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Social Innovation through Precision Farming: An IoT Based Precision Farming System for Examining and Improving Soil Fertility and Soil Health

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Abstract: ***Agriculture is the most important sector of Indian Economy. Indian agriculture sector provides employment to 50% of the countries workforce. India is the world's largest producer of pulses, rice, wheat, sugarcane, pomegranates etc. The current scenario of agriculture business in India is not up to the mark as expected. There are number of reasons which causes less yield in the agriculture such as unpredictable environmental conditions, excess use of fertilizers (cost is increasing day by day), increased draught frequency and its severity, increasing labor rate, less difference between the income and expenditure, ripeness of soil, influenced suspensions, non-appropriate water management, diseases on crops, invasion of animals and so on. There is need to find the ways which makes the use of Information Technology (IT) concepts and tools wherever possible for increasing automation in the agriculture business, which results in the efficient and effective outcome of agriculture i.e. higher yields. The production efficiency can be increased significantly with technological advancement in agriculture. Internet of Things (IoT) is a novel design approach for precision farming. Farming has seen number of technological transformations in the last decade. By using various smart agriculture gadgets, farmers have gained better control over the process of raising the growing crops and livestocks. One of the major issues which cause fewer yields is the soil health. This paper mainly analyses/reviews the problems related to the soil health (soil fertility), which is a main obstacle in the crop production. Also this study focuses on the use of IoT applications in precision farming. It gives an overview of the relation between crop productivity and soil health.***

Keywords: Internet of Things, Information Technology, Precision farming, Sensors, Soil fertility.

I. INTRODUCTION

Internet of Things (IoT) is a system of interconnected computing devices, digital and mechanical machines, objects, animals or people that have ability to transfer the data over a network without requiring human-to-human or human-to-computer interaction. IoT is an extension of internet connectivity into the physical devices and everyday objects. IoT enabled devices can communicate with each other over the internet [13]. They can remotely monitor and controlled. Agriculture is an art and science of cultivating the soil, growing crops, raising livestocks etc. It includes the preparation of plant and animal products for people to use.

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Agriculture provides most of the world's food and fabrics. It also helps to reduce the poverty, raise income and improve food security. The Latin root of agriculture is 'agri' as 'field' plus 'cultral' as 'cultivation'. We know the agriculture is a backbone of Indian economy. The current situation of Indian agriculture is not up to the mark as expected. There are number of reasons behind it. Due to the rise in population and major change in climatic conditions day by day, the maximum and required crop production is challenging task in front of farmers. It is requirement of today's market that at every stage the farmer should get accurate information about which particular factor he has to deal with or work with for getting the maximum production. Use of IoT in agriculture business for monitoring soil health plays an important role. In this paper we have focused on the issues of soil fertility and crop production.

II. LITERATURE REVIEW

Muthunoori Naresh and P. Munaswamy presented the work on recent innovation into the agrarian field by the use of IoT. Generally farmers refer the rapiness of soil and influenced suspicions for crop production. They don't think about the soil humidity, water level, nutrient level and especially the changing climatic conditions. IoT gives the energy for agriculture business for empowering the agriculturists. IoT modernization helps in collecting the data or information on various circumstances like climate, dampness, temperature and fruitfulness of the soil [1]. For collecting information various types of sensors such as soil moisture sensor, temperature sensor, humidity sensor, water level sensor, NPK sensors, pH sensor etc. are used [5]. Suhatha Anand, Silviya Shanmuga and A. Sneatha [2] discussed the issues which affects on the crop growth. Basically the crop growth is based on soil nutrients and its moisture level. Day by day population is increasing; the production of crop has to be increased. To produce more efficient crops soil moisture, temperature, pH, nutrients, minerals are need to be maintained [5]. So for effective crop production the nutrient level has to be monitored frequently. Authors discussed that there are various methods available for nutrient detection [2]. Nutrient level, pH, moisture level and temperature of soil can be detected and monitored using various sensors such as pH sensor, temperature sensor, soil moisture sensor and microcontroller. The collected values are stored and uploaded to server for future use. In this system electrochemical sensor is developed to determine the percentage of soil nutrients i.e. Nitrogen (N), Phosphorous (P), and Potassium (K). The system will analyze soil nutrient content present in soil at real time and will also suggest improvements.

Monitoring the field and providing proper fertilizers depending on the soil nutrients is main factor of agriculture business.

Agriculture development using IoT technology is very much helpful in cultivation. In the precision farming, without knowing or monitoring the parameters of soil, cultivation is difficult. In this case farmers may suffer from financial losses [3]. Author Shilpa Chavan and her team focused on soil monitoring system using sensors. In this system various soil monitoring sensors are used to measure the parameter of soil such as temperature, moisture, NPK, light, pH value etc. [2] [3] [5]. The information from the sensors in the soil is send to MCP2304 A/D convertor then from A/D converter it send to the cloud through Rasberry pi. Finally we see the information received and saved to cloud on mobile as well as on laptop. Based on this information farmer will get an information that, which crop is suitable with given soil parameters [3] [12].

Apart from above mentioned parameters of soil there is need to analyze the mineral contents of soil using IoT. There is no specific sensor available for measuring the mineral contents of the soil [4] [8] [11].

In the smart farming IoT can play crucial role for solving the problems like climate change, temperature, rainfall, ground level etc. Use of IoT can be extended to improve the efficient ise of inputs in agriculture like fertilizers, soil nutrients, pesticides, water etc. The IoT can suggest if pH rate of soil is lower than the normal one then which pesticides are needs to be used to improve cultivation and increase the productivity [5].

IoT has the capability to modernize agriculture and initiate exponential growth in the sector. It is all set to change the way cultivation is done. Moreover, it is expected to reduce wastage and improve profit margins remarkably [13].

The benefits of using IoT in agriculture include [9] [10][16]:

- The effective use of inputs helps in reducing wastage and thus, decreases costs incurred.
- Losses due to diseases and infections can be reduced, by continuous and real-time crop monitoring.
- The use of IoT-based devices allows better management of farm activities.

Our study has analyzed recently developed IoT applications in the agriculture field and addresses some issues which affect the performance of productivity.

According to the challenges we are giving focus on soil health, which is decreasing day by day with non-appropriate management of water, fertilizers, pesticides etc.

The remainder of this paper is as below:

Section-II includes the data collection methodology, data inclusion criteria and data analysis methods. Section-III describes the results which describes NPK consumptions by various crops per year, use of fertilizers (in tons) during 2014-2018 and area, production and productivity of major crops in Solapur district. The raw data is collected from the web site of agriculture department of Solapur district, Maharashtra. Section IV describes the issues and challenges and Section V concludes the paper.

III. MATERIALS AND METHODS

Data collection involves finding the research articles based on precision farming using IoT. Particularly 34 peer-reviewed scientific publications on precision farming using IoT and use of IoT in agriculture business are used. The raw data is collected region wise from 2014 to 2018 related to the article from the Solapur district agriculture department website [6].

The data gathered for this review is collected from IEEE database (2016-2019). All these publications have different applications in agriculture field that have been studied and analyzed in this survey. For the data inclusion different tables and graphs are drawn. The analytical and descriptive details of the study based on publication year were observed from 2016-2019.

IV. RESULTS

The main aim of this review is to analyze the use of IoT in smart agriculture for increasing yields and maintaining the health of soil. The study focuses on collecting the issues and challenges in precision farming using IoT to increase the productivity and efficiency [14] [15]. Also to collect and enlist the parameters which plays an important role in increasing the yield and maintaining the health of soil. In the field of agriculture, there are many environmental factors that need to be considered to enhance crops productivity [7].

Table 1 shows the consumption of soil nutrients (NPK) by various crops in the Solapur district area per year.

Crop	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	Total
Cotton	100	50	50	200
Jawar	50	25	0	75
Soyabean	50	75	0	125
Sunflower	50	25	25	100
Maize	50	40	40	130
Sugarcane	150	50	80	280
Vegetables	20	20	20	60
Banana	400	200	300	900

Table 1. The consumption of soil nutrients (NPK) by various crops in the Solapur district area per year.

Around fifteen essential nutrients which are supplied by soil to plants for proper growth. Out of these Nitrogen (N), Phosphorous (P), and Potassium (K) are referred as primary/micronutrients. Due to this, in the large amount they are required by the plants. These nutrients plays an important in the development and proper growth of plants. Table 1 shows the consumption of NPK nutrients by various crops per year. On the other hand, Calcium (Ca), magnesium (Mg) and sulphur (S) are secondary nutrients. As compared to primary nutrients these are required in less amount. Other remaining minerals are very rarely required for the plants such as Zinc (Zn), Chlorine (Cl), Boron (B), Molybdenum (Mo), Copper (Cu), Iron (Fe), Manganese (Mn), Cobalt (Co) and Nickel.

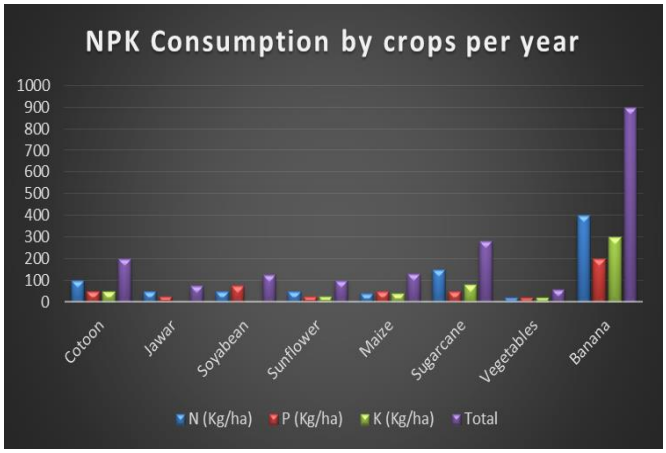

Fig. 1 Consumption of soil nutrients (NPK) per year by various crops in the Solapur district area.

Normally it is a thought process that more use of fertilizers increases the production. Majority of the farmers doesn't check which particular fertilizer is required for both soil and plant for the proper growth of plant. Day by day the use of fertilizers is increasing, but on the other hand the health of soil is degrades. So there is need to check the requirement of fertilizer before its actual use for both soil and plant. By the use of IoT one can check soil health and its actual requirement. Table 2 and Fig. 2 show the actual use of fertilizers in 10 different regions of Solapur district. It shows that day by day use of fertilizers is increasing, which may effect on the soil fertility. This is one of the major reasons of decreasing yield now a day.

Table 2 Use of fertilizers (in tons) during 2014-2018 by farmers for the production of various crops in the Solapur district area.

Tehsil (Region)	Use of fertilizers during 2014-15 (In Tons)	Use of fertilizers during 2015-16 (In Tons)	Use of fertilizers during 2016-17 (In Tons)	Use of fertilizers during 2017-18 (In Tons)
North Solapur	12630	13893	15282	16071
South Solapur	32060	35266	38793	42193
Akkalkot	29146	32060	35266	38472
Mohol	32384	35623	39185	42147
Barshi	37889	41678	45846	50014
Madha	32060	35266	38793	42320
Karmala	34975	38472	42320	46168
Malshiras	28822	31704	34874	38044
Pandharpur	41452	45597	50156	53712
Sangola	19430	21374	23511	25648
Mangalwedha	22993	25292	27821	30350

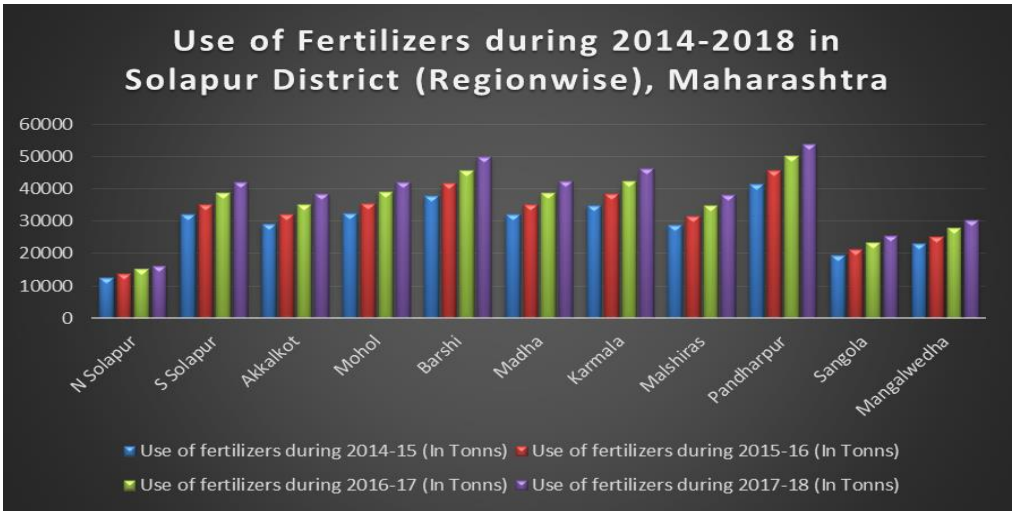

Fig. 2 Use of fertilizers (in tons) during 2014-2018 by farmers for the production of various crops in the Solapur district area.

Table 3 shows Area, Production and productivity of Major crops in Solapur district.

	Year 2014-15			Year 2015-16			Year 2016-17		
Crop	Area (ha)	Production (M.T.)	Productivity (Kg/ha)	Area (ha)	Production (M.T.)	Productivity (Kg/ha)	Area (ha)	Production (M.T.)	Productivity (Kg/ha)
Kh. Jowar	3.04	1.24032	408	4	1.64	410	4.1	1.722	420
Rice	0.54	0.13392	248	1	0.25	250	1.2	0.36	300
Bajra	303.15	110.9529	366	325	120.25	370	350	140	400
Maize	272.7	563.3982	2066	300	621	2070	310	651	2100
Tur	518.81	238.6526	460	525	249.375	475	550	275	500
Mung	78.01	53.59287	687	80	55.2	690	90	63	700
Udid	140.69	94.82506	674	145.7	100.533	690	147	102.9	700
Soybean	380.97	412.59051	1083	400.2	440.22	1100	425.25	478.40625	1125
Sugarcane	1038.98	107014.94	103	1080.4	113442	105	1090	109000	100
Cotton	35.67	10.62966	298	38.7	11.61	300	40.1	12.832	320
Wheat	452.02	616.55528	1364	475	653.125	1375	500	700	1400
Sunflower	65.23	43.83456	672	60.25	41.5725	690	75.2	52.64	700

The current scenario of agriculture business and the laboratory record of previous 3 years tell us that productivity of plant increases but not up to the mark. There is no proper management of fertilizers, water, soil nutrients etc. By the use of IoT it possible to check the requirement of soil nutrients, humidity, water level, fertilizers etc. for getting maximum by maintaining the health of soil. Table 3 in relation with Fig. 3, Fig. 4 and Fig. 5 shows the productivity of major crops in Solapur district for previous three years.

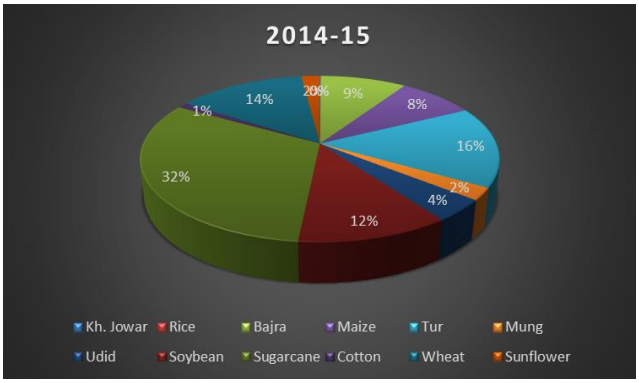

Fig. 3 The Area, Production and Productivity of Major crops during 2014-15 in Solapur District.

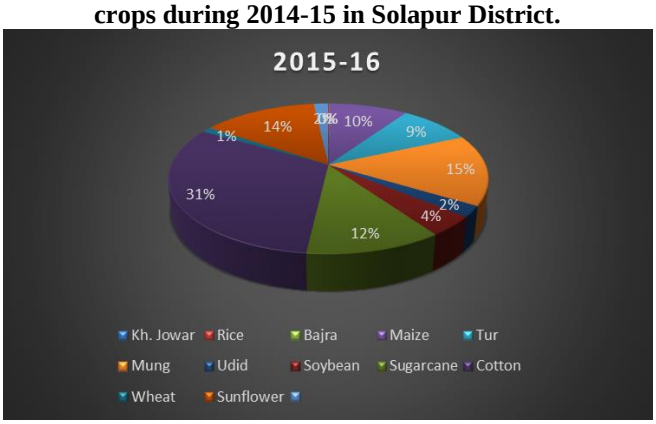

Fig. 4 The Area, Production and Productivity of Major crops during 2015-16 in Solapur District.

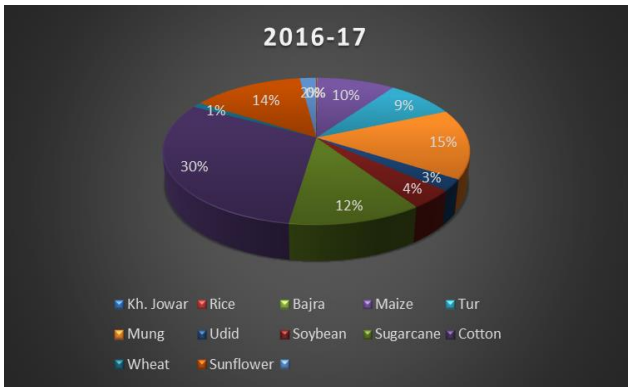

Fig. 5 The Area, Production and Productivity of Major crops during 2016-17 in Solapur District.

V. ISSUES AND CHALLENGES

From this review we present several issues and challenges in the field of agriculture automation where researchers can pay attention. There is a need to develop such a system using IoT which measures the mineral contents of the soil along with other parameters such soil moisture, humidity, temperature, pH etc. for suggesting the crop to be planted. This helps to get the nature of soil by extracting the contents of soil, which will be beneficial to the farmers for finding the right crop for right field. In the precision farming, monitoring environmental factors/conditions is major issue for improving yield. There is need to design electrochemical sensor which determine the percentage of soil nutrients in less time. Also there is need to predict the diseases of plant using IoT enabled application in earlier stage so that it will not effect on overall production efficiency.

VI. CONCLUSION

The use of recent technologies increasing day by day in every sector. Several areas are there where the use of IoT is possible including agriculture field.

The literature survey shows that there are lots of works ongoing in the development of precision farming using IoT. There are number of benefits offering by precision farming using IoT for improving efficiency and productivity. However still there are number of issues need to find and address for increasing the yields. The key issues are identifying and maintaining the soil health frequently in less time, checking the nutrients in the soil, improving soil fertility, prediction of frost etc. Soil fertility is the ability of soil to sustain plant growth and optimize crop yield. Soil fertility includes nitrogen, phosphorus and potassium. It also consists of adequate minerals, chlorine, cobalt, copper, iron, manganese, sulphur and zinc. These minerals promote the plant nutrition. One major area where we need to pay attention is to make use of IoT which checks soil minerals in less time that will be helpful to farmers to take necessary and corrective action. Normally the checking the soil nutrients or minerals require more time, which wastes the time and effects on the further care of plant. So this needs to reduce by using IoT. The results shown in this paper promotes the use of IoT or similar technology for achieving the goal in precision farming. This paper is useful to the researcher for getting new ways in current agriculture era to make automation process.

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