Internet of Things for Smart Farming

Md Alimul Haque, Deepa Sonal, Shameemul Haque and Kailash Kumar

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Chapter

INTERNET OF THINGS FOR SMART FARMING

Md. Alimul Haque[1,*], Deepa Sonal[2,†], Shameemul Haque[3,‡] and Kailash Kumar[4,§]

[1]Department of Computer Science,
Veer Kunwar Singh University, Ara, India
[2]Department of Computer Science,
Patna Women's College, Patna, India
[3]Al-Hafeez College, Ara, India
[4]College of Computing and Informatics, Saudi Electronic University,
Riyadh, Kingdom of Saudi Arabia

ABSTRACT

Amid people's thinking of the farming operation, the fact is that today's agriculture is data-centric, accurate and better than before. Nearly every sector, including "intelligent farming," was revolutionized by the rapid advent of Internet-of-Things (IoT) technology, which led the sector

[*] Corresponding Author's Email: shadvksu@gmail.com.
[†] Corresponding Author's Email: deepsonapwc@gmail.com.
[‡] Corresponding Author's Email: shameem32123@gmail.com.
[§] Corresponding Author's Email: k.kumar@seu.edu.sa.

from statistical to quantitative solutions. Such innovative advances are changing the current farming practices and posing new obstacles. This chapter provides the importance of wireless and IoT sensors in agriculture as well as the obstacles facing the integration of this technology with conventional agricultural practices. Detailed analysis of crop condition, fertilizer, insect detection and pesticide is carried out on IoT products and wireless sensor connectivity methods in farm applications. This chapter proposes an IoT-based model to alert farmers for soil moisture conditions, potential damage in agricultural land from the fire and automatic water irrigation started at low moisture of soil or fire. Finally, this chapter covers contemporary and future IoT trends in smart farming and research difficulties.

Keywords: Internet-of-Things, smart farming, advanced agriculture practices, soil moisture sensor, fire/smoke sensor

1. INTRODUCTION

Internet of Things (IoT) is the network or web of connected devices. The devices can be computing devices, mechanical or digital devices. Every connected device has a Unique Identifier. When two or more objects can communicate (send and receive signal or messages), a communicating network is created between these objects. That network between objects is called the Internet of Things.

Basically, we can say that when the power of the Internet is extended from a computer and mobile phones to other household devices, it is called *Internet of Things.* IoT has changed today's world Living and Working style. All the devices present in the surrounding can become smart devices when IoT is implemented on that. Many concepts have already been developed and are working with good outputs. Such as Smart homes, smart cities, smart cars, smart factories, etc., are some of the concepts that are being used these days[1]. Any cropland with fire detection sensors to send alert message to farmer or any home with smart door lock sensor are

[1] Haque et al., "An IoT-Based Model for Defending Against the Novel Coronavirus (COVID-19) Outbreak."

example of Things in IoT[2]. Due to this feature, it has applicability in various fields. Figure 1 shows some of its application areas.

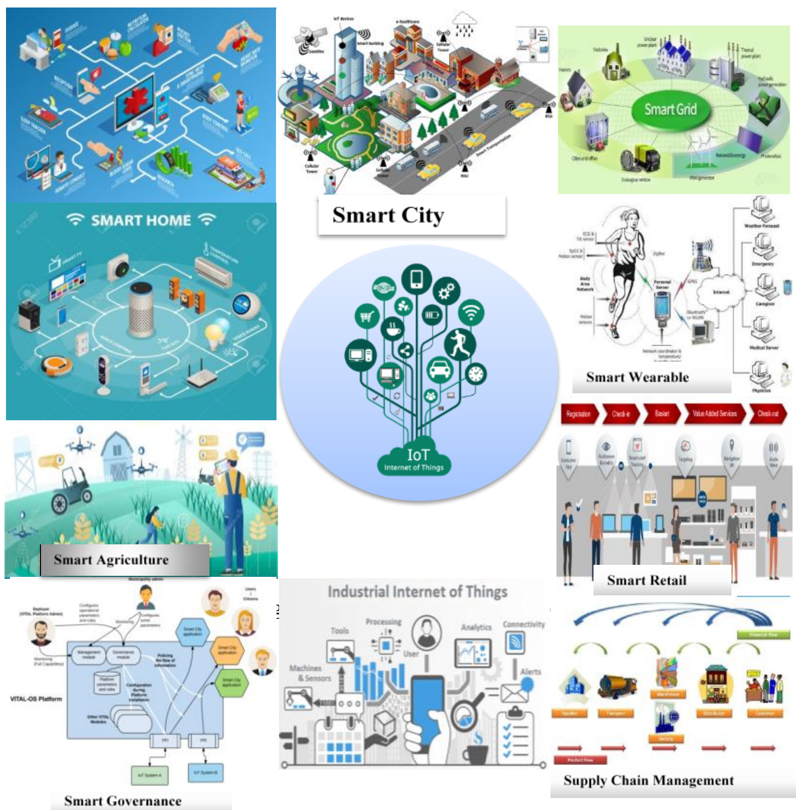

Figure 1. IoT Applications.[3]

Keeping these features of IoT in mind, this research paper has been written to apply these in the agriculture field. Therefore, the main objective of this research is:

- To make agricultural techniques used in India advanced with the help of IoT.

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[2] Haque et al.
[3] Haque et al., "A Comprehensive Study of Cyber Security Attacks, Classification, and Countermeasures in the Internet of Things."

- To increase the productivity of agriculture.
- To protect the crop destruction from fire in cropland.
- To make farmers up-to-date with the use of the latest technology.

The remainder of this chapter is arranged accordingly. Section 2 reviews the literature. Section 3 briefly details the IoT Ecosystem. Section 4 and 5 deal with IoT agriculture and its structure including the components. Section 6 smart farming with IoT. Section 7 methodology and proposed model. Section 8 deals with limitation and section 9 discusses future scope in the product with advancements in IoT. Lastly, section 10 concludes this chapter.

2. LITERATURE SURVEY

B. Ragavi et al.[4] proposed the "AGROBOT" model for monitoring weather, fertilizers and status, and water requirement, which was based on AI and IoT. This model improves the crop yield with low cost. Shibin David et al.[5] proposed a model, which used AI and Ardunio UNO for measuring pH, temperature, and wetness of varied soils are all aspects to consider. All measuring values can be accessed through the GSM module. This model increased the production of crops. Deepak Sinwar et al.[6] used IoT, AI Cloud Computing, and Arduino Raspberry Pi and proposed a CS-HYSIS system. D. Sivaganesan [7] predicted soil moisture and plant growth pestilence assault, climate change and time for harvest in a small part of the land. It also forecasts when and how to apply fertilizers to the irrigation crops and the right moment. Sunil Kumar[7] used ML and Drone technology and using AI and IoT frameworks. By analyzing previous behaviors, he proposed a new irrigation model using sensors and ML

[4] Ragavi et al., "Smart Agriculture with AI Sensor by Using Agrobot."
[5] David, Anand, and Sagayam, "Enhancing AI Based Evaluation for Smart Cultivation and Crop Testing Using Agro-Datasets."
[6] Sinwar et al., "AI-Based Yield Prediction and Smart Irrigation."
[7] Kumar, "Artificial Intelligence in Indian Irrigation."

algorithms. He also spoke about water conservation, optimal seeding, crop rotation, and time for harvesting. Including temperature sensor, moisture sensor, GSM module, Wi-Fi module, Arduino UNO module, and web servers, B.Vidheya Raju[8] introduced a low-cost farm-field surveillance system. R. Divya et al.[9] proposed “SATURAS” and Stem Water Potential (SWP) system. It is low-cost technology for farmers because one or two sensors are used per hectare. Siddhant Kumar et al.[10] presented a new system based on gCrop that is IoLT (Internet of Leaf Things). The picture of a camera embedded in an ultrasound sensor is collected to monitor growth using sensors in real-time. For observing the growth trend, ML model data collected by sensors is used. By measuring the length of the leaves, the device calculates the age of the leaves. 98% accuracy in the identification of leaf formation, health and maturity, and thus the improvement in crop quality and yield. S. S. Mane et al.[11] presented a GSM-based Automatic Irrigation System. The upper and lower soil moisture parameters can be set in this model. The automatic greenhouse control system for crop production was introduced by K. Radha Gowri[12] in conducting the use of sensors under favorable conditions. It is useful in that the labour cost of smallholder farming and offers a safer farming atmosphere than open farming.

3. IoT Ecosystem

The Internet of Things ecosystem is difficult to describe. Due to the vastness and evolving possibilities and the rapidity with which it is spreading across the entire market, it is very hard to define its picture. The IoT ecosystem, on the other hand, is a collection of various types of

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[8] Raju, “An IOT Based Low Cost Agriculture Field Monitoring System.”
[9] Divya and Chinnaiyan, “Reliable AI-Based Smart Sensors for Managing Irrigation Resources in Agriculture—A Review.”
[10] Kumar et al., “GCrop: Internet-of-Leaf-Things (IoLT) for Monitoring of the Growth of Crops in Smart Agriculture.”
[11] Kumar, Raja, and Bhargavi, “A Comparative Study on Modern Smart Irrigation System and Monitoring the Field by Using IoT.”
[12] Gowri, “Greenhouse Monitoring and Scheming Based IoT Technology.”

devices that sense and evaluate data and communicate with one another through networks.

The client in the IoT ecosystem has smart devices such as tablets, smartphones, sensors, and other devices to communicate commands or requests for information to various devices through networks. After being evaluated, the system responds and executes the command to send information back to the user through networks.

The four main components of IoT are:

- *Low power embedded system:* Designing of IoT-based electronic system includes high performance and low consumption of battery.
- *Cloud computing* - In IoT embedded system, data generated from the devices are stored on reliable storage servers, that is cloud computing.
- *Availability of Big Data:* Since IoT Technique is heavily reliant on real-time sensors. As a result, the use of electronic devices has spread into every area, resulting in a huge data flow.
- *Network connection:* Internet networking is required for communication, and each physical entity is assigned an IP address. These addresses are used to create a network link between the devices.

The picture of a typical IoT ecosystem is depicted in Figure 2 given below, in which smart devices send and receive data from other smart devices in the surroundings through network and cloud computing.

The Internet of Things is a network of data transfer devices in and of itself. However, it also has a lot of links to Cloud Computing and Big Data.

- *Sensing, Embedded Processing, and Connectivity:* Any IoT ecosystem senses its environment, such as pressure, temperature, and gyroscope, and uses devices to perform embedded processing. These devices communicate over networks using any form of system, such as GPS, Wi-Fi, RFID, and so on.

- *Technology, Software, and Application:* To communicate and interact with smart devices and the world, this ecosystem uses a variety of software, technologies and applications.
- *Smart devices and environments, Cloud Computing, Big Data:* Data received or transferred from IoT embedded devices and environments is communicated via Cloud Computing or other Servers. This data is stored as Big Data.
- *Users or communities:* The IoT ecosystem's products and services are used up by users or populations to help them live smarter lives.

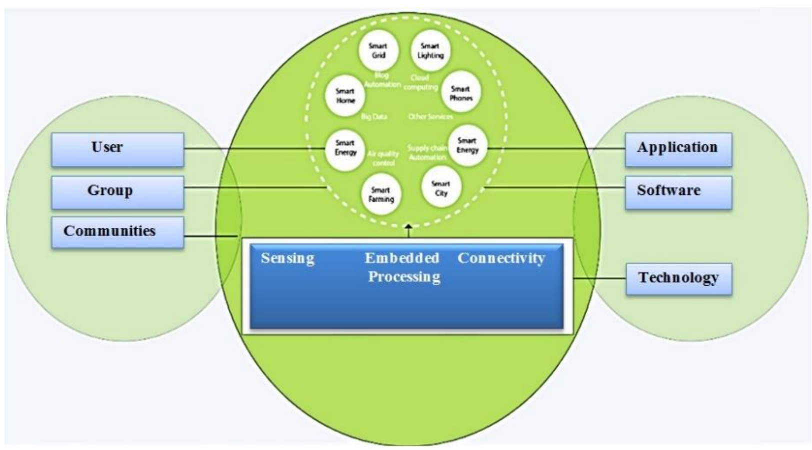

Figure 2. IoT Ecosystem.

3.1. Advantages of IoT

1. *Efficiently resource utilization:* If we comprehend the characteristics and how any system operates, we can enhance sustainable resource utilization and track natural resources.
2. *Minimalize human work:* IoT devices minimize our labor by connecting and communicating with one another and doing a range of functions for us.

3. *Save time:* It undoubtedly saves time by minimizing energy input. Time is the most essential thing that can be saved by utilizing an IoT platform.
4. *Enhance Data Collection:* As devices in IoT continuously communicate with each other so data is always shared by them which enhance the data collection.
5. *Improve security:* We can make our system secure if we have connections between everything in that system.

3.2. Disadvantages of IoT

1. *Security:* In IoT systems, all the devices are interlinked and connected to communicate with one another. Even with several safekeeping measures, the device provides control and can be used to launch different sorts of network attacks.
2. *Privacy:* Even though the users don't keenly play a part, the IoT structure offers widespread personal data in great detail.
3. *Complexity:* It is very tough of planning, building, managing, and enabling a broad technology in IoT systems[13].

4. IoT in Agriculture

The Internet of Things has the potential to change people's lives around the world dramatically. In just a few years, the world's population would have surpassed 3 billion. As a result, the agriculture industry must accept IoT to feed such a large population. Extreme weather conditions, weather change, and various environmental effects resulting from agricultural activities are all problems that must be addressed to come across the demand for more food.

[13] Haque et al., "A Comprehensive Study of Cyber Security Attacks, Classification, and Countermeasures in the Internet of Things."

The future of Indian agriculture must be shaped by a thorough understanding of and excessive reliance on technologies that can increase productivity while also regaining farmers' interest in the industry. As a result, these smart farming practices would support farmers to reduce scrap and increase capacity. It is a high-technology-based, capital-intensive method for mass-producing crops in a sustainable manner. Farmers may use this technology to track agricultural land situations from anywhere using sensors and irrigate fields using an automated device. It is the use of ICT (i.e., information and communication technology) in agriculture. Figure 3 shows the use of IoT in Smart Farming.

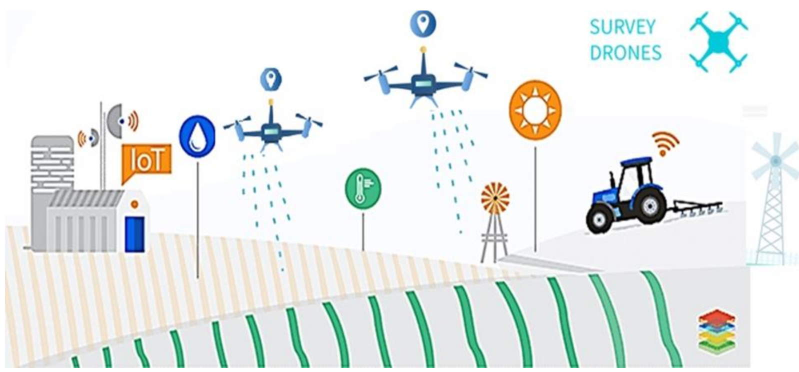

Figure 3. Smart Farming.

5. STRUCTURE OF IOT IN AGRICULTURE

The sensor layer, transport layer, and application layer are the three layers that make up this device structure, and the functions of these layers are mentioned below.

5.1. Sensor Layer

One of this layer's challenges is to obtain automated and real-time transformations of real-world agricultural processing figures into digital transformations or details that can be processed in the virtual world using various methods. The data that are collected are:

- Sensor information: Senses data about humidity, temperature, pressure etc.
- Products information: fetches data about name, model, price and features.
- Working condition: get data about operating parameters of different equipment, apparatus etc.
- Location information

The main goal of the Information Layer is to spot various types of information or data, collect the information and marking information in the real world using sensing techniques, and then remodel them for processing into digital data. RFID tags, sensors, two-dimensional code labels, and sensor networks are some of the techniques used in this sensor layer.

5.2. Transport Layer

The role of this layer is to gather and summarize agricultural data for processing from the previous layer (Sensor Layer). It is thought to be the IoT's nerve center. This layer contains a telecommunication operations center and an internet network, a data center, and smart processing centers.

5.3. Application Layer

This layer aims to examine and process the information collected for the cultivation of digital knowledge of the actual world. It's a hybrid of the Internet of Things and agricultural business intelligence.[14]

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[14] Parashar, *Candidate Declaration "Iot Based Smart Agriculture Monitoring System."*

6. How IoT Can Be Used for Smart Farming

Precision agriculture is another phrase for smart agriculture. Farmers can improve yields by employing minimal resources such as water, seeds, and fertilizer in this type of farming. By placing sensors and mapping their fields, farmers will be able to gain a micro-level understanding of their crops, save resources, and mitigate climate impacts.

The role of *Sensors* is very important in Smart Farming. IoT can be used for Smart Farming with the help of various Sensors and Controllers. Following are some sensors that can be used in Agriculture for Smart Farming:

- *Location Sensors* – These sensors measure latitude, longitude, and altitude to just a few feet using GPS satellite signals. To triangulate a location, at least three satellites are needed. Precision agriculture relies heavily on precise positioning.
- *Optical Sensors* – Light is used to test soil properties in these sensors. Varying wavelengths of light reflectance are scanned using sensors in the near-infrared, mid-infrared, and polarized light bands. Sensors can be used on vehicles, aerial platforms like drones, and even satellites. Just two examples of variables that can be aggregated and evaluated are optical sensor data on soil reflectance and plant color. Optical sensors may be used to measure clay, organic matter, and soil moisture content. As shown in Figure 4, Vishay has hundreds of photo-detectors and photodiodes, which are the fundamental components of optical sensors.
- *Electrochemical Sensors:* These sensors provide crucial data for precision agriculture, such as pH and soil nutrient levels. Unique ions in the soil are detected by sensor electrodes. Sensors mounted on specially built "sleds" are currently used to collect, process, and map soil chemical data.
- *Mechanical Sensors:* Soil compaction, or "mechanical resistance," is measured by these sensors. The sensors use a probe that

penetrates the soil and uses load cells or strain gauges to record resistive forces. A unique methodology is employed on big tractors to forecast the pulling requirement of ground-engaging apparatus. As shown in Figure 5, tensiometers, such as the Honeywell FSG15N1A, are extremely useful for irrigation since they monitor the forces exerted by the roots in water intake.

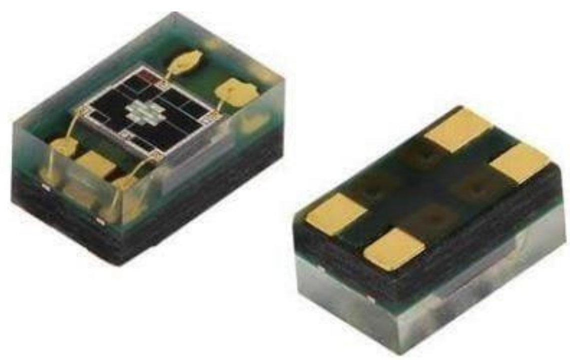

Figure 4. Vishay Photo IC Sensor.

- *Dielectric Soil Moisture Sensors:* By measuring the dielectric constant (an electrical property that varies reliant on the amount of moisture available), this sensor determines the quantity of moisture in the soil[15].
- *Airflow Sensors:* The air permeability of the soil is measured by this sensor. Measurements may be taken at specific locations or in real-time when moving. The pressure needed to force a predetermined amount of air into the ground at a specified depth is the desired performance. Unique identifying signatures are generated by a variety of soil properties and soil type, compaction, construction, and humidity level.
- *Agricultural Weather Stations:* Agricultural Weather Stations are self-contained units that are located in rising fields at different locations. These stations have a mix of sensors that are suitable for

[15] Giordano et al., "IoT Solutions for Crop Protection against Wild Animal Attacks."

the yields and weather in the region. Data related to air temperature, rainfall, soil temperature at various rock bottom, the wetness of leaf, wind speed, relative humidity, solar radiation, wind direction, and atmospheric pressure are collected at scheduled intervals. This data is collected and wirelessly transmitted to a central data logger at predetermined intervals. Because of their portability and low cost, weather stations are appealing to farms of all sizes[16].

Figure 5. Honeywell Force Sensor.

7. METHODOLOGY

This section will describe the proposed model along with its block diagram, flow chart, circuit connection diagram, and program coding for this model.

7.1. Proposed Model

One of the Use Cases of IoT in Smart farming can be when the soil moisture sensor reads the soil's moisture level and automatically switches

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[16] Journal and Engineering, "Smart Crop Protection System from Animals and Fire Using Arduino."

on the water motor. Whereas, temperature sensor reads the temperature near the crop field and sends this detail to the farmer's mobile. So that farmers can take necessary action if the temperature is adverse for a crop. The smoke sensor can also be used in the field so that if there is an accidental fire in the field, the message can be sent to the farmer on mobile and automatically water sprinkler can be switched on in the field to extinguish the fire[17]. Figure 6 is given below in section ‘a’ that describes the block diagram of the proposed model for this Use Case. In section ‘b’, the flow chart is given to describe the flow of logic in the system. In section ‘c’, the required Arduino coding is given for soil moisture sensing to upload on Arduino UNO Microcontroller.

a) Block Diagram of Proposed Model

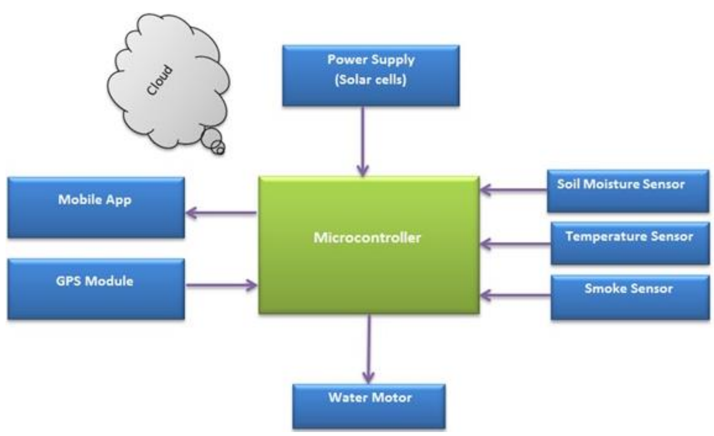

Figure 6. Block Diagram.

b) Flow Chart

The given flow chart shows the flow of logic for the given system, which describes how the data from various sensors is read by a microcontroller and how these data are processed and an output signal is sent to output devices attached.

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[17] Haque et al., “Security Enhancement for IoT Enabled Agriculture.”

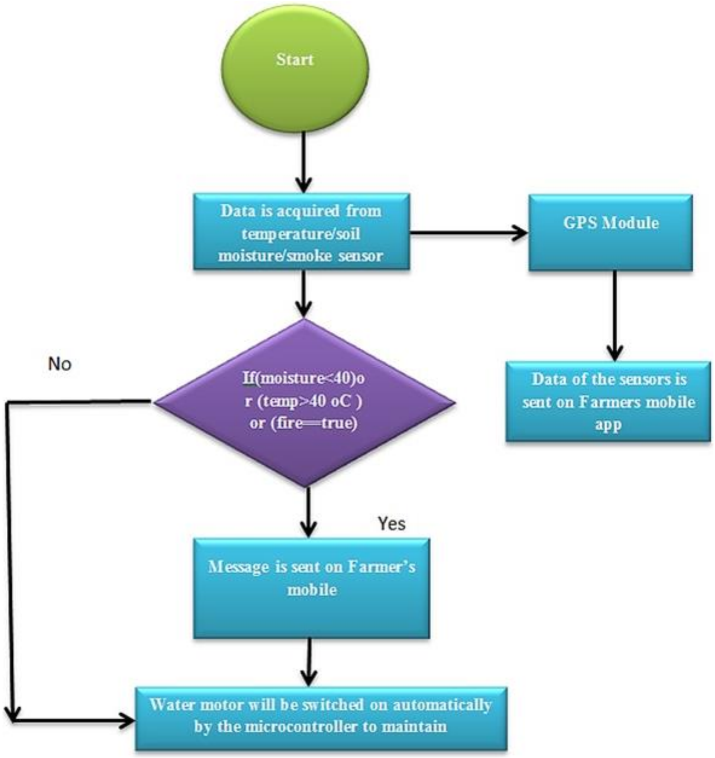

Figure 7. Flow Chart of Proposed Model.

c) Arduino Code for soil moisture sensing along with circuit diagram

i. Circuit connection for soil moisture sensor with Arduino UNO microcontroller and depicting Pin setup for Arduino and moisture sensor is given in Figure 8.

Figure 8. Circuit Connection between Arduino UNO and Soil moisture sensor and Pin Setup for Arduino.

ii. Coding for Working of Soil Moisture Sensor

Coding given in Figure 9 will sense and measure the moisture level in soil and will display the value on the Serial Monitor of Arduino. We can read the data value of the soil moisture sensor from the sensor analog pin and store the values in the “output_ value” variable in the loop function. Since moisture is calculated in percentages, we can map the OUTPUT values to 0-100. When we took readings from the dry soil, the sensor value was 550, and when we took readings from the wet soil, it was 10. So, to get the moisture, we mapped these values. These values were then printed on the serial display.

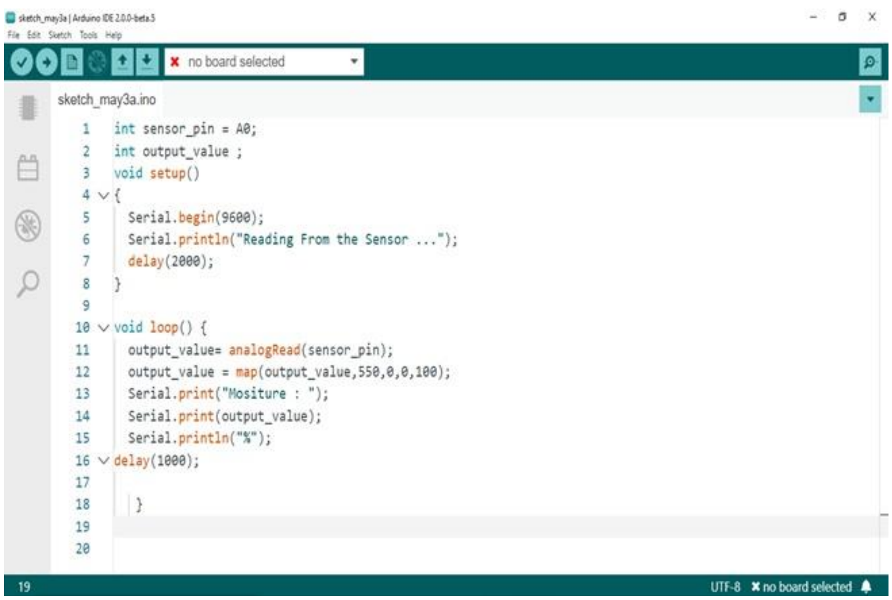

Figure 9. Coding for sensing Soil Moisture sing Sensor and Arduino UNO.

8. LIMITATIONS

As we know, everything in this world has some limitations, so this model too. Following are some of the limitations of this model:

- *Cost-effectiveness:* This model may cost high for the farmers. As in India, the economic condition of farmers is very bad so they might feel it costly to assemble in their fields.
- *Lack of Infrastructure:* For assembling this model, basic infrastructure is needed for an internet connection. In our country, many far areas of cropland don't have reach to these infrastructures required for this model.
- *Lack of security:* This IoT-based model has to communicate with older devices. So sometimes the connection issues may come and security-related issues arise.

9. FUTURE SCOPE

As we know, India is an agro-based country. A significant part of the population is working in this primary sector of agriculture. But the contribution of agriculture in National Income is lowest of all three sectors. So there is a tremendous future scope of IoT application in Smart farming so that the output from this sector can also be maximized and it gets added to the Gross National Income of the country. This proposed model can also be enhanced by applying a weather monitoring system to it to monitor the weather and alert farmer before any unwanted weather conditions.

CONCLUSION

Farmers face huge agricultural challenges, including irrigation, accurate knowledge of soils, proper time of use of pesticides, crop diseases forecasting, cost of machinery implementation of the new system, demand & supply of crops and, above all, professional experiences among farmers, advantages and adverse effects of crops, farmers' needs are highly sensitive to farming. Technology plays a vital role in combining farming infrastructure with modern technologies and strategies to solve these problems. Some papers in this chapter were analyzed and it was observed that IoT productivity in agriculture could be used. IoT-based smart farming is definitely a high-tech use of ICT which can be proved as a milestone in securing the crop and increasing the productivity from agriculture. Furthermore, the proposed IoT model will help the farmers to become financially strong and help them to monitor their land from remote areas also.

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