



Ecosystem Model for Agriculture Platform

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Abstract | In this paper, I propose the platform business model to transform the classical Agriculture model to a platform agribusiness model using digital technologies. An ecosystem framework is developed for Agricultural (Agri) product and service sectors where all the stakeholders: Core providers (Farmers, Seed, Fertilizer and Machine manufacturers), Complementors (Agri labs, Cold chains, Food processing companies, Mandis, Warehouses, Transporters, Retailers, Cloud kitchens, Restaurants, Startups), Social media, R&D labs, Software apps, Agri schools, Banks, Insurance companies, Government departments, consumers etc., deliver Agri and food products or services through both competition and cooperation. The platform model for the entire Agri ecosystem is developed and the performance measures, risk mitigation strategies, innovation and finally the platform governance mechanisms are highlighted. This research is aimed at helping the community to be future ready.

1 Introduction

New technologies such as mobile Internet, IOT (Internet of things), Cloud, Big Data Analytics, 3D printing, Blockchain, Digital Valets, Drones, and Robots are creating new Agri industry giants.^{1,2} Use of machine learning and AI is becoming the new norm for predictive and prescriptive decision making in all Industries including agriculture. Start-ups in every area such as Agriculture, EdTech, Fintech, Healthcare and Entertainment are disrupting well-established institutions such as Hotels, Shopping malls, Banks, Restaurants, Entertainment, Movie Studios, Universities, etc. We are currently witnessing Industry 4.0 in auto, real estate, IT, finance, and several other sectors. The flourishing companies follow the open platform-based business models collaborating with ecosystem partners. A robust governance framework that is intelligent and dynamic is required in order to establish a seamless orchestration between the three main aspects of a platform business model: partner selection, coordination and control. Both Google and Microsoft are collaborating with food and

agriculture partners and funding startups in agriculture. Their current attention is in the use of AI, ML, Blockchain and NLP in decision making using big data analytics. We will soon see the agriculture industry transition to 4.0.¹ Retail food services and the food processing sector open doors for start-ups to address the challenges and fill gaps in the food value chain thereby developing robust and scalable models which can transform the agricultural economies.^{2,3}

In recent times, IoT has found a plethora of applications in agriculture: In crop farming leaf wetness, rainfall, temperature, soil moisture, pest movement, etc., can be monitored. The machinery can be operated in autopilot mode by use of GPS or other global navigation satellite systems. Unmanned aerial vehicles (UAVs) are very useful for observations as well as operations such as spraying crops. Robots can be remotely controlled. Machinery can also collect real time data, and such data can help farmers in mapping their field for planning programs, such as fertilizing, irrigation, and nutrition.⁴ Tracking and tracing of agricultural product chain makes the consumer

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privity to the entire history of the product, thereby improving the consumer's trust on the product safety and health related issues.

According to the report published by FICCI⁵: The consumption of processed food in India is on an upswing and the demand for healthy, safe, hygienic and convenience driven food is slated to increase at an even more significant pace in the future. Start-ups are now offering healthy, value added, value for money, safe and hygienic products. Coupled with strong technology, data analytics, blockchain, state of the art cold chains and integrated logistics network, the building blocks of a world class food supply chain are being developed by Indian E-commerce platform-based Start-ups. Consumers are increasingly preferring local service providers who can cater to the customized needs of food delivery and who can respond to quick turnaround of orders. Many food delivery Start-ups have sprung up in larger cities of India and have been offering services in fresh products of dairy, fruits, vegetables, and meat segments. Some of them are currently Unicorns.

India ranks first in the production of milk and pulses, and second in producing wheat, rice, groundnut, vegetables, fruits, cotton, and sugarcane. It is also among the leading producers of fish, livestock, poultry, spices, and plantation crops. Due to smaller landholdings, farmers' incomes are not sufficient. Farmer incomes may be improved using new-age Digital Technologies in Agriculture to enhance the entire value chain. These instances highlight the need for an integration brought by platform-based ecosystem models that are interoperable and coordinated among all players within the value chain.⁶⁻⁹

1.1 Agriculture 4.0

Agriculture began more than 10,000 years ago and is one among mankind's most ancient professions. Early humans were foragers or hunters—hunting wild animals and gathering wild fruits and roots. As humans evolved, so did farming. Agriculture as we know it today, has evolved remarkably from the labour-intensive stage to the mechanized farming stage, and finally we are geared to see the coming of age—Agriculture 4.0, marking the adoption of digital technologies for increasing agricultural production and farm incomes.

Agriculture 1.0 was labor intensive with low productivity tools: plows, tilling stick, water wheel, canals, etc. Agriculture 2.0 involved mass farming, large acreage, mechanization of

processes from seeding to harvesting, processing automation etc. cooperating with other players in the chain like processors, input suppliers, distributors, retailers and traders. Agriculture 3.0 uses technologies such as GPS, Remote sensing, VRT, Geo-mapping systems, Sensors on the farm equipment etc. to drive "Precision Agriculture" and "Smart Farming". Precision Farming uses real-time data from Sensor technologies & application methods to optimize the agri-processes to increase resource and cost efficiency and reduce environmental impact. Precision farming allows decisions to be made per unit area or per unit resource.

Smart farming (Farming 4.0 or Digital Farming): Smart farming is managing farms using IoT and artificial intelligence to increase the quantity and quality of products while optimizing the human labor required for production. Sensors, Software, Connectivity, Location (GPS, Satellites etc.), Robotics, Drones and Data analytics are technologies used in smart agriculture. Plants and cattle get precisely the treatment they need, determined by machines with superhuman accuracy. In the coming-of-age Agriculture 4.0, Robots replace humans for labor intensive tasks, Crop and Soil health is monitored using computer vision and deep-learning algorithms; machine learning, deep learning and artificial intelligence models are used to track and predict diseases of the plants, various environmental impacts such as weather changes on crop yield. Predictive analytics is used to determine issues such as when to sow and when to harvest, yield and price predictions, crop recommendations systems and pest control. Agriculture 4.0 will not depend on resources like water, fertilizers and pesticides. Crops will be capable of growing in arid areas using naturally available sunlight and seawater. Startups using new technologies are doing well. An institutionalized collaboration between the industry and the Start-ups is critical to provide an opportunity to discuss on ground challenges and share experiences with each other for mutual benefits.^{5,8,10-12}

1.2 Disruptions Faced by Indian Agriculture

Across the globe, changing weather patterns are a major concern since they are affecting crop productivity and thus, the lives of farmers. India also experiences delayed monsoon and severe drought like conditions in several regions of the country, resulting in low agricultural output. In India, rainfall is the primary source of water.

Three-fifths of land under cultivation is watered only by rainfall; Therefore, agriculture in India is often held hostage to the vagaries of rainfall. Also, unseasonal rains during harvesting times in South India cause mass destruction of crops like rice, wheat, and horticultural produce.^{7,13,14}

A serious issue is the decrease in arable land and low per acre yield. As per Indian agriculture census 2010–11, 85% of farms are less than two hectares in size. While the average size of land-holding is decreasing, the number of operational holdings is increasing, leading to poor harvest and low incomes for the farmers. As per World Bank statistics for FY14, the hectare yield in India is among the lowest in the world. With better farming practices, notably digital, India will be able to achieve higher hectare yields like in USA, UK, France, Germany, etc. Climate change, increasing ocean temperatures, hurricanes, wildfires, and many other environmental catastrophes are becoming frequent. The World's Population is growing and is expected to grow to almost 10 billion by 2050, up from current 7.6 billion. Also, the global diet is changing for high-value animal protein.¹⁵ All countries including India need to adopt Agri 4.0 for global food safety and farmers income.

The damage that pests cause to crops and the associated crop-losses that threaten food security are well known. Rice, wheat, and cotton crops are increasingly incurring huge losses owing to whitefly pest attack. Development of agrochemicals is a very important research issue. Climate sustainability is gaining attention. Over the past 50 years, greenhouse gas emissions resulting from agriculture, forestry, and other land use have nearly doubled. Agriculture contributes the largest share of global methane and nitrous oxide emissions. Also, water resources are highly stressed, with more than 40% of the world's rural population living in water-scarce areas.^{7,13,14}

Given the above disruptions and risks faced mainly from nature, how do we redesign the Agri business, which is the main source of livelihood for the world's population?

2 Outline of the Paper

In Sect. 3, we define the agriculture business ecosystem and business model and identify the most suitable business model patterns suitable for agriculture. In Sect. 4, we describe the platform business models for the agriculture as an industry and its elements customer value proposition, actor network, resources, delivery mechanisms and the institutions that affect the Agri sector. Finally,

in the rest of the paper we develop the Governance, Risk, Innovations and Performance (GRIP) framework for the Agriculture Platform model.⁷ The future is digital agriculture but as we mention in the conclusions, the transition will take several complementary innovations, and their implementation may take a decade.

3 Agri Business Ecosystem

A Business ecosystem is a network of independent companies working together to gain comparative advantages through symbiotic relationships benefiting all parties. The Agri Network organization has: Core providers (Farmers, Seed suppliers, Fertilizer manufacturers), Complementors (Agri labs, Cold chains, Food processing companies, Mandis, Warehouses, Transporters, Retailers, Restaurants, Startups), social media, R&D labs, Software apps, Agri schools, Banks, Insurance cos., Government depts, consumers etc., delivers Agri and food products or services through both competition and cooperation.

An Ecosystem thrives when the participants streamline the flow of ideas, talent, and capital throughout the system. Ecosystems emerge due to modularity, interactions and the co-existence of different types of complementarities. Farm modularity allows the platform to cultivate several different products such as rice, wheat, Fruits, vegetables, livestock, etc. to maximize crop diversity from the same portion of land. Technological modularity allows interdependent components of a system to be produced by different producers, with limited coordination. Modularity allows for coordination of independent yet interdependent firms through the ecosystem. Ecosystems require that providers of complementary innovations, products, or services belonging to different industries not be bound by contractual arrangements—but have significant interdependence. Ecosystems encourage alignment through rules of engagement, standards, and codified interfaces.

3.1 Business Model-Definition

A business model is a conceptual tool and a description of how a company does business and makes money. It is a description of the value a company offers to one or several segments of customers: the architecture of the firm, its network of partners and resources for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams. Thus, a business model is a description of how a company does business and makes money.

3.1.1 Business Model Patterns

Patterns describe proven solutions for recurring problems. Architectural theorist Christopher Alexander introduced the concept of patterns for designing towns, buildings, and constructions. *Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice.* Patterns allow reusing solutions by making them accessible and applicable to others and thus reducing complexity and improving effectiveness and efficiency in problem solving processes.¹⁶

Examples of Business Model Patterns include Razor and Blade, Freemium, Long Tail, Sharing Economy, Cloud Business Models such as Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS), Data-as-a-service, Two-Sided Market, Platform, and many more. Here we consider the platform model for agribusiness applications.¹⁷ Agri platforms bring together farmers, seeds and fertilizer producers, software and logistics service providers, warehousing, mandis, retailers and other participants. Their chief assets are information and interactions, which are also the source of the value they create and their competitive advantage. Platforms create value by facilitating interactions between the participants. Platform Ecosystems have four types of players. The owners of platforms control the intellectual property and governance. Complementors and service providers serve as the platforms' interface with users and other actors.¹⁸ Core actors such as Producers of agriproducts and food create their offerings. Consumers use the offerings. The rise of platforms is being driven by three transformative technological networks: cloud, social, and mobile which make globally accessible networks of entrepreneurs, workers, and consumers which enables them to create businesses, contribute content and purchase goods and services.

4 The Platform Ecosystem

We define the agribusiness ecosystem platform model and its main components which are the customer value proposition (CVP), value creation formula, actor network for agri supply chain and service chain processes, key resources, delivery mechanisms, institutional and social constraints, and finally the operational governance. The platform makes money by delivering food and agriculture products/services to various customer

segments using the resources following the social and institutional constraints using all the opportunities including the retailers, e-commerce centers and mandis. We then present the Governance framework. In this paper, we extend our ecosystem framework of,⁷ to include the Agribusiness perspective with various customer segments.

4.1 Customer Value Proposition (CVP)

The Actor network has several customer segments. They include Core and Complementary providers of farms, seeds, fertilizers products and services, 3rd party developers who create boundary resources, such as APIs, software development kits and finally the consumers. Each customer segment contributes to the growth of the Ecosystem either directly or indirectly. The CVP identifies the jobs that fulfil important needs for the targeted customers segments and deliver value. Each customer segment has its value proposition and a revenue stream. They could be dependent on each other i.e., results of one segment could be inputs to the other. The platform should generate value for each. The platform does the match making: Attract farmers, FPOs, and producers of products and services, and the consumers including the retailers who need those products and services making sure of the network effects. Platform costs should be lower than market costs and the matching should be more competitive for both sides. This match-making may be facilitated through various clustering algorithms (like k-means and agglomerative hierarchical clustering) that enable pattern-identification to understand purchasing patterns, supply-side factors and marketplaces, to name a few. Additionally, selecting the optimal hyper-parameters is key to ensuring that the customer segmentation is effectively carried out. The elbow method is commonly used for k-means clustering where the optimum number of clusters ("k") may be selected by analysing the "elbow" from the graph plotted between the number of clusters and the variation.

4.2 Actor Network

The agri actor network has core providers (Farmers, Seed, Fertilizer and equipment manufacturers), Complementors (Agri labs, Cold chains, Food processing companies, Mandis, Warehouses, Transporters, Retailers, Restaurants, Startups), social media, R&D labs, Software apps, Agri schools, Banks, Insurance companies, Government departments, consumers etc., and it delivers and receives Agri and

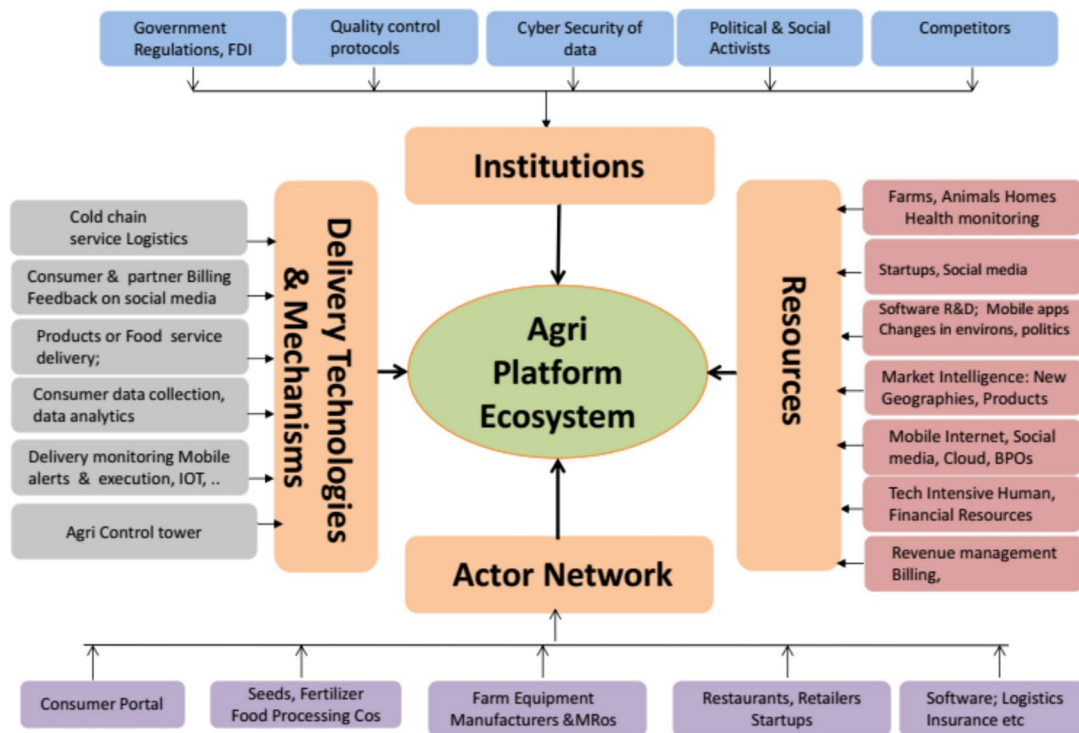


Figure 1: The Agri platform has: Core providers (Farmers, Seed, Fertilizer manufacturers), Complementors (Agri labs, Cold chains, Food processing cos., Mandis, Warehouses, Transporters, Retailers, Restaurants, Startups), social media, R&D labs, Software apps, Agri schools, Banks, Insurance cos., Government depts, consumers etc.

food products or services through competition, coordination and cooperation.

The third-party developer collects data regarding the weather, market for the produce and prices, etc. and develops applications, services or systems for the farmers and retailers on behalf of the platform owner. NLP algorithms may be used to make contextual inferences from the silos of data. Platform owner attracts and connects all the actor network members and coordinates and executes the interaction, data exchange and the product or service delivery through electronic data interchange (EDI). Platform acts as an intermediary between customers and product or service providers. For each order, the platform needs to map and manage the chain of activities identifying the firms involved and executes the product delivery from farm to the consumer. This works analogous to a cloud-based ERP system that extends on a larger scale. Various search algorithms may be utilized to find the suitable actor for this product delivery based on the goal-state conditions provided by the platform owners: Informed search techniques may be suitable in these cases

as specific characteristics of the actor need to be factored for each functionality that the user needs.

4.3 Institutional and Societal Constraints

The products and services delivered need to follow government regulations on privacy, safety, data protection and labor welfare as well as pay taxes. The government policies are still evolving in cases such as e-retailing, internet money transfer, insurance, and fixing responsibility for an accident in case of driverless trucks. Cooperation of the Industry associations and conforming to the societal norms is important. The platform management is responsible for the safety and integrity of the customers and partners. One such example includes the government restrictions and societal perceptions about the utility of drones for precision agriculture. The security of IoT device and end-to-end data security will continue to attract more research interest. More research work is needed in the development of IoT devices that can support new security schemes (Fig. 1).

4.4 Resources

The Resources for agri platform include Human (Farmers, Skilled and Research staff), Financial (Banks, VCs, insurance etc.) and Industrial (Clusters, farm equipment, fertilizer companies, logistics, Robots, Drones, etc.), Relationship capital (partner network) and Digital (Cloud, Control Tower, Blockchain, Analytics, Mobile apps, Digital Twins, etc.) resources required to deliver the value proposition to the targeted customers. The technology-driven resources such as Internet, Cloud, Mobile, Big data and analytics, and Blockchain make high impact. Ordinary resources such as salespeople in retailing; websites and motorbikes in e-retail; mobile internet for WhatsApp, prepaid sim cards for SMS-based push notifications are also required for the business to function properly. User-friendly website with 24/7 customer care service allows people to communicate and share data with other partners for business transactions. The concept of the Agent-based stochastic simulation may be used for inferential learning and predictive analytics with regards to the relationships among these specific resources.

4.5 Delivery Mechanisms

The function of delivery is to ensure the availability of the right product at the right place, in right quantities and right condition at the right time and right cost for the right customers. To achieve this, integration and synchronization of material, information and financial flows across all organizations is needed. Physical delivery of products can be made efficient through use of IOT, sensor networks and augmented reality. Coordinating and monitoring the delivery process is an important issue and is often done through a control tower using an execution dashboard for real time visibility. Customers are increasingly vouching for apps with real-time tracking. Order management APIs may be integrated into the platform's interface to track orders from different views and manage end-to-end customer fulfillment. The usage of bar codes and RFID technology is facilitating this traceability.

4.6 Governance: Partner Selection, Coordination and Control

A well-defined Governance structure has the following features:

- Identifies functions relating to government, trade, social groups, labour, resources and heavy weight cargo delivery mechanisms.
- Allocates the tasks and responsibilities to stakeholder organizations.
- Builds systems for effective communication, coordination, and integration of effort in both the horizontal and vertical directions.

Manages a control room for monitoring and execution of the planned activities in timely and efficient manner under normal as well severe conditions (Fig. 2).

The orchestrating platform mobilizes the needed assets of other companies to support its own growth initiative. The platform should get involved in an end-to-end orchestration and run a high-end Food and agriculture supply chain as a joint venture. The platform owner should keep innovating and look for additional or new partners.

4.6.1 Platform Assets and Services

The Products that the platform offers to the clients are Network, Visibility, Trust, Relationships and Knowledge. Its competitive advantage lies in the scope and timeliness of its knowledge and in the number and depth of its relationships with its members including the Government. Platform Providers not only need to enrol all the players to use technology, but recruit and train frontline staff, particularly near the farm locations in villages to facilitate digital transformation.

The platform assets that are difficult to imitate are the community (actor network and farmers), and the resources its members own and contribute including data and ideas on food and agriculture, intellectual property, etc.. Because members of the partner network are mutually dependent, good performance by one boost success of others. Platform should provide a definitive asset for its partners to build their presence, to grow their practice or business, and to engage the players in a way that was never possible before.

A Well-defined governance structure should

1. follow the regulations of the government, and environmental standards.
2. maintain friendly relationships with social groups and labor, as well as identify and manage relationships between farmers, retailers and end customers. Establishing trust is increasingly becoming a key metric

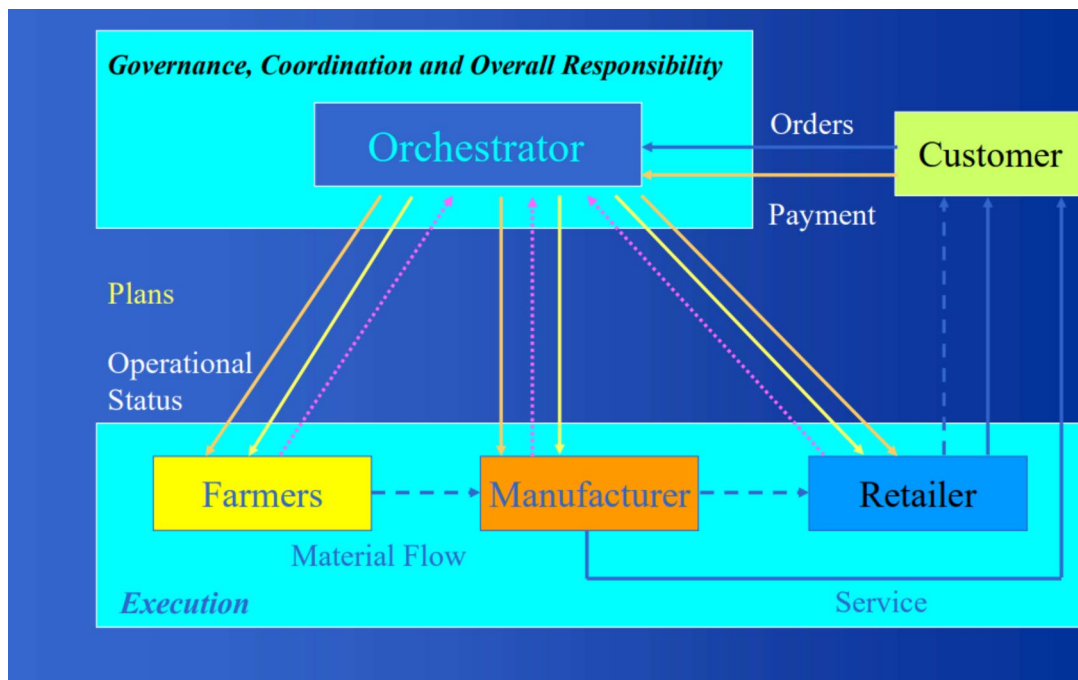


Figure 2: Orchestration is the coordinated execution of multiple technology related automation tasks or processes.

for driving efficient supply chains. Defining factors that build trust need to be identified and implemented.

3. build and manage effective communication, collaboration, and coordination among the network partners for growth enhancement.
4. identify and categorize risks from various ecosystem sources and put in place risk mitigation strategies in operational readiness.

Also, for every farmer, the governor selects the partners, allocates the tasks and responsibilities to form the network and manages a control room for monitoring and execution of the planned activities in a timely manner under both normal and severe conditions. This can be facilitated using the matching algorithms discussed in Sect. 4.1.

A separate agribusiness service chain is formed for each order: let it be food or the agri products or pest control in a farm. The second step is coordination where the tasks assignment and scheduling are done (who does what and when) using scheduling algorithms like round robin, multiple-level queues, priority scheduling, etc., and communicated to everyone. Finally, in the execution step the order status is monitored to ensure that the expected value is accurately delivered.

4.6.2 Performance of Agribusiness Platform⁷

The performance of a platform is judged by the partners: the farmers, partners and the consumers. General performance measures include lead time, quality, and consumer satisfaction. The other measures that need attention include traceability, data protection, climate disruptions, price fluctuations, farming regulations, disease predictability both for the plants and the society, etc. Traceability is the ability to track a product batch and its history through the whole, or part, of a production chain from harvest through transport, storage, processing, distribution and sales. Ultimately the products delivered to consumers should be safe, secure, and authentic.

How much do we know about the products we use each day? Do we know where they come from, or how many hands they touch on their journey to us between manufacturers, distributors, and retailers? Their journeys are not transparent, leading to counterfeit, contamination, substandard and low-quality parts, fake goods, unethical labour and false sustainability standards and certifications. Consumers are increasingly becoming concerned about product origins, the authenticity and transparency of their transactions. People die or fall ill in all countries due to foodborne contamination.

New digital technologies such as IoT tags, data analytics, blockchain, etc. are now coming into focus. IOT tags may be attached to shipments with a unique identification number. These IDs will be capable of tracing products' origins, processing data, expiration dates, etc. Blockchain can track the product over time by creating a formal registry to identify individual goods, and track possession of a good through different points in a supply chain. IBM and Walmart along with ten other CPG and food companies are pioneering the use of blockchain for food safety.¹⁹

4.6.3 Risks in the Platform Ecosystem^{7,16}

There are several social, political, and environmental risks that may affect the agribusiness supply and service chains as well as the information and financial flows. We need to identify the risks that the platform as well as the partner companies may face from various sources and determine what it takes for their resolution. Risk monitoring and mitigation strategies are important. The platform should be resilient and should be able to recover to the working state as soon as possible.

We mention a few types of risks below

1. There is a risk of competition from existing retailers, cooperatives, contract farmers or food processing manufacturers who already have established customer base and goodwill in the community.
2. There are risks from weather, governments, and society. Excess rain or temperatures, thunderstorms, hurricanes, floods, droughts, earthquakes, crop diseases, contamination of seeds, fertilizers, etc.
3. Cybersecurity is a new priority as ransomware attackers can hit agribusiness systems. Hackers stepped up attacks on e-retail companies going beyond phishing attacks, stealing data and information, and selling on the dark web. Ransomware attacks shut down IT systems and slow operations.
4. There is a need to identify the government risks such as change in the government, state—central government relations, international relations, and corruption. Trade tax increase, import and export restrictions, etc. can occur as governments change.
5. Social risks, for example: those that involve land acquisition, environmental degradation

or people displacement are also to be identified.

Fraudulent activities like these can be managed and monitored using machine learning techniques like neural networks, logistic regression and decision trees, to name a few.

In addition to the risks mentioned above, food contaminations have become very common disruptions effecting the agriculture business and food security severely many times. As per a report published by Indian Council of Food and Agriculture (ICFA)²⁰: There is a significant share of non-genuine pesticides which include counterfeit, spurious, adulterated, or sub-standard products. According to industry estimates the non-genuine pesticides could account for more than 40% of the pesticides sold in India. These products are inferior formulations which are unable to entirely kill the pests or kill them efficiently. They also result in by-products which may significantly harm the soil and environment. Apart from crop loss and damage to soil fertility, use of non-genuine products leads to loss of revenue to farmers, agrochemical companies and government. Some of the key reasons for use of non-genuine products are lack of awareness amongst the farmers, difficulty in differentiating between genuine and non-genuine products, supply chain inefficiencies, law enforcement challenges and influencing power of distributors/retailers.

Food waste is a massive market inefficiency and an environmental threat. Between 30–50% of all foods produced globally is never eaten, and the value of this wasted food is more than \$1 trillion. Food that is never eaten accounts for 25% of all fresh water consumption globally. Not only are all the resources that went into creating the uneaten food wasted (land, water, labour, energy, manufacturing, and packaging), but when food waste goes to the landfill, which is where most of it ends up, it decomposes without access to oxygen and creates methane, which is 23 times more deadly than carbon dioxide. If food waste was a nation, it would be the third-largest emitter of greenhouse gases after China and the US.¹⁵

4.6.4 Innovations

Traditional agribusiness innovations are rooted on a standard and well-accepted model characterized by heavy investments in soil fertility, seeds, produce, and increasing use of fertilizers. After analysing and correlating information about various agricultural parameters like soil

quality, weather, types of seeds and historical prices, farmers make informed decisions.

New Innovations that are making waves include new technologies such as robots, drones and big data analytics. Predictive and prescriptive data analytics using AI and ML models, trade policies of the governments, open collaborative strategies with ecosystem partners, sharing economies, new business models, organic and nimble farming, desert agriculture, green farming, waterless agriculture and many more can be analysed.

Specific to digital agribusiness ecosystem, innovations maybe envisioned in a way that completely relies on artificial intelligence with zero to minimum human intervention. This may use advanced real time dashboards for effective predictive models. The broader question is how to make a farmer switch from a traditional approach to such a platform-based model. Additionally, we may need to consider the explainability of AI and technology to farmers and make it digitally accessible and useful to all players in the value chain.

Services innovation is about creativity, technology, R&D, and entrepreneurship and new ways of doing business and interacting with society. Broadband, mobile, and wireless networks, devices and services allow for richer services: communication, commerce, media, health, marketing and security.²¹ The Internet, Facebook, YouTube, Wikipedia, WhatsApp, E-commerce, Ports, Airports, Suez and Panama canals, etc. provide the key to open the doors for integration and betterment of the world economy. The supply chain or service chains consist of global partners collaborating in serving the customers who are also globally dispersed. Government policies have in many respects been constructive. There has been a co-evolution of public policy and firm strategy. One needs to formulate an integrative, co-evolutionary innovation strategy that would lead to high agriculture industry growth or excellent service quality by working with innovations in several of the ecosystem elements and their convergence to provide easy access to quality products and services at affordable cost to the people.

Future innovations in Desert agriculture and Seawater farming will help a world with increased population. Most of the world's surface is covered in water, in the form of oceans. The remaining landmass of the Earth amounts to approximately 29% of this one-third are deserts of all types. To tackle the food crisis, the world must turn the world's desert and sea into food production facilities, an effort that will

need the combined brainpower of the brightest minds, universities, and research facilities.¹¹

5 Conclusions

Establishing a digital ecosystem of agriculture should consider characteristics like data governance and standards, interoperability, privacy and security, along with promoting open innovation. Opportunities for transformation include developing big data infrastructure, cyber secure infrastructure, trained workforce etc. These transformative opportunities can be realized with the participation of Government, Education and research Institutions, Science and Technology Industry and Society. Agri ecosystem platform development may follow an S curve with a slow start, followed by a steep acceleration as technologies mature. The goal of "going digital" is not enough; people must have tools with skills to utilize them and transit to the new technologies. Digitalization of food and agriculture services should provide food that is accessible, affordable, and available to all. The noble prize winner Solow's (1987) Paradox is appropriate here as well. He said, "We see transformative new technologies everywhere but in the productivity statistics". Steam engine, electricity and computers increased productivity both directly and by complementary innovations, but each has taken decades to develop complementary technologies and products and finally become productive in the economic and customer sense. Similar will be the case with digital platform agriculture. Benefits require complementary co-inventions and investments in additional technologies (robotics, 3D printing, intelligent farm equipment like tractors, drones, smart farm care, etc.) applications, processes, business models, and regulatory policies. In view of the increased connectedness of people and the societies, it may take lesser time. The key factors that will determine the success of Digital Agriculture in India are affordability of technology, ease of access and operations, easy maintenance of systems, timely grievance redressal and appropriate policy support. There is also need for robust R&D that also factors in last mile delivery and ground challenges so that Digital Agriculture can empower Indian farmers in a meaningful way.⁹ Regulation and legal framework regarding the control and ownership of farm data between farmers and data companies needs to be sorted out.

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Data availability

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Declarations

Conflict of Interest

This work is done independently and there is no conflict of interest with any other individuals and institutions.

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