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The project is about IOT Based Smart Agricultural System , specifically focusing on the development of an intelligent farming system that optimizes irrigation and environmental monitoring.

The objective is to work on designing and implementing an automated system that ensures efficient result, management and improved crop health by using IoT components such as sensors and cloud based platforms. The project aims to provide real time monitoring and data driven decision making for farmers.

Introduction

Internet of Things (IoT) is a developing concept that connects everyday objects and devices to the internet enables automated data collection. This technology has advanced various industries and agriculture as well. By integrating IoT into farming we can create a great intelligent system that enhances productivity which also conserves resources and make real-time decisions based on environmental conditions. Whereas, sensors, cloud computing, and automated controls are some of the core components of the IoT-Based agricultural System that help optimize irrigation, monitor soil and manage climate effectively (Zhang et al., 2021).

In agriculture, IoT enables farmers to do remote monitoring to their fields using smart sensors, actuators and devices. These sensors collect data of sensor (soil moisture, temperature and humidity) which then helps the farmer in automating irrigation and improving water efficiency (To minimize the waste of water). The implementation of IoT-based agricultural systems devices will not only reduce human labour but will also minimize crop loss due to the unpredictable weather condition. As the global demand for food increases in the whole world the adoption of IoT in agriculture becomes very crucial which will then help in ensuring sustainable and efficient farming practices.

Therefore, IoT Based Agricultural System farming solutions combine AI and ML to analyze the historical agricultural data and predict the future of Nepal by leveraging AI-driven analytics farmers can make precise decisions about irrigation schedules, pest control, and crop rotations. This predictive capability allows for better risk management which also utilize resources ensuring that agricultural practices remain both profitable and environmentally sustainable (Anand, 2023).

Agriculture plays a very significant role not only in Nepal's economy but also in many other countries, employing approximately 66% of the population and contributing nearly 27% to the country's GDP (Central Bureau of Statistics, 2021) (Ministry of Agricultural Development, Government of Nepal, 2015). However, traditional farming has unpredictable weather conditions and a lack of modern technology which is yet to be known, that pose challenges to productivity for farmers. Farmers still rely on conventional irrigation methods which often lead to inefficient water usage (waste of water) and crop losses. Therefore, climate change has increased the frequency of thirst on a global scale, agriculture is undergoing

According to a report by Markets and Markets (2022), the global smart agriculture market is expected to grow to $22 billion by 2025 which is a very big deal in comparison to Nepal's economy, (Nepal Rastra Bank, 2015/2022) (Anand, 2023) driven by the increasing need for sustainable farming solutions which helps the farmer grow large number of crops in a healthy way (Ministry of Agricultural Development, Government of Nepal, 2015).

Nepal is an agriculture-based country where more than 65% of the population engages in agriculture in a daily basis for livelihood and agriculture shares and about 33% of the GDP at current price and 35% at 2000/01 constant price (Ministry of Agricultural Development, Government of Nepal, 2015). Agriculture is the backbone of our country Nepal. There is traditional agriculture system in Nepal even in the twenty first century. In traditional agricultural practices farmers face a variety of challenges that reduces crop yields and sustainability including inefficient water usage (Wastage of water) poor soil quality, unpredictable weather in different areas and a lack of real time data in crop health.

Farmers sometimes provide too much water to the and affect their growth. This issue often leads to many wasted resources, increased operational costs, and lower overall productivity. Therefore, agriculture sector has not been developed satisfactorily.

To solve these challenges, we have developed an IOT Based Smart Agricultural System farming project as a solution that uses various sensors such as ultrasonic sensor, Dht11 sensor, soil moisture sensor and devices like esp32 to optimize most of the resources. By continuously monitoring environmental conditions, the system that automatically adjust irrigation then having the rights on real time data improving crop health and enhancing overall productivity. The IOT-Based Smart Agriculture tools because it will help the farmers grow trust over the IOT-Based tools so that they know where to invest their money. A more sustainable data driven practice that maximizes resources and increases agricultural efficiency in Nepal (Sharma et al., 2022).

Aim

The main aim of developing an IOT-based smart agricultural system is to help farmer to automate agricultural task such as managing irrigation, adapting to climate change and optimizing resource management.

Objectives

- To develop a soil moisture monitoring system that automatically activates irrigation based on real-time moisture levels ensuring crops are provided with the right amount of water preventing from over irrigation.
- To provide a user-friendly application to farmers to monitor the conditions remotely and receive alerts if any parameters go out of the expected range, potentially harming the crops.
- To monitor the water supply in storage tanks to optimize water usage and prevent shortages.
- To viral the concept of IoT Based Smart Agricultural System throughout the globe.
- To develop the country with the help of IoT devices.

This IOT based smart irrigation system is proposed to automate the irrigation and monitor the environmental conditions to get the optimal crop growth and use the resources minimally which will be done by integrating different sensors including ultrasonic, DHT11 (temperature, humidity) and soil moisture sensors with ESP32 microcontroller and real-time monitoring and control will be done through Blynk .

There will be soil moisture sensor implanted inside the soil which is going to get the measurements on the soil moisture level continuously and whenever the level of moisture is below the threshold it will then turn on the water pump which will irrigate the soil to needed moisture and this process will be repeated again and again so that the soil never remains dry and also there is no overflow of water ensuring the minimal use of water.

So, whenever the temperature rise or drop the system will be changing the irrigation schedule so that the crops are not overstressed with over irrigation or under irrigation also, we have the monitoring and control system whereby all the data from the sensors will be transmitted to Blynk app whereby there will be alerts, reports about conditions and from where farmers will be controlling the system remotely this is whole system with which a farmer can improve overall crop yield. (Kumar and Singh, 2021).

The hardware required for this system are:

ESP32 Microcontroller: It is a central microcontroller developed by Express if that includes Wi-Fi and Bluetooth wireless capabilities and dual-core processor used for processing and communication.

Soil Moisture Sensor: It measure the soil moisture if the soil is dry it will detect and if the soil is moist when poured water it will then detect the soil is moist.

DHT11: This sensor allows the user to measure the temperature and humidity.

HC-SR04: This sensor detects the distance between an object.

Water pump: It automatically irrigates the soil whenever needed by transferring the water in the tank to the soil.

Buzzer: Whenever, there is low water level or there is a bad weather it alerts the farmers with its alarm system.

5V Relay Module: It controls the water pump based on the date provided by the sensors.

LCD Display: It displays the environmental conditions.
Jumper Wires: It is used to make connection between items on your breadboard and your microcontroller header pins.

Breadboard: It is used for building temporary circuits.

5V 2A DC Adapter: It powers ESP32 and components.

The software required for this system are as:

Arduino IDE: All the codes for esp32 will be written over this IDE.

Blynk: It's a cloud platform for real-time monitoring and alerts.

Fritzing: It is used for designing circuit diagrams.

For this case study, we focus on a local community farm growing tomatoes, lettuce, and carrots—crops that require careful monitoring of soil moisture and climate conditions using tools like ESP32, Ultrasonic Sensor (HC-SR04), DHT11 Temperature and Humidity Sensor, Soil Moisture Sensor , Buzzer, Water Pump, LCD Display (I2C), Jumper Wires, Breadboard, 5V relay module, 5V 2A DC adapter, etc.

The implementation of an IoT-based smart agricultural system will help farmers overcome traditional inefficiencies, enabling better decision making through real time data collection and automation. (Ahmed et al., 2022).

The community farm OF Nepal faces major challenges related to inconsistent irrigation, water wastage, and the impact of climate change not only that the main thing it lacks are the advanced tools of IOT system. Farmers manually check soil conditions, which often leads to overwatering or underwatering, reducing crop yields and also affects the farmer health.

Additionally, the lack of automated monitoring means farmers has limited access to real time weather or soil data and too much labor making it difficult to optimize farming practices.

System Analysis

By implementing an IOT (Internet of things) driven solution, the farm can improve its irrigation process by using soil moisture sensors to determine the exact water requirements of crops, applying pesticides automatically using AI-driven tools which helps to destroy insects that are harmful to the cultivated plants and humans.

A temperature and humidity sensor will provide real-time weather updates ensuring the farm adjusts watering schedules according to environmental changes, an ultrasonic sensor will monitor water tank levels to prevent shortages and optimize resource use, Buzzer for alerts, allowing farmers to track conditions remotely and receive alerts if any parameters go beyond the optimal range (Sabu, 2023).

As from our research of this case study, we recommended that the project on the IoT based agricultural system which was invented by our team. The IoT Based system has an insane capability to develop and improve crop yields and reduce the wastage of water usage which leads to a great futuristic agricultural system and profitable for farmers as well. As from our analysis throughout this project we came to acknowledgment of all the components used synced perfectly with the system's nature and design. So, we recommend that the idea on further research should be done to explore the capability for integrating machine learning and artificial intelligence. (Yadav, n.d.) By implementing this it could not only improve the agricultural system but also be used on other platforms for insane accurate predictions about crop growth and water

usage.
Therefore, increasing the efficiency and productivity too. The IoT-Based Agricultural System has the potentiality to modernize the agricultural sector of Nepal by automation, optimization and management. This system can help farmers make good real-time decisions regarding enlarge pest control, good environment monitoring, fertilizer usage and crop harvesting times which will increase the growth of crop yields, profitable investments and cheap costs. To implement the effects of this system, it is recommended to:

- Advertise the Ideal use of Artificial Intelligence and Machine learning .
- Inspection of laws on the country before implementing the analysis.

The phases in which we have developed an IOT-Based Smart Agricultural System using various gadgets such as: Sensors, Actuators, Microcontroller, Jumper wires, Breadboard, Adapters & cables, Water pump, Integrated circuits (Relay module), Buzzer, LCD, etc. To create a system for farmers to make there work easier and sustainable.

The designing for the IOT-Based Smart Agricultural System are given below:

- User requirements
- Aim of the project
- Developing
- Testing

Phase 1

Connecting ESP-32, Breadboard and DHT11 sensor

Initially, DHT11 was placed on breadboard. The 3.3V and GND pin of ESP32 were connected to the Breadboard positive and negative rail respectively. Then the signal pin of DHT11 was connected to GPIO5 on ESP32, while the DHT VCC and GND of the DHT11 were connected to the breadboard positive and negative port.

Phase 2

Connecting the Ultrasonic Sensor (HC-SR04) with the **Circuits**

Moving on ultrasonic sensor, Trig and Echo pin of ultrasonic sensor (HC-SR04) were connected to GPIO12 and GPIO13 of ESP32. Further, ultrasonic VCC and GND were connected to the breadboard positive and negative port respectively.

Phase 3

In third phase, buzzer positive terminal were connected to ESP32 GPIO14 pin and buzzer negative terminal was connected to breadboard negative port respectively. Similarly, Soil moisture sensor positive and negative were connected to breadboard positive and negative. Analog pin(A0) of soil moisture sensor was then connected to the GPIO34 pin of esp32.

Phase 4

In the fourth phase, I2C LCD was added with the rest of the circuits. I2C LCD VCC and GND were connected to breadboard positive and negative port. In other hand, I2C LCD SDA (Serial Data Line) and SCL (Serial Clock Line) were connected to the ESP32 GPIO21 and GPIO22 respectively.

Phase 5

Connecting 5V Relay Module, Water Pump and 5V 2A DC Adapter

In Last phase, 5V Relay Module, Water Pump and 5V 2A DC was added with the whole circuit. Relay VCC and GND were connected to breadboard positive and negative port respectively. In other hand, Relay IN pin was connected to ESP32 GPIO32 pin. Then, positive of adapter were connected to NO (Normally Open) port of 5V Relay Module and negative of both water pump and adapter were connected to the negative of breadboard. Lastly, Water pump positive pin was connected to 5V Relay Module COM(Common).

Thus, after connecting all the hardware component and uploading the code, the system functioned successfully.

Connecting with Blynk

In last phase, the whole circuit was connected with blynk to monitor it through online.

After integrating all the sensors and actuators. The advanced IOT Based agriculture system was able to successfully monitor and respond to our implementations. The DHT11 sensor worked well and tracked temperature and humidity levels, while the soil moisture sensors tracked consistent real-time data on soil conditions. These readings were then correctly displayed on the I2C LCD screen making it easy to monitor the environment of the system. The use of the ultrasonic sensor allowed for basic distance measurements acknowledging the setup could measure the distance of the water control efficiently.

The 5V Relay module in connection with a mini water pump functioned reliably whenever the system detected low moisture of the soil (dry soil). This automatic irrigation triggered only when necessary, preventing wastage of water. Moreover, the work of a buzzer helped with alerts for specific conditions like high humidity (DHT11 sensor) or low moisture (Soil moisture sensor) making it more interactive and practical. One key finding was that the system, despite being budget-friendly and compact, delivered stability and gave accurate outputs over multiple test runs. However, during testing the microcontroller needed reboot time to time.

Overall, the project met its main objective on making the work of the farmers by reducing manual labor in farming through automation using IOT. The combination of hardware and software worked well in tandem to simulate a smart mini agriculture environment. While the system is scalable improvements such as remote monitoring via Wi-Fi or GSM, real-time cloud logging, or solar power integration can further make the project suitable for larger-scale farming needs.

In the future this IOT-Based Smart Agricultural System could be improved by integrating wireless connectivity like Wi-Fi or GSM. This would allow farmers to monitor their field data from anywhere using a smartphone or computer which is especially useful for those managing large farms or remote areas. Cloud platforms can be added to store and analyze data giving better insights into patterns over time with platforms like Blynk, automation and remote access can become much easier and more effective.

Another important future improvement could be the use of more advanced sensors and AI based systems. For example: adding PH sensors, rain sensors and even AI driven plant disease detection can make the system much smarter. Artificial Intelligence (AI) can not only analyze environmental conditions but also make automatic adjustments making the system more adaptive.

Hence, the system can be made more sustainable by using solar panels for power. This would help in reducing electricity usage and make the setup eco-friendly especially for rural regions where power supply is not available. Combining IOT with renewable energy sources like solar can make a big difference in real world agricultural usage. This makes the entire model more scalable and suitable for off grid areas as pointed out by experts in smart farming. (Mehta and Jain, 2021).

The adoption of IoT in agriculture explains a significant step toward modernizing traditional farming practices by utilizing real time data from sensors. Farmers can make informed decisions that optimize irrigation, monitor climate conditions and improve overall resource management. This not only reduces manual labor but also minimizes water wastage ensuring that crops receive the right amount of hydration at the right time. As demonstrated in the case study. The implementation of IoT Based Agricultural System farming techniques can drastically improve crop yield and sustainability making it a practical and necessary solution for the challenges faced in agriculture today (Gupta and Sharma, 2020).

In the other hand side, the ability to remotely monitor farm conditions through platforms like Blynk enhances efficiency and convenience for farmers allowing them to respond to environmental changes in real time. This level of automation ensures consistency in crop production, reduces the risk of yield loss due to unpredictable weather and ultimately contributes to food security.

It's potential for transforming the industry is undeniable. Future developments may include AI driven tools, enhanced automation and even integration with renewable energy sources for more eco-friendly farming solutions by embracing these innovations agriculture can continue to evolve providing higher productivity, improved resource management and more sustainable future for farmers worldwide.

Test 1

Objective	To test the working of DHT11 sensor.
Activity	Power was supplied to the DHT11 sensor and the temperature and humidity readings were taken at different intervals.
Expected Result	The sensor should provide valid readings with the temperature and humidity values fluctuating as the environment changes.
Actual Result	The sensor provided accurate readings.
Conclusion	Test was successful

Test 2

Test	2
Objective	To test the working of Ultrasonic Sensor (HC-SR04).
Activity	Power was supplied to the ultrasonic sensor, distance readings were monitored.
Expected Result	The ultrasonic sensor (HC-SR04) should accurately detect and display distance measurement based on object position from it.

Actual Result	Ultrasonic sensor accurately detected and displayed measurement corresponding to object position.
Conclusion	Test was successful!

Test 3

Test	3
Objective	To test the working of soil moisture and buzzer.
Activity	Soil moisture sensor was connected to the ESP32, and the analog value was read and printed on the serial monitor and alert buzzer when soil moisture is low.
Expected Result	The soil moisture sensor should display values on the serial monitor with the readings changing according to the soil 's moisture level and alert user with the help of buzzer.
Actual Result	The soil moisture sensor successfully output values on the serial monitor and alert when soil moisture is low using buzzer.
Conclusion	Test was successful!

Test 4

Test	4
Objective	To test the printing functionality of the LCD display.
Activity	Uploaded the code to Arduino using Arduino IDE.
Expected Result	It should display “Hello World” message.
Actual Result	It displayed “Hello World”.
Conclusion	Test was successful

Test 5

Test	5
Objective	To test the working of Adapter, Water pump and 5V Relay Module

Activity	The water pump, relay, and adapter were connected to the ESP32. The relay was controlled through the GPIO32 pin and the water pump was turned on and off by toggling the relay.
Expected Result	The water pump should turn on when relay is activated and the water pump should turns off when relay is deactivated.
Actual Result	The relay successfully activated and deactivated the water pump when the control pin on the ESP32 was toggled between LOW and HIGH
Conclusion	Test was successful

Test 6

Test	6
Objective	To check the working of blynk by alerting user when water level is low through notification
Activity	Water Tank was made empty.
Expected Result	It should detect low water level and trigger notification via Blynk.
Actual Result	It successfully delivered notification when water level was low.
Conclusion	Test was successful.

Pin Name	**ESP32 Pin**	**Breadboard**	**5V Relay Module**
DHT11 - Signal Pin	GPIO5	-	-
DHT11 - GND	-	Negative	-
DHT11 - VCC	-	Positive	-

Ultrasonic Sensor (HC-SR04) - Trig Pin	GPIO12	-	-
Ultrasonic Sensor (HC-SR04) - Echo Pin	GPIO13	-	-
Ultrasonic Sensor (HC-SR04) - VCC	-	Positive	-
Ultrasonic Sensor (HC-SR04) - GND	-	Negative	-
I2C LCD - SDA	GPIO 21	-	-
I2C LCD - SCL	GPIO 22	-	-
I2C LCD - VCC	-	Positive	-
I2C LCD - GND	-	Negative	-
Soil Moisture Sensor - VCC	-	Positive	-
Soil Moisture sensor - GND	-	Negative	-
Soil Moisture Sensor - A0	GPIO34	-	-
Buzzer - Positive	GPIO14	-	-
Buzzer - Negative	-	Negative	-
5V Relay Module – VCC	-	Positive	-
5V Relay Module – GND	-	Negative	-
5V Relay Module – IN	-	GPIO32	-
Adapter - Positive	-	Positive	NO
Adapter – Negative	-	Negative	-

Water Pump – Positive	-	-	COM
Water Pump – Negative	-	Negative	-