DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING,
SHARDA SCHOOL OF ENGINEERING AND TECHNOLOGY,
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PRECISION AGRICULTURE USING IOT SENSORS

A project submitted
in partial fulfillment of the requirements for the degree of Bachelor of Technology in Computer Science and Engineering

by

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CERTIFICATE

This is to certify that the report entitled **"PRECISION AGRICULTURE USING IOT SENSORS"** submitted by "YASHWARDHAN (2019003754), AAKRITI KUMARI (2019504663) and YATHARTH NEGI (2019620107)" to Sharda University, towards the fulfillment of requirements of the degree of **"Bachelor of Technology"** is record of bonafide final year Project work carried out by them in the "Department of Computer Science & Engineering, Sharda School of Engineering and Technology, Sharda University".

The results/findings contained in this Project have not been submitted in part or full to any other University/Institute forward of any other Degree/Diploma.

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ABSTRACT

Advancement in IOT technology over years has led to emergence of many new concepts, smart agriculture is one of them. Smart agriculture systems include technologies such as IOT and wireless networks to reduce human intervention by monitoring environmental conditions and then take appropriate action based on user input. In India agriculture sector contributes more than 20% to GDP and above 70% population is involved in farming [6]. To achieve the target of a 5 trillion-dollar economy it is important to resolve the issues in farming. Modernization of traditional farming techniques can be a solution to this. Quality and quantity of agricultural yield can be improved by a smart agriculture system. This project aims at making a model of a smart agriculture system having highlighting features like irrigation that is intelligently controlled and makes decisions based on precise real-time field data. It also includes features of monitoring soil condition, animal intrusion monitoring, weather management, pest control etc. All of these actions will be controlled by any remote smart device or internet-connected computer, and they will be carried out by integrating Esp32 with Wi-Fi or ZigBee modules, actuators, and sensors.

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CHAPTER 1
INTRODUCTION

1.1 Problem Statement

An efficient decision support system can be implemented using wireless sensor networks to monitor and manage different activities of a farm and provide useful information related to soil moisture, temperature, and humidity. This system can help farmers make informed decisions about irrigation, planting, and other farm activities. The wireless sensor network can be deployed across the farm, with sensors placed strategically in the soil, air, and water to collect data on parameters such as soil moisture, temperature, and humidity. The sensors can communicate wirelessly with a central gateway or a mobile application, which can process and analyze the data.

The system can provide real-time information on soil moisture levels, temperature, and humidity content to farmers, helping them make decisions about when and how much to water their crops. In case of weather conditions causing water level to increase, the system can alert farmers to take necessary actions to manage the water levels, either manually or automatically using the mobile application.

The decision support system can be designed to be user-friendly and cost-effective, utilizing minimal hardware and cost resources. It can be accessed through a mobile application, making it convenient for farmers to monitor and manage their farm activities on the go.The system can also have the capability to measure the increase or decrease in water levels and soil moisture, providing valuable information for farmers to optimize irrigation practices and prevent overwatering or underwatering. This can help farmers save water and resources, reduce costs, and improve the overall efficiency of their farming operations.

By leveraging wireless sensor networks and mobile applications, this decision support system can provide farmers with real-time information, automate manual operations, and help them make informed decisions to optimize their agricultural practices. This can lead to improved productivity, reduced distractions caused by weather conditions, and more sustainable and efficient farming practices.

1.2 Project Overview

Agriculture in the Indian economic system is one of the foremost occupations which is done by the rural people on a very large scale as it provides them job opportunities which can help them with earning basic necessities and to cope up with society. This agricultural sector helps in generating food, fiber, various types of spices and other products asked by the sophisticated society out there. Agriculture is the basic source of income for approximately 60% of India's population and is the largest source of livelihoods among all the sectors present. Climatic changes will have a notable impact on the agricultural sector as nowadays the automobile industry, pharmaceutical industries and various others are contributing to air pollution as well as water pollution by generating harmful pollutants and gasses into the atmosphere such as CFCs, carbon dioxide, sulphur dioxide and releasing harmful toxic substances into the water bodies which in turn makes it difficult for irrigation of crops and reduces their productivity. Groundwater irrigation and rain fed agriculture are some of the new concepts which are introduced to produce efficient crops which may use water content in a sustainable way. A smart system is designed to use water efficiently. In the earlier system the planter would manually go to the fields to make the water inflow, but now the system automatically does that efficiently. In India, the main source of employment is in the confederated sectors of agriculture. With 82 percent of growers being small and marginal, 70% of its pastoral houses still rely solely on husbandry for their survival. Total food grain production was predicted to be 275 million tonnes in 2017–18. (MT). India is the world's biggest producer of pulses having production about (25% of total worldwide output), consumption about (27% of total global consumption), and importer (14%) of pulses [1]. The rising global water extremity: In addition to managing failure and conflict between water druggies, the available freshwater is further defiled by the mortal and beast population and the pollution situations have increased at an intimidating rate. If this pattern continues, food product usage will be confined, affecting mortal productivity and, as a result, the entire ecosystem in the future. The population has grown significantly, and at a rate that is quicker than the rate at which food production has expanded. This is the main and most significant cause of the issue

For example, a typical grass crop requires roughly 6.5 mm of water per day in a semi-arid region with a mean temperature of 20°C. A sub-humid climate with a mean temperature of 30°C necessitates about 7.5 mm of water per day for the same grass crop [2].

Table 1.1 Average daily water need of standard grass during irrigation season

Climatic zone	Mean daily temperature		
	low	medium	high
	(less than 15°C)	(15-25°C)	(more than 25°C)
Desert/arid	4-6	7-8	9-10
Semi arid	4-5	6-7	8-9
Sub-humid	3-4	5-6	7-8
Humid	1-2	3-4	5-6

A major contribution to the growth of any nation, especially developing countries, is accounted for by its agricultural sector. The low volume of crops and fruits is a result of the traditional methods of husbandry, which many farmers still use. However, it is observed that the advent of robotisation has made the yields better. It is therefore believed that ultramodern wisdom and technological application in the agrarian sector will improve growth. But there are also many other factors that affect productivity, such as insect attacks. This, to an extent, can be controlled by scattering germicides, applying sticky traps or using ultrasonic pest repellers. It is also important to prevent attacks of wild animals and insects when the crop grows. To cater to all these issues, it is imperative to develop an intertwined system that works on all factors that affect productivity growth through all the stages, like cultivation, harvesting and storage. This paper examines a useful system to capture field data and control field operations. It aims at making husbandry "smart" through application of robots and IOT technologies. The paper features sensors, which are interconnected with each other to provide real time field data and to perform tasks like humidity and temperature sensing, moisture sensing etc. Additionally, it includes aspects of smart irrigation with smart control, which would be grounded on real time field data. Lastly, detecting wild animal intrusions may destroy the crops using motion sensors. Any remote smart device or computer will be used to control all of these procedures. Further actions will be carried out by integrating Arduino with Wi-Fi or ZigBee modules, actuators and sensors.

1.3 Expected Outcome

The use of IoT in agriculture is transforming farming practices by enabling real-time monitoring of environmental parameters through sensor devices. Data on temperature, humidity, and soil moisture is collected and stored in the cloud, allowing farmers to remotely access and analyze the information. This enables data-driven decision making, optimized resource usage, and improved production efficiency. IoT in agriculture promotes sustainable farming practices by optimizing irrigation, minimizing the use of pesticides and fertilizers, and reducing resource wastage.

Overall, the adoption of IoT in agriculture has the potential to revolutionize the way farmers manage their crops and land, leading to more efficient and sustainable farming practices.

1.4 Hardware & Software Specifications

1.4.1 Hardware

- ESP32- We have used a more powerful microcontroller than arduino i.e ESP32. The Arduino falls short in many areas despite its great assets. Arduino has clock speed of around 16Mhz whereas ESP32 has up to 240Mhz.It has 520 KB SRAM, 448KB ROM, and 16KB RTC SRAM. It also supports 802.11 b/g/n Wi-Fi connections at speeds up to 150Mbps.

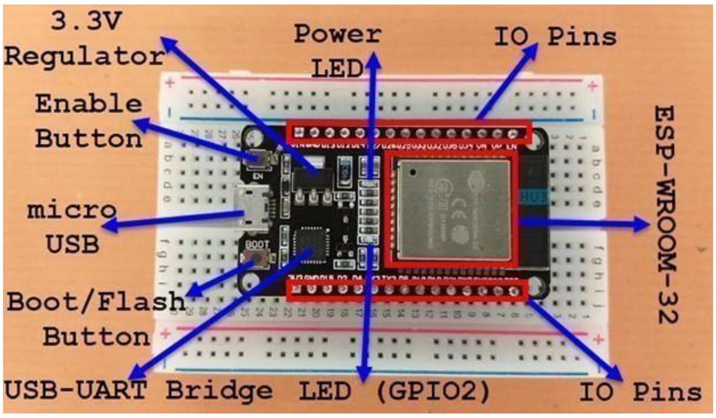

Fig 1.1 ESP32 microcontroller

- DHT11- For better crop yield it is important to check all soil parameters. DHT11 sensor is used for temperature and humidity sensing. It outputs both temperature and humidity as serial data. DHT11 sensors can be purchased as sensors or modules. The only difference between sensors and modules is that modules have internal filter capacitors and pull-up resistors, and sensors must use them externally if needed. It has an operating voltage between 3.5V to 5.5V and accuracy of -1% to +1%.

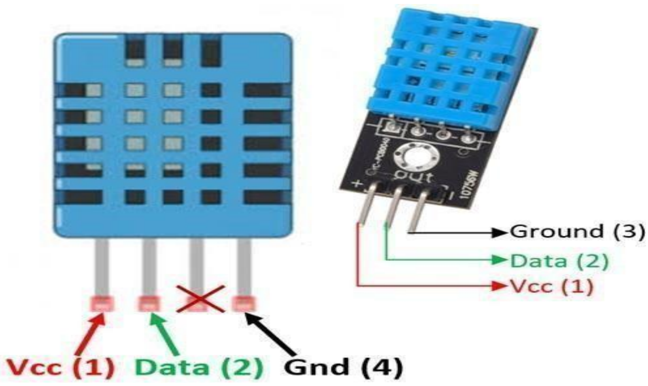

Fig 1.2 DHT11 temperature and humidity sensor

- MOISTURE SENSOR- A soil moisture sensor is a device that measures the moisture content of the soil. It typically consists of a fork-shaped probe with two conductors that measure the electrical resistance in the soil. The data collected helps farmers determine the optimal irrigation schedule, avoiding overwatering or underwatering. Soil moisture sensors are essential for modern agriculture, enabling data-driven decisions for efficient and sustainable farming practices.

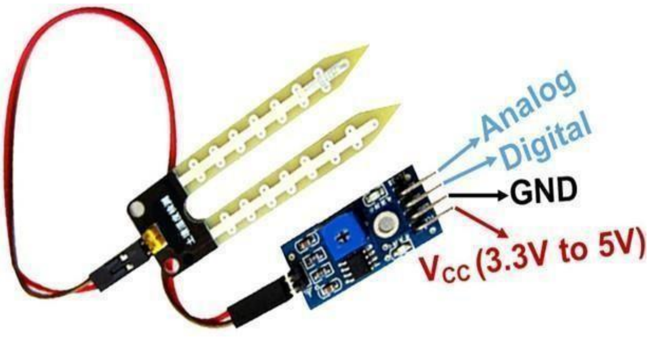

Fig1.3 Moisture Sensor

- UV LEDS- Usage of pesticides in traditional agricultural practices can often lead to some of the major human diseases such as Alzheimer, asthma, etc. Therefore usage of UV light can reduce the usage of pesticides and can help in high productivity of crops without any major drawback.

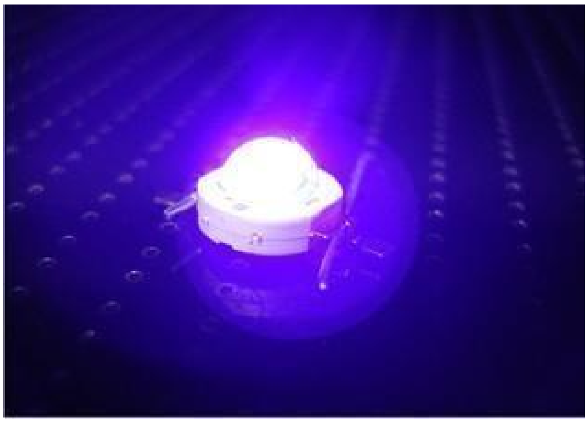

Fig 1.4 UV LEDs

- IC7805- The IC 7805 is a popular 5V voltage regulator that provides a stable output voltage despite input voltage fluctuations. It is widely used in electronic circuits to ensure a reliable power supply. With its ability to regulate the output voltage to 5V, it acts as a protective component that safeguards the circuit from potential damage caused by varying input voltages. The IC 7805 is affordable, easily accessible, and commonly used in various applications.

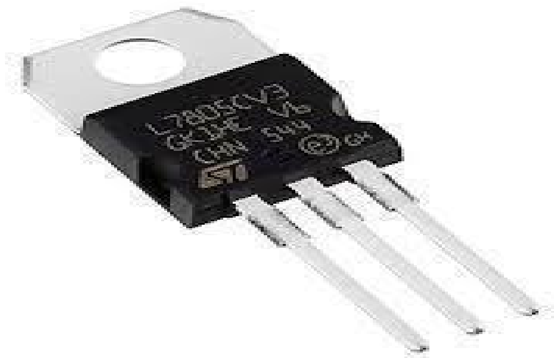

Fig 1.5 IC7805 Voltage Regulator

- CAPACITOR 12V 1000UF- Capacitors are devices used to store electrical charge in electrical circuits. Capacitors work on the principle that bringing a grounded conductor closer together significantly increases the capacitance of the conductor. So a capacitor has two plates spaced apart with equal and opposite charges.

Fig 1.6 Capacitor 12V 1000UF

- HC - SR04- In our proposed system, HC - SR04 sensor detects the animal intrusion in the field. The transmitter releases a specially designed 8-pulse pattern. If pulses are reflected back it indicates the presence of obstruction. The distance of obstruction is calculated by multiplying the speed of sound(340m/s) and the time taken by Echo pin to get the reflected pulse.

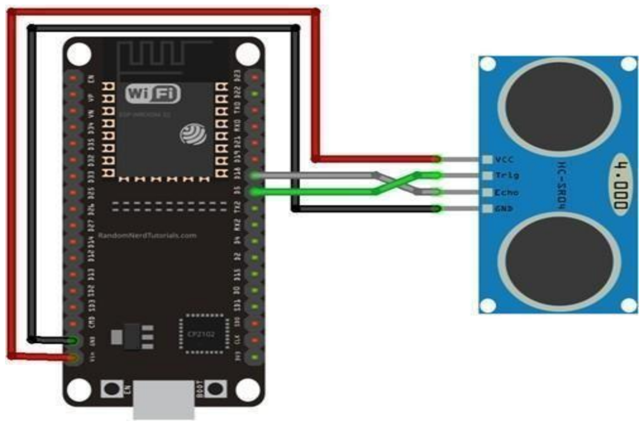

Fig 1.7 HC - SR04 Motion Sensor

1.4.2 Software

There are several software requirements for an IoT-based smart agriculture system. These may include:

1. IoT Platform: A robust and scalable IoT platform is essential for collecting, storing, and processing data from various agricultural sensors and devices. The platform should have the capability to handle large amounts of data and provide real-time analytics for decision-making.

2. Data Visualization and Dashboard: A user-friendly interface that provides visualization of data in the form of graphs, charts, and dashboards is crucial for farmers and agriculture stakeholders to monitor and analyze the data collected from sensors. This helps in making informed decisions about crop management, irrigation, pest control, and other agricultural activities.

3. Mobile Applications: Mobile applications can provide farmers with real-time access to the system, allowing them to monitor and control various parameters remotely. Mobile apps can also provide alerts and notifications about critical events, such as changes in weather conditions or pest infestations.

4. Communication Protocols: IoT-based smart agriculture systems require reliable communication protocols for seamless data exchange between sensors, devices, and the central system. Common protocols used in such systems include MQTT, CoAP, and LoRaWAN.

5. Security and Privacy: Strong security measures, such as encryption, authentication, and access control, are essential to protect the data collected from sensors and devices. Ensuring the privacy and integrity of the data is crucial to maintain the trust of farmers and other stakeholders in the system.

Chapter 2
LITERATURE SURVEY

2.1 Existing Work

Horticulture, being the foundation of our country's economy, has been traditionally reliant on manual methods for estimating soil maturity, selecting crops, and determining irrigation needs. However, these traditional methods lack precision and can be affected by climatic conditions, leading to reduced yields and profitability. The reliance on rainfall patterns for irrigation further adds to the uncertainty and inefficiency of traditional farming practices.With the advent of modern technologies like IoT and data-driven approaches, there is a need to provide farmers with solutions that can maximize crop yield based on real-time data, weather forecasting, and other parameters. Farmers can benefit from using soil moisture sensors, weather sensors, and other IoT devices to monitor and analyze various agricultural parameters accurately and in a timely manner. This can enable farmers to make informed decisions about crop selection, irrigation schedules, and pest control, resulting in improved productivity and profitability.The traditional Indian agricultural system, which heavily relies on manual methods, may not be cost-effective and may yield comparatively low outputs. Therefore, there is a growing need for farmers and agriculturalists to adopt modern solutions that utilize data, technology, and advanced analytics to optimize farming practices and maximize crop production. By leveraging IoT and other innovative technologies, farmers can overcome the limitations of traditional methods and achieve sustainable and efficient agricultural practices, leading to better economic outcomes for the agriculture sector as a whole.

2.2 Proposed System

Therefore, in order to improve production efficiency, we need to use innovations that evaluate and recommend harvest types by supporting both ranchers and land. The Internet of Things (IOT) is transforming agribusiness, engaging farmers through a wide range of technologies such as precision and conservative cultivation, and facing challenges on the ground. The project enables farm managers to effectively monitor various environmental parameters using sensor devices such as temperature sensors, and soil moisture sensors. At regular intervals (30 seconds), the sensor collects information about the farmland area, which is recorded and stored online using cloud computing and the Internet of Things. A user can remotely monitor and control the system using an application that presents her web interface to the user.

2.3 Paper Review

Table 2.1 Paper Review

Author	Title	Software Used	Hardware Used	Advantages
D.Hemanth Kumar, P.Ramesh, Bhavana Godavarthi, P.Nalajala	Design and implementation of modern automated real time monitoring systems for agriculture using IOT	ARM module interfaced with sensors, Monitoring the plant through IOT and server.	Temperature sensor, Humidity sensor , ARM controller, Relay driver, Solenoid valve.	An integrated wired/wireless solution allows one to exploit the positive aspects of both technologies and this is handled from any place.
Adithya Vadapalli, Swapna Peravali and Venkata Rao Dadi	Smart Agriculture System using IoT Technology		Arduino UNO board, Temperature & Humidity sensor, Raindrop sensor, soil moisture sensor, relay switch on / off the Pump.	With the use of remote sensor frameworks, farmers get the farm conditions while seated at home or in another location.
Nikesh Gondchawar1 , Prof. Dr. R. S. Kawitkar2	IoT based Smart Agriculture	AVR Studio Version 4, Proteus 8 Simulator, Raspbian Operating System, SinaProg	AVR Microcontroller Atmega, ZigBee Module, Temperature Sensor, Moisture sensor, Obstacle sensor, Raspberry Pi	The main feature of this paper is it comprises intelligent decision-making based on exact real-time field data and smart irrigation . Smart warehouse management, which involves monitoring the humidity , temperature, and thefts.
Muthu Noori Naresh, P Munaswamy	Smart Agriculture System using IoT Technology		ARM Processor, Water level sensor, moisture sensor, humidity sensor, temperature sensor	The invention that evaluates the harvest's nature and offers suggestions.

Prathibha S R1, Anupama Hongal 2, Jyothi M P3	IOT BASED MONITORING SYSTEM IN SMART AGRICULTURE		Temperature sensor, Humidity sensor, 600-Whigh-efficiency power supply, CC 3200 Single chip with integrated microcontroller, Camera	By monitoring the efficiency of the soil, temperature and humidity, rainfall, fertilizer efficiency, monitoring water tank storage capacity, and also detecting theft in agricultural regions, this research expects a rise in output at a cheap cost.
G. Sushanth and S. Sujatha	IOT based Smart Agriculture System		Arduino Uno board , Power supply, moisture sensor, Temperature sensor, Humidity sensor	For the purpose of controlling water flow, an algorithm was c r e a t e d u s i n g t e m p e r a t u r e a n d moisture in the soil threshold values that was then put into a microcontroller-based gateway.
Devesh Mishra, Tanuja Pande, Dr. Krishna Kant Agrawal, Akhilesh Kumar Pandey, Prof. Ram Suchit Yadav	Smart Agriculture System Using IOT	Arduino IDE, Blynk, ThinkSpk	Node MCU (ESP8266-12E), Humidity and Temperature Sensor, Soil Moisture Sensor	Parameters from the Soil, moisture Temperature and Humidity has been displayed on the application.Notification of watering the plants according to the value of moisture content measured by soil moisture sensor is also received. The threshold value for activating the pump can also be set accordingly.

Abhiram MSD, Jyothsnavi Kuppili, N.Alivelu Manga	Smart Farming System using IoT for Efficient Crop Growth	Blynk (User Interface)	Node MCU , Humidity & Temperature Sensor (DHT11), Soil Moisture Sensor, DC Motor	All the values of the distinct parameters are sent to the smartphone using the internet. This system is very much helpful to farmers as they need to regularly pump water and check the status of each crop. From anywhere in the world, farmers can know the values of humidity, temperature and soil moisture and if the DC motor is ON through the blynk app present in their smartphones.
Prof. K. A. Patil, Prof. N. R. Kale	A Model for Smart Agriculture Using IoT		Ubi-Sense mote, Zigbee IEEE 802.15.4	The proposed system will help the farmers to cope up with the real time problems such as the amount of water needed for a particular crop for efficient growth.
Pratibha SR , Anupama Hongal , Jyothi MP	IOT Based Monitoring System In Smart Agriculture		CC3200(contains networking sub- system with an internal MCU application), Temperature Sensor(TMP007), Humidity Sensor (HDC1010) , Power supply	Wireless monitoring of fields reduces human power and it also allows users to see accurate changes in crop yield. It is cheaper in cost and consumes less power.
Achilles D.Boursianis, Maria S.Papadopoulo, Panagiotis Diamantoulaki, Aglaia Liopa-Tsakalidi,Pantes	Internet of Things (IoT) and Agricultural Unmanned Aerial Vehicles (UAVs) in Smart Farming		IOT smart sensor, unmanned aerial systems usage in agriculture	Various iot technology such as Cloud Computing, Big Data Analytics, Embedded Systems and usage of UAS in irrigation, fertilization is discussed.

Chapter 3
SYSTEM DESIGN & ANALYSIS

3.1 Working

The project works on the bases of ESP32 IOT module which works on 3.3V to 5V, IC7805 is an voltage converter which is used to convert 12V to 5V, the AC power supply is directly passed to step down transformer which is connected to rectifier circuit of 4 PN junction diodes which is used to convert the alternating current to direct current, moreover the 470uf capacitor is further connected to the terminals for smoothing of voltage, now the 12V DC current is converted into 5V via IC7805 and the output of 5V is acquired.

The 5V activates the ESP32 and all the other sensors connected to the ESP32. It is an IOT module which is used to communicate with routers and make local web applications. Sensors are connected to the digital and analog pins accordingly and send the data. ESP32 creates local page which can be accessed by every device which is connected to the router, we have made the web page which is designed in HTML, CSS, Bootstrap and Javascript used in designing and Javascript for client side interaction such as input the value and interaction with button etc. The project has 2 modes for irrigation auto and manual. In automatic mode the farmer has to set maximum and minimum boundaries of moisture from the table we have provided on webpage, as the values are set Json sends parcel to ESP32 and command gets encoded, and pump works automatically decided by that values and moisture sensor. Application also has a weather forecasting system which is implemented with the two in one sensor DHT11 temperature and humidity and the real time data will be sent again using the Json parcel from ESP32 to the server application which will show the current temperature and humidity of the surrounding area. We also have the drastic feature of detection of unneeded animal interference where ultrasonic sensors working on sonar technology detect the presence of activity using variation in distance, this activity can also be accessible from the dashboard. We have used UV lights which work as pesticides boosters so that less amount of pesticides should be used and more organic procedures can be followed, this can also be controlled using a dashboard by the farmer themselves.

3.2 System Features

UV LIGHT

As a complement or alternative to pesticides, UV light offers farmers new options for disease control. The germicidal effects of UV-C have been known for centuries, explains a research expert at the Lighting Research Center (LRC), part of Rensselaer Polytechnic Institute. “It is widely used to kill pathogens in water and HVAC systems. It is also used to pasteurize products such as cider without heat. I think you can get it. Farmers face economic and environmental challenges as pathogens become resistant to traditional fungicides. Research trials conducted by the LRC have shown it to be effective in killing powdery mildew and downy mildew. It is also expected to be effective against other surface fungi, bacterial and viral diseases, and possibly certain insects. It makes their development very difficult," Skinner said. "This is very important for both conventional and organic farmers."

WEATHER FORECASTING

Everything in the atmosphere interacts to create different weather conditions and phenomena. In this system we are developing a user interface through which we can get information regarding the weather at a particular location which in turn will help the user by sowing crops or to maintain moisture level beforehand. This can be done through weather API (Application Programming Interfaces) which allows you to connect large databases of weather forecasts and various other information. Weather is just the sum of all these interactions. Temperature, air pressure, wind (speed and direction), relative humidity, precipitation, visibility, cloud type and extent, sunshine duration, etc. These all are the conditions that determine the weather of a particular location.

ANIMAL INTRUSION DETECTION

The invasion of animals into living areas is increasing day by day, affecting human life and property, causing conflicts between humans and animals, but according to the laws of nature, all living things on this earth must be protected. Agriculture is the backbone of the economy, but animal encroachment on agricultural lands causes enormous crop losses. Elephants and other animals often attack the agricultural field adversely affecting farmers in many ways, including looting crops, damaging grain bins, damaging water supplies, homes and other property, and injuring or killing people. Indian farmers face serious threats from pests, natural disasters and animal damage, leading to lower yields. Because human and animal safety are equally important. Therefore, animal intrusion detection systems are required in agricultural areas. The ultrasonic distance module HC - SR04 provides 2cm - 400cm non-contact measurement, and the distance accuracy reaches 3mm. This module contains an ultrasonic transmitter, receiver, and control circuitry. The transmitter releases a specially designed 8-pulse pattern. If pulses are reflected back it indicates the presence of obstruction. Immediately, the APR board will turn on. A sound is played to distract the animal. The call will be sent to your dashboard.

FERTILIZER RECOMMENDATION

Old traditional methods are no longer suitable for deteriorating soil and weather conditions. In fact, they adversely affect the soil. Unfortunately, even farmer experience is not yet sufficient to assess the impact of climatic conditions and soil on yield. Why? Because his NRT data on the ground is very low, if not zero. So we developed a recommendation system for farmers to help them make informed decisions. Depending on the crop selected, the best pesticides will be suggested based on growth and crop type.

FIELD MONITORING

The real time data that is received from the sensors connected can be shown to the user through the user interface. In that the user will be notified regarding the crops, moisture of soil, temperature, encroachments through various sensors connected to the system and can even set the limit for the water to sprinkle to a particular crop in order to yield high productivity. If the level of water falls, the motor starts automatically, and if the water level rises up to set limit, the motor stops. Soil management can also be done by determining various soil parameters such as moisture content, soil humidity and temperature. IOT sensors make it simple to calculate these parameters.

3.3 Methodology

3.3.1 IOT SYSTEM

IoT (Internet of Things) methodology refers to the systematic approach or process followed in designing, implementing, and managing IoT solutions. It involves various steps and stages that are typically followed to ensure successful deployment and operation of IoT systems. Here is a general overview of the typical IoT methodology:

1. Define Objectives and Scope: The first step in any IoT project is to clearly define the objectives and scope of the project. This involves identifying the specific problem or need that the IoT solution aims to address, defining the desired outcomes, and setting realistic goals and expectations.

2. Identify and Select IoT Technologies: Next, the appropriate IoT technologies and components need to be identified and selected based on the defined objectives and scope. This includes choosing the right sensors, devices, connectivity options, data storage and processing technologies, and communication protocols, among others.

3. Design and Develop IoT Solution: Once the technologies are selected, the design and development of the IoT solution can begin. This involves creating the architecture, designing the data flow, developing the software and applications, and integrating the different components into a cohesive solution.

4. Test and Validate: After the IoT solution is developed, it needs to be thoroughly tested and validated to ensure that it performs as expected. This involves conducting various tests, simulations, and trials to verify the functionality, performance, and reliability of the IoT solution.

5. Deploy and Implement: Once the IoT solution is tested and validated, it can be deployed and implemented in the real-world environment. This involves installing the sensors, devices, and other components, configuring the network, and integrating the solution into the existing infrastructure.

6. Monitor and Manage: Once the IoT solution is deployed, it needs to be monitored and managed on an ongoing basis. This includes monitoring the performance, collecting and analyzing data, managing security and privacy, and making necessary adjustments or optimizations to ensure smooth operation and continuous improvement.

7. Evaluate and Optimize: Regular evaluation and optimization are crucial in IoT methodology. This involves continuously monitoring the performance and outcomes of the IoT solution, identifying areas of improvement, and making necessary adjustments or enhancements to optimize the solution's effectiveness and efficiency.

8. Ensure Security and Privacy: Throughout the entire IoT methodology, ensuring the security and privacy of data and devices is of paramount importance. Appropriate security measures, such as encryption, authentication, access control, and regular security audits, should be implemented to protect against potential security risks and breaches.

9. Scale and Expand: As the IoT solution proves successful, it may be scaled up or expanded to other areas or applications within the defined scope. This may involve adding more devices, integrating with other systems, or expanding the solution to different geographical locations or industries.

10. Maintain and Update: Finally, regular maintenance and updates are essential in IoT methodology to ensure the continued performance and reliability of the IoT solution. This includes monitoring for potential issues, applying updates and patches, and addressing any maintenance needs to keep the solution up-to-date and operating smoothly.

Overall, IoT methodology follows a systematic approach, encompassing various stages from defining objectives and selecting technologies to designing, developing, deploying, monitoring, optimizing, and maintaining IoT solutions. It aims to ensure successful implementation and operation of IoT systems while considering factors such as security, privacy, scalability, and sustainability.

3.3.2 WHAT IS IOT MONITORING?

IOT monitoring, or monitoring of Internet of Things devices, allows for the analysis of dynamic systems and the processing of billions of events and alerts. By collecting and analyzing diverse IOT data at web-scale across connected devices, customers, and applications, IOT monitoring enables the bridging of the gap between devices and business operations.

One of the key benefits of IOT monitoring is the ability to optimize performance across multiple applications, APIs, networks, and protocols. By identifying and addressing performance gaps, IOT monitoring helps ensure that IOT devices and applications are functioning optimally, improving overall system efficiency.

Furthermore, IOT monitoring provides actionable insights that can be used to enhance customer experience, remediate problems, and maximize IOT opportunities. Through the analysis of IOT data, businesses can gain valuable insights into customer behavior, usage patterns, and performance trends, which can be used to drive improvements in product development, customer service, and overall business strategy.

Finally, IOT monitoring can also contribute to reducing potential security and privacy risks associated with IOT devices. By continuously monitoring IOT devices and networks for anomalies and potential security breaches, businesses can proactively identify and address security vulnerabilities, mitigating the risk of data breaches, cyber attacks, and other security threats.

In summary, IOT monitoring offers numerous benefits, including the ability to analyze dynamic systems, optimize performance, gain actionable insights, and reduce potential security risks. It enables businesses to bridge the gap between devices and business operations, improving overall efficiency, customer experience, and business outcomes.

3.3.3 IOT IN AGRICULTURE

Agriculture is indeed a crucial sector for a country's economic development, and recent advancements in IoT technology have been leveraged to improve agricultural practices for a better future. IoT-enabled agriculture parameters utilize sensors and systems to collect and analyze data from various sources, allowing for remote monitoring and control of agricultural processes.

By integrating IoT technology into agriculture, farmers can gather data on various parameters such as soil moisture, temperature, humidity, weather conditions, and crop growth stages. This data can be processed and analyzed to gain insights into the optimal conditions for crop growth, pest management, irrigation scheduling, and resource management.

IoT-enabled agriculture systems also provide the advantage of real-time monitoring and remote control. Farmers can access data and receive alerts or notifications through web-based or mobile applications, allowing them to make timely decisions and take actions to optimize productivity and reduce losses.

Furthermore, IoT in agriculture enables the integration of different components of the farming ecosystem, including machines, devices, sensors, and software, into a unified system. This interconnected network of devices and data helps farmers make informed decisions, improve operational efficiency, and enhance productivity. The use of IoT in agriculture also promotes sustainable farming practices. By monitoring and managing resources such as water, fertilizers, and pesticides more efficiently, farmers can reduce waste, minimize environmental impact, and promote sustainable use of resources.

However, like any technology, there may be challenges associated with the adoption and implementation of IoT in agriculture, such as cost, infrastructure, data security, and privacy concerns. Proper measures need to be in place to address these challenges and ensure the responsible and secure use of IoT in agriculture.

In conclusion, IoT technology has the potential to revolutionize agriculture by providing data-driven insights, remote monitoring and control, and improved efficiency. When integrated with sensors and actuators, IoT transforms agriculture into a part of the broader category of smart systems, such as smart grids, smart homes, smart transportation, and smart cities, leading to enhanced productivity and sustainability in agriculture.

3.4 Required Code for System Design

3.4.1 HTML code for interface

```
<!DOCTYPE html>
<html>
<head>
    <meta charset="utf-8">
    <meta name="viewport" content="width=device-width, initial-scale=1">
    <title></title>
    <link href="https://cdn.jsdelivr.net/npm/bootstrap@5.2.3/dist/css/bootstrap.min.css" rel="stylesheet" in
</head>
<body>
    <div class="container py-4">
        <header class="pb-3 mb-4 border-bottom">
            <a href="#" class="d-flex align-items-center text-dark text-decoration-none">
                <span class="fs-4">Smart Farming Monitoring and Control System</span>
            </a>
        </header>

        <div class="mb-4 bg-light rounded-3">
            <div style="background-image: linear-gradient(to right,#FFFFFF 51%, #f6d365 100%);" class="conta
                <img style="width: 15%; top: 70px; right: 30px; float: right; position: relative;" src="http
                <h1 class="display-5 fw-bold">WEATHER</h1>
                <p class="col-md-8 fs-4">Temperature : </p>
                <p class="col-md-8 fs-4">Humidity : </p>
                <p class="col-md-8 fs-4">Atmospheric Pressure : </p>
            </div>
        </div>

        <div class="row align-items-md-stretch">
            <div class="col-md-6 mt-3">
                <div class="h-100 p-5 text-white bg-dark rounded-3">
                    <h2>PUMP CONTROLS : AUTO</h2><br />
                    <form>
                        <input type="text" class="form-control" id="email" placeholder="Moisture: Enter Max Limit"
                        <input type="text" class="form-control" id="email" placeholder="Moisture: Enter Min Limit"
                        <button class="btn btn-outline-light" type="button">SUBMIT</button>
                    </form>
                </div>
            </div>
            <div class="col-md-6 mt-3">
                <div class="h-100 p-5 bg-light border rounded-3">
                    <h2>PUMP CONTROLS : MANUAL</h2><br />
                    <form>
                        <input type="submit" style="width: 100%;" name="on" class="btn btn-primary" value="ON"><br
```

```
            <input type="submit" style="width: 100%;" name="off" class="btn btn-primary" value="OFF"><br />
            </form>
            <hr />
            <h3>ANIMAL PRESENCE :</h3>
        </div>
    </div>
</div>
<div class="col-md-12 mt-3">
    <table class="table table-bordered table-striped">
        <thead>
            <tr>
                <th scope="col">Crop</th>
                <th scope="col">Water required (mm)</th>
                <th scope="col">Crop</th>
                <th scope="col">Water required (mm)</th>
            </tr>
        </thead>
        <tbody>
            <tr>
                <td>rice</td>
                <td>1200</td>
                <td>Tomato</td>
                <td>600 - 800</td>
            </tr>
            <tr>
                <td>Wheat</td>
                <td>450 - 650</td>
                <td>Potato</td>
                <td>500 - 700</td>
            </tr>
            <tr>
                <td>Sorghum</td>
                <td>450 - 650</td>
                <td>Pea</td>
                <td>350 - 500</td>
            </tr>
            <tr>
                <td>Maize</td>
                <td>500 - 800</td>
                <td>Onion</td>
                <td>350 - 550</td>
            </tr>
```

```
<tr>
    <td>Sugercane</td>
    <td>1500 - 2500</td>
    <td>Chillies</td>
    <td>400 - 600</td>
</tr>
<tr>
    <td>Sugarbeet</td>
    <td>550 - 750</td>
    <td>Cabbage</td>
    <td>380 - 500</td>
</tr>
<tr>
    <td>Groundnut</td>
    <td>500 - 700</td>
    <td>Banana</td>
    <td>1200 - 2200</td>
</tr>
<tr>
    <td>Cotton</td>
    <td>700 - 1300</td>
    <td>Citrus</td>
    <td>900 - 1200</td>
</tr>
<tr>
    <td>Soybean</td>
    <td>450 - 700</td>
    <td>Grapes</td>
    <td>700 - 1200</td>
</tr>
<tr>
    <td>Tobacco</td>
    <td>400 - 600</td>
    <td>Mango</td>
    <td>1000 - 1200</td>
</tr>
<tr>
    <td>Beans</td>
    <td>300 - 600</td>
    <td>Turmeric</td>
    <td>1200 - 1400</td>
</tr>
```

```
            </tr>

        </tbody>
    </table>
</div>
<div class="col-md-12 mt-3">
    <div class="h-100 p-5 text-white bg-primary border rounded-3">
        <h2>List of Major Crops and required Geo-climatic condition across the world</h2><br />
        <p style="text-align: justify;">The Geo-Climate is the long-term pattern of weather in a particular
        <p style="text-align: justify;">The Geo-Climate is the long-term pattern of weather in a particular
    </div>
</div>
<div class="row">
    <div class="col-md-3 mt-3">
        <div class="card">
            <div class="card-header bg-dark text-white">
                <b>1. Rice</b>
            </div>
            <div class="card-body">
                <h5 class="card-title"><b>TEMP:</b> 15Â°-27Â° C</h5>
                <p class="card-text"><b>Rainfall: </b> 100- 150 cm</p>
                <p class="card-text"><b>Soil: </b> Heavy-clayey to-clayey-loam</p>
                <p class="card-text"><b>Producers: </b> China, India, Indonesia, Bangladesh, Thailand, Japa
            </div>
            <div class="card-footer">
                <p class="card-text"><b>Leading exporter in the world: </b> Thailand</p>
            </div>
        </div>
    </div>
    <div class="col-md-3 mt-3">
        <div class="card">
            <div class="card-header bg-dark text-white">
                <b>2. Wheat</b>
            </div>
            <div class="card-body">
                <h5 class="card-title"><b>TEMP:</b> 12Â°-25Â°C</h5>
                <p class="card-text"><b>Rainfall: </b> 25-75 cm</p>
                <p class="card-text"><b>Soil: </b> well-drained-light clay to heavy clay  </p>
                <p class="card-text"><b>Producers: </b>China, India, USA, Russia, Australia, Canada, Pakist
            </div>
            <div class="card-footer">
                <p class="card-text"><b>Leading exporter in the world: </b> USA</p>
```

```
            </div>
        </div>
    </div>
    <div class="col-md-3 mt-3">
        <div class="card">
            <div class="card-header bg-dark text-white">
                <b>3. Maize</b>
            </div>
            <div class="card-body">
                <h5 class="card-title"><b>TEMP:</b> 15Â°-27Â° C</h5>
                <p class="card-text"><b>Rainfall: </b>  65-125 cm</p>
                <p class="card-text"><b>Soil: </b>  Deep-heavy clay to light sandy loam</p>
                <p class="card-text"><b>Producers: </b> USA, China, Brazil, Mexico, Russia, Romania, India,
            </div>
            <div class="card-footer">
                <p class="card-text"><b>Leading exporter in the world: </b> USA</p>
            </div>
        </div>
    </div>
    <div class="col-md-3 mt-3">
        <div class="card">
```

```
            <div class="card-header bg-dark text-white">
                <b>4. Millets</b>
            </div>
            <div class="card-body">
                <h5 class="card-title"><b>TEMP:</b>  20Â°-35Â°C</h5>
                <p class="card-text"><b>Rainfall: </b> 25-75 cm</p>
                <p class="card-text"><b>Soil: </b> Sandy-loam to clayey loam</p>
                <p class="card-text"><b>Producers: </b>  China, USA, India, Nigeria, Ukraine, Thailand, Rus
            </div>
            <div class="card-footer">
                <p class="card-text"><b>Leading exporter in the world: </b> USA</p>
            </div>
        </div>
    </div>
    <div class="col-md-3 mt-3">
        <div class="card">
            <div class="card-header bg-dark text-white">
                <b>5. Bajra (Pearl Millet)</b>
            </div>
            <div class="card-body">
                <h5 class="card-title"><b>TEMP:</b>  25Â°-35Â°C</h5>
```

```
            <p class="card-text"><b>Rainfall: </b> 25-60 cm</p>
            <p class="card-text"><b>Soil: </b> Sandy loam to loam</p>
            <p class="card-text"><b>Producers: </b> In India: Rajasthan, Maharashtra, Gujarat, Uttar Pra
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> India</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>6. Pulses (Kharif)</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 20Â°-27Â° C</h5>
            <p class="card-text"><b>Rainfall: </b> 25- 60 cm</p>
            <p class="card-text"><b>Soil: </b> Sandy-loam Producers: In India: Madhya Pradesh, Rajasthar
            <p class="card-text"><b>Producers: </b> China, India, Indonesia, Bangladesh, Thailand, Japar
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> <a href="https://www.jagranjosh.
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>7.  Lentil (Rabi)</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 15Â° to 25Â°C</h5>
            <p class="card-text"><b>Rainfall: </b> 25 to 50 cm</p>
            <p class="card-text"><b>Soil: </b>  Loamy to clayey loam</p>
            <p class="card-text"><b>Producers: </b> Mediterranean countries of Europe, Egypt, Greece, Tu
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Canada</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
```

```
        <div class="card">
            <div class="card-header bg-dark text-white">
                <b>8. Oilseeds</b>
            </div>
            <div class="card-body">
                <h5 class="card-title"><b>TEMP:</b> 15Â°-30Â°C</h5>
                <p class="card-text"><b>Rainfall: </b> 30-50 cm</p>
                <p class="card-text"><b>Soil: </b>  loam to clayey loam</p>
                <p class="card-text"><b>Producers: </b>  In India: Rajasthan, Uttar Pradesh, Madhya Pradesh,
            </div>
            <div class="card-footer">
                <p class="card-text"><b>Leading exporter in the world: </b> India</p>
            </div>
        </div>
    </div>
    <div class="col-md-3 mt-3">
        <div class="card">
            <div class="card-header bg-dark text-white">
                <b>9. Groundnut</b>
            </div>
            <div class="card-body">
```

```
            <h5 class="card-title"><b>TEMP:</b> 20Â°-30Â°C</h5>
            <p class="card-text"><b>Rainfall: </b> 50-75 cm</p>
            <p class="card-text"><b>Soil: </b> well-drained-sandy loams, red and black cotton</p>
            <p class="card-text"><b>Producers: </b> India, China, USA, Sudan, Senegal, Indonesia, Argentina
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> USA</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>10. Sugarcane</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 20Â°-35Â°C</h5>
            <p class="card-text"><b>Rainfall: </b>  85-165 cm</p>
            <p class="card-text"><b>Soil: </b> Well-drained alluvium, black, red and brown regur soil </p>
            <p class="card-text"><b>Producers: </b> Brazil, India, China, Pakistan, Thailand, Mexico, Cuba,
        </div>
```

```
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Brazil</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>11. Sugar beet</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 10Â°-25Â°C</h5>
            <p class="card-text"><b>Rainfall: </b> 25-50 cm</p>
            <p class="card-text"><b>Soil: </b> Well-drained-loamy soil   Producers: France, USA, Germany, R
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> India</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>12. Cotton</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 18Â°-27Â°C</h5>
            <p class="card-text"><b>Rainfall: </b>  60-110 cm</p>
            <p class="card-text"><b>Soil: </b> well-drained loam, and regur (black-earth) </p>
            <p class="card-text"><b>Producers: </b> China, USA, India, Brazil, Pakistan, Uzbekistan, Egypt,
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> USA</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>13. Tea</b>
        </div>
        <div class="card-body">
```

```
            <h5 class="card-title"><b>TEMP:</b> 15Â° -35Â°C</h5>
            <p class="card-text"><b>Rainfall: </b> 100-250 cm</p>
            <p class="card-text"><b>Soil: </b> well-drained, light loamy Soil   Producers: India, China, Sri
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> India</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>14. Coffee</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 15Â°-28Â°C</h5>
            <p class="card-text"><b>Rainfall: </b> 125-225 cm</p>
            <p class="card-text"><b>Soil: </b> well-drained alluvial Soil Producers: Brazil, Colombia, Indon
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Brazil</p>
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Brazil</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>15. Cocoa</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 18Â°-35Â°C</h5>
            <p class="card-text"><b>Rainfall: </b> 100-250 cm</p>
            <p class="card-text"><b>Soil: </b> Well-drained alluvium</p>
            <p class="card-text"><b>Producers: </b>  Ivory-Coast, Ghana, Indonesia, Brazil, Cameroon, Niger
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Ivory-Coast</p>
        </div>
    </div>
```

```
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>16. Rubber</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 27Â° C</h5>
            <p class="card-text"><b>Rainfall: </b> 150-250 cm</p>
            <p class="card-text"><b>Soil: </b> rich-well-drained alluvial Soil  </p>
            <p class="card-text"><b>Producers: </b>  Thailand, Indonesia, Malaysia, India, China, Sri-Lanka,
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Thailand</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>17. Jute</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 25Â°-35Â°C</h5>
            <p class="card-text"><b>Rainfall: </b> about 150-250 cm</p>
            <p class="card-text"><b>Soil: </b> Well drained alluvial Soil</p>
            <p class="card-text"><b>Producers: </b> Bangladesh, India, China, Thailand, Myanmar, Brazil and
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Bangladesh</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>18. Flax</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b>  10Â°-20Â°C</h5>
            <p class="card-text"><b>Rainfall: </b> 15-20 cm</p>
```

```
            <p class="card-text"><b>Soil: </b> Rich loam or clayey loam</p>
            <p class="card-text"><b>Producers: </b> In India: Himachal Pradesh, Uttarakhand and the Jammu Di
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Germany</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>19. Coconut</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 27Â° C</h5>
            <p class="card-text"><b>Rainfall: </b> 100-250 cm, up-to 600 m above the sea level</p>
            <p class="card-text"><b>Soil: </b> lateritic red, sandy alluvial sandy</p>
            <p class="card-text"><b>Producers: </b>  In India: Kerala (55%), Tamil Nadu, Andhra Pradesh, Kar
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Indonesia</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>20. Oil-palm</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 27Â°-33Â°C (maximum), 22Â°-24Â°C (minimum)</h5>
            <p class="card-text"><b>Rainfall: </b> 100- 150 cm</p>
            <p class="card-text"><b>Soil: </b> Deep-loamy and alluvial soil</p>
            <p class="card-text"><b>Producers: </b>  India: Andhra Pradesh, Karnataka, Assam, Gujarat, Goa,
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Indonesia</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
```

```
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>20. Oil-palm</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 27Â°-33Â°C (maximum), 22Â°-24Â°C (minimum)</h5>
            <p class="card-text"><b>Rainfall: </b> 100- 150 cm</p>
            <p class="card-text"><b>Soil: </b> Deep-loamy and alluvial soil</p>
            <p class="card-text"><b>Producers: </b>  India: Andhra Pradesh, Karnataka, Assam, Gujarat, Goa,
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Indonesia</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>21. Clove</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 25Â°-35Â°C</h5>
            <p class="card-text"><b>Rainfall: </b> 200- 250 cm</p>
            <p class="card-text"><b>Soil: </b>  Red alluvial Soil</p>
            <p class="card-text"><b>Producers: </b> In India: Kerala, Tamil Nadu, Karnataka, Andaman and Ni
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Indonesia and Tanzania</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>22. Black Pepper</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 15Â°C to 40Â°C</h5>
            <p class="card-text"><b>Rainfall: </b> 200-300'cm. Height up-to 1500 m above sea level</p>
            <p class="card-text"><b>Soil: </b> rich in hums, red-loam to sandy loam, and red lateritic sand
```

```
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Vietnam and Brazil</p>
        </div>
    </div>
</div>
<div class="col-md-3 mt-3">
    <div class="card">
        <div class="card-header bg-dark text-white">
            <b>23. Cardamom</b>
        </div>
        <div class="card-body">
            <h5 class="card-title"><b>TEMP:</b> 10Â°-35Â°C</h5>
            <p class="card-text"><b>Rainfall: </b> 150-400 cm, height 600-1500 m</p>
            <p class="card-text"><b>Soil: </b> well-drained lateritic</p>
            <p class="card-text"><b>Producers: </b>  In India: Kerala (60%), Karnataka (30%), and Tamil Nad
        </div>
        <div class="card-footer">
            <p class="card-text"><b>Leading exporter in the world: </b> Guatemala, India</p>
        </div>
    </div>
```

```
            <div class="col-md-3 mt-3">
                <div class="card">
                    <div class="card-header bg-dark text-white">
                        <b>24. Turmeric</b>
                    </div>
                    <div class="card-body">
                        <h5 class="card-title"><b>TEMP:</b>  20Â°-30Â°C</h5>
                        <p class="card-text"><b>Rainfall: </b> 150-250 cm</p>
                        <p class="card-text"><b>Soil: </b> well-drained clayey loam or red loamy soil  </p>
                        <p class="card-text"><b>Producers: </b> In India: Andhra Pradesh, Karnataka, Kerala
                    </div>
                    <div class="card-footer">
                        <p class="card-text"><b>Leading exporter in the world: </b> India</p>
                    </div>
                </div>
            </div>
        </div>
        <footer class="pt-3 mt-4 text-muted border-top">
            Â© DASHBOARD
        </footer>
    </div>
```

```
                <div class="card-body">
                    <h5 class="card-title"><b>TEMP:</b>  20Â°-30Â°C</h5>
                    <p class="card-text"><b>Rainfall: </b> 150-250 cm</p>
                    <p class="card-text"><b>Soil: </b> well-drained clayey loam or red loamy soil  </p>
                    <p class="card-text"><b>Producers: </b> In India: Andhra Pradesh, Karnataka, Kerala
                </div>
                <div class="card-footer">
                    <p class="card-text"><b>Leading exporter in the world: </b> India</p>
                </div>
            </div>
        </div>
    </div>
    <footer class="pt-3 mt-4 text-muted border-top">
        Â© DASHBOARD
    </footer>
  </div>
  <link href="https://cdn.jsdelivr.net/npm/bootstrap@5.2.3/dist/css/bootstrap.min.css" rel="stylesheet" i
</body>
</html>
```

3.4.2 Code For Arduino in C

```
#include "DHT.h"
#include <WiFi.h>
#include <HTTPClient.h>
#define echoPin 18 // attach pin D2 Arduino to pin Echo of HC-SR04
#define trigPin 5 //attach pin D3 Arduino to pin Trig of HC-SR04

// defines variables
long duration; // variable for the duration of sound wave travel
int distance; // variable

#define DHTPIN 2     // Digital pin connected to the DHT sensor
#define DHTTYPE DHT11   // DHT 11
DHT dht(DHTPIN, DHTTYPE);

int sensor_pin = 36;
int moist_value;

String output26State;
```

```
// Replace with your network credentials
const char* ssid = "nikkkhil";
const char* password = "Samsung@971#";

const int pump =  13;      // the number of the LED pin
const int buttonPin = 2;     // the number of the pushbutton pin
int buttonState = 0;         // variable for reading the pushbutton status

// Set web server port number to 80
WiFiServer server(80);

// Variable to store the HTTP request
String header;

// Current time
unsigned long currentTime = millis();
// Previous time
unsigned long previousTime = 0;
```

```
const long timeoutTime = 2000;

void setup() {
  Serial.begin(115200);

  pinMode(trigPin, OUTPUT); // Sets the trigPin as an OUTPUT
  pinMode(echoPin, INPUT);

  pinMode(pump, OUTPUT);

  // Connect to Wi-Fi network with SSID and password
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  // Print local IP address and start web server
  Serial.println("");
  Serial.println("WiFi connected.");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());
  server.begin();
  dht.begin();

}

void loop() {
  WiFiClient client = server.available();   // Listen for incoming clients

  // Clears the trigPin condition
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  // Sets the trigPin HIGH (ACTIVE) for 10 microseconds
  digitalWrite(trigPin, HIGH);
```

```
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  // Reads the echoPin, returns the sound wave travel time in microseconds
  duration = pulseIn(echoPin, HIGH);
  // Calculating the distance
  distance = duration * 0.034 / 2; // Speed of sound wave divided by 2 (go and back)
  // Displays the distance on the Serial Monitor

  moist_value = analogRead(sensor_pin);
  moist_value = map(moist_value, 550, 0, 0, 100);
  /*
    Serial.print("Moisture : ");
    Serial.print(moist_value);
    Serial.println("%");
  */
  // Reading temperature or humidity takes about 250 milliseconds!
  // Sensor readings may also be up to 2 seconds 'old' (its a very slow sensor)
  float h = dht.readHumidity();
  // Read temperature as Celsius (the default)
  float t = dht.readTemperature();

  pinMode(buttonPin, INPUT);

  // Compute heat index in Fahrenheit (the default)
  float hic = dht.computeHeatIndex(t, h, false);

  buttonState = digitalRead(buttonPin);

/*

  Serial.print(F(" Humidity: "));
  Serial.print(h);
  Serial.print(F("%  Temperature: "));
  Serial.print(t);
  Serial.print(F("C "));
*/
```

```
if (client) {
  // If a new client connects,
  currentTime = millis();
  previousTime = currentTime;
  Serial.println("New Client.");          // print a message out in the serial port
  String currentLine = "";                // make a String to hold incoming data from the client
  while (client.connected() && currentTime - previousTime <= timeoutTime) {  // loop while the client's co
    currentTime = millis();
    if (client.available()) {             // if there's bytes to read from the client,
      char c = client.read();             // read a byte, then
      Serial.write(c);                    // print it out the serial monitor
      header += c;
      if (c == '\n') {                    // if the byte is a newline character
        // if the current line is blank, you got two newline characters in a row.
        // that's the end of the client HTTP request, so send a response:
        if (currentLine.length() == 0) {
          // HTTP headers always start with a response code (e.g. HTTP/1.1 200 OK)
          // and a content-type so the client knows what's coming, then a blank line:
          client.println("HTTP/1.1 200 OK");
          client.println("Content-type:text/html");
          client.println("Connection: close");
          client.println();

          if(buttonState == HIGH){
            if (header.indexOf("GET / maxval") >= moist_value) {
            Serial.println("GPIO 26 on");
            output26State = "off";
            digitalWrite(pump, LOW);
            } else if (header.indexOf("GET / minval") <= moist_value) {
            Serial.println("GPIO 26 off");
            output26State = "on";
            digitalWrite(pump, HIGH);
            }
          } else{
            if (header.indexOf("GET /on") >= 0) {
            Serial.println("GPIO 26 on");
```

```
    output26State = "off";
    digitalWrite(pump, HIGH);
    } else if (header.indexOf("GET / off") >= 0) {
    Serial.println("GPIO 26 off");
    output26State = "on";
    digitalWrite(pump, LOW);
    }
  }
  Serial.println();
  // Display the HTML web page
  client.println("<!DOCTYPE html> <html> <head> <title>TechnoGeekZone</title> <link rel=\"stylesheet\" href
  client.println("<body> <div class=\"container py-4\"> <header class=\"pb-3 mb-4 border-bottom\"> <a href=
  client.println("<div class=\"mb-4 bg-light rounded-3\"> <div style=\"background-image: linear-gradient(to
  client.println(t);
  client.println("</p>");
  client.println("<p class=\"col-md-8 fs-4\">Humidity :");
  client.println(h);
  client.println("</p>");
          client.println("<p class=\"col-md-8 fs-4\">Atmospheric Pressure : nan</p>");
          client.println("</div> </div>");
          client.println("<div class=\"row align-items-md-stretch\"> <div class=\"col-md-6 mt-3\"> <div clas
          client.println("</body> </html>");

          // The HTTP response ends with another blank line
          client.println();
          // Break out of the while loop
          break;
        } else { // if you got a newline, then clear currentLine
          currentLine = "";
        }
      } else if (c != '\r') {  // if you got anything else but a carriage return character,
        currentLine += c;      // add it to the end of the currentLine
      }
    }
  }
// Clear the header variable
            client.println();
            // Break out of the while loop
            break;
          } else { // if you got a newline, then clear currentLine
            currentLine = "";
          }
        } else if (c != '\r') {  // if you got anything else but a carriage return character,
          currentLine += c;      // add it to the end of the currentLine
        }
      }
    }
    // Clear the header variable
    header = "";
    // Close the connection
    client.stop();
    Serial.println("Client disconnected.");
    Serial.println("");
  }
}
```

Chapter 4
RESULTS & TESTING

4.1 Results

As shown in the figure 9, the experimental setup for the smart agriculture system in which the various sensors such as motion sensor, soil moisture sensor (HC - SR04), humidity sensor and temperature sensor (DHT11) are connected to the microcontroller board (ESP32).The sensors will be fetching near real time data from the environment and sending it to the controller. The result shows that if the moisture content is greater than the threshold value that is being set up by the user for the effective productivity of a particular crop then the water pump will automatically turn OFF and vice versa. And the trespassing of animals that may harm crop fields will be detected by motion sensors that will notify the user by an alert.

Fig 4.1 Prototype Setup

In figure (10) the webpage has been developed which will be interfaced with the system in which the necessary information regarding the moisture content, temperature, fertilizers suggestion for the crops has been mentioned, by this the user will get a fair idea about setting up of threshold value. This interface will be used to turn ON/OFF the uv light from a remote location. It will also provide us with the weather forecast feature in which the user gets to know about the humidity, temperature, and prediction of rainfall beforehand so that crops will not get damaged by climatic conditions.

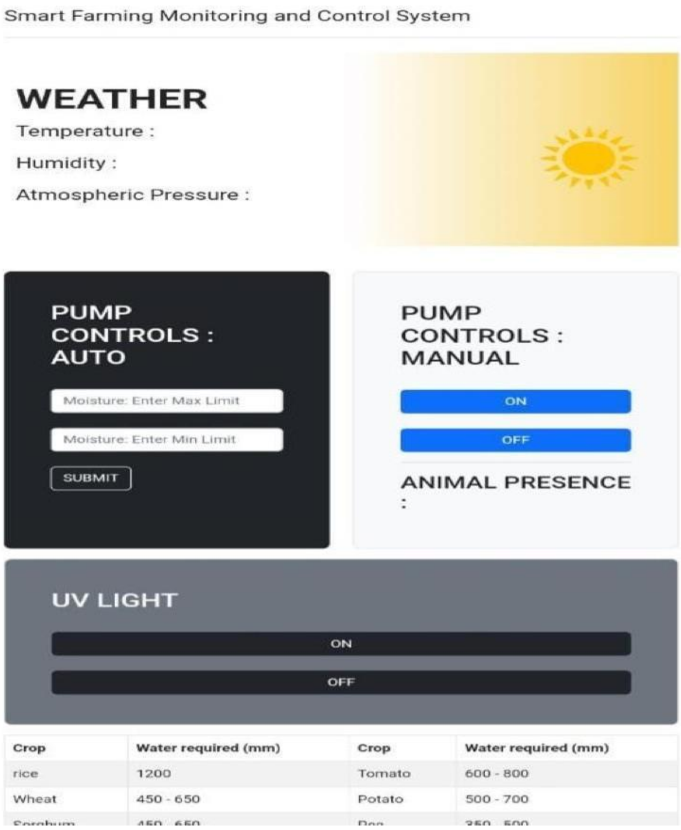

Fig 4.2 Designed web application

4.2 Testing

The entire testing phase has been divided into two parts. First one is real time device testing and the other is testing the web application. The device is tested in agricultural fields for different crops to determine the soil parameters. UV light is applied on the plant crops to check its effect on the powdery mildew and a fake scenario of animal intrusion is created to check the working of the motion sensor. The web app is checked for its responsiveness and its ability to set the moisture level for different crops.

Chapter 5
CONCLUSION

The above project aims to infuse technology to the field of agriculture (that has already been performed since ages through old traditional methods) The referred project does not aim to launch and improve any new technology or method whereas it is focusing on modifying our old traditional methods to ease out the process of agriculture. As a result, it has been observed that using this method the field of agriculture needs less manpower, more yield, less time consuming; it will also definitely reduce the percentage of crops being wasted due to undesired amount of water or fertilizers applied to it. The sensor provided will automatically control the amount of water to be provided to the field for respective crops. We also aim to reduce the occurrence of diseases in the crops by introducing "yellow sticky straps" to the crops that will trap the insects causing diseases. The various data are automatically sensed by the sensor installed which therefore brings the requirements of the crops into the knowledge of the farmer exactly at the time when required and thus keeping the crops much healthy and controlling wastage of crops. This prototype is flexible enough to modify itself according to the need at the specific moment.

As we have already said, that in this project we have proposed a prototype, hence immense further modifications can be continued it in future, if any sort of further work is to be performed, the proposed modifications can be further enhanced by introducing of cameras to the crops which may further helps in “image based plant diseases detection”. Installing any disease in the crops can be diagnosed at a very initial or primary stage itself and hence will be cured faster, which again saves our crops from getting wasted.

5.1 Future Scope

- The project has many scopes in the development of the system, More user- friendly and additional features Systems such as:
- By installing a webcam on the system, you can monitor your crops and by using machine learning algorithms crop disease can easily be predicted and prevented. Language-based options can be implemented in the system. uneducated people.
- GPS (Global Positioning System) can be integrated to Show a farmer's specific location more accurately.
- Implement regional language features to make it easy for farmers .

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