International Journal of Computer Science, Engineering and Applications (IJCSEA)
Vol.11, No.5, October 2021

# IoT Based Smart Irrigation System by Exploiting Distributed Sensorial Network

Md. Omar Faruk and Tarun Debnath

Department of Information and Communication Engineering, Pabna University of Science and Technology, Pabna Sadar-6600, Pabna Bangladesh

***ABSTRACT***

*In this research the Internet of Things (IoT) based smart irrigation system is developed for large scale farming to ensure appropriate water management as well as to minimize unnecessary water utilization. This system can control water wastage for irrigation purpose by using wireless sensor network (WSN) and IoT. Each WSN node contains a unit of combined sensors which has been made by several external sensors such as soil moisture, soil pH, and temperature sensor along with Node MCU for data transmission in the cloud. Other nodes are distributed in the field to collect field data for different positions and this information is sent to the server. Data processing and analysis are performed according to the proposed algorithm. Obtained result as well as weather forecasting report is checked for three days from a developed android app. The accomplished result is sent to the farmers through SMS; depending upon the SMS, farmers take necessary steps for watering or not in the crops field through IoT. Using the particular sensors in this system along with microcontroller board plays an important aspect for bringing automation for a particular model. In this work wireless sensor technology in irrigation purposes can show the direction to the rural farming community to replace some of the traditional techniques.*

***KEYWORDS***

*Internet of Things (IoT), Weather Forecasting, Android App, WSN and Smart Farming, Threshold value.*

## 1. Introduction

Agriculture is one of the important sectors in Bangladesh. This sector contributes about 14.23 percent to the country's Gross Domestic Product (GDP) and employs around 40.60% of total labour force [1]. Water is one of the most important factors for better production of crops. But still now traditional irrigation methods have been used in our country that methods are not much more efficient. According to the information of Bangladesh Agricultural Development Corporation (BADC) about 50 Billion Cubic Meters (BCM) is lifted from underground and 20 BCM from surface whereas 32.50% water is misused from underground water and 13% from surface which means billion of litres of water is wasted every year. If farmer's misuse of water keeps rising, the layer of underground water will go down day by day [2]. On the other hand, water usage is increasing day by day along with the population increasing in this country. As a result, this rapid demand of natural groundwater has become our main concern at this moment. Now a days sinkhole is being observed across worldwide. Sinkholes are giant holes in ground, created naturally. Sinkholes are being found in North America, Venezuela, China, Papua New Guinea and India. It could also be a threat to the crop production of Bangladesh. The main reason behind these largest holes is heavy suction of ground water [3]. Cultivation or farming sector has been using major water rather than daily household use [4]. Although, water usage in cultivation cannot be eradicated, it can be minimized. Already researchers have proposed a lot of mechanism to reduce water usage. Authors in [5] have introduced a mechanism to improve crop water

DOI: 10.5121/ijcsea.2021.11501 

efficiency and regional water productivity by a novel irrigation method. Authors presented an IOT based irrigation system that monitors soil moisture and temperature and performs data analysis. Based on the deviation from sensor data user is informed via text messages. This study found that, in a moderate temperature plants can sustain at low moisture level [6]. A sustainable agriculture monitoring system and automatic irrigation system using raspberry pi camera, soil temperature humidity and moisture sensor is proposed by another researcher who uses real time data transmission from sensors to the server and farmers can turn on motor by logging into the server [7]. Authors in [8] have developed a field monitoring mobile application based on GPS, motion sensor, temperature and humidity sensors. However the only limitation of this paper is that, the implementation of this work is not feasible for large areas of land. Authors in [9] have offered a smart crop-field monitoring and automation irrigation system using two sensors for collection of data and the day time calculation. This method calculates the need of water. However, the paper introduces a wired hardware kit, which is difficult to integrate in Wireless Sensor Network (WSN). It can only detect field data for a particular position. Authors in [10] have developed an IoT based field data monitoring system using MicaZ nodes and WSN. Using the developed system user can both access and observe light intensity, temperature, and humidity and battery voltage information over internet but this technique does not control any actuator function like irrigation motor on-off activities. In another paper, authors have represented a survey on current state of irrigation system by explaining water quality, soil characteristics and weather conditions and authors have also discussed the challenges such as water quality reduction, water shortage, increase of soil salinity and biodiversity loss for sensor based irrigation model [11]. All the paper introduces recent trends and technologies used in precision agriculture to save water usage in agriculture. The limitations from the study can be found as most of the proposed techniques do not concentrate on weather forecasting result. It should be added that the farmers in developing and under developed countries lives below poverty line they may not be interested to implement the system. No research was found to implement IoT based irrigation model in large scale. By addressing these limitations this paper introduces an IoT based novel technique for automatic large scale farming by implementing soil sensors and weather forecasting report for upcoming days. In this paper, a number of data collection modules are distributed across the field. These data collection modules can collect soil pH, temperature and moisture information, which is achieved through soil pH sensor, DS18B20 temperature sensor, and low cost soil moisture sensor. Each module consists of a rechargeable power unit which will be recharged through solar panel. The data processing unit of this module is Arduino and after processing data the Node MCU transmits data over Wi-Fi network. The data collection is done after every 3 hours. Later data analysis is done using threshold value and a decision message is developed for a dedicated person, who may be an agriculture officer for monitoring data. If irrigation is required at this stage, a customized android application will be used to observe whether forecasting report for the next 2 days using location of the user. The mobile app will automatically generate suggestion and forecasting report for the agriculture officer. Later he can select specific farmer from the mobile application for sending decision support message about irrigation. Through this way, a large area of agricultural land which is owned by a number of farmers can be served with minimal groundwater consumption based on IoT and weather forecasting report.

## 2. PROPOSED SYSTEM

The system is made by mainly two parts - one part is hardware and another is software. The hardware part consists of various sensors, microcontroller, memory etc. While the software part consists of applications which are made android based. All components are connected to the Arduino board and other hardware components using internet of Things (IoT). The field data are collected form installed sensors and are stored using hardware via the android based application. This research tries to build an automatic irrigation process that will be enabled for data collection, data processing, and monitoring and finally taking decision for right time irrigation using required quantity of surface or groundwater. The block diagram of proposed irrigation system is shown in Figure 1.

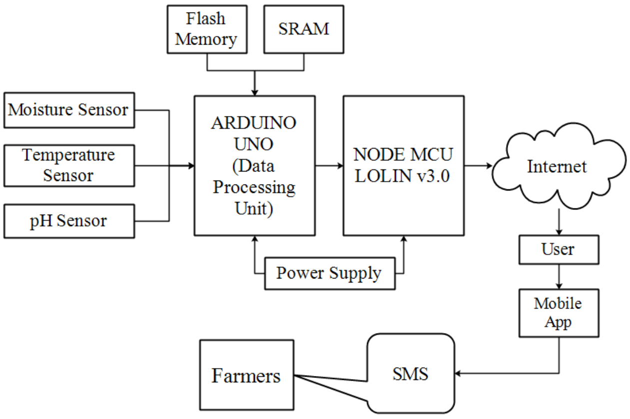


Figure 1. Block diagram of the system.

## 2.1. Hardware Unit

### 2.1.1. Field data

The data that measure soil pertinence for cultivation is termed as field data. These data plays the most important role for better food production as well as their imbalance in soil is responsible lower food production. Researchers have already studied the factors, and have fixed a range for each factor. After studying the factors, soil temperature, moisture and pH level of the soil are taken into account. These factors can be measured by temperature sensor, moisture sensor and pH sensor sequentially. There are some other factors such as nitrogen, phosphorus, and potassium, which are more important for the plants and can be measured by NPK sensor, but our intention is to develop an automated irrigation system that will reduce the unnecessary water usage. So, field data will be considered as soil moisture, temperature and pH level of the soil in a combination.

### 2.1.2. Data Collection Module

As the factors measuring sensors are available in the market, and the costs of these devices are not too much, we can develop a data collection module to collect field data. The data collection module consists of three sensors - temperature sensor, moisture sensor, and pH sensor. As there is only one analog input in the Node MCU, an Arduino processes these data in the appropriate format and Node MCU is used to send data to server using Wi-Fi network. To power up all the devices a battery or power supply is required. In addition the large distributed network requires a large amount of power. To reduce the power each module contains a 5 volt DC power supply. In spite of doing so, the module battery requires a recharge system, otherwise it will lose its power after certain time. In order to take care of it, we have added an additional 5 volt solar panel with LDR (Light Dependent Resistor) sensor. This will provide the data collection module more sustainability. The brief summary of the sensors and components is provided below:

#### 2.1.2.1. Temperature sensor

Temperature sensor is one that senses the environmental temperature from its surrounding environments and provides a corresponding reference voltage supplied to the sensor. Soil temperature is the factor that varies from day to day. The heat energy is stored by soil in day time and acts as heat source at night [12]. Soil temperature influences plant growth and chemical and biological ingredients of soil. So, soil temperature should be considered to maintain at a uniform rate and this can be solved if it is possible to measure the soil temperature accurately and the sensor precision can be maintained for long time. By considering these issues we have chosen the DS18B20 temperature sensor probe that is shown in the Figure 2. This sensor is capable of covering $-10^0\mathrm{C}$ to $+85^0\mathrm{C}$ with an accuracy of $\pm 0.5^0\mathrm{C}$. Moreover these sensors are water proof and are developed specially for wet environment which is suitable enough for our system development.

Figure 2. DS18B20 Temperature sensor.

### 2.1.2.2. Moisture Sensor

The soil moisture sensor detects the amount of moisture in the soil. This sensor contains two probes which are aligned in parallel. The detection mechanism of this sensor is passing current through this probes and measuring resistance between them. In case of dry soil there is less amount of water. Probes pass less current through this water and shows higher resistance. Similarly, soil containing more water, passes current through these sensors, as a result less resistance will be detected. The controlling module of the sensor calculates moisture level by this resistance. These sensors are cost effective with wide operating voltage such as 3.3V-5v, dual output mode including digital and analog output interface and are highly stable.

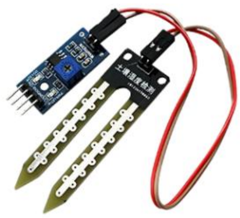

Figure 3. Soil Moisture sensor module.

### 2.1.2.3. $pH$ Sensor

Soil pH is another important factor for plant growth. Soil can be both acidic and alkaline type. An acidic or alkaline soil can damage trees growth. So, pH perfection is a crucial element for healthy plants. pH value is measured based on Hydrogen ion concentration. This is measured in the scale of 0 to 14. While 7 is considered neutrality, less than 7 indicates acidity and more than 7 indicates that the concentration is of alkaline type. It is observed that different types of soil have different pH values in the range of 3.5 to 10 and the standard is considered as 6.5 to 7.5 [13]- [14].

Figure 4. Soil $pH$ sensor.

To measure the pH value we have used soil pH sensor rather than traditional pH sensor and the sensor output is mapped into 0 to 14 through data processing unit.

### 2.1.3. Data Processing Unit

For processing data from sensors and transmitting them to server via Node MCU an Arduino board is used. Arduino is an open source hardware and software platform. Arduino boards are being used as the brain of a huge number of projects. For having inexpensive device, cross-platform, simple, clear programming features, Arduino boards are used in many system development purpose. There are several versions or boards those can be used to develop any system as per requirements. These are Arduino UNO, Mega, Nano, Pro-mini, Fio, Lilypad and many more. Here, an Arduino UNO is used. The reasons behind choosing this device are that they have 6 analog input pins, 14 digital I/O pins, 5v dc operating voltage, with 7-12volt varying input voltage. It could be replaced by the Arduino pro-mini which will transform the system into a miniaturization version.


Figure 5(a). Arduino UNO Figure 5(b). Arduino Pro Mini
Figure 5. Arduino Board

### 2.1.4. Data Transmission and Scheduling Unit

The requirement of data scheduling unit arises from two issues. First issue is that the above mentioned module processes data for transmission to server but we do not require transmitting the data for all time. Arbitrarily it's quite enough if we send data after a few hours. The second issue is that we need to save power as much as possible for each module, so that it can cover minimum 1 or 2 days. So, two issues can be solved by introducing a scheduling approach, which can be achieved by Node MCU.

Figure 6. Node MCU (LOLIN V3.0)

It's an open source IoT platform having embedded hardware and firmware, which is inexpensive and widely used for IoT based applications. As this device includes a Wi-Fi System on Chip (SoC), data can be sent to server over internet by programming [15]. This device hears the data from Arduino after everythree hours and sends them to a dedicated server and remains in silent mode for rest of the time. It includes firmware embedded in ESP8266 Wi-Fi SoC and ESP-32 bit MCU unit as hardware. The motives behind choosing this device are having low operating voltage and input voltage such as 3.3v and 4.5v-10v DC supply respectively. A 4MB of flash memory and 64KB SRAM are included. Moreover, it can work at a wide temperature range, i.e. $-40^0\text{C} - 125^0\text{C}$[16].

### 2.1.5. Power unit

Driving power for the entire system is supplied by the combination of solar panel and battery. A solar panel provides energy transformation from sunlight to electricity. This is achieved by using the embedded photovoltaic cells in the solar panel [17]. As we are concerned about the WSN and the application of the system in large scale, we have to provide power individually for each data collection module. That could be done by using a battery but to make the system energy efficient and reusable we need to recharge the battery. In fact, it is not easy but it could be feasible by using a solar panel with LDR (Light Dependent Resistor). This will ensure proper usage of solar power in day time for driving the sensor modules in the network and when the system is idle (not sending data through the network), the panel could be used for recharging the battery.

Figure 7. Solar panel.

For successful data transmission at night the sensor module will use battery power at night. In this prototype we have used 3.7volt li-ion battery. For increasing battery life or capacity more than a single battery are used in parallel. The solar panel used here is of 5 volt that provides maximum 5.10 volt at full sunlight.

#### 2.1.6. Data Analysis

The soil ingredient changes from day to day and season to season. So, the data analysis method cannot be set properly. In that case, thresholding can be a fruitful solution. Using thresholding technique we can easily set the edge values for the soil. As large area coverage Wi-Fi device is used, a star topology approach is followed for collection of data from the nodes. It must be noted that the threshold value selection should be done carefully, which can be set manually.

### 2.2. Software Unit

Arduino is open source hardware and software platform as mentioned before. An Arduino IDE is cross platform application software for all operating system, which is used for firmware development for any Arduino board. Using Arduino IDE one can develop any customized system through logical statements. This IDE uses C++ and C language structure for coding Arduino devices. The main benefits of the platform are that it supplies a lot of library functions, through which one can easily program any peripherals with the dedicated hardware and expansion boards. Moreover, it includes a lot of features, such as brace matching, syntax highlighting, error checking etc. In this work, both NODE MCU and Arduino are programmed using this IDE. The Arduino UNO is programmed for sensing data, while Node MCU programmed for data scheduling and transmission [18]- [19].

## 3. SYSTEM FLOWCHART

In Figure 8, the first part aims to ensure water irrigation necessity based on field data analysis along with thresholding process where pH, moisture and temperature value has been compared with respective selected threshold value. Selection of threshold value has been discussed in later section. At the end of this section, a decision message is developed for the agriculture officer. Here, the decision message confirms water irrigation obligation by this developed message. The first part of the system ends and the second part of the system is initiated. Here, a star topology is used in which sensor nodes are placed in the field area. As sensors are deployed in the field according to the mentioned topology and base station is stationary, it collects data from sensor nodes for different angles and processes them. In this case, Wi-Fi device is used for large area coverage and it must be noted that the threshold value should be done carefully, which can be set manually from the server. The information belonging to the soil are sent to the Arduino, which is resent to the server via Node MCU. Later, first decision message is developed based on threshold value comparison. The second part is initiated if and only if the water is required for irrigation. If water irrigation is required, a developed mobile application will be taken in hand to observe and analyze the weather forecasting report for that particular area as well as it will be observed for the next 2 days.

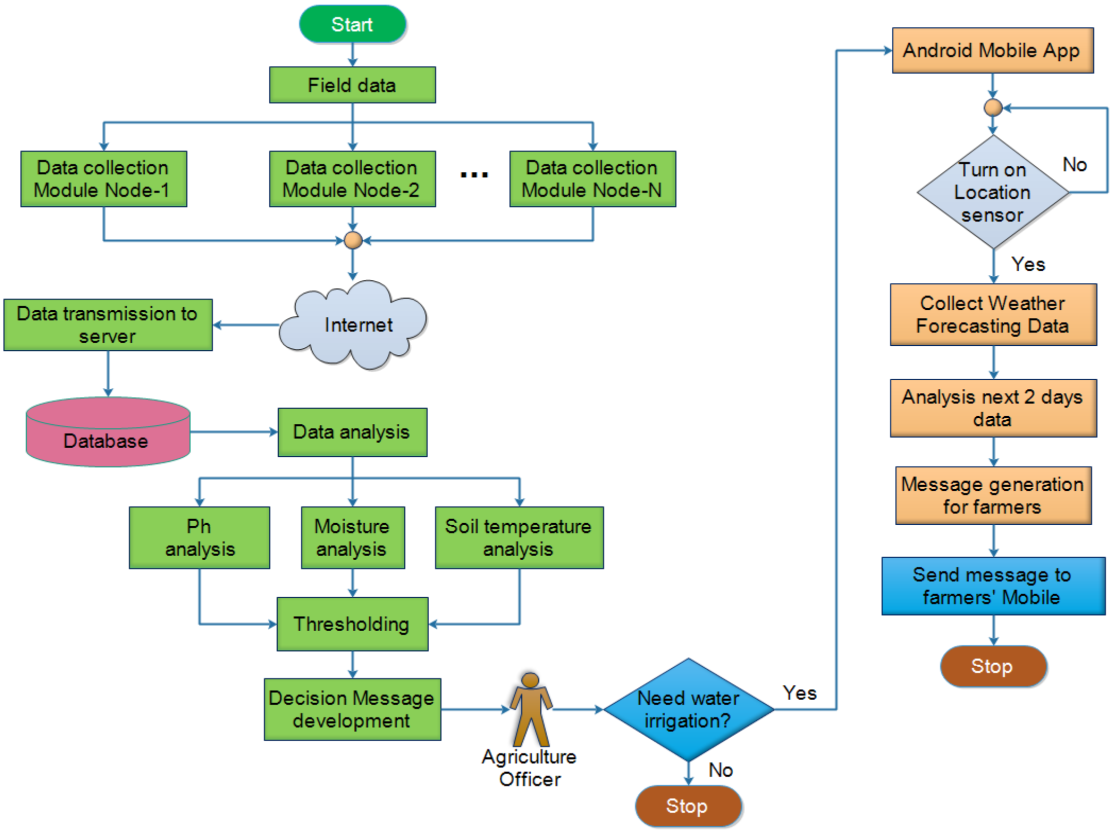


Figure 8. Flow chart of the entire proposed methodology.

The developed mobile application will collect weather data and finally a message will be generated for the farmers and will be sent to the farmers' mobile. The flowchart of the proposed irrigation system is shown in Figure 8. Importance, necessity and actions of different hardware and software are already discussed in section 2.

## 4. Android Mobile Application

The essential mobile application is developed in Android Studio by JAVA android programming. The main function of the android application is to generate suggestion from weather forecast of three days. The required data is integrated through weather forecasting API. These data are fetched from [20], which takes number of days and location as argument and provides data in JSON format. Later these weather forecasting data are translated, retrieved and further processed for the user. However, for simplicity the app UI (User Interface) is described here. After installing the mobile application, the home layout will appear first. This home layout is shown in the Figure 9(a). The home layout will take city name as input. The city name is converted into latitude and longitude; otherwise it will be fetched from the location sensor and passed into the API. The process requires internet connectivity for the entire operation. If an appropriate city name is inserted, then the "view report" button will let the user to view a summary of total 3 days weather forecasting reports as shown in the Figure 9(b).

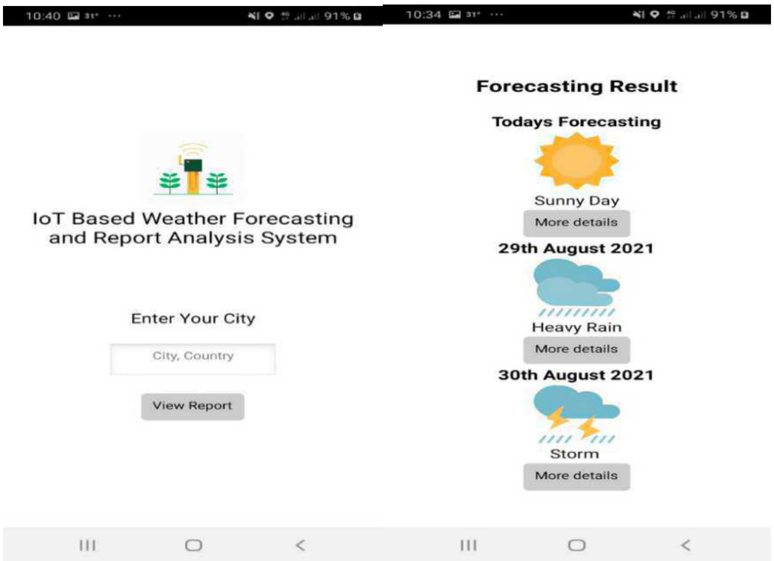


Figure 9. (a) Android application home layout (b) Weather forecasting result at a glance

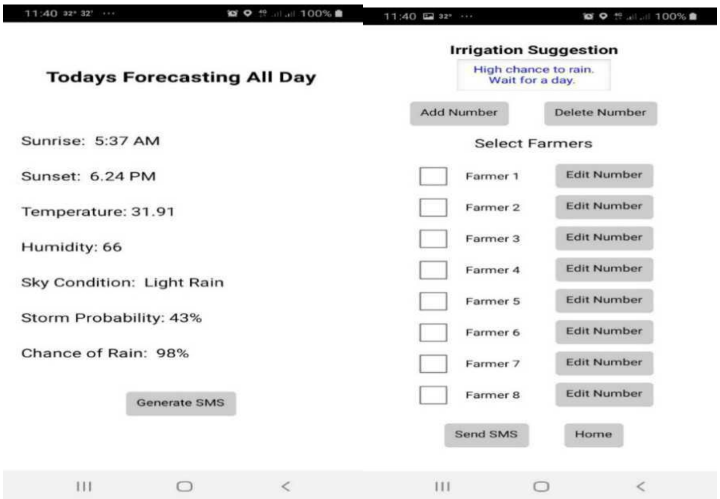


Figure 10. (a) Present day forecasting result (b) Irrigation suggestion and message sending layout

Here, the user can show that day's weather condition and next 2 days weather condition details in three isolated layouts. This number of observation days can be extended up to 16 days from the open weather map API. The forecasting result of three days weather conditions can be viewed by text and weather icon. A user can see weather in details by pressing the "more details" button from any of the three buttons. In Figure 10(a), the layout shows forecasting result in details, which includes sunrise, sunset, overall temperature, humidity, sky condition, storm probability and chance of rain. From any of the three details page the user will be redirected to the irrigation suggestion layout. This layout will be generated and displayed an irrigation suggestion based on the present day and next two days weather results as shown in Figure 10 (b). If the app detects more possibility of rain it will generate a related message and let the user to send message to the farmers. From Figure 10(b), the user or agriculture officer can select any number of farmers later he can send the message to the farmers by tapping the send SMS button. The layout also provides Add, Delete or Edit options for modifying farmer's contact number.

## 5. Result and Discussion

The image shown in Figure 11 was taken at the time of prototype or data collection module testing using renewable energy i.e. solar panel. The prototype tests were done properly and necessary precautions were followed for successful data transmission. Data are uploaded in the server based on time span.

Figure 11. Prototype image.

As mentioned before, depending on the threshold value, if any data deviation occurs, the system provides a message from the server to a dedicated number. Let, the threshold values of $pH_T, M_T, T_T$ are the threshold values for $pH$, Moisture and Temperature respectively.

Table 1. Message development from the server side

| **Temperature** | **Moisture** | ***pH*** | **Creation of Decision Message for Irrigation** |
|---|---|---|---|
| $Temp < T_T$ | $Moist < M_T$ | $pH < pH_T$ | No |
| $Temp < T_T$ | $Moist < M_T$ | $pH > pH_T$ | Moderate Irrigation |
| $Temp < T_T$ | $Moist > M_T$ | $pH < pH_T$ | Moderate Irrigation |
| $Temp < T_T$ | $Moist > M_T$ | $pH > pH_T$ | High Irrigation |
| $Temp > T_T$ | $Moist < M_T$ | $pH < pH_T$ | No |
| $Temp > T_T$ | $Moist < M_T$ | $pH > pH_T$ | High Irrigation |
| $Temp > T_T$ | $Moist > M_T$ | $pH < pH_T$ | High Irrigation |
| $Temp > T_T$ | $Moist > M_T$ | $pH > pH_T$ | High Irrigation |

The generated decision message at this stage confirms that the land needs water or not. In this experiment, the values of $M_T = 800, T_T = 30$ and $Ph_T = 7$ is assumed after certain level of testing. The following table will describe each possible scenario for the output of decision message development from the server side. The table 1 explains background decision algorithm. The highlighted lines indicate requiring irrigation condition based on the specific parameter. In this algorithm, high priority is set for the $Moisture$, then second priority is set for the $pH$ value and the third priority is set for $Temperature$. Then, if any two of index deviation is observed then high Irrigation is suggested. Otherwise moderate irrigation is suggested and observed for next time span. As soon as, the suggested decision message is developed for the android user, second stage suggestion will be required and the mobile application will generate that message. The generation of this message, involves an assumption and this is accomplished by the procedure shown below. In this procedure, we have considered a lot of weather conditions for our system and assigned a probability value for the calculation of rain occurrence [21]- [22]. The assigned value is determined from several agricultural officers and converted into probability. They have proposed the rated value in respect of Bangladesh. As a result, we have not considered some situations such as tornadoes, thunder snows, hurricanes, and sandstorms in this prototype. The scenario for rain occurring conditions are shown in table 2.

Table 2. Rain occurring condition with corresponding probability.

| Sl. | Weather | Occurrence probability on any day ($O_{pi}$) | Assumption of Chance of rain |
|---|---|---|---|
| 1. | Sunny/ Clear | 0.0 | Based on calculation and threshold value of equation (2) |
| 2. | Fog | 0.0 | |
| 3. | Partially cloudy | 0.1 | |
| 4. | Drizzle | 0.2 | |
| 5. | Cloudy | 0.3 | |
| 6. | Light rain | 0.4 | |
| 7. | Overcast | 0.7 | |
| 8. | Storm | 0.8 | |
| 9. | Heavy Rain | 0.9 | |

The Occurrence of rain involves a calculation based on threshold value$T$. The calculation involves N days of observation on weather condition. The value of N is 2 in this case. The determination of T is typical, i.e. if a wrong value is chosen it will not provide accurate result. So, observations are made for a particular time.  It is observed from the experiment, that if the threshold value becomes$T = 1$, then a significant rain is observed. Otherwise, the rain does not become significant. So, the occurrence of rain becomes 1 (true) if the certain condition shown at the right hand on the equation (1) satisfy and it becomes 0 (false) otherwise. This calculation is performed in the android background, which is the key point of decision message generation. The chance of rain occurring is calculated using equation (2).

$$Occurance\ of\ Rain = \begin{cases} 1 & \frac{1}{N}\sum_{i=0}^{N} O_{pi} > T \\ 0 & otherwise \end{cases} \quad (1)$$

$$ChanceofRain = \frac{1}{N}\sum_{i=0}^{N} O_{pi} * 100 \quad (2)$$

## 6. Conclusion and Future Scope

This system is found to be cost effective to reduce water consumption and to optimize water usage for agricultural production. Using the system, a large area for irrigation can be served through IoT and WSN. The devices used to design the system are chosen based on scalability and longevity. The outcomes from the server indicate an optimal monitoring through IoT from any corner of the world. In this proposed model, irrigation suggestion is established through 2 steps. For the first step, the selection of threshold values for server side application$M_T = 800, T_T = 30$ and $pH_T = 7$ are showing better performance than others. In the last step, occurrence probability calculation helps to take final decision. This ensures a lot of farmers can be served together through this system. As a result, it would be possible to save a significant groundwater. The system was developed concerning for real life application, to ensure autonomous irrigation support for farmers. In future, this system could be more efficient which may provide better information about user actions, nutrient level of the plants, time to harvest, etc. Incorporation of Machine Learning techniques could be more appropriate for enhancing the decision message development.

## ACKNOWLEDGEMENTS

I would like to express my profound gratitude and deep regard to the authority ofPabna University of Science and Technology for full funding to complete this project.

## REFERENCES


[1] B. B. o. S. (BBS), (2018) "Yearbook of Agricultural Statistics, 30th series," Statistics and Informatics Division(SID) Ministry of Planning Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

[2] M. Hoque, "Why Farmers in Bangladesh Waste 800 Liters of Water to Produce 1 Kg of Paddy," 2018. [Online]. Available: http://www.ipsnews.net/2018/12/farmers-bangladesh-waste-800-liters-water-produce-1-kg-paddy/.

[3] Tills Tony, "Sinkhole," Wikipedia Foundation, 2021. [Online]. Available: https://en.wikipedia.org/wiki/Sinkhole.

[4] X. Liu, Y. Ai, F. Zhang, S. Lu, X. Zeng & M. Fan, (2005) "Crop production, nitrogen recovery and water use efficiency in rice–wheat rotation as affected by non-flooded mulching cultivation (NFMC)", Nutrient Cycling in Agroecosystems, Vol. 71, No. 3, pp. 289-299.

[5] S. Kang, X. Hao, T. Du, L. Tong, X. Su, H. Lu, X. Li, Z. Huo, S. Li, & R. Ding, (2017) "Improving agricultural water productivity to ensure food security in China under changing environment: From research to practice", Agricultural Water Management, Vol. 179, pp. 5-17.

[6] P. K & Dr. S. Rathi, (2017) "AN IoT BASED SMART IRRIGATION SYSTEM", International Journal of Scientific & Engineering Research, Vol. 8, No. 5, pp. 44-51.

[7] R. Venkatesan & A. Tamilvanan, (2017) "A sustainable agricultural system using IoT", in 2017 International Conference on Communication and Signal Processing (ICCSP), Chennai, India.

[8] Dr. N. Suma, S. R. Samson, & S. Saranya, (2017) "IOT Based Smart Agriculture Monitoring System", International Journal on Recent and Innovation Trends in Computing and Communication, Vol. 5, No. 2, pp. 177-181.

[9] R. N. Rao & B. Sridhar, (2018) "IoT based smart crop-field monitoring and automation irrigation system," in 2018 2nd International Conference on Inventive Systems and Control (ICISC), Coimbatore, India.

[10] M. A. Akkaş, & R. Sokullu, (2017) "An IoT-based greenhouse monitoring system with Micaz motes", Procedia Computer Science, Vol. 113, pp. 603-608.

[11] L. García, L. Parra, J. M. Jimenez, J. Lloret, & P. Lorenz, (2020) "IoT-Based Smart Irrigation Systems: An Overview on the Recent Trends on Sensors and IoT Systems for Irrigation in Precision Agriculture", Sensors, Vol. 20, No. 4, pp. 1042.

[12] B. Onwuka, & B. Mang, (2016) "Effects of soil temperature on Some Soil properties and plant growth," Scholarly Journal of Agricultural Sciences, vol. 6, no. 3, pp. 89-93.

[13] Queensland, "Soil pH," 2016. [Online]. Available: https://www.qld.gov.au/environment/land/management/soil/soil-properties/ph-levels.

[14] B. Hailu & H. Mehari, (2021) "Impacts of Soil Salinity/Sodicity on Soil-Water Relations and Plant Growth in Dry Land Areas: A Review," Journal of Natural Sciences Research, Vol. 12, No. 3, pp. 1-10.

[15] W. Foundation, "NodeMCU," 2021. [Online]. Available: https://en.wikipedia.org/wiki/NodeMCU.

[16] PCBoard.ca, "NodeMCU ESP8266 Detailed Review," 02 October 2019. [Online]. Available: https://www.make-it.ca/nodemcu-arduino/nodemcu-details-specifications/.

[17] G. Singh, (2013) "Solar power generation by PV (photovoltaic) technology: A review," Energy, Vol. 53, pp. 1-13.

[18] Arduino, "What is Arduino?," 2018. [Online]. Available: https://www.arduino.cc/en/Guide/Introduction.

[19] S. Zafar, G. Miraj, R. Baloch, D. Murtaza, & K. Arshad, (2018) "An IoT based real-time environmental monitoring system using Arduino and cloud service", Engineering, Technology & Applied Science Research, Vol. 8, No. 4, pp. 3238-3242.

[20] O. Team, “https://openweathermap.org/api,” 2014. [Online]. Available: https://openweathermap.org/api.

[21] “Types of Weather,” fandom.com, 2012. [Online]. Available: https://weather.fandom.com/wiki/Types_of_Weather.

[22] A. Nicolae, A. Korodi, & I. Silea, (2020) “Weather-Based Prediction Strategy inside the Proactive Historian with Application in Wastewater Treatment Plants”, Applied Sciences, Vol. 10, No. 9, pp. 3015-3032.

## AUTHORS

**Md. Omar Faruk,** received the B.Sc., M.Sc. and the Ph.D. degree in Applied Physics and Electronic Engineering from University of Rajshahi, Bangladesh, in 1994, 1996 and 2012 respectively. He worked as an Assistant Instrument Engineer from 2001-2004, Instrument Engineer from 2004-2008, Senior Instrument Engineer from 2008-2011, and Principal Instrument Engineer from 2011-2013 at Science Workshop, University of Rajshahi, Rajshahi, Bangladesh. In 2013 he joined the department of Information and Communication Engineering of the Pabna University of Science and Technology, Pabna, Bangladesh as an assistant professor. He was promoted to Associate professor in 2019. His research interests include Seismology, Machine Learning and Internet of Things.

**Tarun Debnath**, has completed his B.Sc. in Engineering from the Department of Information and Communication Engineering of Pabna University of Science and Technology in 2016. After completing B.Sc. degree, he joined as a lecturer in the same department of Pabna University of Science and Technology, Pabna, which is one of the prominent universities in Bangladesh where he is serving with devotion. He has published several journal articles in the field of embedded system design.