

WORKING PAPER NO: 685

**Raising Farmer Income and Sustainable Farming – A
Roadmap for AgTech Evolution in India**

V. Ravi Anshuman

*Finance & Accounting Area
Indian Institute of Management Bangalore
Bannerghatta Road, Bangalore – 560 076
anshuman@iimb.ac.in*

Venkatesh Akella

*Department of Electrical & Computer Engineering
University of California
akella@ucdavis.edu*

Year of Publication – August 2023

Raising Farmer Income and Sustainable Farming – A Roadmap for AgTech Evolution in India

V. Ravi Anshuman

Dept. of Finance & Accounting

Indian Institute of Management

Bangalore, 560076

Venkatesh Akella

Department of Electrical & Computer Engineering

University of California

Davis, CA 95616

Final Report

The authors thank NSRCEL and NITI AAYOG for providing a research grant to conduct this study. We also wish to thank Sahajdeep Kaur and Jacqueline Gomes for their valuable input in preparing this document.

Abstract

Significant venture capital investments are being made in agricultural technology (Agtech) start-ups in India. The main benefit of a technology-based solution is its potential for scalability. However, there is also huge uncertainty about how these efforts will pan out in the future. In this study, we present a framework to understand how the Agtech sector in India is likely to evolve in the coming decades. We argue that a trust deficit issue arises due to an information asymmetry problem between producers and consumers, causing a breakdown in the market mechanism – thus, hindering the flow of investments in business opportunities in the Agtech sector. Resolving trust deficit issues is key to creating a vibrant and scalable Agtech ecosystem. More importantly, we show that a critical mass of technology investments in the digitization of the supply side of the market is required to unlock the true potential of the Agtech sector. Based on these insights, we not only develop a framework to understand what is required to accelerate growth in this sector but also present a likely road map of the future evolution of this sector.

Keywords: Agtech, Agricultural technology, Trust, Signalling, Sustainable Farming, Organic Farming, Startups

1. Introduction

Agriculture accounts for 49% of the Indian workforce, however, it constitutes only 16% of the national GDP. The growth rate in the agricultural sector has been languishing at low levels for several decades. Improvements in agricultural productivity are therefore critical for ensuring the food security of 1.3 billion people. Furthermore, the future of agriculture is closely tied to global warming and unpredictable weather phenomena due to climate change.

Doubling farmers' income and improving sustainable agricultural practices are urgent national priorities. Niti Aayog's 2018 discussion paper, National Strategy for Artificial Intelligence AI For All notes new AgTech solutions based on advanced data analytics, robotics, digital platforms, and advanced sensors are required to address this challenge immediately.

Armed with significant inflows of venture capital and government investment, AgTech is emerging as a new industry worldwide. Many new businesses and marketplaces are waking up to the importance of providing fresh, locally grown organic products, and ensuring food safety. They are working towards adopting sustainable agriculture practices, and using technology to streamline their supply chains. See Figure 1.



Figure 1 - Emerging AgTech Themes

There is widespread optimism, especially amongst AgTech companies (and their investors) that the latest technological advances in AgTech such as blockchain, smart sensors, AI-based precision-agriculture, and smartphone-based apps can improve transparency, remove middlemen, and help consumers. However, despite the optimism, private and public investments, and deployment of these technologies in many market segments, the progress at the ground level remains far from satisfactory.

In this white paper, we provide insights into possible reasons behind this slow evolution of AgTech in India; more specifically, we take the context of sustainable farming to lay out an *optimal framework* that will help us (i) understand the key bottlenecks in the agricultural ecosystem, (ii) comprehend how market mechanisms will evolve to overcome these hurdles, and thereby (iii) present a road-map of how AgTech will evolve in India in the next few decades.

Using this framework, we provide a comprehensive list of actionable insights that policymakers can use to accelerate the development of the agriculture sector and help small farmers double their income. Even if no proactive action is taken by the government, market forces will

themselves evolve mechanisms to facilitate the growth of this sector. A nudge by the government can help accelerate this process and avoid the possibility of “ruing the loss of another decade”. The framework will be helpful to both entrepreneurs and investors in identifying pockets of growth opportunities. Finally, it would be important to mention that most of the driving forces that we will discuss in the framework are already existing. Then, where do we add value? *Our contribution is to sort out the jigsaw puzzle and show how these potential forces will coalesce in the next two decades to create huge growth in the agriculture sector.*

The rest of the paper is organized as follows. Section 2 presents an overview of the trust deficit problem in terms of information asymmetry, a key economic concept that explains why the market mechanism can sometimes fail, leading to (agricultural) market breakdowns, as witnessed in the Indian agricultural ecosystem. In Section 3, we discuss the critical factors that facilitate the signaling of trust in agricultural marketplaces. In Section 4, we discuss the current landscape of innovation in the Indian Agtech sector. In Section 5, we propose a novel framework of a marketplace based on the TRIOS Scorecard (Transparent, Real-time, Immutable, Organic, Sustainable farming practices) that facilitates the two-way flow of trust between consumers and farmer-producers. Section 7 presents the challenges of our proposed solution., Section 6 discusses how this two-way trust flow can be bootstrapped to become a self-sustainable ecosystem. Finally, Section 8 discusses how the AgTech scenario in India is likely to evolve in India in the next two decades.

2. Trust Deficit and Market Breakdowns

In an agricultural marketplace, businesses source agricultural produce from farmers and sell them to consumers. These businesses are based on delivering not just a product (such as milk, or vegetables), but a product that has some dynamic (possibly ephemeral) attribute such as “freshness”, or a product that comes with the promise of being free from contamination, or an attribute such as being local (sourced from a certain radius from the consumer), or that the product is an outcome of “sustainable farming practices”, or that the business helps in raising farmers’ income or pays them higher than the average price, etc.

Consider sustainable farming. With the Sustainable Development Goals (SDGs) and the COP26 summit demanding action from every sector, there is a latent demand globally for agricultural products cultivated using sustainable farming practices. Many customers would be willing to pay a premium for such agricultural products but are unwilling to do so because of several sellers making claims about sustainable farming practices that are difficult to verify. This situation reflects a market failure because there is an unresolved mismatch between supply and demand. As Akerlof (1970) points out, market breakdowns can occur due to an information asymmetry problem between the buyer and the seller. To cite from his most famous work, *“The cost of dishonesty, therefore, lies not only in the amount by which the purchaser is cheated; the cost also must include the loss incurred from driving legitimate business out of existence”*.¹

| |
|--|
| Lack of trust , therefore, poses significant friction in the formation of a market. |
|--|

Interestingly, Akerlof fine-tuned some of his ideas on market failure during the time he spent at the Indian Statistical Institute (Delhi) in 1969. Akerlof’s insights were shaped to some degree by his experiences in India where he tried to explore the issue of why *“doing business in under-developed countries is difficult”*. He assessed that, *“There is considerable evidence that quality variation is greater in underdeveloped than in developed areas. For instance, the need for quality control of exports and State Trading Corporations can be taken as one indicator. In India, for example, under the Export Quality Control and Inspection Act of 1963, “about 85 percent of Indian exports are covered under one or the other type of quality control”.Indian housewives must carefully glean the rice of the local*

¹ George A. Akerlof, Market for “Lemons”: Quality Uncertainty and the Market Mechanism, Quarterly Journal of Economics, 1970, Vol. 84(3).

bazaar to sort out stones of the same color and shape which have been intentionally added to the rice. Any comparison of the heterogeneity of quality in the street market and the canned qualities of the American supermarket suggests that quality variation is a greater problem in the East than in the West.”

On the demand side, only a niche segment of consumers is concerned about the features like traceability. The promise of higher prices could be the motivation for farmers to digitize their processes and invest in technologies that improve transparency, traceability, etc. However, there is uncertainty about the consumers’ willingness to pay for the features that may be offered with the new technology. This in turn acts as a deterrent for farmers stopping them from making large investments in the fields.

Our research shows that this trust deficit is not one-sided. It is not just that the demand-side consumers are wary of being cheated by a dishonest producer, but the supply-side producer (or the farmer) is also wary of the system, in the sense that she/he is not sure whether making costly investments in new technologies or bringing about sustainable changes in farming practices will be a rewarding experience in the marketplace. Often there is a long gestation period before investments can bear fruit. Farmers, especially those with small holdings cannot afford to make such investments. Farmers are concerned about regular and predictable cash flows and access to loans, insurance, and faster settlements of claims.

So, from the consumer’s side, the trust deficit is due to concerns of quality, while from the producer’s side (especially for the farmers with smaller holdings), the lack of trust is because the “system” has failed them thus far, in terms of getting a fair price, faster settlements of claims, and access to credit. This introduces additional friction in the marketplace and causes a further breakdown in the marketplace. Hence, we have a vicious cycle that needs to be broken to unleash the true potential of AgTech.

Key Insight: Unlike in developed countries where the focus has largely been on developing mechanisms to resolve trust deficit issues on the demand side of the market, the Indian Agtech ecosystem is burdened by a two-way trust deficit, both on the supply-side as well as the demand-side of the market. Overcoming this two-way trust deficit effectively is a prerequisite to the wider adoption of AgTech in India.

One might ask, is this lack of trust from the producer’s side unique to India? The answer is yes. This is not a major issue in countries that have more effective legal systems and developed financial service firms with mechanisms such as credit history and claims settlements. The developed nations also have less fragmentation of farms, enabling their farmers to have more leverage. Unfortunately, in India, most of the farmers have very small holdings and the ones who have a dairy business can afford only one or two cows. Access to legal help or financial services such as loans and insurance is almost not available to farmers in the country. These concerns make Indian farmers extremely vulnerable and even more unwilling to take risks, thereby resulting in the trust deficit getting even more acute.

The resolution of this trust deficit requires mechanisms/intermediaries that facilitate the exchange of information between supply-side consumers and demand-side producers. From an intellectual perspective, information asymmetry-driven market breakdowns due to trust deficit can only be resolved by institutionalizing signaling mechanisms that credibly convey relevant information. For instance, if there is a mechanism in place to ensure that farmer-producers get predictable cash flow payments upon delivery, it will go a long way in reducing trust deficit issues on the supply side of the market. Likewise, if there are mechanisms in place to credibly convey relevant information about the quality of goods, the trust deficit on the demand side is mitigated. The critical issue is that these mechanisms should facilitate the reduction in the information asymmetry problem raised by Akerlof (1970), thereby resolving the trust deficit issues leading to a market breakdown.

3. Critical Factors that Facilitate for Signaling Trust and Reputation in AgTech Marketplaces

There are three critical factors that can accelerate the growth of AgTech adoption in India. The first critical factor is the quality of information flow in the marketplace. For trust to be established between the counterparties in the marketplace, namely, the farmer-producer and the consumer, the information being exchanged in the marketplace must be of high quality, by which we mean that information must be objective, relevant, and verifiable.

The second critical factor is that the solution must be scalable because both the supply side and demand side segments are highly fragmented. For scalability, there is no better alternative than the digitization of information flow, i.e., the digitization of the entire value chain. With the support of advanced technologies like blockchain, information can be made objective by relying on measurable data recorded in digital repositories. The information must also be relevant in the sense that it is useful for both counterparties. It is also equally important that information must be verifiable to ensure that it is credible.

Large businesses that have been selling for a long time have managed to successfully establish trust and enjoy a brand premium. There is no signaling in the market. With all the noise about businesses claiming their products are good, the customers have no means to verify whether a product being sold is genuine or fake. It is all chaos (what academics refer to as “cheap talk”). In such a scenario, the large businesses that have been around for a long time succeed at the expense of innovative entrants because they have built a brand over time. Relying on this approach of building credibility over time lacks scalability, thus rendering an agricultural ecosystem that fails to meet the requirements of India.

Digitization is required for scalability and to create objective and reliable signals of quality. However, it is an arduous task because most farmers in India cultivate small land holdings, and unless a vast majority of farmers are enrolled in the digital infrastructure, there cannot be any flow of information between farmer-producers and consumers. Digitizing data from fragmented land holding is a tedious and expensive process, and it will take a few years and financial investments for a critical mass of data to be collected across different geographies, crop cycles, and crop varieties.

The third critical factor is the recognition that the Indian agricultural ecosystem is different from that in most developed countries, where supply-side holdings are concentrated, and digitization is a well-established practice that has been prevalent for the last 2-3 decades. Bridging the trust deficit from both the producer’s as well as the consumer’s sides in India **requires an iterative process because there is an inherent deadlock or a vicious cycle that exacerbates the trust deficit between the consumer and the farmer-producer.** Basically, we need a mechanism to bootstrap the system, so that it grows naturally and in scale to millions of farmers and hundreds of millions of consumers. This implies that we need to recognize the need for investments to grow a technology-enabled marketplace and think about how such investments should be made by the government and other stakeholders so that the system is scalable and self-sustaining.

Key Insight: Bootstrapping the Indian Agtech ecosystem requires an iterative investment process, which is sequential in nature. The initial seeds of bootstrapping must necessarily focus on digitizing the supply chain, i.e., digitizing the farmer-producer end of the value chain. Until a critical degree of digitization on the supply side is attained, trust deficit issues on the supply side will pose an insurmountable barrier to meaningful progress in the Indian Agtech ecosystem. Once this tipping point in digitization has been achieved, an iterative process of investments in both the supply side and demand side of the market can help generate a virtuous cycle of productive investments for start-ups in the Indian Agtech ecosystem.

The importance of addressing two-way trust is being recognized by many of the emerging startups that we had a chance to interact with. Here are some examples of how some startups in the AgTech space are addressing these concerns.

4. Current Landscape of Agtech Innovation in India

We conducted a field study of a select set of AgTech firms (see Akella, Anshuman, and Kaur (2022)).² The start-ups in our study included Jivabhumi and Adi Naturals (marketplace for organic produce), Milk Mantra and TraceX, which deploy technology solutions for digitizing the value chain. The key findings from this study can be summarized as follows:

For instance, TraceX introduced blockchain technology to bring transparency in the food chain. After some time, they also introduced their own product brand - Jivabhumi, building a brand name that the consumers trust in terms of quality. Jivabhumi connects the local farmers to the nearest consumers. They explicitly provide information about farmers, the area in which a particular product is grown, and the income share of the farmers from each product that is bought from them. Similarly, Adi Naturals provides proof of the authenticity of its organic products via certification and testing reports along with pertinent information about farmers. Milk Mantra provides a digital record of all the links in the supply chain starting from information on farmers. However, all this information is given as a value-added service that the consumers may or may not consider significant while making a purchase. The pivotal factor is the trust the firm builds with its consumer through this information. In essence, again, the firms are leveraging this extra information to signal their reputation in the marketplace. These examples suggest that the consumer side values signals, but the effectiveness of these signals depends on the ambient noise as well as the richness of the signal in terms of information about different attributes of the product. More specifically, Milk Mantra and TraceX have initiated the first steps toward the digitization of the value chain. As in the case of agricultural farming, the source of milk supply is also based on many dairy farmers, who on average own two or three cows. Apart from the issue of fragmented ownership, the problem of digital illiteracy also stands in the way of creating digital records. Digitization, therefore, requires significant investments in terms of effort and time. This slow process of mapping the supply chain will eventually yield significant benefits but as of now, there are only a few players who have taken up this arduous exercise.

The current scenario of AgTech in the agricultural space in India can be described as an embryonic or a nascent phase. We have initiated the first step toward digitization of the value chain. As the pace of digitization picks up, we can expect market forces to push the industry toward standardized metrics (such as the TRIOS Scorecard we have proposed below), which can be used as credible signals to mitigate the information asymmetry problem.

The main reason why seamless adoption of digital technologies from the developed world is not possible in emerging markets is that these technologies assume a high degree of digitization in the upstream segment of the value chain. Therefore, while developed market AgTech firms are concerned about using blockchain to target traceability, food safety, and verifiability of farming practices, AgTech firms in India must first invest in digitizing the upstream farmer-producer activities before they can turn their attention toward consumer-side pull factors. In essence, upstream digitization is the key driver of change, and unlike the developed world where such digitization has been an ongoing exercise that began in the 1990s, Indian AgTech is taking the first steps in this direction; however, given the huge market potential and the rapid adoption of digital technologies in the recent 5 year period, there are encouraging signs on this front.

Gaining the farmers' trust is critical to facilitating upstream digitization. This will be possible only when farmer-producers see tangible gains from participating in the digitization exercise. The two main

² An Exploratory Field Study of Select AgTech Startups, Akella, Anshuman, and Kaur, NSRCEL Working Paper (2022).

concerns of farmers in the prevailing ecosystem of middlemen are delay and uncertainty in payments. The carrot that can attract upstream farmer-producers to participate in the digitization efforts is prompt and predictable payments using digital platforms. Recent advances in payment technologies in India have led to a rapid increase in digital transactions that span urban as well as rural areas. Thus, we can expect a virtuous cycle where increasing penetration of digital payment systems in rural areas will attract more farmer-producers to join the digitization bandwagon.

In the next section, we will describe a framework for signaling trust and reputation applicable to AgTech marketplaces. The acronym for this framework is TRIOS, as discussed below.

5. The TRIOS Framework

In this section, we consider a marketplace for produce generated in farms that employ sustainable agricultural practices. We develop a framework for signaling trust in this marketplace. We call our framework TRIOS, which captures the five main attributes – transparency, real-time, immutable, organic, and sustainability, that are being signaled in the marketplace. Our framework offers an implementable blueprint that could be used by policymakers, government agencies, or industry bodies to push national and global initiatives for sustainable development.

Rationale for TRIOS

Latest developments in digital technologies, internet-of-things (IoT) sensors, and artificial intelligence (AI), provide opportunities to build a digital platform that offers a greater degree of verifiability and credibility about organic and sustainable farming practices used by the seller. Discerning customers would be willing to pay a price premium for the verification service. More importantly, such a digital platform would also mitigate the influence of middlemen, thereby allowing the farmer to obtain a reasonable share of the rents arising from premium pricing. Furthermore, smart contracts that lead to faster settlements, can add to the predictability of farmer earnings. In short, sustainable farming practices would create higher, and more predictable revenue streams. The combined effect would make banks more willing to finance loans to the farmer and reduce the overall NPA exposure of banks to agricultural loans. Farmers participating in this venture would find that the financing costs would decrease over time. The net effect of higher revenues and lower financing costs would increase farmer income. The knock-on effect is that other farmers would be incentivized to take up this business model.

Figure 2 shows the high-level overview of TRIOS. The central piece of the architecture is the notion of a TRIOS Score, which captures the performance history of the farmer. This is analogous to credit history in the financial world. The history captures the identity (basically something like a KYC for a farmer, or a Know Your Farmer (KYF)) and the “performance” of the farmer in terms of his/her agriculture practices for a given farm. What is being grown? Where is it being grown? When is it grown? What are the inputs for a production cycle in terms of seeds, fertilizers, treatments, and water? Where are the inputs coming from? How are they being purchased or financed? This data is key to transparency. Not just providing the data upon request or in some indecipherable fine print on a label, or for a specific product, but the data over time. We believe that a custom blockchain is the right technology for collecting such information because we want to guarantee that the data is immutable. We also want the data in real-time, so that it can signal some domain-specific attributes such as freshness, when some product was harvested, etc. Thanks to parallel efforts by many agencies and programs initiated by the Government of India over the past few years, a large fraction of this data is already available in a digital format. Unfortunately, this data is in different silos, with banks, tax receipts, invoices, tax bills, water and electricity meter data, etc. *What we are calling for, is consolidating the relevant data in a single place and developing a framework to monetize that data.*

Overview of TRIOS (Or Principle of Operation)

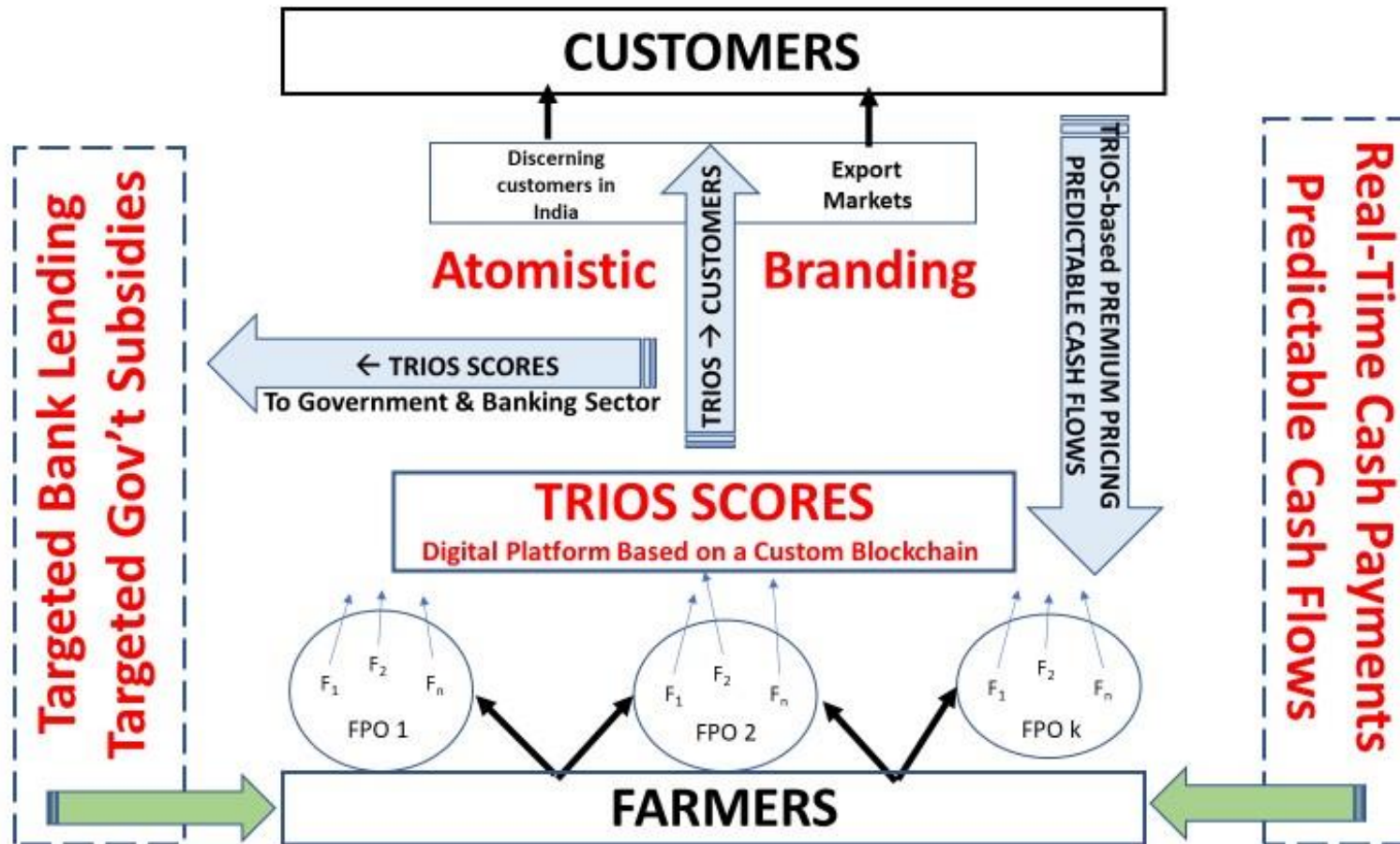


Figure 2 - The TRIOS Framework (($F_1 \dots F_n$: Farmers, FPO: Farmer Producer Organizations)

Clearly, the framework signals “quality” based on transparency, immutability, and more importantly the performance history over time which can be valuable to a discerning customer who is interested in conservation, renewables, or sustainable or organic practices. What is more important is that the same TRIOS score can also be used by banks and insurance companies to build better models of risk and identify opportunities for investment. The performance history can also be used by businesses to pay the farmers automatically (very simple smart contracts that are triggered automatically) or even advance loans to deserving farmers. This can then help with the trust deficit that exists between the farmer and the system. The farmers who are performing well can be assured that they can not only get premium prices from discerning customers (and possibly export markets) but can also get faster payments and possibly lower-cost loans/lower insurance premiums.

Furthermore, this can also be used by the government to tie subsidies to actual performance, a holy grail for any government.

Atomistic Branding

Once farmers see other farmers getting paid faster, and getting higher premiums for sustainable farming practices, it is likely that more farmers will embrace these practices and be willing to share more data about their farming practice. We call this atomistic branding. So, farmers can build a brand around their farming practices and indirectly about their quality, which in turn can increase their reach and customer base outside what was possible.

An innovative solution that is increasingly gaining traction is the formation of Farmer Producer Organizations (FPOs). These umbrella organizations can help mitigate the upstream trust issues where farmers face two key challenges: delayed and uncertain payments from the middlemen who extract rents from small marginal farmers who are, fragmented, perennially short of cash, illiterate and naïve in financial and legal matters, besides being subject to prevailing local social structures that curtail their bargaining power. While FPOs can serve as the bridge to initiate trust with farmer-producers, the key to establishing trust on the supply side is to make it incentive compatible for them to participate in the digitization process. The FPO behaves like a collective that protects the interests of the farmers and stands as a certifier of any external party that wishes to transact with farmers for their produce. More importantly, the FPOs can create repositories of certified data about farmers’ activities that can be useful for creating trust in the marketplace.

As discussed above, trust can be gained by demonstrating quick (real-time) and credible settlement of claims with the help of digital payment systems that automatically trigger instantaneous payments upon uploading proof of supply that meets the quality standards. This is essentially an unwritten smart contract that is a key driver of digitization; when farmers see their neighboring farmers getting a real-time settlement, leading to predictable cash flows, it has a huge positive impact on them, and they are more likely to participate in the digitization process.

Digital intermediaries who are connected to the demand-side customers are also required to complete the value chain. We refer to these intermediaries as Brand Builders. They can use the TRIOS score to convey an objective measure of the quality of produce being sourced and offer TRIOS-based premium pricing to customers who value the extent of sustainable farming employed by farmer-producers. The Brand Builder then acts as a dealer intermediary. *It is critical to recognize that there should be sufficient competition between Brand Builders to ensure that they do not expropriate a larger share of the margin; there is a sense of equity and balance required to facilitate the success of this model because one of the reasons farmer-producers are reluctant to participate in a digital ecosystem is that they fear that the rents would be disproportionately extracted by middlemen.*

In summary, supply-side farmer-producers rely on the FPO intermediation to connect to the Brand Builder, who in turn, connects to the demand-side customers. Intermediation in this value chain can also be offered by a single entity if a Brand Builder is able to pool together a set of farmer-producers

to source supply. In general, it is more likely that Brand Builders will tie up with FPOs to get access to supply-side farmer-producers and achieve the requisite economies of scale. They would then leverage this tie-up to invest in the digitization of the supply side of the value chain. Once digitization has been achieved, Brand Builders can invest in a distribution network to gain access to discerning customers. In the Indian context, ITC Ltd. is an example of a Brand Builder which has established direct linkages with farmer-producers on the supply side, as well as with demand-side customers.

The value chain of trust transmission is summarized below.

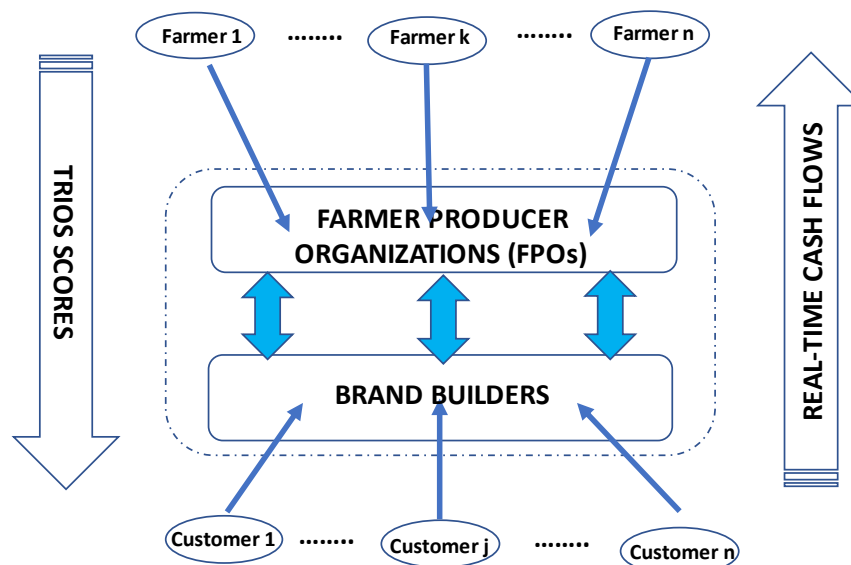


Figure 3 - Trust Transmission Value Chain

6. Bootstrapping the TRIOS-based Agricultural Ecosystem

In this section, we consider the key question of bootstrapping the business model discussed in the previous sections. We also keep in mind the learnings from the initial forays of AgTech start-ups in India. We suggest the following approach:

1. The government sets up a special entity with seed funding to bootstrap and propagate the mission (as discussed below). This entity should involve state-of-the-art sustainable farming experts from India, experienced real-time farmers who practice traditional sustainable methods of farming, as well as experts in the domain of blockchain, AgTech analytics tools, etc. The government should also be actively involved to ensure transparent governance and protect farmers from vested interests.
2. This GSE (Government Special Entity) selects four to five FPOs near metros as pilot projects. A **market survey** is required to estimate the number of discerning customers in a metro who would be willing to pay for produce generated from sustainable farming practices. Evidence from developed countries shows Indian customers are likely to follow these trends: 17 percent of people who purchase organic sometimes were willing to pay up to 35 percent more for organic

vegetables, and 27 percent of customers were willing to pay 20 to 34 percent more, according to the ***Organic & Natural 2016 report***, by **The Hartman Group**, in Bellevue, WA. This is especially true of Millennials, who prioritize spending more on food they see as being of higher quality, healthier, and better tasting. Millennials, aged between 18 to 34, overtook Baby Boomers as the largest consumer group in 2016, according to the **U.S. Census Bureau** data.)

3. A field study is required to assess the exact funding requirements to install agri-infrastructure required for sustainable farming practices. (**seed funding**).
4. The GSE selects a group of farmers who are willing to invest some money in sustainable farming practices. (**Skin in the game**). The GSE finances the remainder of the investment required to set up the sustainability-enhancing infrastructure, e.g., IoTs (sensors), multispectral cameras for estimating NDVI, crop cover, soil health, etc., drip irrigation, solar panels, organic fertilizers, seeds, soil nutrients, electricity, and water meters, weed control methods, etc.
5. A digital platform records real-time inputs on pesticide/organic fertilizer usage, electricity usage, solar power usage, water utilization, soil health (humidity, nitrogen), irrigation, crop storage and post-harvest handling, crop rotation, yield, etc., to generate a time series of **TRIOS Score Card**. The TRIOS scorecard is a weighted index that captures the degree to which the farm is embracing sustainable farming practices.
6. Farms will be ranked on the TRIOS score and the digital platform will keep track of the scores over time (**verifiable and immutable track record of performance**). A detailed study is required to design the TRIOS score card keeping in mind the evolving technologies (blockchain and artificial intelligence).
7. Converging to international best practices would help create an export market. This requires the TRIOS score to be benchmarked to internationally accepted norms for sustainable farming practices (**exports**).
8. Setting up agri-infrastructure for sustainable farming practices can be done in two phases: (i) basic agri-infrastructure (solar power, drip irrigation, basic soil health, etc.) and (ii) advanced agri-infrastructure (apps, sensors, drones, etc., that take advantage of blockchain technology and artificial intelligence).
9. The GSE promotes/advertises the pilot project and enables individual retail customers to “buy” pesticide-free produce through an online portal with a professional delivery system, i.e., the **digital platform can be linked to a delivery platform**.
10. The prices farmers charge would be linked to their TRIOS scores; discerning customers who value the benefits of sustainable farming practices would pay an additional premium. Thus, **premium pricing based on TRIOS scores** would allow **atomistic branding** by farmers. In other words, farmers can charge different prices for their output, but the differentiation will be linked to verifiable TRIOS scores. An artificial intelligence algorithm can be designed to set produce prices in a manner that higher TRIOS score products are sold at higher prices, thereby incentivizing farmers to incorporate sustainable farming practices. Using machine learning algorithms, the TRIOS-price relation can be calibrated to ensure consistency with market demand in a dynamic manner.³
11. The benefits of a digital technology platform (the TRIOS scores) can be used not only to **establish trust** but also to differentiate every farmer from another farmer because premium pricing will be tied to the TRIOS score. This atomistic branding provides the incentive for farmers to invest in the **maintenance of agri-infrastructure** that is required for sustainable farming practices.
12. **The government can use smart contracts** for targeted subsidies. The smart contracts will be executed in a transparent and swift manner, thereby incentivizing farmers to follow recommended best practices regarding soil health, toilets, etc. Smart contracts can also be used

³ For instance, Bayer is deploying outcome-based pricing, see: <https://www.goodfruitandvegetables.com.au/story/6430062/digital-ag-could-provide-new-business-model-for-bayer/> : To quote from the article, “The long-term success of Crop Science (Bayer’s digital agriculture subsidiary) lay not in selling more products but in providing farmers with personalised solutions, enabling them to achieve better harvests more sustainably while using less resources such as water, land, inputs and energy.

to ensure the timeliness of cash payments from discerning customers. Given that marginal farmers are perennially deficient in cash holding, faster settlements can make a big difference.

13. Once a few pilot projects are successful, other farmers within an FPO will be interested in joining the scheme because of the benefits of premium pricing. The GSE should continue sponsoring these farmers to demonstrate that this system can work well for a reasonable number of farmers in the FPOs across the state/country (**brand creation**).
14. **The GSE can monetize its investment** in farms that exhibit consistently high TRIOS scores. The GSE can sell its share to a new sponsor (crowdfunding or peer-to-peer lending),⁴ thereby exiting the investment. In short, the GSE sets up the Agri-infrastructure for sustainable farming practices, facilitates atomistic branding by farmers, and exits at an appropriate time; furthermore, it uses the realized funds to finance a new set of farmers. An initial seed fund to set up the GSE can be rotated many times over (**multiplier effect**). This novel feature will ensure that the business model is self-propagating and will not rely on government expenditures.
15. To access crowdfunding, the government can seek volunteers (crowd funders) who wish to contribute to Atmanirbhar Bharat. The digital technology enabled **KYF (Know Your Farmer)** system will allow crowd funders to know the recipient farmers on a real-time basis before financing the farmer. Crowdfunders would be the “owners” of the agri-infrastructure and would NOT get any ownership claims on the farmers’ land. A return in kind can be provided by waiving premium pricing for their purchases of the farmer’s produce.
16. Also, the peer-to-peer lending model can be a vehicle to raise small amounts of money from several individuals to sponsor one farmer, i.e., **risk-sharing to increase the pool of money**.

Helping the marginal farmer can be viewed from the perspective of charity or from the perspective of empowerment and dignity. For instance, Kiva offers loans based on the crowdfunding model and Rang de India offers interest-free loans using a peer-to-peer lending model. What distinguishes our proposal from standard crowdfunding/peer-to-peer alternatives is that our approach leads to a greater degree of empowerment because farmers are incentivized to become financially independent over time. The GSE requires only a seed fund; from then on, it would be financially independent and can generate its own growth in a sustainable manner using the crowdfunding/peer-to-peer lending model.

Scalable Model of Increasing Farmer Income

The benefits of digital technology can be used not only to establish trust but also to help hard-working farmers to differentiate themselves from other farmers because premium pricing will be tied to the TRIOS score. This atomistic branding provides the incentive for farmers to invest in the maintenance of agri-infrastructure that is required for sustainable farming practices. In addition, the entire ecosystem benefits: (i) discerning customers get superior products, (ii) banks can engage in targeted lending, (iii) NPAs in agricultural loans decrease, (iv) crowdfunding/peer-to-peer lenders’ objectives of promoting sustainable farming practices are achieved, and, most importantly, (v) the government can focus its resources in other avenues for improving social welfare. All these benefits arise because financial viability is built into the business model.

7. The Critical Challenge: Innovation in GSE

The most important driver of trust is credible verification. Developments in digital technology are making it increasingly possible to achieve this goal. However, adopting these cutting-edge technologies requires a willingness to keep pace with technological innovation. This is a nontrivial

⁴ The crowdfunding model is akin to an equity stake with a claim on future profits whereas the peer-to-peer lending model is akin to a debt contract. Typically, crowdfunding is based on altruistic intentions and investors do to not demand any return for the equity investments. Likewise, peer-to-peer lenders with similar objectives provide low-interest or zero-interest loans.

challenge that must be factored in at inception. The organizational structure and governance mechanisms in the GSE must recognize this difficulty.

The market environment is ripe for other private players to step in and play the role of facilitating atomistic branding by farmers with the use of blockchain-based digital verification platforms. If the GSE falters in its mission (or is not set up at all!), the net result will be that several marginal farmers will migrate to the private platforms, due to a lack of alternatives. However, such private players will not have the same incentives as the government to increase farmer income; while their presence would improve farmer welfare to some extent, it is more likely that they will extract a greater share of the rents associated with premium pricing. In this scenario, the government's objective of doubling farmer income will become even more difficult. It is therefore critical for the GSE to nurture organizational human capital that facilitates continuous innovation, both in terms of the scale as well as the scope of verification in the digital platform. If the government fails to take up this task, corporates/private entrepreneurs/NGOs will soon fill up this vacuum at the expense of a superior opportunity for farmers to grow their income at a much higher rate (than what would arise under a non-government initiative).

Critical Steps to Set up the Right Business Model

| Step No. | Brief Description | Comment |
|----------|---|--|
| 1. | Market survey to estimate demand. | Is there a market requirement? |
| 2 | Estimating funding required for Basic Agri-infrastructure and Advanced agri-infrastructure for organic and sustainable farming practices | Staggering investments in agri-infrastructure ensures state-of-the-art technologies are adopted over time. |
| 3. | Defining and constructing the TRIOS scorecard to measure organic farming/sustainable farming practices | TRIOS score can be established as a trustworthy (verifiable) benchmark. |
| 4. | Calibrating the mapping of TRIOS scores to premium pricing and ensuring its consistency with market demand. | Premium pricing that is directly linked to TRIOS scores. |
| 5. | Promoting the digital platform to potential customers and tying it with a delivery platform, linking TRIOS to delivery of subsidies, and linking TRIOS to credit markets. | Efficient delivery of produce, efficient distribution of government subsidies, and efficient delivery of credit. |
| 6 | Monetizing government investment to crowdfunding donors/peer-to-peer lenders. | Exit/rollover strategy that is self-sustaining over time. |

8. THE FUTURE: TWO-WAY TRUST MODELS

The business model we propose in this white paper intends to serve the interest of both farmer-producers as well as consumers. Brand Builders can tie up with FPOs to integrate the farmers and bring them together on a digital platform, thereby offering value for both consumers and farmer-

producers. Farmer-producers' interests are protected by the FPOs which in turn helps mediate between the farmers and Brand Builders.

To capitalize on the societal trust that exists within the Indian social structure, these FPOs can better facilitate the switch from manual records to digital ones. Firstly, FPOs will be able to integrate farmers in a village and then at the district level. Secondly, the first step of digitization i.e., the collection of information on the ground level requires a considerable amount of time, labor, and financial resources that Brand Builders can provide. Finally, Brand Builders can introduce the new digital technology in several phases starting from a small level through FPOs to avoid confusion and mistrust.

Moreover, this model will result in a healthy competition between Brand Builders which will prove to be beneficial for both ends of the supply chain. Brand Builders can bring in the funds required for innovation in the farming sector, and the FPOs will relay the innovative techniques to the farmers and ensure proper implementation to improve the productivity of the crops. All in all, the proposed business model will result in better farmer income and extra facilities for the farmers for ease of operations.

The success of this approach has already been demonstrated in a few places in India. Sahyadri Farms, which was formed in 2010, is a Farmer Producer Company (FPC) in Maharashtra, India [<https://www.sahyadrifarms.com/>]. The company is a collective that is owned and managed by farmers that aims to ensure fair equity for everyone while providing value to the end consumers. So far, it has almost 8000 farmers connected on its platform. Such FPCs or FPOs working in conjunction with Brand Builders can pave the path for digitizing the agriculture sector in India. We can segment the development of the AgTech space in India into three phases.

Phase I involves Brand Builders tying up with FPOs or directly connecting with farmer-producers to invest in digitization as well as the adoption of the latest developments in agricultural practices. This phase will gain traction across a large fraction of small farmers in the next 5-10 years. Farmer producers would be more willing to join the digital platforms because it gives them more predictable cashflows and automatic settlements, bypassing the existing structures. This incentive will expedite the digitization of the supply chains in the highly fragmented and disaggregated AgTech industries such as dairy. *So, we expect the current wave to be producer-focused and financial services to the farmer-producers to be the main driver.*

In Phase II, we can expect (i) farmer-producers to leverage the digital infrastructure to adopt precision agriculture tools based on AI algorithms that analyze real-time data obtained using IoT sensors at the field level, (ii) Brand Builders to deploy artificial intelligence applications to match market demand and supply and offer premium pricing to consumers based on digitized information about the extent of sustainable farming practices, and (iii) the supporting ecosystem of financial services (insurance, bank loans, private equity, etc.), targeted government subsidies, and crowd-funding to kick-in. This phase will pave way for the creation of producer as well as consumer surplus. *In short, the model of two-way trust will be reinforced in a virtuous cycle to create significant improvements in surplus creation due to productivity.* This phase will be well-established a decade and a half from now.

Finally, in Phase III, R&D based on AI algorithms and Life Sciences, will start within a decade but will firmly take shape within two decades. *This phase will witness significant innovations in farming practices that surpass global standards for sustainable growth and development.*