Based Smart Agriculture System, designed to measure the water content in the soil. It works by detecting the electrical resistance or capacitance between two probes inserted into the soil. When the soil is dry, the resistance between the probes is high, indicating low moisture levels. As the soil absorbs water, the resistance decreases, signaling higher moisture content. This data is sent to the ESP32 microcontroller, which uses it to determine when irrigation is needed. By automating the irrigation process based on real-time soil moisture levels, the sensor helps conserve water, ensures optimal crop growth, and enhances resource management.

LDR SENSOR:

An LDR (Light Dependent Resistor) sensor is used in the Smart Village Solar-Based Smart Agriculture System to measure light intensity, helping to monitor the amount of sunlight reaching the crops. The LDR's resistance decreases as the light intensity increases, allowing it to detect variations in sunlight during the day. This information is important for understanding the crops' exposure to sunlight, which directly affects their growth. By integrating the LDR sensor with the system, it can trigger actions such as adjusting the irrigation system based on the available sunlight or alerting the farmer if light levels are suboptimal for plant health.

BUZZER:

The buzzer in the Smart Village Solar-Based Smart Agriculture System serves as an alert mechanism, providing audible notifications to the farmer about the system's status or any critical conditions. It is activated when specific events occur, such as low soil moisture levels, security breaches detected by the fencing sensor, or any malfunctions in the system. By sounding an alarm, the buzzer ensures that the farmer is immediately aware of any potential issues, even from a distance. This feature adds an extra layer of reliability to the system, helping the farmer respond quickly to maintain optimal growing conditions and prevent damage or loss. By sounding an alarm, the buzzer ensures that the farmer is immediately aware of any potential issues, even from a distance.

FENCING SENSOR

The fencing sensor in the Smart Village Solar-Based Smart Agriculture System is used to detect any unauthorized access or intrusions into the farm area, enhancing security. This sensor can be placed along the perimeter of the agricultural land to monitor for any movement or breaches. If an intruder crosses the boundary, the sensor triggers an alert, activating the buzzer and notifying the farmer through the Blynk app. This helps ensure the safety of the farm from theft, animal intrusion, or vandalism, allowing the farmer to take timely action to protect crops and equipment. The fencing sensor thus adds an essential security layer to the overall smart agriculture system.

PUMP MODULE

The pump module in the Smart Village Solar-Based Smart Agriculture System is responsible for automating irrigation based on soil moisture levels. When the soil moisture sensor detects that the soil is too dry, the ESP32 microcontroller triggers the pump module via a relay, activating the water pump to irrigate the crops. This automated system ensures that the plants receive adequate water without manual intervention, optimizing water usage. Powered by solar energy, the pump operates sustainably, reducing water waste and ensuring that the crops are watered only when necessary, promoting efficient resource management and sustainable farming practices.

LED INDICATORS

LED indicators in the Smart Village Solar-Based Smart Agriculture System provide visual feedback on the system's status. The green LED indicates normal, safe conditions, signaling that the soil moisture levels are adequate and the system is functioning properly. In contrast, the red LED serves as an alert, signaling a problem such as low soil moisture, a security breach, or any system malfunction. These visual indicators help the farmer quickly assess the status of the system, ensuring they can take immediate action when necessary. The LED indicators are a simple yet effective way to communicate the system's health and alert the user to potential issues.

BLYNK IoT PLATFORM

Blynk is an IoT application that allows remote monitoring and control of devices through a smartphone. In this project, it is used to:

- Display live video from the ESP32-CAM
- Show real-time sensor data (temperature, pressure, altitude)
- Control the oxygen pump, LED light, and grappler
- Send alerts and updates during the rescue process

SOFTWARE INTEGRATION

ARDUINO IDE:

The Arduino Integrated Development Environment (IDE) serves as the primary platform used for programming and uploading code to the ESP32 microcontroller in this project. It is an open-source software environment widely favored for its simplicity, flexibility, and support for a wide range of microcontrollers. The IDE allows users to write code in a simplified version of C/C++, compile it, and upload it directly to the microcontroller via a USB connection. For this IoT-based child rescue system, the Arduino IDE was chosen due to its compatibility with ESP32, ease of integration with various sensors and modules, and its strong community support.

To begin using the ESP32 with the Arduino IDE, additional board definitions must be installed, as ESP32 is not included by default. This involves adding the ESP32 board manager URL to the preferences section in the IDE and installing the board files via the Board Manager. Once installed, the user can select the ESP32 board type and appropriate COM port from the Tools menu, allowing the IDE to recognize and communicate with the hardware. This setup enables seamless uploading of code and serial communication for debugging purposes.

The IDE also features a built-in serial monitor and serial plotter, which were crucial for real-time debugging and data visualization during development and testing. The serial monitor allowed the developer to verify if the sensor readings were accurate and whether commands from the Blynk app were being received and executed correctly. Any errors, such as sensor initialization failures or Wi-Fi connectivity issues, could be quickly identified and resolved using this tool.

Overall, the Arduino IDE provided a reliable and developer-friendly environment for building, testing, and refining the embedded software used in the child rescue system. Its compatibility with third-party boards, straightforward interface, and support for numerous libraries and examples made it ideal for rapid prototyping and implementation. The use of the Arduino IDE significantly contributed to the successful integration of hardware and software components in this life-saving IoT application.

IV. RESULTS

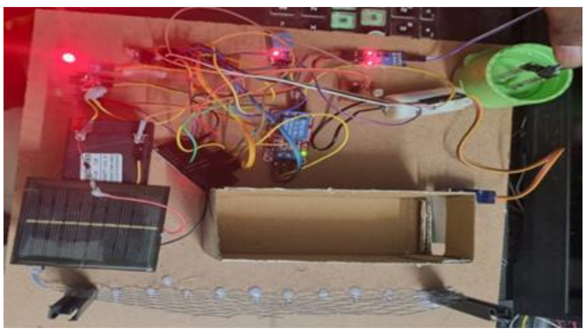

Fig: Practical Representation of experiment

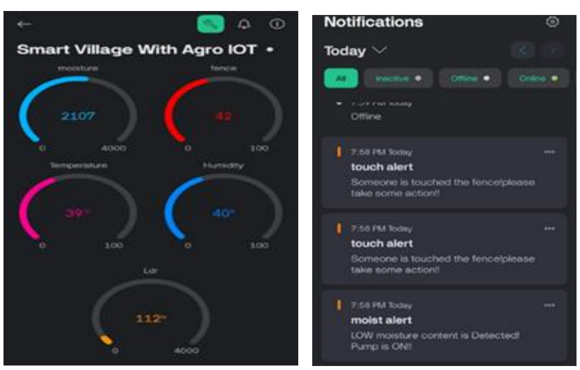

Fig:Output (Notifications in Blynk App)

PROJECT OUTCOMES:

The Smart Village Solar-Based Smart Agriculture with IoT project demonstrates a successful integration of IoT and solar technology to optimize farming practices. By automating irrigation based on real-time soil moisture data, the system helps conserve water, improve soil health, and reduce the use of chemical fertilizers. The Blynk app allows for remote monitoring and control, giving farmers the ability to manage their fields from anywhere. Solar power ensures that the system operates sustainably in rural areas where electricity access may be limited. This solution not only enhances agricultural productivity but also empowers farmers with data-driven insights, enabling them to make informed decisions.

The outcomes of the project go beyond technical efficiency and extend to environmental and social impacts. Water conservation is a key benefit, as the system adjusts irrigation based on actual soil moisture, minimizing waste. The use of solar energy reduces the dependency on fossil fuels, promoting sustainability. Furthermore, the system's ability to optimize resource usage leads to cost reductions for farmers, while also improving their quality of life by automating time-consuming tasks. The technology also holds promise for scalability, allowing it to be replicated in various regions and expanding its impact on rural communities.

Key Outcomes:

1. Water Conservation through automated irrigation based on real-time soil moisture data.
2. Sustainability via solar power integration, reducing reliance on fossil fuels.
3. Cost Reduction by minimizing water wastage and fertilizer use.
4. Improved Agricultural Productivity through efficient resource management.
5. Empowerment of Farmers via IoT technology and remote monitoring capabilities.

ADVANTAGES:

1. Water conservation through automated irrigation based on soil moisture data.
2. Sustainability with solar power, reducing reliance on grid electricity.
3. Cost efficiency by minimizing water wastage, fertilizer use, and labor.
4. Remote monitoring and control via the Blynk app for easy management.
5. Increased crop yield through optimized soil conditions and irrigation.

APPLICATIONS:

1. Smart farming for automated irrigation and environmental monitoring.

2. Climate change mitigation by managing resources in unpredictable weather.
3. Sustainable agriculture by reducing water and fertilizer usage.
4. Rural development by providing affordable, eco-friendly solutions.
5. Precision agriculture for data-driven decision-making and resource optimization.

V. FUTURE SCOPE

Agriculture is the backbone of every nation and agricultural product development is one of the major upcoming fields in India. Use of appropriate technology in this field has made tremendous progress in terms of increased yield and maintaining good quality. Design and development of crop protection systems and implementation of Wireless Sensor platforms developed in the laboratory as well as in the field reported in this thesis signify the initial steps in this field. Efforts to develop a sustainable technology assisted systems for crop protection have been reported in this thesis. Any research work has always some limitations and scope of expansion. The extent of this work is vast and needs large team efforts along with the assistance from the government sectors.

VI. CONCLUSION

In conclusion, the Smart Village Solar-Based Smart Agriculture with IoT project represents a significant step toward improving farming practices through technology. By integrating IoT-enabled sensors, solar power, and remote monitoring via the Blynk app, the system offers a sustainable solution to challenges like water scarcity and inefficient resource usage. The project ensures that water is used optimally by automating irrigation based on real-time soil moisture data, reducing water wastage and increasing agricultural productivity. The use of solar energy also ensures that the system is environmentally friendly and can function independently of grid electricity, which is especially beneficial for rural areas.

Moreover, this project holds immense potential for addressing key issues in modern agriculture, such as resource conservation, cost efficiency, and climate change adaptation. The system's scalability allows it to be replicated in various regions, providing farmers with a practical solution that enhances both their productivity and quality of life. By empowering farmers with data-driven insights and automation, the project not only improves farming efficiency but also fosters sustainability and resilience in agricultural practices.

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