Smart Irrigation System for a Small Plant Nursery Based on Soil Moisture Level

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***Abstract*— This study is an examination about soil moisture level based on an automated watering system for a small plant nursery. The soil moisture sensors sense the current soil moisture level and send a notification to the user if the current soil moisture level is below than the required soil moisture level. Then the user should select the plant which requires watering, and then it displays the current soil moisture level and the required soil moisture level. To start watering automatically, the user must switch on the motor from the mobile application, and if not, he gets a notification to turn on the motor. The motor can be switched off by either from the mobile application or it turns off automatically. The main aim of this project is to develop a wireless smart irrigation system to provide irrigation which is automatic for the plants, which help in saving money and water in return. The main objective is applying the system for improvement of the fertility of the soil and the plant. The project aspires to defeat the challenges addressed above. The whole system is micro control based and can be operated from a remote location through wireless transmission. Hence there is no need to be concerned about the overflowing of water in the process of watering. In Sri Lanka, agriculture plays a vital role in the production of food crops and the economy. In our country, agriculture depends on monsoons which are not an adequate source of water. Therefore, the irrigation methods are used in the agricultural arena. Internet of things (IoT) is a turning point in the interpretation of technology. IoT represents an important role in many fields, one of which is agriculture by which responsible authorities are able to feed almost all the people on the earth in the millennium.**

***Keywords*— Smart irrigation, IoT, Arduino, Soil moisture**

I.INTRODUCTION

A. *STUDY BACKGROUND*

Most of the farmers use large extents of farming land, and it becomes very difficult to have access and track every corner of their large farming lands. Sometimes there are occasions of uneven watering. This brings about bad outcomes of vegetation which also ends in monetary losses. In this situation, the clever irrigation system using cutting-edge IOT era is helpful and results in ease of farming.
[1]. Following statistic shows the share of economic sectors in the gross domestic product (GDP) in Sri Lanka from 2008 to 2018. In 2018, the share of agriculture in Sri Lanka's gross domestic product was 7.87%, the industry contributed approximately 26.99% and the services sector contributed about 56.83%.

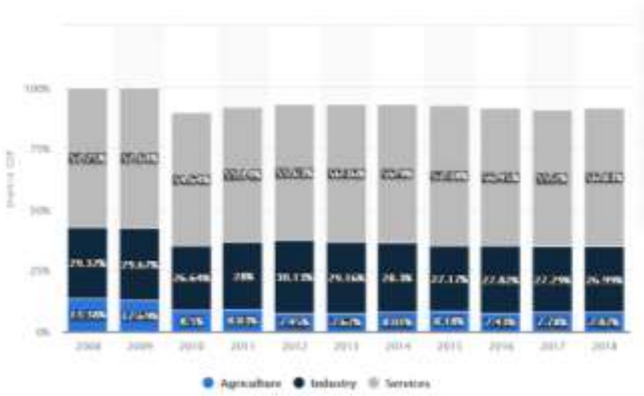

Fig 1: GDP in Sri Lanka from 2008-2018

(Source:*https://www.statista.com/statistics/728539/share-of-economic-sectors-in-the-gdp-in-sri-lanka/)*

In several parts of Sri Lanka, irrigation is administered manually. Concerning this smart irrigation system is thereby believed to be a major answer in the long run. This project presents a smart water irrigation system that optimizes the obtainable water within the water reservoir by providing an efficient and effective water usage solution for the irrigation system. The irrigation system is in a position to start and stop the pump by using the mobile app. There are 2 main factors that are effective in the growth of a plant or cultivation. They are water and varieties of soil.

According to the IUCN [2], the average annual rainfall varies from about 600 mm to over 5,500 mm across the island. Rain is received mainly through two monsoons: the northeast and southwest. Based on rainfall, four main agro-climatic regions have been identified in Sri Lanka: i) the wet zone, including the central hill massif, in the southwestern region of the island; ii) the dry zone extending over much of the flatlands in the north, northwest, east and southeast of the country; iii) the intermediate zone, separating the other two zones; and iv) the arid zone, in the northwest and southeast of the island are two tiny strip of lands — which are very dry and receive less than 600 mm of rainfall per annum[2].

Fig 2: Sri Lanka’s topography and main agro-climatic zones

(Source: Drawn from the National Atlas, Survey Dept., 2007)

B. STUDY AREA

There are so many varieties of soil in Sri Lanka, and it differs from area to area. Therefore, the water requirements of different varieties of soil cause many problems with regard to watering.

Different species of plants need different varieties of soil to grow well. The soil types vary depending on the locality. The most abundant soil type in Sri Lanka is Reddish Brown Earths (RBE), Red Yellow Podzolic (RYD) and Low Humic Gley (LHG).

TABLE I: DISTRIBUTION OF THE SOIL TYPES IN SRI LANKA

(Source: NRMC)

Agro-ecological region	Annual rainfall expectancy at 75% (mm)	Soil	Land use
Low country dry zone	650-1,300	RBE, LHG, NCB, RYL, Regosol, Old alluvial, Grumusol, Solodized Solonetz	Rain-fed upland crops; paddy; home gardens; forests; scrub; sugar cane; cashew; coconut; and condiments.
Low country intermediate zone	1,100-1,600	RYP, RBE, LHG, RBL, Regosol, IBL, NCB	Coconut; home gardens; export agricultural crops; paddy; rubber; sugar cane; rainfed upland crops; and citrus.
Mid country intermediate zone	1,100-2,000	RBL, RYP, IBL, LHG, RBE, Mountain Regosol,	Tea; vegetables; home gardens; paddy; forest; grasslands; and export agricultural crops; and rubber.
Up country intermediate zone	1,300-2,400	RYP, Mountain Regosol, LHG	Tea; vegetables; home gardens; export agricultural crops; forest; and paddy.
Low country wet zone	1,700-3,200	RYP, LHG, Bog & Half Bog, RBL, Regosol	Tea; rubber; coconut; home gardens; paddy; export agricultural crops; and fruit crops.
Mid country wet zone	1,400-3,300	RYP, RBL, LHG, IBL	Tea; home gardens; export agricultural crops; paddy; forests; and rubber.
Up country wet zone	1,800-3,100	RYP, Mountain Regosol	Tea; forests; vegetables; pasture; and home gardens.

Although there are differences in soil varieties in different parts of the country, this research solely concentrates on the soil type found in the low country wet zone which is very suitable for home gardens.

Furthermore, in the project, all the plantations are done in one type of soil for every plant. Also, the project is based on the water saturation of the plant in a particular soil type and the water need of the plant in that soil type.

II.LITERATURE REVIEW

According to Patil and suyash’s research review paper [12] the machine learning is being applied towards grapes cultivation. In here, farmers are incapable of identifying the diseases on grapes, manually. The disease can be only identified after the infection, which takes lots of time. Therefore, accordingly, an agricultural monitoring system was developed by using, relative humidity sensors, temperature sensors and also the leaf wetness sensors.

The data collected at regular intervals are sent using Zigbee module to the server. The server here employs the hidden Markov model algorithm towards training the data sets pertaining to temperature, relative humidity and leaf wetness for analysing the data towards predicting the chance of disease on grapes prior to the infection. This information is sent as an alert message via SMS to the farmer and expert. The system employs machine learning in early and accurate detection of disease in grapes and suggests pesticide to protect the crop from disease and reduce manual disease detection efforts. Also, this system can be helpful for farmers towards giving information on the schedule of fertilizers, pesticide spraying, irrigation etc which would help in improving the quality and quantity of grapes [10]. The main drawback of this system is its inability to handle the system by farmers because of their lack of knowledge in the technology and the literacy problems [12][13].

According to Patil G.L. and Gawande P.S. [8] in the journal of Smart Agriculture Systems based on IoT and its Social Impact they have proposed system with the highlighted features of smart irrigation with smart control based on real-time field data. Secondly with temperature maintenance, humidity maintenance and other environmental parameters. It is a system which collects various data from the sensors like temperature, humidity, lux, moisture and other environmental factors and will do the analysis on the same.

During the time period of the analysis if the system gets better results from the combination of the data which are collected through the sensors, they save them. In the system they are using IoT as the platform for the analysis process. The system will contain many modules from various geographical positions, and all those modules will send all the data to this platform, which will give some idea to be focused on the environmental factor, which will be good for the crop as well as the farmer and the cultivation [8].

The system consists of mainly two sections; the agro logger and the cloud interface with the mobile application. Furthermore, the whole system presents an agro logger system which is capable of sending and receiving data from the various sensors and to get updated data from the cloud.

The main drawback of this system is that it gets only data from the sensors of environmental factors. They have not focused on the effectiveness of the climatic changes and the damage caused to the system by the external parties such as animals, insects, microorganisms etc. [8].

According to Indu *et al.* [9], this has mainly focused on the reviews in the field of remote control and monitoring the technology which has used. And they are proposing an innovative Bluetooth/GSM model based remote controlled embedded system for irrigation in agriculture. The framework sets the watering system time depending on the temperature, and humidity perusing from sensors and type of crop can consequently water the field when unattended. The information is exchanged between ends via SMS and GSM network. The system informs users about many conditions such as status of electricity, dry running motor, increased temperature, the water content in soil and smoke via SMS on GSM network or by Bluetooth [9].

Still many farmers are using traditional agricultural methods which are very slow and not precise and accurate when it comes to the size of crops, quality, time etc [14]. As such the main goal of this project is to improve the quality, amount of the crops while keeping the cost at low by using of smart monitoring system which monitor’s the soil temperature and moisture, pH level, humidity, storage level and rainfall. The main challenge for this system is to convert traditional methods to new systems which are connected with the technology all the way. So it may be a massive problem the farmers may encounter with their literacy and as well as the lack of knowledge regarding the updating technology. They are planning to develop this system to a more accurate one in future also to be integrated with solar power running and irrigation monitoring while it becomes more user friendly for farmers or any other users [14].

According to Sristhi Rawaal [6] research paper, he proposed an automated irrigation system which monitors and maintains the desired soil moisture content via automatic watering. To implement the control unit microcontroller ATMEGA328P on Arduino Uno platform is used. Soil moisture sensors are used to measure the exact moisture level in soil in the setup. This value enables the system to use an appropriate quantity of water which avoids over/under irrigation. IOT is used to keep the farmers updated about the status of sprinklers and the irrigation system. Data retrieved through the sensors are regularly updated on a webpage using GSM-GPRS SIM900A modem through which a farmer can check whether the water sprinklers are in operation or not at any given time. Also, the sensor readings are transmitted to a Thing speak channel to generate graphs for analysis [6].

Data mining algorithm is used to make decisions on the drip irrigation system. Automated drip irrigation system having WSN placed all over the farm and different type of sensors [15]. WSN uses an ad hoc network, which gives self-configuration and flexibility. Sensor data are given to base station, and data are received using Zigbee. The data processing is done at the base station for decision making. The data mining algorithm is used to decide on data from the sensor to drip. All observations are remotely monitored through web application. This system works on the Naïve Bayes algorithm for irrigation control. The algorithm works on previous data set for decision making if any attribute is not the frequent result is zero [16].

Rajalakshmi and Devi [17] have mentioned in their research paper, a system is developed to observe crop-field using sensors (soil moisture, temperature, humidity, Light) and automate the irrigation system. The information from sensors is sent to the web server database using wireless transmission. In the server database, the data are encoded in JSON format. The irrigation is automated if the moisture and temperature of the sector fall below the brink. In greenhouses, light intensity control may be automated additionally to irrigation. The notifications are sent to farmers' mobile periodically. The farmers can readily monitor the field conditions from anywhere. This technique is going to be more useful in areas where water is scarce [17].

Smart farming is an emerging concept, because of IoT sensors capable of providing information about their agriculture fields. The paper aims to make use of evolving technology, i.e. IoT and smart agriculture using automation. Monitoring environmental factors are the major factor in improving the yield of efficient crops. The feature of this paper includes monitoring temperature and humidity in the agricultural field through sensors using CC3200 single chip. The camera is interfaced with CC3200 to capture images and send that pictures through MMS to farmers’ mobile device using Wi-Fi [20].

Vineela and Nagaharini [19] have proposed to monitor crop-fields using sensors for soil moisture, humidity and temperature. By monitoring these parameters, the irrigation system can be automated if soil moisture is low [19].

III. PROPOSED SYSTEM

1) Mobile App Design:

The system wants to monitor the details gained through the database and the Arduino IoT circuit. Hence compulsorily the system should have a process to monitor those details. That system can be a web application, website or a mobile application. Among them, the most suitable solution to monitor those data is a mobile application. There are lots of reasons to choose to develop a mobile application. Such as mobile device is easy to use and it is designed by the Android, as well it is easy to maintain, and its availability is high all around the world. Android devices are the devices mostly used in the world. The user can successfully access the system by using an android application. It is easy to use a mobile device which can hold in the palm rather than using a laptop or a PC.

In the designing phase of the mobile application, for the background green was chosen because it is considered as the colour of nature, life and it is associated with the meaning of growth and the environment. The green colour can enhance vision, and it takes up more spectrums visible to the human eye and it is the dominant colour of nature.

The “OFF” button in the application has used the red colour as it gets highlighted at first sight, and it is the standard colour for something to stop it.

Fig 3: Mobile app interface

In this project, a database is necessary to store data regarding the soil moisture levels of different plants. As the system is a real-time one, the database also should be a real-time database platform. It should have cloud storage.
The benefit of Firebase hosting allows you to set-up a single page, a mobile landing page, web page or progressive web page with ease. It also helps to deliver the content rapidly anywhere.

2) ARTEFACT AND CIRCUIT DESIGN:

The diagram given below is an overall block diagram of Arduino based smart irrigation system which consists of the soil moisture sensor which is connected to the controller and sensed values from those sensors are sent to the mobile application.

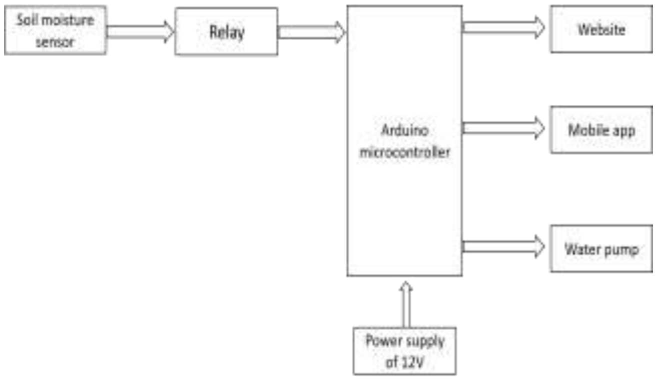

Fig 4: Block Diagram

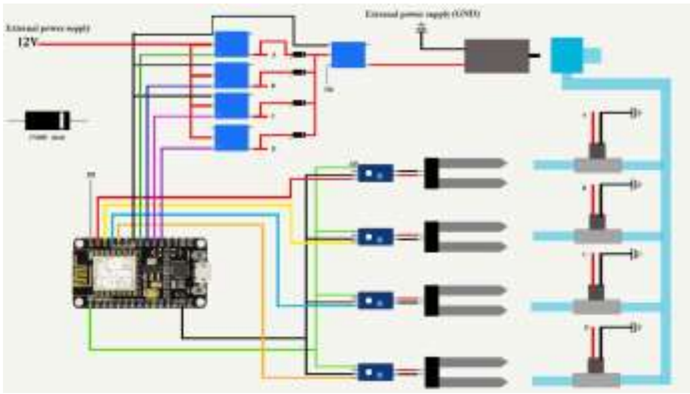

Fig 5: Circuit Diagram

As the outcome of the mobile application, providing a drop-down list of plants by the app, displaying the required soil moisture level gained through the artefact and providing an interface to log in to the account in the mobile application was expected.
By creating a database, the system is expected to store the related data and to retrieve data and to compare the values of current soil moisture level and the required soil moisture level.

The artefact is the only tangible part of the system. It plays a major role within the system, and it does the most important tasks. Detecting the current soil moisture level accurately, controlling the water pump and the watering valve are the areas which are expected to cover by the artefact.

IV. DISCUSSION

The academic question which was selected for this project was “What are the main challenges involved to build up a smart irrigation system?” and the main challenges encountered by the farmers who use a manual system for watering are, the water scarcity, withering or dying of plants due to over watering or less watering and the problems arisen with the updating technology in a globalized world. The agriculture sector is also getting updated with the trending technologies, and it was a reason to build up this type of a system to do the watering.

In the system which has developed, the user gets a notification when the current soil moisture level is below the required soil moisture level of plants. Then the user turns on the water valve manually via the app or if not, the system gets automated, do watering and sends a notification to the user when the system gets started.
Therefore, it may not cause to a less watering or an overwatering of the plants, and it will do watering in a better way more accurately.

When the expected results are obtained, the entire system works according to the project plan, which was designed at the beginning of the project, and then the system performs very accurately and efficiently.

Firstly, the user must create an account and should have a login to the account to get updated about the details of how the system works.

The soil moisture sensors detect the current soil moisture level of plants.

Furthermore, if the current soil moisture level is below than the required soil moisture level, the user gets a notification to the mobile device via the Wi-Fi connection.

If the water pump and the valve have been switched on previously from the mobile app, the system gets the water pump and the water valve switched on automatically and it sends a notification to the user as well. It starts watering again and it sends a notification as to which plant is getting watered at the moment.

If the user turns on the motor manually, firstly user should login and select the relevant crop from the drop-down list displayed in the mobile app interface.
After selecting the crop name, it displays the required soil moisture level automatically by retrieving the data from the database.

Thereafter in the mobile app, it displays the current soil moisture level, which is detected by the soil moisture sensors and compares the values of required and the current levels of soil moisture.

The user gets a notification to do watering only if the current level of soil moisture is below the required level. If not, he does not get any notification.

While watering, if the current soil moisture level is equal or higher than the required soil moisture level the water pump will automatically get switched off and stop watering.
And, the user receives a notification which contains a message that the watering process has stopped. All the notifications will display in the notification bar of the mobile device.

This project is done by using only soil moisture sensors according to the soil moisture level of particular plants. Most of the projects based on the soil moisture level were based on the water saturation level of the soil type. However, here in this project, it has used the different water levels needed for different crops.

To improve the efficiency and the effectiveness of the system, this can be developed to a large cultivation land which the watering system is fully automated. Then it requires less manpower.
Hence as future enhancements can remove all the limitations in an efficient way and expand the project scope.
When developing and implementing this system further, different types of sensors like soil moisture sensors, humidity sensors, temperature sensors, rain sensors etc can be included. Then there is a possibility of gaining the most accurate data from the system.

The advantage of using IoT for the irrigation can come in handy for further activities in farming such as cattle management, climate control. This would lessen human mediation in farming activities.

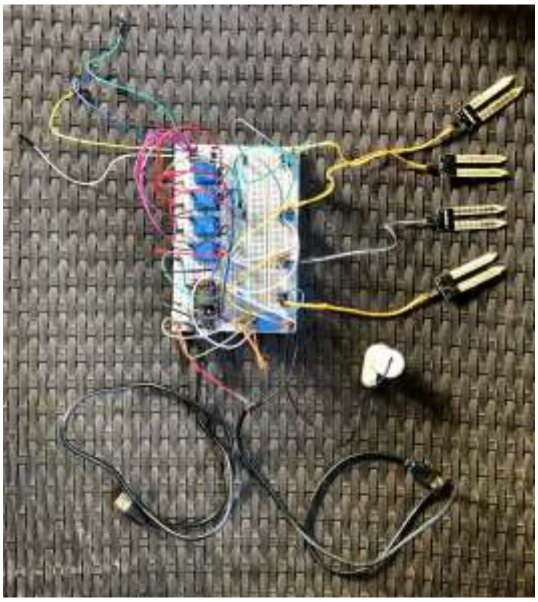

Fig 6: Arduino Circuit

V. CONCLUSION

This review and the project involve establishing a contemporary design technique of smart irrigation system for a small plant nursery based on soil moisture level. It is a system designed to check the soil moisture level and the water need of the plants, and the project provides an opportunity to study the existing systems, along with their features and drawbacks.
The proposed system can be used to switch on/off the watering valve according to the soil moisture level of the plant thereby automating the process of irrigation which is one of the most time-consuming activities in farming.
The system uses information from soil moisture sensors to irrigate soil which helps to prevent overwatering or under watering of soil, thereby avoiding the damage to the plant. Through this project, it can be concluded that there can be considerable development in farming with the use of IoT and automation.

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