IOSR Journal of Business and Management (IOSR-JBM)
e-ISSN:2278-487X, p-ISSN: 2319-7668. Volume 25, Issue 8. Ser. 8 (August. 2023), PP 19-23
www.iosrjournals.org

Artificial Intelligence Impact on Agriculture Sector in India

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Abstract: *Agriculture plays a significant role in the economic sector of a country. The automation in agriculture is the main concern and the emerging subject across the world. Agriculture is seeing rapid adoption of Artificial Intelligence (AI) and Machine Learning (ML) both in terms of agricultural products and in-field farming techniques. According to UN Food and Agriculture Organization, the population will increase by 2 billion in 2050. However, only 4% additional land will come undeAgriculture plays a significant role in the economic sector of a country. The automation in agriculture is the main concern and the emerging subject across the world. Agriculture is seeing rapid adoption of Artificial Intelligence (AI) and Machine Learning (ML) both in terms of agricultural products and in-field farming techniques. According to UN Food and Agriculture Organization, the population will increase by 2 billion in2050[1] However, only 4% additional land will come under cultivation by then. In this context, use of latest technological solutions to make farming more efficient, remains one of the greatest imperatives. While AI sees a lot of direct application across sectors, it can also bring a paradigm shift in how we see farming today. AI-powered solutions will not only enable farmers to do more with less, it will also improve quality and ensure faster go-to-market for crops. Farming solutions which are AI powered enables a farmer to do more with less, enhancing the quality, also ensuring a quick GTM (go-to-market strategy) strategy for crops. Artificial Intelligence provides accurate and timely information regarding crops, weather and insect etc. to the farmers may improve the crop productivity, reduce the risk and improve the income of the farmers. In this article, the author specifically discussed the effective use of AI in changing the landscape of Agriculture sector in India, various projects and programme initiated by the Government of India and it also investigates the AI powered ideas in for future and the challenges anticipated in future.*

Key Word: *Artificial Intelligence (AI), Go-to-market strategy (GTM), Internet of things (IoT), Machine Learning (ML.*

Date of Submission: 13-08-2023 Date of Acceptance: 28-08-2023

I. Introduction

Agriculture plays a pivotal role in India's economy, with over 58% of rural households depending on it as their principal means of livelihood. The vision of the Artificial Intelligence for Agriculture Innovation (AI4AI) initiative is a commitment to improve the state of the farmers' world, with the operating principle to "think big, start small and scale fast". The initiative focuses on strengthening multi-stakeholder collaborations to analyze and exploit the opportunities and challenges of applying upcoming technologies to transform the agricultural landscape, in a way that is profitable and sustainable for farmers. Capitalizing on the value of emerging technologies such as AI, Blockchain, drones and the internet of things (IoT) has the potential to impact productivity and efficiency at all stages of the agricultural value chain. Only by integrating emerging technology into this domain can we hope to meet the aspirational goals of doubling farmers' incomes and increasing farm productivity, while reducing wastage and enhancing supply chain efficiency and transparency. Forbes reports that global spending on "smart" agriculture, including AI and machine learning, is projected to triple to $15.3 billion by 2025. Research suggests that the market size of AI in agriculture should expect a compound annual growth rate (CAGR) of 20%, reaching $2.5 billion by 2026.

Farmers are deploying robots, ground-based wireless sensors, and drones to assess growing conditions. Many researchers and pilot projects have been conducted to test the implications of the involvement of AI applications in improving agriculture. Song and He (2005) carried out a research to develop intelligent and carry-home diagnosis expert system (ES) based on artificial neural networks to detect crop nutrition disorders in time. The field validation indicated that the prediction errors were less than 8%. Shahzadi et al. (2016) conducted research to develop an expert system to discriminate weed from crops with the help of image analysis and neural networks. Out of the 100 farmers who participated in the trial of this system, 65 were satisfied. Arif et al. (2012) developed two ANN models to estimate soil moisture in Paddy fields with limited meteorological

data and estimated soil moisture with R2 values of 0.80 and 0.73 for training and validation processes, respectively, thus, the ANN model reliably estimates soil moisture with limited meteorological data. Researchers Patil and Thorat (2016) developed a ML-based system which predicted grape disease beforehand. The system also suggests the pesticides to use to avoid the spread of the disease.

Challenges faced by the agriculture sector include the following[2]:

- Small and marginal farmers (86% of farmers) own less than two hectares, causing unsustainable farm incomes and poverty[2];
- Unsustainable farming practices, resulting in soil degradation and water stress[2]
- Lack of datasets at farm, farmer and sector levels, leading to higher costs of services[2];
- Gaps in market linkages, challenges in price discovery for farmers and price volatility in the market[2];
- Lack of food processing, logistics and warehousing infrastructure close to farm gates, increasing wastage[2];
- Challenges in financial and digital inclusivity[2];
- Poor farm mechanization due to affordability challenges[2]

Emerging technologies driven by the fourth industrial revolution, such as the IoT, AI, ML, big data, drones and block chain, are disrupting many industries, bringing rapid and large-scale change. Until now, the agriculture sector has been slow to harness the power of these technologies. Low adoption levels of emerging technologies in agriculture are due in large part to the complexity of the sector, which features small farm sizes, lack of telecoms infrastructure in rural areas, high regulatory burdens which raise costs, and revenues constrained by customers' limited ability and willingness to pay. Emerging technologies, however, are likely to introduce new challenges. They can create unintended consequences, including data breaches and lack of digital inclusivity, which must

be considered and explored in advance. Their beneficial effects may be unevenly distributed, potentially deepening the divide between rich and poor. Harnessing the positive impacts of technological innovation and avoiding potential downfalls will require deliberate and coordinated efforts by investors, innovators and policy-makers.

Agricultural exports constitute 10 percent of the country's exports and are the fourth largest exported principal commodity category in India. India still depends on resource intensive agriculture practices. India has 30 million farmers who own smart phones, which is expected to grow three times by 2023 and 315 million rural Indians will be using internet by 2023. It is estimated that AI and connected farm services can impact 70 million farmers by 2023, thereby adding US$ 9 billion to farmer's income. AI also does diagnostic analysis like Satellites for Weather Prediction and Crop Sustainability; this would really help farmers if they previously have idea of weather changes. Driverless Tractors one of the AI techniques as it operates without presence of human inside the tractor itself it will reduce much work of farmers. One of the interesting technologies that must be highlighted is Farmer's Alexa which will be able to converse with farmer same like Chabot's to figure out tough problems. Crop spraying technique also helps farmers by aerial spraying is five times faster with drones than traditional machinery. One of the smart applications is introduced in AI for farming is agri-E Calculator which helps which helps farmer for choosing suitable and affordable crops, it calculates its price.
There are many more applications available in market but problem is it contains high cost, difficult manual. In simple words we can say that, the use of AI in Agriculture is allowing farmers worldwide to run more efficiently.

II. Artificial Intelligence Application in Agriculture

The use of (non-AI) robots in agriculture has been around for quite some time, with robot milking being used for almost two decades now. However, the use of agricultural AI robots is still relatively new. Agricultural robots are being used in a wide variety of ways: crop scouting, pest and weed control, harvesting, spraying, pruning, milking, phenotyping, and sorting (Shamshiri et al. 2018). These types of robots must be able to adapt to their environment and navigate their way through farmland. Most AI robots are still in the early stages of development, with many taking shape in testing facilities, research projects, and research centres. There are very few that have reached a commercial scale, and most cannot compete with the speed of their human counterparts to fulfill their activities (e.g., weeding and harvesting robots) (Shamshiri et al. 2018).

AI is also being deployed in other types of robots, such as drones and self-driving tractors. Drones are being used to spray fields with water, pesticides, herbicides, and so forth. They are also being used to take aerial photographs and images of the farm and its surrounds. Drones are providing insights and mapping of the farm, which would not have been otherwise possible. Whereas self-driving tractors hold great potential for farmers to be able to do other activities. However, self-driving tractors are still in very early stages of development and

have not been deployed in a commercial setting, yet. Similarly, to other self-driving vehicles, there are a lot of safety and security factors that must be considered before they can be integrated.

In addition, AI is also being used in apps, recommendation systems, and software. Image recognition is allowing farmers to determine the health, or illness, of a particular plant or crop and to provide recommendations about what they should do (Ryan 2019). Some AI maps the life-stages and growth of plants, how this will change throughout its cycle, and what actions should be taken by the farmer (Ryan 2019).

Weather Forecasting: AI is being used to provide farmers with accurate weather forecasts, enabling them to plan their operations and reduce the risk of crop failure. AI, in conjunction with remote sensing technology, can play a crucial role in implementing Climate Smart Agriculture on a large scale.

Pest and Disease Detection: Each year, pest damage account for ~20-40% of the crop loss in India. Speedy accurate identification and taking corrective steps using real time data could minimize the yield loss. AI is being used to detect pests and diseases early, allowing farmers to take timely action and minimize crop damage. Various plant sensors have been developed to track plant growth as well as identify plant illnesses. Crop health monitoring (nutritional disorders, insect/ disease damage), irrigation equipment monitoring, weed identification, livestock and animal monitoring, and disaster management now can be done with the use of UAVs in agriculture (Vijayakumar et al 2020; 2021a). This helps in identifying the problem even before the plant produces a visual symptom of deficiency or infection.

Predictive Analytics: AI systems are providing predictive insights such as which crops to grow in a particular season and location. It is also guiding the farmers about optimal dates of sowing and harvesting in a specific area, thereby reducing damages and improving crop yields. Various AI and machine learning tools are being used to predict the optimal time to sow seeds, get alerts on risks from pest attacks, and more. Bengaluru-based Intello Labs was started by IIT-Bombay alumnus Milan Sharma in May 2016. The company claims to provide advanced image recognition technology that can recognize objects, faces, and flora fauna and tag them in any image. The company claim to use deep learning algorithms on which new generations of intelligent applications are being built for applications including agriculture, e Commerce, advertising, manufacturing, and curation. Small farmers around the world follow traditional farming practices due to lack of access to scientific understanding of crop lifecycle, pests, quality metrics and the latest micro-fertilizers. "Our Image based solutions provide insights on the crops‟ health during the growing season and its final harvested quality by click of photograph," the company states on its website.

Intelligent Spraying: We've seen that computer vision is good at spotting disorders in agriculture, but it can also help with preventing them. UAVs equipped with computer vision AI make it possible to automate spraying of pesticides or fertilizer uniformly across a field. With real-time recognition of target spraying areas, UAV sprayers are able to operate with high precision both in terms of the area and amount to be sprayed. This significantly reduces the risk of contaminating crops, humans, animals, and water resources. While the potential here is great, currently some challenges still exist. For example, spraying a large field is much more efficient with multiple UAVs, but assigning specific task sequences and flight trajectories for individual crafts can be tricky. But that doesn't mean its game over for intelligent spraying[7].

Identification of Optimal Mix for Agronomic Products: The common problem in many developing countries is managing the agricultural land as a single unit without considering the variability within the field which leads to low input uses efficiency, increased environmental pollution and reduced returns to the farmer (Vijayakumar et al., 2021b). To overcome this, site specific management of crops is very important, and it demands a huge amount of data/information. The IoT and AI can give farmers massive amounts of information in real time, such as weather, temperature, humidity, and market price, as well as propose the best mix for any specific condition by fully understanding local resources.

Supply Chain Efficiencies: Companies are using real-time data analytics on data-streams coming from multiple sources to build an efficient and smart supply chain. To calculate the crop-sowing period, historic climate data (spanning over 30 years from 1986 to 2015) for the specific area in Andhra Pradesh was analyzed using AI. To determine the optimal sowing period, the Moisture Adequacy Index (MAI) was calculated. MAI is the standardized measure used for assessing the degree of adequacy of rainfall and soil moisture to meet the potential water requirement of crops. Microsoft has also partnered with United Phosphorous (UPL), India's largest producer of agrochemicals, to create the Pest Risk Prediction App that again leverages AI and machine learning to indicate in advance the risk of pest attack. Today, these farmers across the Indian states of Andhra Pradesh and Karnataka wait to get a text message before sowing the seeds. As per the report cited above, in a few dozen villages in Telangana, Maharashtra, and Madhya Pradesh, farmers receive automated voice calls alerting them whether their crops are at risk of a pest attack based on weather conditions and stage of the crop. No specific numbers on the results were reported.

III. The Impact of Artificial Intelligence on Agriculture in India

The World Economic Forum's Artificial Intelligence for Agriculture Innovation (AI4AI) initiative aims to transform the agriculture sector in India by promoting the use of artificial intelligence (AI) and other technologies. Led by the Centre for the Fourth Industrial Revolution (C4IR) India and the Platform for Shaping the Future of Artificial Intelligence and Machine Learning, the initiative brings together government, academia and business representatives to collaborate on the development and implementation of innovative solutions in the agriculture sector.

Through AI4AI, the Saagu Baagu pilot was launched in partnership with the Government of Telangana, making it the first Indian state to implement a framework for scaling up emerging technologies and improving productivity, efficiency and sustainability in the agriculture sector. The pilot is driven by C4IR India, Government of Telangana and Digital Green in collaboration with three agricultural technology businesses: AgNext, Krishitantra and Kalgudi. As of January 2023, more than 7,000 farmers have enrolled in the pilot project, with a focus on chili producers. These farmers are receiving support in the form of various AI technologies, including sowing quality testing, soil testing, crop health monitoring, window prediction and tillage estimation, as well as accessing new customers and suppliers in different geographies.

IV. What's the challenge to implementing AI for agriculture in India?

India is faced with the challenge of feeding a growing population while also addressing such risks as climate change, pandemics and supply chain disruptions. Unclear privacy, security and ethical regulations in India. Inadequate availability of AI expertise, manpower and skilling opportunities is also a great challenge. The low intensity of AI research; and lack of enabling data ecosystems.

To address these challenges, the agricultural sector needs to become more agile and efficient. There are currently more than 1,000 agri-tech startups in India offering a range of tech-based solutions, including digital finance, micro-insurance, access to agricultural inputs, quality testing, traceability and market connect platforms. They have the potential to significantly contribute to improving productivity and sustainability, but fragmented technological infrastructure, high cost of operations, lack of access to data and limited technical expertise, hamper the scale of these technologies. Although AI has a wide range of applications in agriculture, there is still a lack of expertise with high-tech machine learning solutions at most farms throughout the world.

Extensive testing and validation of emerging AI applications in the field are very important as agriculture is affected by environmental factors that cannot be controlled, unlike other industries. It is highly required now that farmers are trained in modern AI technologies. This will ensure that the technologies are used and continue to improve. The next step in this direction is to combine more complex machines, improve contextual data collection techniques and highly developed software.

In 2021, the Centre for the Fourth Industrial Revolution India developed the AI for Agriculture framework for public-private partnership through consultations with the Government of India and state government of Telangana, and supported by the Forum's Artificial Intelligence and Machine Learning Platform. In this effort, C4IR India also consulted other stakeholders including academics, agriculture start-ups and established businesses, professional organizations and civil society.

V. Conclusion

AI is a modern digital frontier that will have a massive impact on the world, transforming the way we live and work. Agriculture has undergone a transformation as a result of AI. The primary challenges that India is facing are absence of collaborative effort between various stakeholders", relevant data is unavailable and there is absence of robust open clinical data sets. Given the huge potential of agriculture in India, it's imperative that technology is used to the maximum so that both farmers and consumers can make the most of it. With recent advancements in technology coupled with calculated and productive government policies, we have seen many Agri tech startups emerge in the country which is a great starting point for the penetration of advanced technologies like AI in agriculture. Climate change, population expansion, employment concerns, and food security issues are just a few of the issues that this technology can solve.

Non-literate farmers can benefit from AI techniques such as auto-translation between various languages, text to speech, and speech to text in Indian languages, which can assist them in retrieving the necessary information and knowledge generated by agricultural research and education systems around the world. Given India's multilingual society and the fact that the majority of farmers are illiterate, this technology has the potential to greatly assist farmers in gaining access to critical information.

With considerable changes occurring in our climate, environment, and global food needs, AI has the ability to transform 21st century agriculture by: Increasing efficiency of time, labor, and resources; improving environmental sustainability; Making resource allocation "smarter"; providing real-time monitoring to promote greater health and quality of produce. Of course, this will require some shifts in the agricultural industry. Farmers' knowledge of their "field" will need to be translated into AI training, and this will depend on greater

technical and educational investments within the agricultural sector in India.

But then again, innovation and adaptation are nothing new in agriculture. Computer vision and agricultural robotics are just the latest way farmers can adopt new technology to meet growing global food demands and increase food security.

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