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ARTIFICIAL INTELLIGENCE AND THE CHANGING DIMENSIONS OF AGRICULTURE SECTOR IN INDIA

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ABSTRACT

Artificial Intelligence is an approach to make a computer, a robot, or a product to think how smart human think. AI is a study of logical thinking of human brain in decision making process which ultimately study outputs intelligent software systems. The study of AI aspires to improve computer functions which are related to human knowledge.[1] *We are a privileged generation to live in this technological advancements era wherein majority of the tasks, complex stuff are taken over by machines, software, and various automatic processes. Artificial intelligence or AI is nothing but the science of computers and machines developing intelligence like humans.*[2]

Agriculture is seeing rapid adoption of Artificial Intelligence (AI) and Machine Learning (ML) both in terms of agricultural products and in-field farming techniques. Cognitive computing in particular is all set to become the most disruptive technology in agriculture services as it can understand, learn, and respond to different situations (based on learning) to increase efficiency.

[1] https://becominghuman.ai/introduction-to-artificial-intelligence-5fba0148ec99
https://www.ibef.org/industry/agriculture-india.aspx
[2] https://www.**enterpriseedges**.com/importance-artificial-intelligence

Providing some of these solutions as a service like chat bots or other conversational platform to all the farmers will help them keep pace with technological advancements as well as apply the same in their daily farming to reap the benefits of this service.

According to UN Food and Agriculture Organization, the population will increase by 2 billion by 2050.[3] *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 Artificial Intelligence (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. In this article, the author specifically discussed the effective use of Artificial Intelligence in changing the landscape of Agriculture sector in India, various projects and programme initiated by the Government of India, Start Ups working effectively under the new dimensions of farming and sustainable development ahead.*

Key Words: Artificial Intelligence (AI), The Defense Advanced Research Projects Agency (DARPA), Food and Agriculture organisation of the United Nations (FAO), Gross Value Added (GVA), India Brand Equity Foundation (IBEF), Foreign Direct Investment (FDI), Department of Industrial Policy and Promotion (DIPP), 'Pradhan Mantri Annadata Aay SanraksHan Abhiyan' (PM-AASHA), ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), Cabinet Committee on Economic Affairs (CCEA), Soil Health Cards (SHCs), Pradhan Mantri Krishi Sinchai Yojana (PMKSY), Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters (SAMPADA). Total Quality Management (TQM), Hazard Analysis and Critical Control Points (HACCP), Good Manufacturing Practices (GMP) and Good Hygienic Practices (GHP), The Electronic National Agriculture Market (eNAM), Paramparagat Krishi Vikas Yojana (PKVY)

[3] https://www.mindtree.com/sites/default/files/2018-04/Artificial%20Intelligence%20in%20Agriculture.pdf

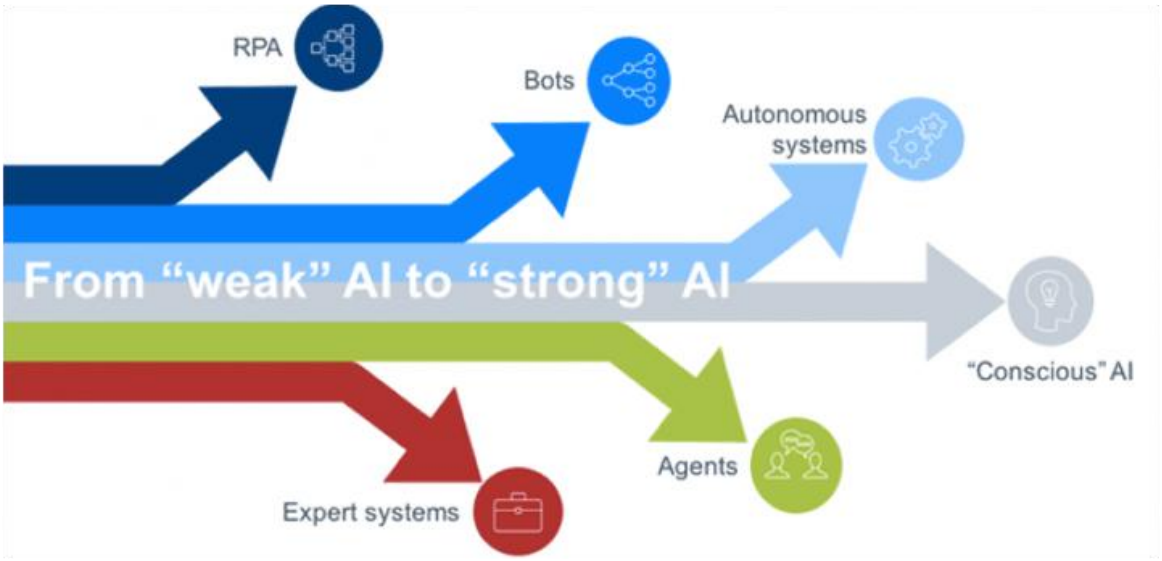
Introduction

AI is a constellation of technologies that enable machines to act with higher levels of intelligence and emulate the human capabilities of sense, comprehend and act. The term artificial intelligence was coined in 1956, but AI has become more popular today thanks to increased data volumes, advanced algorithms, and improvements in computing power and storage. Early AI research in the 1950s explored topics like problem solving and symbolic methods. In the 1960s, the US Department of Defense took interest in this type of work and began training computers to mimic basic human reasoning. For example, the Defense Advanced Research Projects Agency (DARPA) completed street mapping projects in the 1970s. And DARPA produced intelligent personal assistants in 2003, long before Siri, Alexa or Cortana were household names. This early work paved the way for the automation and formal reasoning that we see in computers today, including decision support systems and smart search systems that can be designed to complement and augment human abilities. Instead, AI has evolved to provide many specific benefits in every industry.[4]

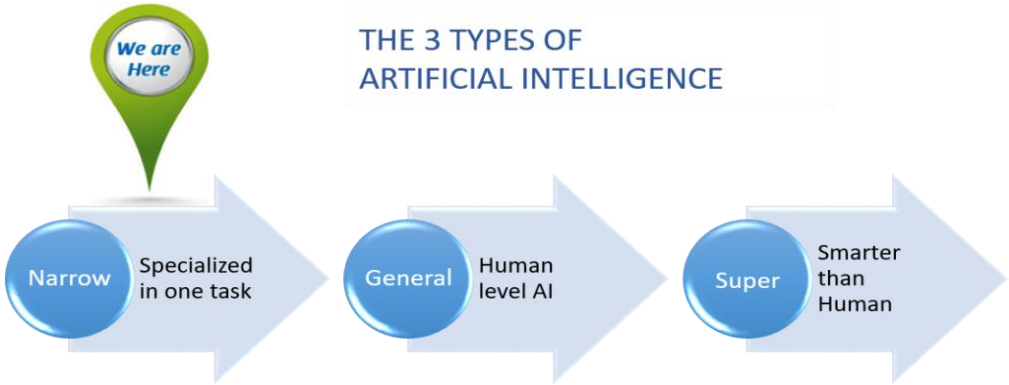
Progression of Artificial Intelligence

Weak AI and Strong AI: Strong Artificial Intelligence can be defined as a phenomenon under which such machines can be built which can actually use human intelligence in their functions. Another way of describing them will be that machines which are able to represent the human mind in the activities they perform. Weak Artificial Intelligence is the phenomenon that machines which is not too intelligent to do their own work can be built in such a way that they seem smart. Weak AI simply acts upon and is bound by the rules imposed on it and it could not go beyond those rules. A good example of weak AI are characters in a computer game that act believably within the context of their game character, but are unable to do anything beyond that.

[4] https://www.sas.com/en_us/insights/analytics/what-is-artificial-intelligence.html



Narrow AI and General AI: General AI, also known as human-level AI or strong AI, is the type of Artificial Intelligence that can understand and reason its environment as a human would. General AI has always been elusive. Narrow AI is the only form of Artificial Intelligence that humanity has achieved so far. This is AI that is good at performing a single task, such as playing chess or goes, making purchase suggestions, sales predictions and weather forecasts. Computer vision, natural language processing are still at the current stage narrow AI.[5]



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[5] https://bdtechtalks.com/2017/05/12/what-is-narrow-general-and-super-artificial-intelligence/

[6] https://www.google.com/search?biw=1366&bih=608&tbm=isch&sa=1&ei=czYXXMCUFovGvgSvqIfIAQ&q=narro

Super intelligence: The term "super intelligence" is often used to refer to general and strong AI at the point at which it surpasses human intelligence, if it ever does.

Technology which will reinvent the world

Scientists across the globe are riding on the back of AI when machine intelligence will surpass the human intelligence and it may reinvent the world that we know today. Think of the world where all the menial tasks such as garbage disposal, construction, digging and so on will be taken care of by the AI application. It will be a time when the hierarchical order dictates the limits of a human. It will be the world where no one will be looked down upon and every human will be considered equal. In this way, the humans can then focus their strengths on higher levels of work to accomplish a lot more and always taking technology to the new heights.

Risk in technology

Although there are numerous benefits attached to new advanced technology, but with every great innovation, there is also a certain amount of risk. Since these technology may be used for mass destruction or other illegal activities. To regulate this crucial aspect of AI application and systems the oversight needs to be on the national and international level so that all the countries can be at peace and experience growth in their respective countries. However, there are various laws, regulatory guidelines, and procedures that monitor the use of artificial intelligence in today's time, and so the safety of us humans is always the prime concern here. Artificial Intelligence plays a very important role in not just the development of business and processes but also the humans to the next level. With the rapid growth in technology and development, we can expect a lot more exciting features and uses of AI in the future.

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Artificial Intelligence and Agriculture Sector in India

Agriculture is the primary source of livelihood for about 58 per cent of India's population. Gross Value Added by agriculture, forestry and fishing is estimated at Rs 17.67 trillion (US$ 274.23 billion) in FY18.[7]

Today, one of the main global challenges is how to ensure food security for a world growing population whilst ensuring long-term sustainable development. According to the FAO, food production will need to grow by 70% to feed world population which will reach 9 billion by 2050.[8]

The Indian food industry is on the edge for huge growth annually, increasing its contribution to world food trade due to its immense potential for value addition, particularly within the food processing industry. The Indian food and grocery market is the world's sixth largest, with retail contributing 70 per cent of the sales. The Indian food processing industry accounts for 32 per cent of the country's total food market, one of the largest industries in India and is ranked fifth in terms of production, consumption, export and expected growth. It contributes around 8.80 and 8.39 per cent of Gross Value Added (GVA) in Manufacturing and Agriculture respectively, 13 per cent of India's exports and six per cent of total industrial investment.[9]

Agriculture plays a vital role in India's economy. Over 58 percent of the rural households depend on agriculture as their principal means of livelihood, according to an IBEF report. An agricultural export constitutes 10 percent of the country's exports and is the fourth-largest exported principal commodity category in India.

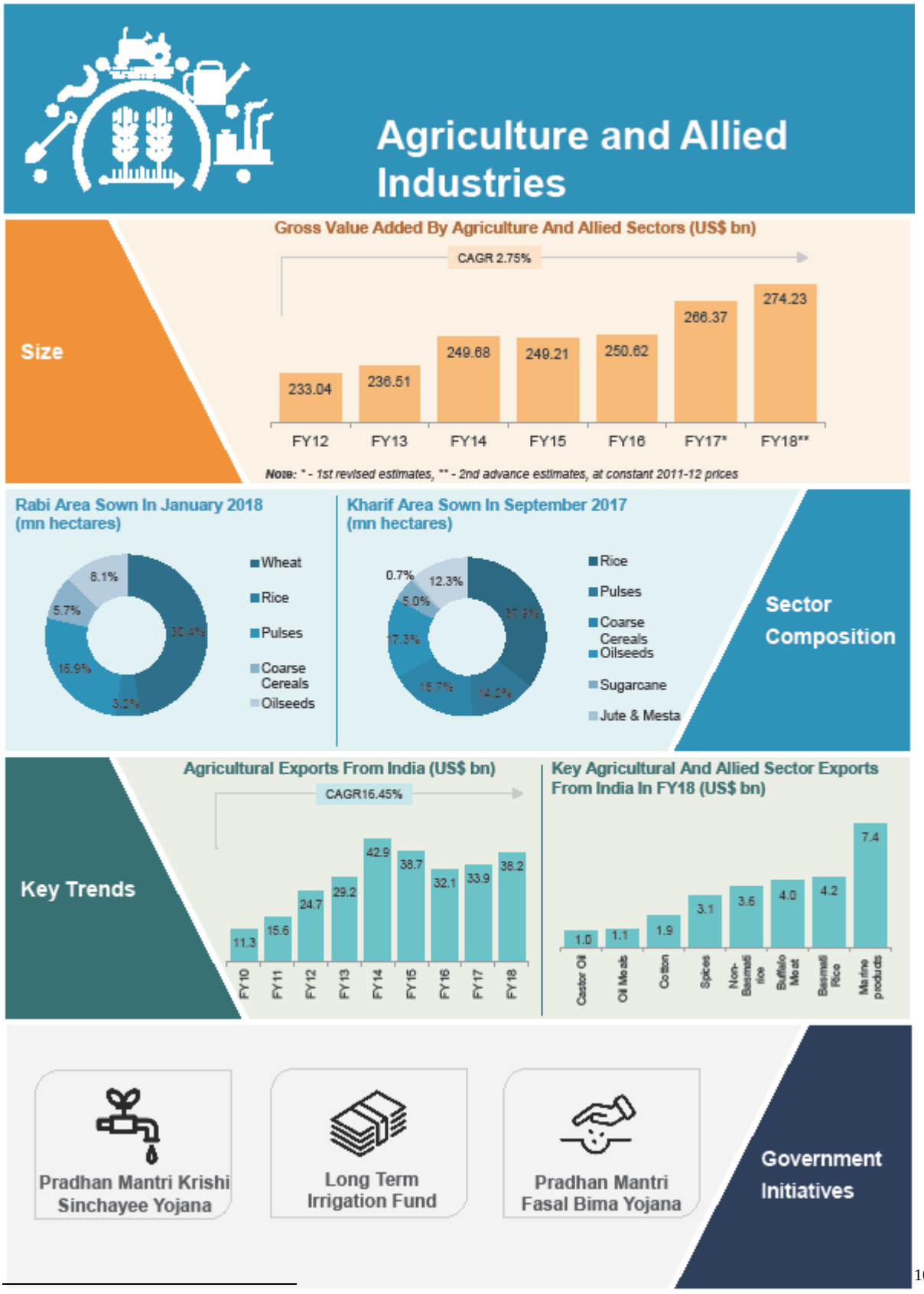
Analyzing Satellite Images

According to the Department of Industrial Policy and Promotion (DIPP), the Indian agricultural services and agricultural machinery sectors have cumulatively attracted Foreign Direct Investment (FDI) equity inflow of about $2.45 billion and the food processing sector has attracted around $7.81 billion during April 2000 to June 2017. With an aim to boost innovation and

[7] https://www.ibef.org/industry/agriculture-india.aspx
[8] http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf
[9] https://www.ibef.org/industry/agriculture-india.aspx

entrepreneurship in agriculture, the government of India is introducing a new AGRI-UDAAN programme to mentor startups and enable them to connect with potential investors.

On the back of increased FDI and the effective government initiatives, the agriculture sector is increasingly looking at ways to leverage technology for better crop yield. Many technology companies and startups have emerged in the past few years with targeted Agri-based solutions that benefit the farmers.



[10] https://www.ibef.org/industry/agriculture-india/infographic

Challenges in Agriculture which AI can solve[11]

The use of artificial intelligence, particularly via the use of robots, will be a key feature of the Agri tech revolution over the coming years as labour shortages intensify and questions over global food security intensify. We have seen robots being utilized in five key areas, including IoT, sensing, planning, automated manipulation, and machine learning. However, there will be key challenges to overcome and research in this space will accelerate.[12]

However following are few prominent areas wherein AI can be beneficial for Agriculture sector

Soil health monitoring and restoration: Image recognition and deep learning models have enabled distributed soil health monitoring without the need of laboratory testing infrastructure. AI solutions integrated with data signals from remote satellites, as well as local image capture in the farm, have made it possible for farmers to take immediate actions to restore soil health.

Crop health monitoring and providing real time action advisories to farmers: The Indian agriculture sector is vulnerable to climate change since the dependency on rain is always on a higher side. Frequent varying weather patterns such as increase in temperature, changes in precipitation levels, and ground water density, drastically affecting the farmers of the country. AI can be used to predict advisories for sowing, pest control, input control can help in ensuring increased income and providing stability for the agricultural community.

Increasing the share of price realisation to producers: Current low levels of price realisation to farmers (as low as 20% in fruits and vegetables19) are primarily due to ineffective price discovery and dissemination mechanisms, supply chain intermediary inefficiency and local regulations. Predictive analytics using AI tools can bring more accurate supply and demand information to farmers, thus reducing information asymmetry between farmers and intermediaries.

In this article, the author explore applications of artificial intelligence (AI) with an understanding of current and emerging trends, and the examples of popular applications in agriculture sector in India.

[11] Inputs were given by Dr. Amit Bhardwaj during 2018 Uncitral Asia Pacific Day Celebration at GNLU on 15th December 2018.

[12] https://www.fitchsolutions.com/corporates/commodities/agriculture-ai-many-applications-future-challenges-28-09-2018

The most popular applications of AI and Start- Up in agriculture Sector in India appear to fall into three major categories:[13]

I. Crop and Soil Monitoring – Companies are leveraging sensors and various IoT-based technologies to monitor crop and soil health.

Crop In[14] is a Bengaluru-based startup which claims to be an intuitive, intelligent, and self-evolving system that delivers future-ready farming solutions to the agricultural sector. To explain the benefits of Crop In technology, the company cites a use case with one of the world's largest producers of potato Specialties Company based in India which leases plots for farming and has 2500+ plots spread across an area of 5200+ acres. Earlier, they used to record farm data manually, thus creating multiple inconsistent entries.

With Crop In 'smart farm' solution, all the plots were geo-tagged to find the actual plot area. The solution helped in remote sensing and weather advisory, scheduling and monitoring farm activities for complete traceability, educating farmers on adoption of right package of practices and inputs, monitoring crop health and harvest estimation, and alerts on pest, diseases etc.

Essentially, Crop In uses technologies such as AI to help clients analyze and interpret data to derive real-time actionable insights on standing crop and projects spanning geographies. Its agri-business intelligence solution called Smart Risk "leverages Agri-alternate data and provides risk mitigation and forecasting for effective credit risk assessment and loan recovery assistance.

II. Predictive Agricultural Analytics – 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[15] 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

[13] https://emerj.com/ai-sector-overviews/artificial-intelligence-in-indian-agriculture-an-industry-and-startup-overview/
[14] http://www.cropin.com/
[15] http://www.intellolabs.com/

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.

Intello Labs claims to provide:

- **Agricultural Product Grading:** Automated quality analysis of images of food products is an accurate and reliable method for grading fresh products (fruits, grains, vegetables, cotton etc.) characterized by color, size and shape. Their solution reads the image that a farmer has taken on his phone and determines the product quality in real time, without any manual intervention.

- **Alerts on Crop Infestation:** Farmers can click an image of their crop and use their solution to understand the pests, diseases, and foreign plants (weeds) growing in their farms. The solution uses deep learning and image processing models to identify any crop diseases or pest infestation in the crops. Along with the parameters, it gives recommendations on how that disease can be cured and prevented from increasing further.

The firm has no case studies or visual demos of the technology at this time.

Predictive Agricultural Analytics

Microsoft India – AI-based Sowing App[16]

Determining the right time to sow crops is often one of the biggest challenges for Indian farmers where drought and excess rainfall can be equally serious challenges. Microsoft in collaboration with ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), developed an AI Sowing App that uses machine learning and business intelligence from the Microsoft Cortina Intelligence Suite.

The app sends sowing advisories to participating farmers on the optimal date to sow "The best part – the farmers don't need to install any sensors in their fields or incur any capital expenditure.

[16] https://www.gizbot.com/apps/news/microsoft-builds-ai-powered-sowing-app-to-help-farmers-in-india-046485.html

All they need is a feature phone capable of receiving text messages," a Microsoft India report stated.

III. 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.

Agri Supply Chain

Gobasco — the Intelligent Agri Supply Chain[17]

Based in the North Indian state of Uttar Pradesh, Gobasco has the advantage of a high-tech team. Vedant Katyar, co-founder & CEO of the company is an engineering graduate from premier Indian technology institute BITS Pilani while CTO Abhishek Sharma is a PhD in Artificial Intelligence from the University of Maryland in the US.

Gobasco claims to employ real-time data analytics on data-streams coming from multiple sources across the country aided with AI-optimized automated pipelines to dramatically increase the

[17] https://www.vccircle.com/matrix-partners-invests-in-agri-supply-chain-optimisation-startup-gobasco/

efficiency of the current Agri supply chain. "Our data-driven online Agri-marketplace affords the best prices for both the producers and buyers at their fingertips.

Through our carefully engineered tech-driven pipeline, designed for the Indian Agri supply-chain, we operate at a higher profit margin than the traditional companies," the company stated in its website.

Gobasco uses AI and related technologies in the various stages of the Agri supply chain to ensure it is efficient and fast. Some of them are listed below:

- **Transition Discovery:** Real-time data analysis on multiple data-streams along with crowd-sourced data from producer/buyer marketplaces and transporters feeds their automatic transaction discovery algorithm to obtain high-margin transactions.
- **Quality Maintenance:** Computer vision and AI-based automatic grading and sorting is done for vegetables and fruits for creating an international Agri-commodity standard for reliable trading across country boundaries.
- **Credit Risk Management:** Crowd-sourced data, algorithms and analytics overcome the credit default problem, the most challenging problem of current supply-chain, to ensure a very low risk operation.
- **Agri-Mapping:** Deep-learning based satellite image analysis and crowd-sourced information fusion obtains a real-time Agri map of commodities at a resolution of 1 sq-km.

Gramophone (Agstack Technologies) – Image Recognition for Soil Science[18]

Based in the Indian state of Madhya Pradesh, Gramophone claims to leverage the power of image recognition and soil science to help farmers with timely information, technology, and right kind of inputs to achieve better yields.

"Our technology platform uses AI and machine learning to predict pest and disease, forecast commodity prices for better price realizations and recommends products to farmers," Tauseef

[18] https://www.gramophone.in/

Khan, co-founder of the company, told *Tech Emergence*. Nishant Vats, co-founder of Gramophone, added: "Image recognition technology in tandem with our proprietary database gives diagnosis of problems. We use temperature, humidity and pathology/entomology data to give accurate advisory to the farmers. Our primary focus is to digitize agriculture science and convert it into actionable information for the farmers to provide personalized farm management solution which would guide farmers across the cropping cycle."

Khan says that the proprietary database developed in-house by them is a result of two years of ground work. "We are a team of agriculture engineers and technology experts from IITs. Our understanding of the ecosystem is the key."

Gramophone claims to reach out to more than 100,000 farmers in the state with a productivity improvement of more than 50 percent in the three cropping cycles that they have been associated with. Their goal this year is to reach a million farmers and localize our platform in few more languages.

Jivabhumi – The "Smart" Agriculture Marketplace[19]

There is often a mismatch in supply and demand of agricultural produce. While on one side farmers are unable to find suitable markets for their produce, on the other hand, consumers are devoid of safe and affordable food. Jivabhumi's 'Foodprint' is a produce aggregation and food traceability solution which aggregates the farm produce, provides e-marketplace services and implements traceability. It claims to use technologies such as blockchain to capture the information of the produce at various levels in the supply chain.

Srivatsa TS, co-founder of Jivabhumi in conversation with Tech Emergence emphasized that "The platform connects institutional buyers directly with farmers thus providing wider market access to the farmers and ensuring fair-trade. Buyers get to discover the produce, price and be able to procure directly from the producers while being sure about the transparency of the transaction and traceability of the produce"

[19] http://coe-iot.com/agritech/

According to Srivatsa, the platform captures comprehensive information about the commodities (growing information, pre- and post-harvest, transportation, warehousing etc) which "will be pushed through block chain to generate a digital identity for a physical commodity and eventually build traceability to prove provenance and movement of commodities from farm to table. On the other hand, AI engine will leverage the comprehensive aggregation of data at various points in supply chain to proactively advice farmers on sowing, pest control, harvesting etc."

When we think about agriculture, we tend to think about old-school farming. But although many of us might think that the agricultural community is behind the curve when it comes to implementing new technologies, there is lots of evidence that farmers are actually moving quite quickly to modernize almost everything about the farming process – they're using artificial intelligence in new and amazing ways to bring the process of food cultivation into the future.

High-tech agriculture starts at the very second that the seed is first placed in the ground. Experts in the field are familiar with "variable rate planting equipment" that does more than just planting a seed down into the dirt somewhere. The power of artificial intelligence is being applied to agricultural big data in order to make farming much more efficient – and that's only the beginning.

Companies like Harvest Croo[20] which has produced an autonomous strawberry picking machine, and Abundant Technologies, where a vacuum apparatus harvests mature apples from trees.

While manufacturing robots have been around for a while, these harvesting technologies are really something new in many ways. Harvest technologies like the Harvest Croo berry picker operate on the basis of machine vision and sensor fusion to "see" where harvest fruits and berries are. They use sophisticated directed movements to pick precisely. This is the kind of functionality that is very much in the "artificial intelligence" field and mimics human cognition and directed action.

Agricultural robotics is filling a need as labor pools decrease. But it's also saving humans from one of the most repetitive and difficult jobs in our economy.

[20] https://harvestcroo.com/

People simply don't want to have to harvest enormous amounts of produce all day, every day. In that sense, harvest robotics is also making our world a little more enjoyable. Now, if people do want to pick by hand, boutique orchards and gardens offer that option!

As for jobs automation, we'll have to see how our societies deal with the reality that we're automating almost every other kind of job as well. But for now, harvest robotics presents a real landmark in the very rapid modernization of the farming world.

How are farms using artificial intelligence to direct crop planting, harvesting and more, and how are they getting that data in the first place?

In some trade journals, you can see unmanned aerial vehicles or drones being outfitted with precision sensors, in order to run the fields and get the data that's needed. These airborne surveillance engines can look for stunted crops, signs of pest or weed damage, dryness and many other variables that are part of the difficulty of farming in general. With all of this data in hand, farmers can enhance their production models and their strategies across the lay of the land to decrease risk, waste and liability.

Yesterday's farmers were living in fear of the windstorm and the grasshopper – not anymore. Farmers are quickly adopting new high-tech ways of protecting plants against weeds and various kinds of pests outdoors. Another alternative is to grow in greenhouses, which is being done as well, but some of the most amazing farming technology is being deployed outside.

We know that artificial intelligence excels at image processing – computers can now "see" almost as well as we can. So by deploying mobile technologies with AI and computer vision built in, farmers can find weeds and eradicate them, instead of blanket spraying an entire crop. That makes the food cleaner, and it saves enormous amounts of money. It's just another example of real new technologies that are having a dramatic impact on yields and everything else.

When we talk about machine learning and artificial intelligence, we often talk about algorithms. The mathematical models behind the computer science are the fundamental basis for how we deal with big data to make decisions.

Companies are now quickly developing agricultural yield boosting algorithms that can show farmers what's going to be best for a crop. Despite some concerns about the difficulty of doing

this type of analysis in nature, farmers and others have been able to make quite a lot of headway in maximizing crop yield, simply by applying the algorithms and intelligence generators that we've built to help computers imitate our own cognitive abilities.

There is one more very interesting groundbreaking technology that might also be one of the highlights in the modern farmer's tech toolkit.

Companies are talking about creating chat bots for farmers, artificial intelligence personalities like the smart home helper "Alexa" that are able to converse with farmers to help them figure out tough problems. We're hoping that these specialized farming chat bots are a little more capable than Alexa, since the current consumer technology basically provides encyclopedic facts and figures and not much else. However, if they're packed with the right answers and analytics information, the farmer's chat bots could be a real boon to busy farm managers who are doing all they can to expand and grow their businesses.

These are some of the best new technologies coming out to help farmers produce all the food that we need in a rapidly changing world. Population growth and climate change will be massive challenges, but artificial intelligence deployment can help blunt the impact of these and other challenges, and make smart farming much more resistant to the problems that farmers face.[21]

Investments

According to the Department of Industrial Policy and Promotion (DIPP), the Indian food processing industry has cumulatively attracted Foreign Direct Investment (FDI) equity inflow of about US$ 8.57 billion between April 2000 and June 2018.

Some major investments and developments in agriculture are as follows:[22]

- The first mega food park in Rajasthan was inaugurated in March 2018.
- In 2017, agriculture sector in India witnessed 18 M&A deals worth US$ 251 million.

[21]https://www.techopedia.com/the-6-most-amazing-ai-advances-in-agriculture/2/33177

[22] Agricultural and Processed Food Products Export Development Authority (APEDA), Department of Commerce and Industry, Union Budget 2018–19, Press Information Bureau, Ministry of Statistics and Programme Implementation, Press Releases, Media Reports, Ministry of Agriculture and Farmers Welfare, Crisil

- A loan agreement of US$ 318 million was signed between the Government of India, Government of Tamil Nadu and the World Bank in December 2017 for the 'Tamil Nadu Irrigated Agriculture Modernization Project' through which is expected to benefit around 500,000 farmers in the state.

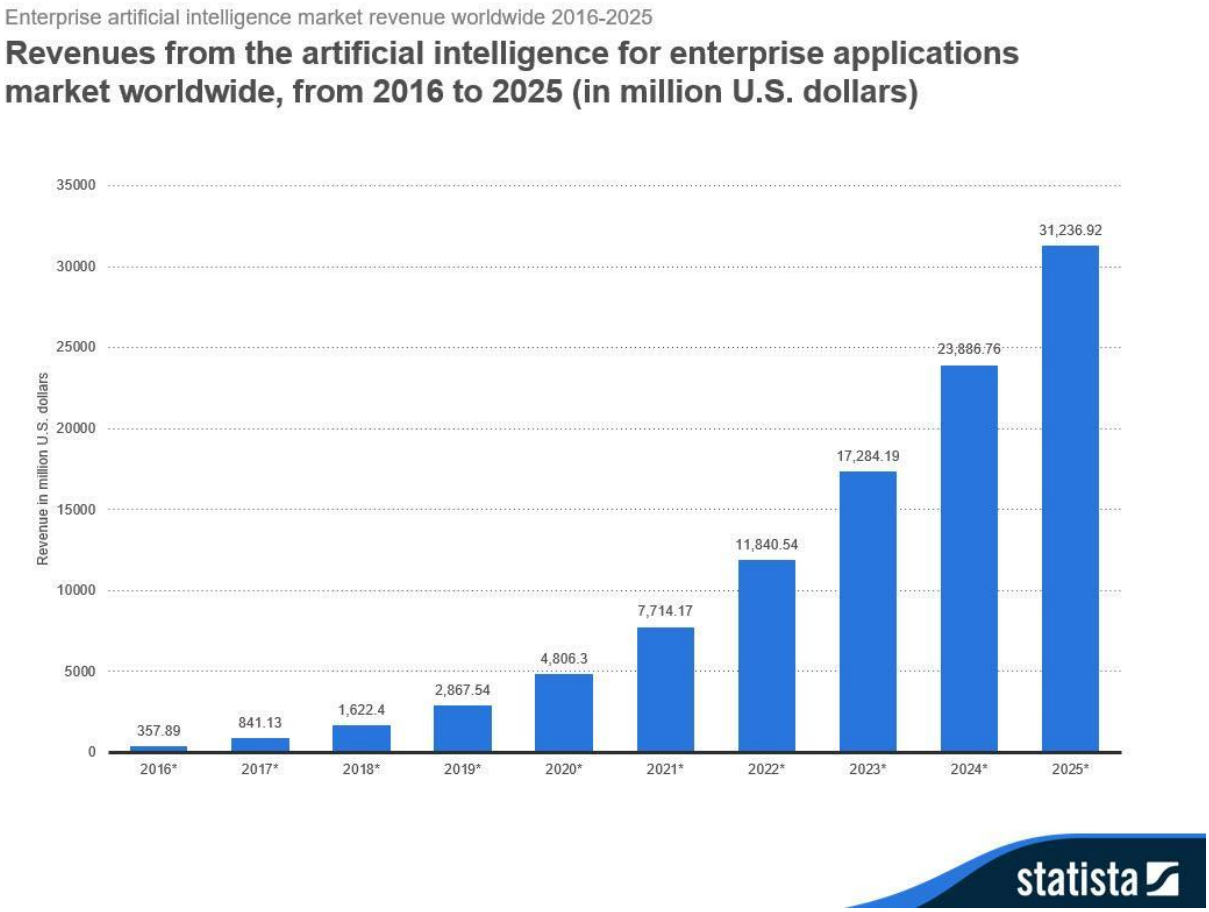
Government Initiatives

Some of the recent major government initiatives in the sector are as follows:

- In September 2018, the Government of India announced Rs 15,053 crore (US$ 2.25 billion) procurement policy named 'Pradhan Mantri Annadata Aay SanraksHan Abhiyan' (PM-AASHA), under which states can decide the compensation scheme and can also partner with private agencies to ensure fair prices for farmers in the country.
- In September 2018, the Cabinet Committee on Economic Affairs (CCEA) approved a Rs 5,500 crore (US$ 820.41 million) assistance package for the sugar industry in India.
- As of March 2018, the Government is working on a plan to provide air cargo support to promote agriculture exports from India.
- The implementation of Pradhan Mantri Fasal Bima Yojana (PMFBY) will be made faster and the government is aiming to increase the coverage under the scheme to 50 per cent of gross cropped area in 2018-19.
- The Government of India is going to provide Rs 2,000 crore (US$ 306.29 million) for computerization of Primary Agricultural Credit Society (PACS) to ensure cooperatives are benefitted through digital technology.
- Around 100 million Soil Health Cards (SHCs) have been distributed in the country during 2015-17 and a soil health mobile app has been launched to help Indian farmers.
- With an aim to boost innovation and entrepreneurship in agriculture, the Government of India is introducing a new AGRI-UDAAN programme to mentor start-ups and to enable them to connect with potential investors.
- The Government of India has launched the Pradhan Mantri Krishi Sinchai Yojana (PMKSY) with an investment of Rs 50,000 crore (US$ 7.7 billion) aimed at development of irrigation sources for providing a permanent solution from drought.
- The Government of India plans to triple the capacity of food processing sector in India from the current 10 per cent of agriculture produce and has also committed Rs 6,000

crore (US$ 936.38 billion) as investments for mega food parks in the country, as a part of the Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters (SAMPADA).

- The Government of India has allowed 100 per cent FDI in marketing of food products and in food product e-commerce under the automatic route.



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Emerging Opportunities for India and Road Ahead

India is expected to achieve the ambitious goal of doubling farm income by 2022. The agriculture sector in India is expected to generate better momentum in the next few years due to increased investments in agricultural infrastructure such as irrigation facilities, warehousing and cold storage. Furthermore, the growing use of genetically modified crops will likely improve the yield for Indian farmers. India is expected to be self-sufficient in pulses in the coming few years due to concerted efforts of scientists to get early-maturing varieties of pulses and the increase in minimum support price.

The government of India targets to increase the average income of a farmer household at current prices to Rs 219,724 (US$ 3,420.21) by 2022-23 from Rs 96,703 (US$ 1,505.27) in 2015-16.

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24 https://www.google.com/search?q=artificial+intelligence+and+development+in+india&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiJgN7koabfAhUeT48KHXbSAzAQ_AUIDigB&biw=1366&bih=608#imgdii=AxBynz1LnoTTQM:&imgrc=0OW6EQjH7h2NLM:

Going forward, the adoption of food safety and quality assurance mechanisms such as Total Quality Management (TQM) including ISO 9000, ISO 22000, Hazard Analysis and Critical Control Points (HACCP), Good Manufacturing Practices (GMP) and Good Hygienic Practices (GHP) by the food processing industry will offer several benefits.

India has the 10th-largest arable land resources in the world. With 20 Agri-climatic regions, all 15 major climates in the world exist in India. The country also possesses 46 of the 60 soil types in the world. India is the largest producer of spices, pulses, milk, tea, cashew and jute; and the second largest producer of wheat, rice, fruits and vegetables, sugarcane, cotton and oilseeds.

Further, India is second in global production of fruits and vegetables, and is the largest producer of mango and banana. During 2017-18 crop years, food grain production is estimated at record 284.83 million tones.

In 2018-19, Government of India is targeting food grain production of 285.2 million tones. Production of horticulture crops is estimated at 306.82million tons (mt) in 2017-18 as per third advance estimates. India is among the 15 leading exporters of agricultural products in the world. Agricultural exports from India reached US$ 38.21 billion in FY18 and US$ 15.67 billion in April-August 2018. Exports of ready to eat items from India reached US$ 689.80 million in FY18. The Government of India is aiming to achieve US$ 60 billion in agricultural exports by 2022. India was the ninth largest exporter of agricultural products in 2017.

The Electronic National Agriculture Market (eNAM) was launched in April 2016 to create a unified national market for agricultural commodities by networking existing Agriculture Produce Marketing Committees (APMCs). Up to May 2018, 9.87 million farmers, 109,725 traders were registered on the e- NAM platform. 585 mandis in India have been linked while 415 additional mandis will be linked in 2018- 19 and 2019-20. Cumulative trade on the platform reached Rs 41,855 crore (US$ 6.49 billion) by March 2018. Under Union Budget 2018-19, an Agri-Market Infrastructure Fund was announced to develop and upgrade the infrastructure in 22,000 Grameen Agricultural Markets (GrAMs) and 585 APMCs. 42 mega food parks have been sanctioned as of 2017 out of which eight had been made operational as of July 2018.

The Government of India has introduced several projects to assist the agriculture sector. They are Pradhanmantri Gram Sinchai Yojana: The scheme aims to irrigate the field of every farmer and improving water use efficiency to achieve the motto `Per Drop More Crop'. Overall the scheme ensures improved access to irrigation. Around 285 new irrigation projects will be undertaken in

2018 to provide irrigation for 18.8 million hectares of land. As per Union Budget 2018-19 the scheme has been allocated US$ 401.6 million. Paramparagat Krishi Vikas Yojana (PKVY): The scheme aims to motivate groups of farmers to take up organic farming.

Conclusion

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.

AI comes as a great boon to the agricultural sector which is heavily dependent on climatic conditions which are often unpredictable. Since various companies are using sensors for crop and soil monitoring, as well as AI and machine learning tools for predictive analytics. In case of Jivabhumi, we have seen the use of block chain to create a transparent online marketplace to buy and sell crops under one platform. More and more use cases of AI in agriculture are likely to show up in the near future because of the immense value it can add.

Though Artificial Intelligence offers vast opportunities for application in agriculture, there still exists a lack of familiarity with high tech machine learning solutions in farms across most parts of the world. Exposure of farming to external factors like weather conditions, soil conditions and presence of pests is quite a lot. So what might look like a good solution while planning during the start of harvesting may not be an optimal one because of changes in external parameters AI systems also needs a lot of data to train machines and to make precise predictions? In case of vast agricultural land, though spatial data can be gathered easily, temporal data is hard to get. For example, most of the crop-specific data can be obtained only once in a year when the crops are growing. Since the data infrastructure takes time to mature, it requires a significant amount of time to build a robust machine learning model. This is one reason why AI sees a lot of use in agronomic products such as seeds, fertilizer, pesticides and so on rather than in-field precision solutions.[25]

[25]https://www.mindtree.com/sites/default/files/2018-04/Artificial%20Intelligence%20in%20Agriculture.pdf

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. Further, the inadequate availability of AI expertise, manpower and skilling opportunities and high resource cost and low awareness for adopting AI in business processes. Hence the AI sowing app, Irrigation patters for crop type and AI for herbicide optimization, enabling data ecosystem and promotion of collaborative research among the established centres of excellence is essential for achieving the parameters of sustainable development in Agriculture sector in India.

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