Sustainable Agriculture using IoT based Automated Soil Fertility Measuring Device

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Abstract— India is likely to become most populated country by 2022 in which people are suffering due to starvation, In spite of agricultural resources, potential, skilled persons for farming. Since independence agricultural sector is backbone of Indian economy which needs to be advanced with latest technology. This thesis is focused on advance farming using Internet of Things (IoT) and Wireless Sensor Networks (WSN) which include soil measurement ,plant growth, nutrition, quality and quantity of crops/fruits, stock analysis and selection of crop cultivation. This Thesis is desired for Soil measurements, Suitable plant growth and effective fertilization. Conventional soil testing methods are not optimal it needs to be implemented with sensor, controller/processor and network for advance farming.

Key words: Internet of Things (IoT), Sustainable Agriculture, Soil Health Card, ThingSpeak, Cloud Computing

I. INTRODUCTION

Agriculture is the spinal column of Indian economy where 54.6% of the population is engaged in agriculture and allied activities (census 2011) and it contributes 17% to the country's Gross Value Added (current price 2015-16, 2011-12 series).[1] Most of the peoples in India are depending on the agriculture directly or indirectly. Some of them are farmers and some people doing business with farm products. There has been a continuous decline in the share of Agriculture and Allied sector in the GVA from 18.2 percent in 2012-13 to 17.0 percent in 2015-16 at current prices.

(Rs. in Crore)

Items	Year			
	2012-13	2013-14	2014-15	2015-16
GVA of Agriculture and Allied Sectors	1680797	1902452	1995251	2093081
Per cent to total GVA	18.2	18.3	17.4	17.0

Table 1: GVA of Agriculture from 2012 TO 2016 [1]

India has large land area for farming. As per the land use statistics 2013-14, the total geographical area of the India is 328.7 million hectares, the net irrigated area is 68.2 million hectares [1]. This is very good comparing to other small country where the geographical area and net irrigated area is less. Still they have high throughput from agriculture sector compare to India which show that we are not able to make optimal, profitable and sustainable use of our land resources. Production of a crop depends on the interaction between the soil and plant properties. Maximization of production of crops is reflected by the biological, chemical and physical condition of the soil. Root absorbs required amount of nutrients and water from the soil where biochemical reactions take place.

Continuous cropping without adequate measurement and provisioning of soil nutrient may endanger the sustainability of agriculture. Soil nutrient measurement is greatly required for proper plant growth and effective fertilization. Existing methods of soil testing are costly and time consuming. Farmer has to go to the soil testing laboratory which is far from the village for the farmers in India. Most of Indian farmer cultivate with their past experience and without testing of soil.

A. Soil Health Card

Government of India took several steps for its sustainable development. Steps have been taken to improve soil fertility on a sustainable basis through the soil health card scheme.

Soil Health Card (SHC) is a Government of India's scheme promoted by the Department of Agriculture & Co-operation under the Ministry of Agriculture and Farmers' Welfare. It is being implemented through the Department of Agriculture of all the State and Union Territory Governments. Soil Health Card Scheme is a very beneficial scheme for farmers. There are many farmers in India who do not know which types of crops they should grow to get maximum yield. SHC is a printed report that a farmer will be handed over for each of his holdings. It will contain the status of his soil with respect to 12 parameters, namely N,P,K (Macro-nutrients); S (Secondary- nutrient); Zn, Fe, Cu, Mn, Bo (Micro - nutrients); and pH, EC, OC (Physical parameters). Based on this, the SHC will also indicate fertilizer recommendations and soil amendment required for the farm. The card will contain an advisory based on the soil nutrient status of a farmer's holding. It will show recommendations on dosage of different nutrients needed. Further, it will advise the farmer on the fertilizers and their quantities he should apply, and also the soil amendments that he should undertake, so as to realize optimal yields.

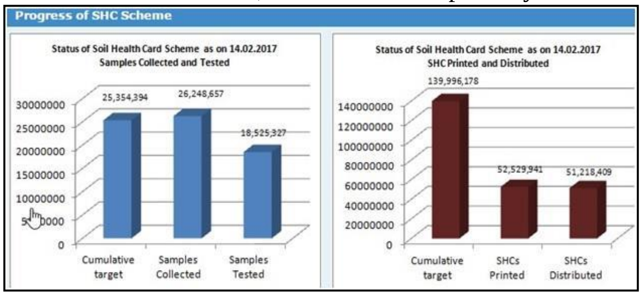

Fig. 1: Status of Soil Health Card Scheme as on 14.11.2017). [2]

The centre's target is to distribute 140 million cards to as many farmers by March 2017, after collecting and testing 25.3 million soil samples. So far, while nearly 79% of the targeted soil samples have been collected, only about 40% have been tested and just 19% of farmers received cards. According to data from the agriculture ministry, states like Assam, Bihar, West Bengal, Punjab, Karnataka, Kerala and Uttar Pradesh are slow in collecting soil samples. Further, 15 states have achieved only between 20-50% of their soil testing targets which include major ones like Madhya Pradesh, Punjab, Maharashtra and Uttar Pradesh, while 23 states have distributed less than 30% of the targeted soil health cards[2].

B. IoT in Agriculture

Internet of Things (IoT) is a concept and paradigm that enables interaction among objects pervasively present in an environment. The Internet of Things (IoT), sometimes referred to as the Internet of Objects, will change everything—including ourselves. According to the Cisco Internet Business Solutions Group (IBSG), IoT is simply the point in time when more “things or objects” were connected to the Internet than people In 2003, there were approximately 6.3 billion people living on the planet and 500 million devices connected to the Internet [4]. By dividing the number of connected devices by the world population, we find that there was less than one (0.08) device for every person.

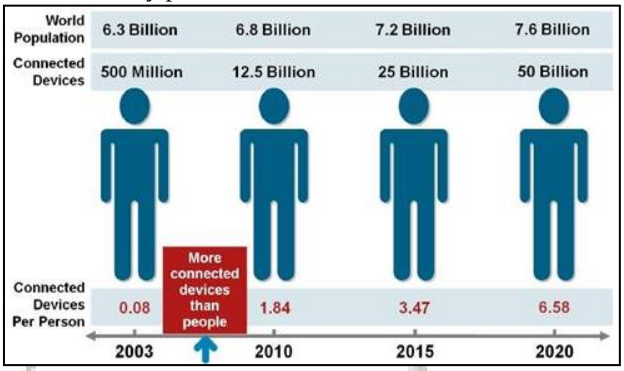

Fig. 2: Advancement in Connected Devices per Person [4]

The development of an IoT based infrastructure that facilitates precision agriculture is one such application that has acquired high attention. To be successful, a farmer must maximize per acre yield, reduce spoilage from inadequate or overuse of fertilizers, reduce the risk of crop failure and minimize the operating costs. Effective management of input resources like water, fertilizers and seed quality is the key to achieve this success. Many farms around the world - particularly those in developing countries are small, comprising of only a few acres. These smallholder farmers continue to follow conventional farming practices and often face the brunt of high crop losses, low yield, inferior quality of farm produce etc. Conventional methods like crop investigation and soil analyses are very time consuming. By using IoT and data based decisions and by predicting the implications of each and every decision, a farmer can reap high profits and use his field more efficiently. This is a means of assisting farmers in optimizing yield, minimizing input costs and reducing environmental impact on crop growth.

Remote monitoring of soil parameters is an emerging trend which has the potential to transform agricultural practices and increase productivity. Cloud computing technology impacted positively on agriculture field and related services they provide for users. The current global market scenario is that cloud computing is considered to be one of the most revolutionary tools that has already started showing its impact in the international market. Three of the most basic cloud computing models are:

1) Software as a Service (SAAS)

It includes the ICT working environment tools such as software, web applications etc., without buying/downloading and installing in specific machines. Another characteristic of this model is that the users are charged for whatever has to be used for a specific duration, against the traditional way of buying and paying for the full application.

2) Platform as a Service (PAAS)

It provides clients the computing platform for designing and developing specific applications with minimum redundancy. It also takes care of hosting of those applications without concerning about hardware and data storage requirement. It also guarantees the availability of most recent platforms and their security.

3) Infrastructure as a Service (IAAS)

This model usually includes tangible as well as intangible components used in availing ICT services, such as virtual computers, traffic monitoring and re-directing, basic network components etc. This is the most prominent benefit of cloud computing as the organizations invest the most in establishing infrastructure.

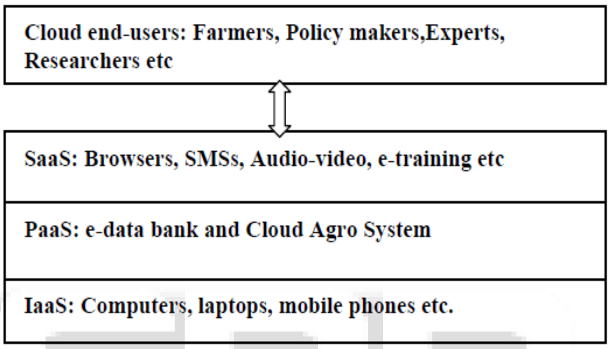

Fig. 3: Basic Cloud Computing Structure [5]

4) e-Data Bank

It is a central data bank and it can be used to store all the agriculture related information in a centralized cloud, which will be available to all the users at anytime, anywhere. The main concept behind having an e-data bank is to disseminate vital information to the local farmers in decision making. In order to do so, the e-data bank includes the following databases:

5) Crop related information

It captures information related to all the crops grown in recent past in different regions. This will help the local farmers of different parts of the nation in crop related decision making.

6) Weather information

It stores the region specific weather information and also the weather forecast for a specific duration. It will benefit the farmers in decision making related to selection of crops.

7) Soil Information

Soil information also plays a vital role in crop related decision making. So, this section provides information on nature of soil of different parts of the country. It can also provide the trend of soil in past and will help in forecasting the future trend of soil.

8) Growth Progress Monitoring

It monitors and captures data on crop growth in different regions on a regular interval. This will be specifically useful in comparing the crop growth region wise and also comparing it with past data will bring a clearer picture.

9) Farmers Data

It captures the region wise farmer related data, to monitor and study the involvement of local farmers in Indian agricultural sector. It will help the policy makers in designing Indian agricultural policies. This will also help in identifying the core Indian agricultural areas, so that the policy makers can take decision on encouraging and promoting agriculture. This may help in overcoming problems such as unemployment and rural-urban migration.

10) Expert Consultation

It provides solutions to common problems that farmers frequently experience. It can also have a provision to post unattended problems seeking for solutions from the experts. It will also have a bundle of frequently asked questions (FAQs) and their answers to make the response reach the farmers faster.

II. PROPOSED SYSTEM

To get the correct amount of nutrients to be provided and to choose the right crop for multiple cropping in the same land, we need to measure the actual amount of nutrients present in the soil. We here proposed a system which can sense the soil health and this data send to cloud. So the history of soil health is stored for future crop prediction. The farmer can get his soil health report from central hub on the need and depending on that data the farmer can be guided by expert for the use of proper fertilizer and right crop for cultivation for more production of crop.

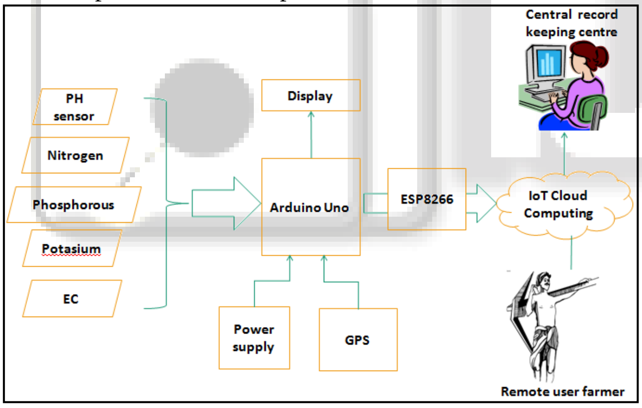

Fig. 4: Functional Block Diagram of Proposed System.

A. Power Supply Unit

Her we use the power supply of +5v and +12v for Arduino and GPS and LCD display.

B. Sensor Unit

Here unit comprise of ph, n, p, k, temperature, humidity etc sensors. Sensors are hardware devices that produce a measurable response to a change in a physical condition like temperature or pressure. Here copper electrodes are used as sensor which measures the ionic particles present in the soil and converts it in to electrical signal.

– PH sensor

PH is a quantity of acidity or alkalinity of any solution; the pH range lies between 0 to 14. The pH indicates the hydrogen [H] + ions concentration present in certain solutions. It can accurately be measured by a sensor it is the potential difference between two electrodes: a glass electrode which is sensitive to [H]+ ions and a reference electrode (silver chloride/silver). PH sensor primarily need 2 different calibrations; 1. OFFSET and 2. STEP. The “ideal” soil pH is close to neutral, and neutral soils are considered to fall within a range from a slightly acidic pH of 6.5 to slightly alkaline pH of 7.5. It has been determined that most plant nutrients are optimally available to plants within this 6.5 to 7.5 pH range, plus this range of pH is generally very compatible to plant root growth. Nitrogen, K, and S are major plant nutrients that appear to be less affected directly by soil pH than many others, but still are to some extent. Phosphorus, however, is directly affected.

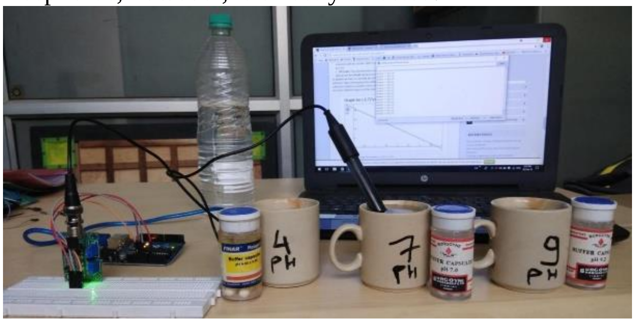

Fig. 5: Practical Setup to Calibrate PH Sensor

– N,P,K Sensor

To measure the available nitrogen (N), Phosphorus (P), and Available Potassium (K) we use the normal colour sensor TCS3200. In India the soil lab testing is done with traditional titration method which is time consuming and tedious. Instead of that we proposed a colour sensor to find out the available N, P, and K. The soil nutrition produce different colour when we add some reagent with soil sample solution. And based on that colour intensity we can predict the availability of that particular nutrition (N, P, and K) in that soil sample.

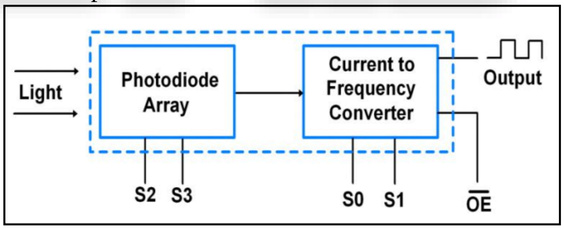

Fig. 6: Functional Block Diagram of TCS3200.

The TCS3200 is programmable colour light-to-frequency converter that combine configurable silicon photodiodes and a current-to-frequency converter on a single monolithic CMOS integrated circuit. The output is a square wave (50% duty cycle) with frequency directly proportional to light intensity (irradiance). In the TCS3200, the light-to-frequency

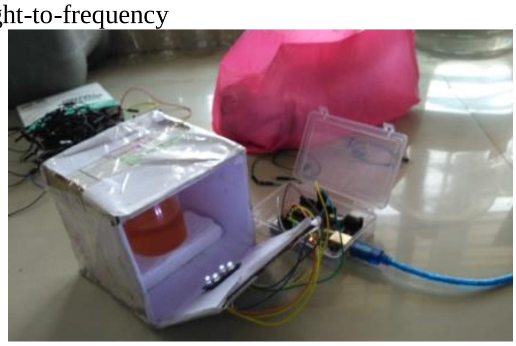

Fig. 7: TCS3200 Sensing A Colour For Soil Nutrition.

Converter reads an 8 x 8 array of photodiodes. Sixteen photodiodes have blue filters, 16 photodiodes have green filters, 16 photodiodes have red filters, and 16 photodiodes are clear with no filters. The four types (colours) of photodiodes are interdigitated to minimize the effect of non-uniformity of incident irradiance. All photodiodes of the same colour are connected in parallel.

– Electric Conductivity (EC)

Conductivity is the measurement of the concentration of dissolved solids which have been ionized in soil solution. The unit of measurement normally used is micro-Siemens per centimeter or µS/cm. Electro conductivity sensor is also used to measure TDS (total dissolved solid).It also specifies the degree of salinity in soil solution.

C. Control Unit

Here Arduino Uno is used for controlling unit. The Arduino Uno is based on the ATmega328 microcontroller with 14 digital input/output pins and 6 analog inputs. Here Arduino collect all the data from the sensor and sense the data to thingspeak using the Wi-Fi module. We select Arduino to make the proposed system cost effective.

D. ESP8266 Wi-Fi Module

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much Wi-Fi -ability as a Wi-Fi Shield offers(and that's just out of the box)! The ESP8266 module is an extremely cost effective board with a huge, and ever growing, community.

E. Cloud (Central Hub/Server Unit)

ThingSpeak is an open source "Internet of Things" application and API to store and retrieve data from things using HTTP over the Internet or via a Local Area Network. With ThingSpeak, you can create sensor logging applications, location tracking applications, and a social network of things with status updates. Things Speak is a free online data aggregation platform which typically used to collect data from sensors (things) and Provides instant visualization of that data.[7] Things speak is very popular for people experimenting in IoT and has more than 50,000 user among world. It can be used to analyze data with MATLAB integration. It can run MATLAB code on data coming on things speaks on scheduling basis. Here in proposed system the thing speaks is used to store the data sensed by the soil health detector.

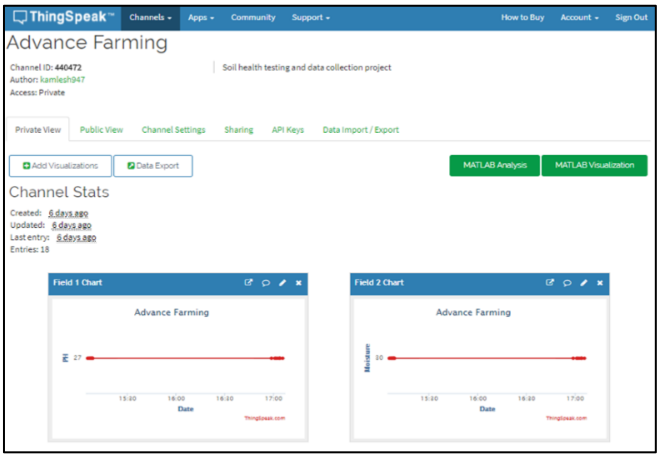

Fig. 8(a): Data Logging on Thingspeak (Part 1) [14].

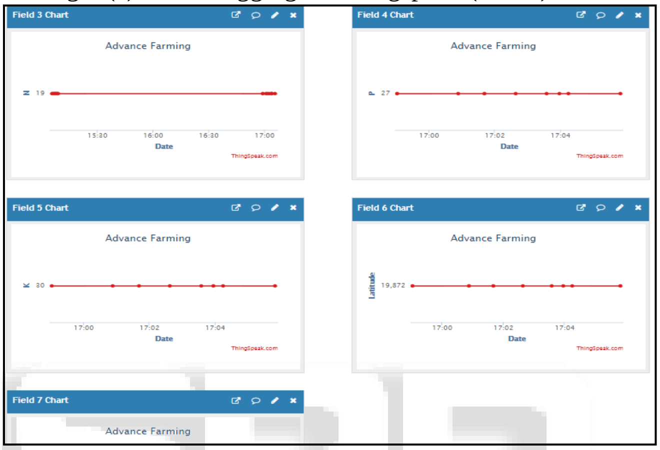

Fig. 8(b): Data Logging On Thingspeak (Part 2) [14]

III. FUTURE WORKS POSSIBLE

1) Make an artificial intelligence at the central server which can predict the proper crop and fertilizer needed for soil.
2) This predicted crop and fertilizer can be sent to farmer for further action.
3) Deficiency of soil nutrition also predicts the production of fertilizer needed for the next year.
4) Quantity of crop should be predicted.

IV. CONCLUSION

We have presented the architecture of our proposed sensing system for soil macronutrient measurements and remote data collection. The system proposed is beneficial and works in cost effective manner for farmers. It also helps to Indian government to enhance the GVA from Agriculture and allied sector by prediction of proper crop to cultivate and also fertilizing in supporting manner of soil health card scheme.

The proposed system will help the farmers to know the soil requirements which will help them take better decisions and preventive measures at the right time. This will lead to tremendous improvement in the crop productivity. This, intern, will save their time, labour, money and make effective use of resources.

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