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SMART IRRIGATION SYSTEMS AND WEBSITE-BASED PLATFORM FOR FARMER WELFARE

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ABSTRACT

Agriculture has a major impact on the Indian economy with the highest employment ratio than any sector of the country. Currently, most of the traditional agricultural practices and farming methods are manual, which results in farmers not realizing their maximum productivity often due to increasing labour costs, inefficient use of water sources leading to wastage of water, inadequate soil moisture content subsequently leading to food insecurity of the country. This research paper aims to solve this problem by developing a full-fledged web application based platform that has the capacity to associate itself with Microcontroller-based Automated Irrigation System which schedules the irrigation of crops based on real-time soil moisture content employing soil moisture sensors centric to the crop's requirements using WSN (Wireless Sensor Networks) & M2M (Machine To Machine Communication) concepts, thus optimising the use of the available limited water resource, thereby maximizing the crop yield. This robust automated irrigation system provides end-to-end automation of Irrigation of crops at any circumstances such as droughts, irregular rainfall patterns, extreme weather conditions etc. This microcontroller-based system integrated with a user-friendly and responsive web platform will be capable of achieving a nationwide united farming community and ensuring the welfare of farmers. This platform is designed to equip farmers with prerequisite knowledge on tech and latest farming practices in general. In order to achieve this, MailChimp mailing service is used through which interested farmers/individuals' email id will be recorded and curated articles on innovations in the world of agriculture will be provided to the farmers via e-mail. In this proposed system, a service is enabled on the web platform where nearby crop vendors will be able to enter their pickup locations, accepted prices and other relevant information which will enable farmers to choose their vendors wisely. Along with this we have created a blogging service which will enable farmers and agricultural enthusiasts to share experiences, helpful knowledge, hardships etc. with the entire farming community. Implementation of the proposed system into a scalable application by incorporation of SAAS cloud architecture has also been envisioned in this system.

KEYWORDS

Web Application, APIs, Database, WSN (Wireless Sensor Networks), M2M (M/C to M/C Communication), Automation, Irrigation System, Sustainability, SAAS (Software As a Service), Soil moisture sensor

I. INTRODUCTION

Agriculture, the backbone of the Indian Economy, contributes to 18.1% of the GDP [1]. This sector provides the highest employment opportunities (almost 45% of the total employment/no. of jobs available in India [Hindustan Times, June 18 2018]). Globally, the market is expected to witness an incremental surge in demand due to increased water scarcity instances and shifting trends towards mechanization of agricultural processes.

However, the increasing water crisis along with unpredictable rainfall patterns are impeding the use of conventional agrarian irrigation techniques, thus escalating the demand for advanced irrigation methods in order to practice sustainable agriculture.

In India, the majority of irrigation systems are manually operated, which results in several disadvantages, such as an increase in labor costs, inefficient use of water resources, low soil moisture content, frequent power cuts and low voltage supply etc., which pose major problems to farmers [2]. There is a need to automate the irrigation system which optimises the use of water sources for irrigation based on the crop's water requirement, thus eliminating wastage of water in order to implement sustainable farming even in areas of limited water source.

Thus, we propose to develop a microcontroller-based automated irrigation system [3] using IoT, which schedules the spraying of an adequate amount of water into the soil based on the real-time soil moisture content measured by soil moisture sensors, calibrated according to the crop's requirements, thus practicing Sustainable Agriculture. Along with MC based system, a full-fledged web application based platform for farmers [4][5][6] is developed providing an interactive dashboard with main features – displaying real-time soil moisture sensor values dynamically, providing prices of crops offered by vendors in their locality and related information for farmers to make informed choices, latest news related to agriculture as blog posts as well as emails to keep our farmers updated with the latest advancements in the field on agriculture. This seamless integration of MC based system with an interactive website would immensely benefit farmers in a variety of ways - increasing the crop yield per hectare by enabling farmers to implement efficient methods of farming, reducing efforts put in by the farmer [3], ensuring crop health and yield in adverse weather conditions/ during erratic availability of water. [4] This automated irrigation system is thus a cost-effective way to improve the food security of the country. In the future, cloud-based platform for Smart Irrigation Control system could be implemented as SAAS (Software As A Service) using AWS/Azure, to increase the scalability of the web application [5] and carry out analytics on stored data which can be accessed by farmers anytime from their smartphones.

II. LITERATURE SURVEY

As a preliminary step to describing the proposed irrigation system in detail, we analyzed existing irrigation systems used in agriculture.

ML integrated Weather-Based Irrigation System: devised employs Raspberry Pi MC equipped with calibrated Temperature-Humidity sensor (DH11) & Soil Moisture Sensor seamlessly integrated with IoT cloud platform based on WSN concepts used to keep track of moisture content of the soil and weather/temperature of surroundings, providing immense benefit to farmers by increasing productivity and making farmers take correct decisions. This paper also proposes an ML model using KNN algorithm to predict plant diseases centric to crops in order to protect the crops at an early stage, thus ensuring good yield in such incidents of disease [8].

Based on the principle of M2M (Machine to Machine) communication, and uses KNN algorithm (ML), cloud computing, and IoT concepts used to propose an intelligent IoT-based irrigation system to auto-irrigate crops. Raspberry Pi system + Arduino UNO MC equipped with soil moisture sensor, temperature & humidity sensors is used as data collection interface and MC respectively in this system which communicates serially. The sensor data is analysed using ML algorithm to make accurate predictions on soil dryness & crop behaviour over time to apply the intelligence in irrigating. Results of ML algorithm and sensor data are displayed using Raspberry Cloud webpage and makes use of Pi3 cloud to host the web application on cloud and to support ML algorithms to function. However, Graphs obtained using KNN algorithm can be graphically represented to farmers in a more understandable manner and Interfacing between CNN algorithm and MC can be further illustrated [5].

Agri CPS(Cyber Phy system) based on CNN model utilizing IoT technologies can be envisioned to develop a sustainable irrigation system along with disease prediction analysis to implement smart agriculture. Hardware components include Node MCU MC equipped with soil moisture sensor, DH11 sensors integrated with Thingspeak cloud using IoAT technology to develop an intelligent disease prediction model to accurately monitor the field and give real-time updates to farmers [9]. However, practical efficiency of disease prediction models can be increased.

WSN framework based Smart Irrigation Systems: Based on the principle of Wireless Sensor Networks, an irrigation system can be developed using Raspberry Pi MC equipped with Soil Moisture and Temperature sensors. In this system, Bluetooth technology is used to control and monitor pump status and temperature through an android application called BlueTerm [2].

Concepts of LSP model(Wireless Sensor Networks) utilized to develop a smart irrigation system using Raspberry Pi system and Arduino UNO MC along with Soil moisture sensor and electromagnetic valve as hardware components integrated with mobile updates feature using WSN protocol in order to implement a low-cost smart irrigation control system [10].

Concepts of Cloud computing, wireless sensor networks, serial communication, DB management are utilized to propose Smart Drip-Irrigation System based on IoT and data mining technologies. This proposed system framework visualizes WSN infrastructure into the agricultural system to intelligently procure sensor data and automatically irrigate the field which can be practically implemented using Android app development and cloud-based server technology [1]. There are no limitations in this review paper.

The concept of WSN (Wireless Sensor Networks) can be utilized to develop sensor-based automated irrigation system using Arduino UNO as MC along with PIR sensor, GSM module, DHT11 sensor, PH sensor, Wi-Fi module, pressure sensors in order to develop robust irrigation system linked to web application using Internet Protocol configuration, and farmers get real-time SMS updates on soil moisture and pump status [6]. Usage of the GSM module for SMS service to customers requires further illustration in the proposed model.

In this paper, concepts of IoT and Wireless Sensor Networks are utilized to develop Smart Irrigation system using Raspberry Pi MC, soil moisture sensor, DHT11 sensor, relay, motor as hardware components integrated over Wi-Fi module over Thingspeak cloud platform [11].
Graphs obtained using the Thingspeak cloud does not provide effective analysis keeping the literacy of farmers in mind, which is the only limitation found in this model.

Smart Irrigation System using LORA module, cloud computing and LTE networks to develop scalable solutions to irrigation using the LORA communication module as the main hardware device along with hydroelectric generator, solenoid/irrigation node valve integrated with Cloud API requests & UDP MQTT protocols to develop long-lasting, high performance system enabling long distance communication b/w irrigation node & gateway [2].

Smart Irrigation System using Wi-Fi module & MQTT protocols: IoT-Based economical farming is developed using ESP8266 WiFi node MCU with humidity, soil Moisture and ultrasonic sensors, MQTT broker and relay as hardware components integrated with software which include MQTT protocol, Wi-Fi interfacing/configuration in order to implement low-cost and economical smart irrigation system with feature to send real-time updates to smartphone via Wi-Fi [13].

In this paper, concepts of M2M communication, IoT are utilized to propose low cost and economical Smart Irrigation System using MQTT (Message Queue Telemetry Transport) protocol. This proposed system requires ESP8266 WiFi node MCU MC as hardware components integrated with the Internet using MQTT protocols and Arduino Pi3 Serial Communications. Key aspect to note in this paper is aspects of Security of web-app for the welfare of farmers handled very effectively for agricultural benefit [14].

Smart irrigation system using Arduino UNO MC along with ESP8266 Wi-Fi module, soil moisture sensors, relay, as hardware components integrated with Thingspeak Cloud App and MATLAB software in order to intelligently irrigate the crops on the field along with providing visually appealing graphs which display real-time soil moisture readings over a duration of week/month along with motor status to keep farmers in sync with developments at field. Keeping literacy among the farmer population in mind, Graphs obtained using Thingspeak cloud may not provide effective analysis and information to the farmer directly [3].

Smart Irrigation System using Cloud:- Based on cloud and web of things-based water system framework [15], one of the proposed systems make use of Arduino UNO MC and Moisture sensor, temp & humidity sensor, relay equipment as hardware components integrated with the proposed cloud framework. The major limitation of the paper is that practical hindrances will arise when converting the formulated broad-level system diagram into a real project.

Webcam-based system:- Concepts of automated systems are utilized to develop a unique smart irrigation system using Raspberry Pi along with soil moisture sensors, DH11 temp. sensor, relay as hardware components integrated with a webcam-based system for continuous monitoring of crops. This paper requires further illustration to demonstrate the interface between soil moisture sensor and water level sensor with dual-control relay via MC connected, which is the shortcomings of the proposed system [16].

Tiny-OS based Smart Irrigation System:- Technology behind Operating Systems (OS), Wireless Sensor Network is utilized to develop a smart irrigation system using IRIS processor equipped with MDAlOOCB sensor, motor driver circuit as hardware components in order to simulate the smart and robust irrigation system using MOTEVIEW 2.0 software simulation and IRIS software [17]. However, one limitation is that the proposed system is not cost-effective, which should be considered when extending Tiny-OS based systems on a large scale with better routing management techniques.

WSN-based Smart Irrigation System using XBee Module:- Using Wireless Sensor Networks smart irrigation system can be developed using Arduino UNO, Raspberry Pi MCs equipped with XBee dongle, soil moisture sensor as hardware components integrated with software which include puTTy launch terminal, mobaXterm software in order to implement robust automated irrigation system with weather-forecasting, in-app control feature and responsive web app display real-time soil moisture data from different irrigation zones [4]. One of the shortcomings of this system is that the proposed system is not cost-effective at a large scale due to expensive modules to implement XBee technology. Another shortcoming is that anyone can control the system through the internet if the IP address of raspberry pi is known, thus compromising the security of the data and control of the system, thirdly this farming technique does not take different crops with respective water requirements grown on the same field into account, which is also another shortcoming of the proposed system.

WSN (Wireless Sensor Networks) technology can be utilized to develop smart automated irrigation systems using WSN node-based architecture. This system can be implemented using Arduino MC along with XBEE radio module, the camera on screen, soil moisture sensors. The Arduino is programmed using proteus software which interfaces with webcam and sensors to implement an intruder-alert system and feedback based automated irrigation system [18]. The Feedback system from the webcam monitor to MC requires illustration, which is the main limitation of the proposed model.

Smart Irrigation System using GSM and Bluetooth technology:- to develop mobile-controlled user-friendly and robust system using GSM, Bluetooth and Cloud technologies. Hardware components required in this system are- Arduino MC, GSM module, Bluetooth module, WiFi module along with Soil moisture sensor, luminosity (LDR sensor), LM35 temperature sensor. Software Employed in this system are- Sparkfun sensor app [to display real-time sensor data] and cloud platform maintaining the sensor data and web application. GSM module used to send real-time updates to customers via SMS service. Syncing motor operations and control with our smartphone via Bluetooth makes irrigation very robust and convenient for farmers. Additionally, sensor data is sent to the IoT cloud via Wi-Fi module [19]. However, further illustration regarding interfacing of soil moisture sensor and water level sensor with dual-control relay via MC connected is required in this paper. One limitation of the proposed system is - System should be made more energy efficient for proper activation of multiple sensors connected to MC. Irrigation System should be configurable to different types of crops (seasonal crops e.g., Kharif, Rabi).

Smart Irrigation System using Zigbee Technology:- An Irrigation monitoring and control system can be devised utilizing Zigbee Technology, Cloud computing and WSN (Wireless Sensor Network) technology. Arduino MC is used for automation equipped with DHT11 ambient temperature and humidity sensor, soil moisture and M116 water level sensors, Zigbee transceiver, relay integrated with Apache Tomcat HTTP web server hosted on cloud in order to develop this smart mobile integrated node-based irrigation system [7].

Fuzzy Logic and IoT based Smart Irrigation System:- IoT-based Smart Irrigation model can be developed utilizing Fuzzy Logic technology with the main objective to control the schedule and frequency of irrigation of crops and to keep the groundwater at an optimum level for sustainable agriculture and water conservation. This model is implemented using Mamdani Fuzzy Controller used to visualise water usage by the crops over time which is visually implemented using MATLAB implementation of the logic. The use of fuzzy logic technology used to enhance water conservation strategy in high water stress areas - using MATLAB graphically [20]. The main limitation of using Fuzzy Logic technology in this model is that this technique does not yield accurate results over time thus reducing the efficiency of the system in the long run.

III. METHODOLOGY

Hardware components of proposed automated system which include Arduino UNO, Soil Moisture Sensors, Relay Module and DC Motor accomplish controlled irrigation of crops along with real-time soil moisture data logging to readable-file format (.CSV file). The appending CSV file with real-time data is parsed using AJAX queries. The dynamically appending CSV data is displayed with date and timestamp in presentable HTML table format for the two irrigation zones in which farmers can grow two types of seasonal crops in one field (Kharif and Rabi Crops for instance). This .csv data can be reviewed again in case the farmer was logged in. Weather data will also be visible in this section as the OpenWeatherMaps API is used in this web application.

The website has been created using the node.js framework and NPM (Node Package Manager) packages such as express, EJS, body-parser, etc. We have used MongoDB Atlas, which is a Cloud-Native Document Database. The styling has been done using CSS and Bootstrap v5. The website has been coded to be highly responsive, i.e., users can experience good UI/UX experience on any screen size.

The blog post section and vendor section essentially consist of html forms. Data from these HTML forms become accessible to the JavaScript code via an NPM package called body-parser. This data then gets stored in the MongoDB Atlas database setup. Data from this database then gets rendered onto these webpages.

Similarly, for the mailing list to work, the data from the form gets passed on to the MailChimp API. Once this post request is made, the MailChimp server logs in the data in the list that has to be mentioned in the code. Thus, the web application can record the data accumulated and use the data obtained.

IV. PROPOSED SYSTEM

A. CIRCUIT DIAGRAM

Fig. 2a. shows the circuit diagram implemented for building this project.

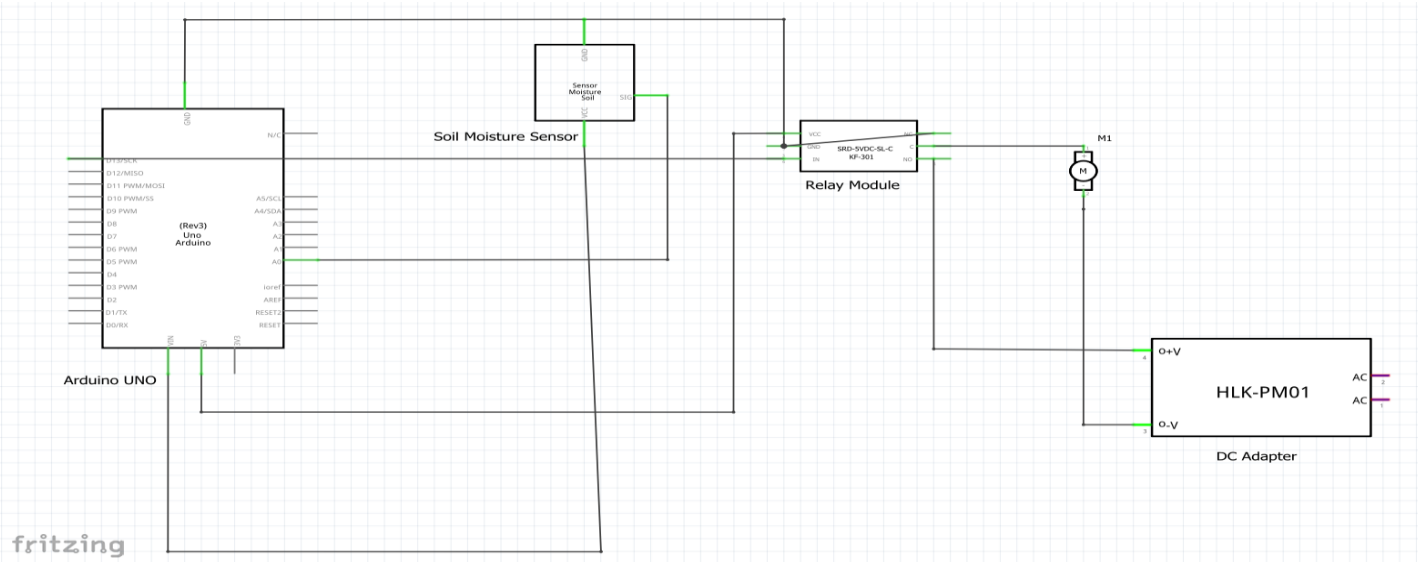


Figure 2 a: Circuit Diagram

The soil moisture sensor (5V) probes are placed into the soil near the crop/plant to be auto irrigated. Sensor measures real-time soil resistance value at intervals of 1s (1000ms configurable). This analogue data is sent as input to Arduino MC. The Arduino MC is programmed in order to generate a digital signal – LOW (0) when the soil moisture resistance is out of WET RANGE and HIGH (1) when soil resistance is within WET RANGE.

B. DATA LOGGING METHODOLOGY

Python Script is written using PySerial, which listens on the COM port, waits until incoming data is waiting in the Serial Buffer. Appends the data record (Consisting of Date: Time, Soil Resistance Val, Motor Status (ON/OFF) at an instantaneous time) into .CSV file [5]. Delay of 1s (1000 ms) given between recurring records.

Converted (.csv file) into JSON object to establish link to website.

Real-Time Data appending to the CSV (Comma-Separated-Values) file is as shown in Fig. 9.

C. DESIGN OF FULL-FLEDGED WEB APPLICATION FOR FARMERS

Templating of the website done using Bootstrap and Embedded JS (EJS templating).

Through our research, we've inferred that the best way to mitigate every single farmer more efficiently is through a highly efficient and dynamic website. Weather forecast displayed on the website through linking Openweathermaps API to the website.

(i) Smart Irrigation System Platform: the website consists of a page which consists of 2 segments: one which takes in wheat crop's soil moisture sensor data and the other which takes in rice crop's soil moisture sensor data. Once the farmer gives access to the .csv file, the website will display the sensor data intuitively [shown in Fig. 7] to the farmer along with forecasted weather conditions for the day.

(ii) Blog Post and Gov. Scheme notifier: the website consists of a blogging system called "The Campfire Corner" [shown in Fig. 6]. Any logged in user can upload a blog with a title, a sub-title, a body and upload a picture along with the blog post. Users will be able to comment on the blog post. This was created in an effort to create a community exclusively for farmers, NGOs, agriculture enthusiasts, etc. to be able to voice their opinions in a safe space.

(iii) Find Vendors Nearby: This part of the website consists of vendor listings as shown in Fig.8. Here, a vendor account will have to enter his/her name, experience, prices the vendor is willing to pay for specific crops, pick up points, contact details, etc. Based on his/her location, he will get associated with a particular state and city/town listing. Any farmer account will just have to enter his/her state and city/town after which he/she will get redirected to a page which will consist of listing of all the vendors nearby. Based on the information of the vendors, the farmer will be able to make informed decisions and sell their crops at the best price. Farmers will also be able to leave ratings and reviews for the vendors that they have worked with via this platform, in the past.

(iv) Periodic Newsletter: Logged in user or not, anyone can access this feature. Interested individuals will just have to drop their first name, last name and email id in the form window shown in Fig. 7 Once their registration is successful, they will be able to receive emails with curated articles on innovations in the world of agriculture. We have achieved this feature via the MailChimp API mailing service.

V. RESULTS

A. SETUP IMPLEMENTATION

The working model setup implemented is as shown in Fig. 3 below.

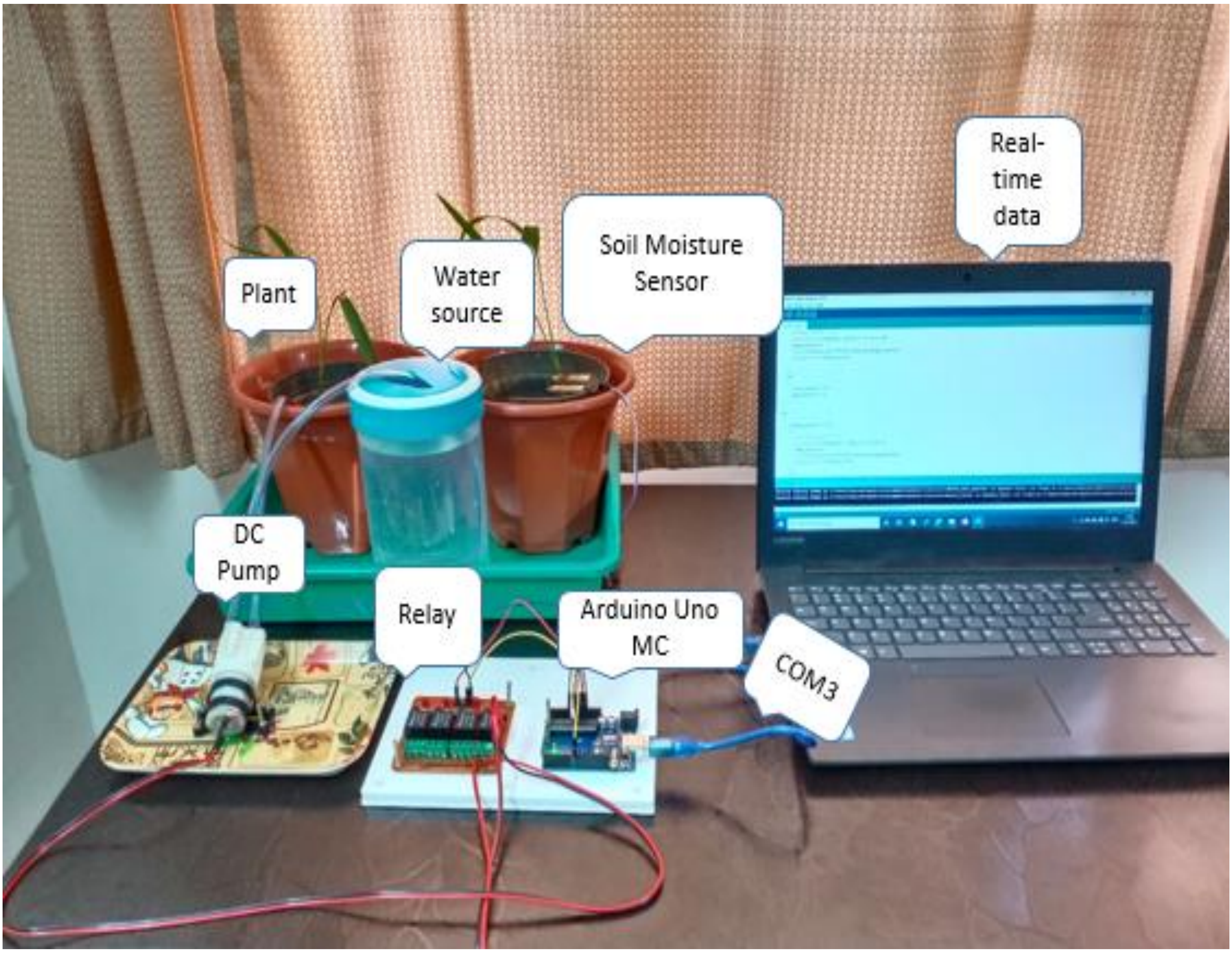


Figure 3: Setup Working Model

B. FULL FLEDGED WEB-APP FOR FARMERS

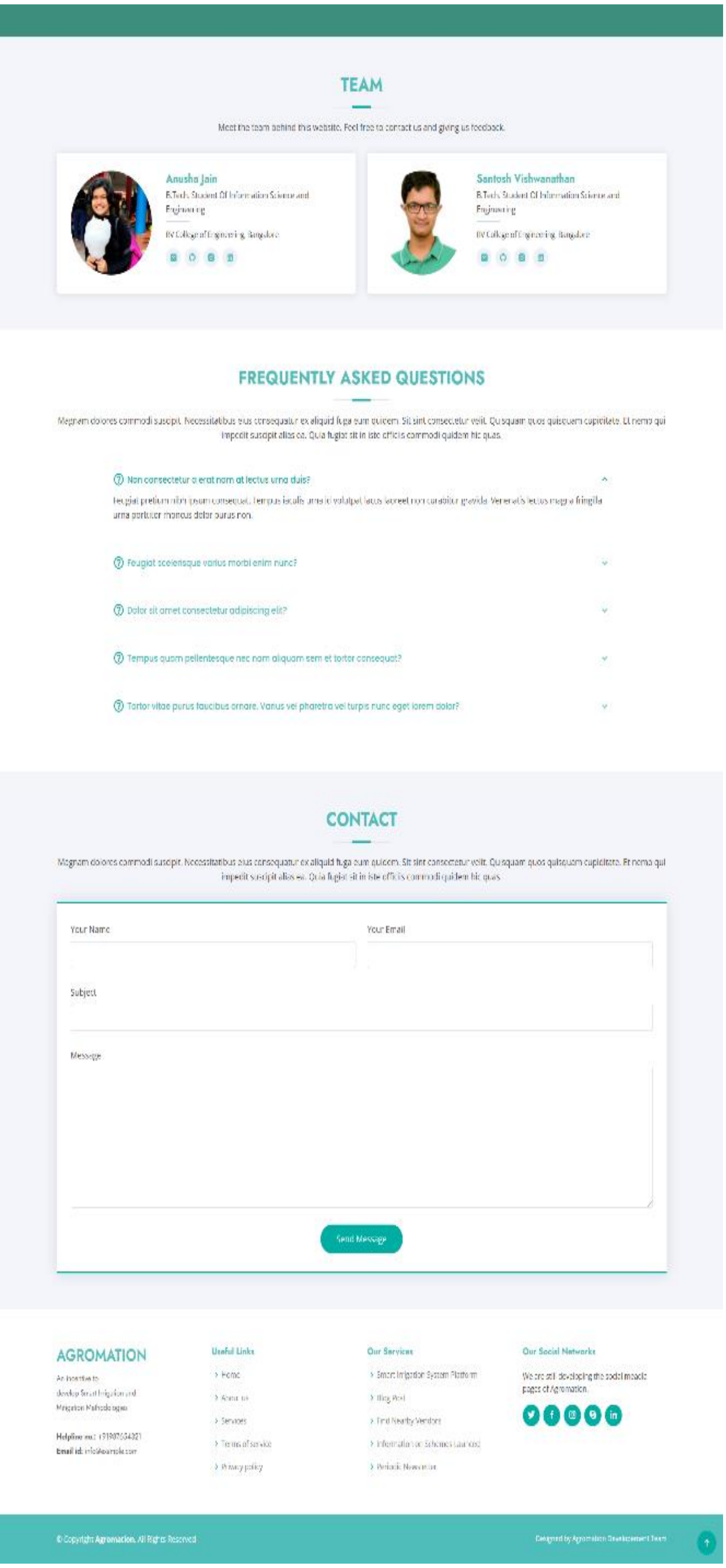


Figure 4: Landing Page Banner (Home Page)

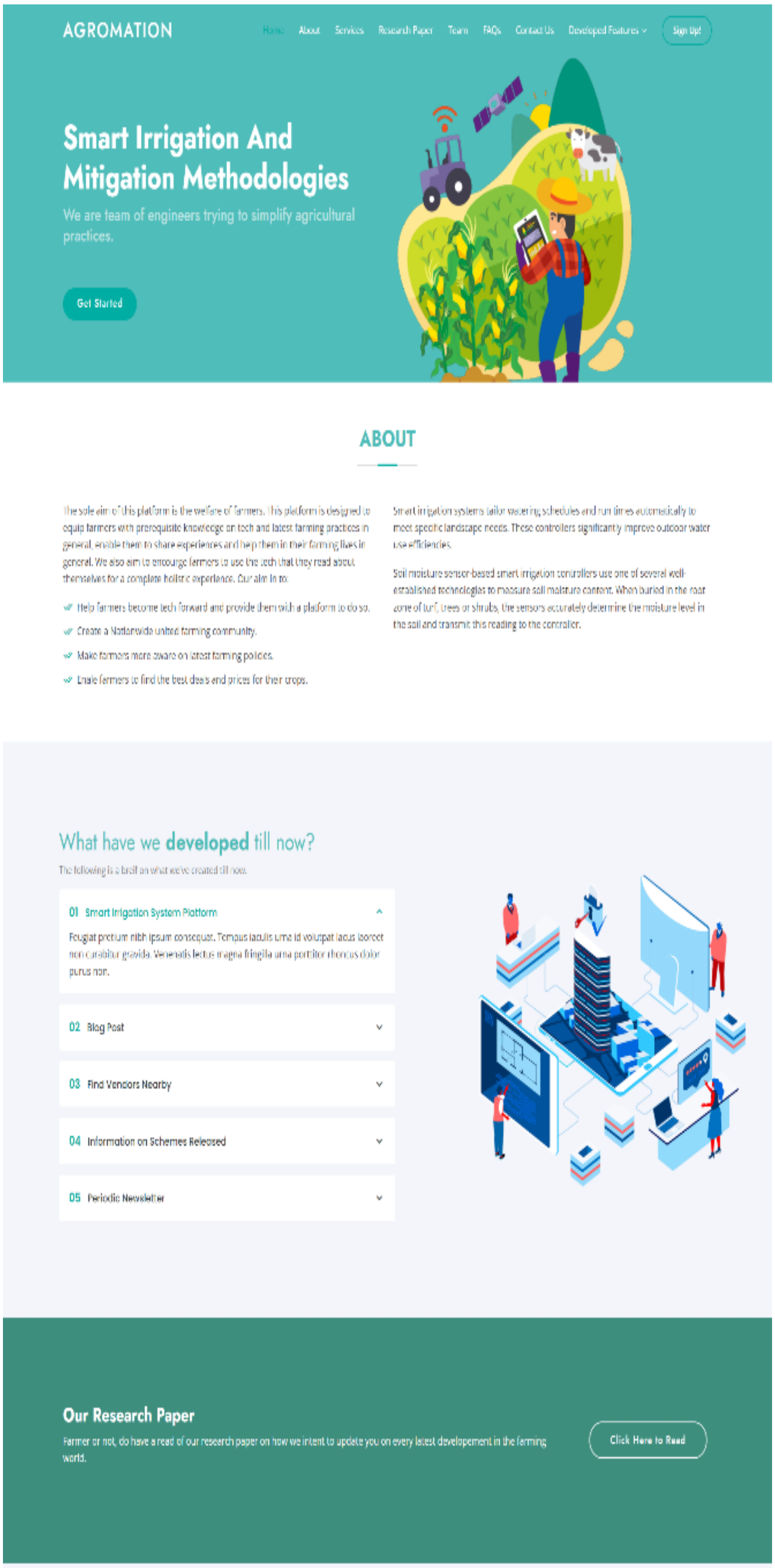
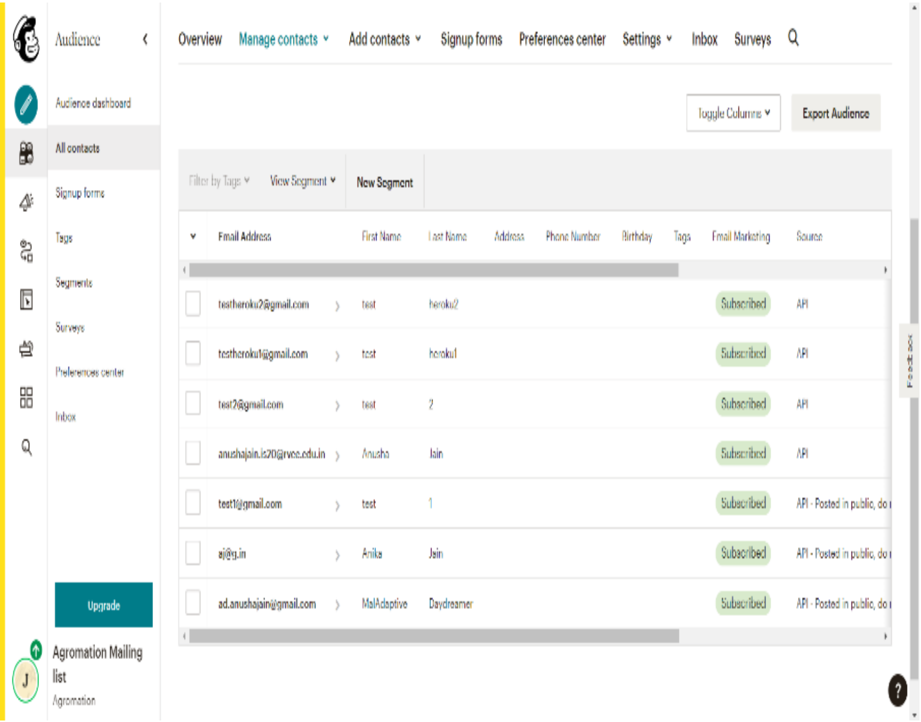


Figure 5: Landing Page Banner (Home Page)



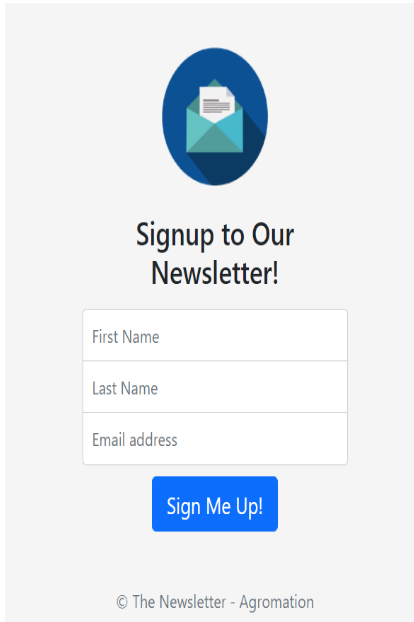


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Figure 7: User Login Database

Figure 7: User Login

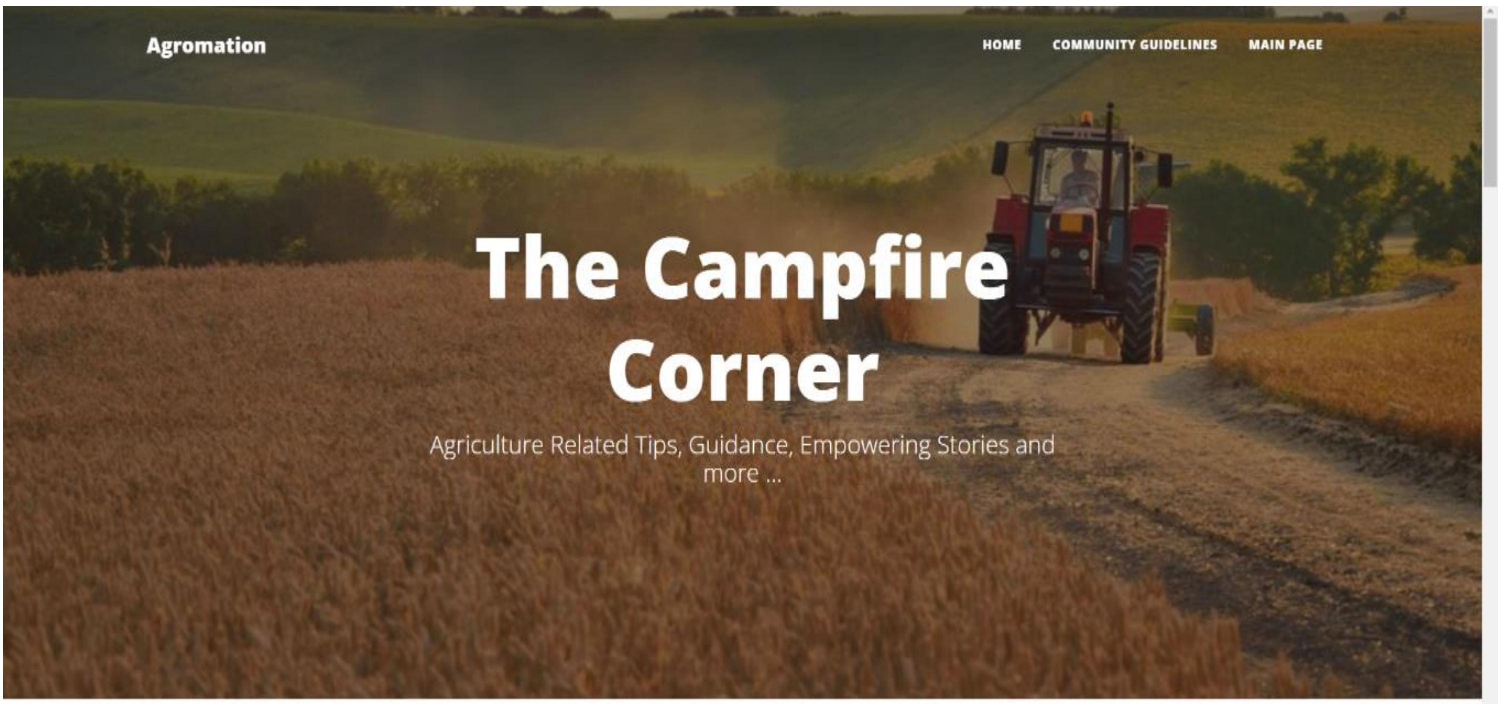

Figure 6: Blog Post

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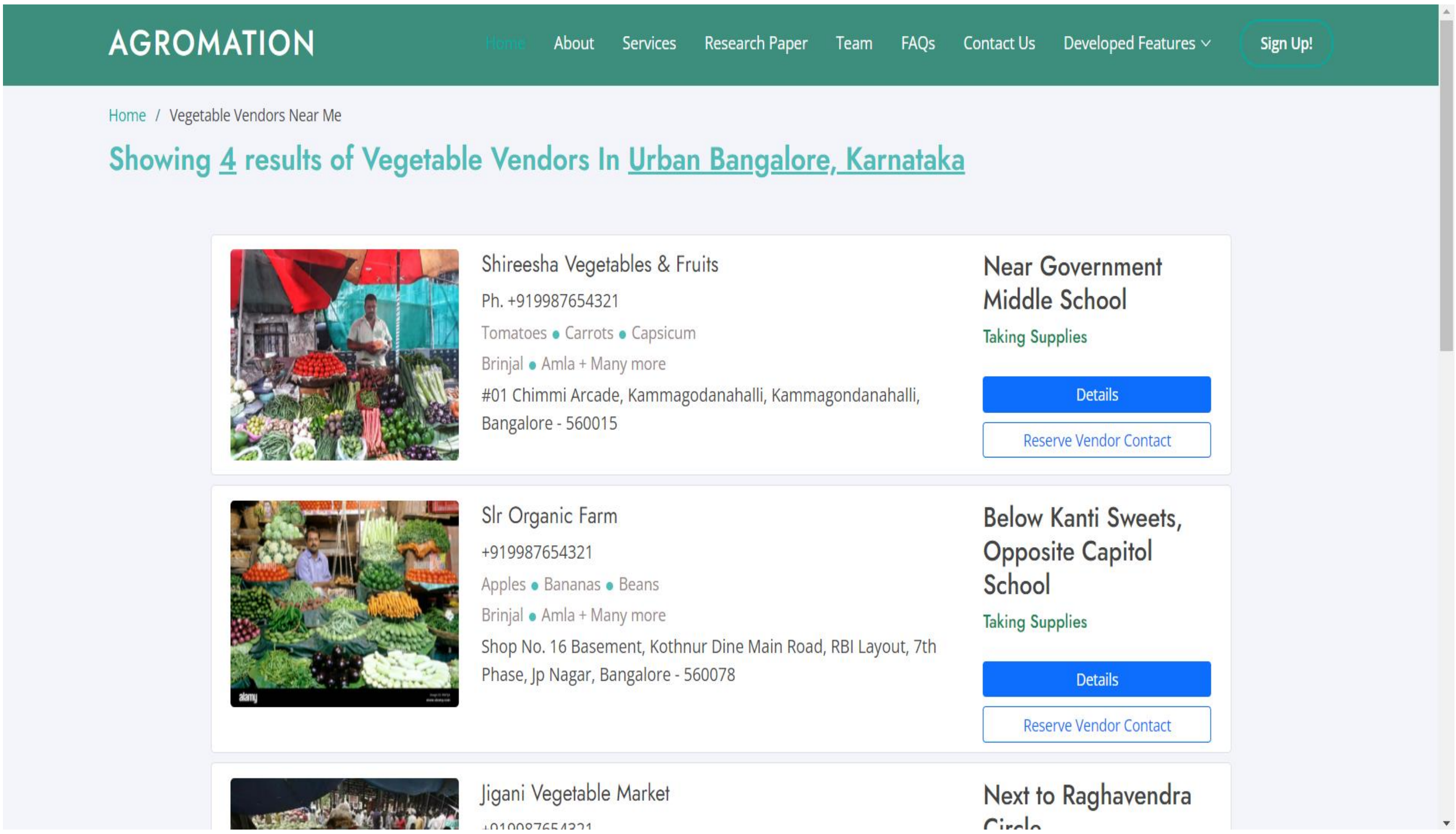

FUTURE ARCHITECTURE

In order to introduce this prototype into the agricultural spectrum, an architecture is devised through which the prototype can scale up to benefit a large number of farmers.

Consider a farmer who maintains many plots of agricultural land, all property owned by the farmer is considered an Irrigation Unit and each of the individual land plots are termed Irrigation Hubs.

If a farmer grows both the varieties of crop i.e., Kharif and Rabi seasonal crops, then the portion of plots growing each variety are termed as Irrigation Zones.

In each Irrigation Unit, there are 3 main subsystems – Pump Subsystem, Control Subsystem and Communication Subsystem.

The pump subsystem connects to each of the irrigation hubs by means of pipes and motor equipment. The control subsystem consists of the microcontroller via Wi-Fi module (ESP8266/Equiv.) employing WSN framework [3][7], which schedules irrigation of crops based on sensor readings, which are distributed across each irrigation zone.

Communication Subsystem synchronously collects and stores the pump status and sensor data, processes, and relays the information to the Smart Irrigation Control Application [5] hosted on a cloud platform[3] such as Amazon AWS/Azure which would provide their platform as Software As A Service for auto-scaling, maintenance of web server and efficient utilization of stored data. Availing and maintenance of the platform at a nominal cost/cost on-demand basis.

This on-cloud control application can provide an interactive dashboard for the farmers, giving curated suggestions to farmers on best farming practices/strategy etc, through Data mining and ML technologies. [1][7]

VII. CONCLUSION

Thus, based on our analysis and study of the interconnected field studies of Internet of Things, Machine-to-Machine communication, and wireless sensor networks, we have proposed the smart robust system through which irrigation of crops can be successfully automated centric to the crop's moisture requirements, which reduces wastage of water drastically (optimisation) and improves Sustainability in practice, power efficiency through this cost effective system and ease of usage of equipment collectively reduces manual intervention to the maximum extent thereby increasing efficiency of the farmer by saving enormous labour cost and time. The Web app can be used as a full-fledged portal for the benefit of farmers with multitudes of features – interactive dashboard, news articles/blog posts on Agri-industry, Real-Time display of soil parameters and more features that would transform the agricultural spectrum of the country.

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