Agriculture, Artificial Intelligence And Food Security: A Case Study Of The United States And India's Agriculture Sector

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ABSTRACT:

This paper provides an overview of the use of Artificial Intelligence such as predictive maintenance of crops, IoT and ICT systems and its impact on the agriculture sector in the United States of America and in India. Through the paper, we see how the increased use of Artificial Intelligence technologies have contributed to the growth in agriculture positively and has thus ensured food security. Drawing upon parallels from both the Indian and the U.S. agriculture economy, the impact of Artificial Intelligence on food security is analysed and its implications are discussed. In this paper, we also reiterate problems that are unique to the Indian agrarian sector and transpose the learnings from to maximise the use of Artificial Intelligence in Agriculture to achieve Food Security in both countries.

INTRODUCTION

The Universal Declaration of Human Rights (1948) recognizes the Right to Food as a Basic Human Right. This is also modeled in the International Cove nant on Economic, Social and Cultural Rights (ICESCR) as a right to an adequate standard of living. In today's day and age where we face problems like increasing population, climate change, soil degradation, pest and disease outbreaks, crop losses etc. food security is threated. Thus, we need to find solutions to these problems, so our food security remains intact and the Human Right to food for all is honoured. Following COVID-19, data from the World Food Programme has predicted that the number of people experiencing acute hunger will near a quarter billion (2500 lakh people approx..). We thus need to build resilient food systems and work towards global nutrition. In a recent summit: AI for Good Global Summit 2020, Emmanuel Faber, the chairman of Danone, a billion-dollar food company emphas ised the need for agricultural biodiversity by empowering food producers locally by using Artificial Intelligence. The United Nations Climate Action Summit 2019 also aims to reintroduce biodiversity in agriculture by using AI as a leverage. India's inspiration from the above international dialogue has led to the creation of institutions such as the Artificial Intelligence for Agriculture Innovation (AI4AI) initiative and collaborated with the Ministry of Agriculture, the National Institution for Transforming India (NITI) Aayog and the Ministry of Electronics aims to transform the agriculture sector in India using AI. The government has partne red with stakeholders such as academic and research institution, agri-tech indust ries, and startups to develop an evidence based, consensus driven frame work to gather better data to address issues within the agriculture industry. We will learn more about this in the paper as we proceed. On the other hand, as India is gearing towards the use of AI cautiou sly, the United States with its 363 million ha i.e., 37% of total land area under agriculture production with more than 2 million open field farms in operation has revolutionized agriculture using advance AI capabilities such as ICT and IoT technologies, remote sensing, satellite imaging, drones, and precision technologies to monitor crops and soil. The information gathered from these systems support production and management. Robots are carrying out labour-intensive jobs, such harvesting crops quickly and in greater quantities than conventional human labourers. AI technologies are also being used to accurately detect infections, allergens, chemicals, and pollutants in foods, plant and animal production systems, water, and soil. USA also ranks first in the Global Innovation Index among 132 countries, and this is an indicator of being adapting to AI in all sectors promptly and effectively. We will explore the learnings as well as drawb acks from the above country in the following sections.

EVOLUTION OF THE INDIAN AGRICULTURE SECTOR

India has always been an abundant producer of crops, fruits, and vegetables since ancient times. It is due to this, among other reasons that the British colonized our country. In the years immediately after independence, India has made enormous progress towards achieving food security. Food grain production in India has more than quadrupled while the population tripled. The amount of food grains that are

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available per person has significantly increased especially after the green revolution. In the 1970s and 1980s, the irrigated areas, which made up around one-third of the harvested crop area, mostly benefited from the long-term effects of the enhanced seeds and new technology. In the 1980s, there was a transition in the Indian agriculture policy to "evolution of a production pattern in line with the demand pattern" which resulted in a shift in emphasis towards other agricultural commodities, such as oilseed, fruit, and vegetables. The 1990s saw the liberalization of India's Economy which resulted in agricultural products being catering to exports and a larger international consumer base. These changes came with its own set of problems. While addressing the diverse food needs of an expanding population, farmers were pressurized to start implementing new techniques and technology to tackle problems such as poor irrigational and infrastructural facilities, inefficient farming practices, soil degradation and low crop yields.. In the advent of the late 2000s with the booming of the Information Technology industry, the Indian government also began making changes and integrating technology with agriculture. Most recently, the India government has created institutions such as national agriculture market (e-NAM), clean energy programme for renewable power facilities and audio-visual communication apps for advising farmers in initiatives like Kisan Call Centres and e-SAGU using the internet. As the world is already moving forward to Industrial Revolution 5.0, AI looks like bringing about food security and a promising future. There are no legislations on AI as such in India today, but a National Programme on AI was formulated in the budget for the 2018–2019 fiscal year with the goal of directing research and development in the new and emerging technologies. Considering this NITI Aayog has developed strategies for the creation of a national plan with the cooperation of experts and stakeholders to develop a proof of concept of the impleme ntation of AI in various sectors-agriculture being one of them. As we have now traced the trajectory of India, will now explore the US agrarian system and its relationship with technological innovation.

TOWARDS AN A.I. DRIVEN UNITED STATES AGRICULTURE SYSTEM

In the U.S., agricultural policies are called farm bills, which generally follow a 5-year legislative cycle. The most recent of these Farm Bills still being implemented is the Agricultural Improv ement Act of 2018. It governs areas such as crop insurance, conservation on agricultural lands, agricultural trade (including foreign food assistance), nutrition (primarily domestic food assistance), farm credit, rural economic development, agricultural research, State and private forestry, bioenergy, and horticulture and organic agricult ure. Law makers as the previous legislation is coming to an end are laying out priorities for their next farm bill 2023. Artificial Intelligence is one of the major priorities. The U.S. Department of Agriculture (USDA) is involving farmers, scientists, educators in various AI projects as a part of the bill to benefit from artificial intelligence by fostering innovation, creating economic opportu nity, supporting the success of rural America, and encouraging more effecti ve and profitable agricultural produc tion. The NIFA has launched a data science initiative, Food and Agriculture Cyber informatics and Tools, to expand and fasten a diverse project related to AI programs. These programs represent a multitude of uses in agricultural produc tion, sensor development, bioin form atics, ecosystem management, rural co mmunity support, and work force development through education and training at all levels. In this work, artificial intelligence (AI) algorithms are used to help identify plant, animal, and tree species that contribute to pest control and ecosys tem management, as well as robotic solutions that use AI technologies to help with pollination, weeding, pesticide applications, and fruit harvesting. Adaptive groundwater and watershed models are also used to maintain the resilience of agricultural systems. The investments made by NIFA support a wide range of AI-related research, including work in big data, machine learning, autonomous systems, computer vision, and intellig ent decision support systems, as well as socioeconomic and workforce issues related to the rapidly expanding role of AI in American agriculture. Also working with NIFA is the Agricultural Research Service (ARS) which is the U.S. Department of Agriculture's chief sci entific in-house research agency. The ARS is working with businesses to advance the use of AI in monitoring livestock, sorting harvests with robots, analysing irrigation systems, and analysing crop health and pesticide application with UAV technology. These projects include self-propelled apple sorting machines that use algorithms to quality sort the fruit, automated calculations to analyse the foliage composition of crops and then guide the application of pesticides, and aerial monitoring of fungi levels on

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maize and other crops using computer vision and deep learning. The use of AI in the U.S. seems certainly promising, we will go on to take a look at the projects that are implemented in the U.S. and in India.

COMPARATIVE STUDY OF A.I IN INDIAN AND US AGRICULTURE

The aim of using A.I in agriculture is to increase profits, decrease environmental impacts, improve land use productivity, and motivate more young people to work in agriculture. Data Management and Smart Farming Smart farming solutions in U.S. are mostly designed as hardware or software products that can operate independently or in combin ation to provide farm management processes. Technologies like GPS-guid ed tractors, yield monitor, variable rate sprayers for pest control, planters and variable rate fertilizer implements. All these technologies have been widely adopted in the U.S., because these aid in the management of large farms. Currently, in the U.S., smart system products developed by private industry (such as Bayer, CropX, John Deere, Lindsay Corporation, Reinke and Valmont, Industries) are available to farmers on the retail market. The Agricultural Research Service (ARS under the Department of Agriculture) is also developing smart farming solutions for precision irrigation management in collaboration with private industry or with state cooperative extension specia lists. Specific smart system solutions like automation and equip ment control (such as pumps, tractor guidance), optimization of machine operations (e.g., tracking maintenance parameters), or provision of decision support tools for irrigation scheduling, forecasting precipitation, or developing variable rate application maps for fertilizer or irrigation are being used in the U.S Today. Unlike the U.S. In India today, the pressure on increasing productivity in a small parcel of land is high as India does not have large tracks of land like the USA. Precision farming in India so far is used to detect diseases, pests, and malnutrition in the field. An example of this is when AI detects the target weed using sensors and then recommend pesticides and weedicides to be used. Seasonal forecast models are also being developed by A.I. to improve farming accuracy and productivity. This helps farmers make better decisions using technologies to predict future trends. Drone based AI enabled cameras are also used to take pictures in the field to analyse images in real time to identify potential problems and improvements. Yield Management using A.I. Smart farming in the U.S. has the potential to reduce the risk of crop loss and failure due to climate change. Sector growth is envisioned if the ICT system affords data strategies providing intelligent information and services to farmers such as potential buyers for their products and predictions for future demands. In India, Microsoft is currently working with the Telangana government to provide consulting servi ces using machine learning and power business intelligence using Contra Intelligence suit. The project developed AI applications to communicate soil preparation, fertilizers based on soil tests, the dates, seed treatment etc. to predict yield. Gobasco is an artificial intelligence- based platform that offers procurement solutions and yield prediction and optimization for the agriculture sector. The aim is to use artificial intelligence and big data to optimize the Agri-supply-chain. This approach provides farmers and agricu ltural SMEs (Small and Medium enter prises) with a data-rich technology platform and network to grow their profits, thereby creating new opportun ities in rural commerce. The global market for smart agricultural goods was estimated at 6.34 billion USD in 2017; this market is projected to reach 13.50 billion USD by 2023. A.I in Water Management Systems There are additional uses of A.I which are directly not related to agriculture that we could gain from the introduction of ICT in both countries, even though both approaches identify several applications for smart farming. Among these applications are ones for controlling and monitoring and providing water supply projections, interstate river systems, water storage facilities, water conveya nce systems, water quality at the waters hed and farm level, and water quality measurements are all included in the USGS report from 2018 (USGS). Gen eral additive models and support vector machines can be used to get accurate month estimates of the water level in the rivers along with data for alluvial aquifer. In India, numerous attempts are being made to use AI-based solutions for water assessment. For instance, to pred ict the groundwater table in agricultural land and to improve management and use of groundwater. Like this, agtech companies are using sensors, remote sensing, and AI to schedule irrigation in a way that is more intelligent. This is an important step for India, as predo minantly farmers rely on monsoon to feed their crops. Although, both countries have understood the need for using A.I. to leverage and find solution in irrigating their farms, India is at a disadvantage as most farmers are not technology savvy or literate and many

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of these services are neither scalable nor affordable for them. Tackling Labour Changes: In the U.S harvest robots such as six axis robots are intelligent and self-sufficient bots who employ sensors and cameras to detect when the crops are ready to be harvested. Once they receive the sensory input, they carefully harvest the crops without tampering with the finished product using robotic arms or other instruments. Similar technology is used to intelligently remove weeds, plant seeds and spray fertilizers. In India the migration of labour is a huge problem unlike in the U.S. where large tracts of land are available to farmers. Therefore, India is also leveraging the labour challenge posed by using robots to harvest crops. These bots are faster and locate and remove crops, weeds etc more accurately. Research has also shown that the operation cost of using these technologies is relatively cheaper than per head labour costs. AgriTech Companies Innovating in A.I for Agriculture: Agriculture technology (Agri-tech) is swiftly emerging as a significant field of innovation in the United States and in India in 2023. Agri-tech companies are working hard to develop new innovations that will improve the skill, effectiveness, and manageability of agricultural practises. CropX, a leading provider of cutting-edge sensing and analytics-powered smart solutions for professional farm ers, was established in 2017. CropX choses ranchers with ongoing experie nces in soil environment and harvest conditions, empowering them to adva nce their water system choices and increase in yields. Indigo AG provide them with data-driven insights and solutions for increasing soil health, decreasing inputs, increasing crop performance, and making better farming decisions. Granular focuses on developing cutting-edge tools that assist businesses in managing their operations more effectively. Granular Platform, their most popular product, is a platfo rm that can handle all a company's data and processes from a single loc ation. Their area of expertise in Farmlogs- a startup aids farmers in managing their farms, maximising agricultural produc tion, and maximising earnings. Their product line includes FarmLogs Crop Manager, FarmLogs Field Maps, FarmLogs Weather, and FarmLogs Soil. Blue River Technology, since its establishment in 2011, the organisation has grown to become a pioneer in autonomous cultivation thanks to its innovative arrangements. Blue River's technology helps farmers cut labour costs and boost productivity by autom ating crucial crop management proce sses including weed detection, fertiliser application, and crop harve sting. In India, startups such as Prospera which uses images from air and land/water sensors to predict and analyse farm data for optimization, Jivabhumi which is a "smart agriculture marketplace "are revolutionizing agri tech today. Harvest CROO Robotics which is a robotic harvesting system which predominantly harvests fruits by identifying the ripe ones over unripe is contributing positively. Soilsens Techn ologies Pvt. Ltd, a start-up incubated at Indian Insti tute of Technology Bombay (IITB), Mumbai with support from the Ministry of Department of Science and Techno logy (DST) and Ministry of Electronics and Information Technolog y works on sensor based technology to prevent over irrigation and water consumption. Microsoft India and the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) have created a sowing application for farmers utilising AI in conjunction with a customised village advising dashboard for Andhra Pradesh. According to weather, soil, and other variables, the sowing app gives farmers advice on when to plant crops. These are among the most well-known Agri Tech startups in both countries that use A.I. to leverage problems in agriculture.

FOOD SECURITY IN INDIA AND U.S. AFTER USING A.I IN AGRICULTURE

According to FAO (2008) there are four pillars to food security, the first is availability, second access, third - utilization, and lastly stability. The Use of AI technologies are certainly guaranteeing the availability and access to food crops and produce. This transgresses to even the farming of livestock and fisheries. The challenge is to utilize food in a sustainable way so that it guarantees stability in the long run. In the USA, the total amount spent on AI in the agriculture sector is anticipated to increase from $1 billion this year to $4 billion by 2026. AI technology is enhancing farmer's lives because there are so many advantages that AI may provide to the agricultural sector in terms of availability and access of food crops and the people who work in it. In the most recent year, the use of AI technologies in the United States reached 81%, i.e., up by 33 percentage points since 2018. It will keep increasing in the coming years. This growth will ensure food security as more produ ction of food is likely to be the result. In India in the years 2021-2022, the GDP contribution by the agriculture sector went to 19.9% from 17.8% in 2019-20 due to the use of technology and A.I. Even after COVID's effect, the agriculture sector exhibited growth of

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3.4% that year. This was possible only because we used technology to leverage the production of crops and opted by more mechanized and technologically savvy methods. The Indian agri-tech market, presently valued at USD 204 million is expected to undergo expon ential transformation owing to the adop tion of technologies like artificial intelligence and supportive government policies. According to an Industrial survey conducted recently, the favou rable impact of govt initiatives is expected to take the market valuation to US$ 30-35 billion by 2025. India is the world's third-largest recipient of agrite ch funding after the US and Germany and has the third-largest number of agritech start-ups after the US and the UK. In 2020, India received investments worth US$ 329 million from PE/VC firms and registered a staggering CAGR of 53% from 2017 (US$ 91 million) to 2020 (US$ 329 million). With such government support, India's agricultu ral value chain is expected to witness growth across the whole ecosystem in the coming decades. India is about to transform its agriculture using A.I and thereby guaranteeing the kind of food security which was only a variable until the last few decades.

CONCLUSION

According to the United Nations, an estimated 17% of total global food production is wasted, and food that is lost or wasted accounts for 38% of the total energy usage of the global food system. When food is squandered, the resources—land, water, energy, labour, and capital—used to produce it are likewise misused. In addition, the landfilling of food waste and loss produces greenhouse gas emissions that fuel climate change. Today, a person needs 2000 calories on average to live a healthy lifestyle. The world is faced with a huge issue as population growth and increased food production, furthermore climate change puts increasing stress on water resources and agricultural produ ction. To deal with these changes, farmers need to be experts in fertilizers and soil, insecticides specific to different crops, planting and irrigation cycles and weather impacts, among other things. When agriculture itself is dependent on variables, it is necessary to take the help of A.I and its predictive and leveraging technologies to make the process of food production efficient. Using these technologies, farmers must aim to produce more food while using less energy and water. Due to urbanization, immigration issues and a generational shift away from farming, there has been a farm labour shortage which means farmers also need to reduce their reliance on a workforce and use robots to conduct harvesting, weeding, and seeding. A successful crop cycle has never been more dependent on techno logy. A.I can also aid in making better crop inputs, such as- before seeds are sown is the early stages of an agric ultural lifecycle. For instance, an initiative by CRISPR is gene editing to create and altering corn seed genes and has created 32,000 varieties of weather and pest resistant seeds using A.I. There are over 200 AI-based agricultural firms in the United States alone, which indicates that the autonomous farming sector is starting to develop. Self-driving tractors, combine harvesters, robot swarms for crop inspection, and auton omous sprayers are a few exampl es of artificial intelligence in agriculture. Aside from using AI and computer vision to collect data on crops and modify the atmosphere for the best nutrition and flavour, indoor farming businesses like Plenty and AppHarvest are also employing these technologies. Despite of the global population doubling over the last 50 years and a finite supply of agricultural land, the proportion of people without access to sufficient healthy food has dropped significantly. But the challenge is not over: millions of people still lack food access, the threats that climate change pose to farming are intensifying, and two billion more people will be on the planet by 2050. Thus, to ensure long term food security it is a critical for the agriculture industry to draw on emer ging technologies to solve real-world problems — namely building a durable, resilient global food supply and thereby become food secure by fore sting the spirt of Human Rights.

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