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Enhancing Crop Production and Water Conservation through IoT-Based Smart Irrigation Systems

Durdana Rehman[1], Muhammad Ahsan Jamil[2], Hafiz Muhammad Sanaullah Badar[2], Malik Daler Ali Awan[3], Muhammad Umar Chaudhry[4] , and Nadeem Iqbal Kajla[2,*]

[1]Department of Computer Science, MNS University of Engineering & Technology, Multan, 60000, Pakistan.
[2]Department of Computer Science, MNS University of Agriculture, Multan, 60000, Pakistan.
[3]Department of Information Technology, The Islamia University of Bahawalpur, Bahawalpur, 63100, Pakistan.
[4]Department of Computer Engineering, Bahauddin Zakariya University, Multan, Pakistan.
[*]Corresponding Author: Nadeem Iqbal Kajla. Email: nadeem.iqbal@mnsuam.edu.pk.

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Abstract: One of the most varied economic sectors in our nation is agriculture. It is an important sector for food security, rural development, and economic growth, and it continues to play a critical role in supporting the livelihoods of millions of farmers in our country. The economy of Pakistan mainly depends on the agriculture sector. Water is used for agriculture to the tune of 80% of the total. By 2050, the global and Pakistani populations are expected to reach 9.6 billion and 403 million, respectively. Pakistan is also one of the top ten countries that are affected by a lack of fresh water. If we implement the smart irrigation system in the agriculture system during pandemics to get better crops. In this way, we enhance food production and save water easily. An IoT-based smart irrigation system can detect soil wetness and automatically adjust crop watering. It maintains soil moisture levels so that crops are not harmed. The information from the soil sensors is collected by a microcontroller, which is then sent to the internet via a firebase. Firebase sends data to the mobile Application. Smart agriculture program helps to conserve natural resources such as land, water, and energy, and reduce the impact of agriculture on the environment. This can lead to a more sustainable and resilient food system, which is essential for national food security and the well-being of future generations.

Keywords: IoT's, Moisture level of soil, Mobile Application, Temperature Sensor, Smart Framework.

1. Introduction

Water is a necessity for all life, including crops. the concept of a "water economy" is used to describe how heavily dependent crops are on the water for growth. In Pakistan, the user is responsible for recovering the capital costs associated with creating an irrigation system. [1] Agriculture in the world is retting on the monsoons, which are in short supply. Every year, irrigation uses more water than rainfall, posing a serious water resource challenge for future generations. It detects temperature and also checks humidity and soil level with the help of different sensors using the microcontroller by monitoring with a mobile application that will ultimately be an installation in real-time. [2] Water availability assessment in the agricultural context is critical for the efficient use of a valuable but increasingly limited resource and for producing excellent results [3] Farmers also have a difficult time finding a suitable way to find cultivate crops that use less water. If the use of freshwater percentage of total consumption continues to increase, it will become a severe issue in terms of climate change. [4]. IoT is the type of technology that allows us to link with Android applications to implement techniques for monitoring the usage of water resources in agricultural fields. [5] The healthy state and degrading of soils can be determined in part by evaluating the structure and surface of the soil. Changing in climate and its effects on agriculture pose. [6]. Nutrient-deficient soils are a significant challenge for farmers in Sub-Saharan Africa and South Asia Farmers require training and collaboration to adapt to new market and technology trends and establish dependable farming organizations. [7]. Water is one of the most important components of soil, especially for plant growth and well-being. Water content, often known as soil moisture, may be used to determine how much water is accessible in the soil. Seasonal and environmental variations affect the amount of water in the soil [8]

My research is creating a new approach that uses sensors for real-time and collects data for uniform watering routines and modified watering schedules for the purpose of developing a smart irrigation system in a very short time. This system reduces human intervention in the agriculture field. it is significant and efficient as farmers will adopt drip smart irrigation systems which will utilize an efficient and limited quantity of water available.

The main contribution of my research is discussed below:

- The important contribution of my research is creating a new approach that uses sensors in real-time and collects data for uniform watering routines and modified watering schedules to develop a smart irrigation system in a very short time. This system reduces human intervention in the agriculture field. The proposed approach is quite different from another approach of previous due to timing.
- Timing is the main contribution of the research and proposed works to check continuously monitor the status of soil through sensors.
- To detect the air quality of carbon gas and save fresh water.
- To use sensors to continuously monitor the state of the soil and provide alerts for taking appropriate action.

The objective of this research is the detect temperature and also check humidity and soil level with the help of different sensors using the microcontroller by monitoring with a mobile application that will ultimately be installation cut of installation of cost of this system.

2. Literature Review

Devraj Sen studied Perseverance and soil excessive moisture sensors installed in the plant's root zone. The microprocessor is utilized to manage water storage in the ground, taking into account the identified parameters. This approach does not keep the rancher informed about the status of the field. [9] Published a framework that looks at soil factors such as pH, moisture, sogginess, and temperature is examined. This system has been completely upgraded and now controls whether the motor guidance is ON or OFF depending on the amount of moisture in the ground. [10] A paper in which the switch on and off of the light is controlled by the determined value of the soil and a temperature sensor inserted in the roots of plants a water engine Their project's flaw is that they didn't plan forward urban incorporate any method for sending information about the state of the farm field to the client [11]. This project is to depend on a device that will control how much alcohol is consumed. Water in a farming field Research has been conducted to establish the proposed scenario utilizing sensors and the Arduino UNO microcontroller to create an effective automated IoT system Wireless network and bulletin board We can use the following study article as an example as well as the system's architecture [12] The author has introduced the Internet of multimedia things (IoMT), a variant of the Internet of things (IoT). The proposed framework, which is based on DIP and MATLAB analysis of detected multimedia data, as well as an exact hybrid application of IoMT techniques with machine learning (ML) principles for irrigation, has employed IoMT, or multimedia wireless sensors network [13]. Using different sensors multi-operator frameworks and Internet of Things-enabled sensors, it claims to be able to create a controllable scenario and a smart DC microgrid irrigation system. PV panels and water tanks are utilized in a solar-powered water pumping system that is low-cost and widely used. All of these elements can be combined to form a load-shuffling algorithm. an irrigation system [14]. Water availability assessment in the agricultural context is critical for the efficient use of a valuable but increasingly limited resource and for producing excellent results. [15] Water availability assessment in the agricultural context is critical for the efficient use of a valuable but increasingly limited resource and for producing excellent results [16]. It is also prone to contamination as a result of anthropogenic activities such as improper garbage collection, among others. ICT-based observation frameworks have a wide range of applications in agriculture. Cell phone apps may be used to monitor farm conditions from afar and manage agricultural equipment, such as the water system, using these frameworks. In addition, recent research has developed a great network for information and communication Technology and explicit apps for farming structures or business strategies. [17] Proposed water controlling network based on Wireless Sensor Networks, which included information observing nodes, various monitoring centers, and database stations (WSN) [18] improved the efficiency of water systems by constructing a framework based on ICT frameworks. Bartlett and colleagues [19] and realistic ICT at the size of a water system. They used the overwhelming majority of existing technology, including monitoring, remote detection, crop modeling, and water system remote control. A smart irrigation network develops and operates this channel at the smallest amount of memory (for example, any field crop) [20]. The urban water system accounts for around 30% to 70% of private water capital consumption (FDEP, 2002). Automation water system frameworks that aren't based on a balanced approach to climate and frequent changes in crop needs have provided for larger amounts of water to be applied to city landscapes, resulting in a water system with poorer usage efficiency [21] The authors confirm that they have no established financial or relational concerns that would have appeared to have an impact on the research presented in this study. [22]. The summary of related work is presented in Table 1.

Table 1. Summary of related work

Research paper	Factors	Key contribution	Limitation
1 Internet of multi-media things in smart and future Agriculture (2019)	Reduce water wastage and man-power	To create a device to control all sensors things	To make better in your way
2. Wireless sensor network Smart (2019)	Check the amount of moisture level	Motor turn OFF/ON of the light	Better to way check the moisture levels in a different way
3. Smart Irrigation Using IoT (2020)	Wastage of water	focuses on the system's framework, which aims to detect soil quality and moisture	Efficient food corporations in the agriculture system
4. Intelligent and Smart Irrigation System Using Edge Computing and IoT (2020)	Save to sweet water	impacting the need for water Drinking water should be used sparingly to conserve scarce sweet water resources.	Data processing is assigned to the server. and presenting the outcomes of the machine learning algorithm.

5. Smart Irrigation Using IoT (2020)	focuses on the system's framework which aims to reduce and control water waste	targets on and also control wastage of water	Less human interference in a better way
6 A DC micro-grid smart-irrigation system using Internet of things technology (2021)	Manageable the DC water system to control load shading	Solar power water pumping automated monitoring using sensor used limited water	To control load shading and save water age in a better way
7 Smart Irrigation Systems Using the Internet of Things (2021)	To control the irrigation system	Using IoT model to the save crop	To improve the way the system works and the locations where it can be used
8. An overview of smart irrigation systems using IoT (2022)	Focused on the water management	Target the efficiency of water management	Increase the implementation of water efficiency and increase the cost of operating activities
9 Smart Irrigation Techniques Using IoT (2022)	Focus on crop production	Data sever	Increase the indoor and outdoor temperature
10. Images using Machine Learning Techniques (2022)	Focused on wastage of water	supervised machine learning (ML) techniques	Accuracy OF classification can be attained by using a hybrid machine IN Future
11. Smart Irrigation System (2022)	reduces the growth of wastage and thereby getting good quality and healthy crops.	PWM techniques	To increase the health of the crop

3. **System Configuration Block Diagram**

Both hardware and software components make up this system. The firmware is the hardware component, while the mobile App produced with language is the software component. The mobile application is available through the internet and comprises a database into which sensor readings from the hardware are entered. The input pin of the microcontroller band is coupled to the sensor’s temperature soil, moisture sensor, humidity sensor, and Rain prediction to detect carbon gas in the Air in this popular system. To regulate water, a threshold value was set at which irrigation should begin. When the sensors detect a moisture level below the set point, the drip starts and continues until the soil is completely soaked. In the mobile application, the sensed values are shown. The water motor is turned on/off automatically based on the measured value in comparison to a previously set threshold value.

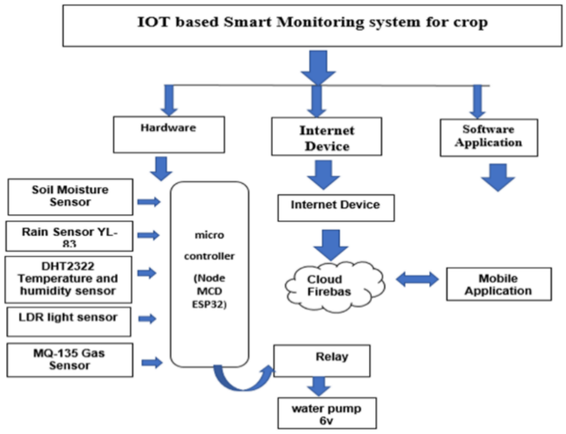

Figure 1. Research Process Model

4. Research Methodology and Design

Five sensors are used in the system which are Soil & Moisture, Temperature & Humidity, Light, Rain, and Gas. Smart drip Irrigation System uses sensors to measure the relative parameters in order to give the water via drip to plant. Microcontroller EPS-32 sends the measure values to wireless communication to the farmer via mobile application.

The mobile application can be designed to analyze the received data and allow the farmer to take suitable action accordingly In this study of the problem develop and design a framework to get results. This problem solves with a special design to deal with the moisture of the soil, easily managing the watering system and plant production who do now and check the water level. The humidity sensor provides a signal to the Esp32 board if the humidity level goes below the desired amount. Which causes the Water Pump to turn on and give water to the specific plant. The proposed system of working model is shown in Figure 2.

Figure 2. Research Model

We developed a mobile application, the range of IoT devices connected to the firebase that should show the rest of the different sensors. Mobile Application developed by Android studio and used two different languages front end XML and back-end Java. We can access this application from anywhere to get data. The ESP8266 Wi-Fi module must be linked to the internet through a router (with a unique username and password that are inserted into the program code). The data will subsequently be displayed on a mobile application as shown in figure 3.

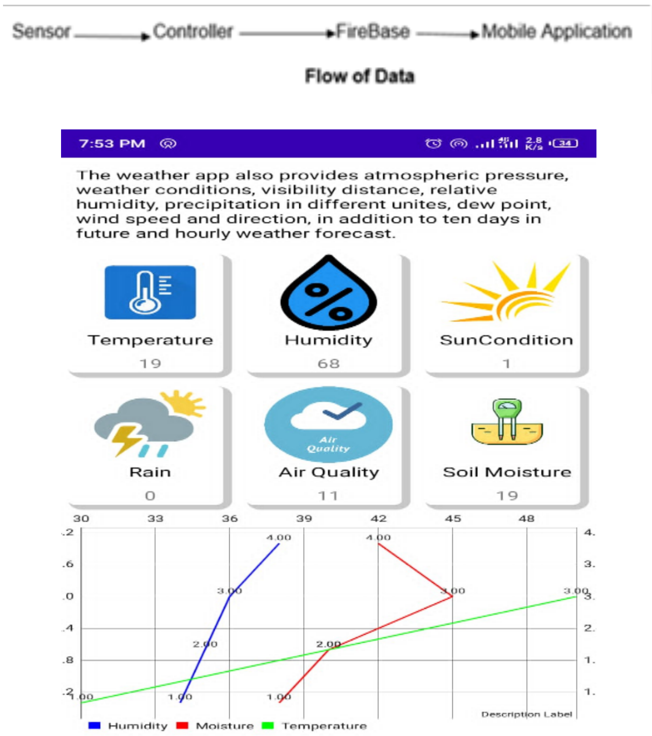

Figure 3. Android Mobile application

The different sensors (Temperature, humidity, gas light, and moisture) to gather data in this area. Collected data send to the connected board. The Esp32 receives the data from the board. The receiving data from ESP32 send to Firebase using an internet service and then a mobile APP TO display the Firebase Data The programming language utilized executes instructions that extract and reflect data.

5. Methodology And Prototype Testing

The sensors are linked to Esp-32. The user can easily access data through his mobile application, which can obtain sensor data from the Esp-32 with a Wi-Fi internet device because this hardware connects via Wi-Fi transmission. Java is used in the programming of the Esp-32 board to control both the operation of the motors and the transfer of sensor data. The program in the Esp-32 supports the placement of the motor and five sensors. The sensors continuously transmit information about the soil's moisture content. The motor is turned on and water is delivered to the area if a sensor identifies low moisture content. If the moisture is of high value, turning off the motor will halt the water pumping. The soil moisture, temperature, and humidity threshold values will be set and saved using the Esp-32 and a mobile application. Depending on the weather, the sensor value changes. After accounting for all of these environmental and climatic factors, the threshold value will alter depending on the soil moisture levels in the summer and winter as well as the temperature and humidity levels. If the soil moisture reading goes below the threshold, the motor will immediately start. utilizing a mobile application. The watering system is automatic after receiving the command from the mobile application. The motor switches are actuated as a result of the decision being transmitted to the ESP-32 via a Wi-Fi connection.

6. Results

The level of the soil is a monitored with Moisture sensor and get the result and display on a graph. Plant of soil range between 13 to 24 % range. Minimum to need to on the motor. I can research through this IOT proposal more efficiently because we all time monitor the moisture of the soil. when the plant needs water then the motor is on otherwise Motor is off. In the future Smart IoT irrigation system will be more effective and helpful. Those are no proper fresh water in the sense of lack of fresh water this smart irrigation system properly works.

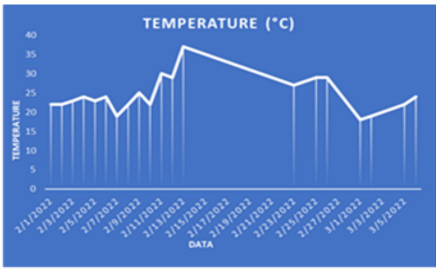

Figure 4. Temperature Recorded by Temperature Sensor

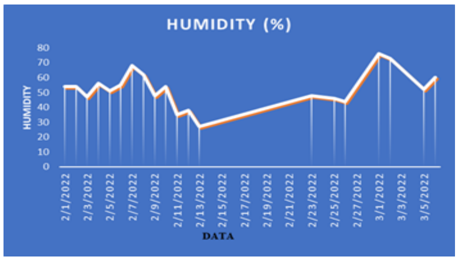

Figure 5. Humidity Recorded by Humidity Sensor

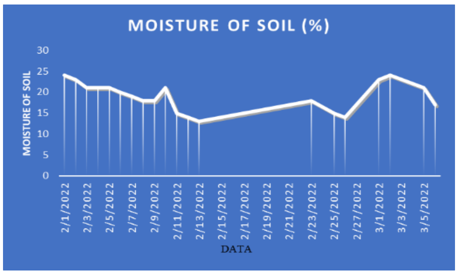

Figure 6. Moisture of the soil measured by Moisture sensors.

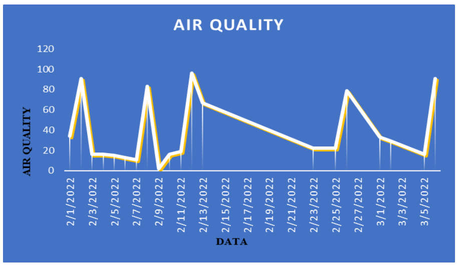

Figure 7. Polluted Air Recorded through MQ-135

The temperature measured by the DTH11sensor on various dates and over varied periods is shown in figure 4. Similarly, the graph depicts the humidity measured by the DTH11 sensor at various locations in figure 5. The level of the soil is monitored with a Moisture sensor and get the result and display on a graph in figure 6. Plant of soil range between 13 to 24 % range. Minimum to need to on the motor. when the plant needs water then the motor is on otherwise Motor is off. In the future Smart IoT irrigation system more effective and helpful. Those are no proper fresh water in the sense of lack of fresh water this smart irrigation system properly work. Figure 7 shows the air pollution recorded.

This sensor works similarly to detect the environment of Air. MQ-135 semiconductor sensor for air quality which clean air has a lower conductivity. It is a kind of low-cost sensor for all kinds of applications.

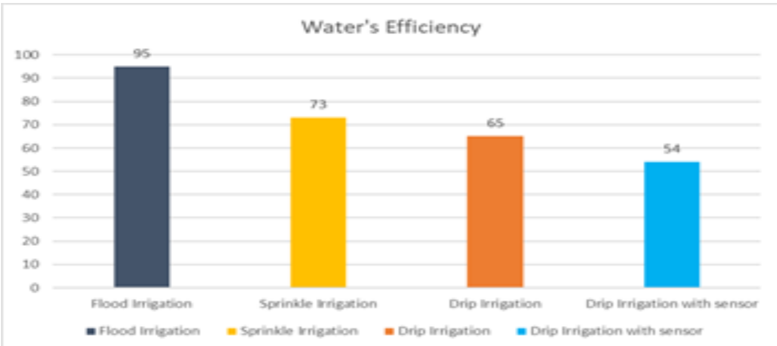

Figure 8. Water efficiency

There are three main types of irrigation systems:

Flood/Surface irrigation, Sprinkler System, Drip Irrigation System: Drip Irrigation System with Sensors. Water efficiency chart is in figure 8.

The graph presents the water efficiency using a different type of irrigation system. Drip irrigation is the most water-efficient way to irrigate the plants. It is an ideal way to water in clay soil because the water is applied slowly, allowing the sol to absorb the water and avoid d runoff

Table 2. Comparison of Study with state of the art

Serial No	**Work years**	**Sensor occupied**	**Methodology**	**Save water**

1	Parameswrana and Sivaprasars (2016)	Soil moisture	Drip irrigation with IoT	No results
2	Rawal (2019)	Soil Moisture sensor	Sprinkle with IoT	25.7%
3	Saqib (2020)	Soil moisture	WSNS	No result
4	Xiao et al (2019)	Rain sensor	Soil moisture sensor	34%
5	Smart Irrigation System (2022)	PWM techniques	To increase the health of the crop	30%
6	Images using Machine Learning Techniques (2022)	supervised machine learning (ML) techniques	Focused on wastage of water	33%
7	Proposed Study	Soil moisture Rain sensor Humidity sensor Light sensor Gas sensor	Drip Irrigation with IoT and Android application	54%

7. Conclusions

In the past, a large amount of freshwater percentage will be decreased but the need for water is due to the increase in population. We know better than fresh water used in usage e amount of agricultural. System. This system was designed to solve the problem of fresh water and monitoring in real-time and also control both automated manual systems. Nowadays due to limited resources in freshwater future r, it is difficult to sustain in the future then indicates that there is a need of developing a smart irrigation system Our model to modify the agricultural system because basic problems are arising in the production of crops with the increase of population, there is a requirement to enhance the growth of agriculture. My proposed research was developed through a based system and collaborated with drip irrigation techniques. I developed a smart control system for high-value crops. In these techniques, I controlled all factors of plants' needs such as light, temperature, moisture, rain, humidity, and gas. Its performance calibrates with corn growing experiments, they produce an excellent result, 23% improving the performance from previous research work. Approximate 15 to17 days reduced as compared to traditional farming Framer can remotely monitor the growth of crops by using the App of smart irrigation system on his mobile, it creates the temperature, moisture level, and humidity in the soil and sends signals to the controller which analyzes the data and output that weather to switch on or off of the motor pump. This system helps the farmer to stay home and monitor the crop safely and effectively. In the coming year, smart irrigation-controlled farming replaces traditional farming because they don't depend upon crop sowing time and place. Smart farming starts at any place like the house roof, basement, and any place you wish. Mobile App controlled smart farming gives us a vast amount of food and a source of income.

7.1 Future work:

In the future population feeding and food security will be prevented too difficult to due increasing domestic area replication as compared to food production. It maximizes the use of water by lowering wastage and reducing human intervention for farmers by using an autonomous irrigation system. The automation process can be carried out using microcontroller technology. In the future, this technology will allow farmers to control and see farming directions from their homes using various technologies like the internet and cell phones.

References

1. Ravi KumarVenu Gopal, V.Sridhar, G.Nagendra,(2018) SMART IRRIGATION SYSTEM International Journal of Pure and Applied Mathematics Volume 119 No. 15 2018, 1155-1168
2. Wedpathak, G., Pawar, V., Kadam, S., & Thigale, S.” IoT Based Farming with Live Monitoring of Temperature, Soil Moisture, Weather Conditions through Image Processing Techniques
3. Tapan Kumar Das1, Dilip Kumar Barik, K V G Raj Kumar3 “Land-Use Land-Cover Prediction from Satellite Images using Machine Learning Techniques” 2022 International Conference on Machine Learning
4. Han P., Dong, D., Zhao, X., Jiao, L., & Lang, Y. (2016). “A smartphone-based soil color sensor: For soil type classification. Computers and Electronics in Agriculture”, 123, 232-241
5. ONUKA, B. (2018).” Effects of Soil Temperature on Some Soil Properties and Plant Growth. Advances In Plants & Agriculture Research, “8(1). doi 10.15406/apar.2018.08.00288
6. Abhijit Pathak, Mohammad Amaz Uddin, Md. Jainal Abedin, Karl Andersson, Rasheed, Mustafa, Mohammad Shahadat Hossain,19-21-2019 www.sciencedirect.com
7. Devraj Sen, Madhulika Dey, Shubham Kumar, Dr:.C.S.Boopathi,2020 ” Smart Irrigation Using IoT International Journal of Advanced Science and Technology" Vol. 29, No. 4s,
8. M. Safdar Munir, Imran Sarwar Bajwa, Amna Ashraf, Waheed Anwar, and Rubina Rashid (2020) Intelligent and Smart Irrigation System Using Edge Computing and IoT International Journal of Engineering & Technology vol.2021
9. AlZubi, S., et al.:(2019), An efficient employment of internet of multimedia things in smart and future agriculture. Multimedia Tools Appl. 1–25
10. Wireless sensor networks Wikipedia. https://en.wikipedia.org/wiki/Wirelesssensornetwork.Accessed on 16 Dec 2019
11. Kalezhi, J., et al.: Smart Agriculture System in India Using Internet of Things In 2019 IEEE PES/IAS Power Africa. IEEE, New York
12. Madhurima Bhattacharya, Alak Roy, and Jayanta Pal: Smart Irrigation System Using Internet of Things https:www.researchgate.net/publication/343427611
13. Devraj Sen, Shubham Kumar, Dr.C.S.BoopathiSmart Irrigation Using IoT www.ijariit.com
14. Ravi Kumar, T.Venu Gopal, V.Sridhar, G.Nagendra,(2018) SMART IRRIGATION SYSTEM International Journal of Pure and Applied Mathematics Volume 119 No. 15 2018, 1155-1168
15. Devraj Sen, Madhulika Dey, Shubham Kumar, Dr.C.S.Boopathi4, (2020), Smart Irrigation Using IoT, International Journal of Advanced Science and Technology Vol. 29, No. 4s, (2020), pp. 3080-3090
16. Safdar Munir, Imran Sarwar Bajwa, Amna Ashraf , Waheed Anwar,and Rubina Rashid Intelligent and Smart Irrigation System Using Edge Computing and IoT2021, volume Article ID 6691571
17. Muhammad Shoaib Farooq, and Sobia Ikram,(2021) IoT IN AGRICULTURE: CHALLENGES AND OPPORTUNITIES, J Agric. Res., 2021, Vol. 59(1):63-87 www.jar.com.pk
18. Ashwini B V,(2018), A Study on Smart Irrigation System Using IoT for Surveillance of Crop-Field, International Journal of Engineering & Technology, 7 (4.5) 370-373
19. Dr. J. Jegathesh Amalraj, S. Banumathi, J. Jereena JohnA December 2020 Study On Smart Irrigation Systems for Agriculture Using IoT INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 8, Mrunal Wabale1, Prachi Phadatare2, Rutuja Kharche3, Samruddhi Shelke4, Prof. P. R. Patil ISSN: 2321-9653 Volume 10 Issue V May 2022 “Smart Irrigation Technique Using IOT” https://www.ijraset.com/
20. Dr.S. Gnanavel, Mrs M.Sreekrishna, Mr.N DuraiMurugan, Ms.jaeyalakshmi M “The Smart IoT based Automated Irrigation System using Arduino UNO and Soil Moisture Sensor” Fourth International Conference on Smart Systems
21. Taslina Akt, Yeaser Sadman, Shatabdee Bala “Use Machine Learning Technologies in E-learning” 2022