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ADOPTION OF AI IN AGRICULTURE: THE GAME-CHANGER FOR INDIAN FARMERS

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ABSTRACT

This paper presents a study of various AI-powered ICT applications to numerous challenges related to the agriculture life cycle and its positive impact on the well-being of Indian farmers. Technology-driven solutions to various problems, such as soil fertility, inadequate irrigation, pest control, weed management and yield prediction have been discussed, along with, affirmative actions taken by the Indian government to promote smart agriculture. The agricultural life cycle faces many impediments, such as disease, weeds, pest infestation, improper soil conditions, outdated irrigation methods, unpredictable weather conditions, etc. These lead to severe crop failure, food shortage and increasing environmental hazards, driving the farmers to poverty. Extensive research has been done to address these problems in the past few decades. Further, due to the outbreak of pandemic COVID 19, certain restrictions have been imposed by the Indian Government in the farming sector to ensure the safety of farmers from getting infected with the deadly virus. This has resulted in an acute shortage of farmworkers. The use of ICT in agriculture becomes even more important at this crucial time, when, the pandemic has spread across the globe. The ICT based solutions reduce the dependence of farmers on farm-workers and enable them to maintain stable income levels and farm yield, despite the shortage of farm labourers. Various agro-intelligent practices adopted in the last 15 years, worldwide, have also been surveyed, in this paper. Some of the tools and platforms developed by Indian Start-ups to implement smart agriculture and to deal with the shortage of manpower and supply chain disruption due to lockdown during pandemic, have also been discussed.

KEYWORDS

Artificial Intelligence, Smart Agriculture, Yield Prediction, Biomagnification

1. INTRODUCTION

The agricultural activities across the world continue to shift towards ICT enabled automated systems that perform real-time predictions. Farmers are increasingly using the latest technologies, from intelligent irrigation systems, to drones taking aerial photos of arable fields and using drones/robots to spray pesticides. The impact of the adoption of smart agriculture in improving the lifestyle and prosperity of Indian farmers has been phenomenal. The rapid growth of the population in India demands a ramp up in food production. According to the Food and Agriculture Organization of the United Nations, with a population of 1.3 billion, India is the world's second-most populous country. It is also an agrarian society, being the seventh-largest country in the world in terms of area, with 67% of it's population dependent of agriculture (FAO, 2020). Traditional agriculture methods are not enough to meet the present needs, as they are obsolete and facing huge challenges ranging from sowing to harvesting. Major challenges are weed control, irrigation, yield prediction, excessive use of pesticides, climatic conditions, soil conditions, and overuse of chemical fertilizers (Bannerjee, et.al., 2018). In addition to these problems, to combat the sudden outbreak of COVID 19, several restrictions have been imposed in the farming sector during lockdown, resulting in a huge shortage of migrant farm-workers. In the present scenario, the adoption of ICT in the farm sector can mitigate these challenges and reduce the distress level of farmers to a great extent. Few AI-inspired ICT solutions in farming are discussed in the following sections of this paper.

2. ICT IN SOIL TREATMENT

India is the land of diversity. According to the Indian Council of Agriculture Research, Indian agriculture land has different types of soil such as, alluvial soil (43%), red soil (18.5%), black /regur soil (15%), other soil (23.5%). Presently, 661 soil-testing centres established by the government of India are in place, where the soil samples are taken to laboratories and tested for essential nutrients against the crop grown in that region. It is a time-consuming process with low accuracy.

With the adoption of ICT and AI in agriculture, the Indian landscape has undergone a major transformation. Artificial Neural Network (ANN) based model can be effectively used to test the Indian soil using three parameters (texture, color, moisture) for on-site soil testing (Zhai et al., 2006). The data can be collected through a wireless sensor network (WSN) which measures soil moisture of the field in real-time and connects to the farmer's mobile phone through Zigbee, wifi, or cellular network, depending on the area of the farm land. It is observed that this AI-based on-line solution gives more accurate results over traditional soil testing methods done in the labs offline. Moreover, the traditional method of soil testing requires huge manpower, whereas, ICT based soil testing requires less manpower and useful in such unprecedented times during pandemic, when human movement is minimal and restricted.

3. ICT IN IRRIGATION

Indian irrigation system uses traditional methods such as irrigation through the river, pond, canal using water pumps. Presently, two-third of farmers in India use traditional methods of irrigation. Inadequate rainfall and outdated irrigation methods lead to a huge loss in crop yield. The latest developments in the field of automation in irrigation using artificial intelligence is discussed in this section.

Various wireless technologies (Kumar, 2014) and ANN-based models were proposed for drip irrigation through Automatic plant irrigators and rainfall prediction using climate variables during year 2010 to 2019 (Yadav and Sagar, 2019). Using various parameters like soil moisture, precipitation level, wetting pattern, ANN-based models are developed for Indian farmers. The simulation shows, that the cost of irrigation is likely to be reduced up to 50% over traditional irrigation methods along with improved yield. With the adoption of ICT and AI in irrigation the prediction of total monsoon rainfall would be possible a few weeks and days in advance.

4. ICT IN PEST CONTROL

Pest control is one of the most challenging activities in agriculture, that leads to severe health issues and biomagnification. The traditional agriculture life cycle in India involves indiscriminate usage of pesticides, such as Insecticides (61%), Fungicides (19%), Herbicides (17%), and other pesticides (3%). An integrated pest management system using a fuzzy expert system has been deployed in Malaysia, to monitor the pest activity in rice crop (Siraj and Arbaiy, 2006). A pesticide spraying system has been deployed in China, where variable spraying technique has been adopted based on fuzzy control and sensor networks (Shi et. al., 2007). The same has been extended to include geographic information and geolocation for pest control for olive culture in Portugal (Jesus and Panagopoulos, 2008). A Bayesian Network-based Expert System in Pest Management has been proposed in India (Singh and Gupta, 2020). A model combining image capturing using camera and ANN is under trial, which identifies the exact location of pests and minimizes the use of pesticides in rice, wheat, and cotton crops, through targeted spraying. A LoRa Wide Area Network is used to connect a wireless sensor network in the fields with the farmer's mobile for live updates.

5. ICT IN WEED CONTROL

Traditional weed control methods include the application of hoses, cultivators, mulch, and chemical control such as herbicides. The excessive application of herbicides directly impacts human health and the

environment due to the phenomena of Bio-magnification. The usage of ICT in weed control is gaining momentum and various AI approaches are being applied to minimize the application of herbicides.

John Deere, an agricultural and forestry equipment company, acquired Blue River Technology, which uses AI based algorithms to plan targeted herbicide spraying for crops. The program selects for spraying only those parts of the field that require it. This solution minimizes the wastage by reducing the amount of herbicide needed for spraying. The image analysis using ANN is commonly used for real-time weed identification and control to minimize the usage of herbicides/weedicides. A smart sprayer for precision weed control using deep learning frameworks, distinguishes target weeds from non-target objects (e.g. vegetable/crops) and precisely sprays on the desired target/location (Partel et.al., 2019). A novel computer vision-based robotic weeding control system is highly effective in weed identification and control (Wu et.al., 2020) and also reduces health hazards for farmers by spraying the right amount of herbicides only on desired spots. A deep learning framework using computer vision is to be trained on the images of various Indian crops like rice, wheat, and cotton, to identify the unrecognized images of weeds and spray them with herbicides using drones and robots. This technique not only reduces the consumption of herbicides, but also, reduces agrochemical residues on food products and protects the environment from bio-magnification.

6. ICT IN YIELD PREDICTION

The crop yield prediction is very important for determining the minimum support prices (MSP) and crop cost estimation. Further, the analysis of relevant factors, that directly affect the yield can also be done through predictive modelling. To predict yield, growth, and water consumption in a greenhouse environment, a neural network-based predictive model integrated with GIS was used in 2011(Thongboonnak and Sarapirome, 2011). The energy output has been used as a means of yield prediction for basil plants in a greenhouse in 2012 (Pahlavan et. al., 2012). Later on, a CNN-RNN based framework has been applied for yield prediction of corn and soybean crops (Khaki et.al., 2020).

A similar model is proposed for yield prediction for the Indian farm sector which uses soil parameters, compost, fertilizers, and climate conditions as input to a neural network that is trained on known dataset of the past 20 years.

7. INITIATIVES IN SMART AGRICULTURE

The Indian government is promoting and funding projects and start-ups for innovations in the farm sector.

7.1 Project on Weather Prediction & Soil Moisture Analysis

The agriculture ministry of India has initiated a pilot project on climate prediction and soil moisture analysis in three regions of India namely, Bhopal, Rajkot, and Nanded for the Kharif crop of 2019. IBM's Watson Decision Support System has been used to provide weather forecast and soil moisture information on a pro bono basis to help farmers in taking decisions regarding water and crop management. This has resulted in achieving bumper rice crops in these regions.

7.2 Sowing App

The pilot project, to experiment with an innovative sowing procedure, was launched in 2016 for Indian farmers. The Sowing App was developed to assist farmers to attain best groundnut harvests by sending the notification to the farmers their mobile phones about the most suitable time to sow depending upon climate conditions. The sowing app inputs data provided by farmers and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) regarding soil and climate conditions for different crops. AI and Machine Learning based data-driven weather forecasting models are applied to this data to predict a suitable sowing date. The Microsoft Power Business Intelligence (BI) platform was used to develop this model which sends an SMS to farmers about the appropriate sowing dates in their local language. This pilot project was

implemented in the Indian province of Andhra Pradesh, which resulted in a 30% higher average in yield per hectare. A bumper harvest resulted despite irregular and insufficient rainfall. This, ICT enabled solution resulted in better financial returns to Indian farmers by improving their income and quality of life.

7.3 Agri-Intelligent Solutions offered by Indian Start-ups

The government of India has introduced a new AGRI-UDAAN program to mentor start-ups innovating in the field of smart agriculture and to connect them with potential investors. Some of the tools and Apps launched by Indian start-ups for smart agriculture are as follows:

7.3.1 Intello Labs

This start-up has developed an AI platform using a deep learning algorithm on which intelligent solutions are developed for various applications in smart agriculture, e-commerce, advertising, manufacturing, etc. Intello Labs also provides automated grading of fresh products by quality analysis of images and helps farmers get a better price for their produce. Their solution uses deep learning algorithms integrated with image processing to recognize any disease or pest infestation in the farm produce.

7.3.2 Smartfarm

CropIn is a start-up, which, has developed Smart-farm an intuitive, intelligent, self-evolving system that addresses future-ready farming solutions to the entire agricultural sector of India. The system supports decision-making tools that bring consistency, dependability, and sustainability to agri-businesses by providing cloud-based solutions for smart farming based on local/regional conditions and connects the farmer through his mobile phone using the cellular network.

7.3.3 Gobasco

The Intelligent Agri supply chain based start-up in India uses an AI platform for their operations. It deals with commodity flow maps, customer preference maps, credit rating systems, GoProcure AI tools, and price prediction modules. It helps in the transport of grains from farmers to vendors at Minimum Support Price (MSP) set by the government of India, making farmer's life easy and stress-free.

7.3.4 Gramophone (Agstack Technologies)

This Indian start-up offers a decision support system and an IoT based hardware integrated with mobile phones of the farmers to carry out agricultural activities, such as seed selection, crop protection, irrigation, etc. It also provides customized IoT based hardware for smart agriculture to Indian farmers at their doorstep.

8. CONCLUSION

The AI-based ICT solutions have been a game-changer for Indian farmers in terms of improving the quality of their produce and yield, thereby, enhancing their income levels, lifestyle, and happiness quotient. Indian agriculture activities are gradually shifting towards automated systems that perform real-time predictions and actions. Usage of AI technology not only optimizes the work on farms, using less resources, but also automates many activities, thereby reducing human involvement (and especially the number of farm worker). In this paper, various AI-powered ICT solutions applied to the agricultural domain have been presented. Numerous technology initiatives are taken by the Indian government to promote smart agriculture which increases farmer's income and reduces their dependence on soil and climatic conditions are also discussed. In the last decade, the use of hybrid systems, which, combine image processing with trainable ANNs, integrated with Mobile IoT and Sensor networks is predominant in smart agriculture. The farmers get alerts on their mobile phones and control various farming activities remotely using WSN connected to Zigbee, wifi, LoRa WAN, or 3G/4G mobile networks. Due to the COVID outbreak, there is an acute shortage of farmworkers in the villages of India. Usage of drones and mobile robots reduces manpower requirements in various farming activities and minimizes health hazards experienced by farmers during spray of pesticides.

With ICT interventions, the economic and health condition of the farmers improves and their distress level is reduced. Accordingly, each country can adopt a model based on its soil and climate condition to improve the quality of harvest and yield of farming land by at least 30%-50%. Ultimately, it results in a higher yield per hectare, poverty alleviation, better health, cleaner environment and good quality of life, among farmers. Further, studies are being conducted in India using AI and Machine learning so that conventional farming can shift towards ICT enabled smart farming at an affordable cost.

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