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STUDY OF USAGE OF AI AND MACHINE LEARNING IN AGRICULTURE: PROSPECTS AND CHALLENGES

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Abstract: *The technological revolutions have made their way into many sectors and agriculture is one of them. Innovation in farm management is the key element to promote sustainable agriculture and help improve the economy of everyone dependant on agriculture. Artificial Intelligence, popularly known as AI, is a technological advancement that has recently become another growth driver across various sectors with strong promises of efficiency and growth. This study aims to explore the current usage, potential applications, and future directions of AI and machine learning in agriculture. A detailed literature review has been done to better understand the specific domain, related research, and the benefits in AI and machine learning adoption paradigm. Further efforts have been put to present the challenges in the adoption of these solutions from multiple stakeholders' perspectives.*

Keywords: *Artificial Intelligence, Agriculture, Machine Learning, Transformation, Technology.*

1. Introduction

Agriculture has been the most prevalent occupation for the majority of households in India throughout history. However, in recent times the trend has changed and the share of agriculture on the overall economy has declined progressively owing to the growth of industries and services sector. With 156.46 million hectares Arable land, India stands ranks second next to USA (Pocket Book of AGRICULTURAL STATISTICS 2019, 2020). The Agriculture, Forestry, and Fishing- comprises of 14.60% of GDP and provides 43.86 % of total employment in India as of 2018. The Gross Value Added (GVA) by the economic activity at current basic prices has grown from USD 1073.63 billion in 2011-12 to USD 2449.17 billion in 2019-20*. Although there has been growth in absolute terms, the growth rate of Gross Value Added at constant (2011-12) basic prices have declined from 5.4 in 2012-13 to 4.9* in 2019-20. India's Exports of Principal Agricultural Commodities as a share of national exports stand at 12.86% (Pocket Book of AGRICULTURAL STATISTICS 2019, 2020). India is the largest producer of spices and milk and the second-largest producer of rice, wheat, fruits and oilseeds in the world. India is also one of the major global players in

* Second Advance Estimates

the sub-sectors of agriculture like food processing, fisheries, and agricultural equipment manufacture. India has seen a rising demand worldwide for its products owing to the lifestyle changes across the world. Agriculture in India is also seeing many mergers and acquisition deals from the USA.

In the past decade, the initiatives are taken up focused on improving monetary benefits as well as mechanizing agriculture. Also, the government has been focusing on including technology-based support for farmers across the country using Information and Communication Technology (ICT) and providing knowledge-based information. Some of the initiatives are as mentioned below:

a) ICT enabled channels such as the Internet, Mobile phones, Common Service Centers (CSC) are being introduced by the Government of India (GoI) to achieve rapid agricultural development. The GoI has also sponsored a scheme called NeGP-A: National e-Governance Plan in Agriculture. Farmers now have access to knowledge-based information provided using applications like farmer's portal (www.farmer.gov.in) and mKisan portal (www.mkisan.gov.in). These aim to advise farmers on various issues and educate them with the technological advancements. Table 1 summaries the activities of this scheme.

b) The government introduced the electronic national agricultural market in 2016 to create a unified national market for agricultural commodities for the players in the network. It is an online trading platform where farmers and other members of the APMC (Agricultural Produce Market Committee) can come together to buy and sell the commodities. 16.6 million farmers, 0.128 million traders, and 585 mandis in 26 states and 2 union territories of India were registered on the e-NAM platform("National Agriculture Market portal e-NAM to Complete four Years on 14th April 2020; helped in realizing the vision of "One Nation, One Market" for Agri-produce" (n.d.)). In 2019, eNAM also started inter-state agricultural trade.

c) Apart from these initiatives, the government is also creating Agricultural Export Zones to promote more export of the agricultural commodities produced in India to leverage the rising demand globally. It is also important to promote entrepreneurship at the grassroots levels to achieve sustainable growth in agriculture and improve the economy. Through the Startup India program, the government is ensuring that various agritechstartups are incubated. To promote entrepreneurship at the grassroots level, the Indian government may soon set up a dedicated cell for agriculture startups and small entrepreneurs (Anand &Saravanan, R.,2019). Through the platform, the government will ensure different technologies are uploaded and shared with the public. The idea is to encourage more startups in the agritech sector.

Table 1: Activities of NeGP-A Scheme

Activity	Description
SMS portal	Farmers can register on the portal and they are then grouped based on various factors. The farmers can then get information, advisory, or

	other services in their local languages from the scientists, officers, and experts from across the country including market prices, soil test reports, crop health practices. IVRS and USSD mechanisms are also used to provide services to farmers throughout the country.
Kisan Call Centers	Helpline numbers are provided to the farmers to facilitate seamless communication. Farmers can dial a toll-free number which is functional throughout the clock to get the required help.
AGRISNET	To strengthen the existing technological infrastructure and promote agricultural informatics and communication, AGRISNET has been introduced.

The government has also come up with new irrigation technology through Pradhan Mantri Krishi SinchayeeYojna (PMKSY) ("Pradhan Mantri Krishi Sinchayee Yojana") to bring better irrigation facilities which are technologically driven. Agricultural Technology Management Agency (ATMA) facilitates retrieval of data and data entry from the internet-based web portals without having the internet by using a simple mobile phone.

Though the overall demand for the agricultural products has increased and many food processing companies aiming expansion to leverage their economies of scale, the farmers in the country have been facing many issues like lack of good policies, natural calamities which destroy the harvest leading to the accumulation of loans and the interests. The cultivation of various crops and their care has not changed much as older and outdated methods are still in use.
IT industry is evolving to bring up many products and solutions to challenges in various sectors. Technological revolutions like AI which were initially used for problem-solving are now becoming techniques of cost-cutting and achieving operational efficiency. AI is impacting almost all sectors of businesses with wide-ranging applications creating high value to businesses and customers alike. Harnessing the power of AI and incorporating the technologies in performing business activities efficiently is a litmus test of good leaders to stay relevant in various markets.

1.1 AI Happening

The technology industry is quickly adopting artificial intelligence and is optimistic about its future. AI needs interdisciplinary knowledge like statistics, programming, etc. and thus it's highly technical. The evolution of Machine Learning (ML), which is a subset of Artificial intelligence, from Artificial Neural Networks and Fuzzy systems to Deep learning techniques like Convolutional Neural Networks and Generative Neural Networks. The tasks ML can be broadly classified into supervised and unsupervised learning which can be used for regression, classification, association, clustering. There are multiple applications where each of these techniques are used to derive insights that can help businesses add more value to their offerings and make them customer-centric.

From the daily life perspective, a lot of applications have been developed to ease our lives and make our days more productive. We already see the use of AI in day to day life such as voice assistants such as Siri and Alexa, chatbots, predictive search in google, product recommendation on e-Commerce websites, etc.

In the coming decade, AI is expected to make its way into almost every segment of business and its activities. About 20% of businesses have already invested and started implementing AI to ease their business and improve efficiency through better outputs (Nandy, et al., 2018). Every sector must adapt and start implementing AI to remain relevant and grow. Agriculture, though it is an ancient occupation, has been trying to adopt technology to improve productivity and have a significant growth with AI promising all of this with its potential.

2. Motivation And Scope Of Study

Though many solutions have been evolved through the implementation of AI in agriculture, these advancements have not made their way to the ground level where farmers can utilize them to maximize their harvest and take proper care of the crop in harsher climatic conditions. The main reason for this might be due to the governments focusing on waiving the farmer's loans but not trying to empower them with science and technology by mechanizing agriculture. The current technology adoption seems to be inadequate since the whole of the agricultural sector is not technology-centric. This is leading to more population being involved in agriculture but driving a declining growth in the economy of the country.

With many businesses shifting to a customer-centric approach, it has become widely important for them to understand the customers and their behavior which is a key to enhance the customer experiences and build better business value. Coupled with powerful analytics techniques and sufficient data storage infrastructure in the form of cloud computing, AI can help create more value by segmenting the customers more accurately and reaching them with the right products in the right place and at the right time. Minimizing the factory overheads through effective inventory management and accurate forecasts is of high priority in most of the manufacturing industries which are very important from the economic perspective for the developing nations. AI can be of immense help in achieving the required objectives in manufacturing.

AI is important not only from the business perspective but also from the government's perspective since AI has applications that can help a government-run its operations smoothly. Defense being the backbone of investments of various governments in the world today, AI applications find use in surveillance of the country and also help reduce crime rates.

We wanted to present the review of AI and machine learning and how its perception changed from a mere computer science problem-solving technique to a value-adding aspect in agriculture. We discuss the challenges that are faced by the farming community and the gaps that exist between the organizations coming up with AI solutions and the key players in the agricultural sector.

The study begins with the current scenario of agriculture and the initiatives taken by the government of India, challenges faced by farmers in general, and how they can be solved using AI through thoughtful investments. Lastly, in the adoption cycle of AI and high-tech solutions, this paper discusses expectations from businesses as well as from farmers, government, and regulators. The rest of the paper is structured as :Section III presents a brief on the Indian agriculture sector and the important factors which are driving the need for technology intervention and discuss the related work specific to AI and ML adoption in agriculture. Potential applications and key solution providers in this line are presented in section IV and V. Challenges from overall stakeholders are mentioned in section VI. Section VII and VIII of the article is presented with managerial implications and future directive and conclusion along with its limitations.

3. Agriculture Sector

Agriculture is one of the oldest and important professions in the world. As population and demand increases, technology can be of immense help to farmers to adopt efficient methods to maximize yield. Artificial Intelligence is one such technology that can help agriculture by providing it various applications to yield healthier crops, monitor soil, control pests, and organize the harvest appropriately. The future of farming largely depends on the cognitive solutions being adopted. While research on a large scale is still underway, the industry is still highly under-served and there are only a few applications available in the market. Farming is still at a nascent stage when it comes to solving real challenges faced by farmers through the use of autonomous decision-making and predictive solutions. Applications need to be more robust to explore AI's huge scope in agriculture. Only then will it be able to handle frequent changes in external conditions, facilitate real-time decision-making, and use a suitable framework/platform to efficiently collect contextual data. AI in the agricultural market was valued at USD 600 million in 2018 and is expected to reach USD 2.6 billion by 2025, at a CAGR of 22.5 percent over the forecast period, according to research firm Markets and Markets. With some reports predicting the precision agriculture market will reach $12.9 billion by 2027, there is an increasing need to develop sophisticated data-analysis solutions that can guide management decisions in real-time (Barbosa, et al., 2020). Technology in agriculture is a decisive element in enhancing the scale of production and productivity. As per the Food and Agriculture Organisation (FAO) estimates, India has to double its agriculture output by 2050 to feed the growing population. The major drivers of initiating technological integration in the agriculture domain from farmers, technology, and government perspective are as mentioned below:

Farmers Perspective

- Knowledge gap among farmers about the use of fertilizers which could lead to damage to the crop and impact the yield negatively.
- Technology can help in the reduction of input cost of after studying the soil composition and suggesting farmers the appropriate time and amount of nitrogen used.
- Farmer suicide in India is due to surplus production, drought, etc. lead to the low price of the crop. Suicides can be reduced by predicting drought, weather conditions, and demand and price forecast.
- There is a need for demand and price forecasts before the season of sowing and plantation which is difficult in the case of traditional farming.

Technological Perspective

- The rising adoption of emerging digital technology like IoT, AI along with computer vision, robotics, etc. for improving crop productivity.
- Increasing the awareness of farmers in India because of smartphone penetration and internet accessibility in India due to initiatives like Digital India.
- The increasing trend in the start-ups which are trying to solve problems in the agricultural sector

Government and Economical Perspective

- Multiple initiatives by the government to support modern techniques.
- The population of India is increasing whereas arable land is decreasing, thus there is a need for intervention to make the production more efficient.

Many attempts have been made to address these issues which lead to the development of new technologies. Machine learning algorithms have been developed and applied in this domain.

3.1 Review Of Machine Learning Algorithms In Domain Of Agriculture

Agricultural practice is broad. To understand the related work, a detailed literature study was done. The relevant research articles and scientific papers were collected from the databases like Springer, IEEE, Elsevier, Proquest, JSTOR, etc. along with multiple relevant websites related to the keywords - agriculture; agriculture supply chain; smart devices; artificial intelligence in agriculture; machine learning; integration; government; technology and automation. For this paper, the inclusion criteria decided were: papers published in English only, scholarly and peer-reviewed; complete text, journal, and pdf format. Each of these papers was reviews and analyzed to understand how multiple researchers have used techniques in the field of AI and machine learning in agriculture.

Table 2 presents a review of existing methods related to techniques applicable to machine learning, expert system and decision support system in the domain of soil management, crop management, disease management, yield management, precision modeling in agriculture, weed management, pest management, and agriculture product monitoring and storage control.

It is of paramount importance to review the application of AI in this domain. For example, neural network is used to identify the dryness in the fruit mango, a study was done in France and Mexico (Hernandez-Perez, et al., 2004). Another study was done by Banerjee et al., (2017) in India detects three major types of pests of tea crops using a radial basis function in a neural network with an accuracy of 99.99%.

Table 2: Review of Applications of AI in Agriculture Domain

Domain in Agricultur e	Challenges Faced	Algorithms / Techniques Used to address these challenges

Soil Management	• To protect soil and enhance its performance such as soil fertility or soil mechanics • To handle the complex process associated with soil conservation, and soil amendment	Artificial Neural Network (Tajik, et al., 2012; Levine et al., 1996; Bilgili, 2011; Zhao et al., 2009; Elshorbagy& Parasuraman, 2008; Chang & Islam, 2000; Behrens et al., 2005), DSS (Montas&Madramootoo, 1992); MOM (Li & Yost, 2000); Fuzzy Logic (Lopez, 2008)
Crop Management	• To deal with the applications and practices of crop management • To improve the growth and development of crop and hence the yield	CALEX (Plant, 1989), PROLOG (Lal, et al.,1992), Robotics Demeter(Pilarski et al., 2002; Henten, et al., 2002), Artificial Neural Network (Snehal& Sandeep, 2014; Song & He, 2005; Dai, et al., 2011 Ji, et al., 2007), Fuzzy Cognitive Map (Papageorgiou, et al., 2011), Artificial Neural Network and Fuzzy Logic (Yang et al., 2003)
Disease Management	• To deal with the practices of minimizing disease in crops to increase quantity or quality of harvest yield • To detect an ailing plant and the diseases and to suggest control measures	Genetic algorithm (GA)(Fang et al., 2007), Rule-Based Expert(K. Balleda, et al., 2014), Web GIS (J. Jesus et al., 2008), Web-Based Intelligent Disease Diagnosis System (WIDDS) (Kolhe, et al., 2011), Expert system using rule-base in disease detection (Munirah et al., 2013), Web-Based Expert System (Virparia, 2007), Artificial Neural Network (Wang et al., 2006)
Yield Management & Precision Modeling in Agriculture	• To deal with multiple application which defines the precise and correct amount of inputs like water, fertilizer, pesticides etc. at the correct time to the crop for increasing its productivity and maximizing its yields	Statistical (Kaul et al., 2005), analytical crop models (Aggarwal, 1995), On-Farm Precision Experimentation (Rodriguez et al., 2019), convolutional neural network (CNN) Nevavuori et al. (2019), Decision-Support Systems (DSS) (Abbott & Murphy, 2007).
Weed Management	• To do the management of desirable plants by understanding contaminating harvest • To minimize the the herbicide application through precise weed management.	Artificial Neural Network (Moallem&Razmjooy, 2012; Tobal& Mokhtar, 2014), ROBOTICS (Moallem&Razmjooy, 2018; Ortiz, et al., 2016),Saloma expert system for evaluation, prediction & weed management (Stigliani&Resina, 1993), Support Vector Machine (SVM)(Karimi, et al., 2006), Digital Image Analysis (DIA)& GPS (Gerhards & Christensen, 2003), Learning Vector Quantization (LVQ)(Yang et al., 2002) , Review of weed management (P. Jha et al., 2017), Experimental method

		(Swanton et al., 2015)
Pest Management	• To identify the active pests and suggest control measures.	Rule based expert systems (Pasqual & Mansfield, 1988; Batchelor et al., 1989, 1992; Mozny et al. ,1993; Knight &Cammell, 1994 ;Mahaman et al., 2003; Li et al., 2002; Chakraborty et al., 2013; Ghosh, 2015), Fuzzy logic based expert systems (Saini et al., 2002; Siraj &Arbaiy, 2006; Roussel et al., 2000; Shi et al., 2007; Jesus et al. ,2008)
Agricultural Product Monitoring and Storage Control	• To deal with the process of monitoring, storage, drying, & grading of harvested crops • To addresses various food monitoring and quality control mechanisms	Fuzzy logic based systems (Kavdir et al., 2004; Gottschalk et al., 2003 and Escobar et al., 2004), Artificial neural networks (Taki et al., 2016; Yang, 1993; Nakano, 1997; Capizzi et al. 2016; Melis et al., 2016; Miranda and Castano, 2017; Perez et al.,2004; Martynenko& Yang, 2006; Movagharnejad&Nikzad, 2007; Khazaei et al., 2013; Higgins et al., 2010; Chen & Yang, 2010; and Boniecki et al., 2011)
Water Management	• To estimate the daily, weekly, or monthly evapotranspiration and hence optimize the resource management	Artificial Neural Network (Feng, Y. et al., 2017; Patil, A. P. & Deka, 2016; Mohammadi, K. et al., 2015)

These machine learning algorithms have been used in conjunction with other emerging technologies like IoT, Robotics, etc. These algorithms provide real-time information flow and knowledge sharing with the farmers in the domain of agriculture as seen from the above table. Since timely and accurate information is the need for an hour for various decisions, the importance of AI has increased tremendously. Organizations like ICAR (Indian Council of Agriculture), and NIC (National Informatics Centre) and FAO (Food and Agriculture Organization) are investing in innovation and technology to provide quality and timely information and service to improve productivity and efficiency and to increase the transparency among the stakeholders.

The need for automation is one of the important criteria in this direction at the farmer level, I.e. at a micro-level. The next section brings some upcoming technological solutions in this line.

4. Agriculture Goes Hi Tech With Ai And Emerging Technologies

"The future of agriculture is in the hands of the machines," proclaimed Wired magazine in 2016, (Matt Simon, 2016). The Indian Government wishes to leverage emerging technologies with schemes like Pradhan Mantri FasalBima Yojana (PMFBY).PMFBY will be welcoming AI technology to reduce the time consumption in settling claims of the farmers (Udas, R. 2020). The government also signed an MoU with IBM to monitor the agriculture sector with AI. Because a large amount of data is being generated by farms and farmers, it becomes essential to leverage it by adopting the emerging technologies to strengthen the existing agricultural systems. The following are the few examples in this path.

1. **Agricultural Land Monitoring using Deep Learning**

Deep learning algorithms are explored to analyze the data points associated with the land in real-time to understand its behavior. Authors (Kamilaris&Boldú, 2018; Ferentinos, 2018) have explored the deep learning algorithms to understand the favorable conditions of plants and hence enabling farmers to provide an environment for proper irrigation.

2. **Crop Protection from Wild Animals by Alert Based System using Deep Learning**

Fields and farms near the forest boundaries are difficult to monitor regularly by farmers and are usually more vulnerable to wild animal attacks. Researcher (Priyanka et al., 2018) designed a prototype that is an alert based system that utilizes the deep learning technique to help farmers in protecting crops from animals.

3. **Precise Farming using Aerial Approach**

The aerial approach can be used to gather the data from IoT based sensors, satellites, drones, and analyzed using machine learning to design a digital heal map. These maps can be utilized by farmers to know better about soil moisture levels, climates details, temperature, humidity, and other related information.

4. **Agriculture Robots and Sensors for Land Supervision**

Land supervision robots designed to help farmers to measure, map, monitor, and optimize water resource, and pest control use. The Naïo Technologies team developed agricultural robot, The Dino weeding robot helps farmers in crop weeding with high precision and thereby improving working conditions and profitability for farmers (“DINO vegetable weeding robot for large-scale vegetable farms: Naïo”). Katariya et al. (2015) discussed the use of robots in agriculture land. The University of Sydney’s prototype robot, RIPPA (Robot for Intelligent Perception and Precision Application), navigates through horticulture crops using a global positioning system (GPS).Using VIIPA™ (Variable Injection Intelligent Precision Applicator) technology, RIPPA can autonomously apply herbicide only to the weeds.

5. Empowering Farmers using Mobile Apps

Mobile apps help farmers to plan and manage the required demand for the crops. EMA-i is an early warning app developed by FAO to facilitate quality and real-time livestock disease reporting captured by animal health workers in the field and is used in Africa.

6. Self-Learning Farming System

Technology-enabled solutions can help the farmers to provide relevant information as and when required to increase the agricultural yield. MyCrop is one such solution for farmers to improve their standard of living by innovative business models which are based on self-learning and provide farmer management solution (including buy/sales side of e-commerce, decision-supporting process, and monitoring (“Complete Farm and Farmer Management System”).

7. Health Monitoring and Understanding the Behavior of Livestock

The IDA (Intelligent Dairy Farm Assistant) is a system that tracks the motion of the cattle and gathers useful data. Machine learning algorithms are used to understand the behavior of the cattle-like whether the cattle is ill or ready to breed. Halachmi et al. (2019) discuss the 'sensor-based' individual animal approach involving real-time behavior defined as precision livestock farming.

8. Chatbots for Farmers and Skill Development

One of the emerging technologies, chatbots assists farmers in providing advice and guidance and recommendations related to crop and its supporting environment (Gustavo, M. M. et al., 2018). This mode will be used for providing timely information related to problems associated with crops. This could be one of the tools to develop and enhance the skills of the farmers.

9. Understanding Soil Science using Image Recognition and AI

Understanding the soil science is a complex mechanism and can be leveraged to forecast the pest, quality of the soil, disease if any, to help the farmers with timely and relevant information to have better agricultural yield. Gramophone is one such system that claims " to reach out to more than 100,000 farmers in the state with a productivity improvement of more than 50 percent in the three cropping cycles that they have been associated within the Indian state of Madhya Pradesh"(Baruah, A 2019). It is based on image recognition and uses machine learning to understand soil science.

10. High-Performance Computing and AI in Analysis

National projects viz., eNAM, Agmarknet, Soil Health, Animal Health, and so on, generate an enormous volume of data and require extensive analysis at state, district, village levels. The data handling and analytics require high-performance computing (HPC) for manipulation and analysis related to agricultural genomics, exploring the behavior of soil, and finding the hidden patterns using deep learning.

The shift from existing business models to the models that adopt AI is as promising as it is challenging as it might require an architecture level modification in the enterprises. Agriculture, being a traditional and often considered as the oldest occupation of humankind is still an important sector in some of the developing economies of the world. AI has joined the list of growth drivers by finding immense use in the agricultural sector too with many innovations and investments aiming at aiding the farmers to improve their yield at a much higher efficiency. However, the shift can only happen when all the players in the ecosystem come together to leverage the possibilities that AI has to offer.

5. Key Players - Ai For Agriculture Domain: Global And Indian

There are many players based out of various countries in the world that operate in the agricultural market. Some companies are The Climate Corporation from the USA, Resson from Canada, CropX from Israel, Gamaya from Switzerland, Connecterra from Netherlands ("Rapid adoption of artificial intelligence in agriculture ", 2019).

In India, there are the Krishi Vigyan Kendras (KVKs) and Agricultural Technology Management Agencies (ATMA) Public Extension Service Centers which are the centers for AI applications to help the farmers leverage the technological solutions in their agricultural processes. Table 3 presents the few examples of key players (in India and outside) along with the benefits realized.

Table 3: Key Players in the area of AI and Machine Learning to Agriculture

Objective / Goal	Players / Company : Solution Provider	Benefits
To Monitor soil health and to identify its specific needs	CropIn, Bengaluru, India (Batavia, M 2019)	helping in remote sensing and weather advisory & offering farmers training on how to maintain and monitor crop health
To recognize faces, flora and fauna and other objects and tag them in images	Intello Labs, Bengaluru, India (leverages its deep learning algorithms) (Batavia, M 2019)	Help to identify the quality of the harvested product using the photograph
To suggest the right times to sow the seeds without expensive investment	Microsoft India in collaboration with ICRISAT, India (AI based sowing app) (Batavia, M 2019)	Helping farmers by sending automated voice messages and text messages to know the best times to sow crops. In 2017, during the Kharif crop cycle (rainy season), the program was expanded to touch more than 3,000 farmers across the Andhra Pradesh and Karnataka states for a host of crops including groundnut, ragi, maize, rice, and cotton, among others. There was a 10% to 30% increase in the yield of these crops. ("Bosch: Farmers in India are using AI to increase crop yields").
To help farmers build better crop cycles	Gramophone, Indore, India (AI-powered Chatbot) (Batavia, M 2019)	Providing "personalized farm management solutions" to guide farmers for the optimal cropping cycle
To do the real-time diagnosis for Greenhouse Guardian	Bosch's FUJI (Future with Japanese Innovation) growth initiative, and the Bosch Center for Artificial Intelligence (BCAI) ("How AI helps farmers predict plant diseases",2020)	useful for Greenhouse Guardian to know what tomatoes need and providing Real-time diagnosis
To protect their crops from weeds	Agricultural Robots- Blue River Technology (Kumba, S. 2019)	programming autonomous robots to handle essential agricultural tasks such as harvesting crops at a higher volume and faster pace than human laborers
To monitor the health of crop and soil	Berlin-based agricultural tech startup PEAT(deep learning application called Plantix)	It helps to identifies potential defects and nutrient deficiencies in the soil.

	(Kumba, S. 2019)	

Each coin has two faces. Considering the benefits realization there are uncertainties associated with emerging technologies. The next section discusses the challenges of adopting AI in agriculture.

6. Challenges Of Implementing & Adopting Ai In Agriculture
7.

There are different types of challenges related to the implementation and adoption of AI and machine learning in agriculture. Here presenting the challenges faced by farmers, government, business, legal, investment, and technical perspective.

Farmer's perspective:

a) **Awareness:** Creating awareness in the farmers is a big challenge as they might be technologically ignorant and might find it difficult to cope with the sudden digital migration. Moving from the traditional methods to the modern methods which involve technology can be difficult for the farmers to cope with. Also, any major updates to the designated technology can be difficult to convey and the maintenance of the technology requires a lot of knowledge transfer and training. According to Panagiotopoulos et al., (2017) farmers may use tech platforms to influence policymakers.

b) **Capital Requirement:** The investment required from the farmer's side may be out of the limit to what they can afford and might require taking further loans from the government. This is especially challenging in a country like India where small landholding is prevalent and the ROI on technology might not be attractive. Effective policies need to be designed to bring the technology to all the farmers and for effective mechanization of agriculture to happen.

c) **Possible unemployment:** Agriculture is a huge industry that employs a significant percentage of the world's population. There are forecasts about millions of field workers that might go unemployed in the coming decades mainly due to the effect of AI on the agricultural industry. Many tasks in farming that are monotonous might be automated using smart robots that can traverse the farming fields and perform field operations like identifying and transferring various products making those jobs obsolete.

d) **Labour Cost and Shift in the labor market:** The cost of the land is increasing. A study by Rotz et al., 2019 discusses that since there is huge pressure on farmers because of the increased cost they want to save on the other costs, such as labor cost. One of the solutions is the use of automation using machines in the farms and hence high skilled labor is in the demand as compared to low skilled labor.

e) **Age Factor:** Literature discusses (Daberkow&Mcbride, 2003) that age is one of the important factors in the adoption of technology. The edged farmer is less likely to adopt technology in their farms as compared to the younger ones.

f) **Limited Knowledge:** As per the discussion by researchers (Abdullah, 2015; Mulauzi& Albright, 2008) one important factor in the contribution of the adoption of technology is limited knowledge and skills required to use technology. This can be handled by providing basic training to the farmers.

g) **Basic Training:** There is very low awareness among farmers about technology and how it can be used. Most farmers are comfortable in reading and writing of vernacular languages but not English. Thus, basic training must be provided about technology, and interface to this technology must be provided in vernacular languages. Bello-Bravo, et al. (2018) suggested that farmers use their knowledge through videos.

Government perspective:

a) **Basic IT Infrastructure:** The IT infrastructure that is required might not be available in all rural places. This problem is more prevalent in countries like India where only cities are IT hubs. The penetration of IT infrastructure to the rural areas where agriculture is the main occupation is very limited. Getting the villages AI-ready is one big challenge that the government might face given the high amount of investment that is involved because of the scale at which it needs to be done owing to the huge number of villages in the country. India has taken steps to address this challenge by implementing Digital India which increased smart phone penetration and an increase in internet usage.

b) **Budget constraints:** The economic limitations that the government might have about one particular sector might be another problem. A country might not be able to allocate more than a certain amount of resources to one particular sector. Providing monetary benefits to the farmers and simultaneously investing huge amounts to implement AI-based farming is a challenge that governments throughout the world face.

c) **Unorganized ecosystem:** Agriculture in countries like India is highly unorganized and scattered. There is a high number of farmers with small landholdings. Implementing the AI technologies to each farm individually is a challenge that needs to be strategized properly.

Business or Industry perspective:

a) **Data Infrastructure:** AI systems require a lot of data to train machines and make precise predictions. While spatial data can be easily gathered in the case of vast agricultural land, it is difficult to obtain the temporal data. For example, when the crops grow, it is possible to obtain most of the data about the crop only once a year. Because data infrastructure takes time to mature, building a robust machine learning model takes a considerable amount of time.

Legal/Regulatory perspective:

a) **Data privacy and ownership:** Data privacy is a challenge to AI implementation in every sector and the case with agriculture is no new with misgivings about the ownership of a huge amount of data leading to clusters of data assets and unfair means of monetizing the data creating bigger problems like corruption and other compliance issues.

Investment/Start-up Perspective:

a) **Increased Costs:** The costs of acquiring the AI-powered equipment can be high for the farmers which are a big challenge of implementing agriculture. The cost of technology like drones is high and this has made these technologies inaccessible to the farming community because of limitations to the funding from government and research institutions.

Technical perspective:

a) **Lack of Standards:** Without proper standards to improve the interoperability of these upcoming technologies, their adoption might be further delayed as most databases exist in silos.
b) **The complexity of database:** Managing and integrating the huge volume of data from last so many years across states, districts, villages is a big challenge. Also gathering, collating, manipulating, and analyzing the data across multiple dimensions like soil, weather, pest, disease, etc. requires huge computational processors.
c) **Internet Usage:** Internet and Bandwidth is essential in communication by farmers and to other farmers. As per the study by Abdullah (2015) the Internet speed seems to be an important factor in the adoption of technology.

8. Implications And Future Scope

The various impacts that we anticipate AI would bring to society and businesses to ease many problems would require thought as to whether we are ready for this shift or not. When we look at the societal perspective, the imminent threat of unemployment that AI poses is a thing to seriously consider, especially in the current scenario of the global economic slowdown. The organization should come up with better policies catalyzed by better leaders to upskill labor to put them to better intellectual use. Completely relying on the machines to finish the tasks can also be unsafe sometimes.

AI-powered automation will lead to a shift in the type of jobs available in the market. Monotonous and repetitive jobs could be replaced by machines but more engaging and creative would be created. This will lead to a mismatch in the skills of people and jobs available in the market and thus retraining of the workforce becomes necessary.

When it comes to answering the question of whether businesses or governments are ready for this change, it is important to look at the factors that drive this change. The most important factor is leadership. The shift to AI is a major step towards achieving the digital transformation for organizations that work in different fields. Many companies may have the backing to invest in improving the digital capabilities by investing in various technologies but this must be coupled with effective leadership capabilities to be effective.

The targets that the organizations aim to achieve should be the first point of consideration towards implementing AI. Corresponding strategies that the IT teams come up with to drive the change from there on will be key to achieving success. AI can be used to achieve operational efficiency or to improve customer experience. Each goal should be properly defined to envision the strategies and see them reaching fruition. Keeping these factors in mind, it can be said that organizations that are focusing on nurturing leaders who can envisage the longer-term good that can happen and are ready to adopt technologies like AI to work and serve better.

AI poses certain issues on the ethical, legal, and regulatory front. The real-world data has racial bias, gender bias, and other biases embedded in it. When a machine learning algorithm uses this as training data then they internalize those biases and thus amplifying those problems. There are also some valid concerns regarding algorithms themselves which include the ethical guidelines are subjective, in that case, whose ethical guidelines will be encoded into algorithms, who is responsible for the conclusions of algorithms?, Does accuracy matter? Who is owning the data? Who is accountable for applicability, data accuracy, and quality of data?Who is responsible for safety measures? These questions are fundamentally a call for transparency and accountability of governance structure and policy framework.

Though there are multiple implications there is a need for automation and self-learning systems in agriculture and it is the need for an hour. This sector is continuously evolving and require innovative methods to deal with processes like irrigation for optimal water use, monitoring the health of the land, as well as crops from weather and wild animals. There are a variety of techniques like fuzzy logic, artificial neural networks, deep learning algorithms which have been used in the automation of the various domain in agriculture as seen in the literature also. A recent discussion by Ferentinos, 2018 mentioned the use of convolution neural network (CNN) model along with deep learning to identify the plant disease recognition with accuracy up to 99.53%. Jha, K. et al. (2019) proposed a system which can be implemented in a botanical farm for flower and leaf identification and watering using IoTand deep learning. It is important to understand that the needs and requirements of the individuals are different.

Deep learning is highly efficient and giving more advantages in finding favorable conditions at an individual and personalized level. Usually, a Deep Learning algorithm takes a long time for training the data sets because of the large number of dimensions. As deep learning handle large data sets it requires substantially high computing power that can be combined with clusters or cloud computing.

9. Conclusion

The use of technologies is not uncommon in the agriculture field. ICT intervention, satellites, and weather scanning radars, humidity sensors have been used for a few decades. However, the use of AI and machine learning is changing the way farming is done. The use of smart sensors in the soil can predict the behavior and health of the soil and help the farmers to tell when and how much water and pest is needed. Similarly, there are other examples like precision farming, land monitoring, crop planning, and harvest scheduling to make farming profitable by incorporating AI and machine learning algorithms.

The power of machine learning and deep learning, coupled with the skill of the farmers can prove to be a boost for the sector making the output efficiency. Solutions to many key issues have already been developed with a promising future scope as the technology keeps improving in terms of accuracy. Key players in the ecosystem need to adopt these techniques and ensure their penetration to the grass-root level to secure long term interests and improve the lives of the people dependent on agriculture.

In the coming future, researchers have further scope to extend this study, to address further the issues and build the case related to throughput, efficiency, and resource optimal utilization by adopting deep learning and AI in agriculture. Also, the overall agriculture supply chain can be explored for further integrating and providing end to end solutions using AI, application areas - including logistics, integrating aggregators with suppliers, and consumers. We expect this study to provide an overview of AI and machine learning, deep learning-related research for the benefits of farmers, and shed light on potential applications in agriculture. There is no doubt that by integrating and collaborating all the stakeholders via adopting emerging technology will reduce the risk and losses and thereby increase the efficiency.

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