

# Integrating Renewable Energy Sources with IOT Systems for Smart Farming

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## Abstract

The Internet of Things (IoT) is a technology that shows promise in offering effective and dependable solutions for the advancement of various domains. IoT technology is currently being employed to create automated systems for the maintenance and surveillance of agricultural farms, with the aim of reducing the need for human intervention. The primary objective of the study is to investigate the integration of renewable energy sources with IoT systems for the purpose of enhancing smart farming practices. This study also examined an IoT based system for monitoring, operating, and controlling temperature, humidity, and soil moisture in a land area. The system aimed to make use of renewable resources, in an effective and efficient manner. The projected system incorporates several input and output devices coupled to a power source for energy supply, as well as temperature & humidity sensors as input devices. Additionally, moisture & motor pump are utilized as output devices. The suggested methodology is cost-effective and easily implementable in sufficiently spacious areas suitable for cultivating crops, such as gardens and rooftops. Given the current trend towards increased reliance on renewable energy sources, as the primary power source presents an extra advantage.

**Keywords:** IoT Systems; Renewable Energy Sources; Smart Framing; Renewable Energy; Smart Irrigation; Smart Agriculture.

## Introduction:

In recent years, fast technological advancements in areas such as the IoT, Wireless Sensor Networks (WSN), and Embedded Systems have enabled the development of contemporary systems and applications that have drastically altered the way in which we live [1]. According to research published by the World Resources Institutes (WRI) in 2018 [2,3], the objective of sustainable farming is to enhance agricultural productivity to satisfy the food requirements of 10 billion people by 2050. In the context of agriculture, "smart farming" refers to a farming system in which innovative and cutting-edge technology are combined with more conventional farming practises with the goal of enhancing the quality & quantity of agricultural products while at the same time drastically reducing the number of inputs [4]. The development of the IoT has made it possible to envision smart farming that is both sustainable and environmentally friendly. IoT, which is a crucial component of smart farming, increases the usefulness of collected data over "automatic processing, analysis, and access". This is accomplished by facilitating the flow of data between various devices such as sensors, relays, and gateways. Therefore, a production that is both timelier and cost-effective [5]. Figure 1

illustrates that the architecture of the IoT is fundamentally composed of three distinct layers: "the perception layer, responsible for sensing activities; the network layer, facilitating data transfer; and the application layer, encompassing data storage and manipulation operations" [6].

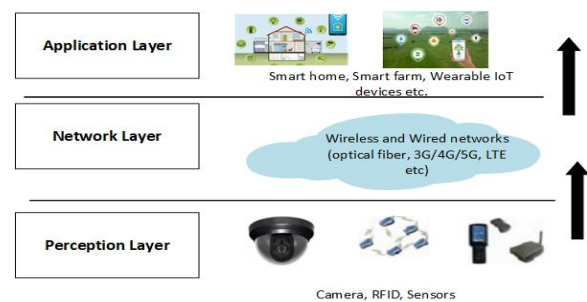


Figure 1: An overview of IoT Architecture [2]

At perception level, sensors are used to collect data on a diverse topic, including but not limited to "temperature, wind speed, humidity, nutrient level, plant diseases, insect pests, and so on" [6]. At this network layer, the data are kept, further analysed, processed, and distributed in order to produce valuable information [7]. The application layers also offer support for the timely detection and control of diseases

and insect pests, infestation, and the traceability of agricultural products' safety. Consequently, the enhancement of production efficiency can be achieved [8]. The agricultural industry necessitates the integration of "information services, automation, robotics, and a fusion of Information and Communication Technologies (ICT), drones, robotics, and Artificial Intelligence (AI) to enhance its operations. AI, IoT, and big data in order to satisfy the enormous need for food [9,10]. The main goal of this study is to carry out research on how IoT systems can be integrated with renewable energy sources to facilitate smart farming.

### **Background Study**

The authors **Liu et al., (2018) [11]** stated that there have been significant issues with renewable energy consumption in the power system and a scarcity of power supply in agriculture over the previous few decades. An extensive assessment was carried out in order to first illustrate the roadmap for integrating a clean energy system with agriculture and assess its benefits and viability. The creation of a combined system comprising smart agriculture production & clean energy consumption involves a summary and evaluation of current technologies and constraints. The advantages of agriculture-clean energy systems for the food and energy sectors are examined through a number of case studies.

Blockchain soon emerged as a significant technology in several applications of the precision agricultural field, according to **Torky & Hassanein (2020) [12]**. The amalgamation of the IoT with blockchain technology within the realm of precision farming holds the potential to facilitate the shift from individual smart farms to a network of interconnected smart farms. This transition is expected to significantly augment the control and management of supply-chain networks in the agricultural sector. When these two factors come together, precision agriculture management will become more intelligent and autonomous, resulting in more optimised and efficient practises.

The authors **Narayanan et al., (2021) [13]** suggested that agricultural goods from the past, present, and future will be the only means of human survival on Earth. By concentrating these two precious resources and employing a range of sensor-based agricultural practises (SBAP) to track variables including temperature, humidity, moisture content, and on-field

water level, this technique makes agriculture more effective. The creation of a novel automated agriculture monitoring system based on IoT-Fog is suggested. This method also suggests raising the water table during floods and rainy seasons by using a ground-level water top-up system.

Dhanaraju et al. (2022) [14] posit that smart farming is a progressive concept that prioritizes the integration of ICT within the framework of sensor technology, machinery, and other components of network-based advanced farm monitoring systems. Cloud computing, IoT, and other technologies are expected to spur growth and introduce robotics and AI into agriculture. This study looked into the gear and instruments utilised in IoT agricultural applications of wireless sensors, as well as the expected difficulties in integrating technology with traditional farming practises.

In the work of **Alam et al., (2023) [15]** provided detailed apparatus to set up a solar PV system that is appropriate for aquaponics operations. They also reviewed the utilities of aquaponics platforms that can be powered by solar energy. It is also explored how IoT integration may be used to remotely monitor such solar-powered aquaponics units. The findings of the analysis indicated that there were no discernible changes in the production & growth rates of the crop and fish within the system, even when the system was working at its maximum capacity for a very short duration of 12 hours.

### **Problem Statement**

Agriculture serves as the fundamental basis for sustaining all forms of life on our planet. A significant proportion of the Earth's land area, around 66%, is dedicated to agricultural activities [2]. Moreover, the agricultural sector consumes a substantial amount of the available clean water, accounting for approximately 80% of its usage [2]. As a result of population growth and the increasing interconnectedness of nations, there has been a notable escalation in the level of water consumption occurring at a decadal interval. The irrigation system has experienced several technological breakthroughs, however the full establishment of renewable energy and the IoT concept has not yet been achieved. The main focus of the study is to investigate the integration of renewable energy sources with IoT systems in the context of smart farming.

### Proposed Method

The primary concern associated with existing irrigation systems pertains to the inequitable allocation of water resources to agricultural crops, leading to an overconsumption of energy. This study examines the utilisation of renewable energy in irrigation systems as a means to address the limitations and challenges associated with conventional methods. The suggested system aims to enhance the efficiency of water and power utilisation through the utilisation of input devices, hence promoting environmental sustainability. In addition, the process of irrigating farms necessitates significant human participation, whereas the proposed approach minimises the need for human involvement.

### Designing Architecture

The proposed system integrates many input and output devices, which are connected to a power supply. The input devices consist of temperature and humidity sensors, while the output devices include moisture and motor pump components. The photovoltaic system is

seamlessly incorporated into the input system, hence facilitating the generation of renewable energy from different sources to effectively operate the interconnected water pump. The "ESP8266" is linked to 3 sensors, namely "temperature, humidity, and soil moisture". Additionally, it is connected to inputs that provide the necessary power for the water pump. The ESP8266 wi-fi connectivity" enables the remote monitoring of weather-related factors, including "temperature, humidity, and soil moisture". Farmers have the ability to remotely access and monitor the prevailing weather conditions within their land region through the utilisation of internet technology. Farmers have the ability to manage soil moisture levels by utilising a cloud-based application on their Android mobile device. This tool allows them to assess the water requirements of their cultivated land and make informed decisions regarding irrigation. The envisioned block is rather elaborate, and the suggested system is visually represented in Figure 2.

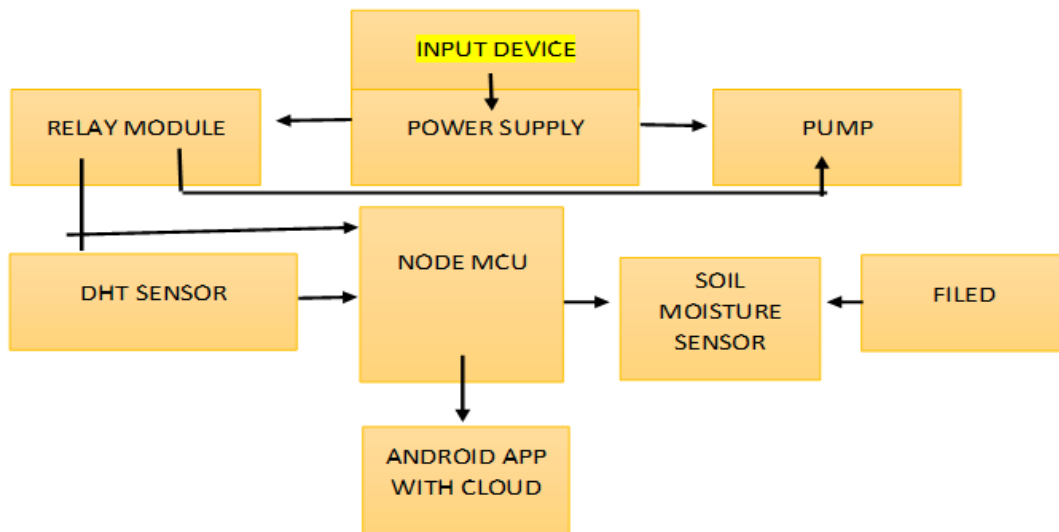


Figure 2: Proposed Architecture

### Implementation

The smart irrigation system, which is powered by renewable energy and operates on the IoT technology, incorporates many hardware components. These include a DHT11 sensor, a Wi-Fi module, an input/output device, a soil moisture sensor, and a relay module. These hardware components work together to detect and monitor the levels of "soil wetness, temperature, and humidity in the irrigation field". The input values of the sensors include "humidity, temperature, and soil moisture". The 2 temperature

functions commonly employed are "hot" and "cold." There are three functions, namely "High" and "Low," that are employed for the purpose of soil moisture and humidity sensing. The water motor is operated by the implementation of fuzzy logic, which involves the utilisation of "if" & "else" conditions. When the application message demonstrates that the temperature is up and the humidity is decreased, water is provided to the crops. On the other hand, in cases when the application note shows that the temperature

is not elevated and the humidity is not diminished, no irrigation is provided to the agricultural area. Temperature and humidity are distinct variables; however, they exhibit a correlation. The mathematical formula describing the relationship between humidity and temperature states that they exhibit an inverse proportionality. An increase in temperature results in a drop in relative humidity, leading to a drier air composition. Conversely, a fall in temperature causes an increase in relative humidity, resulting in a wetter air composition.

**Discussion**

Table 1 presents the quantitative data pertaining to the water use of an IoT enabled smart irrigation system. When the water quantity level ranges from 600 to 700, the motor is not operational. Conversely, when the level is between 1100 and 1200, water is provided through the irrigation system. Simultaneously, the data from temperature and humidity sensors is monitored in the cloud.

**Table1: The utilisation of cloud data for the purpose of controlling a water pump.**

Moisture	Temperature	Humidity	Motor Action
600 - 700	26-28	40 – 60	OFF
1200 – 1400	33-35	<33	ON

The planned design begins a direct connection between the Blynk cloud and the system by utilising the IoT WiFi module. This module facilitates the transmission of field values from the design system to the cloud. The aforementioned sensors are employed for the purpose of data acquisition from the field, with the collected data being subsequently organised within the designated application that is interconnected with the

IoT. The temperature sensors detect the field temperature and subsequently present it in degrees Celsius. The moisture sensor is used to continuously analyse the quantity of water in the field. Farmers are not need to be physically present at the irrigation field, as the condition of the system (as shown in Figure-3) may be monitored remotely by the user through our IoT-based smart irrigation system application.



**Figure 3: The storage and visualisation of data in the cloud using IoT technology.**

The suggested methodology is cost-effective and easily implementable in sufficiently spacious areas suitable for cultivating crops, such as gardens and rooftops. In light of the current trend towards increased reliance on renewable energy sources, the utilisation of renewable energy as the primary power source presents an extra advantage. The use of the wifi module enhanced the adaptability of the design by enabling greater flexibility and the inclusion of additional sensors with less programming requirements. The potential for future scalability of this concept is evident, as it can be adapted to fit larger farm sizes. Furthermore, it has the capability to work autonomously, eliminating the need for human

intervention and personnel in irrigation processes. Additionally, the implementation of this concept has the potential to reduce the expenses associated with the installation and operation of irrigation equipment.

**Conclusion**

A novel automated smart irrigation system has been devised, employing fuzzy logic as well as a diverse range of sensors such as soil moisture and DHT sensors. This system is capable of evaluating the soil's state and making informed decisions regarding the necessity of irrigation for agricultural purposes. Furthermore, by using an ESP8266 module to power all of the sensors

with renewable energy, this study was able to install the system without the need for electricity. The design of this system attempts to address the problems with traditional irrigation systems, which waste a lot of resources. The problem of excess labour was resolved by putting in place an automated feature that enables users to keep an eye on the state of the soil, the demand for water pumping, and other variables from a distance.

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