Smart Urban Farming System

Sangeeta Kurundkar
Electronics and Telecommunication Engineering
Vishwakarma Institute of Technology
Pune, India
sangeeta.kurundkar@vit.edu

Sayali Patukale
Electronics and Telecommunication Engineering
Vishwakarma Institute of Technology
Pune, India
sayali.patukale20@vit.edu

Rahul Ekambaram
Electronics and Telecommunication Engineering
Vishwakarma Institute of Technology
Pune, India
rahul.ekambaram20@vit.edu

Prathamesh Kachkure
Electronics and Telecommunication Engineering
Vishwakarma Institute of Technology
Pune, India
prathamesh.kachkure20@vit.edu

Ritika Sisodiya
Electronics and Telecommunication Engineering
Vishwakarma Institute of Technology
Pune, India
ritika.sisodiya20@vit.edu

Dhiraj Rathod
Electronics and Telecommunication Engineering
Vishwakarma Institute of Technology
Pune, India
dhiraj.rathod20@vit.edu

2022 IEEE 9th Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON) | 979-8-3503-3250-6/22/$31.00 ©2022 IEEE | DOI: 10.1109/UPCON56432.2022.9986403

***Abstract* — Smart agriculture or digital farming systems is a part of urban farming. It is known for their qualitative and quantitative cultivation of different varieties of crops to be grown in the farm or household gardens or kitchen gardens. Under the Internet of Things (IoT), other technologies are involved in the urban farming process include solar panels, soil moisture sensor technology, temperature sensing technology, automation, and irrigation systems. The application of smart agriculture using IoT tools can help us monitor and automate the process which requires regular monitoring. The smart urban farming process helped us to experiment with sensors like soil, temperature (at distinct temperatures), climate, and availability of moisture in the soil. After monitoring the parameters that affect the development of crops, we can provide crops the most suitable condition to grow in.**

Keywords — *Agriculture, Internet of Things (IoT), farming, resources, sensors, technologies, urban*

I. INTRODUCTION

Agriculture has been the backbone of the Indian economy for many ages to come. There are many components when we deal with the agro-sector, right from the soil type chosen to the production harvest, it is a very long and tedious process. Initially, the farmers right from the pre-independence era faced many difficulties to maintain their livelihood and sustain in the ever-growing taxes and with poor technology facilities. They thrived more on natural resources than on implementing sophisticated artificial methods to improve. Over time the population increased rapidly and so did the demand and per capita income which changed the outlook of modern agriculture and eventually led to a better lifestyle for the cultivators.

Adithya Vadapalli, Venkatarao Dadi, and Swapna Peravali [1] have mentioned the introduction of IoT and other technologies that have made comprehensive changes to yielding better results in their “proposed systems”. They included how “Smart Irrigation Systems” which are purely based on IoT services tend to automate major parts of the irrigation process and smartly detect the presence of moisture, adequate temperature and nutrients available in the soil with the help of WSN (wireless sensor nodes).

But despite many facilities that favor the agricultural sector, there still exist a few gray spots that aren't brought to the spotlight unless there is a natural disaster or calamity that causes a decline. As mentioned by Muhammad Ayaz and his co-authors in their paper on “Internet-of-Things (IoT)-Based Smart Agriculture”[2]. This is because of the constant variation in many geological factors such as the overall topology, rainfall patterns, and locality which have a big say in determining the area for agriculture

For agriculture to turn towards the smarter face - it could be better understood by breaking the necessary domains into parts and studying how and what the objective to be dealt with is necessary. To start with, soil sampling and mapping it includes the process of examining the features of soil such as nutrients, temperature, and further overview for long-term practices. The physical, chemical, and biological factors have to be studied for accurate decisions to be taken. Next, it is to check the irrigation facilities wherein, the quality of water, rainfall pattern, and air moisture levels have to be considered. This is followed by crop disease and pest management which is managed by fertilizers and pesticides for proper upbringing of the crops. The final step for checking is to keep a tab on the yield and monitor the harvest ratio. The culmination of all these steps is carefully studied and recorded for further analysis.

II. LITERATURE REVIEW

Kapil Muchandani, Shubham Bannore, Pranita Mor, and Akshay Aserkar in [3], have created a smart plant watering system using an ESP8266 Microcontroller and a Wi-Fi module. It is configured to detect the moisture level as well as the temperature of the plants and provide the necessary water. Along with that the Blynk application is used to indicate the soil moisture level and water level, to regulate the motor/pump performance. They've created a prototype that allows a plant to become more self-sufficient by watering itself from a tank.

The authors in [4] suggest a revolutionary approach for smart farming which involves using wireless communication technologies to link a smart sensing system with a smart irrigator system. Their system focuses on the measurement of physical parameters such as soil moisture content, nutrient content.

Smart techniques like precision farming, efficient water management, soil moisture, and humidity monitoring have been used in [5]. The authors have used the Wireless Sensor Network (WSN) in the process of development in smart and precision agriculture to monitor regularly the changes in environmental conditions such as climate, hydrology, plant physiology, humidity, temperature, and rains dampness of the soil.

Research done in [6] suggests the use of IoT from an agricultural point of view. In agriculture, irrigation plays a critical role in achieving a high yield. The traditional irrigation system is operated manually, resulting in water waste. The problem of attackers can be solved by keeping an eye on the field and threatening the invader. For They have used various sensors, GSM modems, and Wi-Fi with microcontrollers to achieve these goals.

Internet of Things (IoT) is widely used in connecting devices and collecting data information. Internet of Things is used with IoT frameworks to handle and interact with data and information. The combination of traditional methods with latest technologies as Internet of Things and Wireless Sensor Networks can lead to agricultural modernization. [7] The developed system [7] is more efficient and beneficial for farmers. It gives the information about the temperature, humidity of the air in agricultural field through MMS to the farmer, if it fallout from optimal range.

The smart agriculture revolution refers to the use, integration and deployment of the latest technologies such as Internet of Things (IoT) in agriculture, with the aim of improving and increasing the quantity and quality of crop harvest [8].

A Model for Smart Agriculture Using IoT [10]: In this research the integration of IOT technology with sensor technology and wireless network has been examined. In order to provide a real-time monitoring system for soil parameters including temperature, moisture, and pH, a proposed model for smart agriculture is presented in this work.

AgriSys [11]: A Smart and Ubiquitous Controlled-Environment Agriculture System: This study suggests a modern agriculture system that can monitor the environment and take appropriate action to keep it healthy. The major inputs that the system considers are pH, humidity, and temperature. The system also addresses desert-specific issues including dust, dry sandy soil, continuous wind, extremely low humidity.

Integrated multi-dimensional technology of data sensing method in smart agriculture [12]: This research introduces data sensing technology in agriculture sector. It also presents a machine learning-based method for accurately identifying incorrect data.

The authors of [13] presented a complex connected farm based IoT system that consisted of a software platform for smart phone application using Mobius for providing API`s and deploying it in &cube for M2M IOT gateway access. This was advantageous research because it provided dual benefits which included remote monitoring and control combined with providing a platform for knowledge sharing for new farming strategies.

III. METHODOLOGY

a) Flowchart

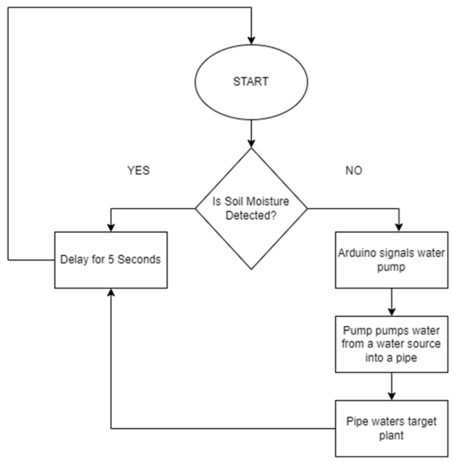

Fig 1. Flowchart of “Smart Urban Farming System”.

This flowchart explains the logic behind the system. The soil moisture sensor is continually detecting whether moisture is present in the soil. If moisture is not present, the water pump will be activated and water will be supplied to the soil till the soil sensor detects sufficient moisture.

b) Circuit Diagram

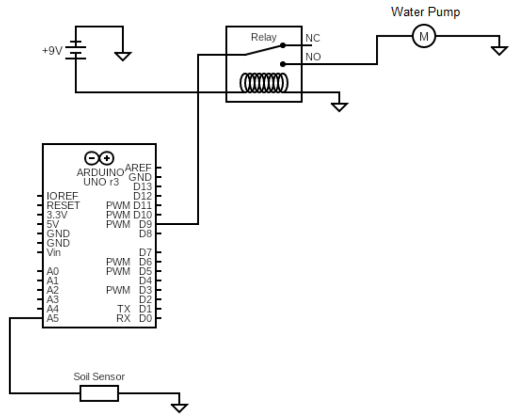

Fig 2. Circuit diagram of the system.

c) Components

1. SOIL SENSOR

The soil moisture sensor is used to measure the volumetric water content indirectly.
Principles used to measure soil moisture content include:

i. Dielectric constant
ii. Electrical resistance
iii. Interaction with neutrons

The prongs act as electrodes of the capacitor. The soil acts as the dielectric present in between the capacitor. Due to the voltage between these electrodes, we can detect how much moisture is present in the soil with the help of the dielectric constant. Due to the variance of moisture in the soil, the

dielectric constant varies. As a result, the value of the voltage changes.
Introducing a dielectric into a capacitor decreases the electric field, which decreases the voltage, which increases the capacitance.

$$C = \epsilon A/d$$

where, C = capacitance (in Farads)
ϵ = absolute permittivity of the dielectric (i.e., dielectric constant)
A = area of plates
d = distance between the plates (in meters)

2. ARDUINO UNO

The Arduino UNO is an open-source microcontroller board based on the microchip atmega328p. We have used Arduino UNO instead of a Node MCU as a Node MCU only has one analog pin while the Arduino has 6 analog pins. This enables 6 soil sensors to be able to be connected to the Arduino simultaneously as opposed to the Node MCU which can support only one.

3. SOLAR PANELS

A solar panel is actually a collection of solar (or photovoltaic) cells, which can be used to generate electricity through the photovoltaic effect. Solar panels are comprised of several individual solar cells which are themselves composed of layers of silicon, phosphorous (which provides the negative charge), and boron (which provides the positive charge). We are using a 6V polycrystalline mini solar panel.

4. WATER PUMP

The pump is built with engineered plastic material, it has a DC voltage range of 2.5 to 6V, a working current of 130 to 220 mA, & power consumption of 0.4 to 1.5. It is a submersible water pump with one end to be submerged in water and the other end can be connected to a pipe.

IV. WORKING

a) SOIL SENSOR AND WATER PUMP WORKING:

The soil moisture sensor is interfaced with the Arduino UNO. It checks the moisture content of the soil at frequent intervals of time (delay in milliseconds coded in the Arduino UNO). When moisture content is detected low it will switch on the pump so that we could water the plants and if the moisture content reaches value 50 or below (as per calculations carried out) then it will switch off the pump.

For the water system we used two water pumps to water the plants in different areas of the backyard. The water pumps are connected to a relay and a 9V battery source. The water pumps are directly integrated to the Arduino UNO. The water pumps will have a source of water supply at one end and an outlet at another end. The outlet is the plant. Water reaches the plant through a pipe which is connected to the water pump. Here we change the source of water, for example, we used rain water harvesting as our source of water in the backyard implementation.

b) RAINWATER HARVESTING:

While implementing our project in a backyard as a prototype, we decided to alter the source of water to help the specific backyard utilise its water resources effectively for the plants which in turn would eliminate water wastage.

There is a pipe outlet for disposing excess water that overflows from the water tanks of the house. Excess rainwater that is collected in the terrace is also eliminated through this pipe. This water is collected in a container (bucket) by means of a substitute pipe. The submersible water pump is then immersed in the container. It provides a sustainable source of water for the plants in the garden. In case there was no water available from rainwater harvesting, the bucket could be filled with a pipe connected to the water tanks by the user.

c) MAKING OUR OWN SOIL SENSOR:

The reason we did this was that soil moisture sensors which were available in the market had an issue, the corrosive nature of the prongs which were in contact with the soil. Due to this corrosion over a period of time, the soil sensor readings became inaccurate. To solve this problem, we made our own soil moisture sensor. This sensor is not connected to the Arduino. It works independently and can be powered with a 3.3 V lithium battery or a solar panel of the same voltage. The red LED stops glowing when moisture content in the soil is detected and the LED starts glowing to indicate that the plant needs more moisture.

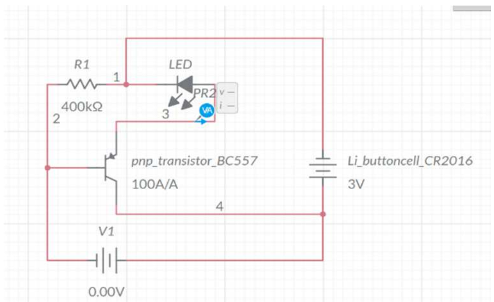

Fig 3. Circuit diagram of soil sensor.

Copper and Nickel are the most conductive metals. However, they corrode easily and hence aren't very durable. Therefore, we chose stainless steel for making the prongs of our sensor. The prongs act as electrodes. Due to the voltage between these electrodes, we can detect how much moisture is present in the soil with the help of the di electric constant. For accuracy of moisture detection, the prongs have to be surrounded completely by the soil. There should not be any space between the soil and the prongs. Dimensions: The prongs are 6cm long and 1cm apart from each other.

d) SOLAR PANELS

We used solar panels as a substitute for energy required. They can be used to power the Arduino UNO, the soil moisture sensors and in turn, the water pumps.

e) SCARECROW / PEST CONTROL:

We connected a DC motor to a toy fan as a separate component. This motor could also be interfaced with the Arduino UNO with the help of a driver. When the motor is switched on, the fan would rotate. This would keep birds and slightly bigger pests away due to the vibrations of the fan without harming the wildlife or the plants. The exhaust fan can be used as a scarecrow for birds and insects and can be used to cool temperature for sensitive plants in a greenhouse environment if needed.

V. RESULTS

a) TESTING THE SOIL SENSOR:

The soil sensor was placed in a number of test cases to find out for which range of values of the sensor in the Arduino IDE was the moisture of the soil appropriate for the plant in concern. The analog values from the soil sensor are divided by 10 before showcasing the output to make it more feasible to understand.

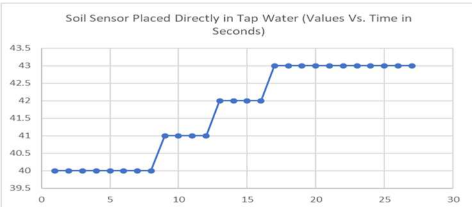

Fig 4. Case 1: Testing a soil sensor placed directly in tap water.

We observed that the values fluctuated between the range of 40 - 43 analog values depending on how the soil sensor was dipped. We found most accurate values when both the prongs of the sensor were completely submerged in the water. We found that the value of the sensor when completely dry was 102.

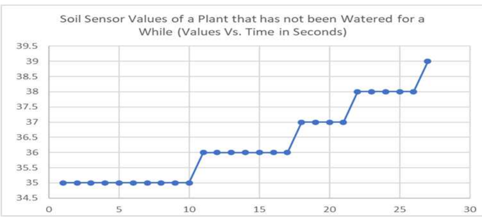

Fig 5. Case 2: Soil sensor values of a plant that has not been watered for a while.

These values showcase the condition of the soil after it has been watered. The soil is still moist; however, it starts losing its moisture rapidly. The speed depends on factors such as the amount of water supplied, size of the pot, absorption power of the plant and moisture retaining ability of the soil.

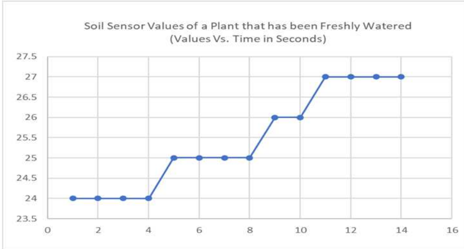

Fig 6. Soil sensor values of a plant when freshly watered.

When the plant is freshly watered, values range from 24-27. The lower the values, the more the soil is moist.

Tap water has a higher value (40-43) as seen in Fig 4. The reason for this is that the soil moisture sensor measures the dielectric constant of the dielectric (in our case, soil) between its prongs. Since water has a lower dielectric than soil (due to mineral content), it leads to such a result. We understood that the ideal moist range of values that the soil of the plant should be in was from 0-50. All values above 50 indicated that the soil required more water (moisture). The Arduino was coded keeping these values in mind.

b) TESTING THE SOIL SENSOR WITH WATER PUMP:

We initially tested the soil sensor interfaced with the Arduino and a water pump in a controlled environment, in a room.

Fig 7. Testing the soil sensor and water pump in a room.

A pot full of black soil was used to conduct the tests. The water pump was able to pump water to the pot through a transparent pipe when the soil was dry.

c) SOIL SENSOR SETUP IN BACKYARD (PROTOTYPE):

Fig 8. Backyard where prototype was set up

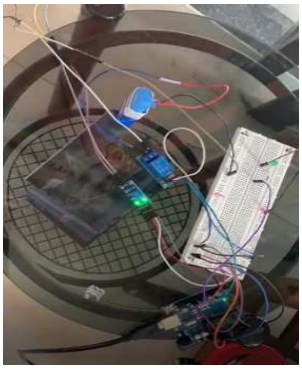

Fig 9. Connections for the backyard prototype.

The project was implemented in the backyard shown in the Fig 8 and Fig 9 above. The implementation consisted of using multiple Arduinos, soil sensors and water pumps to cover the entire area of the plants. The values of the soil moisture sensors were adjusted in accordance with the type of plant we were dealing with.

d) RAINWATER HARVESTING:

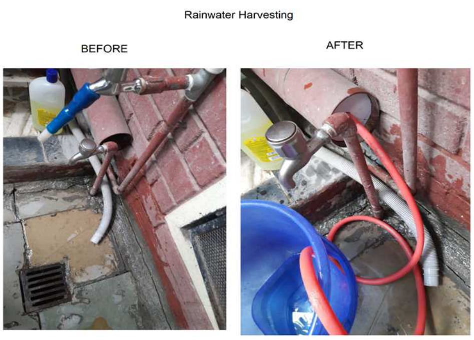

Fig 10. Rainwater harvesting implementation.

In the backyard implementation, this particular pipe carried overflowing water from water tanks and excess water from the terrace. We made a makeshift pipe for the water to collect in a bucket. The submersible water pumps were then placed in the bucket and used as a water source.

e) SOIL SENSOR:

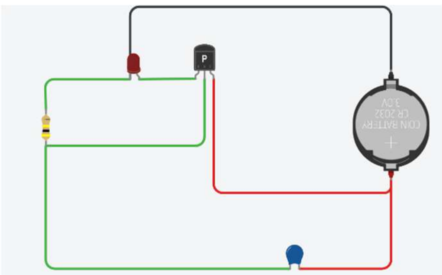

Fig 11. Testing the connections of our own soil sensor on a simulator. (Software used: TinkerCAD)

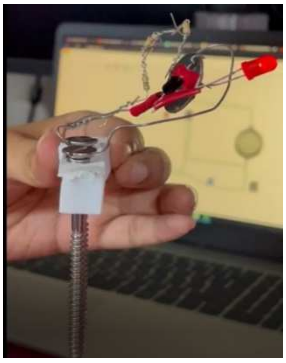

Fig 12. Soil sensor when soil is dry.

In Fig 12, we can clearly see that there is no moisture between the prongs of the soil sensor. Hence, the red LED is glowing. This indicates the user that the plant needs to be watered.

Fig 13. Soil sensor when moisture is detected.

In Fig 13, we can see that the sensor is in water (moisture) hence the LED stops glowing. This helps the user understand that the moisture content is enough for the soil.

The benefit of this soil sensor is that it does not need to be connected to an Arduino and it can be placed in the soil independently. It has a replaceable lithium battery of 3.3 V. The user can also use it with a solar panel of the same voltage to make the product completely renewable.

f) SOLAR PANELS AND FAN:

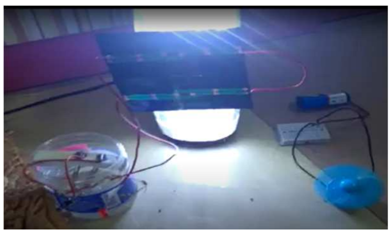

Fig 14. Implementation of solar panels with a self-made soil moisture sensor. A fan powered by an external source of power.

In Fig 14, we have demonstrated the use of solar panels to power the self-made soil sensor with the help of an artificial light source. The solar panels are powered by the artificial light source and the soil moisture sensor is in turn powered by the solar panels. The fan connected to the DC motor can also be powered by the solar panels. However, in this demonstration, it is powered by an external battery.

VI. CONCLUSIONS

This research project aims to explain a prototype of a smart urban farming system. The system implemented in a private backyard works with the help of soil-friendly sensors and an automated irrigation process. With the help of mechanical motors and relay modules the flow of water (from a rainwater harvested source) is controlled. Data via the sensors is received and necessary action is taken for irrigating the soil while deriving power from solar panel sources. It aims to achieve the best possible results for irrigational supervision.

VII. FUTURE SCOPE

The project primarily revolves around the hardware implementation and basic Arduino programming for its working. This could be further extended on the Blynk software where the stats of all the sensors could be recorded and carefully monitored allowing the efficient use of technology being accessed from remote locations. This would allow the user to manually control the gardening system via an app on their phone from anywhere in the world. Humidity, temperature, and soil nutrient composition sensors can be used for checking the overall health of the plant. Extra insulation can be provided to ensure that all electronic devices would work smoothly in times of weather changes (like rainstorms and lightning).

REFERENCES

[1] Vadapalli, Adithya & Peravali, Swapna & Dadi, Venkatarao. "Smart Agriculture System using IoT Technology" Publisher: International Journal of Advance Research in Science and Engineering (2319-8354), 09. 58-65, 2020.

[2] Ayaz, Muhammad & Uddin, Ammad & Sharif, Zubair & Mansour, Ali & Aggoune, el-Hadi. “Internet-of-Things (IoT)-Based Smart Agriculture: Toward Making the Fields Talk”, IEEE Access, 2019.

[3] Sangeeta Kurundkar, Kapil Muchandani, Shubham Bannore, Pranita Mor and Akshay Aserkar,” PLAWATOS-An Automatic Plant Watering IOT Based System Using ESP8266”, IJSART, Vol. 3, July 2017.

[4] Chetan Dwarkani M, Ganesh Ram R, Jagannathan S and R. Priyatharshini, "Smart farming system using sensors for agricultural task automation", IEEE Xplore, December 2015.

[5] Adithya Vadapalli, Swapna Peravali, and Venkatarao Dadi, "Smart Agriculture System using IoT Technology", International Journal of Advanced Research in Science and Engineering (IJARSE), Vol. No. 9, September 2020.

[6] Ranjan Venugopal, Anusha Mannajji, Akshatha H, Megha S and Pratiksha P, "International Journal for Scientific Research & Development (IJSRD), Vol. 7, January 2019.

[7] S. R. Prathibha, A. Hongal and M. P. Jyothi, "IOT Based Monitoring System in Smart Agriculture," 2017 International Conference on Recent Advances in Electronics and Communication Technology (ICRAECT), pp. 81-84, 2017.

[8] M. R. M. Kassim, "IoT Applications in Smart Agriculture: Issues and Challenges," 2020 IEEE Conference on Open Systems (ICOS), pp. 19-24, 2020.

[9] M. Pyingkodi et al., "Sensor Based Smart Agriculture with IoT Technologies: A Review," 2022 International Conference on Computer Communication and Informatics (ICCCI), 2022, pp. 1-7, 2022.

[10] K. A. Patil and N. R. Kale, "A model for smart agriculture using IoT," 2016 International Conference on Global Trends in Signal Processing, Information Computing and Communication (ICGTSPICC), pp. 543-545, 2016.

[11] A. Abdullah, S. Al Enazi and I. Damaj, "AgriSys: A smart and ubiquitous controlled-environment agriculture system," 2016 3rd MEC International Conference on Big Data and Smart City (ICBDSC), pp. 1-6, 2016.

[12] X. Li and R. Zhang, "Integrated multi-dimensional technology of data sensing method in smart agriculture," 2020 IEEE 9th Joint International Information Technology and Artificial Intelligence Conference (ITAIC), pp. 2146-2149, 2020.

[13] M. Ryu, J. Yun, T. Miao, I. -Y. Ahn, S. -C. Choi and J. Kim, "Design and implementation of a connected farm for smart farming system," 2015 IEEE SENSORS, pp. 1-4, 2015.

[14] Rezk, N.G., Hemdan, E.ED., Attia, AF. et al. An efficient IoT based smart farming system using machine learning algorithms. Multimed Tools Appl 80, 773–797, 2021.

[15] M. Liu, "On the Application of Internet of Things in Smart Agriculture," 2020 2nd International Conference on Artificial Intelligence and Advanced Manufacture (AIAM), pp. 113-116, 2020.

[16] R. Dagar, S. Som and S. K. Khatri, "Smart Farming – IoT in Agriculture," 2018 International Conference on Inventive Research in Computing Applications (ICIRCA), pp. 1052-1056, 2018.

[17] G. Sushanth and S. Sujatha, "IOT Based Smart Agriculture System," 2018 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET), pp. 1-4, 2018.

[18] K. L. Krishna, O. Silver, W. F. Malende and K. Anuradha, "Internet of Things application for implementation of smart agriculture system," 2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), pp. 54-59, 2017.

[19] A. Dahane, R. Benameur, B. Kechar and A. Benyamina, "An IoT Based Smart Farming System Using Machine Learning," 2020 International Symposium on Networks, Computers and Communications (ISNCC), pp. 1-6, 2020.

[20] M. S. D. Abhiram, J. Kuppili and N. A. Manga, "Smart Farming System using IoT for Efficient Crop Growth," 2020 IEEE International Students' Conference on Electrical,Electronics and Computer Science (SCEECS), pp. 1-4, 2020.

[21] Gondchawar, N. and Kawitkar, R.S., IoT based smart agriculture. International Journal of advanced research in Computer and Communication Engineering, 5(6), pp.838-842, 2016.