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Prospects of Artificial Intelligence in Indian Agriculture

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Abstract

India being the second largest in populous county and having an increasing population growth rate is going to face an increasing target of food demand. Though the country has self-sufficiency in food grain production, there are so many challenges on part of the whole Indian agriculture community to feed the ever increasing population sustainably. The challenges include the drastic climate change, decrease of arable land, land and water degradation due to unsustainable use of huge amount of fertilizers and pesticides, reduction and soil fertility and water table, poor supply chain management of both agricultural inputs and outputs etc. In this situation, inclusion of artificial intelligence (AI) on innovative technologies in agriculture can be proved to be a boon for Indian agriculture sector. Worldwide, AI-driven technologies are emerging to help in improving the efficiency with respect to crop and soil monitoring, weather forecasting, predictive agricultural analytics, markets and supply chain efficiency. The cloud computing infrastructures with the use of data ecosystems, Internet of Things (IoT) and AI enable the development of digital agriculture and strengthen the farmers in practicing precision agriculture. There are several AI-based technologies *viz*. robotics, drones, geographical positioning system (GPS), remote sensing technologies and computer imaging are being used to predict the incidence of diseases and insect pests, weather forecasts, time of application and optimum dose of pesticide sprays, time of harvest and life of produce. Various low-cost sensors on field and in space are proved to be very efficient in determining soil conditions and groundwater levels and regulate irrigation and fertilization on the farm. The adoption of AI-based technologies and IoT devices in agriculture are getting flourishing success, which necessitates implementations technology-based data-driven agricultural practices for economic, social and environmental prosperity of Indian agriculture.

Keywords: Artificial intelligence, big data analysis, digital farming, farm technology, Indian agriculture

Introduction

Agriculture has been playing as a major role in India since a long way, categorizing it as purely an agrarian economy. Agriculture and allied sector still accounts for 49% of India's workforce, 16% of country's domestic product (GDP), and ensures food security to nearly 1.3 billion people. About 58 percent of the rural households depend on agriculture as their principal means of livelihood (IBEF report), improving GDP being a source of national trade, reducing

unemployment, providing raw materials for production in other industries, and overall develop the economy (Dekle *et al*., 2012**)**. Agricultural export constitutes 10 percent of the country's total exports and is the fourth-largest exported principal commodity category in India. Being the backbone of the country, boosting agriculture sector, is an obvious huge concern for the Indian Government (Kekane *et al*., 2013). In spite of making remarkable progress and getting Government attention, the sector continues to have weak supply chain and low productivity due to its dependence on several unpredictable variables *viz*. climate change, degradation of land, reduction in soil fertility, increased dependence on inorganic fertilizers for higher production, rapidly dropping water tables, emerging pest resistance etc.

As the planet continues to warm, climate change impacts are worsening. Gradually global climate becomes more vulnerable and unpredictable, as a result the conventional dependence on unsustainable and resource intensive agriculture, is going to intensify the risks of food security consequently creating an agricultural agony. The situation having major concerns *viz*. climate change, population growth and food security, warrants more innovative approaches to improve crop production resulting more yield and sustainability. In the midst of rising agricultural debts and unpredictable weather patterns, farmers are facing ever-increasing challenges to maintain farm productivity and profitability. The conventional methods of crop husbandry are not sufficient to meet the food demand. So they are to intensify the inputs resources, as a result soil and natural resources are being hampered by extensive use of fertilizers and harmful pesticides resulting barren lands with no fertility. Therefore, use of advanced technological solutions has become highly essential to make farming more efficient socially, economically and ecologically. In such an area of extremely importance in agriculture, that faces several challenges from sowing to harvest, artificial intelligence (AI) can play as an efficient tool to address the challenges in Indian agriculture.

1. What is artificial intelligence (AI)?

"AI is an area of computer science that emphasizes the creation of tangible or intangible systems which not only behave intelligently but also display behaviour to the same level as human beings think and act (and in times to come, better than them), achieving human-like performance in all cognitive tasks using purely logical reasoning" (Bhar *et al*. 2019). AI is a non-biological intelligence which has ability to accomplish complex goals or tasks. AI is the intellectual process one can associate with human thinking like speech recognition, natural language understanding and translation, knowledge management, image analysis, decision making, learning etc. which will make systems powerful and expedient.

2. The AI based intelligent agents

There are several intelligent agents available now. From Apple's intelligent personal assistant SIRI or Cortana of Microsoft to IBM's Watson to self-driving cars, AI is progressing rapidly. The new set of deep learning algorithms have foreshowed the possibilities of taking the research and applications of AI to much higher levels and with much more precision and are making inroads in all fields including agriculture. Natural Language Processing (NLP), Robotics, Machine Learning (ML), Automated Reasoning, Knowledge Representation, Expert Systems, Computer Vision, Speech Recognition, Automated Data Analytics, Virtual Reality, Augmented Reality, Internet of Things (IoT), Cloud Computing, Statistical Computing, Deep Learning etc. are some major sub-areas of AI having huge potential in resolving the complex problems of agriculture.

3. AI in Indian Agriculture

While addressing the third 'India Agricultural Outlook Forum 2019 with the theme "Universal Basic Income for Farmers," Agriculture Secretary Sanjay Agarwal had stated that AI and Big Data will play major roles in the agriculture sector in coming years since data is "key to targeted development" (Fernandes, 2020). "I see a big role for AI in empowering agriculture, healthcare, education, creating next-generation urban infrastructure and addressing urban issues," Prime Minister Narendra Modi said while inaugurating the Responsible AI for Social Empowerment Summit, RAISE 2020 (Singh, 2020). AI-based agri-tech applications are set to unleash value in agriculture, especially in wake of the recent farm reforms that have opened doors to private sector investments in agriculture. Indian agri-food tech start-ups upraised more than $1 billion through 133 deals in the financial year 2019-20. India's exports of agricultural products incresed to $37.4 billion in 2019 and with investments in supply chain and better storage and packaging, which are estimated to increase further. All these steps will go a long way which will ensure remunerative prices for farmers and reduce agricultural stress.

This progress in agricultural output and productivity is being further boosted by investments in technology. Technologies like AI are making big positive changes across Indian agriculture, and an increasing number of agri-tech startups in the country are working to develop and implement AI-based solutions. AI applications in agriculture reached a valuation of $852.2 million in 2019 and it is estimated to grow up to $8.38 billion by 2030 globally, nearly about 25 per cent growth. The Indian agri-tech market, presently valued at $204 million, has reached just 1 per cent of its estimated potential of $24 billion. So there are ample opportunities to grow with AI-based technologies in India.

Use of AI-based technologies in agriculture will improve farmers' reach to markets, inputs, data, advisory, credit and insurance. Timely and accurate data combined with analytics can help to build a robust demand-driven efficient supply chain. With the use of sensors, photographs through phones, IoT devices, drones and satellite images, agricultural data can be collected and

coordinated with weather data, soil health card data, mandi prices and help build predictive models that can greatly enhance decisions about seeds, fertilizers, pesticides that are of critical importance in both pre-harvest and post-harvest stages. Most of these AI models are low-cost and affordable and can add a lot of value to the Indian agriculture ecosystem having a positive impact on the entire agrarian value chain and meeting the estimated global agriculture $4 billion-opportunity by 2026 (Singh, 2020).

4. Uses of AI in agriculture

Cognitive computing in particular in AI is to become the most advanced and disruptive technology in agriculture services since it can understand, learn, and respond to different situations (based on learning) to increase efficiency. Some of them can be services for the producers. For example, the chatbot that pops up when you visit a banking website could be incorporated into a kisan app. The land owners can have a virtual conversation on the platform and have their basic queries answered instantly. They can also keep tabs on the latest innovations they ought to know about. Seven main areas where AI can benefit agriculture are given bellow.

5.1. Growth driven by IoT

Huge volumes of data are generated every day in both structured and unstructured format via IoT (Internet of Things). These data can be correlated with data on historical weather pattern, soil reports, new research results, rainfall patterns, weeds, pest infestations, images from drones and cameras etc. Cognitive IoT solutions can analyze all these data and provide strong insights to improve crop productivity.

5.2. Soil testing

Two technologies i.e. Proximity Sensing and Remote Sensing stand for intelligent data fusion. These high-resolution data can be utilized for soil testing. Remote sensing requires sensors to be built into airborne or satellite systems, while proximity sensing requires sensors in contact with soil or at a very close range. This helps in soil characterization based on the soil below the surface in a particular place. AI can be used to monitor soil health with the help of sensors, cameras, and infrared rays that scan the soil for its nutritional properties (Sennaar, 2019; Baruah, 2018). An artificial neural network (ANN) model predicts soil texture (sand, clay and silt contents) based on attributes obtained from existing coarse resolution soil maps combined with hydrographic parameters derived from a digital elevation model (Zhao *et al*., 2009). The dynamics of soil moisture are characterized and estimated by a remote sensing device embedded in a higher-order neural network (Elshorbagy and Parasuraman, 2008). This also helps in understanding the reaction of specific seeds to different soils, the impact of weather changes on the soil, and the probability of the spread of diseases and pests (Irimia, 2016).

5.3. Image-based insight generation

Drone-based images can be utilized in in-depth field analysis, crop monitoring, scanning of fields and so on. They can be coupled with computer vision technology and IoT to ensure rapid actions by farmers and better crop management. These feeds can generate real time weather and pest alerts for farmers.

5.4. Detecting crop diseases and pests

Images of various crops of different areas are captured using Computer Vision Technology under white/UV-A light. Farmers can then arrange the produce into separate stacks for better quality categorization before sending it to the market. Pre-processing of images safeguards the leaf images are segmented into areas for further diagnosis. This technique would identify pests more specifically. Beyyala and Beyyala (2012) reviewed few techniques for detection of plant traits or diseases using Image Processing. Chaudhary *et al*. (2012) have implemented an algorithm for disease spot segmentation using image processing techniques in plant leaf. According to authors farmers face great difficulties in changing from one disease control method to another. As naked-eye observation to detect and classify diseases is very expensive various plant diseases pose a great threat to the agricultural sector by reducing the life of the plants. Using the Internet of Things (IoT) technologies, Infosys has built a precision crop management testbed to address this need. It recognizes faces, flora and fauna and other objects and tags them in images.

5.5. Optimal mixture of agri-products

Cognitive computing makes analysis and recommendations to farmers on the simplest choice of crops, seeds and managements; based on multiple parameters *viz.* soil condition, weather position, type of seeds, infestation around a certain area etc. The recommendations are further custom-made on the basis of farm's requirement, local conditions, past crop management strategies, failures and successes. External factors *viz*. market trends, demands, prices and consumer needs can also be taken in to considerations in through artificial intelligence for better understanding and decision making.

5.6. Monitoring crop health

Remote sensing techniques along with hyper spectral imaging and 3D laser scanning are essential to create crop metrics across thousands of acres in a particular area or state. It could escort in an innovative and radical change in the management of cropland and monitoring by farmers in terms of available resources, time and energy. This technology can help in a great way to manage crop health in terms of biotic and abiotic stresses. This will monitor crops end to end their entire life-cycle and generate reports for detecting incongruities, if any.

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5.7. Supply chain Management

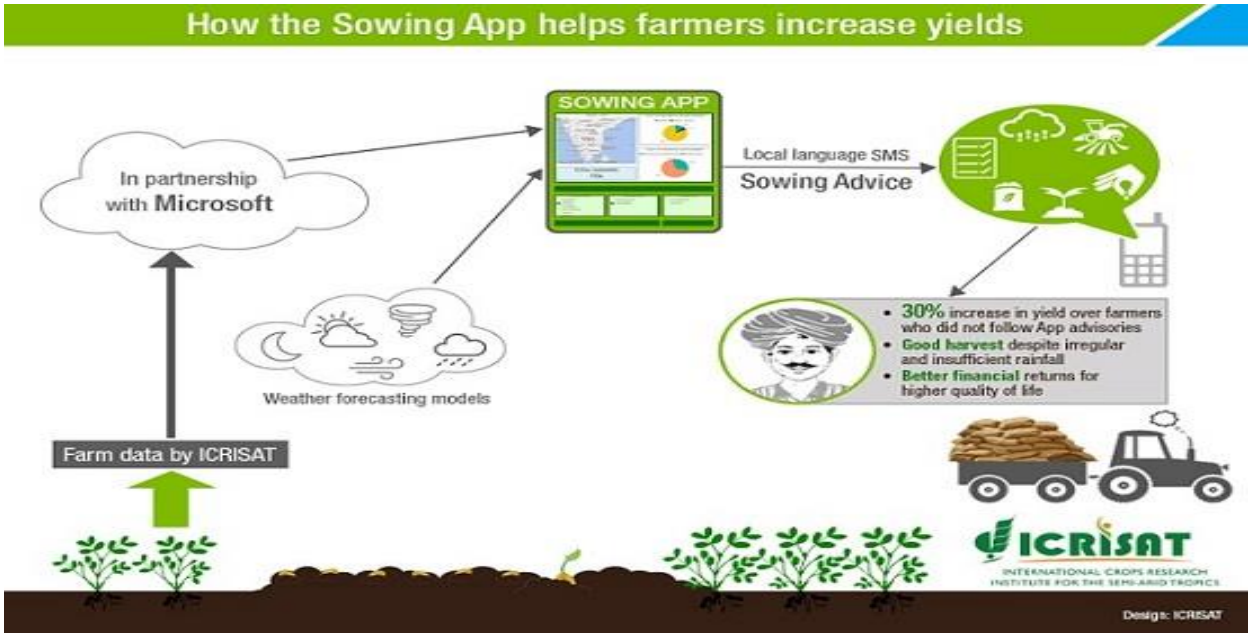
Policymakers have not been able to tackle the agricultural supply chain challenge successfully yet. As a result, on the one hand, farmers either do not receive a suitable price for their produce that continues to rot in *mandis* (or marketplace), and on the other, food consumers either end up paying exorbitant prices or are malnourished. So the application delivers a data-driven online marketplace for agriculture that offers better prices to farmers as well as buyers. Although AI in agricultural supply chain management is yet to make major inroads, its informed application in supply chain planning and optimization, including demand forecasting and logistics, can lead to huge cost savings for farmers, and solve the information asymmetry problem for buyers.

5. Successful public-private partnerships for digital farming

5.1. AI-sowing app by Microsoft

Microsoft and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) collaboratively developed an AI-sowing app which is powered by Microsoft Cortana Intelligence Suite and Power Business Intelligence. The Cortana Intelligence Suite brings the technology which helps to increase the value of data by converting it into readily actionable forms. The developed app is able to use weather models and data on local crop productivity and rainfall for more accurate prediction and recommendation to local farmers on when they should sow their seeds.

Sowing app infographic *(Source: Internet)*



A test pilot for the AI-sowing app was launched with 175 farmers in Andhra Pradesh in June 2016. The farmers benefiting from this application didn't need to expend anything for any upfront capital expenditures such as installing sensors in their fields or purchasing smartphones, but merely needed a simple mobile device capable of receiving text messages. Throughout the summer, the app sent 10 sowing advisory SMS messages to farmers in their native language, Telugu. The sowing-related text messages gave crucial information related to sowing/planting times, weed-management, fertilizer application and harvesting. Besides the app, a personalized village advisory dashboard was set up to enable local Government officials to provide insights about general soil health, fertilizer recommendations and seven-day weather forecasts.

In the impact assessment it was found that the 175 farmers in the pilot grout got a 30% increase in yield per hectare. Farmers told that the advisory messages helped them for protecting their crops and for effective land preparation, management and sowing. Similar result was obtained in the expansion of the pilot project to Karnataka comprising of 3,000 farmers in 2017.

5.2. Price forecasting model

The small holder farmers face difficulties due to lack of information about market condition. The middlemen exploit this knowledge and the farmers often feel compelled to sell their produce to them. Within the context of the pricing issues, the Karnataka Government and Microsoft signed a memorandum of understanding (MoU) in October 2017 confirming their commitment to creating technology-oriented smart farming solutions for farmers in India and declaring a strategy to develop an AI price forecasting model. The Karnataka Agricultural Price Commission (KAPC) and Microsoft worked together to develop a multi-variate commodity price forecasting model by combining artificial intelligence, cloud machine learning, satellite-imaging and other advanced technologies.

The model considers datasets on historical sowing areas, production yields, weather patterns and other relevant information, and it uses remote sensing data from geo-stationary satellite images to predict crop yields at every stage of the farming process. The resulting output from the model includes estimates about arrival dates and crop volumes, enabling local Governments and farmers to predict commodity prices three months in advance for major crop markets. With this data, the Karnataka Government can more accurately plan ahead to set the minimum support price. According to Microsoft, the model is now scalable, efficient, and ready to be applied to other crops and to other regions around India. The summer 2018 harvest season was the first season in which the model was applied.

5.3. Infosys Precision Crop Management

India is now the 2nd most populous country in the world and the population increase is at a rapid pace placing an increasing demand of food supply. Along with growing climate change and shortage of arable land, the agricultural sector is facing and is going to face a challenge of exploring new ways of more output with less input. Using the Internet of Things (IoT) technologies, Infosys has built a precision crop management testbed to address this need. This testbed will improve crop productivity through the analysis of highly granular, real-time sensor data. The testbed will initially focus on improving crop yield through the analysis of real-time data, from environmental sensors located in commercial crop fields.

6. Conclusion

Undeniably, the agricultural sector needs a greater impetus from policymakers in addressing the aforementioned challenges. The aforesaid facts signify the willingness of the Government to facilitate social prosperity through digital farming in India. Though AI has its own limitations, but certainly it's definitely a possible way forward to enhance economic, social and environmental sustainability in Indian agriculture. Cognitive solutions can successfully and smartly act for the prosperity of small and marginal farmers of the country. Therefore, any policy measure on this front needs to be carefully planned and implemented. Undoubtedly, affordable implementation of AI and other technologies in agriculture through public and private sector collaboration can bring prosperity and progress for the end users, the Indian farmers.

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