# Smart Irrigation for Sustainable Agriculture: A Framework for the IoT-Enabled Drip Irrigation System

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***Abstract*— A lot of water is needed for farming, which leads to the problem of water being wasted. To meet the growing need for both quantity and quality, we need to look into new technologies. This study looks at how possible it is to use automated drip irrigation to save water and make farming and production better. Qualitative research methods, like in-depth interviews and observations with local farmers, municipal agriculturists, and agricultural engineers, were used to gather important data for validation. Using the three levels of IoT architecture, data from the natural environment was collected and analyzed. This data was used to control how the actuators worked. All aspects of the irrigation process, from model to application to water distribution, are governed by the proposed smart irrigation system, resulting in high crop yields, water savings, and reduced energy use in agriculture. The framework that has been established makes it simple to develop low-cost, straightforward IoT-driven crop farming.**

**Index Terms—*drip irrigation systems, the internet of things,smart farming, sustainable agriculture***

## I. INTRODUCTION

Up to 80% of the water in Asia and 72% of the water worldwide are used for farming. Agriculture uses 87% of the water in developing countries, which is a big problem. The average efficiency of irrigation, which is less than 40%, could be much higher. Water is especially important for growing rice 40% of the world's food comes from irrigated land, even though it only makes up 16% of all crop land. Asia has the most people and the most irrigated crop land in the world. In many developing countries, keeping or expanding irrigation is important to make sure there is enough food and to reduce poverty [1]**.** Climate change changes the amount of water that crops need to grow in both irrigated and rain-fed systems. Increased evaporation and transpiration by crops and other plants increase the need for water, which speeds up the loss of soil moisture. The main way that climate change will affect ecosystems and ways of life around the world is through water. So, precision agriculture based on technology is needed for more efficient use of water in farming. Computers, smartphones, the Internet, sensors, wireless networking, and systems engineering are just a few examples of IoT-related technology. [2]. The Internet of Things (IoT) is changing agriculture and giving farmers the tools they need to solve big problems. New Internet of Things (IoT) applications make farming more productive and efficient. [3]. Sensors and microcontroller are used in an IoT-based intelligent agricultural system. The microcontroller decides how much water to put on the field by constantly monitoring it. IoT can be used in irrigation, especially with drip irrigation systems, which are part of farming. These goals involve putting a specific watering schedule into the application. Soil moisture and temperature sensors spread out in the root system layers make up a wireless network. These detectors keep an eye on things all the time and send information about them to a microcontroller. This gateway can now connect to WiFi and send data to the cloud. GSM and the IoT gateway could be connected by a module. The GPRS protocol, a packet-based cellular data service that can be used on 2G and 4G networks worldwide, is also used by this receiver unit to establish a two-way network connection. [4]. To regularly water their fields and keep their crops growing, many farmers use hand-controlled drip irrigation. This method can sometimes cause more water to be used because irrigation isn't done when it should be. This could cause crops to lose water or not get enough water. Only data from sensors used in agriculture is displayed in several studies. Smaller farmers are unable to install commercial agriculture and irrigation sensor systems on their farms due to the high cost. Now that manufacturers can mass-produce cheap sensors, it's possible to build node-based, automated systems for controlling irrigation and monitoring agriculture at a low cost. These low-cost sensors can be used to measure soil moisture, air temperature, leaf water potential, crop yield, and other important factors of agricultural production [5], a multi-level soil moisture sensor made of copper rings on a PVC pipe [6], a copper coil water salinity sensor [7], or an infrared and colored LED emitter and receiver water turbidity sensor. Renewable resources with agricultural potential can be used in the proposed research. Sustainable agriculture boosts crop yields, economic stability, and resource use while protecting the environment. The primary goal of this research was to develop a blueprint for an automated drip irrigation system that could serve as a prototype for an IoT-driven agricultural farming system that is both cost-effective and simple to implement. Due to the lack of water and power, it appears that farmers need access to new technologies and systems.

## II. RELATED WORKS

A literature review had to be done to make sure that the study's contribution was better in every way. This is important for figuring out how both theories and ideas contributed to the success of the study. In this section, you can read about automated irrigation, smart and precision agriculture, automated irrigation, and the use of different technologies in agriculture, such as IoT, Edge, and AI. Irrigation is a key part of the infrastructure that helps the agricultural economy get better. The speed at which cities and factories have expanded has harmed people, infrastructure, and farming alike. Researchers are paying close attention to irrigation and farming, which have become very important issues. [8]. Monitoring crops and watering them becomes very important. If you water the plants less or more than they need, it's a big problem that could lead to a lower crop yield. Also, farmers can't stay on the irrigation ground all the time. [9] So, we're coming up with a plan for the automatic crop monitoring so that the system can automatically figure out when plants need water and give it to them. We suggest draining the extra water in the fields so that heavy rains don't hurt the growth of plants. We also think that the irrigation system should use artificial intelligence . [10] Intelligent sensor networks detect soil moisture and nutrient deficiencies. This data can help farmers set up automatic watering systems and determine crop nutrient needs. The cloud receives soil data. Keeping the massive amounts of data obtained by the network of wireless sensors safe is a challenge, but cloud storage, which farmers can access through an app on their smartphones, is a key way to do so. Due to rising water use, there are big worries about the future of agriculture, which uses water to grow crops. With traditional irrigation methods, some parts of a field get too much water while other parts don't get enough. Sensor technology can be used to make irrigation operations use water more efficiently. [11]. Sensors detect changes in the environment's temperature and humidity, and they then send an interrupt signal to the microcontroller. This study's primary objective is to present a system for automatically watering crops. [12]. An all-encompassing system that makes use of sensing, geolocation, the Internet of Things, and remote processing is constructed as part of this research project. This technique, according to researchers at Aberystwyth University in the UK, can be used to automate precise water use without reducing yield. [13]. Precision agricultural greenhouse systems show that there is a lot of room for improvement in irrigation management. This is because growers often water plants based on their own experience. For soil-less systems, the estimated timetable is every hour or even less often, but for soil-based greenhouse crop irrigation management, the estimated timeframe is every day. This article gives a thorough analysis of research on irrigation scheduling techniques used in soil and soil-less greenhouse production systems. [14]. Agriculture is the biggest user of water, and irrigation uses 70% of all the water that is taken out of the ground around the world. Without more effective farming, it is anticipated that by 2050, the global water use for agriculture will increase by about 20%. It was discovered that ICT technology is critical for the advancement of smart and sustainable farming. A summary of a few of the most recent smart irrigation software solutions is provided in this paper. The ICT solutions provided on the basis of this data offer real-time decisions about when to water in addition to forecasts and plans for future watering, modeling of the irrigation schedule, and irrigation system design based on offline data. [15]. In this part, they gave a suggestion for the architecture of an irrigation system that could be used with the Internet of Things. They say that for it to do what it's supposed to do, it needs to be interoperable, scalable, secure, available, and strong [16]. [17] By putting AI, Edge, and IoT together, you can do three things. IoT, edge computing, and data analytics are all used by smart agriculture to make farming more sustainable and profitable. It also uses IoT and data analytics based on the edge of things to predict when diseases will affect crops, soil, and plants. The Internet of Things for agriculture, precise irrigation, monitoring livestock, and a mobile robot for precision horticulture are also discussed in the book. The book focuses primarily on the long-term environmental and economic benefits of intelligent and electronic agriculture. [18] Several wireless sensor networks have sensors that gather information about crops and changes in the environment. This information is sent over the network to devices, which then take action. Farmers can talk to each other and find out about agricultural needs at any time and from anywhere

## III. METHODOLOGY

A qualitative methodology was used for this investigation. A survey questionnaire, the key informant method, and focus group discussions were used to collect primary and secondary data, respectively. The study's goal was to identify the problems and issues plaguing crop farming in Talisay, Camarines Norte, the Philippines, so that a solution could be developed. From Office of the Municipal Agriculturist, I wrote a letter requesting permission to interview crop farmers and observe their operations. Farmers were asked about their most common methods of operation, the challenges they face, how they feel about embracing new technology, and what other factors influence the adoption of such innovations in order to increase yields from their crops. Participants' thoughts and experiences with the topic were elicited through in-depth, semi-structured conversations. In order to collect qualitative information, it is common practice to ask respondents open-ended questions that are guided in some way. The research questions were answered, and the framework was constructed with the help of the document analysis of the various research findings, which was made possible through the expert interviews that were conducted.

The municipality's Registry System for Basic Sectors in Agriculture (RSBSA) includes 154 crop farmers across 15 barangays. The researcher estimated the size of the sample using the Raosoft formula based on the number of respondents. With a 95% confidence interval and a 5% margin of error, the Raosoft procedure recommends a sample size of 111. This study's main goal was to create an IoT architecture for drip irrigation systems. This was accomplished with the assistance of information gathered through a survey, an interview, and a focus group. However, the study was criticized for its lack of rigor on account of the researchers' failure to check for pests or examine the soil's physical and chemical properties. Moreover, the expense of launching the IoT infrastructure was not factored into this research.

## IV. DISCUSSIONOF FINDINGS

Talisay, Camarines Norte, Philippines, is renowned for its bountiful agricultural production because of the region's rich soil, low altitude, and ideal temperature. Agriculture is the primary industry in the city [19].

### *4.1 Farming Techniques Currently used*

Most barangays grow rice, coconuts, legumes, and other high-value products that are sown up to four times a year. The farmer waters his fields with a sprinkler or a dipper and pail three to four times daily. Spread the fertilizer in a band near the sides of or below the seed rows using a shovel. Most of the water used for irrigation comes from either the National Irrigation System or private water pumps and wells dug deep underground.

### *4.2 Issues Encountered*

Figure 1 depicts six of the most pressing problems and necessities for farms. Since 34% of families have trouble getting water and spend more money renting water pumps during dry weather, the watering system is the most crucial aspect of the infrastructure. Most farms are either too old or uneducated to perform their own soil tests, so they continue to waste money and resources on fertilizer and other chemicals that only serve to worsen the quality of the soil. Since this is the case, 16% of producers need help from other people. In addition, 13% of their expenses are due to bugs that eat their plants. The majority of the farms they own are not close to their residences and thus need electricity for lighting. They spend 10% of their budget on the difficulty of acquiring expensive fertilizers on the market, and 11% on the expense of protecting their farmland from thieves and animals that consume their crops.

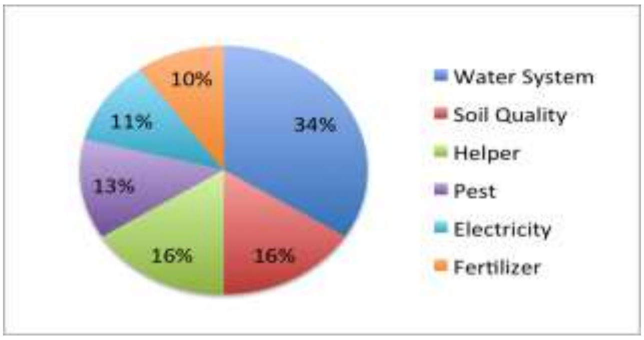


Fig.1 Quantity of Farming's Requirements and Problems

### *4.3 Farmers' Opinions on What They Really Need*

The population of Camarines Norte is expanding quickly, the climate is changing, and there is an increasing demand for food and other necessities. Because of this, farming, especially in the town of Talisay, is becoming more and more dependent on water. As a result, the production of agricultural goods is becoming more and more at risk. Because there isn't enough rain to irrigate their crops, farmers are suffering from a water shortage, which has a negative impact on their production. If there weren't reliable irrigation systems, it would be impossible to modernize farming methods and make them more productive. Some farmers may not be able to make this investment because of the high installation fees and up-front costs that come with buying the system. Long-term, though, it is better because it increases crop production while using less labor, fertilizer, and water.

### *4.4 Attitude toward technological adaptation*

A framework that takes into account the needs and preferences of farmers will help to improve productivity, efficiency, and quality of farming, which will make it more sustainable. Responses to the survey that were positive, open to change, and accepting of new technologies will make this framework better.

## V. INTRODUCING IOT FRAMEWORK

Looking down from above, it is easy to see the main routes, secondary routes, and horizontal lines that bring water to the crops. There are several emission terminals scattered along their routes. As can be seen in Figure 2, the plant's root system has direct access to the water, nutrients, and other substances that it needs for proper growth through each of the dipper openings.

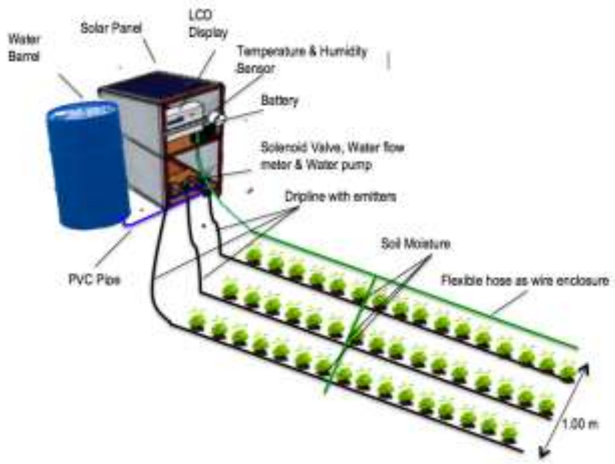


Fig.2 Internet of Things Infrastructure for Drip Watering

Based on their real-world experience making cheap, long-lasting Internet of Things (IoT) hardware for automating farms, they came up with this idea. Experts recommend using simple and generalized component parts. The IoT architecture layers are shown in Figure 3 and consist of three layers: the application, the network, and perception. [20] and [21].

*5.1 Perception Layer*

It involves sensing and gathering information from sensors that measure the soil, the flow of water, temperature, and level of water.

*5.2 Network Layer*

Connecting the Perception and the Implementation layers is the Transmission layer. It uses sensors to collect information about the physical world and sends that information elsewhere. Both wired and wireless methods of interaction are supported. It also links electrical systems and networking hardware.

*5.3 Application Layer*

The monitor and smartphone are parts of this layer. The IoT architecture's front end, which offers services tailored to particular applications, is made up of sensor data.

*5.4 IoT Integrated Environment*

The microcontroller and power supply are already integrated into the IoT device. Its primary functions include processing and understanding data from all layers and supervising all system activities. [22] A solar-powered battery that is rechargeable powers the microcontroller.

## VI. TECHNOLOGY REQUIRED

The three primary methods of mechanization are time-based systems, quantity based systems, and sensor-based systems. The main objective of a time-dependent system is to be configured in such a way that it operates when the crop requires water. The process in this case is based on the passage of time. A large area of land is divided into numerous smaller pieces in a quantity system, each of which is referred to as an area or segment, and each receives the appropriate amount of water. The device communicates with the controller, which acts on the signal to complete the necessary tasks. The main parts of a microcontroller-based automated drip irrigation system are a water pump, switch, drip pipelines with emitters, humidity sensor, microcontroller device, GSM, and display screen. [23].

*A. 6.1 The Water Pump*

The drip irrigation system's micro-submersible water pump uses less energy than conventional irrigation pumps. By sending GSM data to the controller, the farmer can turn on the motor and irrigate the land.

*B. 6.2 Solenoid Valve*

The principle that controls water flow converts electrical power input into the generation of force through mechanical means. This allows the button to be opened and closed electrically from within the building without anyone physically being present. A three-port valve's flow can be diverted to either of its two outlet locations, as opposed to the single option available with a two-port valve.

*C. 6.3 Emitters attached to drip lines*

The sources are primarily in charge of controlling the rate of water release to the soil. Usually made of plastic, emitters are tiny parts that screw or snap onto drip tubes or pipes. In systems with trickling pipes, they come per-assembled and integrated into the pipe assembly.


Fig. 3 The Drip Irrigation System's IoT Architectural Layers

*6.4 Soil Moisture Sensor*

Dry soil has a high resistance when two electrodes are connected to it. Between the electrodes, water is a good electrical conductor, and the ground's resistance decreases as soil moisture content increases. The principle of resistance is what controls the soil moisture sensor. The microcontroller is supplied with the necessary dampness value. [24].

*6.5 Microcontroller unit*

Using microcontroller technology, you can do things like check; the temperature, power, and humidity to reduce the number of motor problems caused by these things. The user can turn off the actuator by talking to a microcontroller that is connected to temperature, power, and moisture sensors through GSM.

### *6.6 GSM (Global System for Mobile Communication)*

The digital data will be processed and analyzed by the microcontroller, and the GSM module will send an SMS to the smart phone [26].

### *6.7 LCD (Liquid Crystal Display)*

The LCD screen shows a wide range of characters, including alphabets, numbers, letters, and symbols. The current temperature and humidity are displayed graphically. [27].

### *6.8 Solar Power*

We utilize solar energy, which is sun-generated energy. The demand for renewable energy sources has increased in recent years. There is an eco-friendly option available. Solar panels use silicon to convert solar energy into electricity. [28].

## CONCLUSIONS AND RECOMMENDATIONS

By combining efficient agriculture with the Internet of Things, this study tried to find out if automated drip irrigation is a good way to save water, make farming better, and increase production. The study found that the current framework provides a full platform for the adoption of crop farming systems powered by the Internet of Things that can help farmers grow more crops. Also, the study gives many examples of how agriculture's natural strengths can be used to solve problems with food security, climate change, and reducing poverty. To fully understand the range of sustainable agricultural production, it is important to take into account factors like attributes of the soil's composition and structure, which are already taken into account in this study, as well as any other variables that might affect agricultural productivity. These variables can also be used as inputs in the Internet of Things (IoT) framework. To better understand what this study's results mean, it is recommended that additional research be conducted to investigate the soil's physical and chemical characteristics. Additional study could be done to create a drip watering system that is straightforward enough for farmers with little knowledge of smart agriculture to understand.

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