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Intelligent Agriscience: Epoch of AI in Indian Agriculture

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Abstract **Cultivation is seeing prompt advocacy of Artificial Intelligence (AI) in terms of cultivated products and in-field farming techniques. Intellectual computing in particular is all set to become the wildest technology in agriculture services as it can understand, learn, and respond to different situations to surge competence. This paper inspects current creativities in AI in Indian agriculture – both private and state-led – and attempt to appraise their prospective for furthering development. It initiate with a momentary overview of the state of agriculture in India, the policy thinking of the Indian state on the part of AI in agriculture and key obstruction that bear upon its efficacious adoption and uptake. This is followed by an analysis of private sector trends in the domain. Lastly, it discusses the prospects for AI in agriculture, along with directions for policy. Insights offered in this paper draw from interviews with AI startup founders, digital platform companies, knowledge experts and public officials, along with secondary research. What this paper attempts is not exhaustive and is limited to a preliminary scoping of the current outlook for the domain. As a result, AI is progressively crop up as a part of the industry's technological appraisal. In this paper, we cover challenges faced by farmers by using traditional methods of farming and the way AI is making a revolution in agriculture by replacing traditional methods by using more efficient methods and helping the planet to become a far better place. Also discuss how AI can commute the cultivation landscape, the appliance of drone-based image processing techniques, precision farming landscape, the longer term of agriculture and therefore the challenges ahead.**

Keywords — Artificial Intelligence, Internet of Things, Agritech, Pharmacogenetics, Agronomist

I. How is AI Revolutionizing Agriculture

At two ends of the planet , in Tokyo and San Francisco , fully automated "vertical indoor farms" powered by AI (AI) technologies and operated by robots are bringing to life the thought of a "next- generation control environment agriculture."

As countries within the global North grapple with a shrinking agricultural labor force, robots are being tested and trained to select fruit by tedious trial and error methods. Like in manufacturing and services, an emerging tide of data-based disruption working on a replacement layer of data activities sanctioned through AI technologies is moreover transforming agriculture. With challenges of resource scarcity, industrial scale of food wastage and global climate change posing immediate imperatives for food security, digital innovations are being looked to because the game-changer in having the ability to deal with these issues. The longer term of food is unequivocally digital, and therefore the way forward for digital is inevitably AI.

Broadly, AI are often defined as "an area of computing dedicated to developing systems which will learn or be taught to form decisions and predictions within specific contexts." AI applications can undertake a number of intelligent behaviors, like process optimization and predictive modeling, based inter alia, on pattern recognition, tongue processing and MT. All of those capabilities funnel the facility of knowledge and algorithms, the key drivers of industry 4.0. Consider the subsequent facts. Deloitte estimates that by 2019, 70 percent of companies will acquire AI capabilities through cloud-based enterprise software. By 2025, over 85 percent of all businesses will have effectively transitioned to the cloud.6 Cloud computing will thus be ready to drive large-scale AI implementation with more assured returns on investment across verticals. This may have implications across a variety of

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sectors, including education, healthcare, criminal justice and agriculture.

Today, terms like "digital farming," "the use of latest and advanced technologies integrated into one system, to enable farmers and other stakeholders within the agriculture value chain to enhance food production"7 and "precision agriculture," where temporal, spatial and individual data are combined with other information to get analysis that supports site-specific farming decisions, became common place.8 From gene sequencing in seed production to Internet of Things (IoT) networks of implements and sensors that give raise to data and image recognition technologies that assay and grade crops and commodities, AI applications are being deployed across non-identical facet of agriculture.

A. AI in agriculture spans three categories

Agricultural robotics: this presume the event of autonomous and intelligent systems which will tackle tasks and functions on farms, like sowing, irrigating, harvesting. For example: Blue River's 'see and spray' herbicide robot

Crop and soil monitoring: This involves capturing and processing data through drones, sensors, GPS chips, etc., to watch crop and soil health through computer vision and deep learning techniques. For example: Plantix, a deep learning application which will estimate soil health by way of image recognition.

Predictive analytics: This involves creating predictive models and digital intelligence around a number of agro-parameters, including inputs, market prices and linkages, and may also apply to allied services, like credit and insurance, fintech, logistics, etc. For example: Where, an analytics company that straps satellite data to supply intelligence on weather, soil, crop health, etc.

In addition, data and AI based revolution also are swiftly transforming the operations of agro businesses. Augmented reality, voice activated transactions, smart packaging, robotized warehouse management and omni-channel distribution are a couple of advancements we will point to.

To understand this phenomenon in economic terms; between 2012 and 2017, global investment in digital technologies for food production trebled reaching a powerful 10 billion US dollars.11 Data-based value propositions are key to just about all of those undertakings. We observe two key patterns within the sector: 1.The rise of agritech startups who, fuelled by risk capital, are meaning to claim a share within the AI market and a couple of .Traditional giants who have recalibrated their business models through datafication.

When Monsanto come by the digital agriculture startup, The Climate Corporation, in 2013, it took the primary step with regard to redefining itself as a "data company". Only a couple of years later, Bayer acquired Monsanto, expanding its intelligence capital—the latter's data on soil and cropping with its own knowledge in pharmacogenetics.

Similarly, John Deere's decision to expand the company's investment into AI startup Blue River to power the adventure of unmanned tractors indicates a next wave in agriculture. Deere's website notes how their future market depends on AI; "As a pacesetter in precision agriculture, Deere recognizes the seriousness of technology to our customers. Machine learning is a pivotal potential for Deere's future."

This trend is additionally observable from the opposite end. In 2018, Chinese digital company Huawei found out an agricultural Internet of Things Global Joint Innovation Center within the Qingdao Saline-Alkali Tolerant Rice Research and Development Center in China. The centre is functioning on developing an "Agricultural Fertile Soil Platform" and is focused on developing smart agriculture solutions through IoT, big data and cloud computing. Within the US, Alphabet Inc, Google's parent company is making investments into startups, like the Farmers Business Network and Bowery Farms.

In allied sectors, a growing global trend is predicted to spur greater digitally enabled value additions within the farm to fork supply chain, with grocery e-tail emerging as a crucial market segment. Not least are agribusiness giants within the food retail market, like Kellogs, who have now donned the hat of venture capital funders during a clear bid to capture a share of a digital ecosystem that's transforming consumption habits rapidly.

These aren't merely blossoming in rich countries, but are suggestive of a reorganization of the world on a intercontinental to local scale. ETC group's research has noted that data-based business value propositions are the driving factor for the rapidly ongoing transnational consolidation within the industrial food supply chain across different verticals, including farm machinery, seeds, agrochemicals and pesticides. Syngenta's multi-million dollar investments in startups in India and Israel are the maximum amount a part of this wave18 as are the various big data partnerships being struck in African agricultural markets, like The Africa Regional Data Cube.

From enhancing crop science breakthroughs to putting together solutions for effective resource optimization, it's clear that AI innovations are going to

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be the key way forward for global food production, more so in global South nations, where agriculture remains the economic mainstay. But how this innovation tide are going to be applied and made to figure for the advantage of all actors, including small land-holders, women farmers, etc., remains an issue and challenge for policy.

In the subsequent sections, we examine current initiatives in AI in Indian agriculture—both private and state- led— and plan to assess their potential for furthering development. We start with a quick recapitulation of the plight of agriculture in India, the policy thinking of the Indian state on the title role of AI in agriculture and key impediments that affect its effective adoption and uptake. This is often followed by an analysis of personal sector trends within the domain. Lastly, the prospects for AI in agriculture are discussed, alongside directions for policy. Insights offered during this paper draw from interviews with AI startup founders, digital platform companies, knowledge experts and public officials, alongside secondary research. What we attempt here isn't exhaustive and is restricted to a preliminary scoping of the present outlook for the domain.

II. THE CURRENT STATE OF INDIAN AGRICULTURE

AI within the sphere of agriculture is seen as an enormous cornerstone area for policy. This is often perhaps logical, considering that over decades, policy processes have did not answer the "agrarian crisis" marked by extreme distress for a bulk of agronomist within the country. Droughts, clubbed with other factors, including a plummet in prices of agricultural produce, low public speculation in agriculture and diminishing agricultural exports, have aggravated this example.

Grassroots movements have sought to visibilise and draw surveillance to the difficulty. In 2017, agronomist from the southern state of Tamil Nadu demonstrated within the country's capital over lack of drought relief measures and escalating farmer suicides. The year 2018 saw two "long marches" during which over 50,000 farmers took to the streets to voice their concerns and advocate for the passage of long outstanding sect oral reforms outlined within the MS Swaminathan Report, 2005.

Precarity continues to be a touchstone of the planet , with prospects being particularly bleak for little and marginal producers and ladies and landless farmers, who comprise a bulk of the inhabitants whose livelihoods are tied to agriculture and are today finding themselves edged out of the planet altogether.24 Unreliable market linkages and ingress to inputs, fluctuating commodity prices, depressed returns and high indebtedness (exacerbated by a predatory micro-finance industry) are contributing factors that make farming a high risk proposition.

Incomes are steadily declining since 2011 for farmers and wage-laborers with the typical annual income of a farmer estimated to be 77,976 Indian rupees. On the opposite side, non-farm activities now usher in on the brink of 65 percent of rural household incomes. it's not surprising then that during a survey on the state of Indian agriculture, 76 percent of farmers reported eager to hand over farming.

III. THE RHETORIC & REALITY ON AI FOR AGRICULTURE

An Inter-Ministerial Committee found out to alleviate agrarian distress has outlined an umbrella approach for "Doubling Farmers' Income by 2022", envisioning a proactive role for digital technologies. NITI Aayog, Government of India's think factory, brought out the National Strategy for AI in June 2018, identifying key priority areas in health care, agriculture, education, smart cities and infrastructure and smart mobility and transportation. In agriculture, enhanced farmers' income, increased farm productivity and reduction of wastage are identified as targets for AI-led innovations, with a replacement thrust on "Farming as a Service" (FaaS). The national strategy document notes that "the agriculture sector in India, which forms the substratum of India's economy, needs multi-layered technology infusion and coordination in the middle of diverse stakeholders."

Other industry forecasts have indicated that AI technologies are often wont to address notable challenges within the sector including market fluctuations, irregular irrigation, eroding soil health and sub-optimal pesticide use. A study by Accenture as an example, notes that digital farming services are likely to possess an impression on on the brink of 70 million Indian farmers by 2020.

The policy rhetoric must be contextualized against the truth. Current efforts led by government to integrate advanced AI technologies in agriculture lack within the scope and pace necessary for a digitally-enabled transformation of the world. Key challenges during this contemplates are discussed below.

A.The Data Problem

Data, the vital ingredient for digital intelligence solutions, remains an underdeveloped resource in India. AI- based modeling in agriculture typically depends on a posh array of knowledge sets, including topography, climate, soil, seed varieties, cropping and input practices, crop diseases and pest management.

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Traditionally, these data pools are maintained by public agencies. Also, to supply the backbone for robust algorithmic solutions, data must satisfy several attributes—volume, variety, velocity, veracity, value, exhaustively, fine grainedness, relationality, etc. However, government data leaves tons to be desired during this regard. Not only are there gaps in data baselines within the sector, but even where public data sets do exist, they're not made available within the property right.

If opened and made usable, government data are often a useful public resource to catalyze innovation. But this is often easier said than done. As Ram Dhulipala, who leads the research team for digital agriculture at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India, points out, "The problems with agriculture are very localized and contextualized? To seek out appropriate solutions we'd like disaggregated data. However, the info from government sources is usually aggregated. This is often a significant gap."

The data problem has far-reaching consequences for AI development in India. The McKinsey Global Institute indicates that among 19 sectors evaluated in India, the potential value of AI for agriculture was within the bottom tercile. **NITI Aayog** has also acknowledged that a push for AI in agriculture may ultimately be only a lukewarm prospect for the private sector as long as, "efforts from private sector may neither be financially optimal nor efficient on a standalone basis."This was also underlined within the expert interview undertaken for this research; insurance companies, as an example, haven't come to the fore to adopt schemes like **Pradhan Mantri Fasal Bima Yojana**, the state led crop-insurance scheme unrolled in 2018. The dearth of excellent quality block level data is seen to form it unviable for companies to style suitable insurance products for farmers.

B. Absence of a Multi-Sector Data and AI Framework

Despite efforts to articulate a vision for data and AI, there's still no coherent "Data and AI" framework for projects across various departments. The government of India's Economic Survey 2019, for instance , recognizes the critical nature of "data infrastructure" necessary to take care of a competitive edge up the worldwide economy and has underlined the aspiration to create such infrastructure supported "data of, by, and for, the people." Yet, there's neither a mention of AI, nor any regard to big data, within the agriculture chapter. The skiving of a coherent "Data and AI" framework also translates into policy ambiguities about private access to public data. While the NITI Aayog strategy paper does conceptualize a National AI Marketplace, including for annotated data, what appear to be missing is that the normative brooding about checks and balances for data access and use.

An official from the Department of Biotechnology, which leads FarmerZone, a public-private agricultural data portal, stressed the importance of such norms in digital intelligence solutions, observing how precision farming and predictive farming solutions to reinforce farm productivity and improve input practices requires a knowledge and intelligence backbone that's publicly owned and managed during a transparent and scrutable way. She cautioned that "without private sector accountability, we could also be left during a situation where private companies are designing their own AI-based modeling solutions which push their own products."

C. *Lack of Integration between Agriculture Reform and AI Policy*

Policy approaches like "Doubling Farmers' Income by 2020" have sought to tackle legacy issues in agriculture without seeking any synergies with data and AI policies on agriculture. Similarly, digital technology initiatives like the **Electronic National Market (e-NAM)** platform for agro-commodities that gives digital assaying and grading and online payment options for commodity auctions, all of which comprise important sources of knowledge, haven't yet integrated a robust data-centric vision.

Part of the matter arises within the liberalization of the agriculture sector itself. New measures like the Model Contract Farming Act of 2018, for instance, look to ease and liberalize contract farming practices by diluting the roles of traditional markets and market regulators, instead seeking to integrate farmers directly with the market, especially, agro-industries. Agricultural trade the approaching years is hence likely to steadily bypass the varied state **Agricultural Produce Market Committees (APMCs)**. While the relative merits of this transition for mitigation of market and price risks for the farmer are still to be assessed, these trends certainly present concerns for the supply of public data sets in agricultural commodity trade. With the APMCs increasingly disinter mediated from the availability chain, the e-NAM system embedded within the APMC architecture also will be bypassed and hence, an important node of potential data capture at scale for public innovation are going to be lost. Market liberalization in agricultural trade and direct procurement by companies also will mean the danger of farm-based data and data about input practices becoming privatized by default.

D.Gaps in Public AI Research

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Another major policy challenge is that the general state of AI research within the country. Current R&D initiatives remain concentrated in elite institutions in India, like the Indian Institutes of Technology (IITs) which too among a close-knit pool of fifty to 75 principal researchers. While the country ranks third globally in bringing out top quality research publications in AI, its impact factor trails far behind world leaders like China.42 the amount and relative quality of students within the space, resource and administrative bottlenecks, siloed research approaches within the academy, combined with poor computing infrastructure and lack of annotated quality data, are noted as major pain points impeding AI research in India. The doubling of the Digital India budget to 477 million US dollars in 2018 with a view to expand AI research may be a welcome initiative, but addressing institutional weaknesses will remain a bigger challenge. It's also unclear how public agriculture universities and research institutions will enjoy this allocation. The prospects a minimum of for the immediate future therefore seem to be rather bleak for public AI innovations in agriculture.

IV. Private Sector Trends

In the commercial sector context in India, the AI phenomenon is nascent; with numerous of the leading edge global advances still within the empire of aspiration **"Agri- food tech"**, a broad term wont to ask a variation of digitally-driven innovations within the universal food and agriculture industry, both upstream (biotechnology, farm management, farm robotics & equipment, bioenergy & biomaterials, agribusiness marketplaces, etc.) and downstream (online restaurants, e-grocery, restaurant marketplaces, etc.), may be a rapidly growing area in India. There's a notable rise in B2C (business to consumer) and B2B(business to business)marketplaces and digital platforms.

Between 2013–17, India saw investments in over 558 deals in agri-food tech totaling 66 billion US dollars. This accounts for about 10 percent of worldwide activity within the domain during an equivalent period. In fact, in 2018, India saw the most important deal within the sector, with the food delivery app, Swiggy, receiving over 1 billion US dollars in funding, moving the country up to the third place in investment geographies for agri- food tech. as long as India's large consumer base has dictated the flow of innovation in other industries, like telecom, downstream investments shaped by consumer preferences are poised to trigger a fork-to-farm, reverse ripple effect. Currently, the subsequent dominant trends are observed within the AI-agritech space in India (including but not restricted to agri-food tech).

A. Traditional Players Move towards Datafication

In keeping with global trends, the digital space in Indian agriculture is seeing companies from the agribusiness end enter the fray. Mahindra, which is that the biggest tractor company in India with multiple verticals within the farm-to-fork supply chain, has been integrating digital intelligence into its business models. it's acquired startups, like the agri-rental platform Trringo, launched its own advisory services platform, and its tractors are now IoT enabled. The company's Information Technology Services division, Tech Mahindra, is additionally developing AI solutions for agriculture. Godrej Agrovet, a diversified agro-company, has introduced a sensible app to capture market intelligence and enhance its data-based deciding abilities. United Phosphorous Limited (UPL), India's largest agrochemical company, has collaborated with Microsoft on a Pest Risk Prediction API through which farmers receive automated calls with predictive insights on pest infestation.

B.Tech Giants Collaborate with Governments

Digital companies have made forays into the agriculture and AI space via public private partnerships with state agencies and governments. as an example , IBM Watson's IoT platform has been deployed in many nations , together with the NITI Aayog. The technology, which uses a "data fusion" approach, combines remote sensing data from The Weather Company, an IBM concern, along idea satellite and field data from sensors, to supply localized and actionable advisory services, including an AI crop yield prediction model.Similarly, Microsoft has been expanding into digital agriculture during a big way. Collaborations with the govt of Andhra Pradesh on a Zero Budget Natural Farming Programmed and with the govt of Karnataka on building a predictive pricing model are some examples during this regard.

C.AI Startups Navigate an Uphill Path

A 2018 report by FICCI observes that nationally, 366 agri-based startups came up between 2013 to 2017, with quite 50 percent of those arising in 2015 and 2016. However, once we examine the range of agritech startups in India, the amount of initiatives that are primarily AI driven are only a few. Many startups have incorporated AI-based value additions to their current platform-based models, but AI isn't their unique value proposition. as an example , NinjaCart is an example of a hyper-local market linkage platform that intermediates transactions between horticultural farmers and little and mid-tier green grocers in cities. The corporate received 35 million US dollars serial B funding from Syngenta and Accel US and 100 million US dollars serial C

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funding from Tiger Global. It is getting to go full throttle and expand its in-house data science capabilities.

As a part of primary research for this paper, four AI startups working during this field were interviewed. A quick snapshot of their work (See Table (1)) and details of their AI solutions are provided here.

Table 1. AI agritech startups in India: An overview

Startup	What it does?	How the AI works?	Funding
Intello Labs	Intello labs is an AI-based commodity testing solution that uses image recognition technology and deep learning algorithms to provide agri-commodity grading. Currently, the company offers testing and grading of wheat, corn, tomato, soy bean, potato and onion. Intello began with a pilot project with the Government of Rajasthan on wheat and grain testing and today works with a wide variety major FMCG, retail and e- commerce companies such as Reliance, Amazon and Big Basket.	Computer vision (image recognition technology) and deep learning techniques are used to train algorithms with sample data of different commodities. An in-house annotator tool sifts through data (supplied from the client end, generated in-house, or sourced from third party private companies) to then build intelligence around commodities.	Seeded by angel investors. Raised seed 2 million US dollars in seed funding from Nexus ventures and Omnivore
Fasal	Fasal offers Climate Smart Precision Agriculture Solutions and works directly with farmers as well as big companies such as, Grover Zampa Vineyards. Fasal's 'Smart Agriculture Solution Kit' allows for monitoring and optimising environmental and climatic parameters in agriculture, vineyards, greenhouses, etc. in real-time.	IoT sensors deployed in farms take periodic readings and feed them into a network. Analytics is performed upon this data.	Earlier incubated at NASSCOM's IoT Centre of Excellence; received seed funding from Zeroth, a Hong Kong based AI startup in 2018 (120,000 US dollars)
Aarav	AUS is an enterprise drone mapping and	Drone mapping is used to collect	Incubated at
Unmanned Systems (AUS)	analytics company that offers mapping and imaging and analytics services. It is empanelled with many state governments in India as part of their surveying and mapping efforts for different undertakings and has also worked with contract farming and seed companies.	and process data. Analytical layers are then applied based on the needs of the client for specific intelligence.	IIT-Kanpur; raised seed funding in 2016 and 2018 (amount undisclosed)
Agricx	Agricx offers AI based grading and certification software for cold storage companies and traders. The company uses its grade determination algorithm to assay commodities such as potatoes, rice, pigeon pea and chocolate.	Image recognition technology is used to assess commodities and grade them. Layers of information—source of commodity, date of procurement and quality parameters—can be tagged to the process, based on client needs.	Series A funding from Ankur Capital & CIIE (500,000 US dollars)

The many hot deals currently being struck within the sector seem to point to a rosy outlook for AI in agriculture. However, what our field work with startups tells us is that larger market dynamics present many constraints, limiting the AI potential.

a. Consumer/client, rather than farmers, the starting point of innovation

Current industry trends tell us that startups within the agri-value chain are deeply concentrated within the rockery/retail end or within the midstream segment for market linkages and value added innovations. These include assaying and grading, certification and standards development, optimization of logistics, beat the B2B (business to business) segment, where startups can work with other actors in additional controlled environments and expect assured returns.

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The focus on B2B or the client end, rather than on farms and farmers, is owing to the following reasons:

• A highly fragmented agricultural market, which makes the walk unattractive, with high resource intensity needed to on-board farmers. This was cited as a standard reason for bypassing the farmer segment. M Ramakrishnan, COO at Intello Labs, opined that a business-to-farmer model could always only "excel in isolated pockets". Achieving scale, he added, was a problem during this model as long as "when you're selling to the farmer, the value of field sales is pretty high and you would like to use an outsized number of individuals to succeed in bent villages."The resource intensity in implementing walk solutions becomes a deterrent in building AI solutions that directly target farmers. As an example, Agricx which works on grading solutions for businesses is launching a free Do-It-Yourself (DIY) app for farmers that help them grade their produce through their phones. Saurabh Kumar, co-founder of the corporate, says that the service is for "anybody who wants a base level app, which can give them a rough idea of exactly what the standard [of the commodity] is." While Agricx is hospitable working with other actors who can innovate through the farmer app, being a lean company, it doesn't see itself taking over the role of field-based intermediation.

• The provocation of monetizing stand-alone, farm-end AI solutions. Convincing farmers to 'buy in' and buy digital services and solutions perhaps a very difficult sell. Dhulipala from ICRISAT explained why shaping farm-based decisions and nudging farmer behavior doesn't always end in a payout; "If you would like startups or private guys to return into this space, obviously they have to possess some idea about how they're getting to make revenue, but farmers are never getting to reward a fee." Startups therefore prefer to train in segments like supply chain simplification, direct market linkages, etc., where there's revenue visibility. Bigger companies within the agritech space on the opposite hand are ready to offer AI-based personalized advisories, bundling this with sale of inputs like seeds or procurement of produce for retail. Dhulipala notes how, "Big e-commerce platforms have stronger revenue visibility. They sell seeds that otherwise cost 100 Indian rupees for 80 Indian rupees. The farmer is anyway receiving a moment benefit then, out of the 20 Indian rupees he saves, he are often charged a little commission for the advisory."

b. Startups face tough competition from big corporations

Rhetoric about enterprising startups having the potentiality to speedily innovate and derange the market doesn't quite pan out. Even within the midstream segment where business value propositions are clearer, there's overall scepticism about new-to-field initiatives. Companies trying to find AI solutions also are likely to back established tech players instead of startups. Early adopters are a rarity within the agriculture industry, and startups got to put during a lot of labor to win business. Time to plug for products and services are often anywhere between six months to a year, with smaller players simply unable to form the leap to mobilize the resources needed.

c. The AI Disjunct in Make in India

Given that AI may be a capital intensive undertaking requiring high-tech hardware devices and machinery, much of which is currently not available domestically must be imported. The high duty on IoT devices, which was until recently at 30 percent, and on other hardware was noted as a price that smaller players find difficult to off-set, especially if they're targeting farmers as within the case of Fasal, an IoT startup that works with horticulture farmers. "We want to sell it [the IoT kit] for 90 Indian rupees, but due to taxes we've to sell it for 140 Indian rupees, and every 10 Indian rupees increase, decreases exponentially the amount of farmers who can
purchase [theservice]," acknowledged companyfounder, ShailendraTiwari.
If import duties are prohibitive on the one hand, high-tech manufacturing has also not began during a huge way
despite policies like Make in India. This particularly applies to manufacturing of drones, which are critical digital intelligence tools for agriculture innovation. Vipul Singh, who heads Aarav Unmanned Systems, believes that past a particular scale, he will have little choice but to outsource manufacturing of drones to China. He reckons that "most of the essential components like high efficiency miniature brushless motors, lithium polymer or lithium ion batteries, etc., aren't in the least fabricated in India... Also, making drones may be a multidisciplinary activity, which needs precise synchronization among different stakeholders a bit like the automotive industry. the present drone industry in India is extremely scattered and little scale, with not much fundamental level technology development."

d.It's all about the data roadblock

As previously discussed, the rickety data infrastructure in India has meant that a lot of startups have had to actively engage within the task of making data baselines and pools. This becomes essential to reinforce their value proposition and strengthen platform performance, whether that be through production of multi spectral data

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sets through drone mapping, climate and soil data through IoT networks of sensors and chips, annotated data through image recognition or building predictive pricing models through statistic data. Intello Labs, as an example, currently sends out people to varied locations, including to APMC mandis (market places), to gather data through photographing commodities and feeding it in through smart phones. These resource intensive efforts administered by small and mid-sized startups are less amenable to putting together complex AI solutions that demand large volumes of highly diverse data sets.

V. IMPLICATIONS FOR AI IN AGRICULTURE

Submission What the scoping study points to is that despite policy aspirations, the roadmap for AI in agriculture in India remains mired in data deficits coming from legacy systems and lack of incentives for farmer-centric data innovations. With tons of players—from small startups, to mid-sized domestic companies and enormous transnational corporations (TNCs)—in the fray, current trends reflect challenges for disruptive innovations which will transform farming practices for greater livelihood sustainability. Business opportunities within the midstream segment seem to drive AI innovations, whilst big players—traditional and digital—are investing in long run, resource intensive strategies to create datasets. Supported this scoping study, we infer the subsequent issues and implications for the longer term of AI in Indian agriculture.

A. Lack of Appropriate Public Intervention for Domestic Innovation

The lack of public data pools features a direct pertaining to the fledgling startup ecosystem and therefore the prospects for AI innovation in agriculture. On the one hand, this forecloses possibilities for public interest innovation. On the opposite, capture of the info marketplace by big corporations finishes up reducing the general competitiveness of the world, creating entry barriers for smaller players. Further, governance mechanisms to make sure data protection and make the checks and balances to stop misuse of public data sets and public interest concerns privately partnerships aren't yet developed. Support for domestic startups seems to rely mainly on incubators and startup contests, with no comprehensive strategy to expand the manufacturing base necessary for leading edge AI. the shortage of support for public R&D is yet one more factor discouraging domestic innovation. Today, India's competitive position in AI is less than countries like China and Israel, where development of AI technologies has received considerable public investment.

B. Trends towards Consolidation, End-To-End Control and Loss of Local Autonomy

While startups are ready to work on AI-enabled innovations at higher levels of the worth chain, they're ill- equipped to reply to the structural problems of agriculture in India. AI solutions which will expand and answer static and dynamic knowledge needs of farmers and improve their farm-based practices and decisions are driven by larger and more entrenched players like Bayer-Monsanto and Walmart-Flipkart. These companies engaged, or looking to interact directly, with farmers within the precision agriculture segment can afford resource intensive investments to consolidate the worth chain. They will exercise complete control of the inputs or procurement segment and thus co-opt farmers into a marketwise agricultural paradigm. This does bring some gains to farmers, but ultimately results in corporatized takeover of agriculture, diminishing farmer autonomy over livelihoods.

Additionally, such arrangements also give corporate players an unfair "knowledge premium" (a first mover advantage with strong IP protections), locking in developing countries and their farmers into a relationship of dependence. Not only does the trail for domestic innovation become foreclosed, but local knowledge systems can also be appropriated through micro-surveillance or discarded altogether in favor of end-to-end integrated solutions.

Currently, local knowledge practices like development of plasma and seed keeping are at tremendous risk of being decimated by predatory IP regimes favoring big corporations. The pre–digital history of patent wars in India around regional commodities like basmati and turmeric has exhibited the convenience with which the ownership of local knowledge systems and intellectual resources of communities are often thrown into question. With vast quantities of gene sequencing data of agricultural produce now available on the cloud and corporations having the ability to model seed science from anywhere, local knowledge faces an imminent threat of appropriation through AI.

Developments like Walmart's decision to integrate AI as value added input services in its contract farming arrangements in India therefore got to be closely watched.54 While it's anyone's guess what the outcomes of such trends are going to be , we will only look to similar developments in other markets to ascertain what the longer term may hold for the tiny Indian farmer within the datafied world of agriculture. Almost like what's unfolding in India, retail end demands are driving particular food production trends in Vietnam, New Zealand, Australia

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and Indonesia. Kartini Samon from GRAIN, a non-profit working with small farmers within the global South notes that, through farm-to-fork consolidation, e-commerce giants establish end-to-end control over entire supply chains of agricultural commodities. Independent farmers lose their bargaining power and therefore the entire agriculture sector becomes completely consumer-driven. Marginal and little farmers tend to be edged out as there's no room for small-scale operations. This has serious gender implications for women's livelihoods, as long as most small holdings within the Asia-Pacific region are managed by women.

AI-based solutions also can amplify social differences and inequality. Consider the arrival of fintech in agriculture and therefore the associated role of credit-based scoring systems in determining farmers' access to stable finances. As exclusive gatekeepers and arbitrators of access to resources, data-driven deciding models could easily edge out marginal players who the AI system deems unworthy.

C.PPPs as a Route to Entrenchment of Digital Giants

Current models in PPPs, like the NITI Aayog-IBM partnership or the proposed collaboration between the govt of Andhra Pradesh and Alibaba, seem to boost questions on the character of massive digital players within the AI ecosystem. It's not yet perspicuous how these partnership arrangements are embracing governed publicly interest so on deter private value capture by big companies and may protect marginalized constituencies. This ambiguity is often a slippery slope towards monopolistic practices and unregulated data control by powerful corporations, leaving other actors during a highly skewed playing field. The Zero Budget Natural Farming initiative of the state of Andhra Pradesh may be a case in point. The project, which has many components of digital integration, involves global financial institutions, banks and charity and is currently backed by massive state guarantees, against the recommendation of the Reserve Bank of India (RBI) (given that this might artificially push up the viability of projects). Although the professed sight of the project targets marginal producers, quite paradoxically, the financial and digital arrangements open up possibilities for greater corporate control of agriculture and run antithetical to the interests of farmers and their livelihoods.

VI. DIRECTIONS FOR POLICY

The current AI-driven knowledge framework in agriculture is yet to redeem the long-standing problems of Indian agriculture. What we'd like therefore is an umbrella policy on AI and agriculture, built on the primary principle of future sustainability of agricultural livelihoods, which will work to ensure rewarding and stable livelihoods for marginal producers, women farmers, landless farmers, co-operatives and Farmer Producer Companies (FPOs). AI technologies must work to sustain diverse and locally relevant practices of agriculture that not only learn from local knowledge systems, but also respect and promote the normal knowledge commons. An AIeco system in agriculture must encourage innovation at the edges—enabling entrepreneurs and SMEs to innovate along the whole value chain. Within a comprehensive policy framework on AI and agriculture, interconnected strategies and actions got to be initiated by multiple nodes within the government. Some suggestions during this regard are offered below.

A. Building Data Infrastructure and Public Goods for Agriculture

Sustained investment for the creation of knowledge infrastructure within the field of agriculture is urgently needed to catalyze research, innovation and application. This includes interventions for digitizing existing sources of knowledge and providing open data and APIs on various aspects, including agricultural mantis (markets), weather, soil, seeds, etc. Global initiatives just like the Platform for giant Data in Agriculture could also be useful models to think about , adapt and refine, during this regard.56 NITI Aayog has also put forth the thought of an annotated national data marketplace, which may function a standard resource for researchers, private actors and government agencies to innovate upon.

The "AI for all" dictum professed by the govt implies measures for a replacement knowledge culture around data that translates into stronger institutional support and actionable information for the last person within the value chain. Simple and relevant advisory services in local languages supported AI-based models can strengthen local agricultural practices. The Farmer Zone project initiated by the Department of Biotechnology to extend farm productivity and improve input practices in potato cultivation may be a useful pilot which will yield many insights in both data management and for suitable replication and localization across many other crops. A national data marketplace also requires to be rooted in laws that respect privacy and supply safeguards for private data protection and collective rights of farming communities to their data.

B. Enhancing R&D for Localized AI innovation Publication Principles

Investments must be made into furthering research and growth within the field, with attention on multiple and

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decentralized capacity building for incubation, acceleration, industry connections, mentoring, etc.
• Dedicated incubators and startups focusing on the sector got to be promoted. One such initiative is that the National Association of Software and Services Companies(NASSCOM) Center of Excellence (CoE) for AI and IoT in India located in Bengaluru.57 The CoE is a ingredient of the Digital India initiative, and as a "deep tech innovation ecosystem" involves startups, innovators, enterprises and therefore the government, with a fanatical cluster on agritech. The NASSCOM CoE has incubated one among the most important agritech AI companies, Cropin, which is currently performing on a "smart farm" platform.58 ICRISAT, which also runs an in-house incubator, I-HUB, works to support startups in digital agriculture and provides the much needed research inputs. Pilot projects involving diverse actors, like small startups, FPOs, agricultural universities and regional engineering institutes got to be implemented to make an environment of small-scale innovation and localized intervention.
• Hardware self reliance for AI-related needs must be fostered through appropriate manufacturing policies and incentives that also account for expensive, high-end infrastructure, like Graphical Processor Units (GPUs) utilized in image recognition.

• Policies got to specialize in upgrading extension services and training field personnel to implement public AI solutions at the farm level. Schemes like MUDRA should support FPOs to create internal data and AI capacities relevant to their business proposition, while mobilizing public data sets to get localized, real time data towards AI solutions. Low-cost IoT kits for real-time data collection are often distributed to farmers. this may help bridge data gaps and enrich the info ecosystem. Farmers and producers also can be trained and incentivized to use these kits and deposit data into a standard data repository over which they enjoy clearly defined rights of access and use.

C. Countering Data-Driven Monopolization

For countries, like India, which have huge swaths of population directly hooked in to agricultural livelihoods, countering corporate capture of the agricultural data ecosystem may be a key priority. Policies should address vertical combination and anti-trust overtures by big companies within the sector and put in situ mandatory data sharing requirements for personal sector actors. Additionally, for public-private arrangements, the state must develop transparent frameworks to make sure that the worth derived is equitably distributed among the partners which public sector stake and ownership over the info, ASCII text file and algorithms are clearly established. Further, public audits of the AI in such consortia got to be undertaken as due process of law.

D. Fostering Alternative Community Data Models

Data governance models got to allow synergies and complementarities among public, private and community agencies towards localized farming innovations. as an example , a singular aspect to Fasal's work is their recognition of farmers' rights to the info collected as a part of their operations. Farmers co-own the info and also receive a share of any value that's monetized from the info . Similarly, the American Farm Bureau Federation in its policy for farm data use and processing explicitly establishes farmers' rights over data collected on their lands, invoking a rights framework to guard community interests within the data. In other cases, social enterprises that support farmers have successfully demonstrated the gains of commoditization of knowledge through ethical data brokerage practices. Examples include EkGaon, a technology solution provider which operates in central India and Vrutti, which works with farmers in South India to secure fair prices for them in commodity markets. Public data models got to co-exist with others where local communities and farmer organizations manage and enjoy data about their own farms and farming practices.

VII. CONCLUSION

AI has both non-biological and human aspects embedded in it. Needless to say, diffusion of AI in all application arenas will also bring a paradigm shift in the way we do research and development in agriculture now. AI systems require continuous feeding of new information and increasing the amount of information in the backend databases used for performing tasks with almost accuracy, including mapping the history of and guiding the predictions from such systems. In this way, the AI systems will get evolved over time akin to human perfection in addition to adaptability.

The agricultural industry faces various provocations such as absence of effectual Irrigation Systems, Weeds, an affair with plant monitoring due to crop height and extreme weather conditions. But the concert can be increased with the aid of technology and thus these problems can be solved.

The problem faced by agronomist is that precision weeding techniques overcome the large amount of crops being lost during the weeding process. The future of cultivation hangs on largely on advocacy of coherent solutions. While large scale research is still in progress and some applications are already available in the market, the industry is still highly underserved. When it comes to handling pragmatic challenges faced by agronomist and using self governing

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decision making and predictive solutions to solve them, cultivation is still at a nascent stage.

For the sake of investigate the boundless horizon of AI in agriculture; applications (use of robot,drones, sensors, & GPS chips for Cultivation) need to be more vigorous. Only then will it be able to handle frequent changes in external conditions, ease real-time decision making and make use of significant framework/platform for collecting contextual data in a productive manner.

Another important aspect is the exorbitant cost of different cognitive solutions available in the market for farming. The solutions need to become more affordable to ensure the technology reaches the masses. An open source platform would make the solutions more affordable, resulting in rapid adoption and higher penetration among the farmers.

In this paper, we focused on use of AI in agriculture which will make farming easy and effective but use of AI gadgets are quite expensive and cannot be affordable by agronomist who are not economically sound. In this case government can develop some policies using which the advancement of farming will be affordable with the help of some fund in associated with government.

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