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IoT Enabled Smart Irrigation System, Monitoring and Water Harvesting in Different Soils

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Abstract:- **This project focuses on an IOT based smart irrigation system which is cost effective and can be used by a middle class farmer in farm field. Today we are living in 21st century where automation is playing important role in social life. Automation allows us to control machines automatically. It not only provide comfort but also reduce energy, efficiency and time saving. Agriculture plays an important role in the life span of human being and not only for their survival but also for the better economic growth of the country as well. Fastidiousness agriculture is the new trending term in the field of technology whose main motive is to reduce the workload of the farmers and increase the productivity of the farms by using technologies like I.O.T, WSNs, Remote Sensing, Drone surveillance and many more. In this paper, we show the work done by our cost effective and reliable device whose aim is to irrigate fields only when there is a need of water and to provide information. The information is sent to the farmers by using cloud website called thing speak. The farmers can monitor their farm's field using simply by just browsing the channel link of thing speak. I am using Node-MICROCONTROLLER-8266, soil moisture sensor and DHT11 for taking the reading of soil moisture and temperature and humidity. All the data is uploaded by Wi-Fi module inbuilt in MICROCONTROLLER, to thing speak cloud database. After all in last I will compare the water savings in different soils like sand, clay and sandy clay. In comparison we can see the reduction of water from this system as of traditional process.**

Keywords:- NodeMICROCONTROLLER-8266, soil moisture sensor, DHT11 sensor, Relay, Arduino Uno, Thing speak, IoT.

1. INTRODUCTION

Internet of Things (IoT) is a new ongoing topic in the field of technology. The IoT is a network of material devices which is composed of embedded system like sensors, actuators, receivers, transmitters and many more hardware devices. The main aim of IoT devices is to reduce the load from human shoulders.

Agriculture is only the major food production system in India to meet demand of feeding of population. Irrigation is a vital process that impacts crop production. Generally farmers visit their agriculture fields from time to time to check soil moisture level and based on requirement water is driven by motors to irrigate respective fields. They need to wait for certain period before switching off motor so that water is allowed to flow in enough quantity in individual fields. This irrigation method takes lot of time and effort particularly when there are multiple agriculture fields distributed in small parts in a distance. Automation in irrigation system makes farmer work much easier. Sensor based automated irrigation system provides hopeful solution to farmers where farmer are not required on field. They can do other works in this time as of their importance.

A device comprising of some sensor and microcontroller is programmed for operating motor in such a way that when soil moisture goes down motor get on automatically, and after reaching a limit it gets off. Now a days there is a huge shortage of water, many places in India facing problem, this system could be helpful as it save water comparing to traditional way.

In this project I have made a working prototype model, using **NodeMICROCONTROLLER-8266**, soil moisture content sensor, DHT11 temperature and humidity sensor, relay module and motor, the programming is done on **Arduino software**. All the system is integrated in such a way that it monitors field temperature, humidity and soil moisture and also monitors the time period till motor is running.

The soil moisture field is sensed by sensor node and the sensed data is sent to microcontroller node through wireless networking means. On getting sensor value the controller node checks it with required soil moisture value. When soil moisture in a particular field is not up to required level (20%) then controller node switch on the motor to irrigate connected field and the Wi-Fi module process all data to thing speak channel.

The limits we set in different soil as for permeability of soil are as, in sand we set the limit for **70%-20%** ,in clay we set it for **50%-20%** and for mix of sand and clay limit of **60%-20%.**

In comparisons after monitoring for alternate 4 days in traditional way and smart irrigation we analysed the reduction of water wastage was nearly **33%** compared to traditional way.

2. LITRETURE REVIEW

A lot of works have been done and is currently going on this topic. Low cost smart irrigation system [01] by chandan Sahu et al. proposed a system whose objective was to control motor automatically and select the direction of flow of water. Which not only provide comfort but also reduced energy and time wastage. He used prototype for fully automation accessing of irrigation. Worked on ATMega-328 and raspberry pi controlling with smart phone. IoT based low cost and intelligent module for smart irrigation system by Neha K. Nawandar et al. [02] worked on a farm monitoring and automatic irrigation system that has three modules: (i) unified sensor, (ii) irrigation unit (iii) sensor information unit. For user access, USP initially remains for some time in admin mode where it gets crop, plantation date and soil data, which it uses in one-time setup mode for evapotranspiration and irrigation schedule computation. They used mosquitto, MQTT broker for user interface to keep updated. Modelled it for neural network and used in different crops production in garden farming. Smart Irrigation and Intrusions Detection in Agricultural Fields Using IoT. by Divyansh Thakur et al. [03] shown their work done by their cost effective and reliable device whose aim is to irrigate fields only when there is need of water and to provide information of intrusions in agriculture fields. Used Arduino, python and C++ as coding language. Water wastage problem was also reduced. Fuzzy Logic based Smart Irrigation System using Internet of Things R. Santhana Krishnan et al. [04]. This study mainly focused on fuzzy logic control to obtain higher level of accuracy to better use water for irrigation. They used GSM module and added temperature and humidity sensor. System automatically turn off when there is availability of rain. Used solar power to run the system, when there is unavailability of sun system switches to battery backup. Used Arduino and android application for work. Smart agriculture sensors in IOT: A review Sanika Ratnaparkhi et al. [05] explored the application of sensors in agriculture sectors. They showed the advantage and disadvantage of sensors. Suggested some sensor like optical sensor, electrochemical sensor etc. finally concluded that if this system correctly used in India, China and African countries, can end the world hunger problem. Soil Monitoring, Fertigation, and Irrigation System Using IoT for Agricultural Application R. Raut et al. [06] gave automatic irrigation system and to check the major macronutrients nitrogen (N), phosphorus (P) and potassium (K). Used colour chart to determine the nutrients presence by its solution. He used reservoir to irrigate and to check all macronutrients are in soil, if lack of some of them is there than add in water and irrigate. Colour sensor used was 1185sun rom, software used were orCAD, MickroC PRO and processor was ARM7. An efficient employment of internet of multimedia things in smart and future agriculture Shadi Alzu'bi et al. [07] research focuses on smart employment of IoM sensor in smart farming. Used raspberry pi, electromagnetic valve to control the flow and coding was on Arduino, information sent to registered mobile with the help of Wi-Fi module. Soil moisture sensor and ultrasonic sensor were implemented to measure soil moisture content and water level in tank respectively. Rain drop sensor were also included for sensing rain. Concluded that a smart irrigation system was implemented based on the analysis of the wireless sensor network. Framework for a smart water management system in the context of smart city initiatives in India Mohammed Shahanas.K et al. [08] used raspberry pi, low cost full functional computer, with Wi-Fi connectivity as the central system detailed study on emerging technology, Internet of Things and predictive analytics is made and its relevance in the context of Smart City has been discussed. Different technologies that can be used for a Smart water management system is also discussed. A study has been made on various IoT based cloud platforms. A design for a cost effective Internet of Things based Smart water management system has been proposed. Alert sent by mail or message system. Advanced System for Garden Irrigation Management Filipe Caetano et al. [09] for capture the signals of the sensors, and also control the actuator outputs, Atmel's microcontroller is used, model 328. This features also a serial port, which is essential for communication with the central computer, done via XBee modules, temperature and humidity sensor were also added. Coder used was Arduino and based on C++. PHP used for webpage design and to send outputs. Study describes a system, which aims to ensure autonomous and efficient irrigation in urban gardens. It consists of a net of sensors and actuators with ZigBee communication and control software for storage and availability of monitoring data on a web portal in real time. The work meant to present an intelligent advanced control system for the irrigation of urban gardens, with a view to a more rational use of water. Water is a major element in living creature, in case of plant we refer the term irrigation for watering the plant. In India irrigation is mainly dependent on rain. Rainfall controls the agriculture but rainfall is mainly controlled by monsoon. In INDIA there are 80% of the total annual rainfall occurs in four months, i.e. from mid-June to mid-October. So it is very necessary to irrigation for farm field during the rest of the eight months [11].

3. PROPOSED SYSTEM COMPONENTS

The system is a composed of hardware equipment and software. In hardware we have used sensors, microcontroller, relay, motor, breadboard and wires. In software I have used open cloud website called thing speak and the coding is done in Arduino language.

3.1 SOFTWARE REQUIRED

A. **Arduino:** The Arduino Uno is an open source software which is used for uploading the code into Arduino board. The working of all the sensor depend on the given code which is written in Arduino IDE. Details of this software can be found on [12].

B. **Cloud website**: the cloud website which is used is Thing Speak. The farmer can see all the data updates on this site, by just clicking the channel link. Details can be seen on [13]

3.2 HARDWARE REQUIRED

A. Soil moisture sensor: The soil moisture sensor is used for calculating the volumetric content of the soil. The working of soil moisture sensor is relying on the working procedure of resistance. If the resistance between two dissimilar points of soil is diminution than there is increase in volumetric content of water in soil. If the resistance between two different points of soil is augmented than there is decrease in volumetric content of water in soil. The soil moisture sensor (fig. 1) is composed of probe and circuit. The probes are injected under the soil surface which is used for measuring the volumetric content of the water. The second component of the soil moisture sensor is a circuit in

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which LED, Comparator, Potentiometer, LM293 and 3 Pins are integrated.[03]

Fig 1. Soil moisture sensor

B. DHT 11: The digital temperature and humidity sensor DHT11 (fig.2) is a composite sensor that contains a calibrated digital signal output of temperature and humidity. Three pins are available for use: VCC, GND, and DATA.

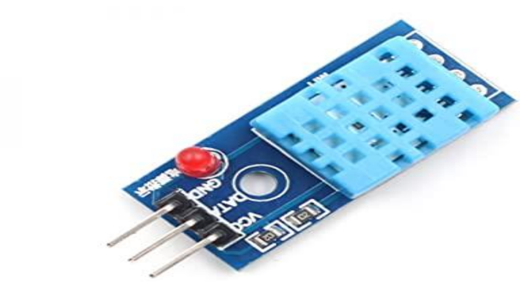

Fig2. DHT 11

C. Node MICROCONTROLLER ESP8266: NodeMICROCONTROLLER is an open source firmware for which open source prototyping board designs are available. Node MICROCONTROLLER (fig.3) is an open-source firmware and development kit that helps you to prototype or build IoT products. It includes firmware that runs on the ESP8266 Wi-Fi system on chip (SoC) from Espressif Systems, and hardware which is based on the ESP-12 module. The firmware uses the Lua scripting language. It is based on the eLua project and built on the Espressif Non-OS SDK for ESP8266. It has in built Wi-Fi Module – ESP-12E module similar to ESP-12 module but with 6 extra GPIOs.[14]

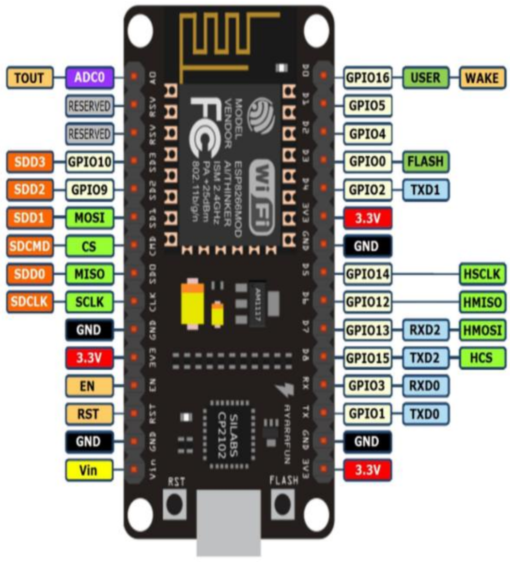

Fig 3. Ports of node microcontroller [24]

D. RELAY MODULE: A relay is an electrically operated switch that can be turned on or off, letting the current go through or not, and can be controlled with low voltages, like the 5V provided by the Arduino pins. This relay module has two channels (those blue cubes). There are other models with one, four and eight channels. This module should be powered with 5V, which is appropriate to use with an Arduino. There are other relay modules that are powered using 3.3V, which is ideal for ESP32, ESP8266, and other microcontrollers (fig. 4).[15]

Fig4. Relay module

E. BREAD BOARD: A breadboard is a solderless device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where suitable (fig.5).[16]

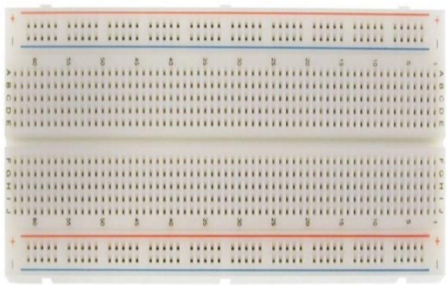

Fig5. Bread board

F. MOTOR: This is a low price, lesser size Submersible Pump Motor which can be functioned from a 3 ~ 9V power supply. It can supply water up to 16 litres per minute with very low current feeding of 220mA. Just connect tube pipe to the motor opening, immerse it in water and power it. Make sure that the water level is at all times higher than the motor. Dry run may harm the motor due to heating system and it will also produce noise. The pump used here is just for demo of prototype.(fig.6)

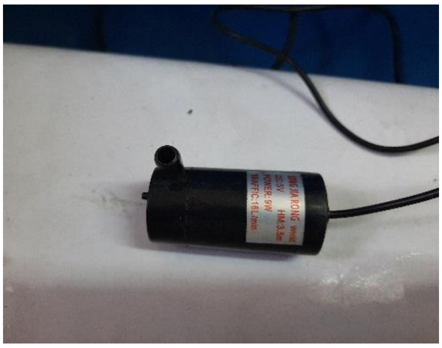

Fig6 Mini submersible pump

G. WIRES: wires are used for connecting the circuit of the model. Here I used two types of wire jumper wire and simple wire.

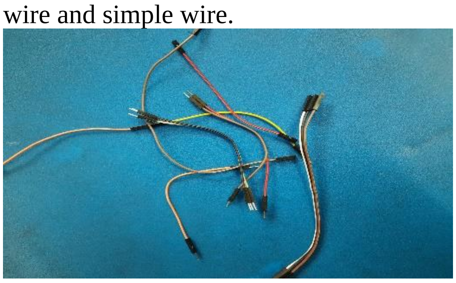

Fig7. Jumper wires

4. PROPOSED SYSTEM

The designed prototype is useful for farmers, till now they have to go on field for irrigation purpose, to make sure that water does not get overflow from field they have to stay there for some hours or may be a whole day for large farming area. This process is followed by them until the base period or last watering from start. It causes a huge time loss for them, and also may cause health problem, as it may be a very sunny day or severe cold. May some of them die due to dehydration or sun stroke. To overcome these accidents and make their life and work easier, this model is proposed, i.e. smart irrigation system, monitoring with IoT.

By using this system they don't have to go regularly on field, as the system is so composed that after a certain value of moisture content, the motor starts automatically and after reaching a limit value set by the farmer or system the motor gets turned off. This require a nominal power of 5V-9V to operate the system. The motor requires power accordingly its rating, since the source will be different for motor and device.

The system works as, the soil moisture sensor senses the moisture content in soil and send the data to microcontroller unit, if the moisture content is less than the limit we have fixed, the microcontroller send command to relay to on the pump, and irrigates until the moisture content is reached till the permissible limit. Once the limit is achieved the moisture sensor sends the data to microcontroller unit, and microcontroller commands the relay to off the motor pump. During the whole time period all the data is uploaded in thing speak cloud website so the farmer can monitor the field stats. I have added DHT11 sensor for monitoring the humidity and temperature on field so the farmer can know whether the climate condition are good or bad respective of their crop. The system works always when there is power source and uploads the data in every 25 seconds to cloud, on thing speak channel we can monitor the stats, when the soil moisture is not less than the limit value the motor will not turn on. There are graphs on channel by which we will monitor the stats. I have made four graphs for monitoring they are temperature, humidity, soil moisture content and motor stat. For real time monitoring we will utilise the system in NIFFT campus for 16 days to check the workability and performance of the system in different soils. Also we will monitor the water irrigated by motor and on same field water irrigated by traditional method, and compare the difference that how much water is saved by this system. Fig 12. Shows my field of work.

On an average using traditional way I used 1 lit water for irrigation when there is lack of moisture in soil. Totally I spent 2 litres of water in four days for clay. On other side my system used approximately 1.34-1.4lit water in duration. The retention capacity of clay was high, so it took 59-60 hours to go below 20% moisture content. For sand in four days I used 4lit water in daily basis, system used 2.7-2.83 lit water approximately the retention capacity was low, so it took 36-38 hours for dewatering and again irrigating. For mix sand and clay I used 3 litres of water in four days, the device used approximately 2-2.2 litres of water and the retention time was 45-47 hours.

So on an average I saved water 30%-33% on an area of 1.5ft*1ft, that I used for my study. (fig.8)

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Fig 8. Field showing soil moisture sensor.

4.1 CONNECTIONS

Fig 9. Shows my composed model of my work.

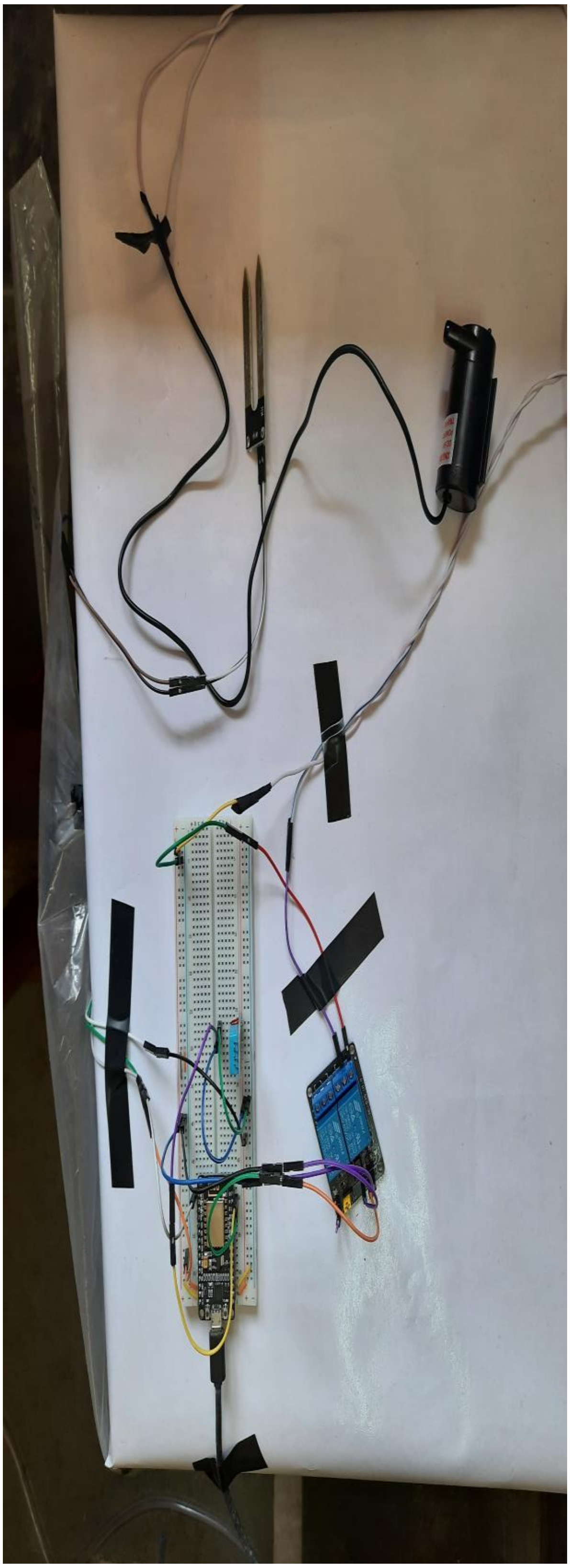

Fig 9.proposed system model

4.2 THING SPEAK WEB PAGE

- I have used this free website for monitoring online my system and also for exporting the data that is have collected. You can see my API key is shown below here.

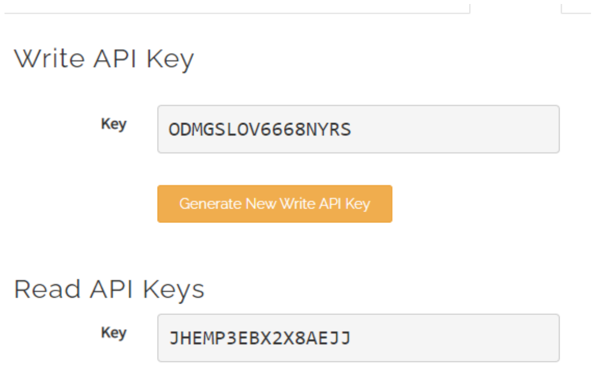

Fig 10. API key details

- Here I have used for visual graphs for monitoring, each data is uploaded in 25 seconds and graph is automatically plotted on site. Some of graphs are below that is used in monitoring the system. Fig 11, 12, 13, and 14 are graphs showing them.

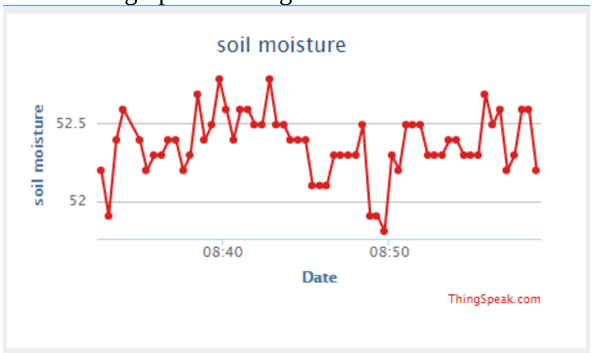

Fig11. Soil moisture graph

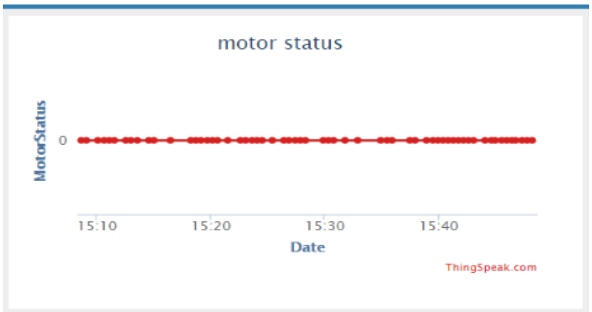

Fig 12 motor status graph

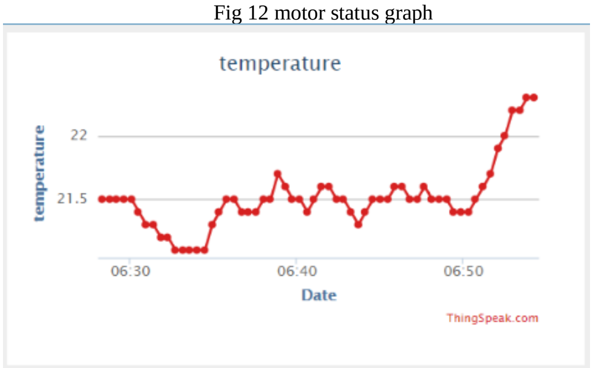

Fig 13. Temperature graph.

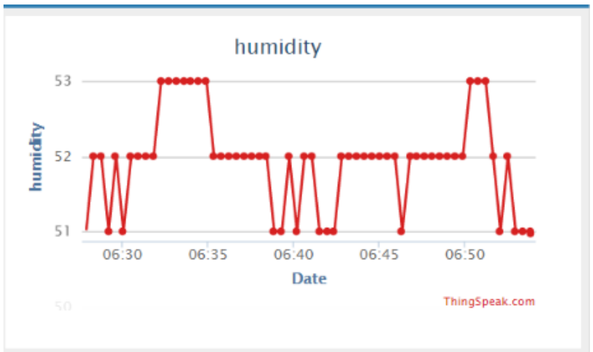

Fig 14 Humidity graph

- Data exported in excel sheet from thing speak as shown here. Fig 15,16 and 17 shows the ecxel data sheet entry of different soils.

created_at	entry_id	temperature	humidity	moisture	motor status
2021-03-15 07:20:42 UTC	2	26	32	3.12805	1
2021-03-15 07:21:08 UTC	3	25.7	30	0.48876	1
2021-03-15 07:21:34 UTC	4	26.2	32	4.78983	1
2021-03-15 07:22:00 UTC	5	25.8	31	14.56501	1
2021-03-15 07:22:27 UTC	6	25.9	30	61.58358	0
2021-03-15 07:22:53 UTC	7	25.9	30	56.50049	0
2021-03-15 07:23:19 UTC	8	25.9	30	56.59824	0
2021-03-15 07:23:45 UTC	9	26	30	50.63539	0
2021-03-15 07:24:12 UTC	10	26.1	31	48.5826	0
2021-03-15 07:24:38 UTC	11	26.3	30	49.26686	0
2021-03-15 07:25:04 UTC	12	26.6	30	51.31965	0
2021-03-15 07:25:30 UTC	13	26.9	30	51.51515	0
2021-03-15 07:25:56 UTC	14	27.1	30	51.31965	0
2021-03-15 07:26:22 UTC	15	27.2	30	51.51515	0
2021-03-15 07:26:49 UTC	16	27.1	30	51.71066	0
2021-03-15 07:27:15 UTC	17	27	30	52.10166	0
2021-03-15 07:27:41 UTC	18	26.9	30	52.10166	0
2021-03-15 07:28:07 UTC	19	26.8	30	52.19941	0
2021-03-15 07:28:34 UTC	20	26.6	30	52.68817	0
2021-03-15 07:29:00 UTC	21	26.6	30	52.59042	0
2021-03-15 07:29:26 UTC	22	26.5	30	52.39492	0
2021-03-15 07:29:53 UTC	23	26.5	30	52.59042	0

Fig 15.clay and sand moisture monitoring data

2021-03-1	3237	27.1	24	25.5132	0
2021-03-1	3238	27.1	24	24.73118	0
2021-03-1	3239	27.2	23	25.61095	0
2021-03-1	3240	27.2	24	24.63343	0
2021-03-1	3241	27.3	23	25.80645	0
2021-03-1	3242	27.3	23	24.53568	0
2021-03-1	3243	27.3	23	24.53568	0
2021-03-1	3244	27.4	23	24.43793	0
2021-03-1	3245	27.4	23	24.43793	0
2021-03-1	3246	27.4	23	25.5132	0
2021-03-1	3247	27.3	23	23.55816	0
2021-03-1	3248	27.3	23	24.53568	0
2021-03-1	3249	27.3	24	25.41545	0
2021-03-1	3250	27.3	24	23.46041	0
2021-03-1	3251	27.3	23	25.31769	0
2021-03-1	3252	27.3	23	24.34018	0
2021-03-1	3253	27.4	23	24.43793	0
2021-03-1	3254	27.4	23	24.43793	0
2021-03-1	3255	27.6	23	8.89541	1
2021-03-1	3256	27.5	25	12.21896	1
2021-03-1	3257	27.5	23	64.02737	0
2021-03-1	3258	27.5	23	64.12512	0
2021-03-1	3259	27.4	24	63.04985	0

Fig 16.sand moisture monitoring data

2021-03-23 16:55:04 IST	2096	28.3	31	27.27273	0
2021-03-23 16:55:30 IST	2097	28.3	31	27.17498	0
2021-03-23 16:55:57 IST	2098	28.3	31	27.95699	0
2021-03-23 16:56:23 IST	2099	28.3	31	27.76149	0
2021-03-23 16:56:49 IST	2100	28.3	31	26.39296	0
2021-03-23 16:57:16 IST	2101	28.3	31	27.46823	0
2021-03-23 16:57:42 IST	2102	28.3	30	26.39296	0
2021-03-23 16:58:09 IST	2103	28.4	30	27.17498	0
2021-03-23 16:58:35 IST	2104	28.4	31	27.07722	0
2021-03-23 16:59:01 IST	2105	28.4	31	26.09971	0
2021-03-23 16:59:27 IST	2106	28.5	31	27.07722	0
2021-03-23 16:59:54 IST	2107	28.4	30	27.17498	0
2021-03-23 17:00:20 IST	2108	28.4	29	27.66373	0
2021-03-23 17:00:46 IST	2109	28.5	29	27.95699	0
2021-03-24 08:00:43 IST	2110	26.6	43	47.70284	1
2021-03-24 08:09:23 IST	2111	26.3	43	57.38025	0
2021-03-24 08:09:49 IST	2112	26.3	43	57.67351	0
2021-03-24 08:10:15 IST	2113	26.3	43	57.67351	0
2021-03-24 08:10:41 IST	2114	26.4	43	57.2825	0
2021-03-24 08:11:07 IST	2115	26.4	44	56.89149	0
2021-03-24 08:11:33 IST	2116	26.5	43	56.30499	0
2021-03-24 08:11:58 IST	2117	26.5	44	56.01173	0
2021-03-24 08:12:24 IST	2118	26.6	43	55.42522	0

Fig 17.clay moisture monitoring data

- Form all data collected in three phases as per soil types, we found that the retention or moisture holding capacity of clay is higher than mix of clay and sand, lowest moisture holding capacity was for sand.

5. RESULT AND DISCUSSION

Designed system worked successfully in field for irrigation purpose. It provides an opportunity to farmers to take some rest, instead of working whole day in summer and winter as it is one of the most time consuming work. The system has many advantages and some disadvantages. A proper working device which irrigates the field when moisture goes down and automatically turn off the motor when certain limit is achieved is composed. Farmer can monitor the field using the IoT platform that is updated in system. If he see some error in reading coming from field he can stop it immediately. Temperature and humidity sensor were working well, it gives an idea, whether the crop is able to sustain the climatic condition. The results of monitoring were also promising as it saved about 33% of water in total. In all the three sample we found the time of retaining water for crops according to the lower limit. Each soil has different capacity of retaining water, as stated in work. Over irrigation can be prevented from this system, which can lead to damage of crops. The plan can be concluded as a major development in the field of agriculture. The system have capacity to reduce the problem faced in traditional agriculture.

6. FUTHER WORK

The device can be programmed for different crops in different season. As of rice and wheat both are cultivated in different season and need water in different quantity. Further modification can be done like using gsm module for inbuilt internet connection, no need for Wi-Fi on field. Security enhancement can be done, as the system can be easily hacked by well others.

7. ACKNOWLEDGMENTS

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