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IoT-Enabled Smart Farming Architecture using CC3220SF Microcontroller

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***Abstract*— Environmental monitoring is really important for managing water in farming. The old ways of irrigating crops are not very good because they are done by hand and do not make decisions quickly. This leads to wasting water and crops not growing well as they should. That is why we made an irrigation system that uses the internet and sensors to measure things like temperature, humidity and soil moisture. The Texas Instruments CC3220SF LaunchPad is the brain of the system and it sends all the data it collects to the ThingSpeak cloud so we can see what is going on in time. The system can even turn on the water by itself when the soil gets too dry or when the wind is not too strong. We tested the system. It works very well sending data quickly and working consistently even when the weather changes. This means that farming can be more efficient and use water, which is good for the environment and for growing crops. The smart irrigation system is a help for farmers because it reduces the need for people to do things by hand and makes sure that water is used in the best way possible which is really important, for smart farming and environmental monitoring and precision agriculture and automated irrigation using IoT and soil moisture sensor and ThingSpeak and wireless sensor network.**

***Keywords*— IoT, Smart Irrigation, Environmental Monitoring, Precision Agriculture, CC3220SF, Soil Moisture Sensor, ThingSpeak, Automated Irrigation, Wireless Sensor Network.**

I. INTRODUCTION

In farming it is really important to keep an eye on things like temperature, humidity, how wet the soil is, the soil pH and wind speed. This helps us use water wisely and grow crops well. But the old ways of watering crops are done by hand take a lot of time. We cannot make decisions quickly. This leads to wasting water. Now with the Internet of Things technology, we can water crops automatically. Keep an eye on things in real time. This helps us use resources better and farm efficiently. This project is about an irrigation system that uses the Texas Instruments CC3220SF LaunchPad and many sensors to monitor the environment. The system collects data in time uses a small computer to process it and sends it to the ThingSpeak cloud platform so we can monitor it from far away. The system can turn on the water pump when the soil is too dry and the wind is just right. It works with both sprinkler and drip irrigation methods. Makes sure water is distributed evenly based on the condition of the field. The main things we did in this project are making a system that can monitor things at once creating a way to water crops automatically based on soil moisture and wind and making it possible to see data in real time, on the cloud.

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II. RELATED WORK

Out in the fields gadgets talk to each other through the air sending updates about what the ground feels like beneath the crops. This is really helpful for growers because of guessing when to water they can now watch live numbers roll in. These numbers show how wet the dirt is, how hot or sticky the day turns. Messages hop from detectors into online spaces where patterns emerge, guiding better choices that save every drop of water possible [1]. Some studies went further by linking earth probes and sky watchers into digital dashboards far away. This means farmers can check field updates on their phones thanks to sensors sending air and soil details wirelessly to online storage. Real-time tracking helps save water without hurting the harvests [2]. Raza and team designed a soil moisture setup using an adaptable antenna. This tweak boosts signal strength during data send-offs. Because signals travel reliably now fewer machines are needed out in the dirt, which also means less chance something breaks when watching crops over huge areas [3]. Singh's group built Smart AgroSense, a mesh of spread-out sensors keeping tabs on weather and earth factors across farmland stretches. Information flows in from spots then gets shipped off to online storage spaces where patterns pop up without delay. Farmers tap into these updates to see how land and air differ spot by spot leading to watering moves [4]. Drones take flight in Karars method they scan fields from above while linked to web- tools and remote servers. What they snap from sky level blends with readings taken right at plant roots. Together those layers help figure out how much water each crop patch truly needs, shifting how schedules get set and cutting down wasted water flow [5]. Out in the field Lloret and team explored how best to place sensors that track soil wetness across farms. Placement matters, they. If you get it right you cover more ground while saving power over time [6]. Greenhouses take an approach there Liaos group built a drip setup smart enough to watch dirt dampness and turn watering on only when needed. This keeps crops happy without wasting drops [7]. Then came Benyezzas idea, farmland into sections each managed separately using fuzzy rules and internet-linked tools. Each zone gets water based on what the soil needs cutting back both electricity and water use [8]. From sensors came insights when Naik teamed up with Nandana on a farming setup powered by machine learning and connected devices. Decisions grew sharper once crop health, moisture levels and surrounding threats were tracked through live data streams [9].Water flow shifted smoothly under Reddy's watch alongside Prasad's design of an automated check on earth quality using internet-linked tools. Of guesswork hydration adjusted itself triggered only when readings demanded it [10]. Close to the sensors Zhang and Li built an Edge-IoT setup for watching nature unfold. By handling information there at the source delays shrink while responses speed up less needs sending far away. Farms spread wide can use this kind of tracking without leaning too hard on distant servers [11]. Over in another look Wagh with Patil peeled back layers on how farming gains when gadgets meet data streams. Machines learn, sensors talk, clouds store it all ties together now. Results water flows harvests grow better spending stays low [12]. One study by Kumar and team brought up a farming setup using internet-connected sensors plus cloud tools to share live updates along with warnings. This design helps manage fields while supporting faster choices thanks to constant tracking [13]. Still problems pop up like readings from sensors, heavy battery drain, difficulty expanding across wide farms. A lot of models watch just a few things at once skipping details like acidity levels in dirt or air movement patterns. Because of that gap what's needed now is an approach tying together wider sensor inputs, self-run watering functions, remote oversight, via online platforms the challenge this paper tackles [14].

III. METHODOLOGY

The framework begins with a power supply unit, where the power is decreased and controlled to a 3.3V to power the Texas Instruments CC3220SF LaunchPad which is the central controller for the system. The Texas Instruments CC3220SF LaunchPad is used for sensing, processing and communication tasks. The system is developed using the Energia IDE, where library files for sensors and Wi-Fi communication are included to make things easier. The system gathers live data from sensors in the field once it is powered on. The Bosch BME280 sensor measures temperature and pressure the soil moisture sensor measures soil moisture percentage, the soil pH sensor measures acidity or alkalinity and the wind sensor measures wind speed. The Texas Instruments CC3220SF LaunchPad reads and analyzes all sensor values and transforms them into parameters. The system uses a soil moisture threshold logic to determine when to turn on the water pump for irrigation. The system sends all processed parameters to the cloud server ThingSpeak via Wi-Fi, where the data is shown on a real-time dashboard. The system also sends notifications, to the farmer when the soil moisture falls below or exceeds the threshold allowing the farmer to take timely action. The Texas Instruments CC3220SF LaunchPad and the system run continuously in a loop merging real-time sensing, data analysis, automated irrigation control and cloud-based monitoring to optimize water management and support agriculture practices.

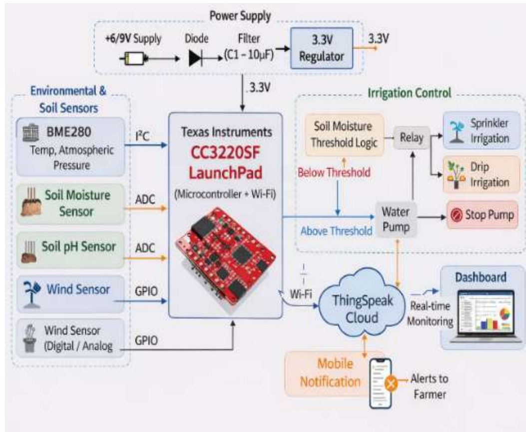

Fig. 1. Block Diagram of IoT-Based Smart Irrigation System

Fig 1. The block diagram shows what the smart irrigation and environmental monitoring system looks like. This system is based on the Texas Instruments CC3220SF LaunchPad. The system gets its power from a supply that gives it 6 to 9 volts. This power is controlled to give the microcontroller and sensors 3.3 volts. The system uses the Bosch BME280 to measure things like the environment. It also uses sensors to measure how much water is in the soil how acidic or basic the soil is and the wind. These sensors send information to the CC3220SF, where it is looked at and figured out using rules about how much water's, in the soil. If the soil does not have water the system turns on a relay that makes a water pump work and this pump can be used for sprinkler or drip irrigation. The system sends the information it collects to the internet using Wi-Fi. It goes to a place called ThingSpeak, where people can see what is going on in real time on a dashboard and it also sends messages to the farmers phone so they can keep an eye on things from far away.

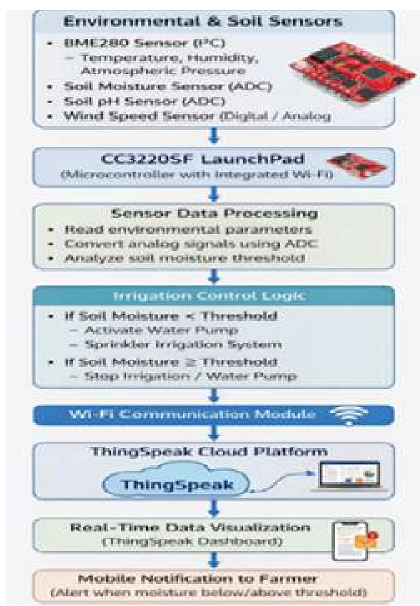

Fig. 2. sensor work flow diagram

The diagram shows the workflow of a based smart irrigation monitoring system. The system has sensors that check the soil to see how moist it is how acidic it's how windy it is. These sensors send the information they collect to the Texas Instruments CC3220SF LaunchPad. This little computer looks at the information from the sensors. Decides if the soil needs water. If the soil is too dry the system turns on the water. At the time all the information that was collected is sent to the internet through Wi-Fi to a website called ThingSpeak, where you can see what is going on with the soil, in real time and look at the information to see what is happening.

IV. RESULT AND DISCUSSION

The proposed IoT-based smart irrigation system was implemented using the CC3220SF LaunchPad. Tested in real environmental conditions. It monitored temperature, humidity, pressure, soil moisture, soil wind speed and sent the data to the ThingSpeak cloud platform. The system provided real-time monitoring with data transmission latency of less than 5 seconds. The sensor data were displayed on the cloud dashboard for monitoring. Soil moisture sensor readings-controlled irrigation based on a threshold value. When moisture levels dropped the system switched off the water pump. Results showed that incorporating wind speed increased irrigation efficiency. The system reduced irrigation and provided a comprehensive understanding of environmental conditions. Compared to existing systems it offered performance with multi-parameter sensing, automated control and real-time cloud monitoring. However, it was tested on a scale and needs further analysis on sensor accuracy, energy usage and long-term reliability. The proposed system demonstrated performance, in reducing water wastage and supporting efficient smart irrigation practices.

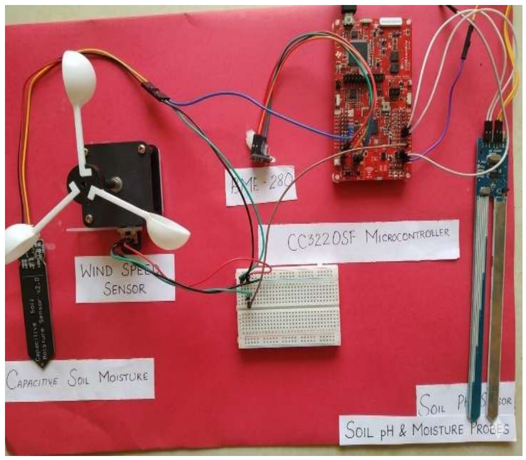

Fig. 3. Implementation of the system hardware

Figure 3 is the hardware implementation of the IoT-enabled automated irrigation system. It uses the CC3220SF microcontroller as the primary controller for data analysis and transmission. The CC3220SF microcontroller analyzes data from the BME280 sensor which measures temperature, humidity and pressure and it also gets data, from soil moisture, soil wind sensors. The IoT-enabled automated irrigation system uses the CC3220SF microcontroller to implement a limit-based logic to regulate irrigation. The CC3220SF microcontroller looks at soil moisture and wind conditions. Then it uses a relay to control the water pump. The IoT-enabled automated irrigation system sends data to the ThingSpeak cloud platform through Wi-Fi so that people can monitor it in time

Fig. 4. BME sensor Air pressure output

Fig 4. This is an image that shows the Atmospheric pressure data that we got from the pressure sensor. It is shown on the ThingSpeak interface. The plot is really useful because it shows the pressure variations that happen when we change the conditions.

Fig. 5. Humidity sensor output

We used a sensor to monitor the humidity value and we sent this data to ThingSpeak so we can see it in real time. The Atmospheric pressure data and the Humidity sensor output are important because they show us how the atmospheric moisture changes, over time when we are monitoring it.

TABLE I

Threshold value	condition
>60%	Humidity level is high
<60%	Humidity level is low

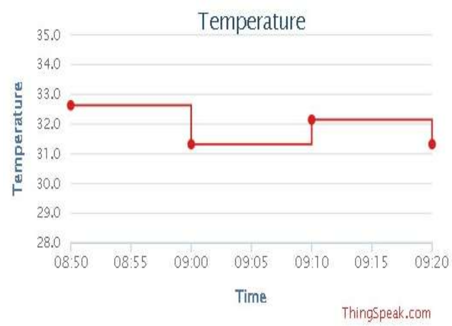

Fig. 6. Temperature senor output

This picture shows us the temperature in the area around us at that moment, which was found using an Internet of Things sensor. The temperature readings are shown on the ThingSpeak cloud platform. We can see the temperature going up and down on the graph over time which helps us keep an eye on what's happening in the environment around us with the Real-time surrounding temperature data, from the IoT sensor on the ThingSpeak cloud platform.

TABLE II

Threshold value	condition
>30°C	High temperature
<30°C	Low temperature

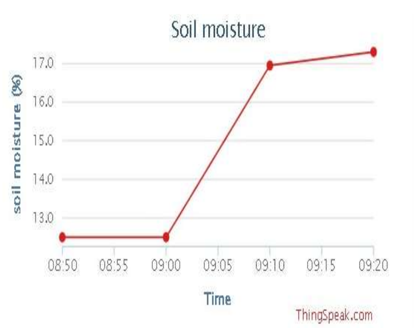

Fig. 7. soil moisture sensor output

Soil moisture data collected from the soil sensor and send to the ThingSpeak cloud. The graph shows soil moisture level changes, enabling smart irrigation decision process

TABLE III

Threshold value	condition
>450	Water level is high
<450	Water level is low

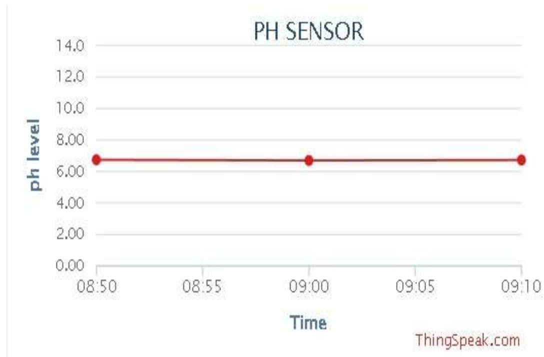

Fig. 8. pH sensor output

The pH sensor data displayed in the ThingSpeak dashboard displayed a steady pH value of approximately 6.5 to 7 over time. This range indicates near-neutral soil conditions, which are generally ideal for most crops. The graph shows minimal change, showing stable soil quality and reliable sensor performance. Monitoring pH levels helps in ensuring ideal soil conditions, ensuring proper nutrient availability and promoting healthy plant growth.

V. CONCLUSION AND FUTURE DEVELOPMENT

This paper is about a based smart irrigation system that uses a special computer chip called the CC3220SF microcontroller. This system has sensors that check the soil moisture, soil pH, temperature, humidity, pressure and wind speed. All these sensors work together to monitor what is happening in the field in time. The system can turn on the water pump by itself when the soil is too dry and the weather is okay. This way we do not waste water. We do not have to check on it all the time. It is better than the way of watering because it looks at many things and we can check on it from a distance through the internet.

The system can be made better by using it on bigger farms and adding better sensors that can work well for a long time. We can also use intelligence to help the system make good decisions about when to water based on what happened in the past and what the weather will be, like. This will help us use water wisely and grow crops. We can also make the system use energy and add a control interface that we can use on our phones to make it easier to use for farming.

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