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Smart Irrigation System for Wheat in Southern Punjab Using IOT-based Wireless Technology

Safira Mustafa[1], Humayun Salahuddin[2*], Ammar Ashraf[2], Mamoona Shafique[1], and Saba Salahuddin[3], and Muneeb Akbar[4]

[1]Department of Computer Science, National College of Business Administration & Economics (Sub Campus) Multan, Pakistan.
[2]Department of Computer Science, Riphah International University Sahiwal Campus, Sahiwal, Pakistan.
[3]Department of Electrical Engineering, The Islamia University of Bahawalpur, Pakistan.
[4]Department of Plant Protection, Ghazi University, DG Khan, Pakistan.
[*]Corresponding Author: Humayun Salahuddin. Email: humayun.salahuddin@riphahsahiwal.edu.pk

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Abstract: Agriculture is an important aspect of Pakistan economy. It employs almost 60% of population and generates one-third of exports per year. State of the art agriculture development highlights modern trends to overcome farmer difficulties faced by implementing traditional methods. The general purpose is to integrate farming on agriculture using IoT technology based on Wireless Sensor Network (WSN). This research work focuses on wheat as cultivation and irrigation. The improvement in wheat production demands special conditions, such as temperature and humidity level 50-60%. The proposed system remotely monitors growth of wheat crops using wireless communication. The monitoring system is based on ESP8266 (microcontroller) and DHT11 sensor to read the temperature and humidity level of crops under remote observation model. Moreover, GSM module transmits message to the farmer regarding environmental parameters impact on wheat crop. If humidity level goes up or down from its optimum range then farmer adopts the precautionary measures to maintain humidity within desired range. This model prevents the crop from environmental losses and increase the productivity of crops in south Punjab region.

Keywords: Agriculture; Wheat Production; IOT Technology; Humidity; Temperature; Fertilizers; ESP8266; WI-FI Module; DHT11 Sensor; Work Flow; Arduino IDE, Crop Monitoring.

1. Introduction

The Agriculture is a significant part of the Pakistan economy. This sector provides direct assistance to the country economy and contributes for 26% of Revenue (GDP). The most important crops are Cotton, wheat, sugarcane, rice, fruits and vegetables. Wheat is still the world's most frequently planted grain. Wheat (Triticum aestivum) is among the first developed agricultural crops and over the last eighty years, it has become the essential basic food of Europe. Wheat covers around one-sixth of all agricultural land on the planet. Internet of things (IoT) is the most common topic of research nowadays. In the agriculture industry, IoT (Internet of things) plays an important role that can feed around 2050, there must be 9.6 billion people around the world [1].

Agriculture contributes well over 70% of Pakistan's workforce. Although agriculture's contribution to the economy is now declining. Agriculture has become a major issue in the presence of water shortage. The smart wheat monitoring system provides a broad scope for automation of entire monitoring system. Here, an IoT smart wheat crop monitoring system with ESP8266 NodeMCU Module and DHT11 sensor. Before starting, it is important to note that the different crops require different temperatures and humidity conditions.

1.1. Global production of Wheat

Wheat is cultivated on some more than 240 million hectares, more than any other crop. According to the Food and Agriculture Organization (FAO), world wheat output in 2020 might be 776.7 million tons, up

6.8% from the current year, suggesting a more than fast recovery from the previous year's decrease and boosting production levels to its greatest level in history.

The US Department of Agriculture estimated the 2021 US all-wheat crop at 1.646 billion tons on September 30, in its Small Grains 2021 Summary, down 51.041 million tons from the most recent previous forecast made in the USDA's August Crop Cultivation report and down 182.279 million tons, or 10%, from 1.828 billion tons in 2020. The 2021 crop is expected to be the weakest since 2002, when 1.606 billion bushels were produced. The most recent five-year average US wheat output (2016-20) was 1.939 billion bushels.

1.2. Wheat Production in Pakistan

Wheat is Pakistan's primary agricultural crop and, consequently, is important to the country's food security. In terms of location under crop cultivation, maximum throughput, and yield per hectare, Pakistan is in the top 10 largest wheat-producing countries worldwide. Table 1, shows the Area, Production and Yield.

Table 1. Area, Production and Yield

Year	Area (000 Hectares)	Production (000 Tons)	Yield (Kgs/Hec.)
2016-2017	8972	26,674	2,973
2017-2018	8797	25,076	2,851
2018-2019	8678	24,349	2,806
2019-2020	8805	25,248	2,867
2020-2021	9,178	27,293	2,974

Wheat is an essential part of the population's basic food requirements, accounting for 60% of the average Pakistani's daily diet, with an annual per capita usage of 125 kilograms. It contributes 9.2 % wealth created and 1.8 % to GDP.

1.3. Wheat Productivity Constraints

In wheat, there may be a yield gap of about 60% that has to be closed. Wheat output in the country, meanwhile, seems to have been significantly below average and unpredictable due to reduced yield. The main reasons for the decline production efficiency and economic uncertainty are delayed collecting of Kharif crops such as cotton, sugarcane, and rice, as well as a lack of inputs such as seed, ineffective fertilizer use, weed growth, irrigation water shortages, connector heat, dry spells in the rainy season, soil pollution, and a weak agricultural extension system.

Low-quality seed: Experts at several research organizations across the world have created new high-yielding, disease-resistant varieties of seed that have increased agricultural production over time. Disease resistance to evolving pathogens are preserved in different varieties, as well as the maximum genetic yield of crops. Farmers must be taught to produce high-quality seed, which will increase wheat output on small farms.

Delayed planting: Due to delayed reaping of Kharif crops (cotton, sugarcane, rice, and summer crop producing (areas) in Pakistan, farmers usually grow wheat late, resulting in reduced production since the crop is exposed to high temperatures pressure during the grain-filling stage, resulting in the development of shriveled grain. Wheat yields can be reduced by up to 35% if the wheat production is damaged.

Inefficient use of Fertilizer: Fertilizer has played an important part in supporting farmers in obtaining their high levels of productivity. Fertilizers offer critical plant nutrients that are required to provide enough and nutritious food for the world growing population. Phosphorous (P) and nitrogen (N) in recent times, zinc, boron, and Sulphur have been identified as the nutrients of greatest importance in grain-producing countries. Unfortunately, our soils are low in phosphorus (90%), zinc (70%), nitrogen (100%), Potassium (K) and boron (55%) levels are typically acceptable, but a deficiency is developing fast.

Different types of fertilizer are used in Pakistan, that are also made locally and others that are imported. The majority of fertilizer used in our country is applied to irrigated wheat, rice, cotton, sugarcane, and crops. One of the most essential techniques for maximum crop output is balanced fertilization. Balanced fertilization is the logical use of plant nutrients for the optimal delivery of all required nutrients for maximum crop output, while also ensuring fertilizer efficiency, promoting potential interaction, and keeping antagonistic interactions out of the agricultural production system.

Water shortage: Water scarcity is already one of the most serious global challenges, and climate change forecasts indicate that it will become even more crucial in the future. Because water accessibility and availability are the most important constraints on agricultural production, solving this issue is critical for water-stressed areas. In Pakistan, the area under cultivation increased from 15.48 million hectares in 1982 to 18.22 million hectares in 2002. The wheat cultivated area grew from 5.962 million hectares in 1985-86 to 7.00 million hectares in 2002-03. In Pakistan, the area under cultivation increased from 15.48 million hectares in 1982 to 18.22 million hectares in 2002. The wheat cultivated area grew from 5.962 million hectares in 1985-86 to 7.00 million hectares in 2002-03.

IoT Technology: In the last few years, the Internet of Things (IoT) has sparked the interest of academics and researchers. In 1999, Proctor & Gamble's Kevin Ashton was the first to coin the idea. He coined the term "RFID awareness" to support for the use of radio-frequency identification (RFID) to enable computers to do all particular functions. This concept was first demonstrated in 1982 at Carnegie Mellon University using a customized Coca-Cola machine, and it became the first network appliance [2].

The Internet of Things is made up of two terms: internet and things (IoT). Objects in the Internet of Things refer to a wide range of connected objects. The Internet of Things (IoT) is a game-changing technology that will enable the creation of a smart upcoming future of us by allowing all internet-connected things to acquire and upload data as needed. By integrating the real and virtual worlds, this revolutionary concept offers a new way to connect all gadgets to the internet, opening up new possibilities. Real-world things are what we feel, sense, or operate, hence the name Things in IoT has a dual meaning. Things, on the other hand, relate to objects that may be stored or retrieved in the virtual world [3-4].

The six main categories of IoT applications are as follows:

· Smart cities
· Smart business
· Smart homes
· Smart healthcare
· Smart security
· Surveillance

Using controlled monitoring, IoT solutions in home automation assist to decrease power and water use. IoT technology may be utilized in smart cities for vehicle parking, traffic control, street lighting, and the identification of anomalous and emergencies. RFID in logistics to track items is an excellent example of how it is commonly employed in the commercial world [3-4].

Interconnection, awareness, economy, protection, sensing, globalization, and dynamics are the core characteristics of IoT technology. It is founded on climatic shifts.

It demonstrates that water savings can reach up to 47%. Wireless networks have revolutionized the field of monitoring and environment monitoring. Network of sensors collect data from the sensors for instance wetness, temperature, power, and voltage, from a remote location and send it across the network to where it is needed for analysis. Even from far away, sensor networks may be utilized to monitor power statistics. The data collected from the sensors is sent by Text messages from the location to the mobile phone (control center) [5-10].

The temperature and humidity sensor (DHT11), power source, NodeMCU (ESP8266), and GSM Module are all part of the experimental system. The created codes are loaded into NodeMCU using the Arduino IDE software (ESP8266). Controlling the sensor activities is possible with this Sensor Network. It works in both directions. This system is designed with very sensitive sensors, precision-directed hardware, and low-latency networks. For practical applications, this technology is quite reliable [5-10].

1.4. Why do we need IoT in agriculture?

The present study focusses on the following objectives:

1. To investigate the humidity level during different stages of wheat.
2. To study the relationship among different weather parameters, crops life cycle, and their Impact on crop yield.
3. Generate alert for smart irrigation.

4. Impact of timely irrigation on basis of data collected on crop yield.

2. Literature Review

A literature study is necessary to gain a full understanding of one's selected research area and to learn more about specific themes. This systematic review aims to get a clearer understanding of the subject's work area and to learn from previous research in the area. This emphasizes the usage of technology and IoT for smart agriculture.

Sensors are used to monitor crop fields and operate the irrigation system. The data from the sensors is wirelessly transferred to the webserver's database. The data in the data center is secured using the JSON format. Farmers able to keep an eye on their crops from wherever. This technique is more effective in areas where water is scarce. This system uses less water than the conventional system. Data irrigation system automation has been saved with PHP script in MySQL database. IoT sensors can provide information about their agriculture fields, smart farming is a new concept. The main feature is the use CC3200 single-chip sensor to monitor and humidity and temperature in the field of agriculture [11-12].

Smart agriculture proposes development on IoT. The study aims to make agriculture intelligent through automation and IoT. The objective of this study is to modify the existing agricultural approach and to supply a remotely controlled IoT and Smart GPS automation technique to the following tasks: spraying, sensing moisture, weeding birds, and animal protection, etc. Wireless sensor - networks are described. Variables such as temperature and humidity are obtained, gathered, and evaluated at the channel's three nodes. Water and environmental problems are being reduced by the advantages of irrigation in agriculture [13-14].

A component of the WSAN, the cloud platform, and the user application are divided into 3 main components. It includes three kinds of nodes, including sink node, actuator node and sensor node [13-14].

Many solutions have been developed employing new technologies to improve traditional approaches, such as reducing crop wastes, avoiding unnecessary and insufficient irrigation of crops, and therefore increasing crop production. Drip irrigation is one such technology that saves both fertilizers [15-18].

The most important elements are soil moisture and field temperature. Humidity in the soil is being detected using sensors. Wireless sensor networks are built using these sensors. To manage adverse situations, the crop cultivation methodology uses the Internet of Things (IoT). The temperature and soil moisture are monitored here, and the data is saved in the Thing Speak database for further processing. Farmers would be capable of monitoring their fields using IoT devices, which would supply them with real-time soil moisture, humidity, and temperature data. When data from the field is collected, a person can access timely measures to handle the field. The data collected could be utilized to develop strategies for achieving greater results in the future [15-18].

The research focuses on the safety and protection of agricultural products in the field and grain stores against the attacks of pests or insects. Python scripts connect sensors and electronic devices. An algorithm is developed to collect data to ensure accurate user notification and repelled activation. To prevent rodents from being stored in grains, the security system will help. Precision agricultural work defines (PA). AWSN is the greatest solution to tackle farm problems like optimizing agricultural resources, supporting decisions, and land inspections. In this strategy, information about lands and crops may be provided in real-time and help farmers make the proper decisions [19-20].

Precision agricultural systems based on IoT technologies address the hardware design, network infrastructure, and systems development control of something like precise irrigation. The programmer collects data from the sensors in a feedback system based on the deployment of the threshold levels [19-20].

A moderate, time-dependent micro-controller irrigated agriculture scheduler including temperature, weather detection, and moisture detection sensors. Based on these parameters, this system determines the appropriate actuators (solenoid valves, relay, and motor). Through the GSM module, the collected data is sent to the user as an SMS and retained on a memory card. For agricultural productivity, researchers looked at control networks and IoT technologies. Based on the internet and wireless communication, the author presented a remote monitoring system. The data is also stored in an information management system. The information gathered can be put to use in agricultural research institutes [21-22].

Smart agriculture depends on the Internet of Things (IoT) and cloud computing. The agriculture information cloud manages a large quantity of data collected through RFID and wireless connectivity. Network control field irrigation and soil sensors are used to offer a deficit irrigation management system. The DSS can be installed on a local 16 computer or a distant server, and the user can consult with it to change irrigation techniques if necessary [23-24].

Wheat at every stage is highly sensitive to water scarcity. Water stress at any of the growing stages of wheat (Triticum aestivum L.) causes a serious decrease in its yield. The severity of impact relies on the variety of wheat and stage of crop exposed to water stress. Water is too important during each growth and developmental period of wheat, from germination of the seed to maturity, but the level of sensitivity of the crop to water shortage rises as plant growth reaches maximum through the early dough stage. (The development of Leaf and tiller, winter wheat during vegetative phases is greatly influenced by water stress, at the jointing stage water stress increases the proportion of the senescence and decreases the number of spikelets per head, while the boot stage has a direct effect on the yield of the crop [25-27].

Harvesting of wheat crops started in April and May. Since there is a shortage of water for irrigation of wheat during the wheat-growing period, the available water must be used most carefully and efficiently. Between April and May, the wheat plants were harvested. Except for a few scattered showers, rainfall is infrequent during this time. As a result, limited irrigation water has a direct relationship with wheat growth and the development of plants. Through the use of IoT, security can be improved by implementing an effective management method. The resting stage of P. storiforms is mycelium in winter. In the cool moist weather, fungus grows and produces vigorous sporulation in the spring lesions. Favorable conditions for the infestation of Stripe Rust are at 30-35 0C (max. temperature), 15- 16 0C (mini. temperature) with more than 70 % relative humidity [28-30].

Propose an integrated soil analyzer that determines the soil ph. as well as the number of different fertilizers based on that value. The method developed here includes data acquisition, monitor, microcontroller unit, sensor, power source, and infrared printer. The primary purpose of this strategy is to completely replace soil testing with electronic soil testing. It automatically analyses the essential soil elements such as potash by monitoring the pH value. This study proposes a model for detecting soil humidity, temperature, sunshine, N, P, and K contents in agricultural fields using sensors. These techniques aid in the quantification of basic nutrients. Framework in which water flow and its direction are supervised and regulated in this study. The DHTT11 and a soil moisture sensor are used to do this. This approach also suggests a means to choose the direction of water flow, and the information is transmitted to the farmer's cell phone and e-mail account. This study also proposes an energy and efficient network model [31-32].

Proposed a system using simulations for IoT devices and with IoT devices, they used data mining techniques. To predict the results. To identify the parameters required for the better growth of the crops. It suggests new, intelligent agriculture based on IoT Agricultural stick that follows these characteristics; Soil Humidity &Temperature. Arduino Mega is used for the construction of the equipment and all data collected through sensors are sent on the ESP8266 Wi-Fi Module, compared to complete solar power and solar power supplies. They claimed 99%accurate results for this device. Ubi-motes are utilized to generate data, and a control application based on android is submitted to the user. For the following parameters, the system produced a solution: Temperature, Sprinkler Control, Fan Control, Solar Moisture Monitoring, and Light Control [33-35].

An IoT-based agricultural monitoring system is proposed in this study. For the monitoring of temperature and humidity, they have utilized a CC3200 temperature and humidity sensor to record images from cropping time to time, in addition to using a camera embedded with the temperature and humidity sensor. Other factors are sensed using humidity and light sensors in the proposed study. It was suggested that an electronic micro - controller rain gun irrigation water be used, in which irrigation occurs whenever there is a great demand for water, therefore conserving a large amount of water. As a result of developing an Android application framework for devices, these technologies altered the way field decision making is done. Cell devices have practically become an integral part of our life, fulfilling a wide range of human needs. This application uses the GPRS capabilities of a mobile phone as an irrigation control system[36-42]. These systems only covered a tiny amount of farmland and were not financially viable [42-46].

3. Methodology

3.1. Materials

The brand-new ESP-8266 aka Node-MCU microcontroller was adopted for this study. Many IoT systems use Arduino or Raspberry-pi as their mother controller, however, Node-MCU gives more options, advantages of combining an Arduino with a 2.4 GHz Wi-Fi module have a strong appearance because this was a demonstration endeavor, we'll need a lot more investigation in real-life situations as a result, standard breadboards and jumpers are used.

3.2. Equipment needed for research

3.2.1. ESP8266 WI-FI Module

Recently, the Arduino Company began working on the development of a new microcontroller. This battle was won when a new MCU was developed and generally known as MCU module because it is responsible for identifying connectivity utilizing Wi-Fi, this circuit is the main connecting link between all of the components. Despite AVR processors and partially utilized as the same as MCU Arduino [80]. As a result, the module is based on the Arduino IDE C++ compiler. New requirements were introduced for the ESP8266 module to reduce the number of components and shields needed to complete a certain operation.

The Arduino core is dominated by the ESP8266 Wi-Fi, which is widely available on the GitHub ESP8266 core homepage. The ESP8266 is a full and self-contained Wi-Fi networking solution, capable of hosting or delegating all Wi-Fi networking functions to a supplemental application processor. Immediately after the function is hosted by the ESP8266, which is the only application. The processor in the gadget boots up immediately from an external flash is used.

3.2.2. ESP8266 Pin out and Functions

Figure 1. Describes the various pins on the Node-MCU microcontroller. With transmitter and receiver pins, 17 GPIO pins for general purpose input /output functions. To collect data, all of the sensors are connected to the microcontroller's analog and digital pins.

Ground: These pins are connected to the ground of the circuit. GPIO – 1: Connected to Rx pin of a programmer to upload program.

GPIO-2: General purpose Input/output.

CH_EN: Chip

Enable – Active high.

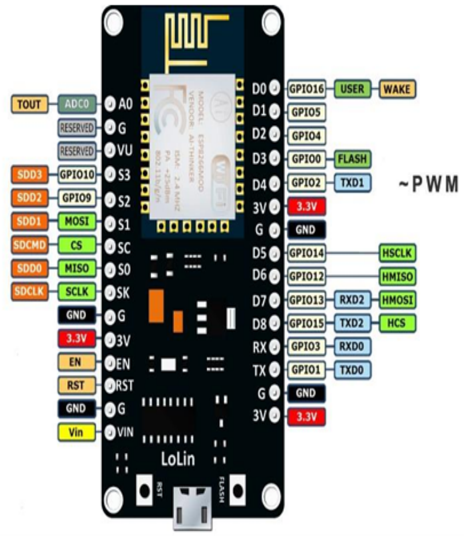

Figure 1. ESP8266 Module with pin diagram

3.3. Features

The NodeMCU version used in this example is DevKit1.0.

It's simple to use on a breadboard.

It is tiny in size and light in weight.

It is compatible with the Arduino C programming language.

The NodeMCU is fueled by USB and operates at a voltage of 3.3V.

It uses the 802.11 b/g/n wireless standards.
The ESP-12E chip has a PCB antenna.
It also has built-in functionality.
The CP2102 Serial Communication Interface Module is used.
It's simple to use with Arduino.

3.3.1. DHT11 Sensor

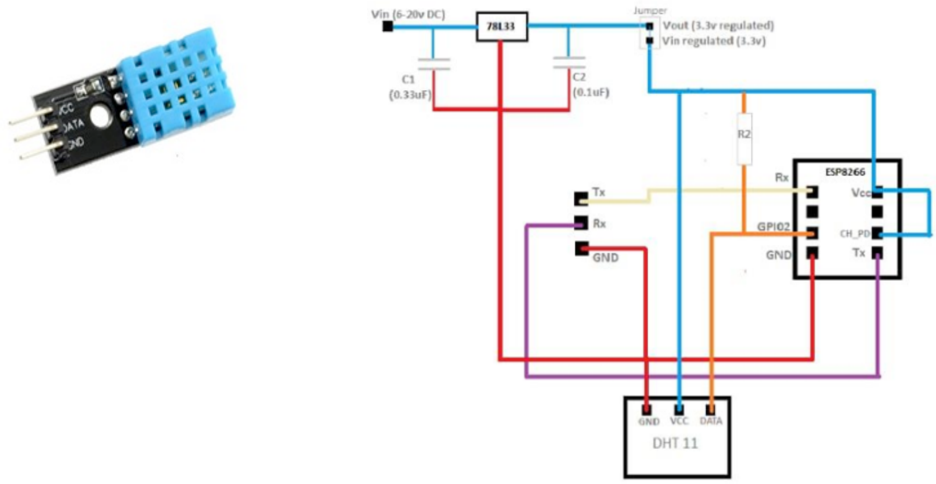

Figure 2. DHT11 sensor and ESP8266 Circuit.

This sensor operates as a cheap digital humidity and temperature sensor. Considering the usage of an ADC, this sensor generates a digital signal and might also be directly connected to microcontroller data ports.

It also has an eight-bit microprocessor that can send serial data with temperature and humidity measurements. VCC, GND, DATA, and NC are the four pins. It is powered by a 3.3-5volt source.

3.3.2. Connection Table

1. DHT-11 sensor has three pins, two for power and one for data transmission.
2. Connect all three pins to the Node MCU.
3. Connect the VCC sensor pin with the VIN pin of Node MCU.
4. Connect GND (Ground) sensor pin with GND pin of Node MCU.
5. The last pin OUT pinned with a digital-2 pin of Node MCU.

Table 2. Connection of DHT11Sensor and ESP 8266 Node MCU.

Dht11 Sensor	ESP 8266 Node MCU
VCC (+)	Vin(+5V)
GND	GND(Ground)
OUT Pin	D2 Pin

3.3.3. Breadboard

A recent breadboard circuit is made mainly of a pierced block of plastic with several tin-coated phosphorus metals or under the slots are platinum silvery metal spring's clips. The amount of control points on a breadboard is typically stated in the design.

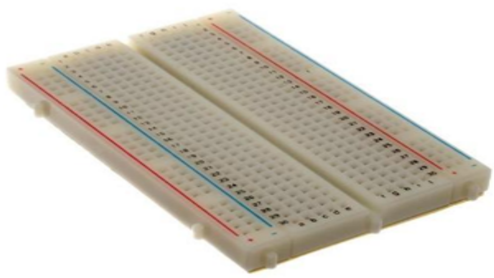

Figure 3. Bread Board

In most cases, the pitch of the leads (the spacing between the clips) is 0.1 inches (2.54 mm). Integrated circuits (ICs) in dual in-line packages can span the block's centerline (DIPs). To connect a breadboard to a computer, jump wires are typically utilized.

3.3.4. Jumper wire:

A jumper wire is an electrical cable that is used to quickly connect two devices. It facilitates the connection of devices without the need for solder. Jumper wires are mostly utilized in breadboard connections to make quick adjustments.

Male to female, Male to male, and female to female are three forms of jumpers. Although jumper wires are available in several colors, the colors have no meaning.

Figure 4. Jumper Wire

3.3.5. Power Bank 5v

The Microcontroller and other modules/sensors are connected to a power bank as a backup supply, just in case, something happens with the system. A normal voltage (5 volts) is required by computer processors and drives.

The power source converts 120 volts alternating current (AC) to 5-volt direct current (DC), 3.3 volts, and 12 volts (Sparkfun,2021).

Figure 5. Power Bank.

3.3.6. GSM Module

The second generation of mobile technology is the Global System for Mobile (GSM) communication.

Because the world is advancing toward the third and fourth generation, GSM has been the most successful and widely used communication technology. In this experiment, we're using a GSM module to communicate with an MC microcontroller. With the help of MC, the message will be sent to a specific GSM mobile number via AT instructions.

Figure 6. GSM Module

3.3.7. Software: Arduino IDE

An Arduino Integrated Development Environment (IDE) is an inter software written in C / C++ that is available for Windows, Mac, and Linux. Only with services of a third core, it is used to write and post applications to Microcontroller-based boards as well as other capability building boards. To accommodate the languages C / C++, the Arduino IDE includes its own coding structure rules.

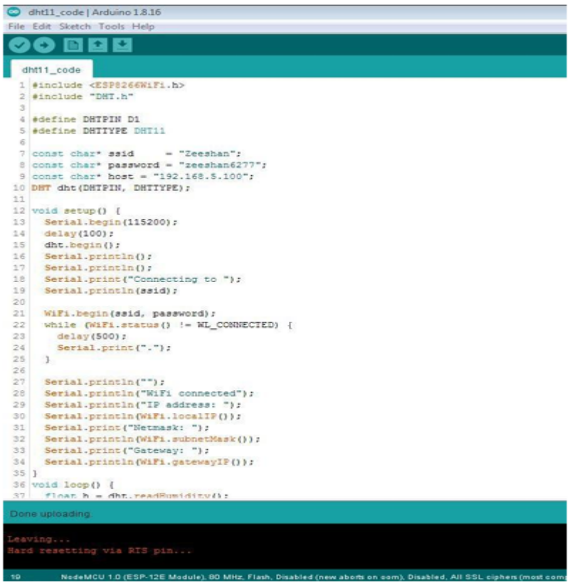

Figure 7. Arduino IDE

3.3.8. Software Connection

Software portion contains code required for NodeMCU to achieve goal. Algorithms are designed to regulate how the microcontroller operates and reacts in various conditions, such as reading the sensor's input signal, flashing LEDs. For the software application, C programming has been chosen as the main software used for the NodeMCU.

3.3.9. Software implementation

This system is designed using the Arduino IDE software and the Embedded C programming language. The Arduino IDE is a multi-platform development platform for programming microcontrollers. It's a free and open-source application. Embedded C is used to assist the embedded device.

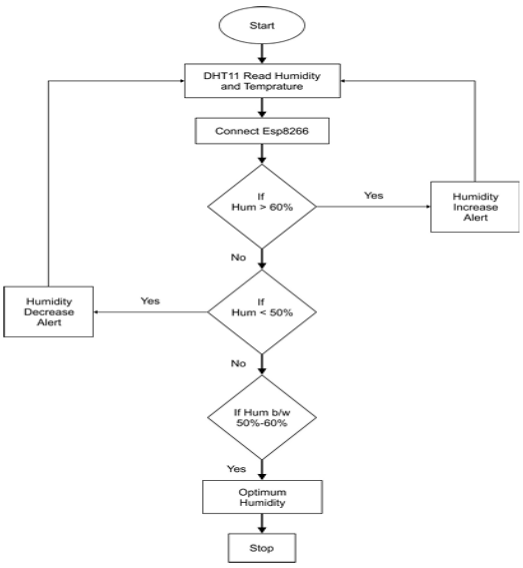

Figure 8. Flow chart of a complete system

3.3.10. Work Flow

Here, purposed the model for controlling the humidity and generating the alert shows the related solution according to the humidity effects. In this methodology, there are 2 parts in 1st part of the humidity asses using a humidity sensing sensor. DHT11 sensor is used for assessing the humidity level from the environment and it sends to the Node MCU that uploads real-time values to the web Server and Humidity and temperature values are displayed on a web page. Humidity levels are given below in table 3.

Table 3. Sensor Data comparison.

Parameters	Sensed Data	Alert	Decision
Humidity	Humidity<50	Humidity Decrease	Irrigation Required
	Humidity>50	Humidity Increased	To increase the time interval of irrigation
	If humidity between 50-60%	Optimum Humidity	Irrigation not Required

Figure 8, summarizes the working mechanism of the system in a flow chart. It indicates that after the system is configured, the NodeMCU connects to Wi Fi and begins accepting readings from the DHT11 sensor. The DHT11 sensor readings are accepted by the Esp8266 and compared to the set threshold values. The DHT11 sensor values were divided into three main categories of humidity that affect the crop. The readings are taken from the humidity monitoring system, which is connected to the surface wheat crop through the DHT11 sensor. If the humidity level is at a normal state, the message "humidity is optimum for the crop" is sent. If the humidity level is increased, it sends the message as "crop in unsafe adopt precautionary measures ". If the humidity level decrease, the message as “Do irrigation” message is sent.

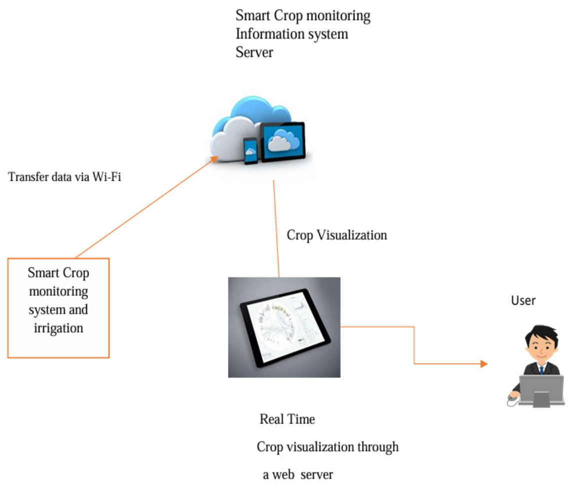

Figure 9. Smart Crop monitoring system and irrigation system.

3.3.11. System Analysis

The system analysis is presented in figure. 10 where the wheat crop monitoring and irrigation system detects humidity levels. Furthermore, the smart crop monitoring and irrigation system send the data of humidity conditions to the smart crop monitoring information system server using Wi-Fi. Data entering the Crop monitoring information system process the data and visualization are done in real-time. Data can be visualized and accessed by the online user.

3.3.12. Design System

As shown in Figure. 10, the design system for this project explains the material requirements. The prototype of the system is divided into two parts: the design of a Wheat Crop Monitoring Information

System and the irrigation decision. Sensors, such as DHT11 sensors that monitor temperature and relative humidity, are used as inputs in the crop monitoring system to determine crop conditions. The ESP8266 is used as a CPU and is connected to sensors. The web application is used to analyze humidity and temperature in a crop monitoring, and the GSM Module is used to send an alert.

There are several supporting software systems, such as XAMPP and Web programming tools, as well as a set of software systems, such as Crop monitoring and irrigation systems. XAMPP is a server application that includes a PHP engine, which acts as a PHP programming language processor, Apache Web Server, and MySQL, which acts as a database management server. The server component system's development manages the data received from the crop monitoring and irrigation systems, storing it in a database that users can access. While web programming is a part of web development.

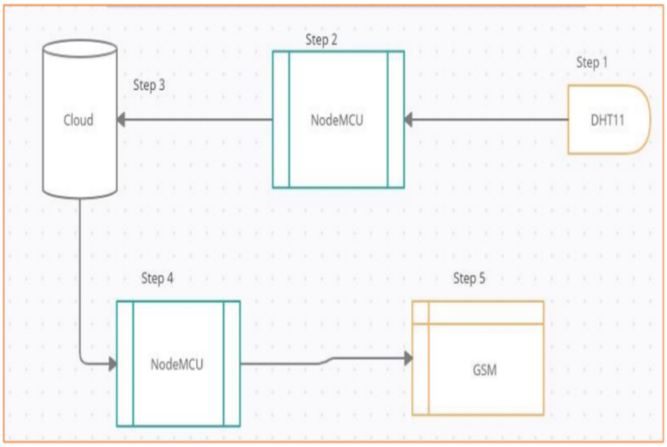

Figure 10. System Design.

3.3.13. Developed Model

The system consists of both software and hardware components. The equipment aspect is consisting of consumer applications, whereas technology refers to the MySQL website. The website is available on the internet and consists of a repository into whatever sensor readings from the technology are recorded.

3.3.14. System Verification

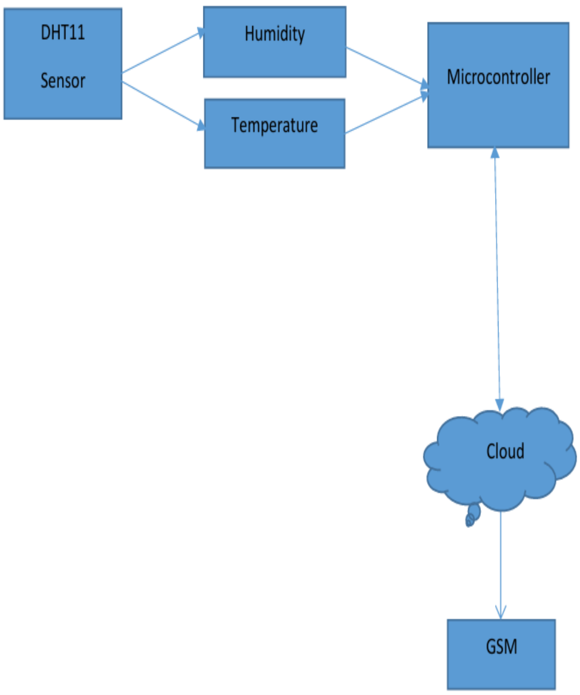

Figure 11. Block diagram of the system.

The crop monitoring and irrigation system composed of DHT11 sensors, NodeMCU, web server, and GSM has been tested and analyzed for confirming that the system can give the alert message. The DHT11 sensor, NodeMCU, and GSM has been checked to be sure that they are working properly

Figure 12. Sensor deployed in Wheat field

4. Results and Discussion

The DHT11 sensors are deployed in the wheat crop for data collection. The data is further evaluated in the form of temperature and humidity from the wheat crop field and send the values of both parameters on daily basis to the farmer. When the humidity exceeds its optimum range (50-60%), then the farmer needs to take preventive action.

The microcontroller, which interfaces with other system components, is the fundamental hardware part of the implementation system. Because the system integrates humidity and temperature management, only one device interface is required and no main data storage is required. This is based on Arduino IDE with a microcontroller. In this system, the sensor detects the humidity and temperature first. Humidity and temperature are displayed in real-time. It is required for plants to grow in level-based systems.

Again, the method is advantageous when it comes to water scarcity issues. The values are uploaded within the time limit using the ESP-8266 Wi-Fi system. The temperature and relative humidity standards are then measured from the cloud using a single Thing Speak platform from anywhere. The data is transmitted live to the farmer mobile phones through GSM Module. They can also keep an eye on their plants from their homes.

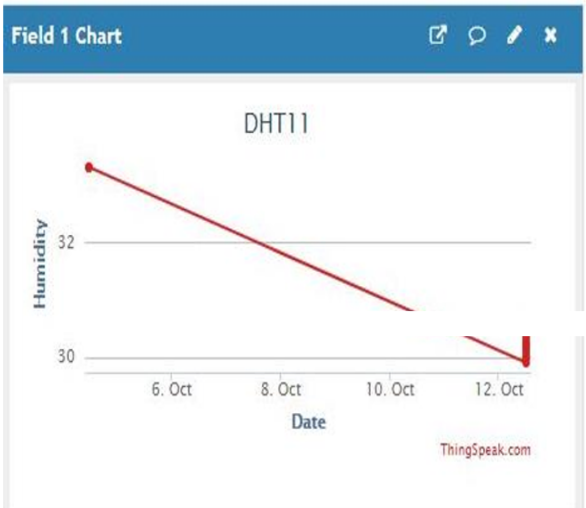

Figure 13. Humidity variation graph

Figure 14. Temperature variation graph.

4.1. Execution

The NodeMCU module is powered by a USB connection, and it is attached to a DHT11 sensor, as well as a GSM module for alarm signals. The Wi-Fi module receives input from the various sensor and is powered by a battery. The USB cable not only provides electricity but also transports data from the device. When the temperature and humidity exceed the threshold, we have established the default value in software programming. When temperature and humidity values go up and down from the default value which acts as an alert signal.

4.2. Results

Based on the inputs from the various sensor, the result of various environmental factors such as temperature and humidity measured. We choose two fields on Thing Speak for this work. We've put humidity in the first field and temperature in the second. The graph in Figure. 14. Depicts humidity vs. time, with variations in humidity updated every 5 seconds. The humidity may be found here, and the average value is 34.

Temperature vs. time is depicted in Figure. 15. Where the temperature changes are updated after some time

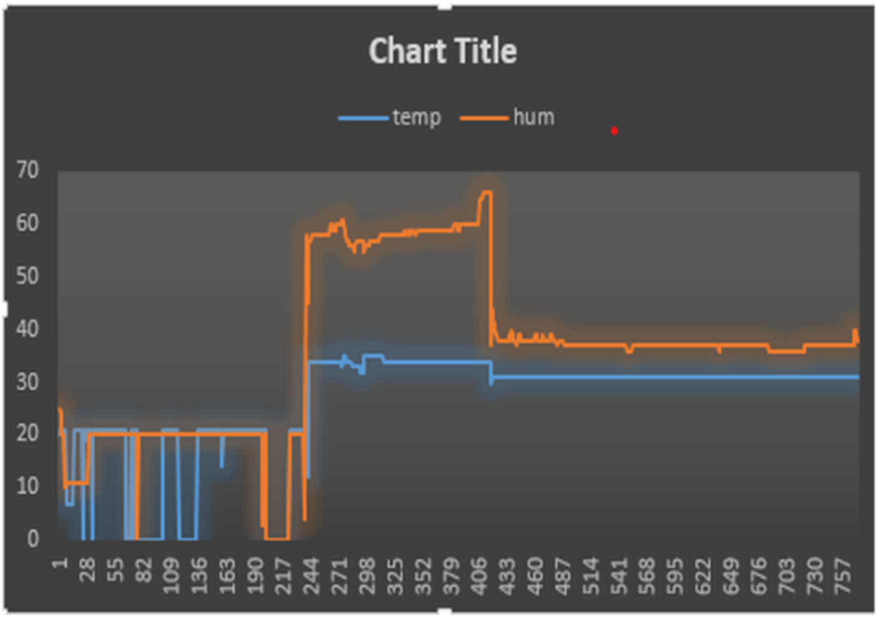

Figure 15. Graphical representation of humidity and temperature.

These sensor readings are transmitted to the database server. Authorized users can access this data from the cloud via the IoT application platform. The local host displays the humidity and temperature sensor information in figure 16.

A graphical representation of temperature and humidity is given below in the figure 17. Farmers take appropriate action which is based on these values. If the humidity is between 50%-60%, desired optimum level that is healthy for wheat crop.

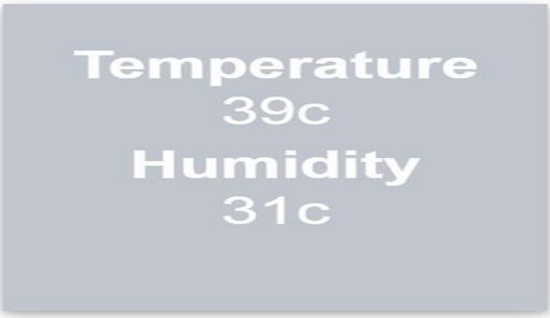

Figure 16. Temperature and Humidity values on the local host.

5. Conclusion

The crop monitoring wireless model based on DHT11 sensor and a NodeMCU ESP8266 to retrieve real-time data. The data collected by NodeMCU is sent through interface to the ThingSpeak monitoring system. The ThingSpeak server adjusts data sent from the designed system on the basis of real-time visualization of humidity and temperature data at a specific place. The system prototype confirmed and worked properly for deployment in southern Punjab remote fields. This monitoring system technology solution helps to manage the humidity and temperature influence on the crop while assisting the optimal use of water. The best performance for crop monitoring solution with high accuracy is being observed after analyzing the features of IoT based wireless application. The IoT based smart model provides wireless data transfer with higher accuracy for guidance of farmers to enhance wheat crop productivity. The farmer can visualize data and receives a message alert from the GSM Module based on the data analysis of the received message. In future, the same model can be employed with state of the art algorithms to enhance productivity and cure against plant disease.

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