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Wireless Sensor Network And Iot-Based Crop And Soil Quality Analysis For Smart Farming: Opportunities And Challenges

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Abstract— Smart farming is suitable for agriculture area where advance technologies are available for all types of information system which enabled farming field. For farming soil, weather, crops and many mores necessarily needed for farmers. The production of crop depends on the soil quality used to produces the plants. Soil has the major nutrients like nitrogen (N), phosphorus (P) and potassium (K) and some minor nutrients as well and humidity, temperature and pH value. Each organism has own important role for crop production. Farming should be smart as advancement is there through technologies. Smart Farming is concept where computer and information technology may take care about farming. Through IoT enabled devices, wireless sensor network (WSN), Machine learning, Deep learning and Agile methodology, farming becomes smart farming. In this paper we describe that how farmer faces challenges about the farming that may be by poor soil quality which may impact the production of crop. We give the systematic literature reviews on the smart farming-based computer technologies. WSN plays the role in smart farming and data collected through IoT devices. Year wise research papers explained with what technologies and methodologies used. Outcomes and future directions are also given in the tabular format. Possible research gaps also mentioned in this paper.

Keywords—smart farming, WSN, machine learning, IoT, Agile.

I. INTRODUCTION

Soil is mixture contains the rock, water and air which are at top of agriculture field whereas farming is one of the most important components of our society. Soil is a medium for plant growth, habitat for different species, and filtration system for surface water. Also gives a vital part of successful agriculture. Soil plays an important role in farm ecosystem by providing nutrients essential for the growth of agricultural crops[1]. The transformation of nutrients from soil to plants that we feed. At the end we have many benefits from healthy soil [2][3]. Many soils vital parameters for crop yielding

like soil moisture content, humidity, temperature and pH level. Soil is a major source of nutrients needed by plants for growth. Soil has three majorly nutrients are nitrogen (N), phosphorus (P) and potassium (K) which represented as NPK [4] and also has minor nutrients as well.

A. Impact of deficiency of these nutrients on quality of crop and livelihood of farmers

Nutrient deficiency symptoms may be classified as follows[5][6]:

- At the seedling stage that proceed to crop failure.
- Due to protein and oil differences may leads to poor quality of crops.
- Through careful experiment work yield differences can be detected by only.

The loss of soil has another immediate major impact on crop productivity[7]. The percentage level of P is 15-20%, N is 30-50% many more mentioned in [8] due to deterioration in chemical, physical and biological health of the soils.

Major problem occurred in farming due to quality of soil, seed, insects and percentage level damaged level of crops [9]. So economically farmers are not so much strong to make decision for their land soil nutrients. The deficiency of nutrients in soil generates on-site costs that directly affect farming land. These costs are paid by farmers, through loss of fertile land. The on-site costs are mainly the value of future lost production due to the decline in soil resources[10]. Finally, a typology for understanding the livelihood implications of different agriculture-nutrition activities and goals, and their possible pathways to improved nutrition for women and children[11][12].

B. Impact of poor-quality crops on human health

Soil plays vital role for all areas of farming of good quality food. Several components added into the system to make the quality-based production of crops. If the quality of soil is not good then it may impact on the growth level of crops some disease can also place in crops [13]. In soil there are two types of nutrients micro and macro which well-defined structure of organic matter. It also some physical and chemical properties conducive to promoting crop growth [14]. As per [15] soil pollution may impact on the environment where life suffer the consequences. If the problem not handled early then the impact on the people. In 2020, target income of farmers can be increased by 2022[16].

C. Existing system

Manual farming systems are there on India. Old and traditional techniques are mostly available for irrigation system and digging. Farmers of India faces so many challenges regarding the farming and about the production system of crops. Balanced fertilizers required to increase the productivity of crops, if there is no balance in between soil and fertilizer then it may lead to decrement. Soil should also be check by professional organization so that can add the nutrients to the soil to make better quality. [17].

Without taking any sample testing farmers going to add pesticides to soil and decrease the quality of soil. Need of analysis of soil before and after the pesticide added to the soil. So later can take forecast decision. A laboratory with a capacity to test 8,000 samples per year will be adequate to cater to a few villages in one block. Government gives schemes to soil testing sample on reasonable charges with excluding micro nutrients and with water sample.

Soil testing provides valuable information on important soil characteristics. The results will greatly assist in cost effective decisions about fertilizers and other soil additions on your farm. It is essential

to collect soil samples that accurately soil health card scheme announced in 2015 these schemes based on the analysis and recommendation [18].

D. Limitation

- sShort coming with current system is no database for soil nutrient details. Need of database for soil monitoring system can be through survey of land and some soil properties, analysis of soil [19].
- Another limitation with existing system is that there is no management system for soil health on basis of fertility of soil maps or with some macro/micro nutrients.
- Missing of Integrated farming system for farmers to give directions to take decisions how to make soil healthy.
- Lack of Agricultural Information Flow System which is started from soil health management to crop cutting. For this system the primary goal is to improve the communication between farmer and organization and also improve the livelihood for farmers.
- There is no knowledge about the advance technology and methods about smart farming [16].
- Need of agricultural environment monitoring system [20].

Motivation (soil nutrient monitoring system)

Early soil monitoring system implementations were focused on data entry and report generation within a farm. New advancement in farming needs to explore the monitoring of soil properties. More recent developments have led to the consideration of extended capabilities to deliver efficiencies within agriculture and have led to an academic interest in the modelling and development of SNMS. Need to gives the direction to the farmers about technology and technique to save soil with suitable [21]. Farmers can concentrate on the growing food [22]. Through GPS and sensor based technology can allow farmers to understand the crops at micro level [18]. Soil moisture, temperature and pH level can be also measures to increase the crop production by farmers and take decision early also so that save money as well [12]. Now the information technology can take place to give the wings in the field of agriculture and smart farming to improve the soil quality [23].

II. BACKGROUND

A. Introduction about technologies used in smart farming

combined application of information and communications technology (ICT) now taking over the farming with solution of precision-based agriculture, IoT[27], sensor-based communication [28][29], scanning of soil, management of soil given. And the combination of Artificial Intelligence (AI), Machine Learning (ML), wireless sensor networks (WSN) and Cloud provide the high level production of crop and better way to control [24]. Existing agriculture information system is developed by applying waterfall model which has many flaws. In order to overcome those issues agile methodology is used for the development of agriculture system[25].

Information technology also improve the soil health monitoring system through some technologies. Production of crops can also increase through the information system. Agriculture organizations play role to make model-based information system as per farmer's needs, so that better decisions can take places in future [26]. Smart farming in India is strongly related to three interconnected technologies which are management information system, precision agriculture (with inclusion of DSS) and agriculture automation and robotics.

Agile methods [30][31] are best solution to develop the software for smart farming as requirements of farmers drastically changed regularly. Need of quick changes, rapid development and high level of customer involvement, all phases agile gives the direction to the development strategy. Scrum based development of smart farming system is well suited for farmer's decisions. Till now waterfall model based smart farming system developed only. To overcome from this agile scrum based solution will be best than water fall model for agriculture system [25]. Scrum method can also applicable to design the soil monitoring system. Scrum is characterized by small work teams, organized so as to optimize communication and make greater sharing of knowledge[32].

Through machine learning methodologies can help to make IoT enabled services. IoT devices collects fruitful information from environment. The sensed data from IoT devices can make a dataset through this in future make prediction level best and give the recommendation system for the farmers. In smart farming data can be type of crop data, soil data and climate data through IoT devices. Later which fertilizers should be added to soil to make soil quality best [33]. Here multiple companies are ready to design the drone-based data collection software through can monitor the crops and soil as well. Deep learning will also help to make more concise monitoring system for soil quality improvement [34]. In this paper literature survey has been done on the basis of WSN usage for smart farming with opportunities along with challenges.

III. CRITICAL LITERATURE REVIEW

We have performed a critical research survey on existing smart farming approaches shown in table I using wireless sensor networks and summaries them as follows:

Diana Elizabeth Minda Gilces et al. [35] (2017) invented a prototype system for monitoring the temperature, humidity and ultraviolet solar radiation stages in a green farming of tomato. Usage of agile scrum-based methodology was applied on the deployment of system prototype. It gives the pictorial representation of the sensed data in the form of charts and visual arts on the basis of daily, monthly and yeas wise as well.

Arun M. Patokar and Vinaya V. Gohokar [36] (2017) proposed a new system for monitoring the multi-parameter in precision agriculture using WSN. With the help of Internet of Things, proposed system supports monitoring, controlling and decision making. Data such as humidity, temperature and soil moisture display on the PC screen.

Ugyen Dorji et al. [37] (2017) designed a e-nose based on WSN to solve the soil problem. This system has the keep track for the online soil status data. This data is based on volatile organic compounds and soil organic matter which are beneficial for soil nutrient management in precision agriculture.

Yaya Suleman et al. [38] (2018) developed a precision farming based WSN GUI system which consists multi node sensor networks, a controller and wireless module. All the sensed data displayed on graphical user interface and further saved into the database. This model has different types of sensors like as nitrogen sensor, phosphorus sensor, potassium sensor, soil moisture sensor. This model also monitors the temperature, humidity and light intensity. This data is available on website for farmer. A farmer is also able to monitor the updated data through android application.

Farzad Kiani et al. [39] (2018) presented a paper on that divides the farm into regions for further investigates the soil moisture, humidity and temperature using WSN and IoT based. This generates a report of ten days data for farmers to take decision for crop production, irrigation and fertilization.

Sabrine Khriji et al. [40] (2019) investigated energy efficient technique for agriculture application using distributed sensor network. As energy is main concern for WSN, so clustering gives usage of

less energy consumption to collects the sensed data from agriculture land. Thus proposed a routing algorithm as the combination of localization and clustering to improve the energy level of sensor network. Another add-on is fuzzy based unequal clustering to balance the energy of each node of network.

Yousef Hamouda and Mohammed Msallam [41] (2020) introduced a variable sampling interval precision agriculture framework using WSN to monitors the water level, soil moisture and temperature area wise. In comparison of some other fixed techniques, variable based approach provides the improvement in energy consumption. So, productions of crops can also be enhanced to get better results.

Khalid Haseeb et al. [42] (2020) proposed a new IoT based WSN framework for smart farming to improve production yields via taking smart decisions. It comprises different levels; first to find out the set of cluster heads for efficient transmission, second is secure transmission. This framework shows the throughput, packet drop ratio, energy consumption and routing overhead for smart farming.

Kashif Naseer Qureshi et al. [43] (2020) focused on sensor based agriculture field and gives a gateway clustering energy efficient centroid routing protocol. In which cluster head selection is based on the centroid position. The experiment provides more feasible WSN monitoring for the humidity, temperature of farming field.

P. Sanjeevi et al. [44] (2020) demonstrate the system which used WSN architecture with IoT monitoring and controlling to enhance the farming area. This proposed work gives an energy efficient communication for WSN to prolong the network for framers' productivity. It works for various parameters such as soil moisture, temperature and humidity.

Alexandros Zervopoulos et al. [45] (2020) focused on installation and design process for a WSN that is applicable for smart farming. This system implemented on olive grove to serving the low cost and assessment of the clock synchronization. This proposed work shows the graph for humidity, temperature, UV and soil moisture.

TABLE I. SUMMARY OF THE SURVEY

Authors\ Citation	**Techniques and Methodologies**	**Outcome/ Limitations**	**Scope for Further Work**
Subramania Ananda Kumar, Paramasivam Ilango[46] (2017)	This paper gives the importance of WSN in precision agriculture and WSN technologies for remote monitoring of agriculture field. Sensor will monitor the soil moisture, humidity, temperature and pH level.	This review paper shows the technologies usage of WSN in precision agriculture. Also explain the impact of sensors and how the zone wise monitoring of field. For future aspect the WSN has remarkable potential in precision agriculture.	In future we will try to give the usage of WSN to early identification and diagnosis the disease.
A Venkateshw	Authors invented a system for precision agriculture using WSN to minimize the	It gives the cluster-based approach and has the comparison with	In future we will try to develop a multi-hop

ar et al.[47] (2017)	production cost which affects the increment in crop field output. Distinguish types of sensors deployed in agriculture field to gather the soil data like as moisture, humidity and many more.	different routing protocols of energy consumption. It works with different area sizes of farming field to gain the production of crop.	communication system for WSN using clustering which improve the energy efficiency of the network.
Haider Mahmood Jawad et al.[48] (2017)	This paper gives the energy efficient routing protocols systematic reviews for precision algorithm. This gives the idea how cluster architecture is beneficial for energy efficiency. And also focus on the sensor types like temperature, soil moisture, humidity, air speed and many more.	This survey paper shows the sensors, actuators, platforms and energy harvesting techniques used in agriculture applications based on IoT. For further enhancement clustering gives the high energy level of sensor network.	In future we will cover beyond the range of 80 m communication using cluster-based architecture. More usage of soil parameter to improve the production of crop farming.
Arun M. Patokar et al.[36] (2017)	This system is invented to work on monitoring the crop parameters which is based on low power Intel's Galileo Gen 2 platform. Fetched data like temperature, humidity and moisture shown on PC.	The farming field is divided into parts and each part has the separate crop as per requirements. Further sensors spread into the whole field and upload the sensed data to the cloud and water level sensor also put into reservoir to show the level of water. In future aspect the nutrient can also give to the soil demands to make healthy soil.	In future we can try to give nutrients information to make soil healthy. Also same respond to the farmers to take decision for production through smart app.
Farzad Kiani et al.[39] (2018)	Authors presented a paper on that divides the farm into regions for further investigates the soil moisture, humidity and	This generates a report of ten days data for farmers to take decision for crop production, irrigation and fertilization. As	Further enhancement will be implements some reinforcement

	temperature using WSN and IoT based.	limitation of the system later can use the reinforcement learning system to collect and make prediction.	learning methods to collects the data for farmers to give suggestions. We will try to develop some cluster-based approach for the energy efficiency issue.
T. Rajasekaran et al. [49] (2019)	This survey discussed about the challenges of agriculture in WSNs. It gives the comparison between smart farming and traditional farming and gives direction to the smart farming.	By implementation of smart farming in agriculture farmers may have the profit in crop production and best usage of water in irrigation. In future needs to work with automatic system for smart farming which gives help to farmers.	We will focus on the how to make agriculture works smartly by providing the remote-control system for requirement of crop production like as environment parameters. We will try to create an application for future prediction to enhance the profitability by using learning methods.
Divyansh Thakur et al.[50] (2019)	A systematic literature review presents the smart farming adopted the various WSNs technologies that improves the soil parameters and minimizes the resources utilizations.	The output of this review paper represents the work report on crop monitoring, which shows tools, techniques, environment parameters and sensors used in crop. For achieving the precision agriculture work report shows on irrigation system. Intrusion detection and utilization of fertilizers	Intrusion detection can be considered as future development. Much work is needed further to extends the precision agriculture by giving the healthy soil with add-on and

		to make healthy soil for smart farming are still their further investigation.	intrusion detection monitoring system.
Somali Chaterji et al.[51] (2020)	The study aims to fill the gap between digitization and smart farming, this gap was due to farmer's interaction. It gives the end-to-end process for evolution of advanced agriculture solutions.	Results give those new technologies reduce cost of production and expands the middle size farms. Soil sampling can also improve by adding making nutrient to making the soil healthy for more utilization. It observed that further studies are required on soil real time data uploading on cloud for farmer's decision making.	Open space for future scope is to collect the real time data of soil parameters like humidity, moisture, temperature and pH value. So that in future can add nutrients to soil and take decision for farmer's steps further.
Yemeserach Mekonnen et al.[52] (2020)	A comprehensive and qualitative literature survey of machine learning methods usage in precision agriculture along with WSN. Apply the distinguish models of ML to make smart farming. Not only WSN based PA specifically but ML has crucial role which applies on sensed data and take future decision for smart farming.	Outcome of this review shows application of the different ML algorithms for sensor sensed data. Also discuss the case study IoT based application prototype of smart farming. Data visualization of soil moisture content, temperature by this paper also.	For future aspect we will try to analyze the sensed data for predicting the temperature, humidity and soil moisture of crops.
Firasath Nabi et al. [53] (2020)	This paper gives the technical review of different diseases appear in apple crop and usages of sensors in precision agriculture. With the help of forecasting system smart farming can be helpful for farmers to take further decision. Also gives the comparative study of	This survey gives the direction to select the technologies to increase the production using optimized sensor networks based on smart farming system. For future direction need a real time forecasting system which spreads the information to the farmers. Support of soft	In future we will try to implements the soft computing techniques to make intelligent system for future forecasting.

	different application with sensor type usage.	computing methods to create an intelligent support system can also be research gap.	
Kashif Naseer Qureshi et al. [43] (2020)	Authors focused on sensor-based agriculture field and gives a gateway clustering energy efficient centroid routing protocol. In which cluster head selection is based on the centroid position. The experiment provides more feasible WSN monitoring for the humidity, temperature of farming field.	The result of proposed work indicates the better performance given by centroid-based CH selection approach in WSN based precision agriculture and monitoring for soil data. In future separate soil-based application can also developed which also indicates the new nutrients addition to soil to make more fertilized.	Further advancement in CH based precision agriculture to be given by an application which gives the soil-based cloud and gives the indication to the farmers to add the nutrients in soil to make more fertilized farm land.

IV. RESEARCH GAP AND DISCUSSION

Research gaps are as follows: -

- Usage of WSN to early identification and diagnosis the crop disease.
- Multi-hop communication system for WSN using clustering which improve the energy efficiency of the network for smart farming.
- More usage of soil parameter to improve the production of crop farming.
- Nutrients information to make soil healthy can also maintained. Also same respond to the farmers to take decision for production through smart app.
- Implementation of some reinforcement learning methods to collects the data for farmers to give suggestions. We will try to develop some cluster-based approach for the energy efficiency issue.
- Providing the remote-control system for requirement of crop production like as environment parameters. We will try to create an application for future prediction to enhance the profitability by using learning methods.
- Work is needed further to extends the precision agriculture by giving the healthy soil with add-on and intrusion detection monitoring system.
- Open space for future scope is to collect the real time data of soil parameters like humidity, moisture, temperature and pH value. So that in future can add nutrients to soil and take decision for farmer's steps further.

- Analyze the sensed data for predicting the temperature, humidity and soil moisture of crops.
- To implements the soft computing techniques to make intelligent system for future forecasting.
- Cluster head based precision agriculture to be given by an application which gives the soil-based cloud and gives the indication to the farmers to add the nutrients in soil to make more fertilized farm land.

V. CONCLUSION

Smart Farming is wing for farmers where computer and information technology may take care about farming. IoT, wireless sensor network (WSN), machine learning, deep learning and agile methodology these are concept of farming that becomes smart farming. We give the systematic literature reviews on the smart farming-based computer technologies. WSN plays the role in smart farming and data collected through IoT devices. Year wise research papers explained with what technologies and methodologies used. Outcomes and future directions are also given in the tabular format. Possible research gaps also mentioned in this paper. Research gaps are based cluster-based sensor network can applied in smart farming; machine learning can give prediction to farmers for future forecasting. Smart application for farmers can also be developed to make quick decision about the production.

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