
omnivore
The Future of Indian Agriculture &
Food Systems: Vision 2030

Foreword: Jinesh Shah and Mark Kahn, Managing Partners, Omnivore

"What will agriculture look like in 2030?" we asked ourselves.
We wanted to think beyond 2020, beyond COVID-19, beyond our second fund, one decade into the future.

Why? Because Indian agriculture and food systems need to be reformed, disrupted, and rebuilt.

- Agriculture must become profitable for India's 130 million farmers and their families
- Farmers must be made more resilient, capable of thriving from season to season
- India's food systems must produce more than just calories and deliver complete nutrition for all
- Environmental impacts from agriculture must be reduced, and sustainable solutions prioritized

At Omnivore, we believe agritech entrepreneurs will lead this change, driving a transformation in Indian agriculture towards profitability, resilience, nutrition, and sustainability. We know these brave founders and their teams will leverage innovation, technology, and persistence to remake the world around us. But what will it look like in 2030?

Agriculture is a commodity industry, so can growth truly be exponential? How will technology, social, and ecological trends impact Indian agriculture? We asked leading experts, technologists, researchers, policymakers, and entrepreneurs. We did our own analysis and extrapolated the answers.

This report details some of our findings, their implications, and likely scenarios. It is deliberately a bold vision. We see tremendous opportunities *and* risks ahead, and the worst mistake we can make is to assume that change will be incremental.

We hope that this report will spur debate and action. We know that together, we can reinvent Indian agriculture and food systems, and build a better world.

Acknowledgements

The study is built on the advice and inputs of a range of experts, entrepreneurs, and advisors in the agricultural ecosystem in India and abroad, who added practical knowledge and experience to statistical trends reported widely. Together, Umang Prabhakar (author) and Subinder Khurana (lead) of this study would like to thank the following people for the time and inputs they offered so generously: Mr. T Nanda Kumar, Mr. Ashutosh Mal, Mr. Nikunj Biyani, Mr. Devdutt Dalal, Dr. Partha Dasgupta, Mr. Sharad Sharma, Mr. Rohan Mirchandani, Mr. Ashish Jangle, Mr. Maruti Chapke, Mr. Ashok Methil, Mr. Ashish Khaitan, Mr. Jatin Singh, Mr. Suresh Saraf, Mr. Sudhir Goel, Mr. Eric Ward, Mr. Tanay Mahindru, Mr. Kannan Sitaram, Ms. Saswati Bora, Mr. Hemendra Mathur, Mr. Jaspreet Bindra, Mr. Vishnu B.N., Mr. Baskar Reddy, Mr. Hari Rajagopal, Mr. Raghav Rungta, Mrs. Meera Mishra, Mrs. Renuka Diwan, Mr. Shashank Kumar, Mr. Umesh Prajapat, Mr. Peeyush Pallava, Mr. Pankaj Khandelwal, and Mr. Aditya Sethi.

We would like to thank the author of this report, Umang Prabhakar, for his efforts studying and analysing a comprehensive list of ideas and trends in agriculture, engaging deeply with the aforementioned list of stakeholders, and then synthesizing his learnings into the content of this report. His efforts would be incomplete without the support of his team members Aviral Marwal and Maitreyi Menon who supported him on various parts of data collection and analysis for this study.

Finally, it would be remiss not to mention the guidance and vision of the people who envisaged this product at Omnivore, namely Jinesh Shah, Subinder Khurana and Mark Kahn, and the entire Omnivore team who helped brainstorm ideas and offered the author tactical support throughout the study. Finally, we want to thank the CDC group for their support.

This report was sponsored by CDC Plus, which is funded by UK Aid from the UK government. This report has been prepared by Omnivore, and as such does not necessarily reflect the opinions of CDC Group

The vision we present in this report is consciously bold, and is meant to approach opportunities and challenges in food and agriculture systems in India with radical ideas

This study was initiated in early 2020, five years into the period that has seen the biggest growth of startups and venture funding in the space. It is built on a philosophy of optimism for the future, and belief in the importance of disruption of the status quo. We have focused on ideas that can have an outsized impact on the lives of farmers and consumers, despite significant investments and behaviour changes required. These activities will tackle critical problems of the future – climate change, population growth, and shrinking biodiversity – that may not appear as apparent to some today, but are fast at work behind the scenes. Some of the trends covered here may seem overly ambitious, but as they say, we often tend to overestimate change in the short-term but underestimate it in the long-run. We predict that the compounding effects of technology over the next ten years, particularly in computing and life sciences, will be remarkable. For this reason, trends in this report have been formed with a sense of certainty, as we believe this is the only way to inspire action and cooperation. As a result, some assumptions we have made could prove wrong due to unforeseen events that occur this decade. This is a risk we are willing to take.

That said, we are cognizant of the many systemic issues that underlie the agricultural sector that require more than just technological disruption driven by the private sector. We believe issues such as social-equity, gender-equality, and environmental justice are critical pillars of agricultural and societal progress, and areas where India must make giant leaps in the coming years. Given the volumes of work being published in these areas by experts in the field, we do not go into them in detail in this report.

This study was commissioned before the onset of the COVID-19 pandemic, and therefore not written with consideration to post-Covid systems. However, the authors of this report were able to input early observations of the pandemic into this report and review its effects on the trends outlined here. We believe these trends remain equally relevant for the future. As a matter of fact, many of the trends in this study have been accelerated by the pandemic, particularly those associated with digitalization, food safety, and traceability. The government's agriculture-specific ordinances announced during Covid (to deregulate APMC and ECA) have also contributed to this acceleration. However, some trends may need greater gestation time due to impacts on the cash flows of agricultural businesses, workers, and financial institutions. All in all, this pandemic serves us with a thorough reminder of the urgency of improving our food systems for a brighter, better tomorrow.

omnivore

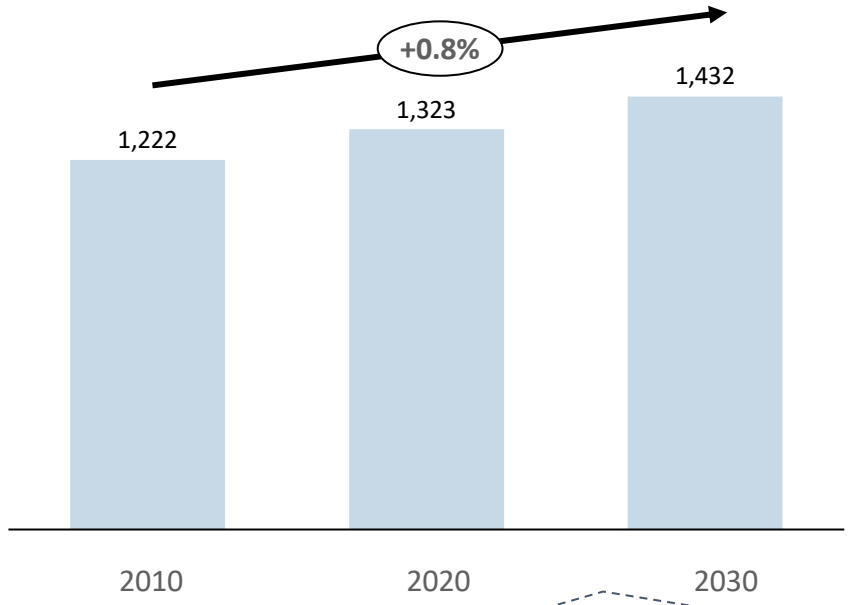
The Detailed Report

The Future of Indian Agriculture & Food Systems: Vision 2030

India will become the world's most populous nation this decade; more than half its population will be under the age of 40

Total Population, in millions

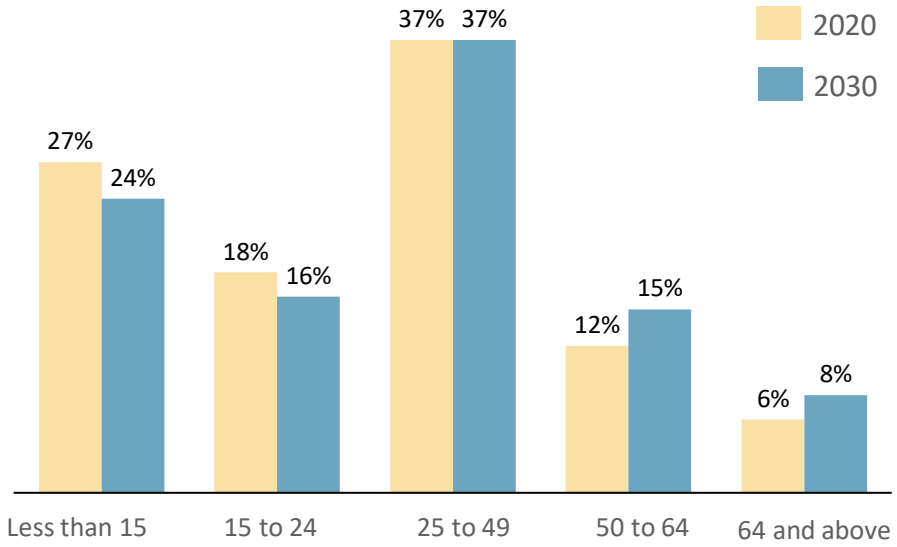
Source: AICRP on ESA



The share of upper middle households will **double between 2020 to 2030**, equivalent of adding nearly **350 million individuals** to this high consuming category

Breakup of age, %

Source: CBRE; India 2030, N = 1,222 million for 2020, 1,432 for 2030



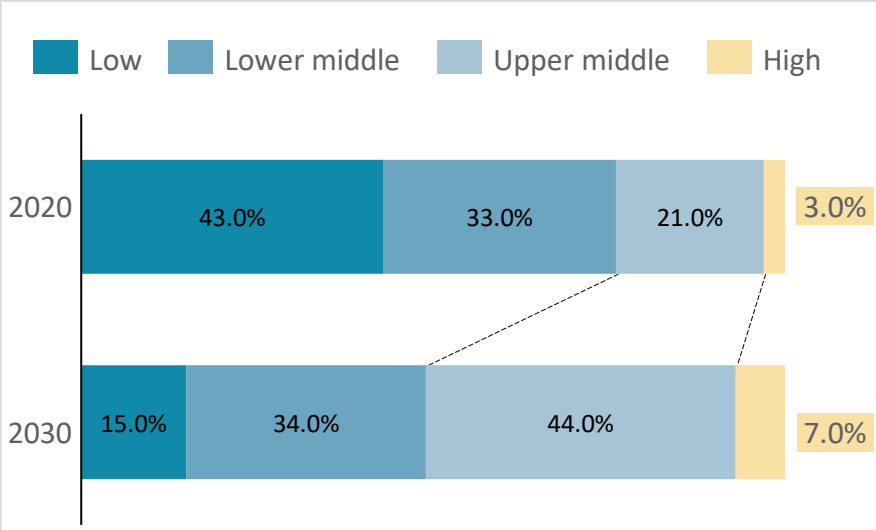
Most of India's population will be young, their consumption choices and behaviours influenced by global trends adapted to nationalist themes like "Proudly Indian" goods

omnivore

The world's largest consumer base will be Richer, Urbanized, and More Digitalized and Internet Savvy

Income split for the population[1]

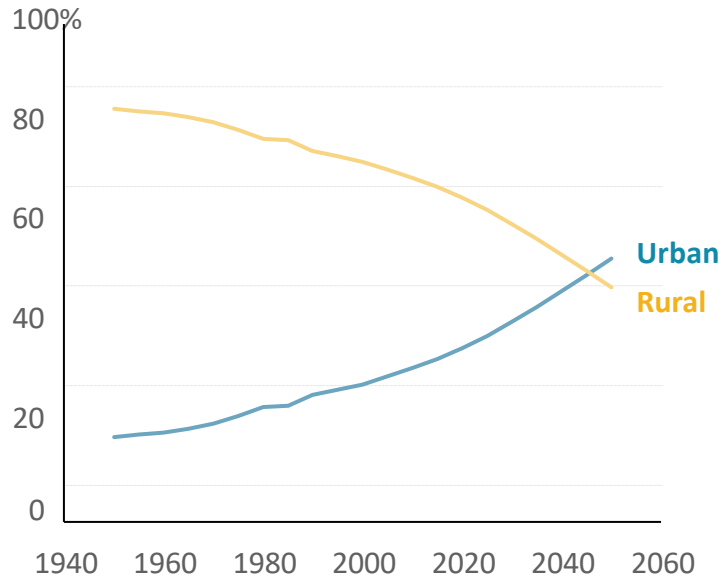
Source: WEF future on consumption, N = 1,222 million for 2020, 1,432 for 2030



The share of upper middle households will **double between 2020 to 2030**, equivalent of adding nearly **350 million individuals** to this high consuming category

Breakup of rural-urban, %

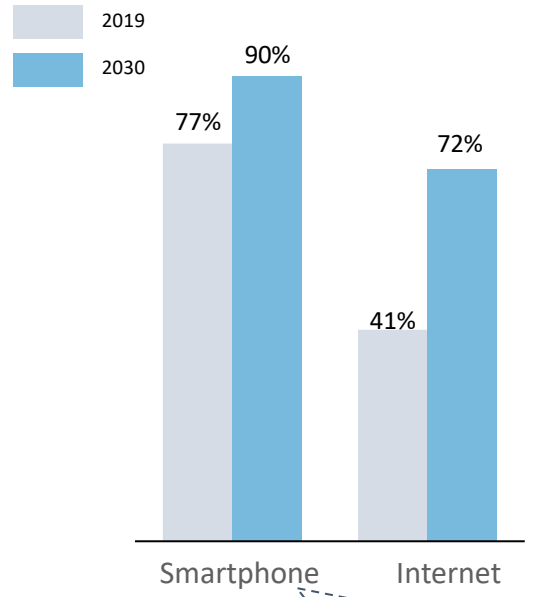
Source: News18



India's rate of **urbanization** is **accelerating**. By 2050, the **share of urban** population will **exceed rural**

Smartphone and internet users, %

Source: KPMG, India Media and Entertainment Report, 2019



By 2030, **1 billion Indians** will have access to **internet**; 50% of them will be Digital "enthusiasts" conducting a bulk of search and shopping online

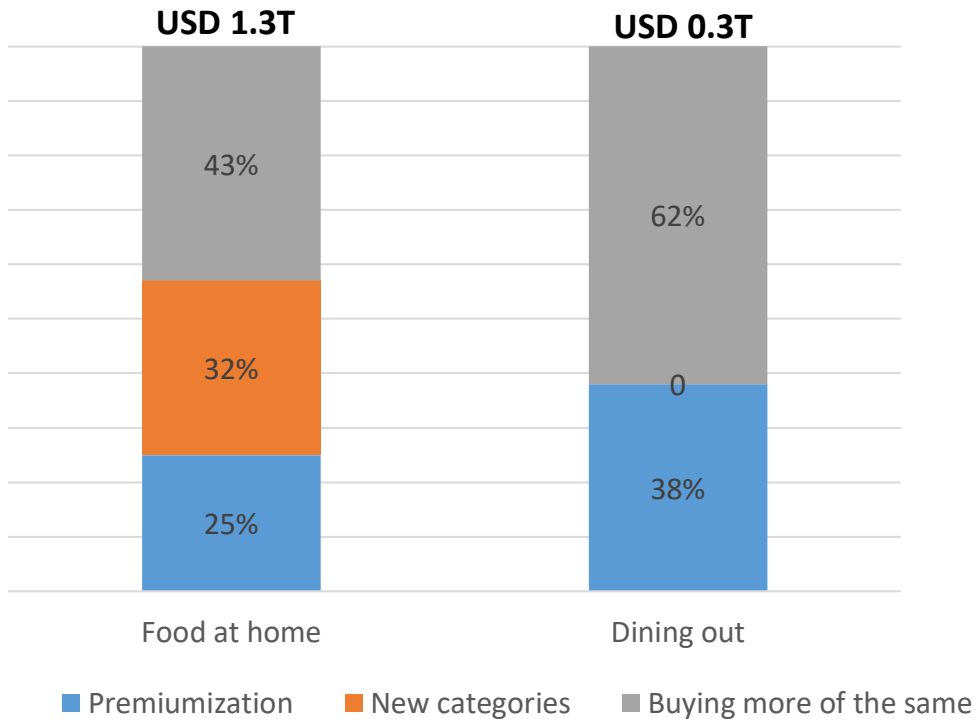
omnivore

Notes: (1) WEF defines income classes as Low income: <$4,000, Lower-mid: $4,000-8,500, Upper-mid: $8,500-40,000, High income: >$40,000 basis income per household in real terms

…and will spend an estimated additional 1.6 trillion dollars on food and dining out compared to 2020, a large part of which will be driven by consumption of more aspirational foods, and healthier and safer options

Drivers of Future Incremental Spend, of total incremental spend of USD 1.6T on food by 2030

Source: Bain & Co., WEF future of consumption, 2019; N = 1,222 million for 2020, 1,432 for 2030



omnivore

Technology and infrastructure in the future will bring considerable changes to the operating context of tomorrow's consumer and farmer

2030 Operating context

Nearly all Indian villages will be connected with paved roads, bringing smooth access to approximately 195,000 *additional* villages. This will fold in millions of excluded consumers and markets into modern trade and commerce.

All of India will have a reliable electricity supply. Widescale penetration of household and commercial off-grid renewables in areas excluded by the grid will make rural entrepreneurship a lot more viable, especially in food processing industries

Internet will be cheap and universal. 1 billion Indians are expected to have access to the internet by 2030, and nearly half of them will access it local regional languages, increasing digital user engagement substantially from 2020.

6G will arrive, increasing data transfer rates by 10x compared to the 5G that's coming in the early 2020s. IoT will be able to connect to trillions of connected objects, taking incredibly complex systems live and interactive

AI will near human intelligence, and be able to solve industrial problems effortlessly. Supply chains will be optimized further and further, reaching unbelievable efficiency. Self-guided machines will substitute a mechanistic human jobs in manufacturing and services, including in agriculture and food processing.

A majority of enterprise data globally will be stored on the cloud. Drastic drops in the price and bandwidth of cloud storage will make it the go to option for the smallest of businesses. This will make data transfer and analysis, between satellites, computers, sensors, and servers across the world hit unprecedented speed and efficiency

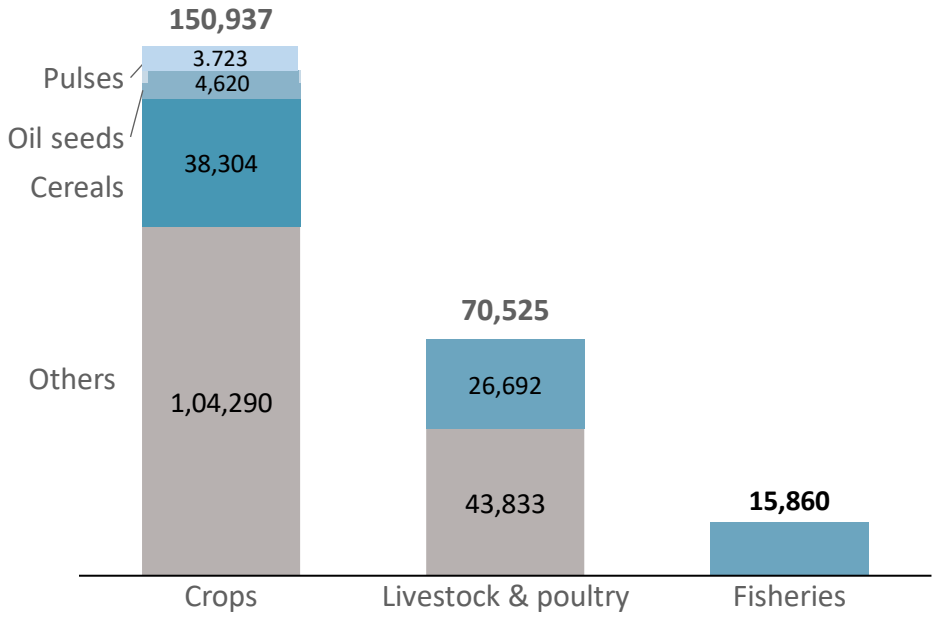
omnivore

https://www.futuretimeline.net/21stcentury/2030.htm; https://www.technologyreview.com/2020/02/26/905686/predictions-2030-people-shaping-the-world-davos/; https://www.un.org/sustainabledevelopment/blog/2015/07/un-projects-world-population-to-reach-8-5-billion-by-2030-driven-by-growth-in-developing-countries/; https://www.hiveforhousing.com/article/21-technology-milestones-we-will-achieve-by-2030_c; https://www.un.org/sustainabledevelopment/blog/2015/07/un-projects-world-population-to-reach-8-5-billion-by-2030-driven-by-growth-in-developing-countries/

This new operating context will create ideal conditions for disruption of India's large and growing agriculture industry

Breakup of value added in agriculture, 2018, USD millions

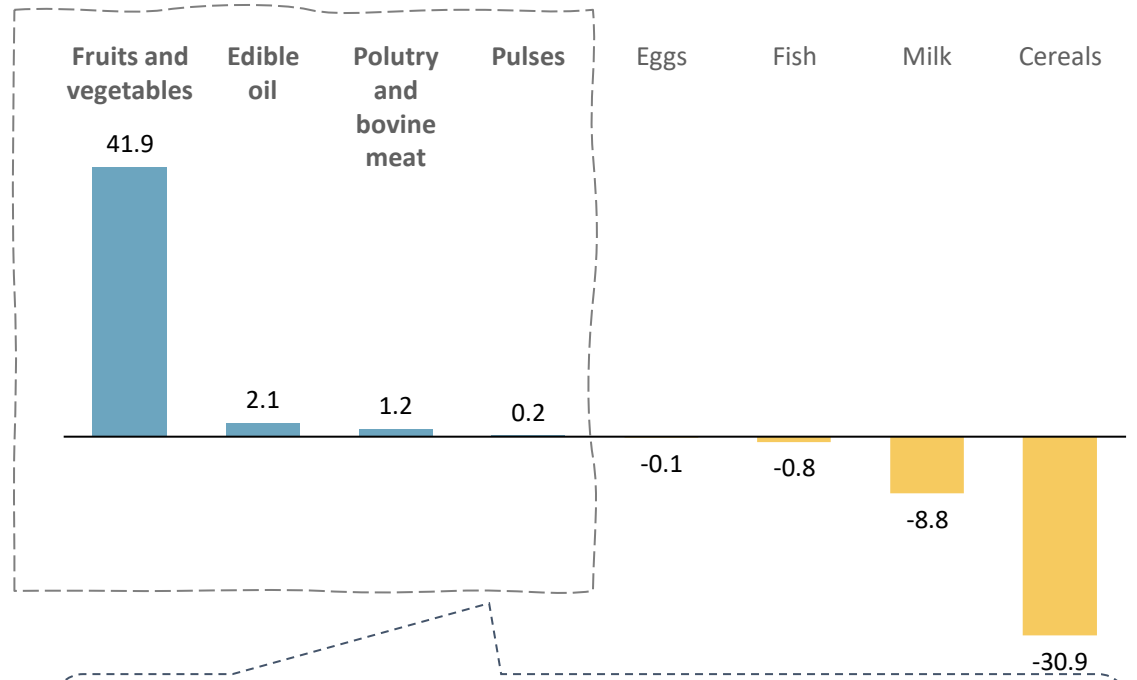
Source: Agricultural statistics at a glance, Ministry of Agriculture



The market size of agricultural products is enormous, making it ideal for disruption this coming decade. The total value of India's agri output stood at USD ~250 billion in 2019, and is expected to grow to **USD ~360 billion by 2030**

Demand supply gap, 2030, in million tons

Source: Kumar et al (2016), negative values denote surplus



Investments will need to focus on high-value horticulture and meat sectors, which assure much higher livelihood gains than programs in cereals and grains. By 2030, India may suffer a shortfall of nearly 42 million tons of fruits and vegetables unless there are significant changes in the focus areas of the industry

omnivore

Source: https://www.thinkag.in/post/de-coding-farmer-s-balance-sheet

However, in order to feed its expanding population, India will have to address sticky challenges in agriculture that have plagued it for decades

Agriculture uses **85% of freshwater resources….**

Low yield and productivity

Poor farming practices, low-yield varieties and fragmented farms result in **35-50 per cent lower yields against global benchmarks**

Low access to credit

Nearly **60 per cent of India's small and marginal farmers** still do **not have access to institutional credit**

… contributes to 20**% of national GHG emissions**…

Poor farm infrastructure

Overall level of **mechanization is less than 50%**, as compared to 90% in developed countries; nearly **40% of the food produced in India is lost or wasted**

Limited value addition and marketing

Low processing activities (e.g. **only 2.2% per cent of fruits** compared to other benchmark countries, such as 23 per cent in China, 50 per cent in Indonesia and 70 per cent in Brazil). Indian farmers realize only 8-10% of their products final value, compared to upwards of 30% in developed markets

… and uses over **60% of total land**

omnivore

Source: https://www.businesswire.com/news/home/20191125005468/en/Indias-Fruit-Vegetable-Processing-Market-2018-2019-2023 ; https://www.businesstoday.in/magazine/cover-story/agriculture-time-to-add-value-to-value-chain/story/227531.html; https://www.thehindubusinessline.com/opinion/editorial/institutional-credit-small-farmers-need-better-access-for-farming-allied-activities/article29451165.ece; Mechanization and Technology, Chapter 8, Agriculture and Food Management, Economic Survey 2013-14, http://unionbudget.nic.in/budget2014-2015/es2013-14/echap-08.pdf.; Central Water Commission, 2000; FAO 2016; World Bank Development Indicators 2016; https://tradingeconomics.com/india/agricultural-land-percent-of-land-area-wb-data.html

With this in mind, we highlight 8 trends that we believe will disrupt the status quo of the Indian agricultural system by 2030, while meeting the objectives of climate-smart agriculture

1. Precision agriculture and automation will be the norm, even among smallholders, across the sowing to harvesting value chain
2. Quantum leap in biotechnologies will produce plants that are more nutritious and resilient, and regulate farm health more efficiently
3. Fragmented landholdings and asset ownership will go through widespread consolidation, real and virtual, to achieve economies of scale for smallholders
4. Farmers will improve their relationship with global and local consumers, offer enhanced safety & quality, and improve income
5. Agricultural labour will contract and move towards higher productivity jobs, higher up in the value chain; agricultural training will respond to cater to a younger farmer
6. Production of high-value output such as leafy greens and cruciferous will become more specialized and protected, and have its own dedicated logistics chain
7. Rising animal protein and dairy consumption will push technology adoption across the animal and fisheries value-chain, increasing diversity of diets, driving up efficiency and lowering costs in a safe and conscious manner
8. Food science will pursue consumer-centricity, yielding affordable processed products that address malnourishment, lifestyle diseases, and ecological concerns

We envision a hyper precise and streamlined agricultural ecosystem in India that balances three pillars of productivity, sustainability, and wellbeing

The Indian farmer of 2030 will follow principles of precision through and through, using advanced mechanization for production, predictive analysis for production planning, and biotechnology to improve yield while reducing input use considerably as compared to 2020. Farmers will participate in a highly digitalized ecosystem, receiving services and transacting on smartphones, and engaging with consumers to assure them of quality while retaining higher margins for themselves. Crop choices and production planning will be based on a market driven approach enabled by technology as opposed to tradition.

The Indian consumer will be a highly aware and vocal consumer that places health, safety, and nutrition at the top of its consumption priorities, and will expect these guarantees from retailers and farmers. In addition to consuming more of all food, most incremental spending will be spent on upgrading to fresh produce and proteins, where freshness and quality matter even more. Convenience combined with precision healthcare will drive the consumer towards greater quantities of processed and packaged foods that deliver precise set of nutrients in easy-to-consume formats for each individual's unique needs, rather than a one-size-fits-all product.

Indian retailers will be modern and organized, with even Kirana stores taking the shape and form of modern retailers with digitalized inventory and transaction systems. Food companies and retailers together will respond to consumer demands of certified quality and safety by institutionalizing strict traceability and hygiene standards. Economic and environmental priorities will push companies to adopt advanced forecasting systems in a closed loop system with other stakeholders in the ecosystem, ensuring that little to no food is wasted, and only what is demanded is produced in the appropriate quantities, at the right time.

Logistics and distributors will be highly formalized and consolidated players that offer a range of intermediate services, digitally, to farmers and retailers under one umbrella, including finance, transport, and storage. They will be critical nodes in traceability systems and ensure that capacity utilization of store and warehouses is optimized to meet the needs of farmers and retailers through continuous, real-time monitoring of supply and demand. With this integration, no longer will "logistics" be subject to recurring search and negotiation by farmers, but be an automated system that is triggered by block-chain based smart contracts with farmers and retailers.

Trend 1:

Precision agriculture and automation will be the norm, even among smallholders, across the sowing to harvesting value chain

The slow advancement of mechanization in India will leapfrog in the coming decade towards a "farm of one"

1. Mechanization of power heavy activities of tilling, harvesting, threshing – tractors, tillers, harvesters

2008 Start of the IoT revolution.

2012 The Mahalanobis National Crop Forecast Centre is set up, and begins using satellite data and remote sensing for yield prediction, drought prediction, and crop insurance down to district level

2015. AI beats human at AlphaGO

Global IoT market reaches USD 9 trillion, with 36 billion total IoT devices

2021 entry of 5G which makes IoT much faster and smoother

6G – internet of everything, communication between devices, connection to satellites. Space to sea channels

1990

2010

2020

2030

2. Mechanization of input application for cash and high-value crops like cotton, fruits, vegetables – drip irrigation system, manual sprayers

3. Information-enablement using sensors and advisory but disparately – GPS enabled tractors, weather advisory services, soil health cards

4. Technology becomes semi or fully autonomous, "social", and varies its application based on advanced analysis done by AI and machine learning drones, terrestrial robots, IoT enabled sensors, AI and machine learning based advisory mean that farms can be operated by one person, greatly boosting labour productivity

omnivore

Cost, quality and reliability will be the key driver of this exponential growth for many years to come

DRIVERS

1 Labor is becoming costly and inaccessible, and so, is being replaced by technology

- **There will be fewer farm workers this decade, and most of them will be women.** By 2030, total agricultural workforce would come down by ~8% to 220 million workers, compared to 2010, mostly due to men exiting the profession. As a result, there has been a nearly 30% increase in women agri labourers since 2000
- **Labour is becoming increasingly expensive:** Cost of labour has increased by 20-50% in the past few years in the major cereal producing states and is showing a continued upward trend. Laborious drudgery will not be taken up by most young workers
- **Adoption of farm machinery has finally passed the tipping point.** The Economic Survey in 2018 supports this: uptake of farm machinery has outpaced any period in the past three decades in India
- **Young farmer workers are digitally connected and eager to upgrade skills.** Robotics and operator jobs are aspirational and can draw workers leaving field work through relevant upskilling programs

2 Inputs are becoming prohibitively expensive, necessitating more efficient use

- **Rising use and cost of agrochemicals is hurting farm bottom lines.** Per hectare real value of output increased for most crops in the last decade, however, input costs rose more than output, resulting in a net loss of income
- **Materials for inputs will continue to become scarcer this decade.** Raw materials for inputs are on a steady upward curve. For example- prices of pesticides have gone up 40-100%, and Naptha prices rose by a whopping 473% in the past decade.
- **Precise dosage of agrochemicals is the only way forward in the context of a climate sensitive future.** Remote sensing and variable rate technologies present the option to reduce input use by helping with 4rs: right source, right rate, right time, right place, and have shown to reduce water and chemical use by more than ~50%

3 Precision technology is becoming cheaper and more powerful

- **Remote sensing of farm data is reaching mass market prices.** The cost of industrial IoT sensors is falling steadily, dropping from USD 0.8 per device in 2010 to USD 0.38 in 2020**.** Global IoT devices for agriculture growing at CAGR of 20% at the turn of the decade
- **And becoming a lot more accurate.** Low altitude hyperspectral observations using unmanned aerial vehicles (UAVs) are bringing down cost and precision of imaging
- **Storing and transmitting data will no longer be an access issue.** Wi-fi and cloud computing is becoming cheaper and faster. In the past 3 years, the cost of cloud computing fell by a net average of 58% per year, while its computing power and memory increased
- **We've hit critical mass in digitized data ripe for analysis and prediction:** agritech start-ups with full-stack services are building rich multi-dimensional datasets on farmers, improving the predictive powers of machine learning models

4 The "shared economy" is disrupting expensive outright ownership models for farm tech

- **Affiliation to producer organizations is helping the remotest smallholders get access through the power of the group.** NABARD alone is expected to have onboarded 14 million farmers to a producer organization by 2030, uniting fragmented landholders under various economic functions. These groups enable sharing of assets like tractors and solar pumps, and enabling move into higher-value crops that yield better returns on precision technology
- **Rental and pay-as-you-go models for farm machinery are the way forward.** They reduce upfront costs for small farmers and allow for assets to be utilized over larger areas of farmland. Precision technology providers are opting for B2B models where large fleet owners bulk purchase technologies and lease them out

omnivore

Source: India's Digital Future, KPMG, 2019; https://www.iotsworldcongress.com/iot-transforming-the-future-of-agriculture/; https://www.thehindubusinessline.com/economy/agri-business/input-prices-have-pulled-down-farm-income/article9828657.ece; https://www.downtoearth.org.in/coverage/farming-made-unprofitable-5085; https://www.statista.com/statistics/682846/vr-tethered-hmd-average-selling-price/I Development of a Low-Cost, Lightweight Hyperspectral Imaging System; IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 2015; https://appdevelopermagazine.com/why-the-cost-of-cloud-computing-is-dropping-dramatically/

The future of precision technologies in India is being built on two components – Automation of farm activities with smart machines and Remote Sensing of detailed farm parameters that enable these machines to act with precision for desired outcomes

1 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
Farm robotics – unmanned aerial and terrestrial robots	**Autonomous and semi-autonomous farm robots will substitute labour intensive human tasks and drudgery in major commercial crop and animal value-chains.** India is in very nascent stages of farm automation at the turn of the decade – unmanned vehicles have entered operations, but mostly for remote sensing (capturing data) by institutional users (e.g., revenue department, insurance companies). While this will continue to be a major use case, fleet operators and large farmers will begin to demand autonomous robots for activities like weeding, spraying, and harvesting that involve a lot of labour and have high human error rates. To begin with, variable rate technology (VRT) will be added to existing equipment like tractors (for land preparation), gradually making their way into new purpose-built machines. This phased entry will enable continued prototyping of robots to increase their functionality, payload, and ease of handling. The goal will be to enable the use of a wider range of end effectors ("hands" of a robot) and manipulators ("muscles") that can dig, spray, pull, prune, and pluck. Another is to make sure there is enough diversity of robots on the market to address the variation in India's agroclimatic zones, topography, and types of crops grown. One of the most promising uses is precision spraying of agrochemicals through the use of VRT on robots. This is a use case that addresses India's twin problem of rising input costs and hazardous residues of chemicals due to improper application. Value-chains with high adoption are likely to include those with large contiguous holdings, like cotton, sugarcane, and grapes, as well as large protected farms	**Enablers:** • Helps offset large increase in labour costs expected this decade • Can lower input cost through more precise use, and lower resource footprint of farms • Can improve yields where labour shortages and imprecise input use were barriers • Has the potential to create new employment opportunities for tech-savvy young labour • Global investments in deep-tech farm automation on an upswing **Barriers** • Women face additional challenges of operating advanced farm tech compared to men due to lower confidence levels and lack of prior technological experience • Robots are prohibitively expensive for outright purchase by end-consumers • Products in the market have limited range, payload, and crop applicability limiting their appeal and will need considerably more prototyping in India • UVs require specialized skills to operate that are missing amongst farmers • Players remain weary of frequent policy changes on UAVs, but recent Digital Sky Initiative could be an opening to the future

omnivore

Source: https://www.raconteur.net/technology/how-drones-are-being-put-to-work; Hyperspectral Imaging Applications in Agriculture and Agro-Food Product Quality and Safety Control: A Review, Applied Spectroscopy Reviews, 2013; https://www.usgs.gov/centers/wgsc/science/global-hyperspectral-imaging-spectroscopy-agricultural-crops-vegetation-ghisa?qt-science_center_objects=0#qt-science_center_objects;

The future of precision technologies in India is being built on two components – Automation of farm activities with smart machines and Remote Sensing of detailed farm parameters that enable these machines to act with precision for desired outcomes

2 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
IoT sensors and actuators	**Farms will go "live" this decade, sensing and communicating their vitals of weather, nutrients, moisture, and crop health, as living breathing systems, and** we will be able to create digital-twins of farms, greatly enhancing our ability to simulate the impact of interventions virtually before testing them in the physical world. The accuracy and detail of remote sensors for complex visual inspection surpass tests administered by humans. This has great significance for how soil and crop growth is studied in the Indian context. NIS and electrical conductivity (EC) sensors will render traditional titration tests for soils obsolete, revealing the microbiome that lies underneath each plant. Advancements in high spectral imagery (HSI), near-infrared spectroscopy (NIS), and machine learning will enable farmers to track the health and growth of individual plants on their farms without having to laboriously inspect their fields (through Normalized Difference Vegetation Index NDVI). 5G networks launched in 2021, and 7G by the end of the decade, will boost the efficacy of IoT, allowing for cross-exchanges between phones, sensors, and satellites at breakneck speed and allow for hyper precise early detection crop monitoring. When combined with VRTs on farm robots, this sensing will allow each plant in each region of the field to be treated on a case-by-case basis; a standard never seen before in scaled agriculture. These technologies will be widespread in estate and cash crops grown by large and medium farmers, who together control 30% of agricultural land. Overtime, rental models and farmer groups will allow costs and sensing to be distributed over larger areas run by smallholders, making Indian agricultural "alive" and observable in real-time.	**Enablers:** • Strong product-market fit with the global and national priorities to reduce water use in agriculture • Enables farmers to cut down on input use and save costs that can help recover the cost of sensor systems in 2-3 years **Barriers** • While cheap IoT sensors have begun to flood the market, more complex multi-probe can be over USD 1000, and only affordable through subscription models • IoT sensors work best when they are connected to each other, which requires common software standards that are currently missing in the market • IoT sensors currently have three major use barriers in the Indian context – poor network, complex user interfaces for reading results, and maintenance and service networks

omnivore

Source: https://www.raconteur.net/technology/how-drones-are-being-put-to-work; Hyperspectral Imaging Applications in Agriculture and Agro-Food Product Quality and Safety Control: A Review, Applied Spectroscopy Reviews, 2013; https://www.usgs.gov/centers/wgsc/science/global-hyperspectral-imaging-spectroscopy-agricultural-crops-vegetation-ghisa?qt-science_center_objects=0#qt-science_center_objects;

These two combined are generating large volumes of data that are being processed by machine learning algorithms to produce ever more accurate models on crop growth, pest attacks, weather and climatic stresses, and market intelligence

3 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
Artificial intelligence in agriculture	**Artificial intelligence tools will allow agriculture to be viewed and operated as a controlled system for the first time in its history.** By 2030, public and private agencies are expected to possess gargantuan amounts of personal and statistical data about farmers and the agricultural system, after nearly 20 years of data collection from digital services and remote sensors. The key trends in AI, namely large-scale machine learning, deep learning, computer vision learning will help build models (including neural models for machines) of never-seen-before accuracy and reliability. The convergence of market, climate and weather, soil health, and hydrological models from local to regional up to national level will enable a strategic and coordinated approach to food production, rather than one based largely on path dependency and instinct today. The continued improvement in computing power will lead to optimization of every stage of agriculture – from production to consumption – bringing down costs, improving access, and increasing quality of outcomes at the same time. In addition, data-driven experiments will supercharge the pace of innovation i.e. enable more experiments and rapid prototyping with data-driven precision. **The nature of farm work too will change for the farmer.** By 2030, AI will move beyond the current Artificial Narrow Intelligence[1] in agriculture, which seeks to replicate human intelligence within narrow domains defined by programmers. Agriculture will begin to see the application of general intelligence and to a smaller extent Super Intelligence, where computers can self-guide and match human intelligence. This will allow for true and deep automation of farm activities, taking farm robots from simple command-driven machines to smart self-directing and self-correcting workers on the farm.	**Enablers:** • The economic benefits of applying artificial intelligence to the large datasets produced by agriculture cannot be overstated – applying insights from AI tools enhances value and reduces risk across the value-chains: in farm production, in logistics, in retail, and back **Barriers** • For AI to have maximum impact, companies need to be able to access and use datasets that are currently dispersed amongst public and private agencies and departments. The government holds troves of data between departments, which unless digitized and licensed, will restrict the potential of machine learning tools • Data collection, licensing, processing and storage are expensive, although most of the cost is upfront. Without government support, no single private company will be able to provide nation-wide solutions

omnivore

Source: https://www.raconteur.net/technology/how-drones-are-being-put-to-work; Hyperspectral Imaging Applications in Agriculture and Agro-Food Product Quality and Safety Control: A Review, Applied Spectroscopy Reviews, 2013; https://www.usgs.gov/centers/wgsc/science/global-hyperspectral-imaging-spectroscopy-agricultural-crops-vegetation-ghisa?qt-science_center_objects=0#qt-science_center_objects;

We will not only see India adapt advanced solutions as affordability increases, but create high-quality, low-cost solutions which will in turn be exported to geographies like Africa, and even parts of the West

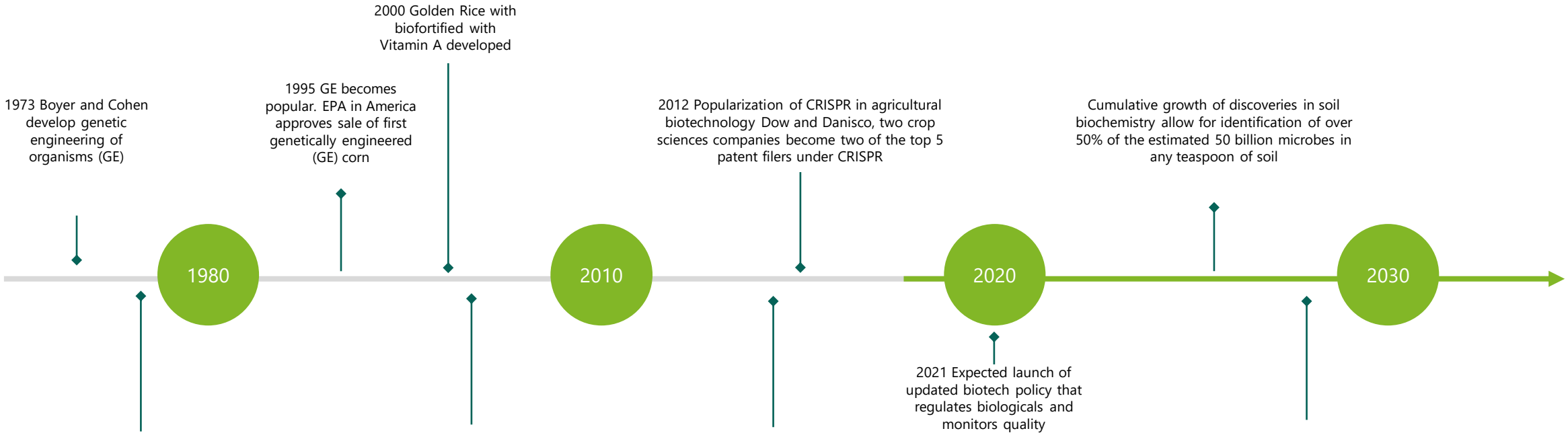
PLAYERS

Innovation category	Select players (not exhaustive)		Spotlight	
Smart farm machines and robots	• Trimble • John Deere • Mahindra Trringo • TAFE • Ecorobotics • Naio robotics	• Tartan Sense • Xaircraft • Case III • Dropcopter • Biocarbon engineering		Xaircraft XPlanet Agricultural UAS is an upcoming best-in-class drone, the successor to the 2018 Red Dot design award winning Xaircraft P30, which has the capability to apply precise dosage of liquid and granular agri inputs (chemicals and seeds) using VRT, carrying payloads of up to 20 litres. The drone defines what the future of robotics could look like, with its ability to seed, spray, and spread inputs precisely across complex topography (thanks to 4D imaging and AI), all from the palm of a farmer/operator
Smart IoT sensors and advanced remote sensing	• Fasal • Jain Irrigation • SoilOptics* • Eruvaka • Teralytic • Samsara	• Agrocare soil scanner, • GAMAYA, • Field Inn • Cropx	Eruvaka	**Eruvaka** is a precision agriculture solutions provider for the aquaculture sector. It develops on-farm diagnostic equipment for aquaculture farmers to help them monitor and control their ponds more efficiently and reduce risks. Their solution integrates advanced sensors, IoT, mobile connectivity, and decision tools to help farmers monitor production cost-effectively and easily. This is a giant leap from the predominant methods of farm monitoring currently in use in India, which are mostly based on cosmetic visual inspections and post-hoc disease management. Eruvaka's solutions, on the other hand, monitor pond parameters (temperature, pH, etc.) in real-time, automatically feed fish as per optimized feeding schedules and offer instant voice alerts to farmers in case of urgent interventions required. This is helping drastically reduce shrimp mortality, feed costs, and quality of produce for India's crucial shrimp industry.
Big data advisory services	• Skymet • CropIn • SatSure • Fasal	• Sammunati • Mahanabolis National Crop Forecast Centre • Gamaya	GAMAYA	**Gamaya** is an award winning precision agri advisory service that combines airborne and spaceborne hyperspectral imagery data, historical weather and climate records, crop, variety, and region specific data, to generate detailed maps on agronomic issues ranging from nutrient needs, pestilence, and weed infestations. Its patented 40-band hyperspectral camera, AI models, cloud solution, and advisory interface gives a glimpse into the hyper-detailed, predictive solutions that will be available to farmers in India this decade

Trend 2:

Quantum leap in biotechnology will produce plants that are more nutritious and resilient, and regulate farm health more efficiently

The story of biotechnology in India, previously ridden with bad press and social stigma, is beginning to change as climate change unites agriculturalists, policy makers, and agrochemical companies under a common purpose



1. 1960-1980: Green Revolution: first wave of biotechnology in India focused on yields through HYV of cereal grains. Increase in yields accompanied by a rise in synthetic agrochemicals observed nation wide

2. 2000 – 2010: First GMO crop, Bt Cotton introduced in India, and goes on to cover 90% of all cotton sowed by 2020. India's first indigenous Other transgenic indigenous GE Crops like mustard and brinjal never see light of day in the market

3. 2010 – 2020: Nascent stage of biologicals, as interest in advanced plant breeding in India begins to dwindle, and "organic" starts to become big. However due to unregulated market, biologicals are largely of poor quality and efficiency

4. 2020- 2030: Precision gene editing and microbial tools provide farmers with a menu of crop varieties they can choose from depending on local climate, growth conditions, and customer tastes. Each crop is tended to by a sharply customized microbial toolkit that provides precise nutrition and defensive mechanisms to the plant, drastically cutting down input costs while improving long-term soil health

omnivore

Source: https://www.nature.com/scitable/knowledge/library/history-of-agricultural-biotechnology-how-crop-development-25885295/; https://www.downtoearth.org.in/news/india-launches-its-first-genetically-modified-crop-8031; https://www.livemint.com/industry/agriculture/inside-india-s-genetic-crop-battlefield-1561054298998.html

Modern biotechnology can increase yields and sustainability in agricultural production

DRIVERS

1 Inputs are becoming too expensive or inaccessible, making the economic case for biotechnology more apparent

- **High agricultural growth is contributing to the rampant use of chemical inputs.** India will need to produce an estimated **300 million tonnes** of food by 2025 to feed its population, requiring an estimated **45 million tonnes of fertilizers.**
- **However, input costs are already unsustainable for farmers.** Increases in non-targeted use and cost of inputs over the past decade have negated productivity gains made by farmers from high yielding seed varieties.
- **Soil and water conditions are declining steadily.** An estimated **5.3 billion tonnes of soil** is degraded each year due to incorrect fertilization . India uses 2-3x water to produce one tonne of grain compared to China and the USA, which contributes to greater chemical runoffs and major declines in water tables, especially in the north-West belt
- **Adoption of the latest technology can lead to a reduction in fertilizer use.** Most plant chemicals have a **30% conversion efficiency** into plant matter currently. Nano-fertilizers and 3D polymers printed by nano printing are enabling targeted delivery of chemicals, at the right time, to the right plant.
- **Input technology, for example, is improving the efficiency in the use of fertilizers,** increasing it up by 20-30 percentage points by 2025.

2 The industry is witnessing an unprecedented increase in knowledge and precision in plant and soil study

- **Plant science has returned to the center stage of agricultural research.** Advanced molecular analysis is allowing for the identification of biochemical molecules that signal "on" specific plant genes and affect their functioning. Plant genomics studies are capturing a vast array of species in plant genome libraries.
- **Efficiency of plant breeding technology has expanded in leaps.** Conventional cross-breeding programs can take up to 40 years to obtain a new field variety. Mutagenesis takes about 15. TALEN and CRISPR are bringing development time down to 3-5 years, and the cost of CRISPR ha fallen to USD 30 in recent years. Between 2012-2020, scientific publications mentioning CRISPR jumped from 127 to 14,000.
- **Soil microbiome is a leading research topic in universities and R&D departments.** Between 2005-2015 citations referring to soil microbes in American scientific journals increased 10x; a peak in the research into the subject. Our current understanding of 10% of the ~50 billion microbes in one teaspoon of soil is expected to more than double in coming years
- **Micronutrients increasingly considered critical to plant health.** Agrochemical companies expanding the focus from NPK to include secondary macronutrients like Calcium, Magnesium, and micronutrients like Iron, Zinc, Copper, Manganese, etc.
- **A growing global market of agri-biologicals,** at 13% CAGR over the next 5 years, reaching USD 21 billion by 2026. Niche players from developed markets are seeking entry into India for the first time

3 Policy makers and consumers are recognizing the importance of biotechnology in solving for the problems of the future

- **Climate change will dramatically alter the environmental context of crop and animal production,** making adaptations to genes and therefore performance absolutely critical.
- **Food safety and food quality in India will be a major requirement in the coming decade.** The average dietary intake of pesticide residue is ~350 mg per day per person in India, compared to 149 in Germany, 156 in Europe. and 7 in The USA. Bringing down this number is going to be business and consumer priority
- **Globally, nations are bringing soil as a focus area for agriculture and climate change mitigation.** At the Paris Climate Deal in 2015, signatories agreed to increase **soil carbon** by **0.4% per year.**
- **Only radical solutions can meet demand.** Increasing temperature variations, pestilence, and erratic precipitation all heighten the challenge of doubling food production while reducing input utilization.
- **Policy makers are recognizing this, and opening the doors to a new phase of biotech.** Most countries, including India, are expected to exempt genome-edited plants from GMO regulations as long as no transgenic transfers take place. India has started drafting enabling policies for agri-biologicals to manufacturers and entrepreneurs

omnivore

Source: https://www.prsindia.org/report-summaries/impact-of-chemical-fertilizers-and-pesticides-on-agriculture-and-allied-sectors-in-the-country-4417; https://www.nature.com/news/crispr-the-disruptor-1.17673; https://www.sciencemag.org/news/2016/09/india-s-first-transgenic-food-crop-edges-toward-approval; https://www.politico.com/agenda/story/2017/09/13/soil-health-agriculture-trend-usda-000513/; https://www.albertabarley.com/intelligent-nano-fertilizers-herald-the-future/; https://www.reuters.com/article/us-global-food-fertilizers-idUSKBN15B1SL; Growing for the Future, Agricen, 2019; https://www.sciencemag.org/news/2019/08/its-crispr-revolution-china-becomes-world-leader-genome-editing#; https://www.downtoearth.org.in/blog/agriculture/the-government-needs-to-midwife-indian-agriculture-to-an-organic-revolution-67177;

Going forward, gene editing in plants and biologicals in soil-plant systems will harmonize action-reaction between soils and the plants they nurture, relegating a "one-size-fits-all" approach to nutrition and plant protection to the past

1 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
Non-transgenic precision gene editing	**India will usher an era of "designer plants" that are tailor-made for specific agro-climactic zones and their individual stresses, and for consumers.** The rallying calls for greater plant resilience are getting louder than ever – against temperature change, pests, herbicides, viruses, and drought - all of which are expected to increase this decade. Genetic Modification (GM) as we know it, has been stuck in social stigma and policy paralysis, and classical breeding (cross-breeding) takes too long to yield new varieties. Enter nuclease technologies like CRISPR/Cas and TALEN, which are able to make precise cuts and pastes in a plant's DNA to achieve desired traits. These technologies can yield successful variants in 3-5 years of development compared to 10-15 in traditional breeding. Due to their precision, turnaround time, and policy favourability (they are not transgenic i.e. do not take DNA from other species), nuclease technologies have become the focus of breeding programs recently and expected to receive heavy investments this decade. Early signs can be seen in the use of CRISPR in laboratories of leading bioscience companies to move beyond increased yield goals, and into nutritional outcomes (e.g., low trans fats in oils) Going ahead, plant breeding goals in India will finally be linked to market needs, and expand to include *nutrition* (biofortification of plants for micronutrients), *shelf-life* (to overcome storage shortages in India), *healthcare* (for plant products low in sugar, trans fats, gluten, etc.), and *flavour* (to ensure food does not compromise flavour due to enhanced nutrients or shelf life). To get there, India will tap into its massive repository of indigenous plant varieties that have many secrets yet to reveal, and are the country's best toolkit yet against climate change stresses.	**Enablers:** • Go-to-market in 3-5 years for nuclease tech, compared to 10-12 for GMO • Cost of new traits down from USD 135 million for GMOs to approximately USD 100k for non-transgenics. • Greater specificity of desired mutations or traits in plants **Barriers** • New seed varieties can be 2-3x the cost of regular OPVs and hybrids, and retailers can often lock-in farmers into loyalty contracts that are difficult to exit • Products in the market have limited range, payload, and crop applicability limiting their appeal and will need considerably more prototyping to fit Indian operating context • Unmanned vehicles require significant training to operate safely. KVKs and private companies will have to invest to train a operator workforce • Players remain weary of frequent policy changes on UAVs, but recent Digital Sky Initiative could be an opening to the future

omnivore

Source:https://blogs.scientificamerican.com/observations/gmos-are-not-agricultures-future-biotech-is; https://www.fortunebusinessinsights.com/industry-reports/agricultural-biologicals-market-100411 /; https://www.nationalgeographic.com/magazine/2017/09/holland-agriculture-sustainable-farming/; https://ethz.ch/en/news-and-events/eth-news/news/2016/09/the-future-of-plant-breeding.html; https://www.genengnews.com/a-lists/top-10-companies-leveraging-gene-editing/; https://www.sciencemag.org/news/2019/08/its-crispr-revolution-china-becomes-world-leader-genome-editing#

Note: (1) Products derived from organisms such as microbes, plants, and insects

Going forward, gene editing in plants and biologicals in soil-plant systems will harmonize action-reaction between soils and the plants they nurture, relegating a "one-size-fits-all" approach to nutrition and plant protection to the past

2 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
Precision agricultural biologicals	**Plant nutrition and protection will undergo a cultural shift this decade, as farmers begin to use organisms to fix problems, rather than synthesized chemicals.** Plant nutrition and protection on most Indians farms involves sweeping addition of synthetic chemicals as a panacea to problems and is being disrupted by the efficacy of a new generation of precision agribiologicals[1]. Microbial solutions – microbes that help stimulate growth, trigger defences, and increase uptake of nutrients, show significant promise given their fit with existing cultural practices of traditional fertigation in India. Our understanding of soil microorganisms is set to double from today's 10% coverage by 2025. Large agrochemical companies like BASF and Syngenta and early-stage startups alike are shifting their R&D focus to discovering and screening properties, and yielding products that are beating conventional agrochemicals at their job, with no/little hazardous residue for the consumer. For example, an indication of plant stress can immediately trigger molecular signalling systems in microbes to improve uptake and use of specific nutrients in soil, as well as to activate plant defence systems against expected pests. By 2030, agricultural biologicals combined with precision technologies that can monitor detailed parameters of soil and plant health, will become a farmer's personal pharmacy that can be drawn from for each plant and soil system, like a microscopic, intelligent army supplying and repairing plants when needed.	**Enablers:** • Lower net fertilizer use due to higher fertilizer conversion ratios brought about by biologicals • Lower pesticide use due activation of natural protection mechanisms of plants through molecular signalling • Improved fertility of soils from enhanced micronutrient availability and microbial activity **Barriers** • Complexity of modelling interconnected relationships between individual soil microorganisms and plants • Complexity of plant genomes due to history of cross breeding • India published 50 papers on CRISPR by 2018, 10th out of 30 countries leading research into the subject. USA and China, in comparison, published 898 and 824 respectively

omnivore

Source:https://blogs.scientificamerican.com/observations/gmos-are-not-agricultures-future-biotech-is; https://www.fortunebusinessinsights.com/industry-reports/agricultural-biologicals-market-100411 /; https://www.nationalgeographic.com/magazine/2017/09/holland-agriculture-sustainable-farming/; https://ethz.ch/en/news-and-events/eth-news/news/2016/09/the-future-of-plant-breeding.html; https://www.genengnews.com/a-lists/top-10-companies-leveraging-gene-editing/; https://www.sciencemag.org/news/2019/08/its-crispr-revolution-china-becomes-world-leader-genome-editing#

Note: (1) Products derived from organisms such as microbes, plants, and insects

With VC funding in their kitty, a range of new start ups are joining the leagues of agrochemical companies to rapidly identify new properties and develop new plant varieties. However there are significant policy shifts required in India to enable this future

PLAYERS

Innovation category	Select players (not exhaustive)	Spotlight
Precision gene editing	• CIBUS • Mahyco • Monsanto • Syngenta • BASF • INARI Agriculture • Pairwise Plants • Corteva	**Calyno Oil** is a new gene-edited soybean oil that was launched in 2019 by Calytxt Inc. The oil is a result of a consumer-centric gene editing project whose goals are to address obesity and cardiac disease caused by consumption of trans fats, channelled through the world's second most consumed vegetable oil. The product is a result of precision editing using TALEN, which has created a high oleic oil with zero trans fats and less saturated fats, a first for soybean oil. This has allowed the company to market this directly to consumers as a non-GMO product due to intra-plant gene editing, rather than transgenic gene editing (between species). The oil is being marketed to the food services industry first, and is expected to hit supermarkets in the coming year, followed by products like high fiber and gluten free wheat. If successful, it will pave the way for a new era of consumer-focused customized plant products this decade.
Agribiologicals	• Pivot Bio • Koppert Biological Systems • Sound Agriculture • Barrix • Agricen, • 3Bar Biologics • Instrinsyx Bio • Atmonia, • Elemental Digest Systems • Phospholutions • BiomeMarkers • Indigo	**Bio-Yield,** 3BarBiologics first commercial product launched this year, and winner of the 2019 Plant Nutrition Startup Showcase Grand Prize, is a microbial bio stimulant that enhances fertilizer uptake of plants and reduces runoffs. Formulation and application is made easy for the farmer, with a one-press button mechanism that enables rapid reproduction to produce billions of microbes within 24 hours, and prepares a solution ready for use within two weeks of planting seeds. Microbes then grow with the seedling, and integrate with the root system, helping it absorb nutrients. Bio-yield is an example of a hyper local and therefore hyper-precise agribiological produced by studying soils in Ohio, for use in the locally dominant corn crop. The same technique applied to India's various agroclimactic zones and crops is expected to produce a large variety of products in the market that are customized for local regions and crops, unlike the homogenous fertilizer products available today – products that will help farmers reduce fertilizer costs and runoffs from their farms.

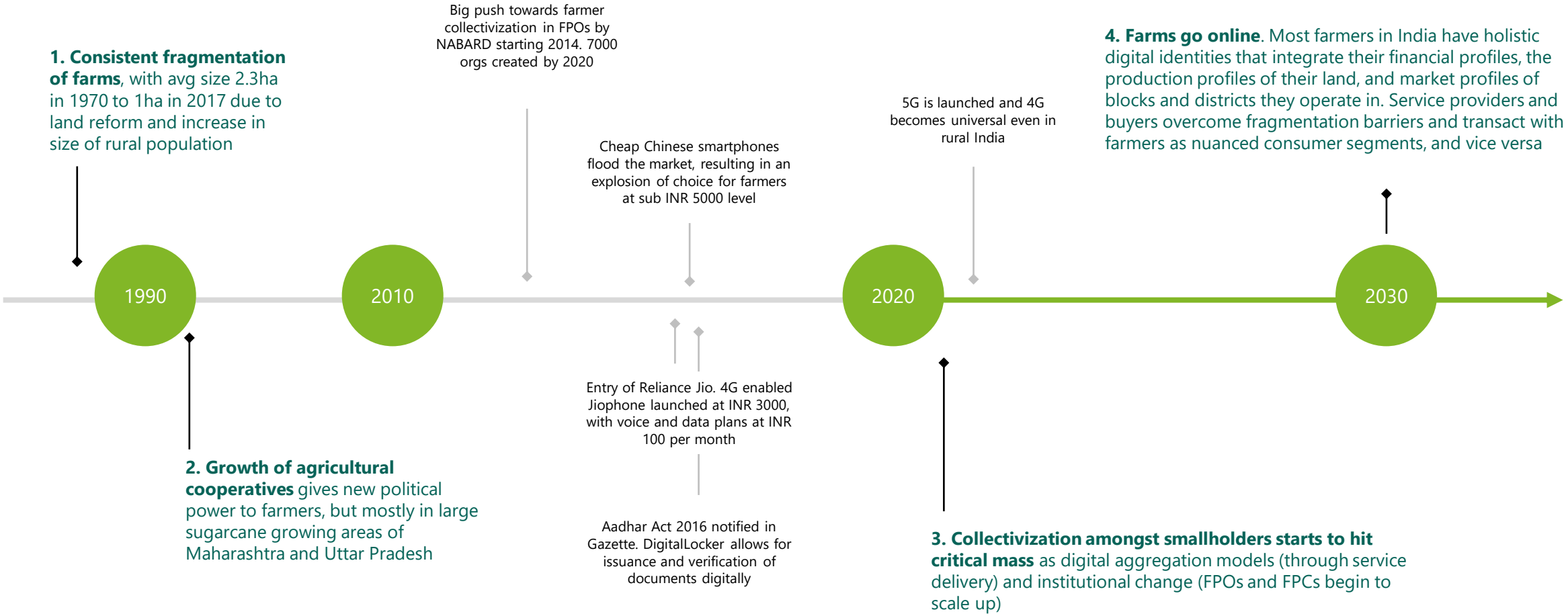
omnivore

Source: https://www.genengnews.com/a-lists/top-10-companies-leveraging-gene-editing/; https://www.sciencemag.org/news/2019/08/its-crispr-revolution-china-becomes-world-leader-genome-editing#; http://www.3barbiologics.com/bio-yield/; https://calyxt.com/our-products/
Note:

Trend 3:

Fragmented landholdings and asset ownership will go through widespread consolidation, real, and virtual, to achieve economies of scale for smallholders

Between 2010-2020, India lay down the foundations of taking rural citizens online. This decade will see the country's agricultural ecosystem migrate into a digital architecture that helps overcome problems of fragmentation



omnivore

While fragmentation has been a much debated subject for years, technology adoption across geographies and income segments in recent years promises to upend the long held status-quo

DRIVERS

1 Near universal access to phones and data services by farmers is building a trail of useful information on them

- **A wider net of the population is accessing the Internet. 95%** reduction in data costs, 2013 to 2020, bringing Internet within the reach of even the rural poor.
- **1 billion** Indians to have access to data services by 2030, and **840 million** estimated smartphone users.
- **Active digital engagement is improving with farmers.** In 2020, Digital Green, one of the largest digital agri training providers, has clocked more than millions
- **Women, however, continue to be excluded from land titles, land control, phone ownership, and internet access** and continue to face landlessness and fragmentation even greater than their male counterparts.

2 Key policy measures geared towards transparency in land ownership, use and consolidation

- **Agricultural reform set in motion** by the central government that passes ordinances relating to model tenancy, bypassing APMCs, and removing stocking limits
- **Digital India Land Records Modernization Programme,** which till the last review had 86% of land records being computerized, and 46% with cadastral maps digitized. By 2025, over 90% of land records may be digitized, verified, and linked to a Records of Rights, bringing financing and investment capability to smallholders.
- **Urgency to spend unutilized Direct Benefit Transfer (DBT) funds efficiently,** that is lying with the government, estimated at 27k crores, especially after the economic ripple effects of the COVID related lockdowns.
- **FPOs have become key policy priorities and will continue to scale and mature going ahead.** In less than a decade since the passing of the National Policy for Promotion of FPOs, nearly 7000 such organizations have been created, from a base of a few hundred at the start of the decade

3 Iterative build up of farmer data through multipurpose affiliation models

- **Affiliation to a suite of agritech services** that are onboarding farmers either as direct customers (information services, financial services) or as partners in B2B service to agri players.
- **Affiliation to producer organizations** facilitated by NABARD and other FPO enabling organizations. NABARD alone is expected to have onboarded 14 million farmers to a producer organization by 2030, uniting fragmented landholders under various economic functions. Sammunati Value Chain Finance has disbursed nearly USD 15 million in loans to over 70 FPOs it is associated with
- **Skymet, Satsure, Cropin, Farmland** are examples of agritech start-ups helping in the collection of layers of farmer data, from satellite maps of land to agronomic profiles of blocks and districts, for the public (government) and private (financial services) clients.

4 Business models designed around fragmentation

- **Rental and pay-as-you-go models for farm machinery** which are reducing upfront costs for small farmers, and allowing for assets to be utilized over larger areas of farmland.
- **Agritech start ups are moving towards full-stack services** bringing inputs, financing, and market linkage under one umbrella. This bundled value proposition is yielding rich, multidimensional engagement with farmers (and their data).
- **Vertical integration by agribusinesses to be closer to the source.** As of 2020, only 4% of India's agricultural output is purchased directly by institutional buyers. By 2030, this number may go up 10x as agribusinesses look to vertically integrate operations and link up with farmers directly, taking advantage of the data ecosystem in place by then.

omnivore

Source: India's Digital Future, KPMG, 2019; Summary of key policies, PRS Legislative Research, https://www.downtoearth.org.in/news/agriculture/defeminisation-of-indian-agriculture-59834

Fragmentation will be disrupted by innovations in operational data management and digital retail that place the farmer at the centre of business model design (1/3)

1 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
India Agristack	**An agristack, like the India Stack, will be a multi-layer agricultural information system containing geotagged data** on (1) producers: farmers and their financial and asset ownership, (2) assets: farmland, including its soil profile, productivity, and prevailing climate conditions, and (3) stock: movement of goods and prices in markets, Current efforts to collect data across these levels is dispersed between private agritech companies and government departments, and is beginning to yield results in small pockets of interventions like credit and insurance. By 2025, it is expected that the central government alongside private partners may institute an SPV to collect, consolidate, and protect the farmer data like the UIDAI does for Aadhar. By 2030, a composite map of the agricultural ecosystem, made up of building blocks that begin from farmer and farm identities, on to hydrological and climatic models, all the way to retail data, will reduce information asymmetries profoundly, making the system predictable, well-planned, and adaptive, three characteristics rarely associated with agriculture today. This information platform will enable private players to cheaply and reliable access farmers, offer them customized products like insurance and credit, and speed up the complete digitization of the agricultural ecosystem. Given this potential, the AgriStack has been rated as one of the most promising interventions in the coming decade and is expected to be a force multiplier for other innovations in agriculture.	**Enablers:** • Reduction in risk profile of farmers with build up of credit and transaction history, land titling, etc for companies needing KYC • Increasing customizability of interventions (crops, inputs, services, etc.) for individuals and regions, leading to improved agricultural outcomes • Digitization of land records by state governments, and financial inclusion and digitization through Jan Dhan Yojana and digilocker • Policy shift to DBTs and its requirement for Aadhar-verified farmer profiles • Agritech led data collection exercise through commercial engagement with farmers **Barriers** • Although the land modernization program started close to a decade ago, a large majority of states and their relevant departments (revenue, agriculture, water resources) lag in meeting their commitments • Women need deeper interventions that just land title recognition, to hand them actual control of assets that they own, that are controlled by men

omnivore

Source: India's Digital Future, KPMG, 2019; PRS Legislative Research; https://medium.com/accel-india-insights/working-the-soil-whats-driving-india-s-agri-preneurs-d10e6c73fa7e
Note:

Fragmentation will be disrupted by innovations in operational data management and digital retail that place the farmer at the centre of business model design (2/3)

2 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
Full stack digital farmer services	**Retail models in agriculture will be fixed on the farmer-as-a-consumer, offering him/her all agricultural needs at the touch of a button.** The past five years have seen the never-before-seen entry of digital farmer services including online input malls and FaaS businesses that deliver everything from seeds to farm machinery through a simple digital interface for farmers. As these companies establish and grow their footprint, moving from Series A to C and even PE funding, they will integrate their services horizontally to offer farmers a full range of products and services under one umbrella. This one-stop "ecosystem" approach will mirror the one taken by big tech companies like Amazon for the general urban consumer, where consumers can buy and sell goods, borrow credit, and even remotely control connected devices all through their accounts on just one provider (Amazon, Google, Facebook, or Apple). Like these big tech players, leading startups like Sammunati, Ninjakart, Jumbotail, Agrostar are collecting so much data on agriculture, climate, and supply-chains today, that armed with AI tools, their understanding of farmer needs by 2030 will be greater than that of individual farmers themselves. Just as Amazon knows when it's time for you to order your monthly supply of razors before you realize it, so will big full-stack players know a farmer's need for the exact variety of seeds or credit product before start of the farming cycle	**Enablers:** • Digitized data collection by agtech start ups across the supply chains • Advancement of AI and machine learning of agricultural parameters like climate, consumer demand, etc. • Target of USD 1 billion to be disbursed to agtech startups by venture capital funds by 2021 • Opportunity to digitize nearly USD 40 billion market (2018) of agri products and services **Barriers** • Data licensing and privacy agreements between retailers and farmers • Success contingent on growth of farmer incomes during this period to allow for spending on agricultural inputs and other farmer-focused products

omnivore

Source: India's Digital Future, KPMG, 2019; PRS Legislative Research; https://medium.com/accel-india-insights/working-the-soil-whats-driving-india-s-agri-preneurs-d10e6c73fa7e
Note:

Fragmentation will be disrupted by innovations in operational data management and digital retail that place the farmer at the centre of business model design (3/3)

3 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
3rd Gen farmer enterprises	**A majority of smallholder production will become collectivized under professional enterprises, rather than operating as unregistered and scattered entities that dominate the landscape today.** 1st generation FPOs were basic collectives like SHGs run on government grants which mostly helped farmers bargain for better prices on inputs when bought in bulk. The 2nd generation FPOs began to access working capital, make investments in technology, and sell the aggregated surplus to markets. The 3rd generation of producer organizations will mirror professional enterprises. These will emerge from the crop of progressive FPOs that have begun transacting with larger private players (e.g., off-takers), and in the process, setting up improved management and accounting systems. We expect this decade to also yield some of the biggest successes in women-run FPOs, as greater swathes of young women begin to challenge restrictive social norms and take up entrepreneurship and agronomy courses online, and many of the SHGs set up by the government between 2000-2020 start to mature and graduate up the productivity chain. On the one hand, leading FPOs will be subscribers to leading agritech services like agronomic and market information, formal finance, insurance, equipment rentals, etc. making them hubs of high quality products and services for farmer members. Alongside, management of FPOs is expected to undergo major upgrades this decade, driven by an uptick in enrolment in agricultural management and agricultural entrepreneurship courses by the younger generation of farmers. The virtualization and digitization of farm data and services will have an effect similar to what cloud computing did to IT infrastructure in the past 5 years. Entrepreneurs, therefore, will be able to launch innovative new services and ventures at a much lower cost and time-to-market	**Enablers:** • Strong central and state level push for creation of producer companies • Scaling up of FPO management training programs such as the one run by Bankers Institute for Rural Development (BIRD) under NABARD • Pull forces from FMCG companies looking to work closer to source • Women-focused SHG programs that have led to the gradual build up of credit history and confidence amongst women farmers **Barriers** • Lack of sufficient entrepreneurship and management training programs for farmers • Legal and financial complexity of setting up and managing incorporated companies

omnivore

Source: India's Digital Future, KPMG, 2019; PRS Legislative Research; https://medium.com/accel-india-insights/working-the-soil-whats-driving-india-s-agri-preneurs-d10e6c73fa7e
Note:

Given the economic and social importance of this transformation, private companies, state governments, and large foundations are joining hands to stimulate entrepreneurship and investment in off-farm agricultural economy

Innovation category	Select players (not exhaustive)	Spotlight
Technology entrepreneurship	• Syngenta Foundation • NABARD • Mann Deshi Foundation • Deshpande Foundation • IIM Ahmedabad	**The NITI Aayog sponsored National Strategy for AI has created early foundations for the creation of an Agristack in India.** Its strategy has a three pronged mission to (1) create foundational datasets for AI application (such as in cropping information, land records, etc.), (2) enable ease of access of existing data sets to ecosystem players, and (3) define standards for data sharing and licensing. It seeks to deliver on this mission through the following action plans, expected to be delivered over the next 2-5 years. First, the creation of annotated data sets with accompanying data standards and set up of data "marketplaces" for data exchange. Second, hosting a cloud computing platform called AIRAWAT for cloud computing n allow AI developers to train algorithms effectively. Third, the creation of AI focused research institutes o promote inter-sector linkages and allow for inter-departmental cooperation. If these plans were to succeed, India will be one of the first nations in the world to set up a holistic agricultural information system this decade.
Full stack digital farmer services	• DeHaat • Sammunati • Satsure • Fasal • Indigo • Farmers Business Network	**DeHaat** is an India full-stack agritech company that offers end-to-end solutions to buyers and growers in India. Its products and services include input sales, agronomic support for production processes, access to a marketplace with registered buyers, transportation ,and logistics solutions. As a result, the DeHaat model caters to farmers, to local micro-entrepreneurs, and to institutional buyers, linking them all in a service delivery loop. DeHaat currently works with nearly 270,000 farmers in Bihar, U.P., and Orissa, and plans to scale up its model to 5 million farmers by 2024.
3rd Gen farmer enterprises	• Sahyadri Farms	**Sahyadri Farms** is India's largest FPO by trade volume. It started in 2003 as a small farmer collective of marginal farmers, focused on grape production, looking to transform their farms into agri-enterprises by participation in export markets. Their initial success spurred them to register as a Farmer Producer Company (FPC) in 2011, and to set up their internal advisory team, packing house, cold storage, and farm infrastructure. Nearly 10 years later, they have become India's largest FPO with 8000 farmer members, a retail division (selling produce to consumers and buyers directly), and a processed foods division with value added products. The FPC also became one of the first FPC's in the country to adopt traceability solutions (partnering with CropIn). Its model and story is one that sets the stage to many more progressive FPCs expected to rise this decade

omnivore

Source: https://farmer.gov.in/iaof/iaof_admin/Data/403_Role%20of%20Digital%20and%20AI%20Technologies%20in%20Indian%20Agriculture-%20Mr.%20Tanay%20Mahindru.pdf; https://www.indigoag.com/for-growers/indigo-acres-complete; https://economictimes.indiatimes.com/news/economy/agriculture/sahyadri-farms-emerges-as-indias-largest-grape-exporter-of-2018-19/articleshow/70058281.cms#:~:text=Sahyadri%20provides%20the%20infrastructure%20to,division%20providing%20100%25%20traceable%20produce.

Trend 4:

Farmers will improve their relationship with global and local consumers, offer enhanced safety & quality, and improve income

As India moves into a future driven by tech enabled modern retail, each food product will become traceable and its production story- from farm to fork, visible to the consumer

1. 1980-2000: Unorganized retail. Quality control focused on homogeneity of ingredients for staple items such as cooking oil, tea, sugar, etc. Most products are sold under white label brands in local markets or kirana stores

2. 2005-2015: Entry and growth of modern retail Introduction of higher quality and safety standards by organized retailers in fresh produce but focused on visual checks and niche organic sections

3. 2010-2020: Exports become a key income driver for industry which begins to improve quality of produce, having some trickle-down effect on output sold through modern retailers and private label brands

India's Food Safety Authority, FSSAI, launched the Food Safety Mitra (FSM) program to extend safety compliance and certification services to the smallest of agricultural entrepreneurs

Reliance Jio launches its digitization program for India's kirana stores, promising to connect nearly 5 million hyperlocal grocers in India to consumers over the next 3-5 years

4. 2020-2030. End-to-end transparency: farm to fork connectivity through traceability, certification, and the "online" farmer. The decade will see food become an increasingly personal subject for households and establishments as consumers look for high standards of trust and safety in everything they consume, and producers and retailers provide this using technologically-aided production and supply chains

omnivore

Source: https://www.livemint.com/politics/policy/fssai-launches-food-safety-mitra-for-ease-of-doing-business-job-creation-11571234476663.html; https://qz.com/india/1864249/mukesh-ambani-and-whatsapps-jiomart-has-a-rocky-start-in-india/

This trend is driven by rich urban consumers and integrated value-chain players who want to trace the farm-to-plate journey of agricultural produce

DRIVERS

1 An enormously powerful and sizeable middle-class that drives consumption

- **The Indian middle class will be one of the largest consumer segments nationally and globally.** As per OECD estimates, India is set to have an additional 600 million Indians in the middle-class income category[1] by 2030, a 144% rise over 2019, bringing the total to 1 billion Indians
- **This segment will drive consumption and shape the market definitively.** The 600 million middle class Indians will have a collective spending power of USD 10.5 trillion by 2030.
- **Nearly 70% of these consumers will be under the age of 45, digitally adept and always connected**
- **Within this, the upper middle class (UMC) will grow as a mature consumer segment with refined tastes and preferences.** UMC expected to comprise 51% of consumers in India by 2030, up from 24% in 2020.

2 A growing concern for food safety, nutrition and sustainability

- **Consumers are looking for markers of safety and trust in food hygiene.** This sentiment is seen in the nearly 20% CAGR in organic food segments, one of the fastest growing food categories in the country
- **Consumers will look to upgrade food choices to premium varieties of food of the top quality.** As per WEF, half of the increase in middle class spending over the next decade will go towards upgrading to premium category
- **Entrepreneurship in food retail booming, in particular for companies with higher standards for food safety and quality.** 20-25% CAGR in the past few years, and into the new decade, of organized retail industry, driven in large part by food retail
- **Experts predict massive growth in traceable food products in the next decade.** USD 20 billion estimated value of food produced in India with some form of traceable identification in 2030

3 Vertical integration of big value chain players for supply-chain efficiencies

- **Modern retail promises huge growth in the next decade among urban middle class consumers.** Food comprises 15-20% of the organized retail market. In large cities, it shares upwards of 30% of the organized retail market. By 2030, **more than ~50%** of all food in cities will be purchased through modern retail.
- **Over 80% of Kirana stores across the country will be digitized by 2025** and be linked to modern traceable logistics.
- **Online retail consumers will demand higher quality and value.** Indian e-commerce market expected to touch USD 200 billion by 2026.
- **Biggest players in supply chain efficiency to be in dairy, marine food processing.** 61% share of dairy and marine processing industries in the total food processing sector, which will lead the way in food traceability.

4 Falling cost of sensors and availability of traceability solutions

- **Traceable technology will be affordable, allowing more new businesses to enter.** The cost of basic IoT sensors has **halved** in the past decade, from USD 0.8 per sensor in 2010 to USD 0.4 in 2020.
- **Storing and transmitting data will no longer be an access issue.** Wi-fi and cloud computing is becoming cheaper and faster. In the past 3 years, the cost of cloud computing fell by a net average of 58% per year, while its computing power and memory increased
- **Advancement in pathogen testing, hyperspectral imagery, and machine learning** is completely reorganizing how fresh or processed food is studied and tested, nudging a slow move away from physical and laboratory inspection methods

omnivore

Source: Indiaretailing.com, 2018; Envisioning India 2030, FICCI, 2017; https://oecd-development-matters.org/2019/05/07/look-east-instead-of-west-for-the-future-global-middle-class/;
Notes: (1) OECD defines "middle-class" as a segment with daily earnings between USD 11 – USD 110 per day

A combination of decentralized and interconnected technologies will bring improved transparency and traceability (1/2)

1 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
"Khet to Kirana" end-to-end traceability systems	**Supply chains between the farmer and the consumer in India will undergo an existential shift, becoming fully transparent and observable systems for participants.** Today, they are notoriously opaque due to the presence of numerous intermediaries, poor data collection, and institutionalized practices of adulteration and pilferage. The status quo is unlikely to persist this decade both due to the entry of advanced data capture technologies like IoT sensors and blockchain, and because of a vocal and demanding middle class. Data from IoT sensors deployed at various parts of the supply chain is being integrated by machine learning software at big modern retailers and FMCG companies. At a nascent stage today, data integration will reach a crescendo in ten years when nearly all production and post-production processes are remotely tracked, and a bulk of the food system comes under modern retail and private label brands. The real-time communication between farm yield monitors, warehouses, and store shelves will help managed inventory so accurately (supported by smart contracts) that pre-consumer food waste will be virtually zero. Notably kirana stores will not be excluded from these systems: as a result of the massive push on digitalization of Kirana stores by Reliance Jio (to be joined by a range of payment and traceability solution providers), shelves at mom-and-pop shops will be included as nodes in traceable systems. This will help complete the loop, providing a giant thrust to supply-chain efficiency. As part of the remote tracking systems across the supply-chains, agribusinesses will mandate data entry into blockchain systems so that ingredients can be traced to source farms, and any form of contamination or disease can be immediately traced and recalled nation-wide. With this capability, premium "single-source" products will become increasingly popular, helping link a batch of chilli powder, for example, to the exact set of farms from where chillies were procured for a particular box. Armed with this trove of rich data on food provenance, sustainability, and safety, premium brands will share the detailed journey of a food item to the consumer through RFID and QR/barcode technology, ultimately resulting in a new urban consumer-farmer contract founded on immutable trust. In real terms, this will mean higher margins retained by compliant farmers in exchange for guarantees of safety and freshness to the consumer. Early signs of this supply chain transformation can be seen in traceability experiments being conducted by the largest retailers. For example, Future Retail's Big Bazaar is starting to use store-level data to predict the upstream needs of procurement and warehousing weeks in advance, and Walmart is piloting blockchain technology for end-to-end traceability of shrimp purchased in Andhra Pradesh that is sold in retail locations in America.	**Enablers:** • IoT sensors and blockchain reduce the cost of monitoring food drastically, bringing compliance within the reach of MSMEs • Traceable foods can be sold at a premium, and more importantly, be sold in export markets with higher prices, increasing incomes of farmers • Traceable systems reduce food wastage and time delays for supply chain players, bringing them tangible monetary savings **Barriers** • Given the nascency of this industry, lack of standards can make interoperability and therefore end-to-end adoption difficult • While advanced tech certainly brings down the cost of tracing, these benefits do not immediately apply to farmers who need to implement them on the field. • Implementation of protocols at the farm level is still expensive as well as technically challenging for farmers

Source: Hyperspectral Imaging Applications in Agriculture and Agro-Food Product Quality and Safety Control: A Review, Applied Spectroscopy Reviews, 2013; https://fesmag.com/features/foodservice-issues/16151-the-future-of-food-safety; https://www.marketsandmarkets.com/Market-Reports/top-10-food-safety-testing-technologies-trends-19285603.html; https://www.foodnavigator.com/Article/2019/09/24/Blockchain-technology-is-improving-food-traceability; TRACEABILITY IN FOOD AND AGRICULTURAL PRODUCTS, International Trade Center, 2015

A combination of decentralized and interconnected technologies will bring improved transparency and traceability (2/2)

2 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
Precision food testing	**A key input in the above traceability system will be accurate and reliable food testing and labelling that guarantees quality and safety to buyers and consumers**. The Indian consumer of 2030 will expect highly reliable certificates of assurance on food products, and be empowered by rigorous safety standards that are being laid down by the FSSAI today. These compliance pressures along with big leaps in testing technologies will fast track India's progression from a nascent to a mature safe food producer. Two areas of testing will undergo major disruption: (1) physical parameters i.e. non-invasive testing for quality (grade, freshness, etc.), and (2) testing of biochemical parameters like pathogens. Advanced means of quality testing such as hyperspectral imaging, spectroscopy, and machine learning are taking error rates below one percent, and in 10 years, will become the gold standard. With this, manual, visually guided quality testing will be replaced by cameras and NIR scanners at major collection points (warehouses, mandis, and store/packhouses). Full genomic profiling of organisms along with rapid pathogen testing is bringing down testing time to 24 hours in recent experiments, compared to the reigning standard of 1-2 weeks. As the cost of such methods continues to drop in the coming years, high-risk pathogen testing will move from the laboratory to the supplier, so risks can be assessed at the point of food movement. This rapid, on-field testing will be capable of automatically triggering warning and recall protocols through traceability systems established by companies, and drastically reduce the risk of mass disease outbreaks from contaminated foods.	**Enablers:** • Increasing consumer interest in food "story" and its safety, health, and sustainability • Opportunity for greater margins for "traceable" and certified foods on the market **Barriers** • Standardization and regulatory approvals to enable parity of usage (to enable one commodity-one quality grading system, across growing regions). • Indigenous hardware development has to increase overcome to reduce import dependency here. • Cost of certifications is prohibitively high for most farmers and most food safety certifications accepted by large western markets have not been tailored to the operating context of the Indian farmer

Source: Hyperspectral Imaging Applications in Agriculture and Agro-Food Product Quality and Safety Control: A Review, Applied Spectroscopy Reviews, 2013; https://fesmag.com/features/foodservice-issues/16151-the-future-of-food-safety; https://www.marketsandmarkets.com/Market-Reports/top-10-food-safety-testing-technologies-trends-19285603.html; https://www.foodnavigator.com/Article/2019/09/24/Blockchain-technology-is-improving-food-traceability; TRACEABILITY IN FOOD AND AGRICULTURAL PRODUCTS, International Trade Center, 2015
Note:

There are a wide spectrum of large technology businesses as well as younger start ups that are launching B2B solutions to streamline supply chains in the country, setting stage for enterprise-wide disruption in agriculture

PLAYERS

Innovation category	Select players (not exhaustive)	Spotlight
End-to-end traceability solutions	• IBM Food Trust • SourceTrace • National Collateral Management Services (NCML) • FarmTrace by FarmLink • Food LogiQ • Provenance • Ripe.io	IBM Food Trust **IBM Food Trust** is a blockchain solution for food safety solutions developed by IBM. The blockchain solution allows users permissions to access a shared view of a selected food commodity from farmer to consumer. The solutions enable users to enter and control access to blockchain data on a food item based on its Global Trade Item Number (GTIN) or Universal Product Code (UPC) and can incorporate a wide range of parameters such as the item's real-time location, and its quality, safety, and provenance certificates. The platform has a variety of benefits including tracking food freshness, guaranteeing safety to consumers, inventory management and planning, and use of smart contracts to trigger automatic transactions between partners. While the product is relatively new, its has been successfully deployed by the New England Scallopers to guarantee provenance and sustainability to buyers, and help sustainably manage its fisheries. This use case is a significant torchbearer for the future, as the fisheries industry is expected to be one of the biggest beneficiaries of end-to-end traceability systems globally and in India (particularly for shrimp).
Sustainable smart feed	• Intello Labs • AgNext • Sample6 • Safetraces • Ancera • Clear Labs • SnapDNA • AstRoNA Biotechnologies	AGNEXT **AGNEXT** is an award winning pre-series A funded startup from India that focuses on improving data collection, analysis, and insights on food quality for different stakeholders in the agricultural value chain. Its proprietary platform called Qualix provides agribusinesses with a holistic solution to assess the quality of their stocks. It does so using AI-based image and spectral analysis of food that is able to conduct an instant physical and chemical inspection of food currently in the hands of error-prone humans or expensive laboratories. This allows for better price realization for buyers and producers, uniform quality within commodities, and minimizes losses and risks from poor quality produce across the value chain. The solution has been successfully used in a wide variety of crop value chains including tea, grains, spices, and herbs and aromatics, and is expected to cover a majority of collection and aggregation points for produce across the country.

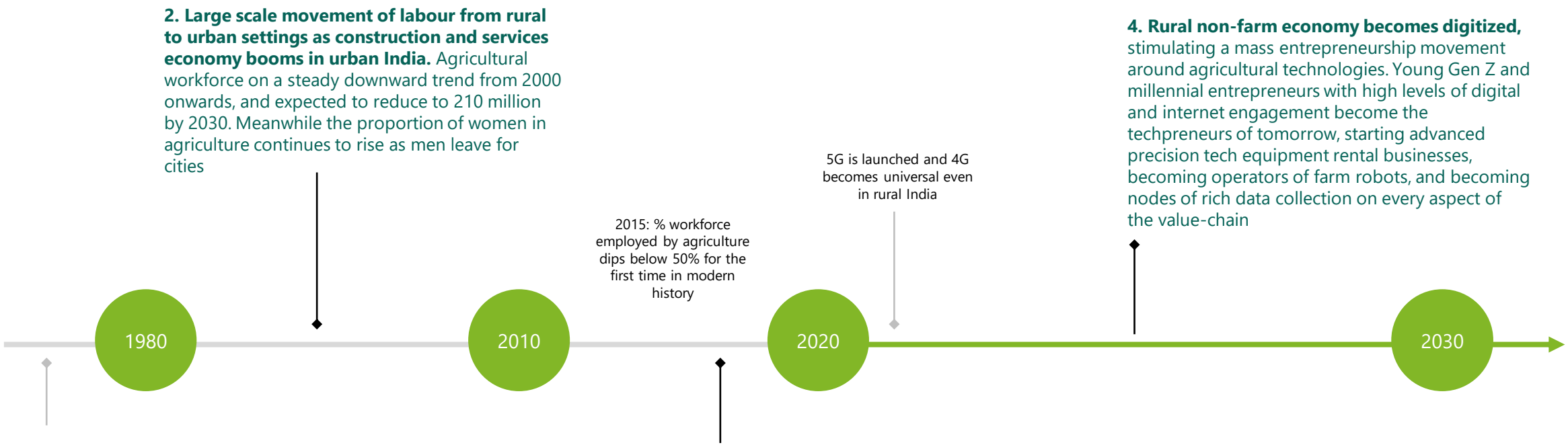
omnivore

Source: https://www.ibm.com/blogs/blockchain/2019/10/blockchain-traced-seafood-helping-historic-new-england-fisheries-thrive/; http://www.ancera.com/#ancera; https://agfundernews.com/fda-produce-rules-food-safety-startups.html; https://www.provenance.org/business/platform; https://agnext.com/product.html
Note:

Trend 5:

Agricultural labour will contract and move towards higher productivity jobs, higher up in the value chain; agricultural training will respond and cater to a younger farmer

The rural farm economy is steadily moving off-farm into allied industries of agritech services and post-production activities, and becoming increasingly feminized



omnivore

India's agricultural workforce will be smaller, younger, and more feminized in the future, which will shape how it is retained in higher productivity jobs of the future

DRIVERS

1 Labour is exiting farm work steadily, leading to the feminization of the workforce

- **Labour is unable to create commensurate economic value on the farm.** 50% of India's labour force is producing only 14% of its GDP.
- **It lags behind competing industries in compensation.** Daily wages in non-farm activities were estimated to be 2.4x higher than agricultural wages in 2018.
- **Farming will not be taken up by a large segment of tomorrow's farmers.** Of 30k rural youth surveyed in 2017, only 1% aspired to be farmers.
- **There is high levels of disguised employment that needs to be redistributed to other industries.** Over 50% of the agricultural workforce is landless and elastic.
- **Agriculture now employs 80% of all economically active women,** who comprise 33% of the agricultural labour force and 48% of self-employed farmers. However, they only own 13% of the land

2 Rural economy is becoming increasingly diversified

- **Food processing industries (FPI) has overtaken growth of rural manufacturing in the past few years.** Gross Value Added growth in FPI was 7.7%, compared to 5.9% and 4.9% for manufacturing and agriculture, respectively in 2017.
- **Foreign investors are taking note of the opportunity in FPI**, pumping in a record USD 630 million in FPI in 2018, increasing by an average of **23% per year since 2010.**
- **Agritech start-ups are looking to build distribution and service teams at the farm gate, across the country.** Approximately ~500 agritech start-ups emerged in this decade, pulling in a funding of nearly USD 300 million. In 10 years, these companies will be one of the biggest off-farm employers in rural areas.

3 Rural communities are striving towards parity with urban counterparts

- **By 2030, internet access will be universal in rural India,** pushed ahead by India's BharatNet program that seeks to connect 2.5 lakh gram panchayats with broadband. Data costs fell by a whopping 95% from 2013 to 2020.
- **Smartphone and internet access has leapfrogged in rural India.** 1 billion Indians to have access to data services by 2030, and 840 million estimated smartphone users.
- **By 2030, rural consumption will grow 4.3 times, compared to 3.5 times in urban India,** breaking the rural-urban consumption divide
- **The quality of digital engagement will be at level with urban areas,** as an entire generation of youth in rural India grows up on smartphones. Services such as Aadhar, Jan Dhan accounts, BHIM, and Digilocker are allowing high-quality financial, civic, and entrepreneurial engagement.

4 The workforce of tomorrow is willing to learn and upgrade skills rapidly and reflexively

- **Skilling is a major area in need of growth.** 30-35 million work seekers may face unemployment by 2030 and only 2.3% of India's workforce is formally skilled.
- **Youth will be conversant in digital learning and skilling modules and rapidly self-learn new techniques for the jobs of tomorrow.** By 2030, India will have 370mn Generation Z consumers between the age of 10-25 for whom online learning will be a norm.
- **Online learning is going mainstream amongst rural youth.** Youtube and whatsapp are the two most common sources of new information for farmers today. By 2030, young workers will primarily learn from local modules on robotics, data analytics, etc,
- **New skills required for the rural future of "phyglitization" or combining of e-commerce and physical presence.** For every online transaction in rural areas, a physical service, be it at a kiosk, a beacon, or at home, will be administered by skilled service staff that can operate scanners, sensors, etc. and offer comfort to customers. The rural workforce will have to be retrained in either one of these two areas of disruption

omnivore

Source: National Accounts Division, Central Statistics Office, 2019; Department of Promotion of Industry and Internal Trade, 2019; Growth of F&B in India, Dart Consulting, 2018; https://www.weforum.org/agenda/2020/01/help-india-rural-population-go-digital/;

There are two key changes to status quo that will respond to these drivers: a transformation of the learning ecosystem in rural India, and a mass entrepreneurship movement built on new business models allied to agriculture (1/2)

1 INNOVATIONS	DESCRIPTION	ENABLERS AND BARRIERS
Peer to peer (P2P) learning networks	**Rural skill development – prompted by a changing agricultural landscape - will undergo a radical transformation this decade.** As skill needs in agricultural change, moving from manual labour work to more value-added technology-aided work, so will the education systems. The democratization of audio-visual content creation because of the smartphone has unleashed a new "train the trainer model" at the turn of the decade. Young progressive farmers (many of them returnees from their time in cities) are documenting experiments with new technologies and practices using smartphone and drone photography, and disseminating through youtube, whatsapp, and tiktok. Leading channels have clocked over a million unique visitors within a few years of existence, and are preferred sources of information and learning for young farmers. This new model solves for two core issues that plague the agricultural extension system: (1) low adaptability to changing circumstances of agricultural work, and (2) high cost of administering to farmers engagingly. Digitally hosted P2P education allows for the first-time democratization of information in rural India (allowing farmers to create and study modules that they *want),* can be disseminated easily and cheaply, and can provide high user engagement and retention due to the highly demonstrative nature of videos. Overtime this will give rise to the first generation of indigenous P2P skill sharing platforms that focus on the future rural economy (like SkillShare and Coursera do for the urban digital economy today), and by 2030, most rural youth will learn and upgrade skills on these platforms, even being certified as drone operators or system administrators by leading agritech partners on these platforms. These platforms can be particularly important for women as they reduce the travel time and costs of receiving education, which is crucial given the growing pressures on women's time spent on farm and household activities.	**Enablers:** • Greater relevance and efficacy of learning modules due to localized content creation • Higher retention and engagement due to customizability of self-learning pathways • Lowered costs of gaining skills • Increased transmission of best practices and ideas across farmer networks • Large enabling push by players such as Syngenta Foundation, GAME, etc. • Entry of agritech companies into new rural geographies • Digital and internet literacy of Generation Z and millennials • Government of India's focus on agricultural entrepreneurship, signalled by the launch of Agri Udaan in 2017 **Barriers** • Quality control and standardization across learning modules is difficult unless regulated under branded content providers • Women lag behind men in their access to smartphones and the internet and will require concerted programming to receive equal benefits

omnivore

Source: Indian Farming's Next Big Moment: FaaS, Bain, 2017;
Note:

There are two key changes to status quo that will respond to these drivers: a transformation of the learning ecosystem in rural India, and a mass entrepreneurship movement built on new business models allied to agriculture (2/2)

2 INNOVATIONS	DESCRIPTION	ENABLERS AND BARRIERS
Technology entrepreneurs	**The rural agri-entrepreneur of tomorrow will be a technology entrepreneur.** New business models in agriculture, particularly FaaS, are driving technology adoption across the value-chain. As precision tech such as farm advisory, drones, rovers, smart-tractors, IoT sensors, etc. spread across production and post-production activities, the demand for skilled machine remote operators, data collectors, and system administrators, and maintenance service providers is going to increase exponentially. These professions have the aspirational qualities of being cutting-edge and can be remunerative (where farmers can't pay, large value chain players can). The above characteristics will attract entrepreneurs from the rural Generation Z and millennials (the bulk of the workforce by 2030) looking for off-farm work. Overtime, broadening, and deepening of expertise through P2P learning will lead rural entrepreneurs to create their own localized FaaS companies that provide data, equipment, and market linking services. With support from big players like Syngenta Foundation, NABARD, and agritech companies themselves, this will unfurl a mass entrepreneurship movement across rural India whose time has finally come. This movement will have to consciously include women entrepreneurs in training programs to ensure benefits are received by women who are in charge of more and more activities on the farm today.	**Enablers:** • Increase in the supply of high-quality local services such as precision technology • Expansion of rural fintech services as employers as well as enablers for other services • Improved livelihoods for youth unable to secure jobs in cities or in manufacturing • Strong central and state level push for the creation of producer companies • Scaling up of FPO management training programs such as the one run by Bankers Institute for Rural Development (BIRD) under NABARD • Pull forces from FMCG companies looking to work closer to source **Barriers** • Base skill levels of rural youth many of who have undergone poor quality secondary and higher education, and lack necessary language and soft skills to get upskilled • Lack of sufficient debt and equity financing for rural entrepreneurship due to overdependence on risk-averse rural regional bankers

omnivore

Source: Indian Farming's Next Big Moment: FaaS, Bain, 2017;
Note:

Given the economic and social importance of this transformation, private companies, state governments, and large foundations are joining hands to stimulate entrepreneurship and investment in off-farm agricultural economy

Innovation category	Select players (not exhaustive)	Spotlight
Technology entrepreneurship	• Syngenta Foundation • NABARD • Mann Deshi Foundation • Deshpande Foundation • IIM Ahmedabad	**Syngenta Foundation's Agricultural Entrepreneurship (AE)** program is one of the largest privately led initiatives to train rural technology entrepreneurs in India. Under this flagship program, the foundation has partnered with a host of agritech companies and state governments to extend training on and access to their products and services. The AEs then use the product and services of agritech companies to provide advisory, market linkages, and credit to farmers. The AE Program hopes to scale to nearly 100,000 AEs in the next 5 years with the newly created SPV "AE Growth Foundation", where Tata Trusts and IDH are core partners. AEGF will forge technical partnerships with a range of agritech companies eager in creating upskilled field management staff and partner enterprises in rural India. In the long term, this program hopes to create self-sustaining and independent entrepreneurs who can scale enough to employ their own staff and create sustainable businesses across rural India.
Peer to peer (P2P) learning networks	• India Farmer (Youtube) • Desi Kheti (YouTube) • Farming Leader (YouTube)l • Google Internet Saathi • Digital Green	 **Indian farmer** is one of the biggest (630k subscribers at last count) farmer-focused youtube channels in India. It was started by a 26 year old farmer, Santosh Jadhav, who hails from Sangli, Maharashtra. Jadhav set up his channel in 2018 to share the new farming techniques he had learned with a wider rural audience. His comfort and experience with smartphone camera use and basic editing software allowed him to make crisp and tightly edited videos that were rarely seen at the time. The success if his initial videos prompted him to invest in upgrading his teaching tools to a DSLR camera and improved scripting and editing work, all focused on improving the delivery and efficacy of his training. His modules cover a wide range of topics including new agricultural technologies, latest agronomy, and accessing government agricultural subsidies. He is joined by other rising youtube educators like Punjab-based Farming Leader with more than 3 million subscribers and Desi Kheti with nearly 300k subscribers. These rural skill developers are now being recognized as independent brands in their space, and creating an alternate skill-economy that is being hotly pursued by agribusinesses and implement providers keen on tapping into its sizeable reach and engagement with farmer-consumers

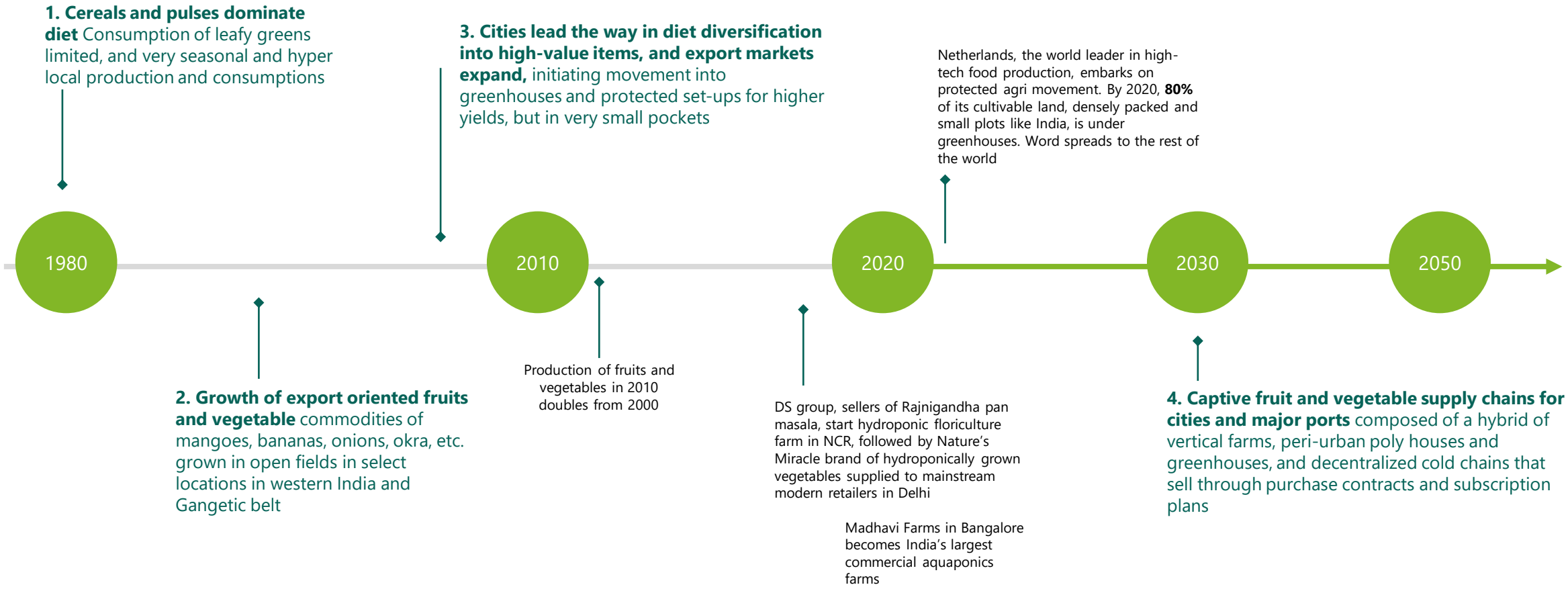
omnivore

https://economictimes.indiatimes.com/news/economy/agriculture/these-youtube-kisans-make-farming-easy/articleshow/69809774.cms#:~:text=Darshan%20Singh%2C%20who%20runs%20the,people%20with%20jobs%20in%20cities.; https://www.syngentafoundation.org/agriservices/whatwedo/ae

Trend 6:

Production of high-value output such as leafy greens and cruciferous vegetables will become more specialized and protected, and have its own dedicated logistics chain

Cities will look to secure their supply chains from external shocks of the upcoming decade. Consumers, driven by a desire for freshness and immediate fulfilment, will pull production of greens closer to them, and have them on demand



Source: Journal of Agricultural Studies, Vol 2 No1, 2014; Investing to Nourish India's Cities, Chicago Council on Global Affairs, 20XX; https://www.hindustantimes.com/india-news/from-meat-and-fish-to-vegetables-these-9-charts-reveal-how-india-eats/story-TuuBXEWSUh8rasldtnongP.html; https://www.nationalgeographic.com/magazine/2017/09/holland-agriculture-sustainable-farming/

This trend is driven by the growing importance of nutrient-dense fresh produce on the plate of the urban consumer and the increasing efficiency of protected technologies that can grow food cheaply, dynamically and perennially for the demanding consumer

DRIVERS

1 A large consumer base with unmet demand for fresh nutritious produce

- **Urban consumers are geographically concentrated, therefore more easily marketed towards.** 55% of 440 mn urban residents **live in 12 urban clusters** and will generate 60% of the country's GDP by 2030.
- **Urban consumers dominate the market for fruits and vegetables (F&V).** 50% and 21% of people consuming vegetables and fruits daily, respectively, are in urban India.
- **Supply of F&V will widen if new players do not enter the market. 41 million tonnes** is the estimated gap between the supply and demand of fruits and veg in domestic markets by 2030.
- **Faltering supply will lead to an increase in imports of F&V. USD 134 million** worth of fruits and vegetables imported by India in 2018, which entrepreneurs are looking to substitute in specialized farms.

2 Preference for high-quality, fresh food year around, on-demand

- **Demand for postharvest tech increasing** to solve for India's high post harvest losses, which in 2016 were estimated at USD 14.33 billion dollars. ICAR estimates that 4-6% of cereals, 6-18% of fruits, and 7-13% of vegetables are lost at this stage
- **Logistics to become more efficient.** 6-10% share of the retail price taken up by logistics in India compared to 4-5% globally, which is being brought down by the establishment of urban farms.
- **Investment in cold storage a major requirement for the private and public sectors.** 90% of perishable foods unable to access cold storages in India making off-season production difficult and wasteful.
- **Farm-to-plate organic operations on the rise.** New companies like Krishi Cress, Two Brothers Organic Farm, Kerehaklu – examples of high-value, commercial farms supplying to HoReCa segment and top-tier households in major Indian cities.
- **New companies are providing technical support to urban farming startups.** Clover**,** Bombay farmer, Hydroponic India, are examples of new-age farm technology (hardware focused) companies catering to urban Indians looking to set up specialized farms in brownfield sites or in peri-urban farms.

3 Falling costs of protected technologies and indoor farms

- **Huge cost savings in switching to efficient agricultural models.** 90% Reduction in water usage by Dutch agriculturalists, leaders in protected agriculture, after moving to greenhouse farming as their mainstay production system since 2000.
- **Electricity utilization in vertical farms much improved.** The cost of LED fixtures dropped by 85% between 2010-2020 and efficiency doubled.
- **Vertical farming can increase yields with protected conditions.** The 1.5-3X average increase in yields of vegetables compared to open-field agriculture, due to a controlled growing environment
- **Vertical farming increases yield on significantly smaller acreage. 200-700X** increase in yields if adding effects of vertical stacking in same floor area

4 Increased consumer standards after shock events

- **Consumers in India are still more optimistic about economic recovery post COVID-19.** McKinsey survey shows that 58% of Indian consumers asked were optimistic about the economic conditions in their country and households' anticipating spending is not predicted to drop dramatically.
- **Consumers will demand more hygienic conditions in modern retail environments, due to the fear of contraction of COVID-19.** Stricter controls are expected in the opening of supermarkets, which are usually overcrowded. A large segment of affluent urban consumers will demand safety and traceability in fresh produce, and move indoors from outdoor wet markets.

omnivore

Source: Journal of Agricultural Studies, Vol 2 No1, 2014; Investing to Nourish India's Cities, Chicago Council on Global Affairs, https://www.hindustantimes.com/india-news/from-meat-and-fish-to-vegetables-these-9-charts-reveal-how-india-eats/story-TuuBXEWSUh8rasldtnongP.html; https://www.nationalgeographic.com/magazine/2017/09/holland-agriculture-sustainable-farming/; Omnivore analysis; https://www.intellecap.com/wp-content/themes/intellecap/pdf/Public-Facing-Report.pdf; https://www.mckinsey.com/business-functions/marketing-and-sales/our-insights/a-global-view-of-how-consumer-behavior-is-changing-amid-covid-19
Notes: ** Projected based on assumptions listed in annexure

The biggest impact of this trend will be felt when production, marketing, and storage of fresh produce becomes an interconnected system in major cities (1/2)

1 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
Hi-tech fresh produce infrastructure	**Cities will have dedicated supply chains for high-value fresh produce grown in automated systems capable of same-day harvest and delivery.** Entrepreneurial farmers from Indian metros are setting up advanced poly houses next to cities with adjustable light sources, light refractors, soil-less growth mediums, etc. as standalones or tuck-ins to open field agriculture. Many of them will follow the efficiency and hygiene standards being set by fully-automated indoor farms coming up in Singapore, New York, and San Francisco, funded by big-ticket VC funding. These systems deploy the latest in robotics, plant science, and consumer-centric design, and have brought down harvest cycles of fresh greens to 1-2 months from conventional 3-6, making them extremely dynamic and responsive to local demand. By 2030, production decisions in these settings will be informed by predictive analysis on smart refrigerators at grocers, restaurants, and cafes, such that only as much is needed, and what is needed, is produced. Many of these will be supplemented by add-on vertical farms built in underutilized real estate in cities (old warehouses, rooftops, low-grade commercial complexes) supplying salad greens and vine fruits to high-end consumers. **This captive urban food loop will be closed by a huge rise in decentralized cold-storage infrastructure.** This will be driven by large-scale investments in captive cold-chains for modern retailers in cities, as well as expansion of last mile temperature-controlled delivery options from on-demand delivery services equipped with sensors. The disruptive effects of the ongoing COVID pandemic will also stimulate investments in a lot more storage "spokes" at the local kirana and household level through communicative refrigerators and smart tags on fresh food that signal expiry dates, inventory needs, etc. to local farms. These will be implemented first at the sizeable retail and regional distribution centers being set up by online and brick and mortar e-grocers.	**Enablers:** • 15-20% CAGR of HoReCa segment that expects high-quality fresh produce regularly • Higher yields, and lower food waste across the supply chain, cutting down the net costs of protective technologies • VC funding in controlled agriculture startups like Clover in India, Ripe.io in America **Barriers** • Greenfield real estate in big metros is prohibitively expensive. Instead, brownfield sites like old warehouses will need to be retrofitted for urban food consumption • For produce from these settings to be competitive with open field produce, energy input (renewables) and lighting costs (LED) must continue to fall at the rate seen in the past decade • Labour costs can be one of the biggest barriers to profitability as indoor agriculture requires high-skilled and specialized labour to operate farms • Infrastructure for specific produce has to be differentiated due to varying storage and handling needs of fruits, veg, milk, and meat

Source: https://www.business-standard.com/article/economy-policy/cold-storage-capacity-expands-rs-21-000-crore-investment-lined-up-by-2023-119032200623_1.html; https://asia.nikkei.com/Business/Transportation/India-s-retail-modernization-turns-the-cold-chain-business-hot; https://medium.com/bright-agrotech/9-reasons-why-vertical-farms-fail-244deaecd770; https://www.vox.com/energy-and-environment/2017/11/8/16611710/vertical-farms

The biggest impact of this trend will be felt when production, marketing, and storage of fresh produce becomes an interconnected system in major cities (2/2)

2 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
Personalization of farming and food products	**Restaurants, café's and home chefs will have their personalized farms producing curated food products and ingredients for culinary use.** Careers in culinary arts have never been as popular as they are today, boosted by a decade of media influence wielded by shows such as MasterChef and Chef's Table, and a concomitant refinement of the upper-middle class consumer palate in cities. An explosion of culinary artists outside of the traditional restaurant, specializing in bespoke bread, cheese, ferments, sauces, spice blends, and marinade making. Second, a strengthening of the artisan-farmer relationship, where these value-added producers ensure the use of the highest-quality of ingredients sourced directly from farmers that are known to them. Ultimately, premium customers and food artists will subscribe to personal farms at the city gates to source traceable, made-to-order produce baskets. The "farm-fresh" products of these farms will offer premium alternatives to pan-India private label brands that consumers are looking to replace with something more bespoke and personal. The farms patronized by discerning clientele will become extended food labs, helping test and expand the latest in culinary arts coming out of India. Many of these farms will move to a turnkey operator model, where they charge land owners a flat fee for setting up and operating farms in return for a share of profits, thereby allowing for a network of peri-urban farms to crop up nationwide.	**Enablers:** • Movement of urban professionals into agriculture • Rapid turnaround between trial and production of new ingredients • Ability to personalize shopping lists for individual, family, or customer needs **Barriers** • Awareness and respect for fresh produce skipped a large proportion of older (35-39) millennials who grew up in cities detached from production systems. For the niche movements of local and fresh to sustain, the younger segment of millennials moving into their own homes, as well as Gen Z, must get involved in groceries and food prep.

omnivore

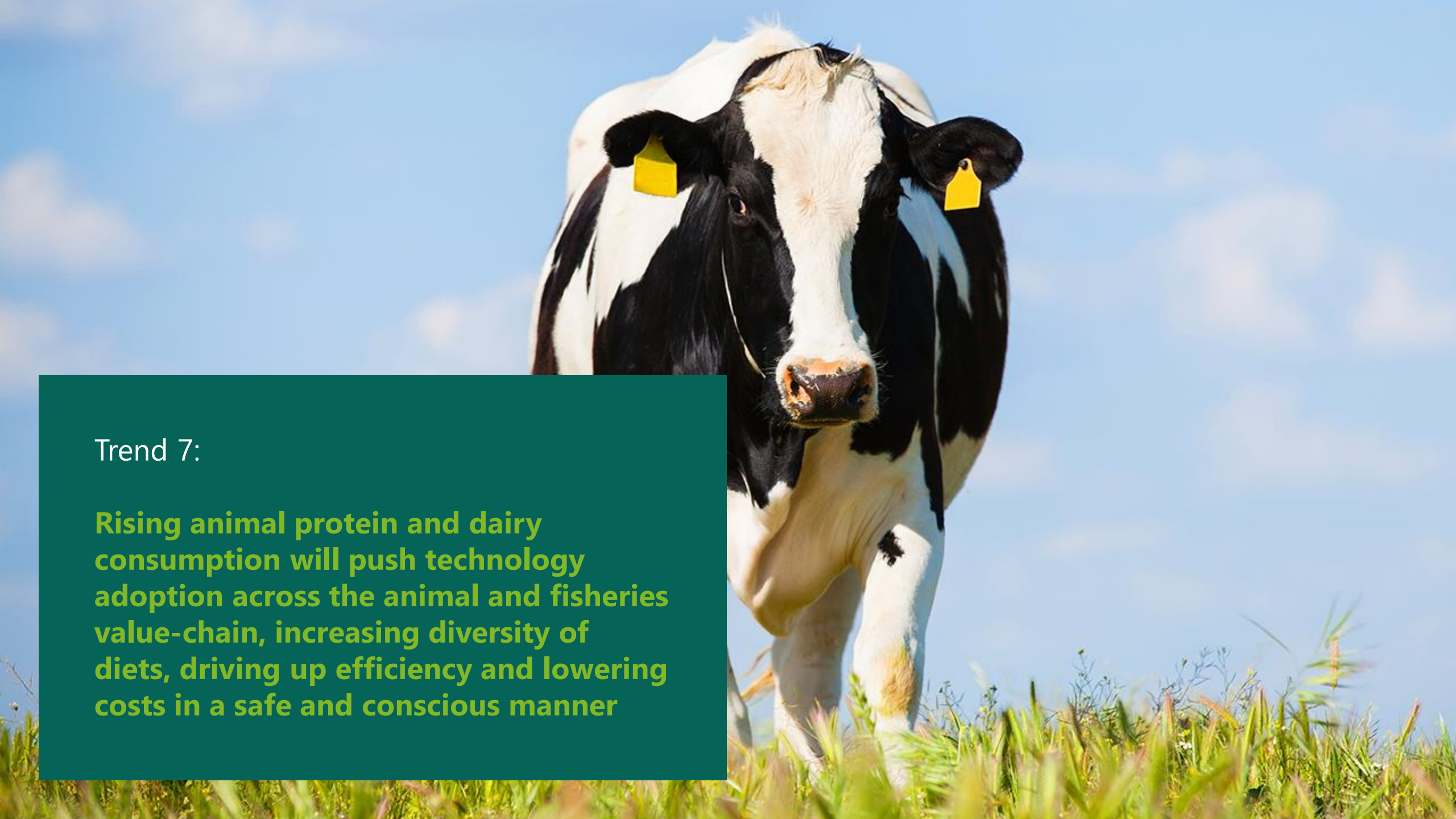
Source: https://www.business-standard.com/article/economy-policy/cold-storage-capacity-expands-rs-21-000-crore-investment-lined-up-by-2023-119032200623_1.html; https://asia.nikkei.com/Business/Transportation/India-s-retail-modernization-turns-the-cold-chain-business-hot; https://medium.com/bright-agrotech/9-reasons-why-vertical-farms-fail-244deaecd770; https://www.vox.com/energy-and-environment/2017/11/8/16611710/vertical-farms

Innovation in this space had been slow to catch up this past decade in India, but has been super charged by the entry of younger, progressive agriculturalists with greater access to capital, and gradual reduction in barriers to scale

Innovation category	Select players (not exhaustive)		Spotlight	
Fresh produce infrastructure	• Clover • Agriplast • Jain Irrigation • Homecrop • iKheti • PindFresh • Urban Kisan • Indian Superheroes	• Food LogiQ • Provenance • Ripe.io • Ecozen, Ovio Smarterware, Promethean Power Systems, Tan90 Innovation	CLOVER	**Clover** is a series A funded start-up from India that is revolutionizing the way fresh produce is produced, packed, and delivered to urban consumption centers in the country. The company is building a large network of technologically-advanced farms (greenhouses, polyhouses) that produce fresh fruits and vegetables for urban consumers. Their innovation lies in providing a full stack of services to the farmer, ranging from demand management and forecasting, advanced agronomy and technology enablement at the farm level, and offtake and marketing to consumers. In due time, this will allow Clover and others like the company to create a network of on-demand production centers close to the city, drastically cutting down the environmental impact and food waste generated from fresh produce supply chains, and delivering nutrition to consumers at better prices.
Sustainable smart feed	• The Millenial Farmer • Zama Organics • Krishi Cress • Two brothers organic farm	• Kisano India, • Vrindavan Farm, • Dream Farm India, • Kerehaklu	KRISHI CRESS	**Krishicress, New Delhi,** is a peri-urban farm on the outskirts of New Delhi that produces high-quality ingredients such as salad greens, exotic vegetables, fruits, as well as value-added products like Kombucha for consumers and chefs in the city. The business sells standalone as well as subscription product packages to consumers. It is now expanding to all-in-one farm-to-fork menu packages that include ingredients and recipes to assemble meals at home, a low-fidelity prototype of the publically-traded Blue Apron in the USA. The farm's USP is its "one-stop-shop" design that can curate, produce, process, and package high-quality foot items for the consumer in a transparent, clean, and environmentally-sustainable process. Krishicress is a thought leader for many upcoming "chef's farms' cropping up on the borders of large urban population centers in India that are slowly solidifying their business models around consumer-centric farm-to-fork models, and which are expected to become a major supplementary source of ingredients to upper middle and upper class consumer segments in cities.

omnivore

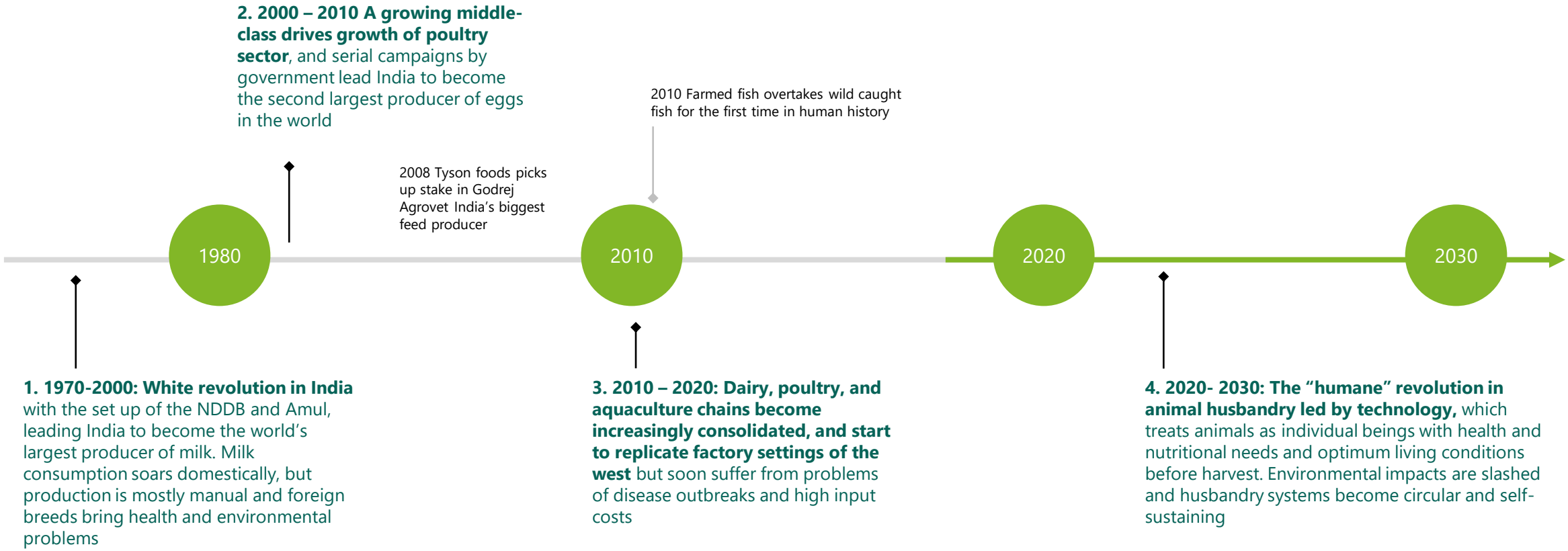
Source: https://www.plenty.ag/join-us/; https://techcrunch.com/2017/07/19/billionaires-make-it-rain-on-plenty-the-indoor-farming-startup/?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAADyQnN5dVVo6I--K30hnxaCXqo-RPDW35k1vAI3Eg83gJUHmtre8h8YfF6XjBdQN_O6lJZrajEor6XdVp9jG4X060yFa1-oYMP70NeugwUZ6Izidjj3z9QHgdeGSGlkJI-vAn-JNLrdIpQLI8tp-EeBcgmjk5Vy7aFchtiHRYYG8; https://clover.ag/



Trend 7:

Rising animal protein and dairy consumption will push technology adoption across the animal and fisheries value-chain, increasing diversity of diets, driving up efficiency and lowering costs in a safe and conscious manner

India is marching steadily towards a more animal protein-intensive future, but with its concern for humaneness and environmental sustainability in tow



omnivore

Source: https://www.nature.com/scitable/knowledge/library/history-of-agricultural-biotechnology-how-crop-development-25885295/; https://www.downtoearth.org.in/news/india-launches-its-first-genetically-modified-crop-8031; https://www.livemint.com/industry/agriculture/inside-india-s-genetic-crop-battlefield-1561054298998.html

This new future is being shaped by rising domestic demand for animal products, and growing concerns for the environmental impacts and safety of these products

DRIVERS

1 Inputs are becoming too expensive or inaccessible, making the economic case for biotechnology more apparent

- **India needs to increase its consumption of protein**, as currently, over 80% of the population is protein deficient, 45% of children suffer from stunting, and 75% are deficient in vital nutrients.
- To meet this demand, **protein consumption needs to increase 20%** to ~33MT of protein every year.
- **These improvements will serve a larger more affluent middle class** by 2030 that demands better quality and guarantees of freshness. 75% of consumer spending will be driven by middle-income groups that will constitute 80% of all households.
- **However, diet improvements need to be observed across the board**, beyond the current focus on high-income groups and men.

2 The industry is witnessing an unprecedented increase in knowledge and precision in plant and soil study

- **Consumer demand for meat is rising.** While plant sources of protein are viable and nutritious alternatives to meat, they are unlikely to substitute the growth in meat consumption this decade due to the dietary aspirations of the enormous middle class in India.
- **Animal protein production will continue to play a key role in improving farmer livelihoods.** Livestock currently contributes a quarter of the total agricultural GDP and 6% of the country's GDP. India is also the second largest producer of fish in the world, which is its top agricultural export.
- **Currently, milk is the largest contributor of protein by volume,** which means technological intervention in milk production and processing can increase protein delivery at a lowest cost to consumers.
- **Future increases will be driven by poultry and aquaculture**, both of which grew faster than dairy production this past decade. These value chains are currently prone to high rates of mortality and yield variations due to manual monitoring and management systems.
- **By 2050, the consumption of protein from animal sources in India is expected to jump 94% from the start of the 21st century.**

3 Policy makers and consumers are recognizing the importance of biotechnology in solving for the problems of the future

- **Animal protein production consumes a large amount of resources diverted from human consumption as feed.** Animal feed uses 50% of global arable land, constitutes nearly half of all GHG emissions from livestock, consumes 12% of global freshwater, and diverts 22% of wild fish capture (85% of stocks of which are exploited or depleted).
- **Livestock utilizes a huge portion of India's resources.** India's **100 million+ buffalo** population consumes 110 billion litres of water in its dry fodder, 200 billion litres in green fodder, and 30 million litres in concentrates, **daily.** Its livestock produces 200 million tonnes of CO2 annually. When combined with other cattle such as goats and cows, these figures are even larger
- **Despite its huge cattle population, the average Indian cattle only produces 50% of milk compared to the global average.**
- **Livestock production requires keen attention to research on diseases and biology.** In addition to reducing its environmental footprint, production increases need to grapple with twin challenges of increasing input costs and rising zoonotic diseases and antimicrobial resistance**.**
- **Livestock production will be accompanied by growth in allied sectors.** Technological solutions will therefore need to address two key components of animal protein production to create a more sustainable pathway for producers and consumers**: animal feed and animal healthcare.**

omnivore

Source: World Resources Institute; https://www.firstpost.com/india/indias-meat-industry-growing-rapidly-but-depleting-a-third-of-worlds-fresh-water-reserves-4360065.html; https://indiabioscience.org/columns/indian-scenario/meating-the-needs-of-the-future; https://india.mongabay.com/2020/01/fish-meal-and-fish-oil-industries-pose-threat-to-the-fishing-sector-in-india/; Feed Behind our Food, Feed Compass, 2018; http://agrospectrumindia.com/analysis/28/159/livestock-sector-in-india-trends-challenges-and-a-way-forward.html; https://economictimes.indiatimes.com/news/economy/agriculture/fisheries-sector-registered-more-than-double-growth-in-past-5-years-emerged-largest-group-in-agri-export-economic-survey/articleshow/70071062.cms?from=mdr

Precision biology – the use of AI, machine learning, genetic engineering, and computational biology – is set to disrupt the animal industry with tailor-made micro and macro organisms designed for food production (1/3)

1 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
Sensor based animal diagnostics	**Animal care and rearing will become as individualistic as modern healthcare for humans.** Currently, the process of management of animal health – for livestock, poultry, and fish, is dependant on visual inspection by their producers, leading to numerous errors in diagnosing disease incorrectly, too late, or for the wrong animal. This method of monitoring is changing with the entry of advanced sensors; 3D cameras that can accurately measure animal's weight and inconsistencies in it, thermal imaging cameras that detect mastitis in cows, cameras that detect behaviour changes of individuals chickens in a flock, and wearables that can monitor detailed parameters of an animals health and fertility. At the turn of the decade, advanced diagnostics are just about entering the dairy and aquaculture industry in pockets where large commercial players looking to optimize yield and quality. With falling sensor costs and consolidation across the meat industry, most commercial poultry farms, goateries, and cattle farms will automate animal diagnostics. The biggest potential, aside from dairy, is in India's burgeoning **shrimp farming industry**. Access to improved health and yield management will allow producers to tap into export markets that expect higher quality and safety controls, and can eventually catapult India into the world's largest shrimp exporter. The datasets this creates will bring a major boost to the predictive abilities of companies and the government looking to mitigate large scale disease outbreaks the likes of COVIID, and result in an ecosystem level push towards better animal and public health management.	**Enablers:** • Reduction in labour costs associated with animal rearing • Reduction in mortality and an increase in yields • Reduction in the usage of antibiotics due to early detection systems, and a general loss in the efficacy of antibiotics due to rising resistance • Increasing policy and regulatory push towards food safety especially after COVID-19 • Consolidation of meat value chain with the entry of large vertically integrated commercial players looking to invest in quality improvement • Falling cost of sensors and wearables **Barriers** • The current cost of animal wearables and sensors are too high for the average poultry, livestock, and fish farmer. A lot more vertical integration (where commercial players own a stake in production) and/or FaaS models for these technologies will be required to put them in every cow and poultry shed and fish farm • Changing traditional animal rearing methods requires intensive training, awareness, and behaviour change, which is slow and expensive for agritech companies to take up independently

omnivore

Source: https://www.nationalgeographic.com/science/2019/03/partner-content-livestock-farming-future/; Livestock production; recent trends, future prospects, Futures Centre, 2019; https://medium.com/@FuturesCentre/which-animal-feeds-are-fit-for-the-future-881c293cb9b;
Note:

Precision biology – the use of AI, machine learning, genetic engineering, and computational biology – is set to disrupt the animal industry with tailor-made micro and macro organisms designed for food production (2/3)

2 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
Sustainable smart feed	**Animal feed of tomorrow will be primarily be made in "circular" systems that use waste as a key input**, replacing wild-caught fish and food grains almost entirely. Currently, feed constitutes between 50-70% of the cost of animal protein, places a significant financial burden on farmers, and consumes large quantities of water, land, and food crops. The challenge lies in supplying protein and essential micronutrients to animals without drawing too many resources from the ecosystem, or from food that can be used to feed people. The solution is to use microorganisms and insects, some of the most efficient creatures on the planet, to process widely available inputs into feed. Applying this principle, startups first, followed by large feed companies, will begin to replace animal and food crop biomass with insects, algae, and bacteria. **The feed itself is becoming "smarter,"** and focusing on animal wellness rather than just calorific intake. Future feed will include microbial cultures and agents which optimize for gut health, immunity and resistance, and reduce methane emissions (for cattle). These production systems are expected to enter India within the next 5 years, and scale up as viable alternatives to the common feed industry by 2030	**Enablers:** • Reduction in resources used by the feed industry – water, land, and food crops • Reduction in GHG emissions of the feed industry • Reduction in overall cost of feed due to circular systems • Improved yields and incomes for farmers • Policy pushes to reduce GHG emissions emerging from Paris Accords and SDGs • Investments into new feed technologies by integrated value-chain players especially in aquaculture • Existing deficits in feed and fodder, and dwindling wild fish stocks for fish meal **Barriers** • Regulation on the use of algal and insect products in animal feed does not exist in India. Dedicated advocacy efforts and building proof-of-concept within the Indian context is necessary to get the ball rolling

omnivore

Source: https://www.nationalgeographic.com/science/2019/03/partner-content-livestock-farming-future/; Livestock production; recent trends, future prospects, Futures Centre, 2019; https://medium.com/@FuturesCentre/which-animal-feeds-are-fit-for-the-future-881c293cb9b;
Note:

Precision biology – the use of AI, machine learning, genetic engineering, and computational biology – is set to disrupt the animal industry with tailor-made micro and macro organisms designed for food production (3/3)

3 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
Precision animal breeding	**Just as plants will become custom-built nutrient producing machines, so will animals in the food industry.** There are immense pressures on animals to become more (1) efficient engines of food production, and (2) resilient to diseases, given declining natural resources, carbon emissions from the industry, and increasing virality of zoonotic diseases. One way to boost productivity within ethical and safety limits is through precision genetic engineering of animals to produce desired traits and mute undesirable ones. Nudged by the rapidly changing forces around the domestic meat industry, India will put in practice the giant leaps made in precision biology over the next 10 years. This will overhaul the Indian farmer's current reliance on natural selection and cross-breeding programs, and expand the genetic pool available to draw from. There are two key value-chains where disruption will be most swift and impactful: **(dairy) cattle and aquaculture.** Breeders will be able to select traits for reproduction faster and more accurately than ever seen before through advanced genomic selection and marker-aided breeding. These new breeds will be distributed by the growing meat and life sciences companies that are backward integrating into industrial production. Female cattle, which give India its enormous dairy output, will be made more resilient to diseases, and produce milk that is rich in fat and protein content. Changes in the animal's gut DNA will also help reduce GHG emissions of individual cattle. The spread of artificial insemination solutions will substantially reduce India's male cattle population that is becoming an economic burden on producers. Fish, particularly shrimp, will be made more resilient to disease and tolerant to changing climatic conditions. These innovations will enable the Indian meat sector to industrialize without compromising on environmental sustainability, animal health, and consumer safety.	**Enablers:** • Falling costs of DNA sequencing, genomic selection, and artificial insemination • Rising computational power of AI allowing for rapid processing and screening of genetic information • Vertical integration of large feed companies down to production, and disintermediation of value-chain • Climate commitments made by India compelling it to control GHG emissions from agriculture **Barriers** • Training and awareness of farmers heavily dependant on traditional breeding techniques, and averse to new varieties due to perceived costs • Distribution channels for new varieties given disaggregated production and dispersed herds

omnivore

Source: https://www.nationalgeographic.com/science/2019/03/partner-content-livestock-farming-future/; Livestock production; recent trends, future prospects, Futures Centre, 2019; https://medium.com/@FuturesCentre/which-animal-feeds-are-fit-for-the-future-881c293cb9b;
Note:

India is expected to become a market leader in animal technology in the two sectors it leads in the world – dairy and aquaculture. In others, particularly feed, it will adapt innovations from abroad to suit input availability domestically

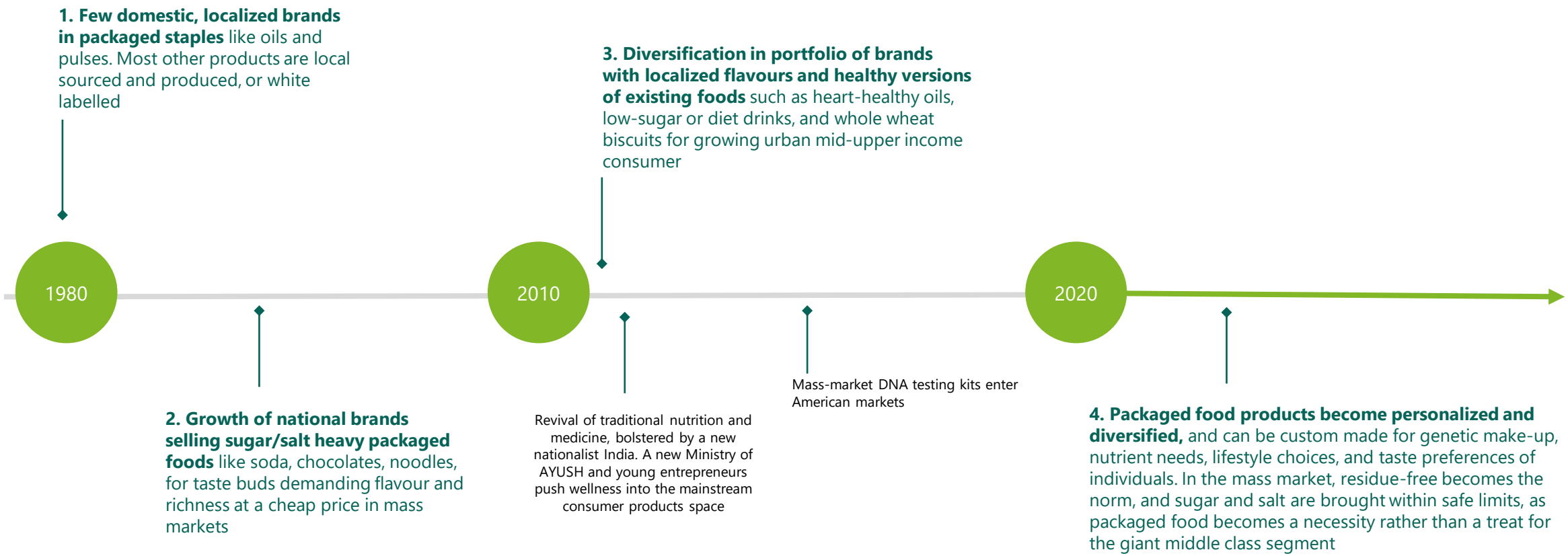
Innovation category	Select players (not exhaustive)	Spotlight
Sensor based animal diagnostics	• Stellaps • EIO Diagnostics • Smart Shephard • Apix	**Stellaps** is a dairy supply chain digitization solution provider that allows for across-the-board monitoring of milk production from cow to cold chain. Its cattle monitoring solution moon allows for monitoring the animal's health and provides early detection for diseases to farmers. Its second software, smartAMCU allows buyers to monitor procurement through IoT devices while mooPay can be used to pay farmers at the stage of collection. ConTrak its cold chain management system helps prolong the shelf life of milk by monitoring power, volume, temperature, and tampering of storage vats. These solutions individually provide the user with between 30-60% of cost reductions, and have demonstrated tangible improvements in milk yields, farmer price realization, milk quality, and enterprise profits. India's leader in digital cattle and dairy technology, Stellaps has scaled up to ~30,000 sites of installation by 2020 and aims to completely upend the current arbitrary dairy management systems in the next 5 years.
Sustainable smart feed	• Molofeed, • Energaia • Ynsect, • Protix • Calysta, • Novonutrients, • Because Animals, • Hexafly	**Protix** is a Netherlands-based world leader in sustainable smart feed production. The company's products are made from ingredients from the Black Solider Fry, which it breeds to feed on food waste, and then processes into various critical inputs into the food industry including fish feed, poultry feed, pet food, and plant fertilizers. This system allows Protix to deliver on multiple environmental objectives that are of utmost importance – of reducing overfishing caused by the capture of live feed, of carbon-emissions from food waste, and of reducing resource intensity of the animal-protein industry. Its breakthrough innovation in insect-based animal feed is the result of a partnership-led approach, bringing together scientists from leading universities in Europe and the Americas, and investing in deep-advocacy efforts to legalize the very nascent insect-feed market in Europe. This partnership and advocacy effort is a telling sign of the approach required for radical agricultural innovations to succeed in countries like India.

Source: https://www.stellapps.com/contrak/; Interviews with Stellaps team; https://protix.eu/protix-journey/protix-history/
Note:

Trend 8:

Food science will pursue consumer-centricity, yielding affordable processed products that address malnourishment, lifestyle diseases, and ecological concerns

The story of consumer food products in India is shifting from mass-market, standardized products for satiation, to hyper personalized wellness and nutrition product lines



This change is marked by a blurring of lines between nutrition and wellness across income segments, as consumers recognise the role of food in preventing disease and ensuring longevity

DRIVERS

1 Mainstreaming of high-quality branded packaged food in the mass market

- **Nutritious packaged food is increasingly popular. ~17%** growth rate of branded packaged food in 2018, during a general consumption slowdown in India, indicating its strength going forward.
- **GST paves way for organized food retail:** New tax law pushed out unorganized players when launched in 2018, which paved the way forward for branded packaged goods.
- **Health conscious food consumption on the rise. 30%** Estimated share of agricultural GDP contributed by the packaged food industry in **2030**, a **threefold** increase since 2020, led by growth in health-conscious consumer foods.

2 A large-scale push towards health and wellness amongst middle, upper middle and top tier of consumers

- **High quality food demand on the rise.** 16% CAGR of organic foods and superfoods, some of the fastest growing product categories for modern retailers at the turn of the decade.
- **Youth are increasingly spending money on wellness.** FICCI analysts report the wellness industry in India's value at ~USD 6.5 billion.
- **Value for money, private-label brands will grow** to serve India's deeply ingrained value consciousness. With limited pre-existing knowledge of brands, customers will move directly from unorganized purchases to private-label brands. Private-label apparel and grocery is already growing rapidly and expected to constitute up to 50% of organized retail sales by 2030, up from 5%-10% share today
- **Demand for super-foods on the rise.** Spirulina, Chia, finger millets, moringa, amaranth. Examples of ingredient lists in new launches in modern markets
- **Eat.fit, Fresh Menu, Grow Fit, Epigamia, Yoga Bar, Goodness!** Start-ups that have received Series A or more funding, targeting the health and wellness space in India

3 Leaps in health and nutritional diagnostic capabilities

- **Cost of genetic research is decreasing. DNA and RNA** testing is becoming cheaper and more reliable, and guide nutritional choices based on personal predispositions to diseases. A simple DNA test kit can cost as low as **USD 99 in 2020.**
- **Cost of DNA sequencing has fallen dramatically**, from USD 800 in 2007, to around UDS 0.01 per raw mega base of DNA sequence
- **Genetic research can help improve the diets of newborns.** Going forward, DNA tests will be carried for most newborns and infants, who will grow up to have more individualized and informed choices about the right kind of food for their bodily makeup.
- **Research on diet-gene interactions, called neutrogenetics, is on the rise in India.** An Institute of Neutrogenetics in Kerala is launching a new generation of scientists.

4 Increased consumer standards after shock events

- **The science of synthesizing proteins from non-animal sources has moved faster in the past five years than ever in human history.** Climate change and the rise of the alternate-protein industry in America has stimulated by far the largest movement in protein-based food science in the world, leading to the first ever public listing of alternate-protein companies like Beyond Meat and Impossible Foods.
- **Yet, we have only scratched the surface of the potential that lies ahead.** The world is at an early stage of protein synthesis using microorganisms like bacteria and algae. As big-ticket investments in agritech, biotech, and life sciences startups continue to rise this decade, protein fit for human consumption will be able to be produced cheaply and effectively in decentralized production systems all across the world. Finished products will reach a stage of flavour and texture mimicry that make them indistinguishable from their substitutable counterparts

omnivore

Source: https://www.entrepreneur.com/article/324665; https://www.business-standard.com/article/companies/despite-consumption-slowdown-packaged-food-sector-grows-14-4-iip-data-119102501384_1.html; https://www.ibef.org/industry/indian-food-industry.aspx; http://ficci.in/sector/83/Project_docs/Wellness_profile.pdf; National Human Genome Research Institute, genome/gov/sequencingcosts; https://www.sciencedaily.com/releases/2018/03/180323132704.htm

The combination of health, wellness, and nutrition will be delivered not by cultural imports alone, but through the indigenization and personalization of high-margin food categories (1/2)

1 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
Personalization of nutrition	**Personalized nutrition – a blending of precision healthcare and wellness industries – will come to dominate the health food market.** The global wellness industry has been based on general dietary guidelines that do not differentiate for the individual. However, the latest discoveries in health science is revealing how our bodies respond to nutrients based on genetics, the microbes in our gut, and variations in our organs' internal physiology. In addition, DNA and RNA sequencing is becoming cheaper and widely accessible, nudged by heavy investments by silicon valley in personal DNA testing start-ups. These tests, which are expected to scale-up in Indian markets over the next five years, provide advice based on parameters like a person's DNA, intestinal health, salt pathways, digestive efficiency etc, paving the way for a whole new paradigm of personalized nutrition (e.g., nutrigenomics). In parallel, improved technology is enabling biotech companies to identify, screen, and extract beneficial compounds from foods ever more accurately, compounds which can then be formulated into nutritious food products. This will disrupt how nutrition is put into practice by major health-focused food companies as they replace **"one size fits all" approach with personalization** on the basis of easy and/or self-administered genetic and blood marker tests that help curate nutrition plans for the "me" profile. Partnerships between health, biotech, and FMCG companies will ultimately provide customers with all-in-one packages of testing, advisory, meal plans, and food products custom made for their genetic profiles.	**Enablers:** • Push towards premium healthcare that is predictive, preventative, and personal • Falling cost of DNA and RNA sequencing • Increasing sophistication of personal test kits and analysis • Digitization of healthcare data through insurance companies and modern hospitals **Barriers** • Small (but growing) market of consumers willing to spend on testing and personalization of food • High production costs of personalized product formulations compared to homogenous goods

omnivore

Source: https://www.nationalgeographic.com/magazine/2020/01/these-traditional-diets-from-the-blue-zones-can-lead-to-long-lives-feature/; https://www.foodandnutritionjournal.org/volume6number3/superfoodsrecent-data-on-their-rolein-the-prevention-of-diseases/; https://www.scmp.com/lifestyle/food-drink/article/2038989/why-indians-have-belatedly-awoken-superfoods-all-around-them

The combination of health, wellness, and nutrition will be delivered not by cultural imports alone, but through the indigenization and personalization of high-margin food categories (2/2)

2 SUB-TRENDS	DESCRIPTION	ENABLERS AND BARRIERS
Plant-based foods	**India will lead its own variant of the plant-based food revolution driven by its unique dietary and cultural traditions.** The movement here will primarily be an extension of India's vegetarian cuisine and snack market. Improved processing and extraction technologies will enable FMCG companies to incorporate indigenous plant nutrients into ready-to-eat products far more efficiently. With this, plant-based products will seek to match animal products in their protein and micronutrient (zinc, iron, etc.) availability. This will cater to consumers across the spectrum who desire healthier and more nutritious alternatives to today's carb-heavy vegetarian snack options, without having to eat animal-based products. Another large segment will focus on offering **dairy alternatives** to those who are lactose intolerant (a steadily growing figure as awareness levels rise). These products **will go beyond milk towards more value-added, nutrient-rich products** like ice-cream, yogurt, cheese, and ready-to-drink beverages that meet the population's aspirations. Parent plants of derivatives will graduate from soy and almond, towards more nutritious and sustainable options like coconut, hemp, and oats that reinforce the "goodness" and "local" USP. India's leading yogurt start-up, Epigamia has been one of the first to launch a coconut-based yogurt, the first of many such innovative dairy-alternatives expected to carve a large market for themselves this decade. True meat substitutes like Beyond Meat will cater to a very small and niche market catering to primarily to restaurants who can sell deception deliciously. This segment's growth will depend on how industrialized meat farming becomes in India, and what trade-offs consumers are willing to make. At the turn of the decade, neither of the two holds true for a sizeable enough population but change is in sight.	**Enablers:** • An enormous portfolio of indigenous plat ingredients grown in India ripe for use in FMCG products • Rapid advancements in plant-based protein synthesis technologies • Big investments in meat-alternatives space spurring R&D and product development world over • 10%+ CAGR of ready-to-eat food market • Growing concern over animal ethics and environmental impact of meat industry • Growing awareness of food allergies and intolerance amongst consumers **Barriers** • Cost of education and awareness in India where animal-product substitution is very low on the consumer's demands today • Low penetration of cold storage at last-mile consumer touch points making access to markets difficult for products requiring temperature control

Source: https://www.nationalgeographic.com/magazine/2020/01/these-traditional-diets-from-the-blue-zones-can-lead-to-long-lives-feature/; https://www.foodandnutritionjournal.org/volume6number3/superfoodsrecent-data-on-their-rolein-the-prevention-of-diseases/; https://www.scmp.com/lifestyle/food-drink/article/2038989/why-indians-have-belatedly-awoken-superfoods-all-around-them

Indian startups have begun upgrading food science and formulations for a more discerning urban consumer, and will eventually adapt food innovations in western countries to local contexts to leapfrog ahead

Innovation category	Select players (not exhaustive)	Spotlight
Personalized nutrition	• Nuritas • Psomagen • Chronomics • Color genomics • 23andMe • Sun Genomics • BiomeSense • Eligio Biosciences • Kaleido Biosciences	 **Flore** is a personalized nutrition and probiotic product from Sun Genomics launched in 2019. The product comes in a package consisting of Flore Gut Test that can indicate which of a numerous set of gut issues a consumer has – abdominal pain, bloating, leaky gut – as well as a customized probiotic tailor-made to address test results. The company is one of the leading players in a market where gut health and uniqueness of gut flora for an individual is becoming widely recognized by consumers, and its appeal lies in the ability to both tell a consumer what his/her probiotic needs are, as well as supply that specific set of probiotics. This hybrid capability – of being able to sequence DNA as well as micro-manufacture custom products - indicates the direction in which a number of premium players in the wellness industry are moving towards, and will remain a trend to stay and grow globally due to its scientific validity.
Plant based foods	• NextFoods • Puris Protein • Myco Technologies • Kite Hill • Geltor • New Age meats • Good Catch • Finless Foods • Wild Type • Cambridge crops	Perfect Day **Perfect Day** Series C funded start-up in America which specializes in synthesizing animal proteins – dairy in their case – to offer taste-replicas of animal-protein products in the market. The company developed a patented process to culture milk proteins using microflora that works on cow-milk genes and is a leader in the nascent space of fermented proteins (different from cold-pressed plant substitutes like almond, oats, etc.). In this process, bacteria ferment plant sugars into milk proteins like whey and casein, which are then constituted into popular formulations such as milk, cheese, yogurt, and ice cream. This allows the brand to sell a product that is identical to cows milk while maintaining a cruelty-free, hormone-free, and carbon and water-light production status. The huge leaps in animal protein synthesis at the turn of this decade will take the next 5 years to spread and occupy store shelves in America and across the world. By 2030, it will displace a sizeable portion of the dairy products market in America and other milk-consuming nations (like India).

omnivore

Source: https://agfundernews.com/top-20-innovative-food-startups-in-2018.html; https://sosv.com/portfolio/geltor; https://www.irishtimes.com/business/technology/nuritas-secures-30m-investment-from-eu-s-financial-arm-1.3715140; https://sungenomics.com/products/flore-precision-probiotics; https://www.globenewswire.com/news-release/2019/10/24/1934923/0/en/Sun-Genomics-Launches-Breakthrough-Solution-To-Deliver-Personalized-Probiotics-In-Only-Six-Weeks.html

Climate change will force Indian agriculture to go through a radical change this coming decade and beyond

The global climate crisis is already underway, and will continue to dramatically alter the operating landscape of global agriculture in the coming decades

INPUTS

Changing temperature patterns:
Rising average temperatures, more extreme heat, longer and shorter cold periods

Changing precipitation patterns:
Longer dry spells, increased duration of heavy rainfall and related weather events

Sea level rise:
Sea ingress, coastal surges, increased soil salinity

Climate change trends

+

Industrial amplifiers

=

Degradation of soils due to over-ploughing, intensive agrochemical use, monocropping, and deforestation, leading to loss of fertility

Decline in water tables caused by unregulated and overuse of water, suboptimal cropping patterns, and deforestation

Vicious cycle of increased agrochemical use to counter lower fertility and pest attacks, exacerbating the problem further

Simplification of landscapes and ecosystems to allow for vast monocropping systems without cover crops, tree barriers, and beneficial insects

OUTPUTS

1. **Crop, livestock, and fisheries viability**: All crop and animal varieties have an optimum range of environmental parameters in which they thrive and produce strong yields. As these parameters change in every agro-climatic region, the health and survival of organisms grown by farmers will decline, and the breeding and selection of species and varieties will have to change
2. **Pests, pathogens, and weeds:** Changing environmental parameters are shifting the habitable zones for harmful pests, pathogens, and weeds, especially in regions that go from cool to warm. This will mean a rise and change in use of agrochemicals and pest control mechanisms that farmers are accustomed to for decades, as well as increased costs of food testing at every stage of production
3. **Extreme weather events:** The combined impacts of climate change trends are making floods, droughts and freak weather events like cyclones and hurricanes more common and severe, leading to unavoidable crop losses. Expensive physical protection and insurance schemes will become non-negotiable needs of farmers

omnivore

Source: https://www.ucsusa.org/resources/climate-change-and-agriculture; https://link.springer.com/article/10.1007/s42398-019-00078-w;

India will be particularly hard-hit by climate change across industries, but most critically in agriculture

Climate change India snapshot:

- India is among the **top 10 countries** on the climate vulnerability index and is expected to be hit hard and deep by climactic changes over the next few decades
- Already, mean temperatures in India have increased by **0.6 degrees** in the past century as per IMD, and could increase by a further **4 degrees Celsius** by the end of the century
- Climate change will affect states will **large populations** particularly hard, such as Maharashtra, Uttar Pradesh, Madhya Pradesh, and Rajasthan
- As per some projections, monsoon precipitation in core areas of the southwest monsoon will **increase by 10-15%** while arid and semi-arid zones will see a **5-25% drop in precipitation.** The effects of these changes on agriculture will be exacerbated by drastic declines in water tables which have already fallen by ~60% between 2007-2017, mostly due to overuse in agriculture.
- Events such as unseasonal and fatal floods in Kerala, precedent-defying cyclones on the eastern coast, and sea ingress in the Sunderbans are becoming more frequent and more intense, and indicate what may become the norm this century

Impacts on Indian agriculture

1. Climate change is diminishing the economic viability of agriculture for farmers, and pushing them into poverty traps that are difficult to recover from. According to the 2017 Economic Survey, extreme temperatures and droughts are already shrinking farmer incomes to the tune of **4-14% for key crops**, a number that is expected to go up this decade
2. Smallholder farmers in areas with **poor irrigation (more than 50% of cropped land in the country)**, will be hit the hardest
3. By 2030, rice and wheat, the two dominant crops in the country, are estimated to see a **6-10% drop in yields,** lower protein and micronutrient content of wheat, and increased amylase content of rice (making it harder to cook) leading to **immense economic and nutritional stress for farmers and low-income consumers**
4. Other crops are likely to benefit from greater carbon concentrations, including potato and mustard, meaning sticky **cropping patterns** will have to become far more **responsive and adaptive** to environmental change
5. In addition to direct impacts on yields of food products, climate change will also lead to poorer working conditions of farmers on the field, and migration of labour from hard-hit areas to safety zones, making **farm work more dangerous and expensive**
6. **In spite of all these challenges, India will have to produce ~50 million tonnes of more food in 2030 than it did in 2019, to feed 200 million more people, while meeting climate commitments**

omnivore

Source: https://indianexpress.com/article/india/india-5th-most-vulnerable-country-to-climate-change-global-climate-risk-index-cop25-madrid-6151322/; https://www.livemint.com/news/india/the-growing-threat-of-climate-change-in-india-1563716968468.html; https://qz.com/india/1191273/economic-survey-2018-climate-change-will-hammer-indias-agriculture-and-farmer-income/; http://pubs.sciepub.com/env/1/4/6/index.html; https://www.grantthornton.in/Press/press-releases-2017/food-grain-demand-is-expected-to-reach-355-million-tonnes-in-2030-and-farm-mechanisation-will-be-instrumental-in-meeting-this-demand-says-grant-thornton-and-ficci-report/

Climate smart agriculture (CSA) – practices across the food system that lower environmental impacts of agriculture while making it more resilient to stresses – is therefore a necessity of this decade

Key objectives for climate smart agriculture specific to India

1 Integration of accurate climate and weather models

Climate models are maturing rapidly**. Insights from these models will need to be seamlessly integrated** in farm-level decision making, feed directly into state-level farm management policies, and inform private supply chains and crop insurance products

2 Increased yields for every drop of water

Water conservation and precision use will have to be the core tenet of future agronomy using a combination of traditional and modern water technologies like community-led watershed management, drip irrigation, soil moisture sensors, and variable rate application of water to crops

3 Modest and safer use of agrochemicals

To keep soils healthy, food safe, and costs down, farmers will have to **diversify into safer products as well as use existing chemicals more precisely**, particularly in intensive-use crops like rice and cotton. Solutions such as soil sensors, agri-biologicals, integrated pest management, and variable rate application will be key

4 Improved resilience of crop and animal varieties

India's investment and R&D partnerships in **biotechnologies** - newer crop and animal breeding programs - will need to increase significantly to offer farmers affordable varieties that are **resilient to threats** of changing temperature, drought, flood, pest, and weed infestations

5 Improved on and off farm biodiversity

The western industrial model of monocropping will have to be skipped in exchange for a more **biodiverse crop, animal, and soil systems** on the farm. Reforestation of degraded lands to protect key predator and pollinator populations, as well as hydrological systems, will be policy imperatives

6 Protection of high-value agriculture

Production of high-value products like horticulture and fish will have to **move indoors to protect farmer investments** from unavoidable weather incidents like cyclones, unseasonal rains, and storms that can destroy an entire season's harvest overnight

7 Safeguarded income and health of farmers

Finally, farmers will have to be **provided income security and risk mitigation products** to safeguard their livelihoods and health against inevitable climate threats. Crop insurance, health insurance, direct benefit transfers, and fair, disintermediated markets will need to be universally accessible to the smallest of farmers

omnivore

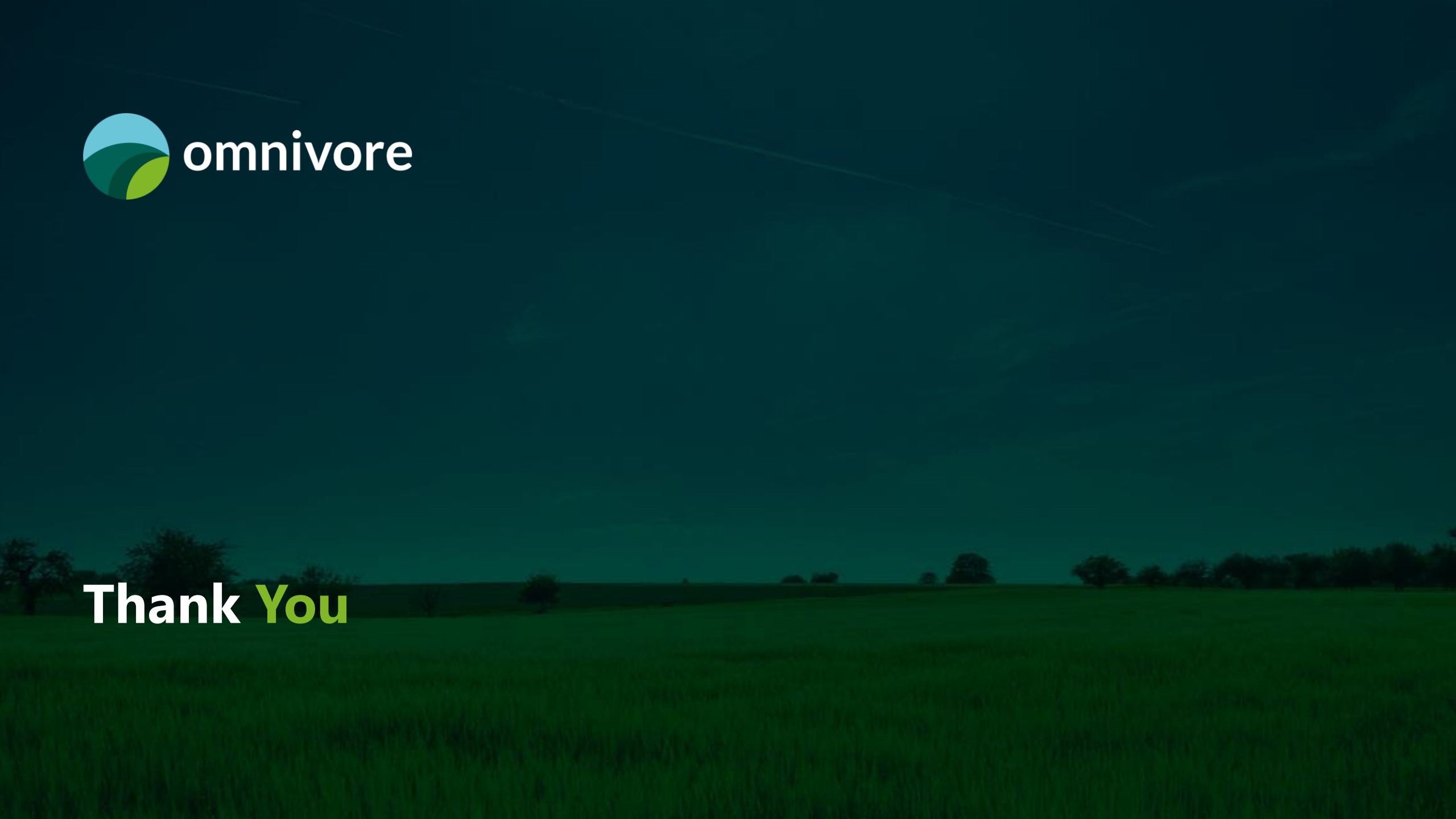
Source: https://www.downtoearth.org.in/blog/water/depleting-groundwater-costs-farmers-heavily-65530; https://www.downtoearth.org.in/news/agriculture/vidarbha-s-toxic-trail-59173; http://pubs.sciepub.com/env/1/4/6/index.html; https://link.springer.com/article/10.1007/s42398-019-00078-w

Just a *glimpse* of the vibrant start-up ecosystem working for the future of humanity...

omnivore

Just a *glimpse* of the vibrant start-up ecosystem working for the future of humanity...

omnivore


omnivore
Thank You