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Technology assisted farming: Implications of IoT and AI

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Abstract. With the advancement of technologies, things became intelligent with the capabilities of self-communication between them. Internet of Things (IoT) connected daily household things to the Internet and make them able to make decisions like the human mind. Sensors collect the real atmospheric data and with the help of Artificial intelligence (AI) algorithms analysis of data takes place so that devices behave more smartly. The present article discusses how IoT revolutionized the agricultural community. According to the study, it is analyzed that 70% population is dependent on agriculture for their livelihood in India, but the status of agriculture is no more concealed from society. With the involvement of technology, it becomes easy to predict temperature, rainfall, humidity, the need for fertilizers, water requirements, etc. The introduction of modern agriculture techniques using IoT & AI is revolutionizing the traditional agriculture methodologies and are making farming a profitable venture also.

KEYWORDS: Agriculture, IOT assisted farming, Smart farming, sensors-based farming

1. Introduction

The way technology touched our life in almost all spheres is not isolated from the world. We are surrounded by things such as fan, air conditioner, refrigerator, plants, doors, etc., which can communicate with each other, take decisions on real situations with almost no human interference. Overwhelming contribution of Artificial Intelligence (AI) and Internet of Things (IoT) along with cloud-based technology [1] contributed in all areas including smart home, wearable, smart city, smart grids, the connected car, Industrial Internet, supply chain management, health care, etc. IoT is a dense cluster of various devices connected to the Internet to make communications and perform specified actions on the collected values from sensors, applying different protocols and architecture. When AI combined with IoT, things become smarter [2], and intelligible decisions are taken with no human interference [3].

As we enter into this technological world, we analyzed that data from heterogeneous devices surround us from everywhere. AI plays a very crucial role in IoT devices when this data is analyzed [4]. With enormous technologies [5], agriculture in this decade is no more exception. AI and IoT impacted agricultural activities to a great extent also. It has been studied that 17-18% of the agricultural share is contributed to the total GDP of India [6]. It depends on various external and internal factors that somehow not possible to predict in advance for better crop production [7] [8] such as weather forecasting, fertilizers use, soil's condition, pest control, crop health, water management, management of weed, increase or decrease in temperature, etc. Real-time field challenges also exist in agriculture that limits the use of resources but a blend of AI and IoT gives a sigh of relief to farmers which

automates almost the whole agriculture process [9]. Proper planning can be done for the cyclic activities involved from sowing to harvesting. With the help of data analytics [10] techniques, it is now easy to predict the demand and supply of crops that somewhere helps farmers in monetary terms [11].

Commonly practiced techniques [12] [13] [14] are not good enough to provide effective and best results especially when it comes to making judgments for the crop's behavior and the need for water it particular requires. If used in excess amount, then the nutrient value will be harmed and if used in less quantity then it harms the growth of crops. Nearly 60% of water is wasted in irrigational activities [15]. Both AI and IoT helps in gathering values from sensors, processed that collected data, and helps in knowing the important factors which ultimately helps in crop production [16]. Water management, soil management, health monitoring of crops, weed management, disease in crops, temperature, and rainfall prediction, are some of the factors that are counted in the agricultural process. IoT & AI gave their tremendous contribution in every sphere [17] such as automated irrigation system, Crop monitoring model, data analytics in demand and supply, crop disease prediction with image processing, the exact use of pesticides with the help of sensors. The Government of India has also taken many productive initiatives in this field as Electronic National Agriculture Market (eNAM), National Mission for Sustainable Agriculture (NMSA), Pradhan Mantri Krishi Sinchai Yojana (PMKSY), Pradhan Mantri Fasal Bima Yojana (PMFBY), and many more [18]. The convergence of technology with agriculture makes farmer's life easy [8] as now they don't have to go along all the farms at night and standing there late till the water or electricity supply starts [18]. Increasingly new methodologies, tools, techniques introduce new concepts in farming which are termed as Precision Farming [19], Smart Farming, and Digital Farming.

1.1 Precision Farming

"It is the optimization technique [20] [21] which includes: observation, measurement, and analyze the precise needs of fields and crops. Precision agriculture is governed by two promising technology such as big data & advanced analytics and robotics. It is more precisely defined by 4 R's [20] i.e. right time, right place, right quantity & by right method."

1.2 Smart Farming

"Smart farming [22] [23] defines how data is collected from the field and how that data is smartly used to perform the desired actions. It is the application of data and information technologies and it works on the whole farm activities."

1.3 Digital Farming

"Digital farming [24] [25] is the concept based on both precision farming and smart farming. It is the technique that adds value to the collected data and makes actionable decisions for future references. It is moreover beneficial for the users as it provides knowledgebase information to the consumers."

Despite the introduction of various modern techniques, there are still many challenges that need to be addressed for contributing to better farming. The present research article is an attempt to explore different existing established techniques in the modern agriculture era and to also present the future perspective of these.

The research article is organized as follows:

1) Section 2 presents a comprehensive literature review of the recent techniques used in agriculture using AI & IoT.
2) In section 3, methodology of literature review is discussed.
3) Section 4, concludes the article with possible assumptions.

2. Literature Review

This section includes the research contribution that has been accomplished using IoT and AI in the domain of agriculture. Through study, it is predicted that each paper has its issues and challenges. To get the accuracy in detection of the real barriers, sensors [26] came into the spotlight such as temperature sensors, humidity sensors, and moisture sensors. On a daily basis, agriculture is not smooth flowing business as it faces many challenges such as:

➢ Lack of irrigation facilities
➢ Lack of determining environmental conditions
➢ Weed management
➢ Lack of knowledge of crop disease
➢ Time period for pesticides

A current study shows how agricultural activities are growing day by day and it largely depends on new trends [27] and technologies. Table 1 gives a deep insight into the technologies used and helps to analyze more productively.

Table 1. Modern Agriculture Techniques

S.No	Authors	Year	Technology used	Contribution
1.	B.Ragavi *et al.* [17]	2020	IoT and AI based "AGROBOT, Cloud based IoT, Arduino, CAD Programming	• Proposed IoT and AI-based "AGROBOT" for seed sowing mechanism. • Monitors weather conditions, fertilizers & pesticides need, water requirements. • By using cloud services, information's sent to the farmers for the live monitoring of the field. • Reduces labor costs and improves crop yield.
2.	Shibin David *et al.* [15]	2020	AI, Sensors, GSM module, Arduino UNO, Bayes algorithm	• Proposed a system that measures various soil factors such as temperature, pH, moisture, etc., through the GSM module. • Based on the sensed values, fertility of soil, and requirement of water and nutrients can be predicted. • All the values can be sent to the user through SMS. • Production of crops can be increased.

3.	Deepak Sinwar *et al.* [6]	2020	AI, IoT, sensors, cloud computing, solar power, Arduino, Raspberry Pi	• Proposed Cloud and Solar Power enabled Hybrid Smart irrigation system (CS-HYSIS). • Along with Arduino, Raspberry Pi is used to work on the concept of previous knowledge in the system so that process of irrigation does not stop in case sensor nodes fail. • Because of cloud storage, users can access data at any time.
4.	Dr. D. Sivaganesan [2]	2019	AI with edge computing, multi-layer feed forward ANN	• Predicted soil moisture, growth of the crop, pestilence attack, temperature, humidity, climatic changes, and harvest time in a small portion of land. • Also, predicts when to water crops and the right time to add fertilizers.
5.	Vaishali Patil *et al.* [11]	2019	IoT based horticultural creation system (AGRIBOT)	• Predicted yield of crops and the appropriate time for that yield by providing the values to the system like soil moisture, temperature, and PH value.
6.	Sunil Kumar [7]	2019	AI and IoT framework using ML, Drone Technology	• Proposed irrigation system with the help of sensors and machine learning algorithms by predicting the past behaviors. • In addition, crop rotation, water management, harvesting time, optimum planting, and yield of crops is also discussed.
7.	B.Vidheya Raju [16]	2019	IOT, GSM module, Arduino UNO, sensors	• Proposed Low-Cost Agriculture Field Monitoring System that includes temp., moisture and rain sensors, GSM Module, Arduino UNO, Wi-Fi module, and web server.
8.	Vaishali Puranik *et al.* [13]	2019	IoT,Arduino,GSM,Sensors,LCD display	• Proposed IoT based solution for automated agriculture. • With the help of Arduino UNO, different sensors, and GSM module, water management, insecticides & pesticides control, monitoring of crops takes place.
9.	T. Rajesh *et al.* [22]	2019	IoT, AI	• Discussed IoT and AI-based E-agricultural solution. • Utilizing various sensors, real-time data is recorded regarding soil & temperature condition. • AI algorithms are used to prioritizing crops according to location, profit, and soil and guide the farmers. • Labor cost is reduced and generate a

				cost-effective solution.
10.	R. Divya *et al.* [8]	2019	IoT, SATURAS Sensor, Stem Water Potential (SWP) technology	• "SATURAS" and Stem Water Potential (SWP) technology-based mechanism is introduced for water requirements in fruit production. • The Sensor is implanted on the stem rather than branches, leaves, or soil for accurate water measurement. • Cost-effective solution for farmers as only 1-2 sensors are used per hectare. • According to the data, a message is delivered to the farmer to take further actions.
11.	Niraj Prasad Bhatta *et al.* [5]	2019	AI, IoT, Image processing	• Proposed a solution based on IoT, AI, and image processing for efficient agricultural activities. • Drones are used for real-time field analysis by capturing the farm images. • ANN and logic gates are used to purpose the solution and predict the behavior of crops in different seasons. • The solution is qualitative and quantitative in nature.
12.	Durai Raj Vincent *et al.* [4]	2019	IoT, AI, Neural network, Multi-Layer Perceptron (MLP)	• Proposed IoT and AI-based expert system for land suitability, by integration of sensor networks, neural networks, and Multi-Layer Perceptron (MLP). • Before cultivation, the land is assessed with the help of sensors, and decision is taken based on MLP results. • Crop production is increased and hence profit by taking appropriate action on gathered soil parameters. • 99% accuracy is obtained.
13.	Siddhant Kumar *et al.* [14]	2019	IoT, Image Processing and Machine learning techniques	• Proposed IoLT (Internet of Leaf Things) based gCrop system by capturing images of leaves from a camera embedded with an ultrasonic sensor to monitor the growth in real-time using sensors. • Machine learning model data which is obtained from sensors is used to observed the growth pattern. • The system predicts age of the leaves by calculating the length of the leaves. • 98% accuracy in identifying leaf

				growth, health, and maturity and hence improve the quality and yield of crops.
14.	S. S. Mane *et al.* [28]	2019	IoT, AI, Arduino, Sensors, Bluetooth, GSM	• Proposed cost-effective Automatic Irrigation System with GSM-based on real-time soil moisture content. • Lower and upper limits of soil moisture can be fixed. • Status of the pump is used and delivered. Recalibration of the system is not required in case of power failure.
15.	K.Radha Gowri [24]	2019	IoT, GSM module, Wi-Fi, ZigBee, sensors, WAN	• Proposed automated greenhouse control system for crop production under favorable conditions using sensors. • Helpful in labor cost reduction, useful for small landholdings farmers, provides a better agricultural environment to crops than open land cropping.
16.	Sneha Patange *et al.* [29]	2019	IoT, MQTT, Sensors, cloud based application, Basic4Android tool, NodeMCU open source IoT platform	• Proposed an IoT based automated irrigation solution "AGROIOT". • Low-cost devices and sensors are used in the solution. • Real-time values are collected using sensors and operated remotely.
17.	Ashutosh Agrawal *et al.* [9]	2018	IoT and AI based action-oriented application,drone technology, ML & deep learning algorithms	• Monitor the irrigation requirement of the field and need of pest control on the basis of images scanned by drone by implementing machine learning and deep learning algorithms.
18.	D. Kumari *et al.* [3]	2018	IoT based agricultural production system as GUI visualization software	• Predicted the behavior of crop activity based on real data. • Management of crop quality is done through working on a complete cycle from sowing to selling.
19.	V. Dharmaraj *et al.* [20]	2018	AI, Robotics	• Discussion over AI impact on agriculture in an enhanced way in different sectors that includes the health of the crop, detection of crop yield and diseases, field and water requirement, automated irrigation system, precision farming.

20.	Pankaj Mohan Gupta *et al.* [26]	2018	IoT, LoRAWAN, Sensors, Cloud with Data Analytics	• IoT based solution for water & yield management, pest control, and safety. • Cloud-based data analytics is used to optimize the usage of resources and improves in yield size. • LoRaWAN protocol is used for communication, due to its long-range & low power capabilities. • The system also informs about the unforeseen situation like an attack of pests, heavy rainfall, drought, etc. • For pest control, drone technology is used to monitor crops and capture images for precision farming and also sprinkles pesticides in the right quantity and from the right place.
21.	Prafful Silakari *et al* [27]	2018	IoT, ultrasonic sensors, Arduino UNO, GSM Module	• IoT based automated ultrasonic pets and insect repeller for protecting the crops and by using the GSM module, notification is sent to the farmer to take appropriate action accordingly. • Ultra-sonic wave repeller, motion sensors, and Arduino UNO board are used in this design.
22.	Sandeep Kumar *et al.* [30]	2018	Raspberry Pi, Sensors, LCD, GSM	• Proposed IoT based remote sensor solution with Raspberry Pi, sensors, LCD, and GSM. • The water system works depending on the value obtained from sensors. • Screening of the field can be done by cameras and an MMS can be sent for further investigation.
23.	Kumar Nalinaksh *et al.* [25]	2018	IoT, sensors, actuators, Raspberry Pi, Wi-Fi module	• IoT based Simulator Virtual Module prototype for monitoring irrigation, crop production, soil health, and storage facility. • The simulator is being tested on a number of basic real situations. • The solution also provides cold storage module for a reduction in wastage by implementing suitable environmental conditions. In the future, Simulator can collaborate with farms with appropriate planning.

24.	Somnath D. Bhagwat *et al.* [31]	2018	IoT, Cloud Computing, Raspberry Pi, Sensors	• Proposed Smart Green House Android App for monitoring conditions in the greenhouse. • The Sensor's collected values are delivered to the user through the app. • An appropriate action will be taken based on values regarding on/off devices. • The productivity and quality of crops can be enhanced through this application.
25.	A V L N Sujith *et al.* [19]	2017	AI,IoT,GCM/JSON	• Proposed automated android-based device using IoT for agricultural activities. • AI is used in Data Center for analyzing data for the automated process. • The implemented mechanism uses GCM or JSON to communicate field data i.e. water management, weed management and soil monitoring to the farmer, and data center.

3. Methodology

The use of technology in agriculture started a long ago, but nowadays, interdependence on the Internet and automation agricultural [28] [29] has shown its niche in the technological world. Since it is an emerging field in this digital and smart era, AI and IoT justifies their role in enhancing the agricultural practices. The analysis of papers for this study has been taken from different journals and various conference proceedings accessible in most of the renowned research databases. Most of the findings and methodologies discussed have practically implemented application and observed predictive analytics.
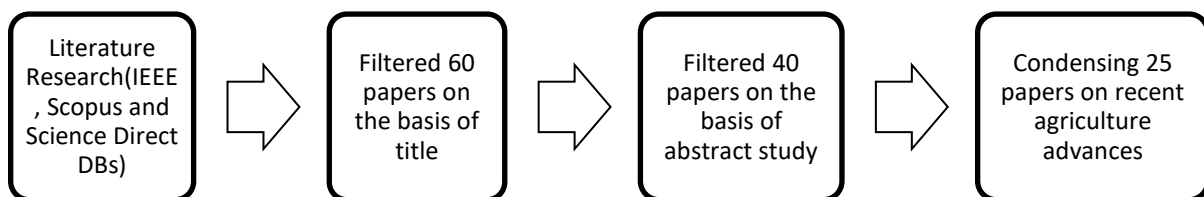

Figure 1. Literature Review Process

Literature survey study (Figure. 1) has been started from searching for foremost scholastic databases (IEEE, Scopus, and Science Direct) about agriculture and its practices. The keywords & phrases included were "smart farming", "irrigational facilities", "AI and IoT in farming", "Implementation of technology in agriculture", and "status of farming in India". There were two main criteria for the initial filtering: Publication year (recent advances of the year 2017-2020) and journal quality (by considering impact factor and no. of citations). Afterward, studies were refined on the basis of title and abstract. At least, 100 papers were recorded for getting an insight. Based on title, 60 papers have been reviewed and then 40 on abstract basis elimination. Finally, on the basis of current advancement in technological agricultural activities, a review of 25 research papers has been recorded.

An implementation technique, functioning was the main aspect to stress upon. All the selected papers were reviewed thoroughly, and every approach mentioned in these papers was taken into consideration and worked upon.

4. Discussion and Conclusion

Farmers are facing big challenges in agriculture which includes either the problem of irrigation, knowing exact factors of soil behavior, appropriate time of usage of insecticides or pesticides, prediction of crop growth, crop disease, cost of hardware implementation of newest technologies, demand & supply of crops and the most importantly, awareness of technology among farmers, pros and cons of using technology in their farms. To address these issues, technology plays an important role in integrating agriculture infrastructure with new methods and techniques. In this paper, several articles have been reviewed and it has been observed that productive work can be possible using IoT and AI in agricultural activities. 25 papers have been examined in the literature survey. All the recent advancements by using these technologies are discussed & reviewed and it is predicted that agriculture based on AI & IOT may reduce the farmer's stress for crop production, their dependability on unexpected trends in weather forecasting, and also reduction in the cost of human labor. The paper presents different proposals and implementation mechanisms using AI and IoT in the field of agriculture. With the help of literature study, it has been observed that some issues are still unnoticed in Indian farming such as-

➢ Most of the farmers in India are still dependent on seasonal rainfall and they do not use any technological irrigational facility due to lack of financial assistance,
➢ Due to small landholdings, farmers are not able to implement automated tools for farming because of high cost of hardware,
➢ Lack of smart and technological skills are also one of the main constraint in modern agriculture.

The concept of smart farming and precision agriculture is for the betterment of agricultural society and the agricultural growth seems only possible when the majority of farmers will use these technologies in their farming practices. Moreover, youth must have to show their interest in the digital era of this new agriculture to properly embed the expertise of the old traditional techniques and inventions of the recent modern era to improve the overall scenario.

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