

Innovation management in agriculture through Artificial Intelligence

Vikram Singh¹, Himanshu Varshney² and Shiv Datt³

ICAR-Intellectual Property and Technology Management unit, New Delhi 110 012

Application of information technology in agriculture changes the life of the farmers from the long queues before government offices to click on their cell phones. Now gone are the days when farmers were used stand in queue to get a copy of their revenue records, payment of electricity bills, subsidy on fertilizers/equipment/seeds, farm loan applications, society memberships, farm inputs at cooperative society etc. All these services are now available on hand, where they can get the information in advance. As our world becomes increasingly digital smart algorithms, bots and Artificial Intelligence tools will no longer be the exception for organizations, but the norm.

Key words: Agriculture, Artificial Intelligence, Mobile app, FarmBeat

ARTIFICIAL intelligence (AI) is a dynamic field, driven by substantial investment in research and rapid advances in knowledge. It is also a field that will have a significant impact, not only on business, with increased productivity and efficiency, but also on health, transportation, entertainment and agriculture, among other areas. AI systems is able to successfully perform any intellectual task that could be undertaken by the human brain or the hypothetical ability of a machine to far surpass the human brain. AI is a cutting-edge technology which is becoming part of our everyday lives by changing how we work, shop, travel and interact with each other. According to many observers, the current AI boom began about seven years ago. It followed a series of ups and downs from its inception in 1956

Artificial intelligence is a new digital frontier that will have a profound impact on the world, transforming the way we live and work.

WIPO Director General,
Francis Gurry

at a Dartmouth conference, which were referred as AI summers and winters. The increased availability of data, connectedness and computational power allow for breakthroughs in machine learning, mainly in neural networks and deep learning, heralding a new era of increased funding and optimism about the AI potential.

The World Economic Forum has characterized AI as the lynchpin of a Fourth Industrial Revolution. From 2013 to 2020, the digital universe will grow by a factor of 10 from 4.4 trillion gigabytes to 44 trillion. It doubles more every two years. AI is expected to have a fundamental impact on the Fourth Industrial Revolution (4IR), a term coined by Klaus Schwab. Schwab sees the 4IR being characterized by a number of emerging technologies including AI, robotics, the Internet of things (IoT), 3D printing and autonomous vehicles which are fusing the physical, digital and biological worlds, and affecting all disciplines, economies, industries and governments.

Importance of AI at global level

AI is not a new phenomenon, it

developed over the past 70 years by computer scientists such as Alan Turing, Marvin Minsky and John McCarthy. Now due to virtually unlimited computing power and the decreasing costs of data storage supports to its increasing waves. In the past, this kind of performance was driven by rules-based data analytics programs, statistical regressions, and early “expert systems”.

AI has the potential to overcome the physical limitations of capital and labour, and open up new sources of value and growth through (a) intelligent automation, (b) labour and capital augmentation: and (c) innovation diffusion.

Key developments responsible for

AI might just be the single largest technology revolution of our live times, with the potential to disrupt almost all aspects of human existence. Andrew Ng, Co-founder of Coursera and formerly head of Baidu AI Group / Google Brain, compares the transformational impact of AI to that of electricity 100 years back.

this optimism are unlimited access to computing power, huge fall in cost of storing data, explosion in data that is digitised. As Barry Smyth, Professor of Computer science at University College Dublin, says: “Data is to AI what food is to humans.” So, in a more digital world, the exponential growth of data is constantly feeding AI waves.

The importance of AI had already realized in the developed world a long ago, but to face the competition in the present era of innovation, Governments of USA (2016), UK (2017), France (2017), Japan (2017) and China (2017) have released their policy and strategy papers relating to AI. AI is worldwide known for its potential economic and social benefits. China and U K estimate that 26% and 10% of their GDPs respectively in 2030 will be sourced from AI-related activities and businesses.

To generate the human resource in the field AI, U.K. has planned to build over 1,000 government supported PhD researchers by 2025 and set up a Turing fellowship to support an initial cohort of AI fellows while China has launched a five-year university program to train at least 500 teachers and 5,000 students working on AI technologies.

A study by EY and NASCCOM found that by 2022, around 46% of the workforce will be engaged in entirely new jobs that do not exist today, or will be deployed in jobs that have radically changed skillsets.

Artificial Intelligence and its Global Intellectual Property Rights perspective

World Intellectual Property Office (WIPO) is the leading organization for protection and promotion of intellectual property rights. In January, 2019 WIPO has published a document on AI with the support from world's leading experts. The analysis offers unique insights into trends in AI techniques, AI functional applications and AI application fields. This study found that deep learning is the biggest and fastest growing technique in AI. Google and Baidu are now fully AI-driven companies.

The first patents related to AI were

filed with the Japanese patent office at the beginning of the 1980s. AI-related patenting is growing rapidly: over half of the identified inventions have been published since 2013. Since AI emerged in the 1950s, innovators and researchers have filed applications for nearly 340,000 AI-related inventions and published over 1.6 million scientific publications. The boom in scientific publications on AI started around 2001. Moreover, the ratio of scientific papers to inventions has decreased from 8:1 in 2010 to 3:1 in 2016 indicative of a shift from theoretical research to the use of AI technologies in commercial products and services.

AI-related inventions are booming, shifting from theory to commercial application. There are immense opportunities lie outside of the software industry viz. agriculture, healthcare and manufacturing. To harness the potential of AI in these industries public-private partnerships, continue promoting the free and open sharing of AI knowledge and resources, and promote increased understanding of AI are essential drivers.

Analysis shows that many sectors and industries are exploring the commercial exploitation of AI. These AI patents were filed in telecommunications and transportation (15% each), life and medical sciences (12%), and personal devices, computing and human-computer interaction (HCI) (11%). Other sectors and sub-categories agriculture secured 32% share.

IBM has the largest portfolio of AI patent applications with 8,290 inventions, followed by Microsoft with 5,930. The leading public research organization applicant is the Chinese Academy of Sciences (CAS), with over 2,500 patent families and over 20,000 scientific papers published on AI. CAS transferred and transformed 7,000 IP assets (transfer, license, self-implementation, price-for-share, technology development and technical services) from 2007 to 2016 with a contract value of more than RMB12 billion.

Baidu is the world's first in-house institute focusing on the study of

deep learning. In March 2017, Baidu set up a new business group, the Artificial Intelligence Group, to bring AI-related departments together, aiming to better develop AI technologies and promote AI applications. Baidu is now among the top AI players in the world, with more than 10,000 R&D engineers.

AI at Indian Patent Office (IPO): **IPO** has received a bulk to 7,000 to 8,000 patent applications on AI related research and processes. Microsoft has filed 624 AI related patents at IPO.

India ranks third in fuzzy logic, fourth in machine learning scientific publications and fourth in machine learning. Top geographical affiliations by number of scientific publications for different AI functional applications are Australia, Canada, Germany, India, and U.K.

Artificial Intelligence and database

Data is one of the primary drivers of AI solutions, where three factors driving are. volume of available data, its quality, and costs incurred in data generations as well as its maintenance and security. Sharing of this data, and its accuracy, and collaboration and coordination with end users is useful in the AI.

Across the focused sectors, challenges are concentrated as follows:

- Lack of enabling data ecosystems
- Low intensity of AI research
- Inadequate availability of AI expertise, manpower and skilling opportunities
- High resource cost and low awareness for adopting AI in business processes
- Unclear privacy, security and ethical regulations
- Unattractive Intellectual Property regime to incentivise research and adoption of AI.

A robust intellectual property framework is required to ride the AI innovation wave in the country and to handle research as well as digitized database. To meet this requirement a National Policy of Intellectual Property Rights (IPR) had already been implemented on 12th May, 2016.

Therefore, the need of the hour for

agricultural research organization like ICAR is to develop a policy framework that will help to set up a vibrant AI ecosystem for facilitating the farming community.

ARTIFICIAL INTELLIGENCE IN INDIA

NASCCOM predicts that by 2022, a startling 46% of the Indian workforce will be engaged in entirely new jobs that do not exist today or jobs that have radically changed skill sets.

India had initiated different programmes to support these cutting edge technologies and use their importance for the growth of the country viz. Digital India, Start Up India, Make in India would help India establish itself as a knowledge and digital society. Recognising the importance of Artificial Intelligence (AI), the National Institution for Transforming India (NITI) Aayog has initiated in establishing the National Program on AI, with a view to guide the research and development in new and emerging technologies, and publish discussion paper on National Strategy for Artificial Intelligence.

NITI Aayog has adopted a three-pronged approach for building a vibrant AI ecosystem in India and collaborating with various experts and stakeholders, to position itself among leaders on the global AI map with a unique brand of AI for All (#AIforAll). This brand will aim at enhancing and empowering human capabilities to address the challenges of access, affordability, shortage and inconsistency of skilled expertise. It will specifically focus on harnessing collaborations and partnerships, and aspires to ensure prosperity for all.

NITI Aayog has decided to focus on five sectors that are envisioned to benefit the most from AI in solving societal needs:

- **Healthcare:** Increased access and affordability of quality healthcare.
- **Agriculture:** Enhanced farmers' income, increased farm productivity and reduction of wastage.
- **Education:** Improved access and quality of education.
- **Smart Cities and Infrastructure:**

Efficient and connectivity for the burgeoning urban population.

- **Smart Mobility and Transportation:** Smarter and safer modes of transportation and better traffic and congestion problems.

Growth of digital database in India

Accenture, in its recent AI research reports, provides a framework for evaluating the economic impact of AI for select G20 countries and estimates AI to boost India's annual growth rate by 1.3% points by 2035.

India is already known for its growth in the field of information technology and data management. Digitization of records and online services boost up this growth. New government policies on e-governance open up the path for common man to connect with digital world, today we can see the growth of the country on a single web page i.e. <https://transformingindia.mygov.in/>; where 117,552 *Gram Panchayats* connected by optical fiber; 1,46,18,767 farmers registered on e-NAM; 18,93,39,995 soil health cards dispatched to farmers; and 17,024 Start-ups recognised.

The banking services are in the reach of common man, where 39.37 million credit cards and 944.00 million debit cards are in operation. Now, the queues in banks for money transaction, loan applications, account opening are the history.

The growth in mobile technology, internet services, with relevant government policies made the India as the second largest smartphone market in the world, which is the

highest estimated growth posted by any country. Many smartphone companies are looking to India as their market of choice. Up to December, 2018 mobile data records, India is the second largest user of mobile phones (89.78 %) after China (96.40). By 2022, it is expected to hit 442 million smartphone users in India.

50 million WhatsApp video-calling minutes logged by Indians a day. 560 million internet subscribers are there in India, which will be increased by 835 million in 2023. 80 out of 100 Indian in high income states will have internet subscription by 2023. Mukesh Ambani's Jio, India has the cheapest mobile data in the world with 1GB costing just ` 18.5 (USD 0.26) as compared to global average of about ` 600. The global average was USD 8.53 for 1GB. All these resources will support to country to be hub for AI. Agriculture is the key sector with its 16% share in Country's GDP with an engagement of 60% population in job security. The use of information technology gave the proven results for people who live in rural area and engaged in farming activities.

Artificial Intelligence in Agriculture

Agriculture is the mainstay for 49% of India's workforce, and having 16% contribution in the its GDP, with the assurance of food security to 1.3 billion people. To achieve and maintain a higher annual growth rate of 8 to 10% for the Indian economy, agriculture sector has to grow with 4% or higher growth rate. In this

ICAR Initiative in the Field of AI

- ICAR institutional a three tier IP Management System for technology transfer, commercialization and having well defined guidelines, which resulted in with 1679 partnerships from 2007 to 2018 (975 from 2017 to 2018); with 967 public private partners.
- 72 ICAR institutes commercialized more than 700 technologies/ process/methods through this process. These partnerships helped ICAR's innovations to spread in 26 States and 3 Union Territories, especially in areas of Bio-formulations (516); Seed and Planting Material (340); Crop Husbandry and Biotechnology (259); Food Processing and Post-harvest Technologies (247) etc.
- 25 Agri-business Incubation (aBI) centres are supported/established in various institutes for facilitating agri-entrepreneurs/start-ups.

regard the Government of India has already prioritised Doubling Farmers' Income as a National Agenda, and putting a considerable focus on supply chain perspectives in agriculture and market development. AI holds the promise of driving a food revolution and meet the increased demand for food (global need to produce 50% more food and cater to an additional 2 billion people by 2050 as compared to today).

AI will have significant global impact on agricultural productivity at all levels of the value chain. Globally, digital and AI technologies are helping solve pressing issues across the agriculture value chain. An estimate by Markets and Markets Research valued AI in agriculture will be valued at USD 2.6 billion by 2025. According to CB Insights, agricultural tech start-ups have raised over USD 800 million in the last 5 years.

Adoption of AI in India has remained rather limited, less than a quarter of firms in India are using AI in any form for their business processes and startup ecosystem in AI is virtually non-existent.

Mobile apps in agriculture: Mobile apps are the key tools in the digital world, where use can get fast services with accuracy. India has around 30 million farmers who own smartphones, which is expected to grow 3 times by 2020 and 315 million rural Indians will be using internet by 2020. An Accenture study indicates that digital farming and connected farm services can impact 70 million Indian farmers in 2020, adding USD 9 billion to farmer incomes. The Indian Council of Agricultural Research (ICAR) being the apex organization for frontline extension education has also embraced the advantages of this pool of media resource and developed 117 farmer-friendly mobile apps i.e Crops 42; Horticulture 27; Veterinary 10; Dairy 6; Poultry 1; Fisheries 3; NRM 17; and Integrated 11.

Expert system in agriculture: The expert system is a computer system that emulates the decision-making ability of a human expert, which aims

to solve complex problems by reasoning knowledge. The concepts for expert system development come from the subject domain of AI, and require a departure from conventional computing practices and programming techniques. AgriDaksh, a tool for building online expert system is developed at Division of Computer Applications at Indian Agricultural Statistics Research Institute (IASRI) to overcome these hurdles. AgriDaksh is available online. AgriDaksh enables domain experts to build online expert system in their crops with minimal intervention of knowledge engineers and programmers. This in turn can reduce losses due to diseases and pest's infestation, improve productivity with proper variety selection and increase in income of the farmer. Maize AgriDaksh is the first expert system developed using AgriDaksh.

Drones can help farmers map their fields, monitor crop canopy remotely and check for anomalies. Over time, all this data can indicate useful practices in farms and make suggestions based on previous crop cycles; resulting in higher yields, lower inputs and less environmental impact.

FarmBeats: FarmBeats an end-to-end IoT platform for data-driven agriculture, that enables seamless data collection from various sensor types, i.e., cameras, drones and soil sensors, with very different bandwidth constraints. This AI tool developed by Microsoft. FarmBeats can ensure system availability even in the face of power and Internet outages caused by bad weather; scenarios that are fairly common for a farm. Further, FarmBeats enables cloud connectivity for the sensor data to enable persistent storage as well as long-term or cross-farm analytics. FarmBeats enable three applications for the farmer: precision agriculture, monitoring temperature and humidity in food storage, and monitoring animal shelters.

FarmBeats makes the following key contributions:

- Long-term large scale deployment

- Novel Inference Techniques for Compression of Aerial Imagery Data
- Wind-Assisted Drone Flight Planning Algorithm.

Policy Issues

Technology is not destiny; economic incentives and public policy can play a significant role in shaping the direction and effects of technological change. Given appropriate attention and the right policy and institutional responses, advanced automation can be compatible with productivity, high levels of employment, and more broadly shared prosperity.

Recommendations

There are potential security threats from malicious uses of artificial intelligence technologies, and proposes ways to better forecast, prevent, and mitigate these threats viz.

- Policymakers should collaborate closely with technical researchers to investigate, prevent, and mitigate potential malicious uses of AI.
- Researchers and engineers in artificial intelligence should take the dual-use nature of their work seriously, allowing misuse related considerations to influence research priorities and norms, and proactively reaching out to relevant actors when harmful applications are foreseeable.
- Best practices should be identified in research areas with more mature methods for addressing dual-use concerns, such as computer security, and imported where applicable to the case of AI.
- Actively seek to expand the range of stakeholders and domain experts involved in discussions of these challenges.

¹Senior Scientist, Intellectual Property and Technology Management Unit, ²Scientist, ICAR-DKMA, and ³Principal Scientist, ICAR-IPTM. e mail: kmnmvs@gmail.com
