2020 20th International Conference on Sciences and Techniques of Automatic Control and Computer Engineering (STA) | 978-1-7281-8815-7/20/$31.00 ©2020 IEEE | DOI: 10.1109/STA50679.2020.9329292

IoT Based Low-cost Weather Station and Monitoring System for Smart Agriculture

Chandoul Marwa[1,*], Soufiene Ben Othman[2], Hedi Sakli[1,3]
[1]MACS Research Laboratory, National Engineering School of Gabes, Gabes University, Gabes, 6029, Tunisia
[2]PRINCE Laboratory Research, ISITcom, Hammam Sousse, University of Sousse, Tunisia
[3]EITA Consulting 5 Rue du Chant des oiseaux, 78360 Montesson, France
[*]Corresponding author: Chandoulmarou@gmail.com

***Abstract*—**

It is estimated that the world's population will be about 9.1 billion by 2050. The UN FAO has reported that food production would need to be increased by approximately 70 percent to feed this increased population. Therefore, to ensure high yields and farm profitability, it is very important to improve agricultural productivity. In this sense, the technology of the Internet of Things (IoT) has become the key road towards novel practice in agriculture. In the agriculture sector, climate change is also a major concern. A solution to completely satisfy the requirements of automated and real-time monitoring of environmental parameters such as humidity, temperature and rain is proposed in this paper. The proposed platform, which collects environmental data (temperature, humidity and rain) over a period of one year was tested on a real farm in Tunisia. The results show that the proposed solution can be used as a reference model to meet the requirements for large-scale agricultural farm calculation, transmission and storage.

***Keywords*—IoT, Smart Agriculture, Environmental monitoring, Weather Station.**

I. Introduction

The Internet of Things is a network of connected devices and machines that communicate with each other. The Internet of Things is one of the most important modern technological industries that have gained fame in this field [1]. The uses of the Internet of Things are varied and have evolved greatly in recent years, as they have been integrated into most areas of life. Because of it the emergence of what was called Smart Homes, Smart Cars, Smart Cities, Smart Agriculture, Healthcare, Power Engagement [2]. etc.

The application of information technology in the agricultural field can play a major role in the development of the rural economy, which has been widely used in industry, environmental monitoring and other aspects of life. [3]. Most farmers do not have information on how much water is required for the plants, they use unnecessary amounts of water that affect soil fertility [4].

The use of new technology in agriculture contributes to giving them all the modern and reliable information needed to increase the yield of their crops, which is called precision farming, where climatic factors are monitored so the crop grows in high quality [5].

Smart agriculture plays a vital role in growing crops, increasing agricultural productivity and helping farmers to be more efficient as it contributes to achieving accurate irrigation to avoid water waste, reduce soil fertility, fertilizer misuse and diseases [6]. Wireless farming sensors are deployed in farmland to extract various information related to soil composition, such as humidity, temperature, humidity levels, and water level detectors and collect data from the environment and securely transmit data to the base station to make effective decisions [7]. This will have a beneficial effect on the farmer's budget, but also on the quality of his land [8].

In this paper, a system for monitoring environmental parameters using Internet of Things has been introduced. The system will monitor changes in climate parameters in the Medenine region (Tunisia). Our system mainly consists of central node (gateway), nodes (field-installed) and cloud storage. The sensor attached to the sensing node measures field data and is sent in single or multiple hops to the gateway using the ZigBee communication module. The central node receives field data from the sensor nodes, fetches weather data, and sends miniature records to the cloud using the 4G / LTE module, Figure 1 shows a comprehensive picture of this system.

The rest of this paper is divided into five sections further. The second section exhibits the proposed work. The third section is to analyze all the implemented data and results. The fourth section is comparison of related and proposed work and finally, concluding the proposed work with outcomes and perspectives.

Figure 1. Smart Agricultural environment based on IoT.

II. PROPOSED WORK

The proposed system is a station to monitor environmental parameters such as humidity, temperature and rain amount. Figure 2 shows the architecture of this system and describes the hardware for the component parts in general. The system is mainly composed of nodes (field-installed), central node (gateway), and cloud storage. The sensor attached to the sensor node measures field data and is sent in single or multiple hops to the gateway using the ZigBee communication module. The central node receives field data from the sensor nodes, fetches weather data, and sends miniature records to the cloud using the 4G / LTE module.

The architecture consists of a sensor layer that contains the various nodes spread out, a gateway layer that transmits the data collected from the network over the internet, and a cloud-based layer. The system is designed with the aim of ensuring high coverage distance at the lowest deployment cost.

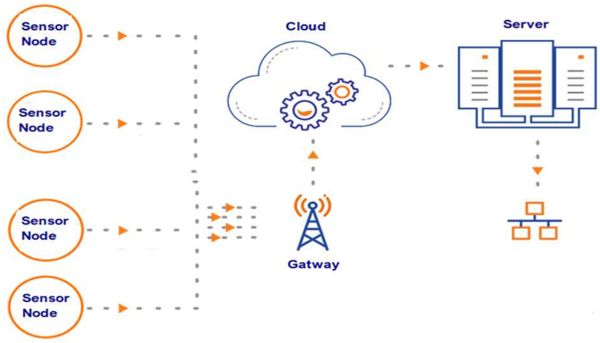

Fig.2: System IoT architecture

A. *Layer of sensor Networks*

The types of sensors that can be used to measure agricultural field parameters differ. In the following paragraph, the sensors used in the system and related specifications are explained briefly below.

- **S-THB-M008 air temperature/humidity sensor**

A HOBO RX-3000 data logger with S-THB-M008 temperature and humidity sensors by see Figure 3 consists of a monitoring system for recording environmental parameters. The temperature range of the S-THB-M008 sensors is between -40 to 75 ° C, the humidity range is between 0-100 percent, the temperature is 0.02 ° C, and the precision of humidity is 0.1 percent. The stainless-steel sensor tip and durable cable, rated for submersion in water at 50 C for up to one year, ensure reliable operation. The length of this model is 2 meters.

Fig.3: Air temperature/humidity sensor

- **S-RGA-M002 and S-RGB-M002 rain gauge.**

Figure 4 displays the Smart Rainfall sensors used with compatible weather stations and recorders. S-RGA-M002 (English System) measures up to 5 inches of rain per hour with an accuracy of 0.01 inches and a maximum interval of 4000 tips, while S-RGB-M002 measures 0.2 mm and a maximum interval of 4000 tips with an accuracy of up to 10 cm of rain per hour. All of the sensors contain two-meter cables. The smart sensor transfers all stored information automatically to the recorder without the need for any programming or comprehensive user configuration.

Fig.4: Rain gauge

With a time, recurrence of 1 h, the environmental parameters have been reported. The acquisition of complex and environmental monitoring began on 1 May 2019 and is active at the present time. In this work reported data will be provided between 01 May 2019 and 01 May 2020, which means the report of 9691 documenting events.

B. *Layer of Gateway*

The gateway is dedicated to all sensor nodes that collect field data and submit micro data records to cloud storage. A computer with two network interfaces is a gateway. Connects the layer of sensors to the cloud.

We used a gateway called Meshlium in this app, the latter being a multi-protocol router since it has five interfaces used to gather all the data from the sensor nodes and store it (2.4GHz Wifi, 5GHz WiFi, Blutooth, ZigBee, and 3G / 4G). Inside the clouds. For storage and processing, real-time stored data arrives in the cloud.

C. *Layer of Cloud*

The Cloud layer is responsible for the management of confidential data and the introduction of digital user assistance. It is divided into two sections, i.e., cloud and user applications. Once it takes the data from the Gateway computer, it stores the data in the Cloud layer database and provides data visualization in several ways.

For the online visualization of environmental data obtained in real time, a web portal was launched. Firstly, the Bitvise Client program sends the data stored in the cloud to the web server in real time via a secure SSH connection. The data is then stored in a SQL database operated by MySQL (Oracle Corporation, California, USA) and managed by Amazon Web Server (Amazon, Washington, USA) services. Finally, the data is graphed using HTML, CSS and JavaScript on the web page.

III. ANALYSIS & IMPLEMENTATION

The environmental equipment was installed at the pilot field on May 1, 2019. Relevant parameters have been continuously sensed, transferred, and processed to the cloud-based data repository since the day of installation. 9691 reports of hourly reported environmental parameters of the following types were obtained from 1 May 2019 to 1 May 2020: date, air temperature, relative humidity and rain.

A. *Temperature*

A primary factor influencing the rate of growth of plants is temperature. Plant production would be impacted by higher temperatures predicted by climate change and the potential for more extreme temperature events.

The temperature difference gathered from the temperature sensor is shown in figure 5. In the summer months of July, August and September, the temperature rose markedly, reaching 42,863 ° C. However, during the winter months of January, February and March, the temperature decreases so that it reaches 2.69°C.

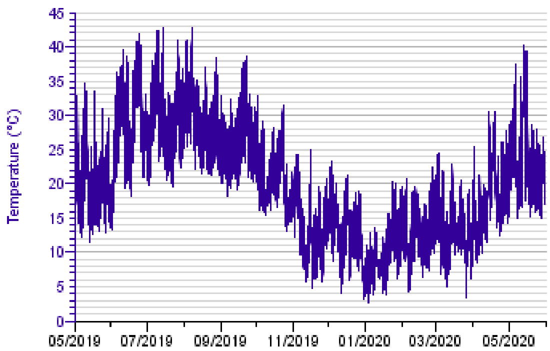

Fig.5: Temperature

Figure 6 indicates that the temperature in the summer varies from 18 °C to 42,863 °C. In summer, crops typically develop at 23.8 ° C to 29.5 ° C with the presence of daylight and 15.5 ° C to 23.8 ° C at night with the highest performance. For example, summer crops such as squash and tomato require a minimum of 12.7 ° C at night to grow and 18.3 ° C during daytime on the other hand. The area is characterized by high summer temperatures, so in order to minimize its impact on the plant on hot days, the grower should pay attention to watering [18].

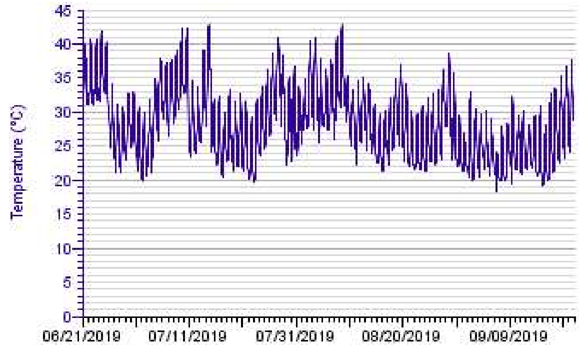

Fig.6: Summer temperatures

Figure 7 shows the day the temperature was at its maximum, referring to 08/08/2019. For a temperature of 40 degrees, we can add an alarm we have picked. As the temperature increases, the grower must consider the days, as this will cause the plant to die. However, with temperatures above 40°C, there are plants that grow more.

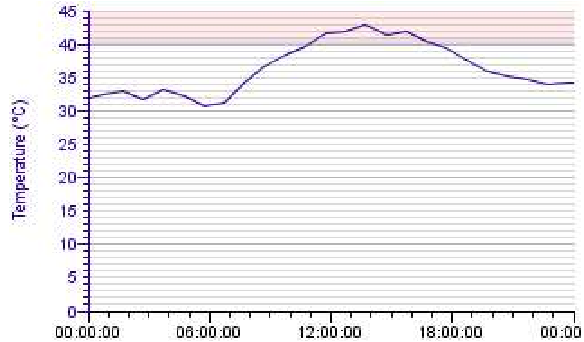

Fig.7: Maximum temperature

The winter temperature is between 2.69 °C and 24.5 °C, as shown in Figure 8. In winter, during the day the temperature does not reach 21 °C for crops to grow normally.

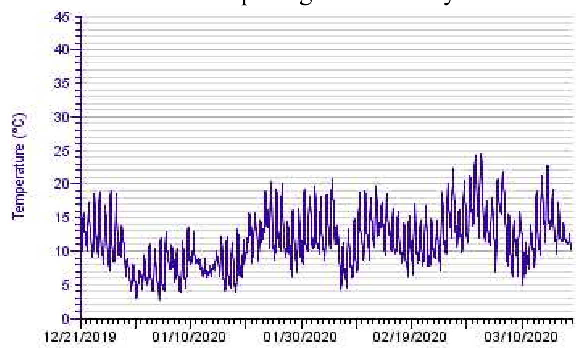

Fig.8: Winter temperatures

The day when the temperature was at its lowest, which corresponds to 01/01/2020, is shown in figure 9. It is better for most cold weather crops like lettuce and broccoli to grow best at 10 ° C during the night and 15.5 ° C during the day, so we have added a warning when the temperature drops below 10 ° C.

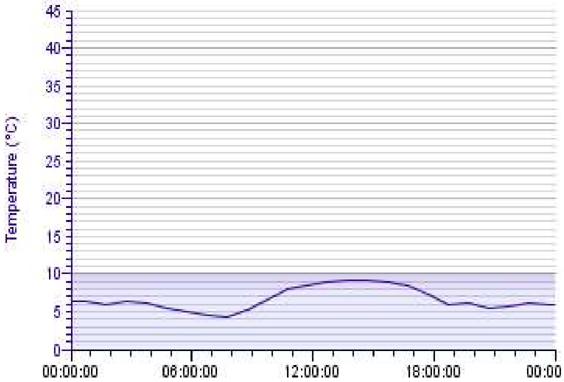

Fig.9: Minimum temperature

During a moderate day which corresponds to 27/06/2019, the temperature measurements in the spring month are shown in Figure 10 as they rise from morning to afternoon and gradually decrease in the evening. It allows the farmer to understand the correct time for irrigation.

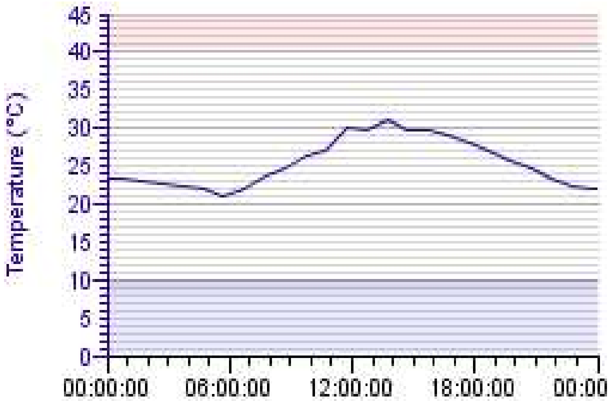

Fig.10: Temperature for a moderate day

B. *Humidity*

To obtain excellent yield, the moisture content necessary for cultivation must be examined. The humidity around it saturates leaves with water vapor as plants transpire. A plant cannot make water evaporate (part of the transpiration process) or draw nutrients from the soil if the relative humidity levels are too high or there is a lack of air circulation. A plant inevitably rots when this happens for a prolonged time. A plant inevitably rots when this happens for a prolonged time. Transpiration rates in a plant increase when surrounded by warm temperatures at low relative humidity levels, reducing the need for a producer to fertilize it.

For example, with additional light in relative humidity, ornamental crops grow healthier and attractive in the range of 21.1 °C to 29.5 °C during high growth periods. The humidity is between 8.1 % and 99.9%, as shown in Figure 11.

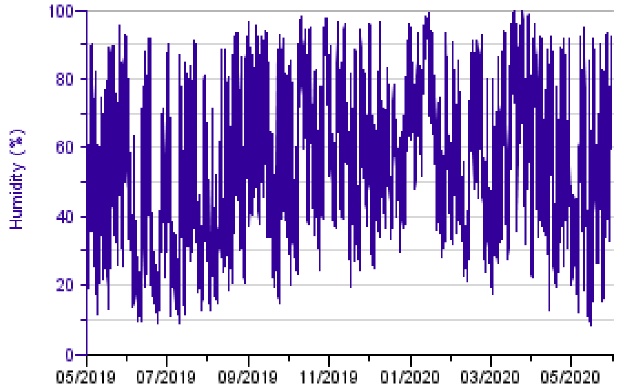

Fig.11: Humidity

Figure 12 shows the maximum humidity that corresponds to 12 °C temperatures on 3/19/2020 and Figure 13 shows that temperature is relatively the reverse of humidity.

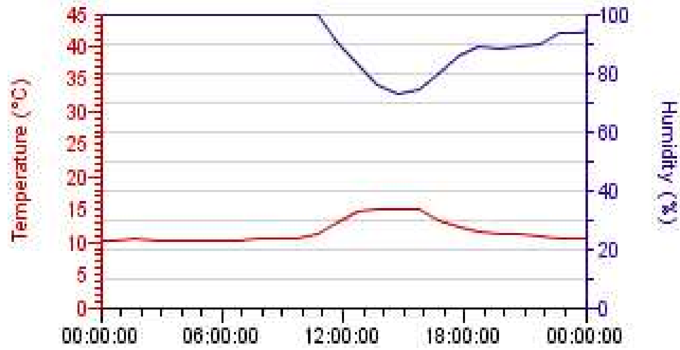

Fig.12: Temperature with maximum humidity

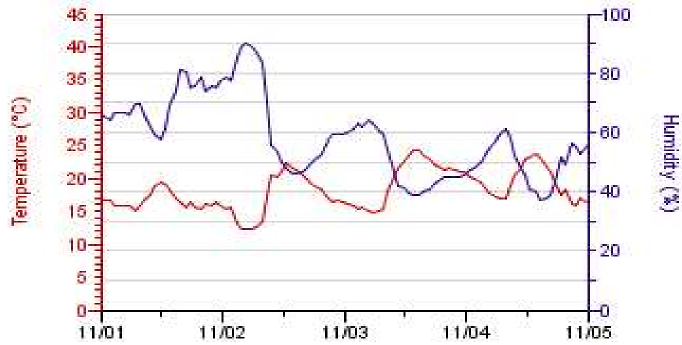

Fig.13: Influence between Temperature and Humidity

C. *Rain*

The difference in the amount of rain in mm is shown in Figure 14, with 20.7 mm being the maximum value. The effect of rainfall on the development of crops can be connected to their total seasonal or intra-seasonal distribution. In the worst case of droughts, crop production suffers the most with very low total seasonal numbers. But more subtle intra-seasonal changes in the distribution of rainfall during crop growing periods, without a change in the overall seasonal quantity, can also lead to major yield reductions. This means that during the rising cycle, the number of rainy days is as significant, if not more, as that of the seasonal total.

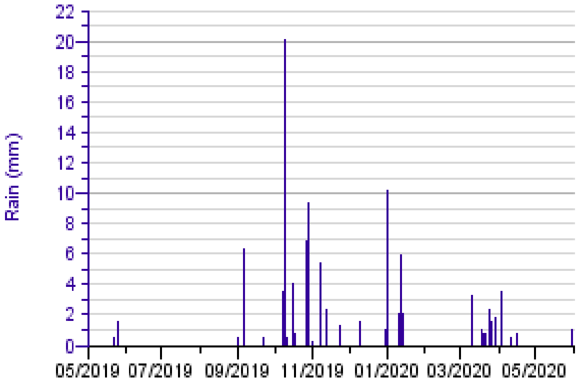

Fig.14: Rain

Figure 14 shows the most rain period, which is October of 2019, when the highest amount of rain was recorded.

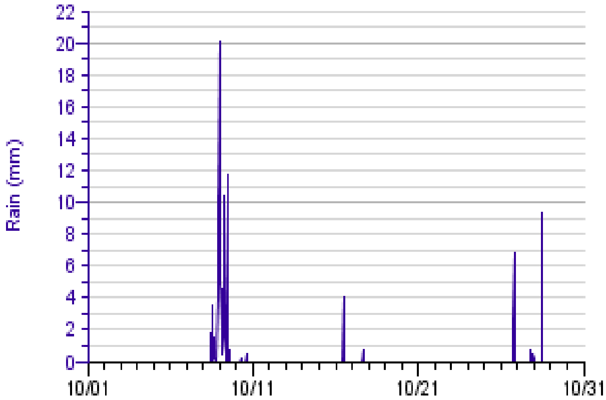

Fig.15: Maximum month for rain

The figure 16 shows that when it rains, the temperature remains low, while the level of humidity rises, which corresponds to 10/08/2019 to 10/10/2019.

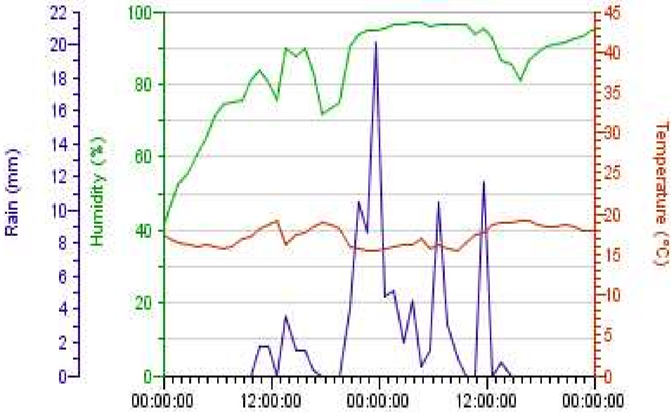

Fig.16: The effect of rain on temperature and humidity

IV. COMPARISON

The surveillance systems mentioned in the previous section differ from the systems presented in the literature depending on the technology and processors used. But they have common advantages of saving energy, low cost and ease of use. The table 1 shows the techniques used in each system and the differences between them as needed.

Ref.	Processing	Parameters	Tech.	Monitoring station
[9]	Node MCU	Temperature Relative humidity Soil moisture Light intensity	WiFi	Mobile Thingspeak
[10]	Raspberry Pi 3 Arduino Uno	Humidity Temperature Soil moisture	MQTT	Thingspeak Firebase
[11]	Libelium	Temperature Relative humidity Relative of soil Solar radiation Leaf wetness	WiFi 3G/ GPRS	Meshlium Xterm gatway
[12]	Microcontroller	Temperature Humidity PH Rainfall detection Air quality Motion detection	GSM WiFi	PC Mobile
[13]	ATmega 328 microcontroller	Temperature Turbidity PH DO	LoRa WiFi	Thingspeak
[14]	Raspberry Pi 2	Temperature Humidity Soil moisture CO2 PH PIR	Zigbee WiFi	PC
Prop. Syst.	Monitoring station	Temperature Humidity Rain	Zigbee 4G	Cloud Web Platform

Table 1: Previous Work done with Weather stations

V. CONCLUSION AND PERSPECTIVES

In this article, we have proposed an ongoing research and implementation work on a climatic monitoring system primarily aimed at agriculture called monitoring station based IoT. The system monitors temperature, humidity and quantity of rain. This system contributes to conserving natural resources, saving energy in addition to being low cost and easy to use.

As a future scope the system can be extended by integration of other nodes environment sensors in order to enlarge the spatial network coverage and more agricultural parameters observations. We can also integrate artificial intelligence, as Machine learning and its applications especially data collection, provide real complementarity at the decision-making level.

REFERENCES

[1] Alem Colakovic and Mesud Hadziali, “Internet of Things (IoT): A review of enabling technologies, challenges, and open research issues”, Computer Networks, Volume 144, October 2018.

[2] Bassirou Diène, Joel J.P.C.Rodrigues, Ousmane Diallo, “Data management techniques for Internet of Things, Mechanical Systems and Signal Processing”, Volume 138, April 2020.

[3] N. Ahmed, D. De, and I. Hussain, “Internet of Things (IoT) for smart precision agriculture and farming in rural areas”, IEEE Internet Things J., vol. 5, no. 6, pp. 4890-4899, Dec. 2018.

[4] Mohammad Salah and al,” IoT Based Real-time River Water Quality Monitoring System”, The 16th International Conference on Mobile Systems and Pervasive Computing, August 19-21, 2019, Canada.

[5] Fabrizio Balducci, Davide Fornarelli, “Smart Farms for a Sustainable and Optimized Model of Agriculture”, Applied Engineering And Information Technology, Bari, Italy, pp. 497-502, October 3-5, 2018.

[6] Khalid Haseeb , Ikram Ud Din , Ahmad Almogren, and Naveed Islam, “An Energy Efficient and Secure IoT-Based WSN Framework: An Application to Smart Agriculture”, Sensors 2020, 20, 208.

[7] Simitha K M and al,” IoT and WSN Based Water Quality Monitoring System”, 3rd International Conference on Electronics Communication and Aerospace Technology, 12-14, June 2019, Coimbatore, Tamil Nadu, India.

[8] Yanjiao Zheng and al, “The Interactive Effects of Daytime High Temperature and Humidity on Growth and Endogenous Hormone Concentration of Tomato Seedlings”, Publish Ahead of Issue, P 1–9, 04 Sep 2020.

[9] Manishkumar Dholu, Mrs. K. A. Ghodinde, “Internet of Things (IoT) for Precision Agriculture Application”, Proceedings of the 2nd International Conference on Trends in Electronics and Informatics (ICOEI 2018), 11-12, May 2018 at Tirunelveli, India.

[10] G. S. Nagaraja and al,” IoT based smart agriculture management system”, 4th International Conference on Computational Systems and Information Technology for Sustainable Solution (CSITSS), 2019, Bengaluru, India, India, 20-21 Dec. 2019.

[11] Ioana M. Marcu and al, “IoT based System for Smart Agriculture", ECAI 2019 - International Conference – 11th Edition Electronics, Computers and Artificial Intelligence 27 June -29 June, 2019, Pitesti, ROMÂNIA.

[12] Mobasshir Mahbub, “A smart farming concept based on smart embedded electronics, internet of things and wireless sensor network”, 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology, 2017.

[13] Simitha K M and al, “IoT and WSN Based Water Quality Monitoring System”, 3rd International Conference on Electronics Communication and Aerospace Technology, 12-14, June 2019, Coimbatore, Tamil Nadu, India.

[14] K.Lokesh Krishna and al, “Internet of Things Application for Implementation of Smart Agriculture System”, International conference on IoT in Social, Mobile, Analytics and Cloud, I-SMAC 2017, 10-11 February 2017, Coimbatore,India.