Data Analytics System for Irrigation Alert, Fertilizer and Pesticide Recommendation towards Sustainable Agriculture

K. Sumathi, P. Deepalakshmi, K. Selvarani

Abstract: ***Ministry of statistics and program implementation says that, the agriculture sector's contribution to the Gross Domestic Product (GDP) decreased gradually from 54% in 1950-51 to 15.4% in 2015-16. Farmers are suffering because of non-availability of information and no proper guidance (advisory services). Farmers in rural areas are detached from technology and essential agricultural support services needed to carry out in farming activities and their productivity per acre is low due to lack of adopting recent mechanisms and technology usage. This paper presents a Data Analytics System for Irrigation Alert, Fertilizer and Pesticide Recommendation. The system is developed using modern digital technologies by bringing the necessary supporting elements in one place and to deliver necessary insights to farmers throughout crop cultivation to improve the farming actives. The proposed system includes 2 modules a) External Intelligence Module b) Data Analytics Module. In first module, data is gathered from farmer's dataset, irrigation partners, pesticide vendors, fertilizer dataset. The second module will work on the grounds of output being "yes" of EIS, will generate alert regarding Irrigation, pesticides and Fertilizer Recommendation. The proposed system offers personalized advisory services using communication devices to maximize the crop yield and to minimize the cost of production.***

Keywords: ***Data Analytics, Pesticide Recommendation System, Fertilizer Recommendation System, Irrigation Alert System***

I. INTRODUCTION

In India, 70% of the people live in rural areas. Agriculture is a major industry and plays an important role in Indian economy. Nowadays, this industry needs more support than any other. The Agri-Sector contribution to the GDP is gradually decreased from 1950. Most of the researchers are doing their work in smart farming, an application of science and technology. Recent technologies used in smart farming applications [1] are Internet of Things (IoT), Big Data and analytics, Cloud Computing, AI & Machine Learning Techniques. Technologies like Advanced Machine Learning Techniques, Big Data and Cloud computing concepts enable the farmers to get enhanced insights on consequence of agricultural activities and to take better decision making process in farming activities.

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The recent technologies delivering efficient farming solutions to stakeholders are a) to store the data from field sensors (real time data) on the cloud b) to use mobile app-based data generation and extraction c) to avail satellite monitoring System d) to use machine learning and real-time data visualization techniques for better understanding.

Smart farming is a network of interdisciplinary technologies which includes generally a database where all chunks of data from various sensors and resources are gathered, stored, analyzed, and retrieved for actions. For crop monitoring, i) crop related data such as crop tissue nutrients status, crop population, crop yield, fungal / insect infestation etc. ii) Soil related data such as physical soil structure, soil texture, soil moisture, soil temperature iii) climate related details such as humidity, temperature, wind speed, rainfall are all required. The pH value of the normal soil suitable for most of the crops [2] is between 6.5 and 8. When the pH value of the soil is less than 6.5, the soil becomes acidic and if pH value of the soil is greater than 7.5, then it is alkaline. Soil can be classified with the values of Nutrients.

Global positioning systems (GPS), Geographical information systems (GIS), RADARS, Drones, Data sensors, Data Transmitters, Cameras and connected devices are used in smart Agriculture Applications. IoT plays vital role in delivering real-time data such as water level, soil moisture, crop status, and humidity, fertilizer level of the soil to the database or cloud. Cloud and GPD data will be analyzed using Analytical tool which will deliver the enhanced insights to farmers to improve the farming activities.

Proposed system deploys various field sensors in the farm (in leaf, to ground, in water) to collect data. Data is collected through base station/micro controllers, stored in the cloud server and accessed by various analytical tools to provide necessary advisory services to the farmers frequently via their mobile phones. The analytical tool also access data from other stakeholder's dataset to provide enhanced insights to the agrarian community.

II. RELATED WORKS

R. Raut, et al [3] proposed an IoT application for Soil Monitoring, Fertigation, and Irrigation System. The researchers have checked the amount of the three major soil macronutrients such as nitrogen (N), phosphorus (P), and potassium (K) and described the level of N, P and K as High, Medium and Low. Researchers have used various sensors to sense the humidity, temperature and initiate the irrigation automatically based on the interrupt signal to ARM7 processor.

Mohanraj et al. have proposed an IoT Application for Field Monitoring and Automation in which data is collected from various sensors [4]. Various modules like remainder, irrigation planner, crop profit calculator, monitoring plant growth in various stages, and calamity check and problem identifier are built. A method named Evapotranspiration is defined to calculate the water need of a plant using devised algorithm. A comparative study was also made between various applications available with current developed system based on knowledge base, monitoring modules, efficiency and reliability.

Amrutha A et al [5] proposed system to determine the available NPK nutrients in the soil and estimated the fertilizers to be added. Their system automates the process of addition of fertilizers and thereby reducing the time and manual labor required. The presence of nutrients is determined by sensors and the authors aimed to restore the level of nitrogen, phosphorous, potassium in the soil. An automated system has been proposed to maintain fertilizer level in order to avoid excess or deficient fertilizers in the soil. K.Sumathi et al., [6] proposed framework for intelligent architecture where Data is collected from different multiple heterogeneous resources and necessary recommendation is sent to farmers, other stakeholders through proposed analytical system.

N. Hemageetha et al., have analyzed soil condition based on pH value using classification techniques [7]. The pH value of Salem district soil located in the state of Tamilnadu, India is analyzed and checked whether soil is suitable for crops cultivation or not. Hemageetha et al., [7] collected data from Krishi Vigyan Kendra Farm Science Centre, Tamil Nadu Agricultural University, Santhiyur, Salem and analyzed the level of pH level using various classification algorithms using Weka Tool and described that the major part of the Salem district soil is suitable for crop cultivation.

Many researchers have proposed their findings to improve the farming activates. Solutions are available for effective execution of farming activities, but in bits and pieces. In this paper, an Integrated Data Analytics System for Irrigation Alert, Fertilizer and Pesticide Recommendation is proposed. Smart devices used in this system provide an automated solution for data collection from sensors mounted on the field. NodeMcu is used as an embedded hardware to receive the field data and store the same to the cloud server. Gathered IoT data is analyzed using Thingspeak and the implemented machine learning algorithms analyzes Farmers' data, stakeholder's data and send necessary alert to farmers. The proposed system provides Real time updates on current field conditions. It enables farmers to efficiently plan and carry out farm activities.

III. PROPOSED FRAMEWORK

The proposed framework offers Automatic Irrigation Alert, Fertilizer and Pesticide Alert with recommendation to farmers based on crop type, sowing time, soil internal parameters that are retrieved from field sensors and weather prediction system**.** This system also checks the fertilizer level of the soil**.** Fertilizer calculator is used to analyze the data from **s**oil sensors and color of the leaf to determine what nutrients are needed. The proposed framework ensures in improving the farming efficiency and attempts to remove few disadvantageous effects existing in farming activities.

The proposed system collects its data from the sources like farmers, pesticide vendors, fertilizer dataset, irrigation partners, weather prediction reports and then delivers the necessary alert on time to farmers. The data pertaining to farmers include farmer id, farm area, sowing date, crop name, crop type, crop details, expected harvesting time, etc., The irrigation partner's data includes crop type, soil parameters and irrigation period (time) and duration. The soil characteristics data are collected from field sensors.

The pesticide data includes crop name, crop type, soil parameters, period from sowing time and duration, pesticides recommended, pesticide vendor and quantity /unit details. This system sends the pesticide alert and recommendation to the farmer if pesticide duration of the crop reaches.

Organic or mineral fertilizers are used to improve the inputs of nutrients to soil. The nitrogen, phosphorous, potassium and sulphur are macronutrients which have the major effects on pH of the soil as they are added in larger quantities than micronutrients.

The electrochemical sensor mounted on the field capture the accurate percentage value of the nutrients presents in the soil. The nutrients values include not only the nutrients present in the soil but also in the dissolved water. This proposed system sends the fertilizer alert and recommendation to the farmer if any of the macronutrient is insufficient in the soil.

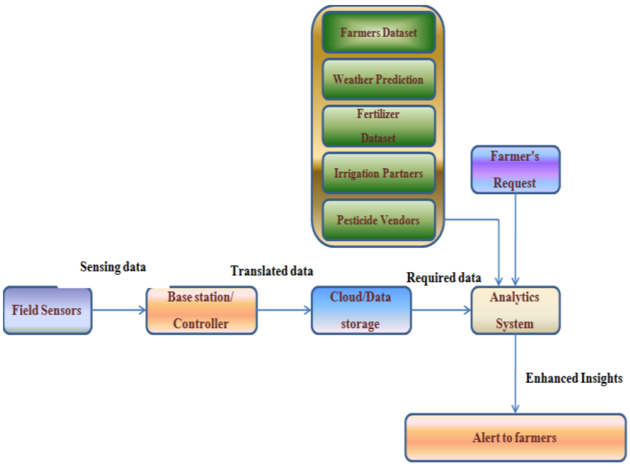

Fig. 1: Framework for Data Analytics System for Irrigation Alert, Fertilizer and Pesticide Recommendation

The farmer's irrigation and pesticide duration, fertilizer level of the soil is monitored frequently by External Intelligence Module. Once the duration is reached, field sensors and weather prediction data is taken and necessary alerts regarding irrigation, pesticide are sent to the appropriate farmers by the data analytics system to save the natural resource. Fertilizer alert will be sent to the farmers based on the Fertilizer Calculator which takes input from Soil sensors and leaf color and suggests what nutrients are needed. Fig. 1 shows the overall framework of Data

Analytics System for Irrigation Alert, Fertilizer and Pesticide Recommendation.

A. Implementation

Data can be collected from different stake holders, and required data can be collected from farmers, field sensors and other weather prediction system. The data is being collected from farmers by asking set of standard questions. The weather information can be collected through relevant APIs based on the moisture level of sensors mounted on the field. The proposed system used NodeMcu to collect the data from the field sensors. The data collected from field is stored in cloud for analysis.

Nowadays most of the research scholars are using NodeMcu which is an open-source firmware and development kit that helps to prototype the application. The significant features of NodeMcu are Open-source, Smart, WI-FI enabled, Interactive, Low cost and Programmable. Fig. 2 shows NodeMcu kit. The specification of the NodeMcu is shown in Table 1. The Pin configuration of NodeMcu is displayed in Fig. 3.

Fig. 2: NodeMcu kit

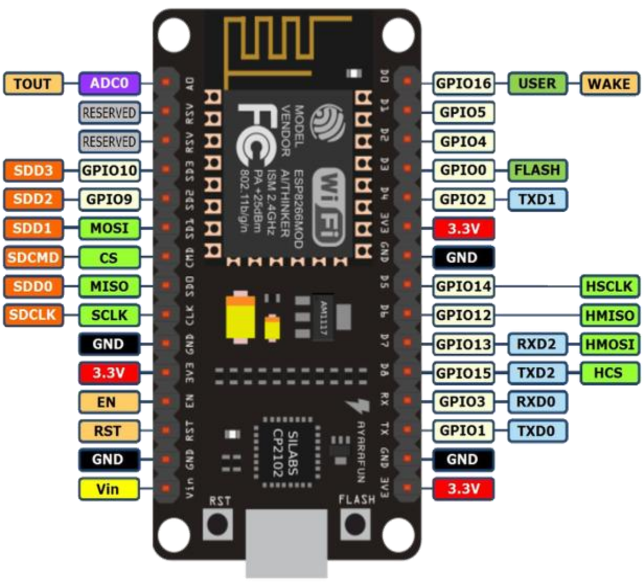

Fig. 3 : NodeMcu Pinmodes

Table 1 : NodeMcU Specification

Parameter	Value
Voltage	3.3V.
Current consumption	10uA~170mA.
Wi-Fi Direct (P2P), soft-AP.	Available
Flash memory attachable	16MB max (512K normal).
Integrated TCP/IP protocol stack.	Available
Processor	Tensilica L106 32-bit.
GPIOs	17 (multiplexed with other functions).
RAM	32K + 80K.
Processor speed	80~160MHz

Pin Description

NodeMcu consists of 30 pins. The controller takes 13 GPIO pins. In these Pins, we have 3 UART TX and 2 UART RX, 1 ADC converter with a single channel, One IIC Bus, SPI and 2 pins are Reserved Pins, 1 EN(Enable) and 1 RST(Reset) for the purpose of LCD functions. The Pin Description of the NodeMcu is shown in Table 2.

Embedded C is used to read the data from various field sensors through NodeMcu, send necessary alert to the farmers and ThingSpeak, an IoT analytics platform service which aggregates, visualizes, and analyzes live data streams in the cloud used to analyze the sensed data. The algorithm to implement the effective irrigation system is as follows:

Automatic Alert to Farmers regarding Irrigation

The proposed Data Analytics System consists of two modules such as External Intelligent System Module (EIS) and Data Analytics Module (DA) as shown in Fig.4. Each module will have specific objective function from data collection from relevant source still delivering necessary insights to farmers to improve the agriculture activities.

Table 2. Pin Description

ADC0	10 bit resolution
UART frequency	80MHz to 160 MHz 5.controller -ESP 8266 6. Operating voltage +5v to +9v
GPIO	50 microsecond resolution
UART default Baud rate	115200.

EIS module takes data from Farmers' dataset and the respective fields of irrigation partners, pesticide vendors, fertilizer dataset are checked based on the crop type. EIS module decides whether field sensor values are to be checked or processed further.

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DA module is applicable on the grounds of output being "yes" of EIS. This module i) analyses the pesticide suitable for the crop and sends the alert with pesticide recommendation to the farmer ii) uses fertilizer calculator to analyze the data from soil sensors to determine what nutrients are needed and send fertilizer recommendation alert to farmers. iii) Analyzes the soil moisture sensors and weather prediction report and send the irrigation-based alert to farmers.

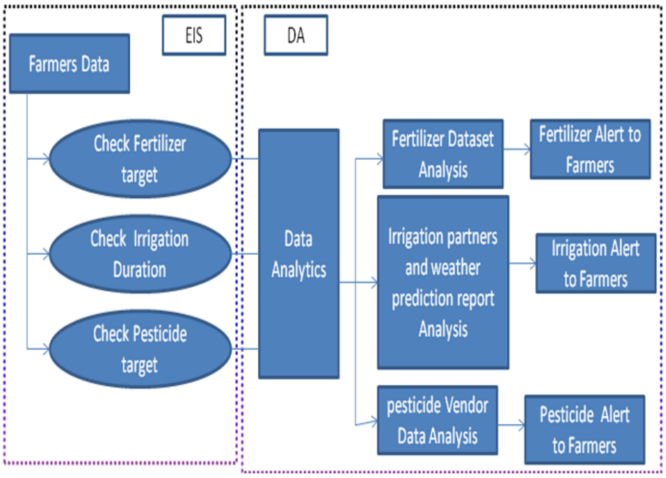

Fig. 4 : EIS and DA Modules

B. PSEUDO CODE

External Intelligent System (EIS) Module

Input: data from farmer's dataset, irrigation partners, pesticide vendors, fertilizer dataset

Output: alert to Data Analytics (DA) Module like "yes" or "no"

1. Read farmers Data such as crop type, soil type and sowing time of the crop from farmer dataset
2. For each farmer data do steps 3 to 5
3. Extract Irrigation partner's data that matches the crop type and soil type of the farmer

    If the irrigation time reaches for the crop then
        Send the IrrigateRresponse "yes" ,"FarmId" to Analytics Module

4. Extract Pesticide Vendors' data that matches the crop type and soil type of the farmer

    If the pesticide duration reaches for the crop then
        Send the PestResponse "yes", "FormId" to Analytics Module

5. Extract fertilizer level data for the crop type and soil type of the farmer

    If the fertilizer level < threshold then
        Send the FertResponse "yes", "FormId" to Analytics Module.

Data Analytics (DA) Module

This algorithm is applicable on the grounds of output being "yes" of EIS.

Input: Output of External Intelligent System (EIS) (Response, "yes", "FarmId")

Case 1 : when input is IrrigateResponse "yes", "FarmId"

Output: Irrigation alert to mobile number of farmer whose farmer-id is "FarmId" like ("go for irrigation" / "wait and go for irrigation")

1. Read past 8 hours data of moisture sensor mounted on the field and calculate the average value of moisture sensors
2. If average data of moisture sensor > threshold-value then send alert to farmer "wait and go for Irrigation" and wait for 24 hours and go to step 1
3. Otherwise, check weather prediction for preceding 24 hours. If weather prediction says "Yes" then send alert to farmer "wait and go for Irrigation" and wait for 24 hours and go to step 1.
4. If weather prediction says "No Rain", send alert to farmer "go for irrigation" and update date and time of irrigation in farmers dataset.

Case 2 : when input is PestResponse "yes", "FarmId"

Output: pesticide alert to mobile number of farmer whose farmer-id is "FarmId" like ("Wait" / "Apply and Pesticide Recommendations") based on weather prediction reports

1. Read past 8 hours data of moisture sensor mounted on the field and calculate the average value of moisture sensors
2. If average data of moisture sensor > threshold-value then check weather prediction for preceding 24 hours if weather prediction says "Yes" then send alert to farmer "wait to apply pesticide" and wait for 24 hours and go to step 1
3. If weather prediction says "No Rain", send alert to farmer "Apply Pesticide and pesticide recommendation details", and update date and time and name of pesticide applied in farmer's dataset.

Case 3 : when input is FertResponse "yes", "FarmId"

Output: Fertilizer alert to mobile number of farmer whose farmer-id is "FarmId" like (""Wait" / " Apply and Fertilizer Recommendations") based on weather prediction reports

1. Read past 8 hours data of moisture sensor mounted on the field and calculate the average value of moisture sensors
2. If average data of moisture sensor > threshold-value then check weather prediction for preceding 24 hours if weather prediction says "Yes" then send alert to farmer "wait to apply Fertilizer" and wait for 24 hours and go to step 1
3. If weather prediction says "No Rain", send alert to farmer "Apply Fertilizer and Fertilizer recommendation (required N,P,K Details) details", and update date and time and name of Fertilizer applied in farmer's dataset.

SAMPLE CODE

```
void loop()
{
int ar = analogRead(A0);
DHT.read11(D0);
int hmdyid = DHT.humidity;
int tmpr = DHT.temperature;
write2TSData(channelID,1,ar,2,tmpr,3,hmdyid);
delay(2000);
}

int write2TSData( long TSChannel, unsigned int TSF1, float FD1, unsigned int TSF2, long FD2, unsigned int TSF3, long FD3 )
{
ThingSpeak.setField( TSF1, FD1);
ThingSpeak.setField( TSF2, FD2);
ThingSpeak.setField( TSF3, FD3);
int writeSuccess = ThingSpeak.writeFields( TSChannel, writeAPIKey );
return writeSuccess;
}
```

temperature and wind speed Plot

```
readChannelID = 12397;
TemperatureFieldID = 4;
windSpeedFieldID = 2;
readAPIKey = '';
 [data, timeStamps] = thingSpeakRead(readChannelID, 'Fields',[TemperatureFieldID windSpeedFieldID], ...
                                                     'NumPoints', 300, ...
                                                     'ReadKey',
readAPIKey);
temperatureData = data(:, 1);
windSpeedData = data(:, 2);
yyaxis left
plot(timeStamps, temperatureData);
ylabel('Temperature');
yyaxis right
plot(timeStamps, windSpeedData);
ylabel('Wind Speed');
```

IV. RESULTS AND DISCUSSION

Data is collected from various field sensors mounted on field through base stations/Micro controllers which send the same to Data servers. ThinkSpeak is used to analyze and visualize the data. Machine Learning algorithms are used to a) analyze data retrieved from smart devices and weather prediction report b) compare field data with stakeholders target data c) provide necessary alert to the farmers frequently via their mobile phones so that farming activities can be improved.

Coding is done in Embedded C to receive data form IoT-devices and gathered data is analyzed with ThingSpeak.

Data is collected from temperature sensor frequently and Fig. 5 shows the temperature comparison of past three days.

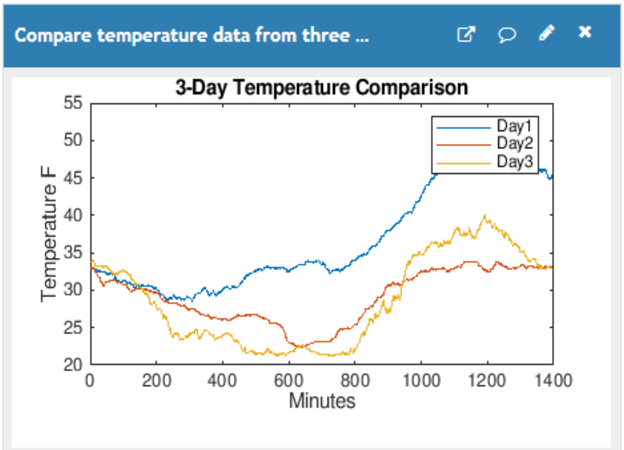

Fig 5. Temperature comparison of past three days

Data is collected from humidity sensors mounted on the field. Fig. 6 shows that correlation between temperature and humidity values in the farm.

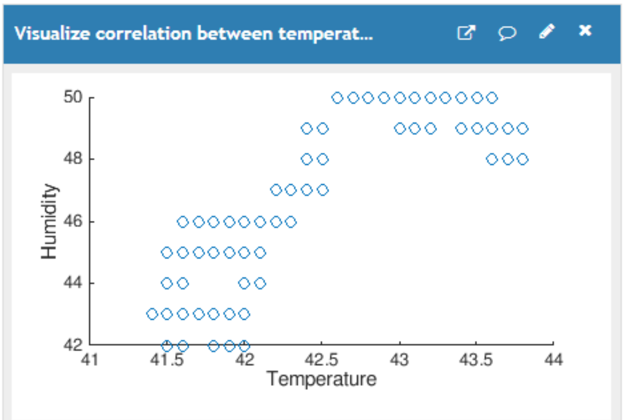

Fig. 6. Correlation between temperature and humidity

Wind speed is also collected from the field and the values are compared to temperature values. Fig. 7 shows that wind speed and temperature plot data is analyzed for ever one hour.

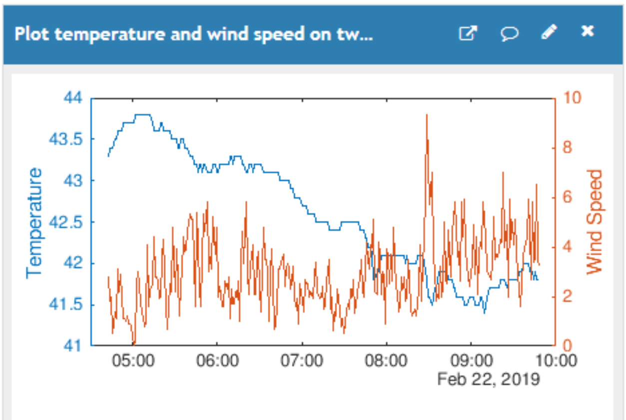

Fig. 7. Temperature and Wind speed Analysis

Fertilizer level of soil, soil moisture level, air temperature in Celsius and light values are collected from the sensors mounted on the field frequently. These are the essential data used by machine learning algorithms to send necessary insights to the farmer so that agricultural activities can be done in an effective manner.

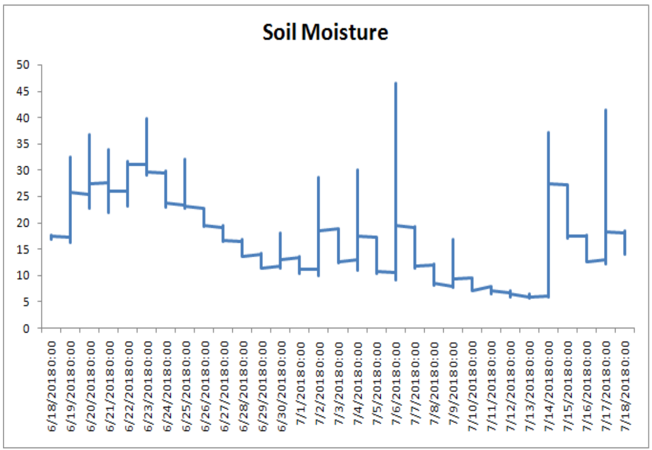

Fig. 8. Soil moisture Analysis

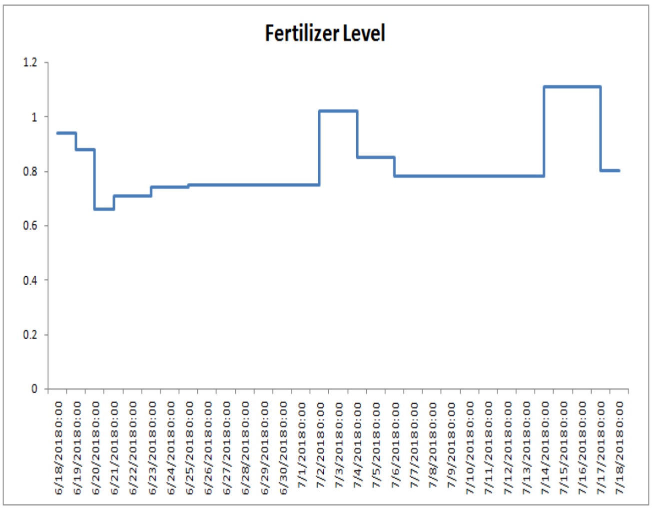

Fig. 9. Soil moisture Analysis

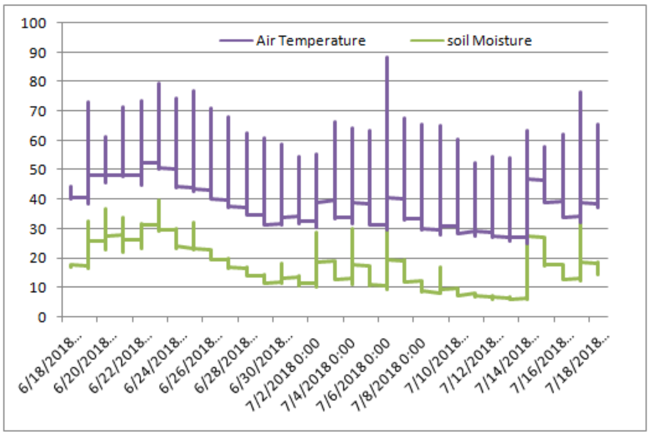

Fig. 9. Air Temperature & Soil moisture Analysis

Moisture level of the soil for 30 days is analyzed and shown in Fig. 8. Similar analysis is done for fertilizer and the results are shown in Fig. 9. Soil moisture level and air Temperature of for the same 30 days period is compared in Fig. 10.

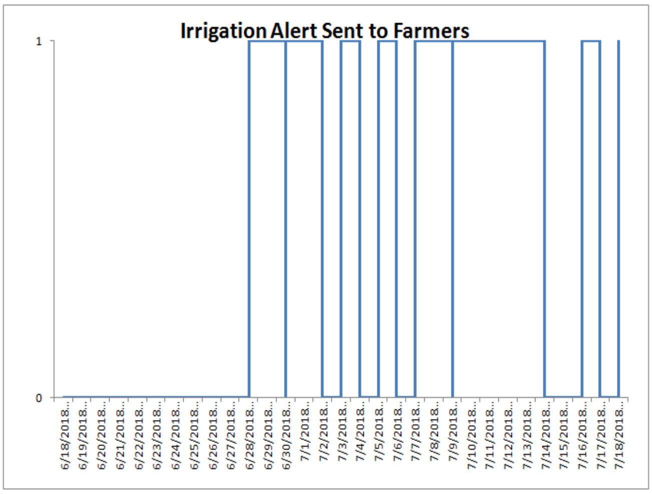

Fig. 11. Irrigation Alert to Farmers

Field sensor values are analyzed to send the required alert to farmers. Irrigation alert are sent to the farmers based on irrigation duration of the crop received from irrigation partner dataset, soil moister value received from field sensor and weather prediction reports. Fig. 11 shows that the days in which irrigation alert was sent to farmers.

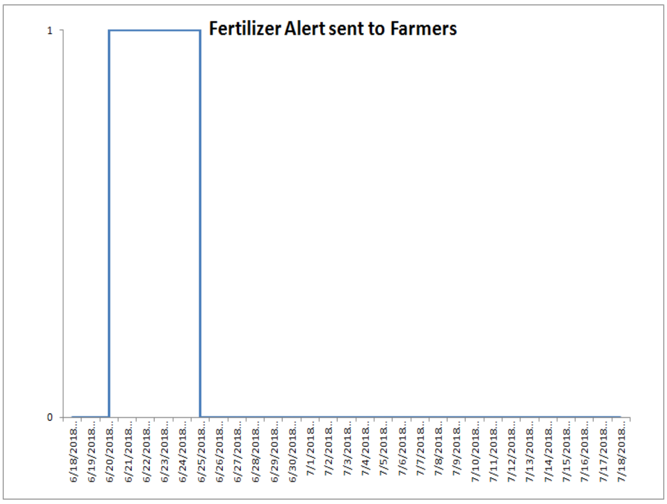

Fig. 12. Fertilizer and Recommendation Alert to Farmers

Fertilizer alert send to the farmers is based on fertilizer level of the farm soil, data received from Fertilizer Recommendation dataset, soil moister value received from field sensor and weather prediction reports. Fig. 12 shows that the days in which Fertilizer alert with Recommendations was sent to farmers.

V. CONCLUSION

Data Analytics System for Irrigation Alert, Fertilizer and Pesticide Recommendation is developed using modern digital technologies by bringing all supporting elements in one place to deliver enhanced insights to farmers throughout crop cultivation to improve the farming actives. The system will be helpful for farmers to improve the yield by delivering necessary insights on time. Using this system, farmers can verify the last 3 days temperature, wind speed, humidity, soil moisture, and soil temperature, correlation between temperature and humidity details.

The proposed system offers personalized advisory services using communication devices to maximize the crop yield and to minimize the cost of production.

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