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# Revolutionizing Automated Agriculture: A Brief Overview of an Advanced Smart Agriculture System Using Arduino UNO

Mohankumar A.[1*] & Gowtham R.[2]

[1,2]*UG Scholar, IFET College of Engineering, Villupuram, Tamilnadu, India.*
*Corresponding Author Email: mohankumar071104@gmail.com*[*]

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ABSTRACT

This project presents a Smart Agriculture System that uses sensor technologies to improve crop monitoring and automate irrigation procedures. A variety of sensors are integrated into the system, such as a temperature sensor, a gas sensor, a photodiode for ambient light sensing, and a soil moisture sensor. When taken as a whole, these sensors offer real-time information on the concentrations of gases, ambient light levels, temperature fluctuations, and soil conditions in agricultural environments. The system's primary function is to continuously monitor soil moisture levels in order to determine when irrigation is necessary. A water pump is activated when a predetermined moisture threshold is reached, guaranteeing timely and precise irrigation for the best possible crop growth. By monitoring the climate, the temperature sensor helps determine the environmental factors that affect crop health. Farmers can monitor important parameters with ease thanks to the convenient and user-friendly interface that the real-time display of sensor data on an LCD screen provides. Furthermore, by measuring the amount of natural light present, the ambient light sensor helps the system to optimize planting schedules and comprehend the impact of sunlight on crop development. The addition of a gas sensor expands the capabilities of the system by identifying possible environmental risks or variations in gas concentrations that could have an impact on crop quality. In addition to providing farmers with useful information about the health of their crops, this integrated smart agriculture system makes irrigation automation easier, saving water and increasing overall agricultural productivity. Due to its flexibility and scalability, the system is an invaluable resource for contemporary precision agriculture, contributing to sustainable farming practices and increased crop yields.

**Keywords:** Environmental Monitoring; Smart Sensors; Smart Agriculture; Automated Farming; Remote Monitoring; Arduino UNO.

## 1. Introduction

Throughout history, agriculture—the foundation of human civilization—has undergone significant changes. Technology has become a catalyst in the modern era, guiding farming practices toward increased productivity and efficiency. With an emphasis on data-driven decision-making, resource efficiency, and sustainability to build a more intelligent and adaptable agricultural ecosystem, precision agriculture represents a dramatic paradigm shift [1-4]. A variety of technological developments are used in precision agriculture, but sensors stand out as particularly important instruments in this revolutionary process. These sensors are essential for providing real-time information about crop conditions because they can measure and track a variety of environmental parameters. A ground-breaking project that expertly combines a number of sensors to build an automated and intelligent farming infrastructure is the Smart Agriculture System [5]. The principal aim of the Smart Agriculture System is to tackle the difficulties associated with traditional farming methods and advance agriculture towards a more advanced and adaptable framework [6-10]. Conventional techniques frequently apply resources, like fertilizer and water, uniformly and broadly without taking into account the unique requirements of each crop. This can have negative effects in addition to resulting in inefficient use of resources environmental impacts [11].

The Smart Agriculture System, on the other hand, integrates a number of carefully placed sensors into the agricultural setting. These sensors act as the eyes and ears of the system, continuously collecting information on vital factors affecting crop growth [12]. A soil moisture sensor, a temperature sensor, a photodiode for ambient light sensing, and a gas sensor are among the essential parts. Every sensor provides important data that goes toward building a thorough knowledge of the agricultural ecosystem. We go into the specifics of the Smart Agriculture System's design, implementation, and assessment in the sections that follow [13]. This system aims to transform farming practices, fostering sustainability, resource efficiency, and improved crop yields in the constantly changing field of modern agriculture by combining the power of sensors, automation, and precision agriculture principles. The system's integration of temperature sensors contributes to climate resilience by enabling informed decision-making in response to evolving climate patterns [14], providing farmers with useful information, improving precision agriculture for increased yields, and capitalizing on technological innovations underscore the system's motivation. Ultimately, the overarching goal is to contribute to global food security by fostering a resilient, technologically advanced, and environmentally conscious agricultural landscape [15].

## 2. Literature Survey

### 2.1. Traditional Soil Moisture Meters

Conventional soil moisture meters measure moisture content manually by putting a probe into the soil. Although popular, this low-tech method has drawbacks [16]. High Labor Requirement: This approach requires a lot of time and effort from farm staff and is labor-intensive owing to its manual nature, especially in big agricultural areas. Limited Level of Data Detail: Because conventional soil moisture meters only capture data at a single place and at a specific moment in time, they may miss changes that occur throughout the field. This lack of information might lead to ineffective watering techniques [17-18]. Operator Proficiency: The operator's capacity to appropriately insert and interpret probes yields reliable readings, hence introducing diversity in the data quality.

### 2.2. Traditional Temperature Gauges

In agricultural settings, traditional temperature gauges, like mercury or digital thermometers, are frequently used to measure the ambient temperature [19]. Limited Spatial Coverage: Single-point measurements only offer a limited amount of spatial coverage since they are unable to record temperature fluctuations across the field. Slow Response Time: Conventional thermometers may respond slowly, particularly under dynamic climatic settings, which might lead them to miss rapid temperature changes that are essential for crop management [20-24]. Vulnerability to Damage: Physical injury, exposure to extreme weather, or incorrect handling can compromise the precision and usefulness of conventional temperature gauges [25].

### 2.3. Vertical Farming

An inventive way to increase agricultural productivity in constrained urban areas is through vertical farming. This method allows for year-round cultivation, reduces the amount of land needed, and maximizes resource efficiency by stacking crops vertically in controlled indoor environments [26].

Expensive Initial Outlays: Setting up climate-controlled and regulated settings for vertical farms, including those with specialized lighting and lighting controls, may be quite costly at first. Energy Use: Artificial lighting and maintaining optimal growth conditions both use a significant amount of energy, which increases the carbon footprint [27]. Limited Crop Variety: Some crops may be more suitable for vertical farming than others, hence there is a limit to the variety of crops that may be cultivated.

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## 3. Proposed Work

### 3.1. Architecture Design

The circuit diagram of the Smart Agriculture System combines several parts to produce an automated and intelligent farming infrastructure. An Arduino board works as the system's central processing unit, coordinating the actions of several sensors and actuators. To determine the soil's moisture content, the system uses a Soil Moisture Sensor that is positioned strategically throughout the agricultural area. Analog pin A0 is used to supply the Arduino with this vital data. Placed next to the soil moisture sensor, the photodiode records ambient light levels and facilitates the evaluation of sunshine exposure. The photodiode, which is connected to analog pin A1, makes sure that the system adjusts to different light levels, which maximizes crop scheduling. In addition, the system incorporates a Gas Sensor (CAS sensor) that provides information on the concentration of gases in the agricultural setting. The Arduino receives the analog output from the gas sensor through pin A2, which allows the system to recognize and react to changes in gas levels. Each sensor's output is shown on a 16x2 LCD that is connected to the Arduino digital pins sparingly via I2C. This display provides farmers with vital information on soil moisture levels and gas concentrations in real time, acting as a dashboard. The circuit has feedback mechanisms in addition to the sensors to notify farmers and enable prompt actions. Three digital pins (D3, D5, and D6) drive an RGB LED, which functions as a visual indicator and emits red, green, and blue light. This LED functions as a visual signal for gas concentrations, ambient light levels, and soil moisture conditions. In the event of low soil moisture, a buzzer attached to digital pin D2 emits an auditory signal, guaranteeing that farmers are informed of critical conditions as soon as possible. To improve visual feedback, the circuit additionally incorporates basic status LEDs (D9, D10, and D11).

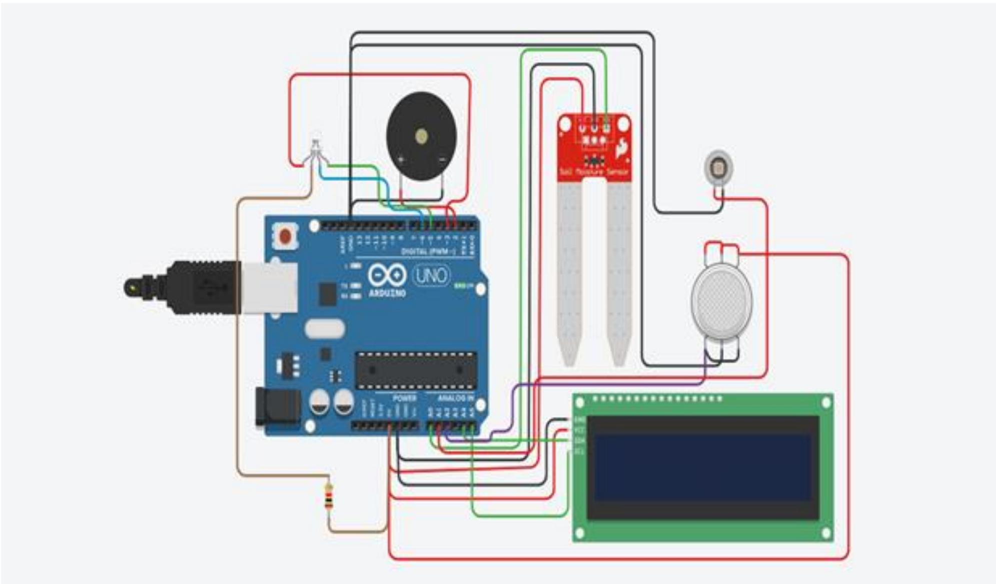

**Figure 1.** Hardware Design of the Proposed Solution

### 3.2. Circuit Operation

The Smart Agriculture System's response is visible and understandable thanks to the thoughtful placement of the LED components. A 5V supply from the Arduino powers the parts, while separate ground connections provide a shared reference point for the circuit. The connectivity of components is organized to form a cohesive system where each part plays a different role in delivering useful insights into the agricultural environment. Furthermore, by maximizing resource utilization through precision agriculture techniques, this circuit supports sustainability and helps to create more productive and environmentally responsible farming. All things considered, the circuit diagram of the Smart Agriculture System represents a well-balanced combination of sensors and actuators, offering a technological advance in the field of precision farming for increased agricultural output and sustainability. The Arduino-based smart agriculture system represents a transformative approach to modern farming practices, leveraging advanced technology to enhance productivity, efficiency, and sustainability. At its core, this system utilizes the Arduino microcontroller, typically the Arduino UNO, as the central processing unit, orchestrating the interaction between various sensors and actuators deployed throughout the farming environment.

One of the primary components integrated into these systems is humidity sensors, strategically placed within the soil to monitor moisture levels. Soil moisture is a critical factor in crop growth and health, directly influencing nutrient uptake, root development, and overall plant vigor. By continuously monitoring soil moisture levels, farmers can ensure that their crops receive adequate hydration, thereby optimizing yield and quality. An LCD panel shows the data gathered from ambient and humidity sensors in real time, giving farmers quick access to vital information about their farming environment. As a user interface, the LCD display shows important data in an easy-to-understand format, including temperature readings, light intensity levels, and soil moisture content. Farmers may now make timely changes to their farming operations, such modifying irrigation schedules, erecting shading structures to shield crops from direct sunshine, or putting climate control measures in place in greenhouses, thanks to this real-time input. Gas sensors are a crucial element of intelligent agricultural systems, as they facilitate the identification of hazardous gases or contaminants inside the agricultural setting. These sensors warn users when harmful compounds like carbon monoxide, ammonia, or methane are present, helping to protect the health and safety of agricultural workers as well as crops. The Arduino UNO can sound a buzzer to notify farmers in the case of a gas leak or contamination, enabling them to take quick action to reduce the danger and safeguard crop health. In conclusion, smart agriculture systems based on Arduino technology offer a thorough method of contemporary farming, combining a wide range of sensors and actuators to track and control important facets of agricultural output.

### 3.3. Component Description

#### 3.3.1. Arduino UNO

The Arduino Uno R3 is one of the most widely used microcontroller boards in the Arduino family. The third and most recent iteration of the Arduino board was released in 2011.The main advantage of this board is that its microcontroller is replaceable in case something goes wrong. The main features of this board are that it is detachable, has an ATmega328 microprocessor, and is offered in dual-inline-package (DIP) form. The Arduino Uno R3 is one kind of microcontroller board that is built around the ATmega328P. It has a ceramic resonator operating at 16 MHz, six analog inputs, fourteen digital input/output pins (six of which can be used as PWM outputs), a reset button, a USB connector, a power jack, and an ICSP header.

### 3.3.2. LCD Display with I2c Module

The solid-state LCD display modulates light using liquid crystals. It might be a visual display or a display screen. Any image can be seen on LCDs because they don't emit light directly—just like on a general-purpose computer display. "16 x 2" LCDs are utilized in this design. Along with ground Vss, a variable resistor pin for LCD contrast adjustment, a Vdd supply pin, and anode "A," cathode "K," allow "E," reset "R/S," read and write "R/W," and input ports D0, D1, D2, D3, D4, D5, D6, D7 are all present.I2C is a contraction of inter-IC. It's a BUS type as well. This was designed by Philips Semiconductors. A synchronous, single-ended, multi-slave, multi-master packet switched bus is called I2C.I2C only employs two bidirectional open collector or open drain lines, the Serial Data Line (SDA) and the Serial Clock Line (SCL), which are pushed up with resistors. While different voltages are acceptable, the most common voltages are +3.3 V or +5 V. Four of the twenty male pins are facing the front, while sixteen are facing the back. The 16 pins are connected to the 16x2 LCD using two of the four connections, SDA and SCL. The remaining two power supply pins (ground and Vcc); the clock pin is called SCL; the serial data pin is designated SDA. We may change the contrast of the LCD display by twisting this POT. Additionally, there is a set number on the module. The LCD display will switch off its backlight when the jumper is removed.

**Table 1.** Pin Configuration of LCD

| **Parameters** | **Representations** | **Corresponding Pins** |
|---|---|---|
| Power Supply | Vss and Vdd | Pin 1 and Pin 2 |
| Ground | GND | Other Pins |
| Instructions | A4 and A5 | Pin SCL and Pin SDA |

### 3.3.3. Soil Moisture Sensor

The purpose of a soil moisture sensor is to determine the volume of water present in the soil and provide us with the moisture content at the output. The sensor is equipped with both analog and digital output, so it can be utilized in either mode. The soil moisture sensor consists of two probes. The volumetric content of water is measured with the help of these probes. With the aid of the probes, current is permitted to flow through the soil, and the moisture value is subsequently determined using the resistance value that is obtained. Conversely, dry soil has a low electrical conductivity. Consequently, electrical conductivity will be very low in the presence of less water, indicating the existence of higher resistance.

### 3.3.4. Gas Sensor

One essential part used in the Smart Agriculture System to identify and gauge the amount of gases present in the agricultural setting is the gas sensor. This sensor, also known as a Chemical (CAS) sensor, interacts with airborne gases through a variety of unique methods. Usually, it is made out of a sensor element that, when exposed to target gasses, chemistry reacts to produce electrical changes that can be measured. After that, the analog signal output is transferred to the Arduino microcontroller for processing and interpretation. When it comes to agriculture, the gas sensor acts as an early warning system, able to identify changes in gas concentrations that can point to possible environmental risks or changes in the condition of the soil.

### 3.3.5. Light Dependent Resistor

One of the most important parts of the Smart Agriculture System for determining ambient light conditions in the agricultural setting is the Light Dependent Resistor (LDR) sensor. The LDR sensor is positioned strategically in the field to detect the intensity of incoming light and provide useful information on sunshine exposure, which is essential for plant growth. Based on the idea of variable resistance in response to variations in light levels, this analog sensor exhibits lower resistance in well-lit surroundings and higher resistance in low light.The real-time readings from the LDR sensor, which is connected to analog pin A1 on the Arduino board, allow the system to adjust cultivation techniques according to the amount of light available. The information obtained from the LDR sensor helps the system arrange planting dates that best match patterns of sunshine.

### 3.3.6. Buzzer

The audio signal is increased by connecting the buzzer to an NPN transistor (BC547). The buzzer is used to do this. The microcontroller is connected to the BC547 transistor via its analog input/port after a resistor with a value of 220k ohms is attached to the transistor's base. This buzzer's main function is to sound an alert if an RFID card doesn't match the requirements that we've set. If the tag doesn't match the ones that have been programmed, the buzzer will keep beeping and the LCD panel will show "Access Denied."

## 4. Results and Discussions

Promising outcomes were obtained across a range of metrics when the Arduino UNO was used to create an advanced smart agriculture system. The use of sensors to monitor temperature, moisture content in soil, and environmental factors resulted in real-time data that greatly aided in making well-informed decisions. The Arduino UNO-operated automatic irrigation system showed effective water management. In order to prevent water waste and guarantee that crops received enough water, the system dynamically adjusted to the levels of soil moisture. The system's data analytics component made it easier to analyze the gathered data in an intelligent way. Predictive modeling and proactive modifications to farming operations were made possible by the identification of patterns and trends in soil moisture, temperature, and other variables.

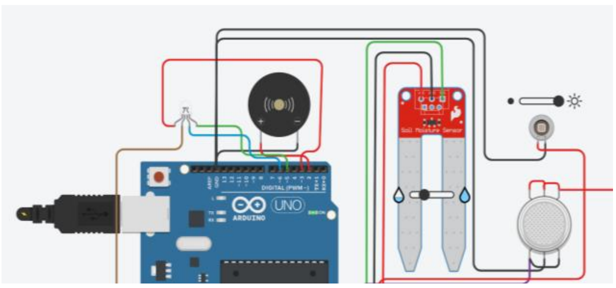

**Figure 2.** Buzzer Alert when low moisture and high heat

Here's a tabulation outlining key findings and discussions related to the results of implementing the Arduino-based smart agriculture system:

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**Table 2.** Outlining key findings and discussions

| **Findings** | **Discussions** |
|---|---|
| Increased Crop Yields | - Adoption of precision agriculture techniques leads to enhanced productivity and higher yields.<br>- Real-time monitoring of soil moisture and environmental conditions optimizes crop growth. |
| Improved Resource Efficiency | - Efficient resource allocation, such as water and energy, contributes to sustainable farming practices.<br>- Data-driven decision-making minimizes resource wastage and maximizes utilization. |
| Enhanced Risk Management | - Early detection of environmental hazards, such as low soil moisture or gas leaks, reduces risks.<br>- Proactive interventions based on real-time data mitigate potential crop damage and losses. |
| Increased Farm Safety | - Monitoring of harmful gases and pollutants ensures a safe working environment for farm personnel.<br>- Prompt alerts and warnings enable timely action to address safety concerns and prevent accidents. |
| Environmental Conservation | - Sustainable farming practices promote soil health, biodiversity, and ecosystem resilience.<br>- Reduced use of chemical inputs and minimized environmental impact contribute to long-term sustainability. |

This tabulation summarizes the main findings related to the results of implementing the Arduino-based smart agriculture system and provides corresponding discussions highlighting the significance and implications of these findings.

This project makes it possible for farmers to make data-driven decisions, allocate resources optimally, and reduce risks by incorporating cutting-edge technology into farming methods. This has a positive impact on crop production and environmental conservation. The project's improvement in crop output and quality is one of its main goals. Farmers can guarantee that crops develop under ideal conditions, leading to bigger yields and superior quality product, by regularly monitoring soil moisture levels, temperature, and light intensity. Furthermore, the system's real-time feedback enables prompt interventions to minimize crop damage and increase yield, such as modifying watering schedules or putting climate control measures in place.

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### 4.1. Discussions

A number of important points should be addressed in the discussion area on the outcomes of using the Arduino-based smart farm system. First off, the increase in crop yields that has been seen is evidence of the effectiveness of precision agriculture methods that are made possible by real-time monitoring and data-driven decision-making. Farmers can achieve increased output and higher-quality products by allocating resources optimally and offering timely interventions based on soil moisture and environmental conditions. Furthermore, there has been a noticeable improvement in resource efficiency, which is noteworthy because effective use of energy and water supports environmentally friendly farming methods. Furthermore, the system's early environmental danger detection capacity improves risk management by allowing proactive steps to reduce future crop losses and damage. Moreover, the need of ensuring a safe working environment for farm people is highlighted by the prioritizing of farm safety through the monitoring of hazardous gases and pollutants.

Here's a tabulation showcasing the key components and functionalities of the Arduino-based smart agriculture system. This tabulation outlines the essential components of the smart agriculture system and their respective functionalities, illustrating how each contributes to the system's overall operation and effectiveness in monitoring and managing agricultural processes. This has a positive impact on crop production and environmental conservation. The project's improvement in crop output and quality is one of its main goals.

**Table 3.** The key components and functionalities

| Component | Functionality |
|---|---|
| Arduino UNO | Central processing unit, collects and processes data from sensors. |
| Humidity Sensor | Monitors soil moisture levels for optimal irrigation scheduling. |
| Ambient Sensor | Tracks temperature and light intensity to determine suitable growing conditions. |
| LCD Display | Provides real-time visualization of data such as soil moisture, temperature, etc. |
| LED Indicators | Alerts users to specific conditions or events requiring attention. |
| Gas Sensor | Detects the presence of harmful gases or pollutants in the farming environment. |
| Buzzer | Activates audible alarms in case of critical conditions or emergencies. |

## 5. Conclusion

In conclusion, the research into using an Arduino UNO to implement a complex smart agricultural system and revolutionize automated agriculture highlights the incredible potential of technology in modern farming practices. The comprehensive assessment highlights how several agricultural tasks, including crop monitoring and irrigation management, can be enhanced by combining sensors, data analytics, and automation. The key component, an Arduino UNO, emphasizes the technology's versatility and accessibility, making it usable by farmers working at different scales. Because the system can deliver data in real time, optimize resource consumption, and speed up decision-making processes, it offers a significant leap in sustainable and efficient farming operations. Through real-time monitoring, data-driven decision-making, and automation, this system enables farmers to optimize crop production, enhance resource efficiency, and improve farm safety. By leveraging advanced technology such as sensors, actuators, and microcontrollers, the system facilitates precise management of environmental factors, leading to increased yields and improved crop quality. Additionally, the integration of automation and remote monitoring capabilities streamlines farm operations, saving time and labor while maximizing productivity.

Furthermore, the emphasis on sustainability through efficient resource utilization and environmental monitoring underscores the system's commitment to responsible farming practices. Overall, the Arduino-based smart agriculture system represents a promising solution for addressing the challenges facing modern agriculture, paving the way for a more efficient, sustainable, and resilient agricultural sector. As the period of smart agriculture draws to a close, it becomes evident that this technological revolution could aid in addressing some of the main problems the sector is currently facing, including overall productivity, resource management, and environmental impact. Automating processes has the potential to improve global food security in addition to raising agricultural productivity. The development and application of these cutting-edge smart agriculture technologies has enormous potential to improve farmer livelihoods, reduce environmental impact, and boost yields. This overview represents a sea change in farming's development toward a future that is more technologically advanced, sustainable, and interconnected. It pays homage to the agricultural technology's revolutionary potential.

**Declarations**

**Source of Funding**

This study has not received any funds from any organization.

**Conflict of Interest**

The authors declare that they have no conflict of interest.

**Consent for Publication**

The authors declare that they consented to the publication of this study.

**Authors' Contribution**

Both the authors took part in literature review, analysis, and manuscript writing equally.

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