Internet of Things (IoT): A Relief for Indian Farmers (Stage II)

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***Abstract*—In this paper the authors would discuss about the enhancement in the existing work done on the Internet of Things (IoT) with reference to the Indian farmers. Here the major discussion would be related to the soil testing and its constituents required for the growth of crops. The major achievement of the paper would be the action/process to be followed post soil testing of the region. Soil testing would give the data and parameters about the soil which usually comprise of soil nutrients like phosphorous, potassium and nitrogen. The work done in this regard is that after the collection of soil data, these data would be entered in the developed software application which would tell the user which crop to grow in that soil. These data about the soil would already be preloaded in the software application and further in addition to current existing temperature and weather conditions (which would be continuously monitored through the sensors) it would recommend the suitable crop to be grown in that specific soil. The authors would discuss about the Application Program Interface (API) systems software which has been developed with reference to this application. The developed software is supported through mobile app for easy access. This app is in use and is a free source for the researchers who are working in soil testing areas or IoT for agriculture application. The authors in paper are also trying to use the above solution to help Indian farmers industrialize the individual farming using the Internet of Things (IoT) and connecting directly with market with the help of one centralized mobile app.**

Keywords— Application Program Interface (API), Energy Management System (EMS), Internet of Things (IoT)

Motivation: India is a land of diverse environment and on the scale of weather conditions its variability and unpredictability is increasing continuously which is directly affecting the natural vegetation of the country. This is a serious threat to the poor farmers who are indirectly been adversely affected by these unpredictable changes in weather conditions. The authors in paper [1] have taken this cause as an increasing alarming situation in India and developed a prototype solution for the farmers through the development of an app which continuously monitored the weather conditions, soil condition and local agricultural news. Along with proposed a solution through centralized data server to analyze the data and report to the farmer to take the advanced precautionary steps for the safety of the crops.

I. INTRODUCTION

Internet of Things (IOT) has become the most significant propelling factor in the major development and sustainability of eco-systems [1]. The integration of research expertise and novel technologies in IoT has attributed momentous yield in diverse fields like industries, academics, logistics and ecosystem which comprise of agriculture as the fastest growing sector in terms of IoT [2]. IoT comprise of three major components viz. sensors, digital communication network and application interface. With reference to the agriculture context, the sensor layer generally senses the external environment factors like temperature, moisture, air pressure, wind speed and mineral contents in soil. The digital network involves wireless internet connection for communication of signals and the generation of next task. The application interface is the end result as per the requirement. In context to the agriculture, the application could be getting the soil and mineral data thereby signaling the task to be taken respectively.

There has been growth in the research in the field of IoT with reference to the agriculture sector. In [3] & [4] the authors have presented a new technique of AgroTick and combination of data analytics with IoT respectively to yield effective production from the agriculture practices. The has been different perspective of using IoT in agriculture. For instance, paper [5]-[7] uses different IoT incorporated techniques for improving agriculture with reference to improving food and farming technology along with following a new concept of *'Precision Farming'* which is the most organized type of farming practice comprising grid-based sampling of soil chemical properties [6] yielding more crops [7]. With new developments in technology and IoT applications there has been tremendous improvement in use of IoT in agriculture through new algorithms and methodologies. Paper [8] details about the use of intelligent system based IoT system for agriculture which act as a production management platform having control on the plant environment, the supply of water and fertilizer. In [9] the authors have discussed about the low cost IoT based system for agriculture while paper [10] discusses about the use of remote sensing and control of greenhouse parameters for agriculture using IoT. This facilitates the control certain factors like moisture in the air, atmospheric carbon dioxide (CO_2), surrounding temperature and incoming sunlight, based on which controlling action can be taken for the greenhouse windows. The objective is to increase the yield and to provide organic farming. Based on these technologies, paper [11] builds up a new IoT based model for *'Smart Agriculture'* while paper [12] studies the application of IoT in agriculture briefing the overall structure of IoT in farming zones. Paper [13] highlights the objective of *sustainable agriculture* using IoT through the discussion of different sensors been used in the overall IoT based system for

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agriculture. In [14], the authors develop the complete agricultural farm using IoT and discusses and describe in detail the functionality of each system as comprised in the complete system. After the establishment of IoT based farming, some authors had started working towards the field monitoring using Arduino in IoT [15] and cloud computing for data sharing and maintaining coherence with the system [16]. Paper [17] describes in detail about the design and development of the agricultural monitoring system for the smart farming. The authors have also discussed about the real challenges and concluded upon certain farming index which they have considered relevant as a crop parameter. Paper [18] and [19] tells about the overall sustainable development achievement through various challenges and mitigation process to achieve it.

Organization: Since every crop requires specific nutrients which is been supplied by soil for its growth, therefore in this paper SECTION II would discuss in detail about different types of crops and their respective nutrients requirement has been reported by the Food and Agricultural Organization (FAO) of United Nations. This section would also constitute some calculation with reference to water requirement and crop factor.

II. CROPS AND THEIR NUTRIENTS REQUIREMENT

The objective of developing an application-based software which could readily notify and alert the farmer about which type of crop to grow in a specific soil, the collection of soil data is a primary necessity. But prior to this, the Application Program Interface (API) systems should have the readily available data about the crop.

TABLE I. CROPS AND THEIR GROWING CONDITIONS REQUIREMENT [20]

Crop	**Water Needed (mm/total growing period)**	**No. of Days Required to Grow**	**Sensitivity to Droughts**	**pH requirement**	**Temp. (°C)**
Beans	300 - 500	75-90	Group 3	6-6.8	22-25
Citrus	900 - 1200	240-365	Group 2	6.0-7.0	26-30
Cotton	700 - 1300	180-195	Group 2	5.5-6.5	24-28
Groundnut	500 - 700	60-80	Group 1	5.5-7.0	35-40
Maize	500 - 800	60-90	Group 4 (Highest)	5.5-6.5	18-27
Sorghum	450 - 650	120-130	Group 2	5.5-6.5	25-32
Soybean	450 - 700	135-150	Group 2	5.5-6.5	10-12
Sunflower	600 - 1000	125-130	Group 2	6.5-7.5	21-25

This data should be about the conditions required for growing the crop which comprise of water capacity requirement, number of days required for growing that crop and pH requirements. Once the soil data matches with the crop data, it alerts the user to proceed with growing that crop. Therefore, TABLE I shows some of the crops and their growing conditions requirement. In addition, if the user knows the pH value of the soil, he can easily determine the crop to be grown based on the crop pH requirement. Table II. Shows the pH range of most common crops. Based on the alkalinity factor as would be extracted from soil data, farmer can know which crop would be suitable to grow accordingly.

TABLE II. pH REQUIREMENTS FOR MOST COMMON CROPS [21]

Acid Soil Crops	**Somewhat Acid Soil Crops**	**Alkaline Soil Plants**
Blackberry (5.0-6.0)	Apple (5.0-6.5)	Artichoke (6.5-7.5)
Blueberry (4.5-5.0)	Basil (5.5-6.5)	Arugula (6.5-7.5)
Cranberry (4.0-5.5)	Carrot (5.5-7.0)	Asparagus (6.0-8.0)
Parsley (5.0-7.0)	Cauliflower (5.5-7.5)	Bean, pole (6.0-7.5)
Peanut (5.0-7.5)	Chervil (6.0-6.7)	Bean, lima (6.0-7.0)
Potato (4.5-6.0)	Corn (5.5-7.5)	Cabbage (6.0-7.5)
Raspberry (5.5-6.5)	Cucumber (5.5-7.0)	Gourd (6.5-7.5)
Sweet potato (5.5-6.0)	Dill (5.5-6.5)	Mustard (6.0-7.5)

The data about the crops and the conditions requirement for their growth has been collected from the Food and Agricultural Organization (FAO) of United Nations [20] which comes among one of the seventeen Sustainable Development goals of United Nations. The authors have merely taken these data to facilitate the FAO of UN through the IoT applications and secondly keeping in context that most of the crops are grown in Indian soil. Some crops have also been explored and added subsequently.

A. Calculation of water requirement for a crop (ET_{crop})

There have been well validated theories for the calculation of certain parameters needed for the growth of a crop. Water requirement method is the most commonly used method to predict the number of days required for the crop to grow. The basic formula for the calculation reads as follows:

$$ET_{crop} = k_c * ET_o \quad (1)$$

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where, ET_{crop} = the water requirement of a given crop in mm per unit of time e.g. mm/day, mm/month or mm/season.

k_c = crop factor

ET_o = reference crop evapo-transpiration" in mm per unit of time e.g. mm/day, mm/month or mm/season.

B. Calculation of Crop Factor (K_c)

To obtain the crop water requirement ET_{crop} the reference crop evapotranspiration, ET_o, must be multiplied by the crop factor, K_c. The crop factor varies according to the growth stage of the crop. There are four growth stages to distinguish viz. *initial stage* where the crop uses little water; *crop development stage*, when the water consumption increases; *mid-season stage*, when water consumption reaches

a peak; and finally, *late-season stage*, when the maturing crop once again requires less water. Table III contains crop factors for the most common crops grown under water harvesting. The table also consists, the number of days taken by each crop to be grown for a respective stage. However, the time and the number of days for different crop stages shall vary depending upon the factors like different variety of crops variety and the surrounding climatic conditions.

TABLE III. CROP FACTORS FOR THE MOST COMMONLY CROPS [20]

Crop	**Initial stage**	**(days)**	**Crop dev. stage**	**(days)**	**Mid-season stage**	**(days)**	**Late season**	**(days)**	**Season average.**
Cotton	0.45	(30)	0.75	(50)	1.15	(55)	0.75	(45)	0.82
Maize	0.40	(20)	0.80	(35)	1.15	(40)	0.70	(30)	0.82
Millet	0.35	(15)	0.70	(25)	1.10	(40)	0.65	(25)	0.79
Sorghum	0.35	(20)	0.75	(30)	1.10	(40)	0.65	(30)	0.78
Grain/small	0.35	(20)	0.75	(30)	1.10	(60)	0.65	(40)	0.78
Legumes	0.45	(15)	0.75	(25)	1.10	(35)	0.50	(15)	0.79
Groundnuts	0.45	(25)	0.75	(35)	1.05	(45)	0.70	(25)	0,79

III. DEVELOPMENT OF CROP DISCERNMENT APPLICATION

In view of the discussions in section II, it gives the clear conditions abstraction about two artefacts viz. soil and the crop. Firstly, the authors are aware about a soil and its nutrients requirement for a specific crop to be grown in it and secondly, about the crop and its requirement for a soil and other environmental conditions for growth. These two investigations further motivate the authors to associate each of them to one another through the development of an application which has the data about the soil and the crop to have a better trade-off for which crop to be grown if we have soil information and vice-versa. The developed application has been shown as a prototype model in Fig.1. The prototype model of a system has Application Program Interface (API) channel which links the server with the IoT network for different operations to be performed for a specific application. Some of the networking channels of IoT are used for soil testing, weather monitoring and water automation as is required for our application. Further connecting some of the channels to the market domain has also been shown in the figure to give the overall view of the software-based application. The app has simple screens with an objective to make the benighted farmers understand the process in a very simple way. The app has also been incorporated with the multi-language support options, which further motivates the local Indian farmers to use the app in their own language. The app is divided in simple screens like: Current Location, Weather Predictions, Soil Properties and Result and Discussions.

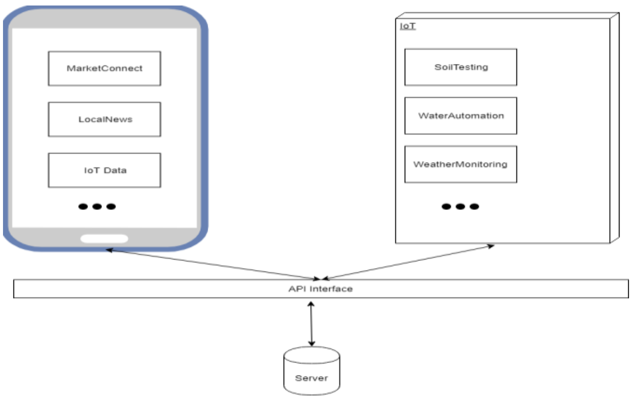

Fig.1 A prototype model of the complete System with Application Program Interface (API)

As can be seen from Fig.2, the developed app has the priority of the location, based on which the soil geology weather conditions play a significant role. The app starts with automatically finding the user current location using mobile Global Positioning System (GPS) signals. The fetched location will be displayed to user screen and if the user wants to change or update the location he can use the text control bellow to select the desired location. The selected location is one of the parameters to determine feasible crop to be grown in that soil.

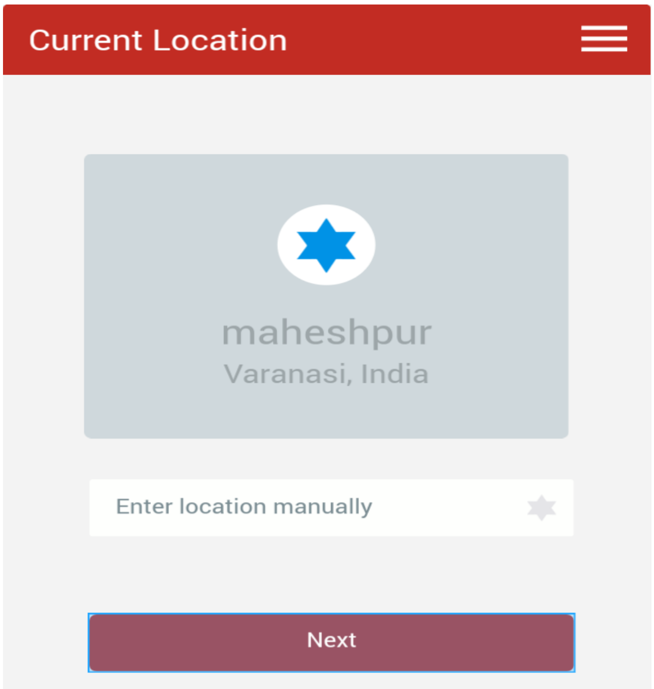

Fig.2 Current location of the farmer detected through GPS

Followed by location comes the weather predictions chart for the next three months in advance. This is significant for the farmers to decide on the vegetation to grow next and be prepared for the unfavorable consequences. Fig.3 shows the weather prediction chart of the software-based app. The parameters such as temperature, wind speed, humidity, precipitation and rainfall prediction shall be clearly shown as digital numbers for each component. Some parameters shall also be described in words to give the farmers more clarity in understanding. The sound provision shall be adopted in future as a part of the project which would further enhance the understanding capability of the farmers by making them listen to every detail about the weather forecast and other several relevant steps to be taken based on the current situation. The weather forecast is one of the most important and determining parameter for the crop to be grown in the soil. Thus, the data displayed on the screen, shall be used effectively by the farmers in deciding which crop would be feasible to grow bases on the location and weather conditions. This will be used as one of the parameters to determine feasible crop.

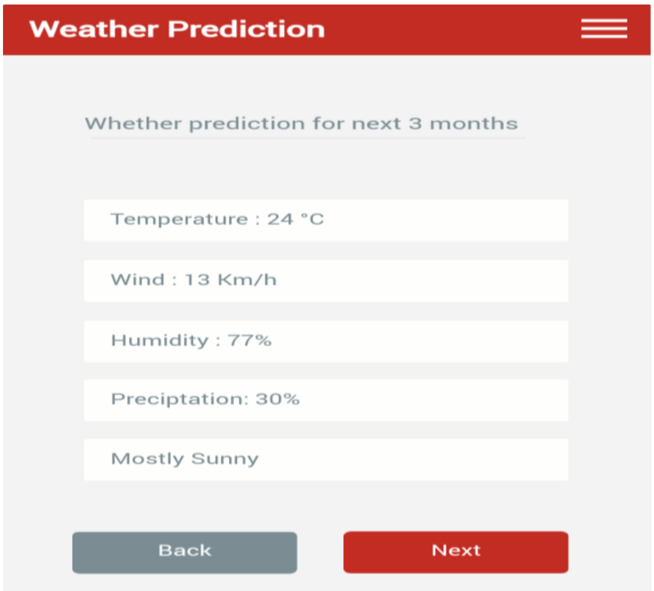

Fig.3 Weather forecasting data for next three months

The soil conditions screen of the application has been shown in Fig.4. On a click for next button on the weather prediction page, the soil conditions page displays, into which the farmer must provide certain parameters related to soils. These parameters generally consist of soil properties like pH value, Nitrogen, Phosphorus, Potassium content in percentage, soil temperature, moisture of the soil and other parameters discussed initially in the paper. These parameters have already been extracted through soil testing and just needs to be put in this section.

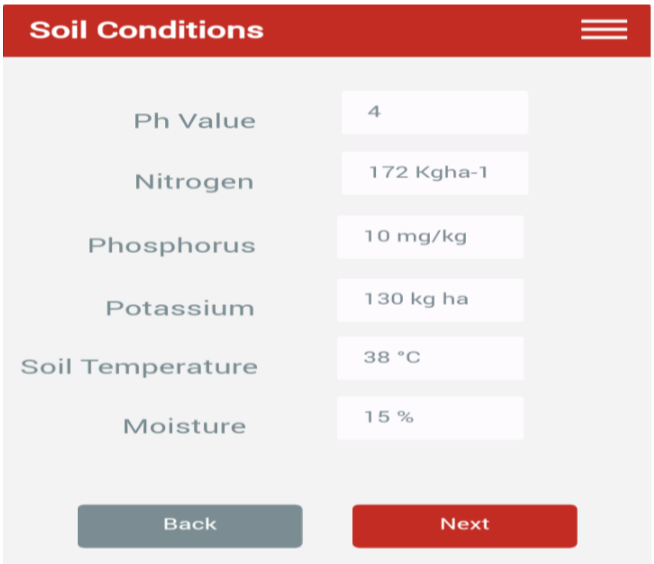

Fig.4 Soil conditions data extracted through soil testing

About the current research going on in soil geology and weather forecasting, the Indian government have formed multiple soil testing labs, weather forecasting stations and satellite meteorological stations for continues weather monitoring to avoid natural disaster and perform a continuous scrutinization on climate change. The soil properties can be found from any of the government authorized soil testing labs situated near by location. Some are readily available through internet and sources like FAO from which the authors have extracted the data for doing the testing in the app. The app shall also list all the centers and their timings based on the current location of the user. Combining the factors location, weather conditions, soil properties and all the available historical data, the app shall predict display the feasible crop to be grown at that location. Fig.5 shows the result page of the app which displays the crop discernment. The button *"Discuss"* shall be used to start a local chat group discussion for the farmer to communicate between nearby farmers for taking suggestions for the crop suggested. It will also help the farmer to decide the effective crop with their command interest and practical conditions. With these simple steps the farmer shall have more confidence on the crop he is going to grow through investing time, money and hard work which shall yield better results.

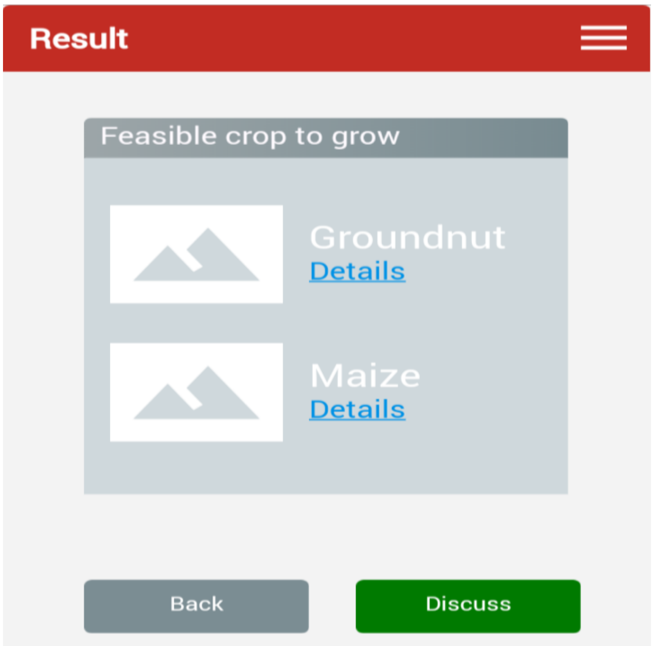

Fig.5 Conditions based decision for a feasible crop for that location

CONCLUSION

Internet of Things has been the most favored technology in today's research and development area. Its applications have been diversified in various sectors, but the increasing leveraging has been seen in the agricultural domain in past few years. The authors in their first paper in 2016 has initiated the project with the development of a prototype which shall make the farmers to take precautionary steps in advance for the safety of the crops also mentioning various stages for the development of IoT devise to be used in farming. This paper, as an extension to the former one, progressed in developing a software application which would tell the user which crop to grow in that soil. These data have been taken from FAO and is preloaded in the software application. Through the detailed discussion in section III it has been cleared how the application shall perform the operations and notify the farmer which crop to grow based on the soil and weather conditions of that location. This app is in use and is a free source for the researchers who are working in soil testing areas or IoT for agriculture application.

The authors are in process to publicize this app and gets the reviewer cum users' feedback to have continuous improvement in it. Continuously extracting more data about various geographic locations with respect to their soil and weather conditions, the app can be made more sophisticated and more reliable. The efforts are in process to distribute this app to the local farmers of Himachal Pradesh and Karnataka respectively (where the authors belong), to get real practical outcomes.

The next stage would be integration of the app and the soil through the IoT on the real farmland and getting the actual results through practical exposure.

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