IoT based Smart Irrigation System at University of Chittagong, Bangladesh

Iqbal Ahmed
Dept. of Computer Science & Engineering
University of Chittagong
Chittagong-4331, Bangladesh

Manoranjan Sikder Akash
Dept. of Computer Science & Engineering
University of Chittagong
Chittagong-4331, Bangladesh

ABSTRACT
In the recent era water is a precious resource at the time of dry season or in the dry places. In such types of regions/places water should be used efficiently because of its shortage. The systems of irrigation are still fruitless as they flood their farms without any reason. The result of wasting water and energy can be used for pumping the water. By the development of the technological infrastructure, feasible management of water usage and power expenditure of irrigation systems can be achieved. It may be done by enabling the irrigation system to place earmarked areas to irrigate. In this paper, a system of smart irrigation is proposed that consists of materials which are micro-controller and sensor integration of water pump. The sensor is placed in around 15 locations in University of Chittagong and where based on the integrated sensor's information, pump is activated. In this situation, pump gives the water where the field is dry. This result gives us the efficient water use. To make it possible to adjust according to the particular locations, the moisture parameter is used.

General Terms
Smart Irrigation using IoT, Cost saving, Water management

Keywords
IoT, Smart Irrigation, Arduino, Soil moisture sensor, DC motor pump, Cost saving.

1. INTRODUCTION
The proposed system has been designed to overcome the unnecessary water flow into the lands. If the land has pumps for irrigation it also needs someone to on/off the pumps. In conventional water quality measurement, samples are taken that does not bring the real time data [1, 2, 3]. In this gateway sensor is used to handle sensor information and helps to present data using internet of things.

Smart irrigation is not a new technology. Yet it is necessary in our practical life. By this process, controlled amount of water can be supplied through artificial means such as pipes, ditches, sprinklers etc. Farmers/Gardeners can monitor their crops/plants without being present at the crop field. This process flows necessary water into the plant or crop field. By this, over irrigation can be avoided.

The aim of the paper is to build a system to overcome over-irrigation. This project can reduce cost too. The objective is to sense the moisture of the soil and start irrigating if the soil is dry and stop the irrigation if the soil is moist.

The main contribution of this paper is to find out the efficiency of 'IoT based smart irrigation system' in University of Chittagong. In this paper, around 15 places/locations of University of Chittagong have been observed. Data were collected from these locations at different time interval. Among the 15 locations 4 location's data were observed most closely because these four location's data were much significant in this region. Then the moisture values of them were compared. Then cost effectiveness was checked with other smart irrigation system available in our country.

2. LITERATURE REVIEW
IoT based smart irrigation system is not a new technology. Many project and research have been conducted in this sector.

Dr. N. K. Choudhari *et al* [1] worked with soil moisture sensor and displayed the data to web application.

S. Abba *et a*l [4] focused on designing an affordable autonomous sensor interface to automate the monitoring and control of irrigation systems in remote locations, and to optimize water use for irrigation farming. They displayed water levels and the amount of needed water on LCD screen. The data were sent to internet server and can be viewed by any device that supports internet. Moisture sensor values in different soil against time are displayed in graphs.

S. Rawal [5] proposed an automatic irrigation system which monitors and preserves the desired soil moisture content via automatic watering. Here moisture sensor values are displayed in a webpage. Information from the sensors is daily updated on an internet site using GSM-GPRS SIM900A modem. By this a farmer can inquiry whether the water sprayers are ON/OFF at any given time. Moisture content against time in normal soil and over irrigated soil are presented in graphs.

P. Naik *et al* [6] used various sensors like temperature, humidity, soil moisture sensors which senses the various parameters of the soil and based on soil moisture value and the land gets automatically irrigated by doing ON/OFF of the motor. These sensed parameters and motor status were displayed on user android application. If the moisture value is less than 30%, the motor gets on otherwise the process stops. Outcome of the system is displayed in an android application.

S Chen *et al* [7] took in real time data of the water content of the plant as input argument. Then they combined it with other parameters such as water cost schedule and precipitation on the crop field. After that, they run the designed linear optimization system periodically and output the most efficient amount of water the plants need, which was translated by a specific actuation time of the water pumps.

B V Ashwini [8] built a micro control based system. It can be operated from distant location through wireless transmission. Therefore there is no need to concern about irrigation timing as per crop or soil condition. Sensor was used to take the soil's sensor reading like soil moisture, temperature, air moisture and decision making was controlled by user (farmer) by using microcontroller. The received data from sensors were sent to server database using wireless transmission. The farmer is notified with the information regarding field condition through mobile periodically.

R. Mistri *et al* [9] displayed the sensor values on LCD screen.

K. Priyadharsnee *et al* [10] worked with soil moisture and temperature sensor. User is acknowledged about the deviation of the values via text message.

H. A. Navin Kumar *et al* [11] proposed the new structures of sensors for high sensitivity and three types of moisture level indication systems which can be easily used in fields to save the power and crop. The performance comparison was made for homemade sensors and readily available sensors. The sensitivity was improved to the homemade sensors. The high sensitivity and steadiness were achieved by tin coating to the sensor electrodes. The system monitored the land moisture every time and maintained the fixed water levels by turning on and off the water motor.

M. Safdar Munir *et al* [12] proposed an method for effective plant irrigation which had a database of day-to-day water requirements of a type of plant. It also decided the volume of water for a plant type on the basis of the existing moisture in soil, humidity and time of the day.

T. Anil Chowdary *et al* [13] used soil moisture, Ph and PIR sensor and showed the sensor data in mobile application through cloud.

K. Singh *et al* [14] used soil moisture sensor and presented the data in a mobile application.

T. H. Senbetu *et al* [15] implemented water level identifier, pH value analyzer, temperature identifier. They measured the soil moisture and by that data, they controlled the pump.

3. PROPOSED SYSTEM ARCHITECTURE

The soil moisture sensor is connected to Arduino [16]. The values of the sensed moisture value of the sensor will be displayed on the serial monitor of the Arduino software on computer through Arduino board. A 5V DC motor pump is connected to Arduino by relay. Arduino cannot provide the pump sufficient power, so an adapter provides the extra power it needs. In the following Figure 1, the whole system architecture is presented in block diagram.

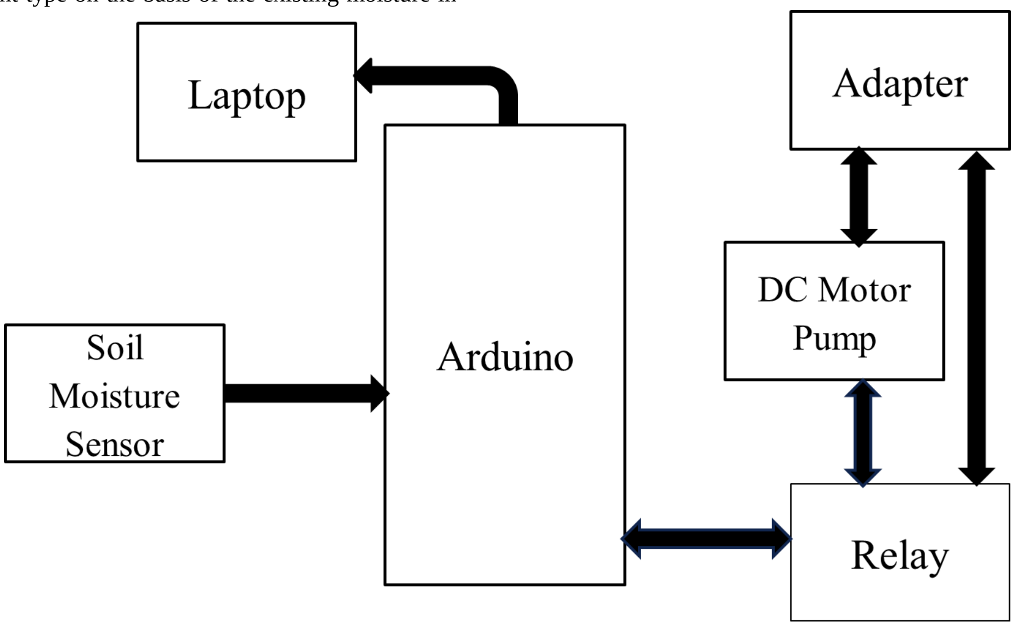

Fig 1: Architecture Model of the Proposed System

4. SYSTEM DESIGN

The proposed system's main part is Arduino and all the other components are connected with it. Following Figure 2 explains the hardware setup of Arduino with other components and later we discussed about the components in brief.

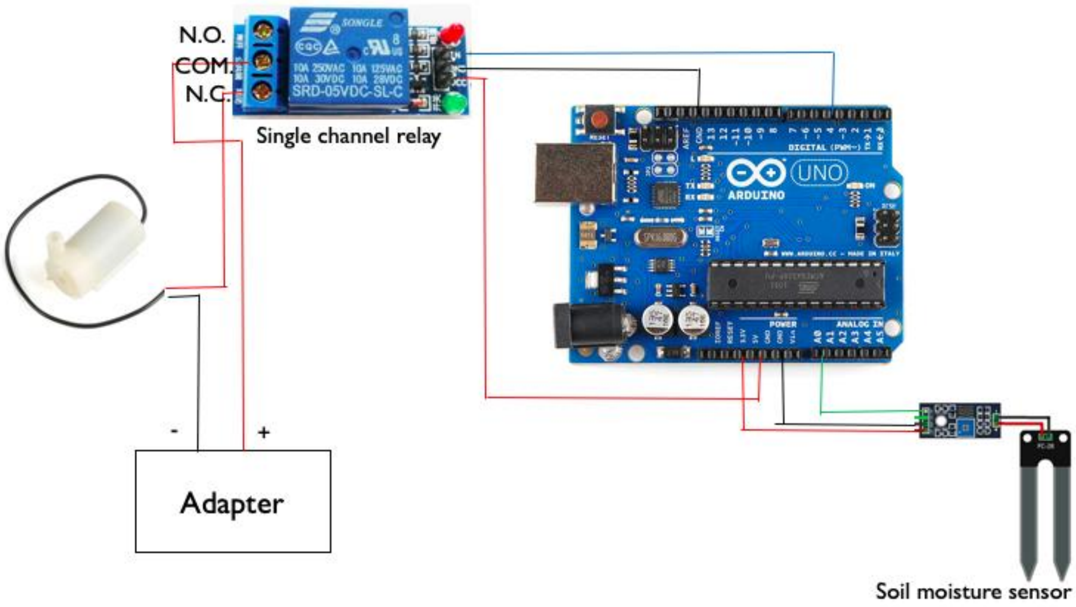

Fig 2: Circuit Diagram of the Proposed System

A. Arduino
Arduino is an open-source electronics platform built on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online [7]. Arduino is accustomed to develop complete interactive objects, or it can be connected to software of our computer. The boards are often assembled by hand or pre-assembled open supply IDE (Integrated Development Environment) are often downloaded at no cost from Arduino website[16].

B.Soil Moisture Sensor
Soil moisture sensors measure the volumetric water content in soil. Since the quantitative measure of free soil moisture needs removing, drying and considering of a sample, soil moisture sensors measure the volumetric water content indirectly with another property of the soil, like ohmic resistance, stuff constant, or interaction with neutrons, as a proxy for the moisture content.

This sensor has 2 probes through that current passes in soil, then scan the resistance of soil for reading moisture level. We know that water creates the soil a lot of liable to electrical conduction ensuing less resistance in soil wherever on different hand dry soil has poor electrical conduction therefore a lot of resistance in soil [7].

The Atmega 328P-PU microcontroller is used for the Arduino Uno. It comprises an onboard 10-bit 6-channel analog-to-digital (A/D) converter. The analog input pin of Arduino can take analog signals being sent from the sensor and return binary integers from 0 to 1023. Greater amount of output implies lesser moisture content [4]. But here the moisture values are shown in percentage. To do this, those ADC values were mapped to analog values. The sensor values were 550 in the dry soil and 10 in the wet soil. So the values were mapped from 10 to 550 to obtain the percentage values.

C.Relay Module
Relay is an electromagnetic device. It is used to separate two circuits electrically and attach them magnetically. They are very convenient devices and allow one circuit to change another one while they are totally detached. They are frequently used to interface a low voltage working electronic circuit to a high voltage working electrical circuit. For instance, a relay can make a 5V DC battery circuit to switch a 220V AC circuit. Thus a tiny sensor circuit can operate a fan or an electric bulb.

A relay switch can be separated into two parts: input and output. The output segment has a coil which creates magnetic field when a small voltage from an electronic circuit is applied to it. This voltage is named the operating voltage.

Normally used relays are accessible in different configuration of operating voltages like 6V, 9V, 12V, 24V etc. The output segment comprises of contactors which connect or disconnect mechanically. In a normal relay there are three contactors: normally open (NO), normally closed (NC) and common (COM). At no point state, the COM is connected to NC. After the operating voltage is applied, the relay coil becomes energized and the COM changes contact to NO.

D. DC Motor Pump
Water pump is used to pump water from water container. Because it requires 5V power and Arduino cannot fully provide 5V power. So a relay and a 12V DC adapter are used. Water pump is connected to a 12V DC adapter first and then the adapter is connected to relay. The relay is connected to the normal AC passage. This can prove water pumps sufficient power. Water pump is also the actuator. It is controlled through controlling relay. The relay can obtain digital signal and has 2 pins: red (digital pin) and black (ground). The relay is connected to Arduino so Arduino can control the relay and the water pump can pump water.

5. METHODOLOGY
The methodology is designed by the flowchart of the soil moisture sensor which shown in next Figure 3.

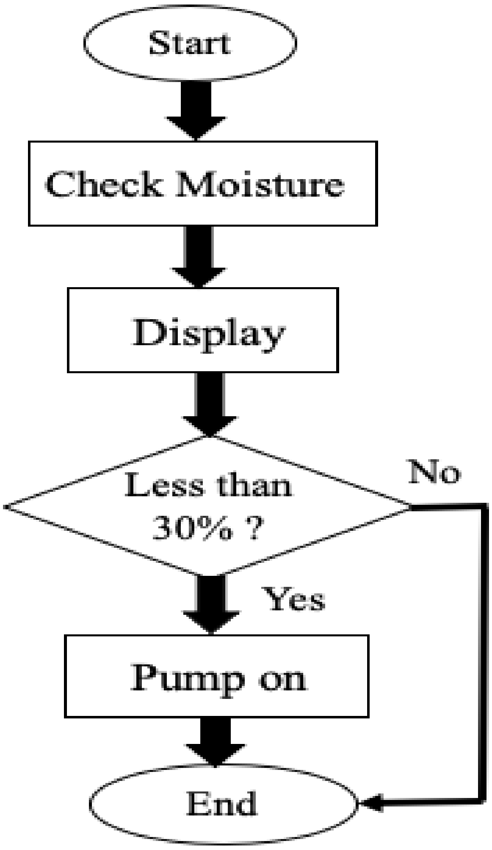

Fig 3: Flowchart of the soil moisture sensor

At first, the soil moisture sensor will be placed inside soil. Then the sensor value will be displayed on the serial monitor of Arduino software. If the moisture is less than 30%, then the motor/water pump will be on. Otherwise, the motor/pump stops and the process is stopped.

6. RESULTS AND DISCUSSIONS

6.1 Data Collections

The system has been run in four different locations in University of Chittagong. The places are 1no. (*ekk-nomber*) gate, Rail crossing, Zero point and Engineering Faculty premises.

The time was captured manually by clock in a random manner. Sensor readings were collected from the serial monitor of the Arduino software. The sensor readings were long. Only in the given time, how much moisture were inside soil are presented. Along with this, the water pump's status was observed in each time and presented in the following tables.

Table 1 represents the data of the place '1 no. (*ekk-nomber*) gate', while Table 2 presents the place of 'Rail crossing' data, Table 3 shows the data of 'Zero point' and finally Table 4 represents the data of 'Engineering faculty premises'.

Table 1: 1 no. (*ekk-nomber*) gate data

Reading no.	Time	Sensor Readings	Pump Status
1	15:53:21	-38%	On
2	16:00:22	-23%	On
3	16:11:23	2%	On
4	16:16:44	17%	On
5	16:30:05	28%	On
6	16:34:45	36%	Off
7	16:43:06	41%	Off
8	16:48:07	45%	Off
9	16:56:08	50%	Off
10	16:59:48	52%	Off
11	17:00:08	53%	Off

Table 2 : Rail crossing data

Reading no.	Time	Sensor Readings	Pump Status
1	15:53:21	-87%	On
2	16:00:22	-25%	On
3	16:11:23	1%	On
4	16:16:44	15%	On
5	16:30:05	25%	On
6	16:34:45	31%	Off
7	16:43:06	38%	Off
8	16:48:07	39%	Off
9	16:56:08	40%	Off

10	16:59:48	51%	Off
11	17:00:08	52%	Off

Table 3: Zero point data

Reading no.	Time	Sensor Readings	Pump Status
1	15:53:21	-25%	On
2	16:00:22	-25%	On
3	16:11:23	2%	On
4	16:16:44	11%	On
5	16:30:05	23%	On
6	16:34:45	35%	Off
7	16:43:06	38%	Off
8	16:48:07	39%	Off
9	16:56:08	40%	Off
10	16:59:48	51%	Off
11	17:00:08	52%	Off

Table 4: Engineering faculty premises data

Reading no.	Time	Sensor Readings	Pump Status
1	15:53:21	-85%	On
2	16:00:22	-51%	On
3	16:11:23	5%	On
4	16:16:44	12%	On
5	16:30:05	25%	On
6	16:34:45	34%	Off
7	16:43:06	39%	Off
8	16:48:07	47%	Off
9	16:56:08	53%	Off
10	16:59:48	59%	Off
11	17:00:08	63%	Off

6.2 Moisture Comparison

The comparison of moistures at four different places are depicted in the following line graph of Figure 4.

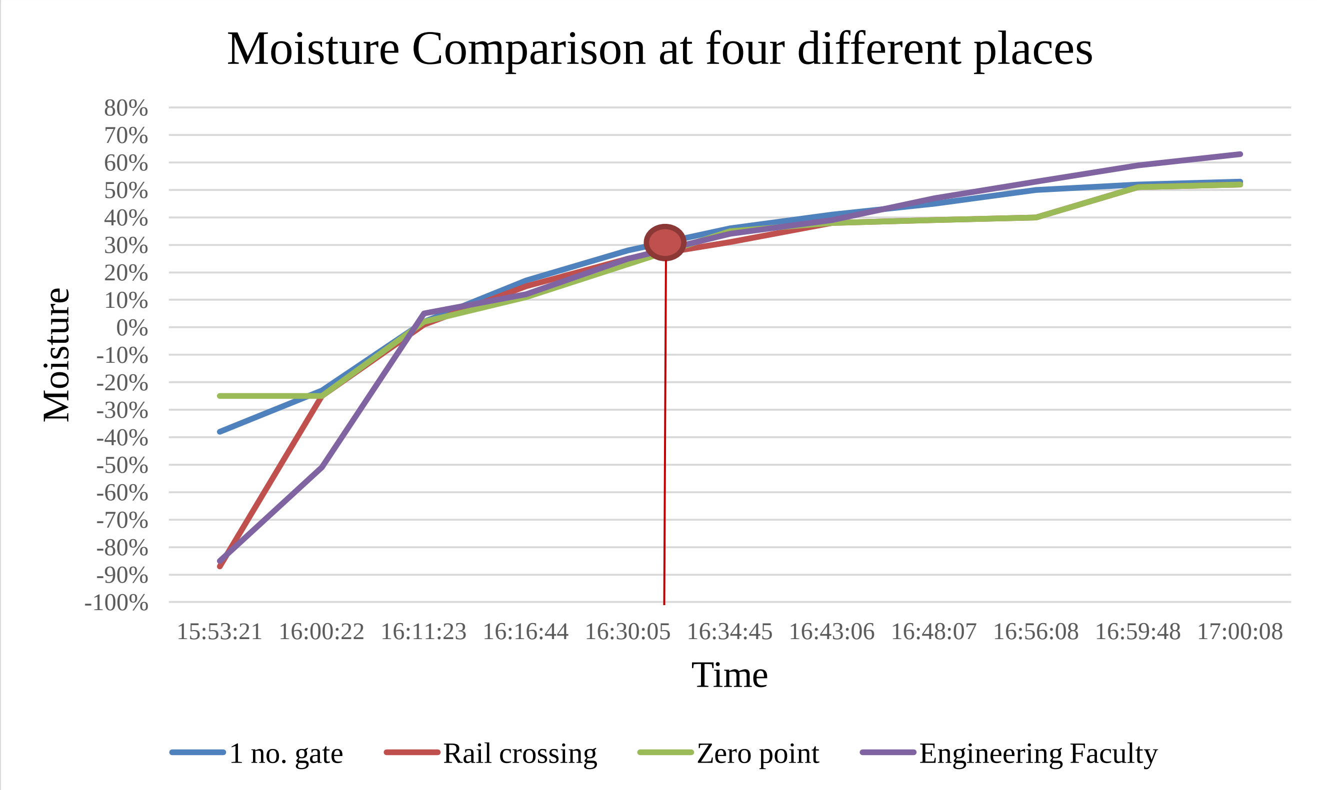

Fig 4: Moisture comparison at four different places

Initially the order of the moisture values of these four places were : Rail crossing (-87%) < Engineering faculty premises (-85%) < 1 no. (*ekk-nomber*) gate (-38%) < Zero point (-25%) From the graph it is evident that, the moisture values of ***Rail crossing*** were the lowest. The reason of its moisture values being lowest might be the low temperature. As it has the lowest moisture, this place needs the maximum water or most irrigation during the dry seasons.

Additionally, ***Engineering faculty premises*** needs less water than ***Rail crossing*** whereas ***1no. (ekk-nomber) gate*** needs more less water than previous two places. Finally, it is also clear from the graph that the ***Zero point*** place needs the minimum water among the four places in Chittagong University.

Moreover, another important point is found that, after or at the sharp 16:32, the moisture value reaches 30%. So the pump turns off as there is no need to irrigate which eventually helps to save energy and cost.

6.3 Cost Analysis

Next, Table 5 shows the list of items, and their descriptions that are used to design and implement the device prototype. The cost analysis is expressed in Bangladeshi Taka (BDT). These cost patterns are subject to vary from time to time, due to fluctuations in the market exchange rate. The cost analysis provided excludes the cost of shipping, value added tax, and labor. It can be observed that the total cost of the complete prototype is valued at Tk. 1179 (maximum USD 14), which indicates a very low-cost device that is affordable and can be utilized by gardeners or farmers with low income compared to 'Automatic Drip Irrigation System Micro Home Sprinkler Garden Watering Equipment in Bangladesh' [17], 'Drip Irrigation System in UK' [18].

Table 5: Total Cost of proposed system

SL NO	Name of components	Quantity	Unit Price in Bangladesh
1	Arduino Uno	1	Tk. 435
2	Soil Moisture Sensor	1	Tk. 180
3	5V DC Motor Pump	1	Tk. 150
4	5V Single Channel Relay Module	1	Tk. 80
5	Jumper Wire	9	Tk. 27
6	12V Adapter	1	Tk. 140
7	Breadboard	1	Tk. 77
8	Small pipe	1	Tk. 90
			Total :Tk. 1179

7. CONCLUSION AND FUTURE WORK

The automatic irrigation management by Arduino uno has been experimented and proven to figure satisfactorily. This method records values of moistures, it additionally controls the motor consequently. Analyzing the atmospheric phenomenon, motor will mechanically maintain water system creating it potential to take care of plants without human intervention. This will enhance high performance device monitoring and control when deployed to large agricultural farmland. Applying internet of things is highly effective in smart irrigation project. Future works will be using more sensors to evaluate the result more accurately. A mobile app can be used to control the process from distant places.

8. REFERENCES

[1] Dr. N. K. Choudhari, Mayuri Harde, "Automated Plant Irrigation System Based on Soil Moisture and Monitoring Over IOT", International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 5 Issue VI, June 2017, ISSN: 2321-9653.

[2] Dr. B. V. Ramana Reddy, "Automated Irrigation System-IoT Based Approach", Universal Review, Vol. VIII, Issue. V, May, 2019, pp. 593-596.

[3] Costo, Magyar, "Information flow in agriculture- through new channels for improved effectiveness", Journal of Agricultural Informatics, Vol. 1, Issue. 2, 2010, pp. 25-34.

[4] Sani Abba et al, "Design and Performance Evaluation of a Low- Cost Autonomous Sensor Interface for a Smart IoT Based Irrigation Monitoring and Control System", Sensors 2019, 19(17), 3643.

[5] Srishti Rawal, "IOT based Smart Irrigation System", International Journal of Computer Applications (0975 – 8887) Volume 159 – No 8, February 2017.

[6] Pavankumar Naik et al , "AUTOMATION OF IRRIGATION SYSTEM USING IoT", International Journal of Engineering and Manufacturing Science, Volume 8, Number 1, 2018 pp. 77-88.

[7] Siyu Chen, Nicholas Fatras, Haoran Su, "Smart Water Irrigation System", Project White Paper, Civil and Environmental Engineering 186: Design of Cyber-physical System, eCAL Berkeley, USA.

[8] Ashwini B V, "A Study on Smart Irrigation System Using IoT for Surveillance of Crop-Field", International Journal of Engineering & Technology, 7 (4.5) (2018) 370-373.

[9] Rajkumar Mistri, Madhupriya Kri. Singh, Eckta, "Automatic Irrigation System", IJSART - Volume 4 Issue 5 – MAY 2018, ISSN [ONLINE]: 2395-1052.

[10] Priyadharsnee.K, Dr.S.Rathi, "AN IoT BASED SMART IRRIGATION SYSTEM", International Journal of Scientific & Engineering Research Volume 8, Issue 5, May-2017 44, ISSN 2229-5518.

[11] H.A.Navin Kumar, G.L.Nagendra, K.Bhaskar, K.Prakash, "High Sensitive Soil-Moisture Sensors Development and Automatic Watering for Irrigation Systems", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (An ISO 3297: 2007 Certified Organization),Vol. 5, Issue 9, September 2016.

[12] M. Safdar Munir, Imran Sarwar Bajwa, M. Asif Naeem and Bushra Ramzan, "Design and Implementation of an IoT System for Smart Energy Consumption and Smart Irrigation in Tunnel Farming", Article in Energies · December 2018.

[13] T. Anil Chowdary, D.V. Chakravarthy, R.V. Siva Rupesh, T. Sai Charan Ashish, V., "Effective Implementation of Low-Cost Smart Irrigation System", International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-8 Issue-6, April 2019.

[14] Krishna Singh, Samyak Jain, Varun Andhra, Shilpi Sharma, "IoT Based Approach for Smart Irrigation System Suited to Multiple Crop Cultivation", International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 12, Number 3 2019, pp. 357-363.

[15] Tigist Hilemariam Senbetu, Kishore Kumar K, G.M. Karpura Dheepan, "IoT Based Irrigation Remote Real-Time Monitoring And Controlling Systems", International Journal of Innovative Technology and Exploring Engineering (IJITEE) ,ISSN: 2278-3075, Volume-8 Issue-7, May, 2019.

[16] Arduino Software, Retrieved from https://www.arduino.cc/en/guide/introduction, on December 2019.

[17] Automatic Drip Irrigation System Micro Home Sprinkler Garden Watering Equipment, Retrieved from https://www.daraz.com.bd/products/automatic-drip-irrigation-system-micro-home-sprinkler-garden-watering-equipment-i102368076-s1016512094.html, on December 2019.

[18] Drip Irrigation System, Retrieved from https://www.easygardenirrigation.co.uk/collections/drip-irrigation-systems, on February 2020.