AI4AI: Artificial Intelligence for Agriculture Innovation

# Agri-tech Innovations in the Farmgate-to-Fork Ecosystem:

## Technology solutions to improve value creation and capture in Farmgate

Prepared in collaboration with TechnoServe India

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## About the Author(s)

**Jianan Li** is a fellow at TechnoServe India. Prior to joining TechnoServe, she worked as a Senior Associate at McKinsey Frankfurt. She has experience in strategy design and implementation for leading global companies, as well as pro-bono consulting experience in Asia, Africa, and Europe. She holds a double Masters in Business Management & Public Policy from HEC Paris and Freie Berlin University.

**Punit Gupta** currently serves as the Country Director at TechnoServe India, where he provides strategic program design guidance. He has more than 20 years of experience in leadership roles in the development and private sectors in India, Europe, and the US. During his 9+ years at TechnoServe, Punit has provided design and implementation leadership to high-value programs aimed at transforming the lives of over 100,000 farmers, entrepreneurs, and youth. Punit has an MBA from INSEAD, France.

# Content

# Executive Summary

## Project Set-up

The Artificial Intelligence for Agriculture Innovation (AI4AI) initiative was launched in August 2020 by the World Economic Forum and the Government of Telangana with the goal of leveraging emerging technologies to transform the agricultural landscape, making agriculture profitable and sustainable for farmers. The AI4AI initiative constituted four Working Groups to discuss technology-based solutions to a range of challenges in the agricultural ecosystem. This report was created by TechnoServe India, with the participation of the organisations from the 'Farmgate to Fork' Working Group.

## Overview of the Indian Agriculture Sector

Agriculture is a critical pillar of the Indian economy, engaging 43% of the national workforce. However, smallholder farmers[1], who account for 86% of all farmers in India, are still some of the poorest people in the country, earning only 39% of what medium holders earn, and only 13% of what large holders earn.

Across states, agriculture is a significant economic driver, contributing to 10-20% of the State Gross Domestic Product, although the larger states contribute a disproportionate amount to the sector value. A closer look at agricultural value by sub-sector reveals that crops are the primary value drivers in the agriculture and allied activities sector, contributing to over 50% of sector value. Among crops, cereals, vegetables, fruits and plantation crops account for 74% of crop value and cover 70% of the country's cultivation area.

The COVID-19 crisis has exposed underlying structural weaknesses in agricultural value chains. Agricultural value is projected to decline by ~4.4 trillion INR in total between 2020 and 2022 (representing an annual decrease of 10-15%). The greatest decrease in agricultural value is likely to be driven by fruits and vegetables, which are expected to see an annual value decline of 24-36%. However, the rapid vaccine rollout is expected to lead to a faster recovery of the Indian economy, which would also accelerate agricultural sector recovery. According to the latest Economic Survey in January 2021, the government estimates a 3.4% growth of the Gross Value Added (GVA) of agriculture and allied sectors. Nevertheless, it remains unclear whether this will translate to improved farmer incomes.

## Key Challenges and Opportunities in the "Farmgate to Fork" (F2F) Space

Traditionally, smallholder farmers capture a small portion of the monetary value of the agricultural commodities versus the market value that they contribute. This is mainly due to low visibility of demand, exploitative intermediation, limited quality assurance, limited access to efficient and low-cost logistics, and low bargaining power.

To improve farmer incomes, it is necessary to improve their value capture and to drive overall value creation Direct matching between farmers and buyers, transparent quality assessment, cost-efficient and timely transportation, and aggregation of small-volume produce can be critical levers to achieve this.

Emerging technologies can be effectively used to drive the above levers at a large scale. Technology offers the potential to develop and iterate solutions rapidly, create cost efficiencies, introduce transparency in information flows, and strengthen connectivity between value chain actors. A variety of technologies in farmer-buyer matching, quality assessment, transportation and small-volume aggregation have emerged in India to drive the above value levers. India is also in a strong position to take these technologies to scale given its high technology readiness and rapidly evolving agricultural technology landscape comprising of innovators, investors and applications.

Recognising this opportunity, the Government of India has taken early steps towards developing these technologies for the agricultural ecosystem. Their efforts include the eNAM portal supported by National Government, Artificial Intelligence (AI) and Machine Learning (ML)-based price forecasting applications backed by the Government of Karnataka, and an 'Agri-tech Data Hub' being developed by the Government of Telangana.

Recent policies and regulations in the country are also supportive of high-potential technologies and can make an important impact in transforming F2F.

## Mature State Projection of Integrated Technology Solutions

To develop technology-based solutions for F2F, we undertook a four-stage process of 1) developing model value chains, 2) identifying technology solutions with high potential, 3) identifying challenges across model value chains, developing integrated solutions to address these challenges, and gauging their capabilities at mature state, and 4) synthesizing solutions and quantifying their ecosystem impact.

We identified five types of technology solutions that can create value in F2F space: B2B Buyer-Supplier Matching Platforms, Farmer Aggregation solutions, Mandi Automation solutions, Hyperlocal Connect solutions, and Online Retail solutions. Among the five solutions, Business-to-Business (B2B) Buyer-Supplier Matching and Mandi Automation are expected to be the Game Changers, driving the majority of value creation.

- B2B Buyer-Supplier Matching platforms would facilitate linkages between aggregators and institutional buyers and processers. These platforms would service a wide range of crops and provide exhaustive information on the quality, quantity and price of produce to facilitate buyer-supplier matching. While different B2B platforms already exist in the market (e.g., NCDEX, NeML, AgriBazaar, and Ninjacart), they still have significant gaps in the functionalities they offer. At a mature state, a fully functional B2B platform could create an extra annual value of $19-24 billion, allowing farmers to capture most of this value.

- The Mandi Automation solution would digitalise the traditional retail channel, i.e., the Agricultural Produce Market Committees (APMCs), and would connect smallholder farmers to intermediaries and institutional buyers. While eNAM is a government-led technology initiative in Mandi Automation, it is facing multiple challenges in effective scaling. It presently handles less than 1% of commodity trading volumes and accounts for less than 0.1% of the total trading value in the APMC channel. To scale up, eNAM would need to on-board more farmers and buyers by extending more incentives, and by optimising functionalities. At a mature state, eNAM could potentially create an extra annual value of $18-22 billion.

- The Farmer Aggregation solution would facilitate the aggregation of produce from smallholder farmers. It would connect farmers with aggregators and institutional buyers and would provide key value-added services such as shared-load aggregation, logistics services, and rapid quality assessments. Existing farmer produce aggregation solutions are still limited in scope and scale, and would need to improve their functionalities to reach a higher scale.

- The Hyperlocal Connect solution would help farmers to sell their fresh produce directly to consumers. Key functionalities of the solution would include a user-friendly sell and purchase interface, an efficient delivery network, and quality assurance. Existing hyperlocal technology solutions are still at a nascent stage of development and functionalities are underdeveloped.

- The Online Retail solution would connect retailers and consumers. To deliver useful e-grocery options, the solution would provide user-friendly buying experiences to consumers, make a large variety of perishable and non-perishable products available for purchase, have an efficient and low-cost logistics network, have a robust quality assessment approach, provide traceability tools from farmgate, and offer high payment flexibility. Existing online retail solutions such as BigBasket and Grofers have demonstrated high maturity of functionality offerings, though still at a limited scale, and are positioned to scale up to reach more consumers.

At a mature stage, we expect that the five technology solutions would add significant value to the ecosystem, estimated at $62-76 billion on an annual basis. Farmers would be able to capture $34–42 billion (50-60%) of this value. It is expected that 75–91 million farmers would benefit from the value creation associated with these solutions, accounting for 35-43% of the farmers in India. With the extra value capture, income in crop cultivation among the farmers impacted would increase by 70-80%.

To accelerate the development of these solutions, immediate actions and collaboration from different actors are required. We anticipate that the five solutions will reach maturity over a 20-year horizon, with B2B Buyer-Supplier Matching Platforms, Mandi Automation solutions and Online Retail solutions reaching maturity sooner than Farmer Aggregation solutions and Hyperlocal Connect solutions.

- All five solutions would need functionality improvements to reach a large user base. Private and government players in B2B platforms would primarily need to expand their services to cover a larger range of crops and enter more geographies in the country to effectively scale. On the other hand, government support will be critical for solutions in Mandi Automation, Farmer Aggregation and Hyperlocal Connect to gain higher traction among farmers, intermediaries and buyers.
- Continuous commitment from different actors would be important to realise this 20-year vision. Key driving actors including technology companies, agri-businesses, ag-tech start-ups, the Central and State governments, development sector donors, and social organisations, would need to offer substantial and long-term resources and support to drive the transformation of F2F in the agricultural ecosystem.

# Project Setup

## Overview of the AI4AI Initiative

The Artificial Intelligence for Agricultural Innovation (AI4AI) is a multi-stakeholder initiative jointly launched by the World Economic Forum's Centre for the Fourth Industrial Revolution India and the Government of Telangana, with the goal of transforming the agricultural landscape and making agriculture profitable and sustainable for farmers through technology innovation. Since its launch in August 2020, the initiative has convened more than 100 stakeholders representing the government, technology industry, food industry, and other key sectors to identify and pilot emerging technologies such as Artificial Intelligence (AI), blockchain, drones and Internet of Things (IoT) to solve pressing challenges in agriculture.

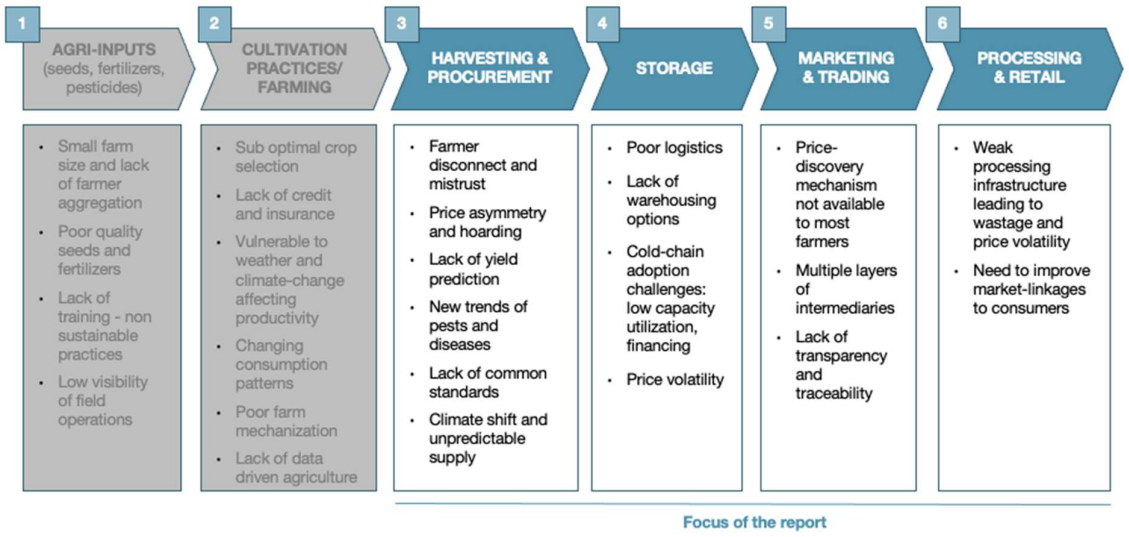
## Background of the Report

The AI4AI initiative constituted four Working Groups to discuss technology-based solutions:

- **Intelligent Crop Planning,** including solutions in price forecasting, weather forecasting, input planning, etc.
- **Smart Farming,** including solutions in crop health monitoring, monsoon prediction, disease/pest recognition, crop performance, harvest prediction, crop health, crop yield prediction, etc.
- **Farm ate to Fork,** including solutions in logistics, warehousing, quality assaying, crop insurance, commodity trading, certifications, etc.
- **Data-driven agriculture,** including solutions in soil health, satellite imagery, weather, land records, imports and exports, real time *mandi* data, etc., and public private partnerships for the same.

TechnoServe led the discussions in the Farmgate to Fork (F2F) Working Group, and explored technology-based solutions to address challenges in harvesting and procurement, storage, marketing and trading, and processing and retail.

*Figure 1: Key Issues Farmgate to Fork part of the value chain*




The following organisations participated in the F2F Working Group discussions:

- **Technology companies:** Amazon Web Services, IBM, Mastercard, Microsoft, SAP, Vodafone Idea
- **Ag-tech startups**: AgNext, Digital Green, Ecozen, MyCrop Technologies, Nurture.Farm, SourceTrace, Statwig
- **Food processing and retail companies**: Cargill, Indus Fresh, 3F Oil Palm, Reliance Retail
- **Government:** Department of Agriculture of the Government of Telangana; Department of Information Technology, Electronics and Communications
- **Academia:** Professor Jayashankar, Telangana State Agricultural University

This report was created by TechnoServe India, with contributions from participants in the Farmgate to Fork Working Group.

## Structure of the Report

We used a three-phased approach to develop this report:

**Identify pain points**: Based on inputs from industry experts, we identified the activities influencing the value of different crops at each point of the value chain. We then determined pain points for various actors participating in the value chain, and identified lost opportunities for value creation and farmer value capture.

**Determine value drivers:** We then determined opportunities for value creation in agricultural value chains, with a focus on F2F-related solutions. We also explored high-potential technology interventions that could drive value creation, and assessed their techno-commercial viability and potential for impact.

**Recommended interventions:** After identifying pain points and determining value drivers, we defined solutions catering to the unique needs of different types of value chains. Key capabilities, prospective partnerships, and important enablers for scale-up were identified. Individual solutions for value chains were synthesised, and integrated ecosystem solutions were developed as a result. Finally, we quantified the potential impact of these solutions over a 5-year, 10-year, 15-year, and 20-year horizon.

# Overview of the Indian Agricultural Sector

## Key highlights

Agriculture is a critical pillar of the Indian economy. Employing 43% of the country's workforce, it boasts globally-competitive production levels for various staple and commercial commodities. Across most states of the country, the sector contributes anywhere from 10-20% of the Gross State Domestic Product (GSDP). Within the agriculture sector, crops contribute 58% of the sector value, with cereals, vegetables, fruits and plantation crops accounting for 74% of crop value and 69% of cultivation area. It also bears noting that more than 70% of the cultivation area is occupied by lower value crops such as cereals, oilseeds, fibres, etc.

*Figure 2: GSDP from agriculture 2016-17 in INR '000 Crores*[2]

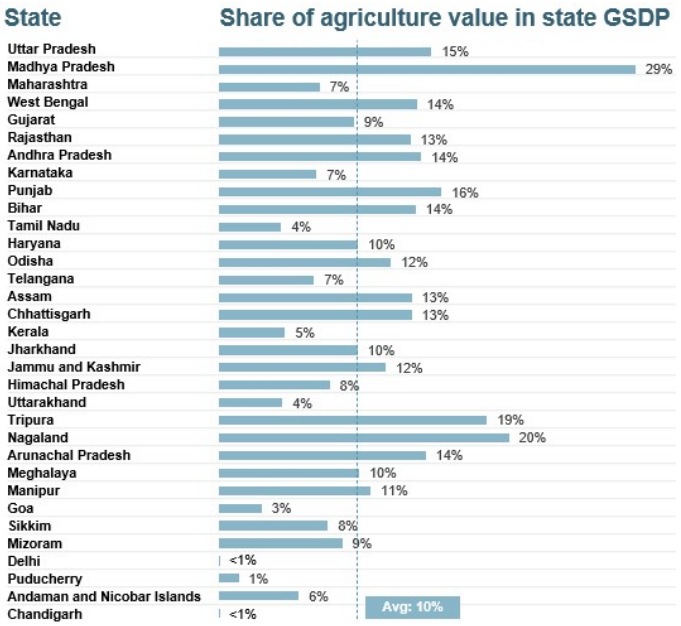
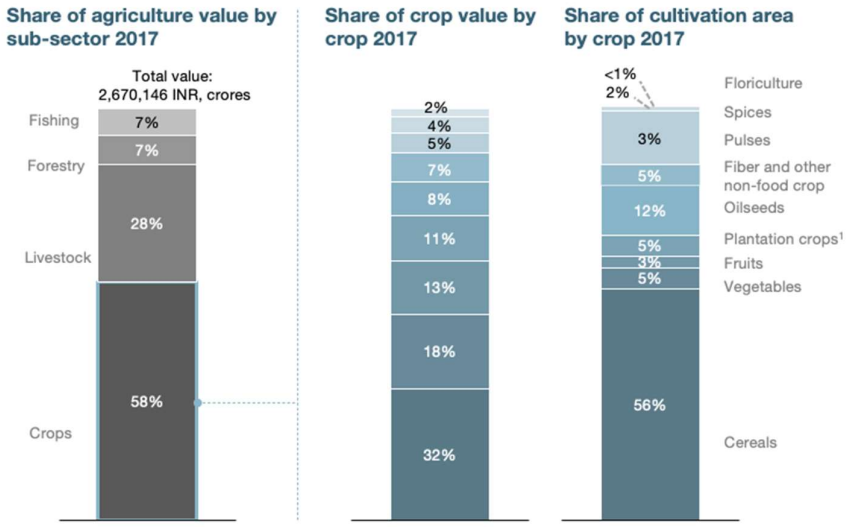



*Figure 3: Share of Sub-Sectors in Agriculture Sector Value*[3]




However, farmers constitute one of the poorest sections of Indian society, and have remained impoverished due to their inability to obtain commensurate returns from agriculture. Economic challenges are most acute for

smallholder farmers, who form 86% of the Indian agrarian population, but earn only 39% of what medium holders earn, and only 13% of what large holders earn.[4]

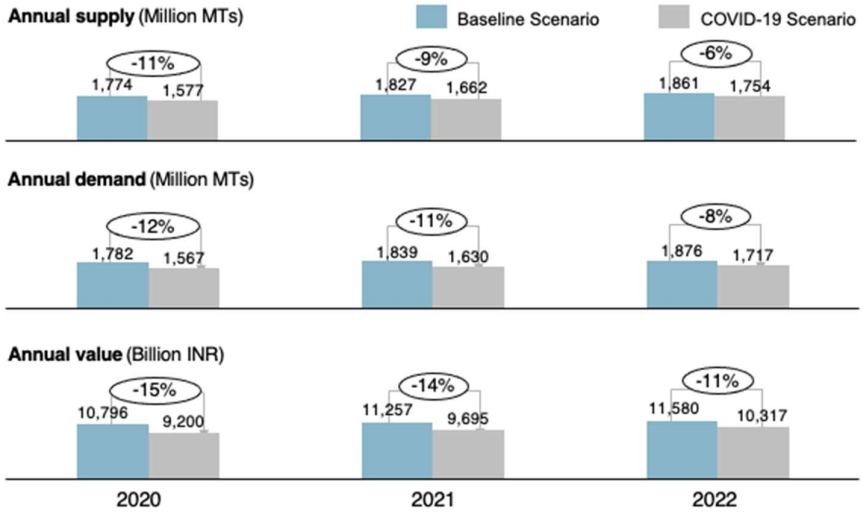
## Vulnerabilities due to COVID-19

The COVID-19 crisis has exposed several structural vulnerabilities in the agriculture sector. According to a forecasting analysis conducted by TechnoServe India in June 2020, the Indian agricultural sector is likely to see a decline in value of around INR 4.4 trillion, with the bulk of value decline in 2020 (INR 1.6 trillion) and 2021 (1.6 trillion), and a smaller decline in 2022 (INR 1.3 trillion). The decline in agricultural value is expected to be driven primarily by:

- A decrease in supply by around 470 million MT from 2020-2022 (an 11% decline in 2020, 9% in 2021, and 6% in 2022) due to supply chain disruptions among crops that are perishable, have weaker supply chains, and are more vulnerable to negative supply shocks and to farm labor unavailability.
- A decrease in farmgate prices for a subset of crops due to changing supply and demand dynamics.

Farmer income is also expected to take a hit as demand for agricultural crops is projected to decline by ~580 million MT, with a decline of ~12% in 2020, ~11% in 2021, and ~8% in 2022. The general economic slowdown, as a result of the pandemic, is expected to place additional stress on farmer economics and potentially lower farmer household incomes by an average of ~33%, with a 31% decrease of income in crop cultivation (the main income source for farmers) and a 35% decrease in daily wages and allied sector wages ( other important sources of income for farmers).

*Figure 4: Estimated Indian agriculture value[5] from 2020 to 2022 under a U-shaped[6] domestic recovery scenario[7]*




It is expected that the greatest decrease in agricultural value will be driven by fruits and vegetables, followed by plantation crops. However, because floriculture comprises a small percentage of total agricultural value (~2%), the greatest value decrease in dollar terms (INR, millions) is expected to be in vegetables, fruits, and plantation crops, which make up close to 50% of total agricultural value.

*Figure 5: Crop segment-wise Indian agriculture value from 2020 to 2022 under a U-shaped domestic recovery scenario[8,9]*

Projection completed in June 2020

Positive | Negative - Low | Negative - Medium | Negative - High

| | Projected change in value (%) | | | Projected change in value (million INR) | | |
|---|---|---|---|---|---|---|
| | 2020 | 2021 | 2022 | 2020 | 2021 | 2022 |
| Cereals and millets | 0.9% | 0.7% | 0.5% | 29,337 | 25,380 | 4,193 |
| Oilseeds | -6.3% | -3.0% | -1.4% | -54,305 | -25,154 | -2,853 |
| Pulses | 0.6% | 0.7% | 0.5% | 3,147 | 3,764 | 755 |
| Fiber and other non-food crops | 0.9% | 0.7% | 0.5% | 373 | 309 | 49 |
| Fruits | -35.7% | -31.8% | -23.9% | -600,373 | -551,545 | -105,525 |
| Vegetables | -31.9% | -31.3% | -24.6% | -605,730 | -625,258 | -127,436 |
| Spices | -11.6% | -12.3% | -10.4% | -55,481 | -68,648 | -16,005 |
| Plantation crops | -12.8% | -12.1% | -9.4% | -214,661 | -208,643 | -41,005 |
| Floriculture | -44.7% | -39.2% | -33.1% | -98,231 | -112,307 | -27,916 |

However, the rapid vaccine rollout is expected to lead to a faster recovery of the Indian economy, which would accelerate agricultural sector recovery. According to the results of the 2021 Economic Survey released by the government, there is a higher possibility of a V-shaped recovery scenario than a U-shaped one. It is estimated that the Indian economy will bounce back to a record 11% growth in 2021-22 after an estimated 8% contraction in 2021. The Survey also presented that the Indian agricultural sector has shown more resilience than expected amid the adversities of COVID-19. The Economic Survey has reported a 3.4% growth of the Gross Value Added (GVA) of the agriculture and allied sector.[10]

Nevertheless, it remains unclear whether agricultural sector growth will translate to improved farmer incomes. Studies released at the time of writing this report have, in fact, validated our hypothesis that farmer livelihoods have been adversely affected by supply chain and market disruptions due to COVID-19. According to the COVID-19 Livelihoods Survey, conducted by the Centre for Sustainable Employment at Azim Premji University, nearly 50% of the farmers surveyed for the study earned less than half of what they expected in 2020, and 89% of farmers reported that they were unable to sell their produce at full prices.[11]

# Key Challenges and Opportunities in the "Farmgate to Fork" Space

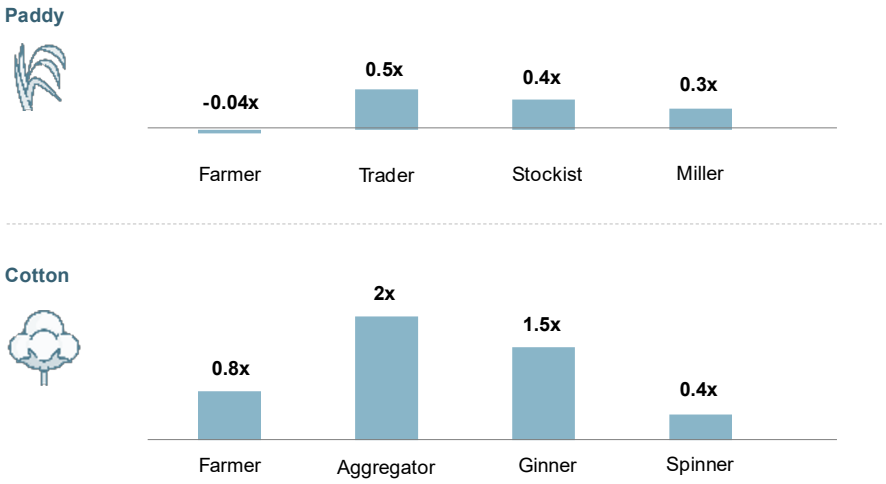
## Common Challenges Faced by Farmers

To ensure sustainable growth of the agriculture sector in India, the incomes of farmers, especially smallholder farmers, must increase substantially. Currently, farmers face multiple challenges in realising remunerative returns from agriculture:

- **Low visibility of demand:** Farmers have poor visibility of demand dynamics, and often produce either in excess or in deficit of market demand. Large quantities of produce often get wasted during supply gluts, because they remain unsold at the farmers' end for a long time. Similarly, farmers often are unable to capitalise on demand surges in agricultural markets, since there are no mechanisms to communicate about upcoming/growing demand centres to them.
- **Exploitative intermediation:** Supply chains are often heavily intermediated, and intermediaries enjoy a disproportionately high value capture at the cost of farmers. Further, intermediation often results in the loss of critical information on quality desired, pricing, time of demand, etc., which, if made available, would critically help farmers plan their production, harvesting and selling decisions.
- **Limited quality assurance:** Farmers know little about the quality requirements of buyers, and often supply produce of the wrong quality to them. Without assurance of appropriate quality, and without mechanisms to remunerate farmers based on quality, buyers often pay farmers less than their produce is worth. **Limited access to efficient and low-cost logistics:** Farmers do not have access to a robust logistics service for transporting their small volumes of produce because an efficient and functional logistics network for small volume aggregation is generally unavailable. Even where available, such a service is prohibitively expensive for most farmers. As a result, buyers are wary of procuring from farmers due to doubts about on-time delivery and quality.
- **Low bargaining power:** An overwhelming majority of farmers in India are smallholders and produce in small quantities. They are unable to attract institutional buyers, and have few opportunities to negotiate with local intermediaries for better pricing and terms of trade.

A closer look at the value realised by farmers in staple and commercial agricultural value chains confirms this hypothesis. For example, our analysis of the paddy value chain – a staple commodity – in Bihar revealed that an average rice farming household operated at a loss due to disproportionately small value capture, upon accounting for the opportunity cost of family labour. This was significantly lower than the value capture enjoyed by millers, stockists, and traders, who saw a value capture 0.3, 0.4 and 0.5 times the value they added to the final product respectively. Similarly, in the case of the cotton value chain – a commercial crop – in Maharashtra, an average farmer saw a value capture 0.8 times the value added to the final product, again less than half of that enjoyed by the aggregator and ginner.

*Figure 6: Value captured versus value-added by actor in Paddy and Cotton value chains*[12]




Essentially, farmers in India need two types of support to earn higher incomes from agriculture: driving value creation and improving value capture:

- **Driving value creation** means creating value for all players in the value chain, including farmers. Value creation necessitates market system-wide interventions. When markets are designed to transmit information on supply and demand, farmers can align their production directly with buyer demands and access the best trade terms for their produce. Such transparent markets create value by shortening supply chains and minimising wastage of produce.
- **Improving value capture** means increasing absolute value realisation and "return on investment". When supported to participate in transparent markets, when connected with other smallholder farmers to increase bargain power, and when connected with buyers that have confidence in their quality of goods, farmers can realise higher value for their produce.

At present, value creation is impeded by a larger demand-supply gap that persists in agricultural value chains. Since buyers have little visibility into production centres and cannot communicate their demands, and since farmers have little visibility into demand centres and cannot adjust their supply to meet demand, a demand-supply gap is created and value is lost. In addition, the current fragmented and dysfunctional logistics network for small volume product transportation also results in value loss. On the other hand, value capture for farmers is impeded by heavy intermediation and small bargaining power of farmers. When there are multiple intermediaries in value chains, value is often captured by middle men between buyers and farmers and information on the quality and quantity demands of buyers is obscured.[13] Also, farmers with small volume of produce usually have difficulties in realizing high value of produce because of limited bargaining power. Moreover, without transparent quality-based pricing systems, farmers that produce high-quality goods capture limited value.

Therefore, this report will recommend interventions in F2F that can create larger value for all players and enable higher value capture by farmers. Recommended interventions will address the above stated challenges in agricultural value chains that inhibit value creation and value capture.

## Levers for value creation and value capture

We believe that the following four levers in F2F can help value flow back to the farmers:

Value levers and impact estimation

| # | Lever | Impact | |
|---|---|---|---|
| | | Value creation | Value capture |
| 1 | **Direct matching between farmers and buyers:**<br>• Provide farmers direct access to both intermediaries and institutional buyers for direct sale of produce<br>• Offer information on quality-linked pricing in national market<br>• Provide market demand and price forecasts to support crop planning and sales |  |  |
| 2 | **Transparent quality assessment process**:<br>• Institutionalise a standardised and efficient methodology for quality assessment<br>• Develop an easy-to-use, low-cost grading system that can be used by buyers or farmers to rapidly assess quality and sort produce |  |  |
| 3 | **Efficiency and quality of transportation**:<br>• Improve transport connectivity from farm to collection centres<br>• Optimise transit planning and set up advanced temperature-controlled transportation systems to transport crops to buyers soon after harvest, and preserve quality during the process |  |  |
| 4 | **Aggregation of small-volume produce**:<br>• Provide services for small-volume aggregation of produce from farmers and provide them with solutions for last-mile delivery |  |  |

 Low impact  High impact

## The Role of Technology in F2F

Technology presents promising solutions to drive the above levers at a large scale. It offers the following benefits over existing solutions:[14]

- **Rapid design-testing-deployment of solutions:** The rapid technology innovation cycle, driven by decentralisation and incentives from industries, accelerates the application of technology to address complex challenges and realise value.
- **Lower costs of deployment:** Digital applications have the potential to offer low-cost access to information and services for Base of Pyramid (BOP) players such as farmers.
- **Information transparency:** Technology has the potential to make large volumes of information freely available for all market actors. BOP players stand to gain from this access to information on agricultural demand, geographies of demand, etc.
- **Connectivity of value chain workflows:** Tech solutions such as digital platforms and IoT can enhance connectivity between value chain activities and workflows to improve value chain efficiency.

## The Indian Ag-Tech Landscape

In the recent years, India has seen the emergence of technology-based solutions to address F2F value levers, some even demonstrating proof of concept. India has the second highest number of agricultural technology start-ups in the world, with 450 start-ups in agriculture, and 3,116 registered start-ups in food and agriculture combined. Funding in this sector is abundant too: 90+ institutional investors and 10 agricultural technology investors are known to be actively investing in ag-tech solutions in the country. The table below summarises some of the emerging innovations in India today.[15]

Overview of emerging agri-technology application in India[16]

| Value lever | Technology applications | Examples |
|---|---|---|
| Direct matching between farmers and buyers | • Digital marketplaces connect farmers, FPO, traders and organised buyers, and enhance price transparency as well as market information exchange. | eNAM, NeML NCDEX Group Company |
| Transparent quality assessment process | • Tech-based quality assessment tools assess physical and chemical quality of produce rapidly and introduce quality transparency and quality-linked incentives. | AGNEXT, INTELLO LABS |
| Efficiency and quality of transportation | • Sensors in logistics and warehousing space support regulation of temperature, moisture and pest attack.<br>• AI and machine learning-based algorithms support the design of optimised routes in smart networks. | ecozen, AeZ godaam |
| Aggregation of small-volume produce | • Digital marketplaces targeting smallholder farmers, and supply chain companies sourcing directly from farmers, support efficient aggregation of produce. | mastercard, Loop |

India is also strongly positioned to take these technologies to scale, primarily due to the following factors:[17]

- **High internet penetration:** With over 560 million internet users (~50% of Indian population), India is the second largest online market in the world and has around 12% of global internet users, half of whom are from rural areas. India also has a high possession ratio of smartphones – smartphone users in India surpassed 500 million in 2020, with as much as 40% of the user base from rural India. Further, India has the cheapest average 4G rate at $0.26 per 1Gb, and has a 4G penetration of 88%.

- **High adoption of technology applications:** The Indian AI market was valued at $6.4Bn in 2019, which is close to 16% of the global AI market. Following the COVID-19 pandemic, India recorded an increase in AI adoption at 45% across different sectors and even eclipsed a few AI leaders like USA (35%), UK (23%) and Japan (28%) with respect to AI adoption in 2020. In 2019-20, the share of digital transactions in the total volume of non-cash retail payments (which forms about 28% of total transactions) also increased to as high as 97%, indicating the at-scale adoption of digital technologies.

- **Increasing participation of organised players:** Organised players in the country are also increasingly active in large-scale technology implementation programs to improve F2F operations in agriculture. Multi-National Companies (MNCs) such as Reliance Industries are foraying into the growing agriculture technology business by deploying technology tools for marketplace coordination, traceability, etc., as part of their move to strengthen their market operations.

Recognising this opportunity, the Government of India has also taken up initiatives in digitising F2F in the agricultural ecosystem. Key initiatives have included:[18]

- **National Agricultural Markets (eNAM):** This is a pan-India electronic trading portal, which networks the existing APMC mandis to create a unified national market for agricultural commodities. It is supported by the Government of India to integrate APMCs across the country through a common online market platform, which facilitates commodity trading and provides better price discovery. As of March 2021, it connected 1,000 markets in 18 states and 3 Union Territories.

- **Price forecasting application by the Government of Karnataka:** In 2019, the Government of Karnataka partnered with IBM to develop a price forecasting application for tomato crop in the state using IBM's Watson Decision Platform for Agriculture. Earlier in 2017, the state government also partnered with

Microsoft to develop an agricultural commodity price forecasting model for *tur* crop based on historical sowing area, production, yield, weather datasets, and other related datasets.

- **Agricultural trading platform by the Government of Karnataka:** The Government of Karnataka also established the Rashtriya e Market Services Private Limited (ReMS) as a joint venture company with NCDEX e-Market Limited to enable price discovery for farmers and buyers, match centres of supply and demand, and facilitate online trading between them.

- **Agritech Data Hub by the Government of Telangana:** The Government of Telangana has started an initiative to develop an 'Agritech Data Hub' to help innovators build marketplace solutions and other tools. A large-scale data collection exercise has been undertaken to this end. A series of agri-tech innovation pilots in traceability, FPO-level supply chain management, and quality assessment have also been kick-started.

Recent policies announced by the Indian government are also supportive of technology-led interventions in F2F:

Select examples of recent government policy and initiative related to F2F[19]

| Policy/initiative | Details |
|---|---|
| The Farmers Produce Trade and Commerce (Promotion & Facilitation) Act, 2020 | It seeks to provide barrier-free trade of farmers' produce outside traditional markets (Agricultural Produce Marketing Committees, also called mandis) notified under the various state agricultural produce market laws. To promote e-commerce in agriculture, the new law also allows the setting up of an electronic platform for the sale and/or purchase of farm produce. The Act also has a provision to prescribe modalities for the registration of traders and trade transactions in trade areas. |
| The Farmers (Empowerment & Protection) Agreement on Price Assurance and Farm Services Act, 2020 | It provides a framework for farmers to engage in contract farming with sponsors prior to the production of any farm produce. The sponsor could be an individual, partnership firms, companies, etc. |
| Essential Commodities (Amendment) Act, 1955[20] | The Essential Commodities Act has been modified for agriculture and food stuffs, including cereals, pulses, potato, onion, edible oilseeds, and oils. The modification says that the Central government may regulate the supply of the above commodities only under extraordinary circumstances, which may include war, famine, extraordinary price rise, and natural calamities. The modification lays down a transparent criterion on imposing or regulating stock limit: it requires is a 100% increase in retail price of horticulture produce or a 50% increase in retail price of non-perishable agri-food stuffs over the prevailing price in the preceding 12 months or average price over the last five years, whichever is lower. |
| Pradhan Mantri Fasal Bima Yojana (Feb '16) | This scheme provides insurance coverage for all stages of the crop cycle, including post-harvest risks in specified instances, with low premium contribution by farmers. |
| Promotion of 10,000 FPOs by 2024 | Through the nationwide formation of Farmer Producer Organisations (FPOs), farmers will have better collective strength for improved access to quality input, technology, credit and for better marketing access through economies of scale, improving realisation of income. |

# Mature State Projection of Integrated Technology Solutions

Based on key challenges and opportunities identified in the F2F ecosystem, TechnoServe worked with different actors in the Working Group to explore pain points within value chains in further detail and develop high-impact solutions for the ecosystem.

## Four Steps of Approach to Solve the Problem

To develop recommendations that can drive maximum value creation and smallholder value capture, we took a four-step approach comprising the following activities:

1. Developing model value chains,
2. Identifying high-impact examples of technology solutions in F2F,
3. Identifying challenges and developing "mature state" integrated solutions to address challenges, and
4. Synthesising solutions and quantifying potential impact.

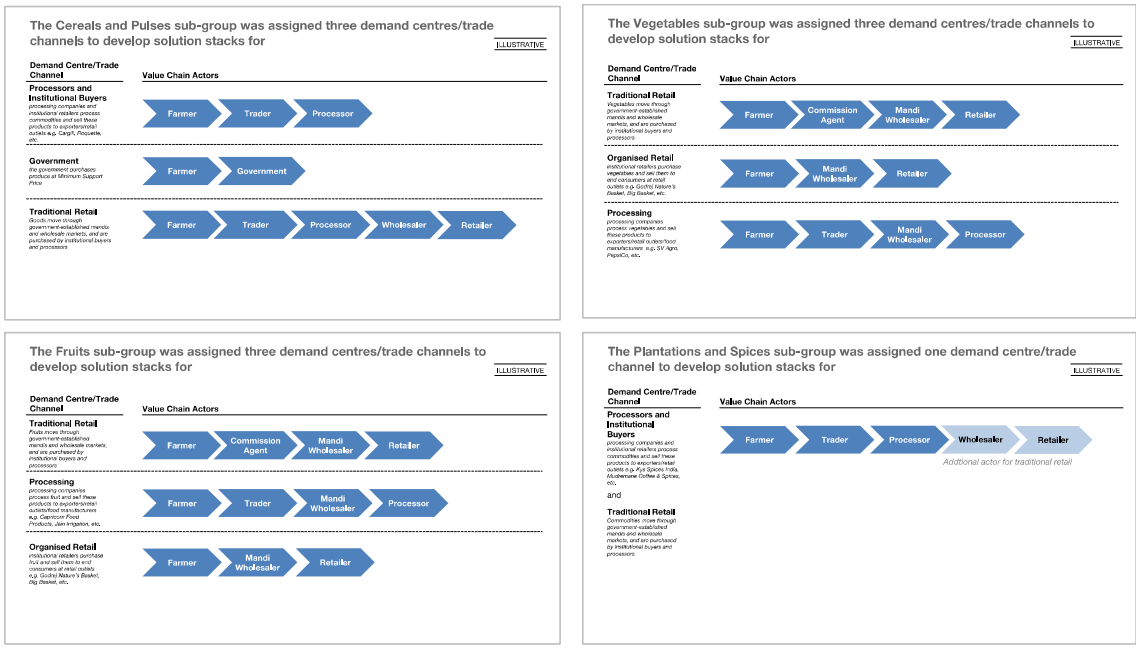
### Step 1: Developing model value chain

As a first step, we identified four broad crop segments for which F2F solutions need to be developed: cereals & pulses; fruits; vegetables; and plantations & spices. Per our understanding, each of these crop segments have unique and distinct producer and market characteristics, and therefore have different value chain dynamics.[21] Following this, we developed "model value chains" for each crop segment. Model value chains were designed to abstractly represent the value-add activities characteristic to different demand centres for each crop segment, and provide an illustrative concept of how crops move through different nodes in the value chain before reaching the final demand centre. Different crop segments have different demand centres, and by extension, different intermediating actors and interaction nodes.

Accordingly, we developed 10 model value chains representing the value chain activities of unique demand centre-crop segment combinations:

- Cereals & Pulses – We developed model value chains for three key demand centres: Institutional Retailers/Traders, Government, and Traditional Retailers
- Vegetables – We developed model value chains for three key demand centres: Institution Retailers/Traders, Value-added Processors, and Traditional Retailers
- Fruits – We developed model value chains for three key demand centres: Institution Retailers/Traders, Value-added Processors, and Traditional Retail
- Plantation & Spices – We developed a model value chain for one demand centre: Institution Retailers/ Traders / Traditional Retail

*Figure 7: 10 Model value chains for F2F analysis*

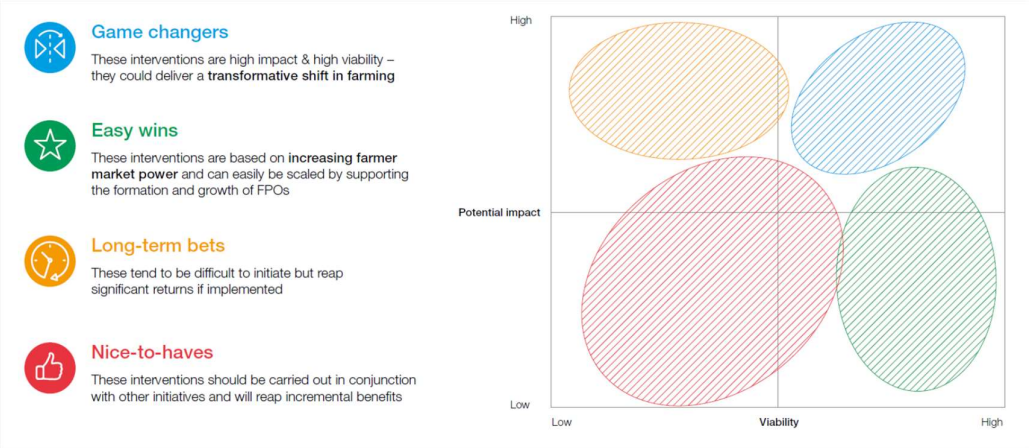



## Step 2 Identifying examples of technology solutions in F2F

To explore feasible and impactful technology solutions existing in the F2F space, we collected 20 examples of technology solutions that have been deployed in agricultural value chains so far and facilitated the Working Group to discuss their potential impact and viability. These examples of technology solutions in F2F were collected through rapid secondary research, and in some cases, were also provided by some participants in the Working Group. The technology solutions broadly fit into six categories: Quality Assessment, Logistics and Warehousing, Financial Services, Buyer-Supplier Matching, Traceability, and Market Risk mitigation.

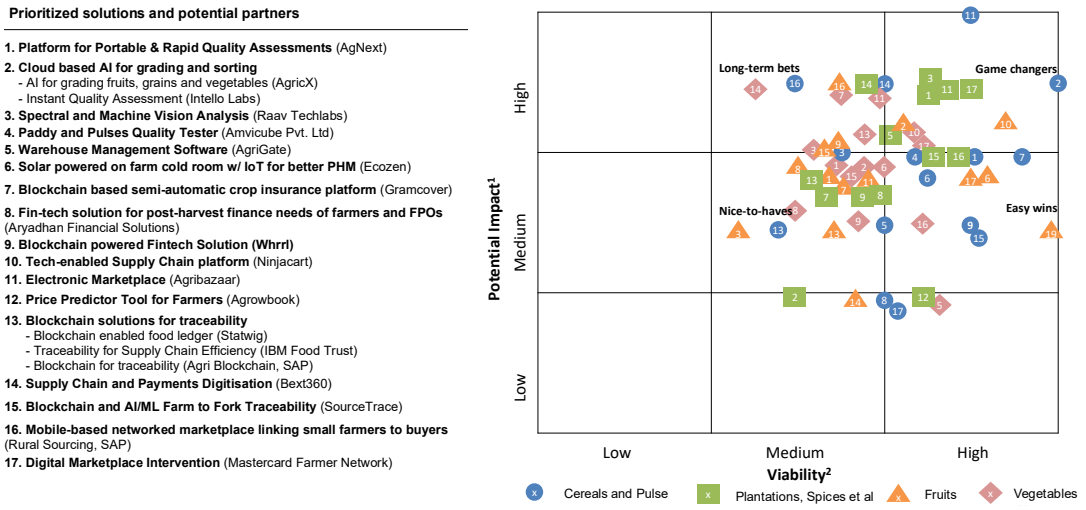
Each solution was assessed for its potential in impact and techno-commercial viability. Potential impact was evaluated by the number of farmers who stand to benefit from the solution and the potential increase in farmer incomes, while viability was assessed based on scalability, financial viability, regulatory viability, and technological complexity. Based on this assessment, solutions were classified as Game changers, Easy wins, Long-term bets and Nice-to-haves.

*Figure 8: Assessment matrix for impact and viability*




We identified six game changing interventions. The shortlisted solutions were considered for larger scale deployment in integrated technology solutions.

*Figure 9: Impact and viability analysis for emerging technological interventions*[22]

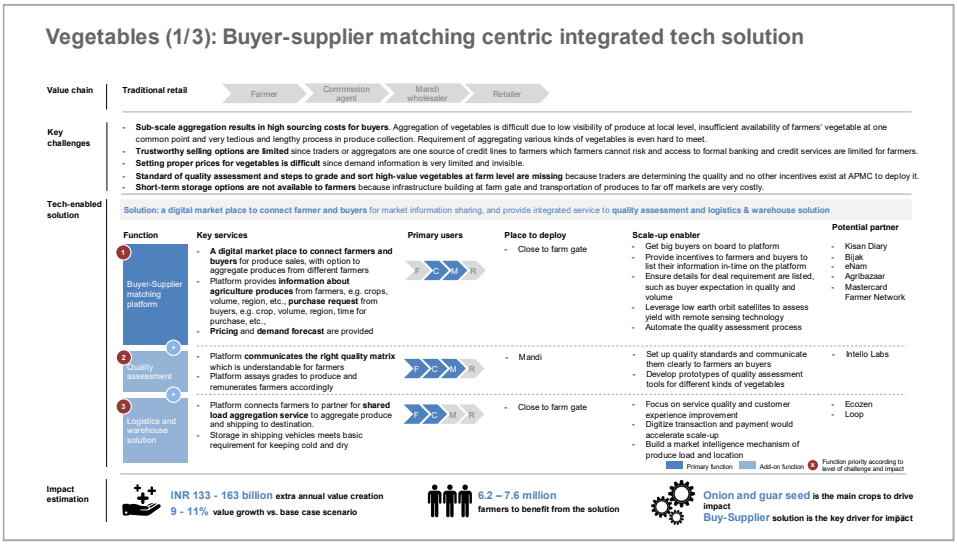



## Step 3 Identify challenges and develop integrated solutions to address challenges

To understand the challenges in each value chain in depth and develop tailored solutions, the pain points of farmers and buyers as well as the needs of each party were identified in each model value chain. For each model value chain, we developed technology-based solutions uniquely responding to the pain points of value chain players. We also specified key details such as the primary users, location for deployment, key scale-up enablers, and potential partners for each technology solution. Finally, we estimated the value creation and value capture that each solution could potentially facilitate, and estimated the number of farmers who would be impacted by the deployment of the solution.

Following this, we assessed how solutions for each model value chain would evolve after reaching maturity, i.e., over the 10 to 20-year horizon. Finally, for each model value chain, we arrived at "integrated technology solutions" that converged multiple individual solutions in their mature-state forms.

*Figure 10: Example of individual solution template for traditional retail demand centre for vegetable*



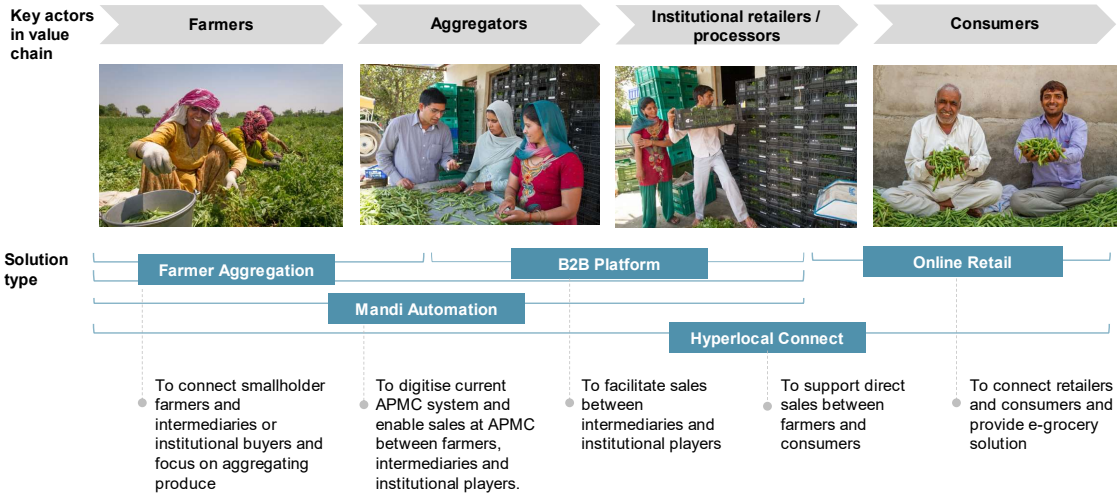

## Step 4 Synthesise solutions and quantify potential impact

By looking at common characteristics of individual solutions among value chains, and potential for evolution to a state of maturity, the solutions developed for model value chains were synthesised into a larger ecosystem solution that reflected their capabilities at mature state. In addition, existing ecosystem solutions were assessed to understand their state of maturity and recommend an action plan. Finally, potential value creation through each ecosystem solution was quantified to specify impact for entire ecosystem and value capture by farmers.

### Five technology solutions along the value chain

Through this exercise, we identified five types of technology solutions that we expect would meet the needs of the Farmgate to Fork ecosystem: The B2B platform, the Mandi Automation solution, the Farmer Aggregation solution, the Online Retail solution, and the Hyperlocal Connect solution.

*Figure 11: Five technology solutions along the value chain*




Each technology solution would primarily drive buyer-supplier matching, connecting different actors in agricultural value chains. Technology solutions would additionally provide other value-added service to sellers and buyers, including quality assessment, traceability, logistics and warehousing, and financial services. Importantly, we expect that each of the five solutions would need to be driven by different actors in the

ecosystem. While B2B platform and Online Retail solutions would primarily be driven by private sector players, the Mandi Automation solution, Farmer Aggregation solutions, and Hyperlocal Connect solutions would be driven by national and state governments.

*Figure 12: Overview of five technology solutions in function, key driving actors, and existing practices*

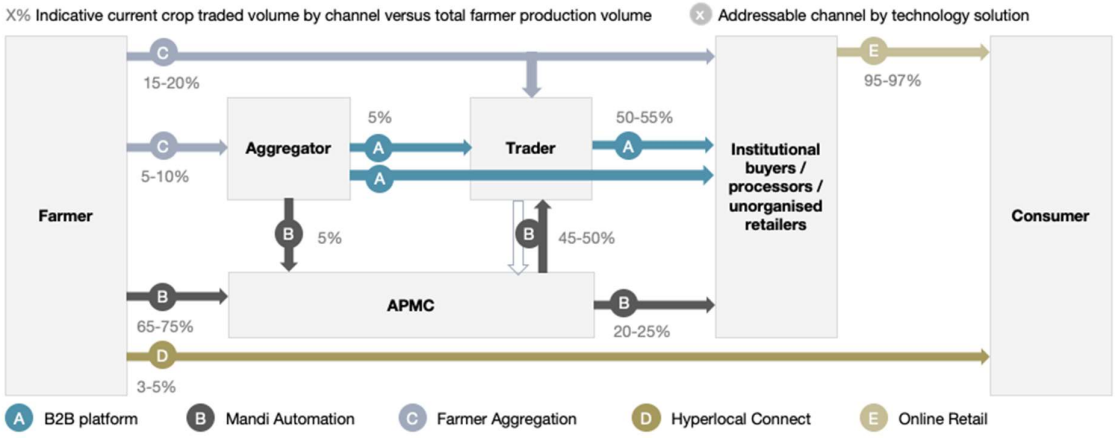
| Solution | B2B platform | Mandi Automation | Farmer Aggregation | Hyperlocal Connect | Online Retail |
|---|---|---|---|---|---|
| Key function | **Centric function:**<br>• Connect intermediaries and institutional players & processors[2]<br>• Provide up-to-date supply and demand information<br><br>**Key value-added functions**<br>• Quality assessment<br>• Traceability<br><br>**Other functions**<br>• Logistics and warehousing<br>• Financial services | **Centric function:**<br>• Digitise current APMC system, connecting smallholder farmers to intermediaries or institutional buyers and intermediaries to institutional buyers[2]<br><br>**Key value-added function**<br>• Logistics and warehousing<br>• Quality assessment<br><br>**Other function**<br>• Traceability<br>• Financial services | **Centric function:**<br>• Link smallholder farmers to intermediaries or institutional buyers[2] for produce aggregation<br><br>**Key value-added function**<br>• Logistics and warehousing<br>• Quality assessment<br><br>**Other function**<br>• Traceability<br>• Financial services | **Centric function:**<br>• Provide platform for consumers to purchase fruits and vegetables directly from farmers<br><br>**Key value-added function**<br>• Logistics and delivery<br>• Quality assessment and assurance<br><br>**Other function**<br>• Traceability<br>• Financial services | **Centric function:**<br>• Provide solution for consumers to purchase perishable and non-perishable food from retailer<br><br>**Key value-added function**<br>• Logistics and delivery<br>• Quality assessment and assurance<br><br>**Other function**<br>• Traceability<br>• Financial services |
| Key driving actor | Private sector players, e.g. institutional players, tech companies, etc. | National government led with private sector support | National government led with private sector support | State and local government led with private sector support | Private sector players led, e.g. institutional players, tech companies, etc. |
| Existing practices | NCDEX, NeML, agribazaar, ninjacart | eNAM | mastercard Loop | Kalgudi | bigbasket, GROFERS, JioMart, zopnow |

The five technology solutions would be able to address challenges in different channels along the value chain and capture part of the existing crop trading volume from the offline channel, while not replacing the existing offline trading channel.

Among the five solutions, the B2B Platform and Mandi Automation solutions have the highest potential to drive farmer value capture and create value. As estimated from market research and agriculture experts, the traditional retail channel, i.e., the APMC channel, presently markets 70-80% of the total marketable crop volumes produced by farmers[23]. Aggregators, traders and institutional buyers, processors, and unorganised retailers form the biggest demand centre for agriculture produce, and procure 55-60% of the total crop volumes produced by farmers. The B2B Platform and Mandi Automation solutions are expected to enable transparent buyer-supplier discovery between aggregators, traders, institutional buyers, processors and unorganised retailers, and facilitate improved market coordination across the traditional retail channel. Therefore, we expect that, together, the two solutions will handle the bulk of the agricultural trade in the country and will create the highest value in the agricultural ecosystem.

We expect that online retail solutions will also add value to the agricultural ecosystem by facilitating trade between retailers and consumers. However, offline retail will continue to dominate consumer retail in the near future, given that the vast majority of Indian consumers will continue to rely on brick-and-mortar retail outlets to purchase fresh and processed produce. Lastly, we expect that Farmer Aggregation solutions and Hyperlocal Connect solutions would contribute to improved value capture for farmers, but would handle smaller trade volumes in comparison to other solutions.

*Figure 13: Estimated current crop traded volume by channel and addressable channel by five technology solutions*[24]

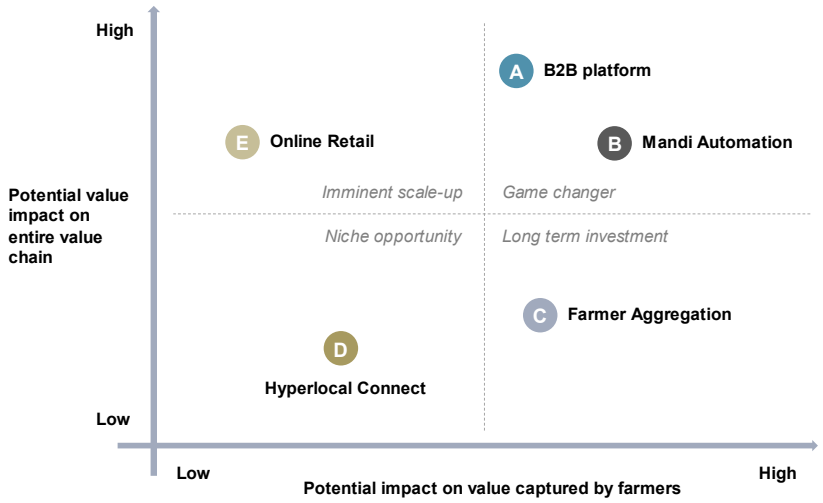



Among the 5 solutions, B2B platforms and the Mandi Automation solution are expected to be the Game Changers in the F2F ecosystem, with the potential to drive highest value for all market players.

B2B platforms and the Mandi automation solution are expected to generate the largest value for the entire value chain and direct a significant portion of this value to farmers. Importantly, we expect that the Mandi automation solution will add handle significant crop volumes and will unlock value capture for farmers (for up to 65%-75% of the volumes marketed by them). On the other hand, we expect that the B2B platform will create large-scale impact by facilitating trade between aggregators and institutional buyers and by improving market coordination and market information transparency. We expect that the benefits of improved market coordination will extend beyond institutional players, and will translate to improved value capture for farmers as well.

Online retail solutions will also create significant value, given the large volumes of produce traded between retailers and consumers. However, we expect that online retail solutions farmers would offer limited value capture for farmers, as they are too far removed from the retailer and consumer ends of the value chain. Rather, the Farmer Aggregation and Hyperlocal Connect solutions will direct larger value to farmers. Between the two solutions, Farmer Aggregation solutions would be more impactful since they would handle larger volumes (estimated at 20-30% of volume flows from farmers to aggregators or business buyers vs. 3-5% of volume flows from farmers directly to consumers). However, we expect that the impact on the entire value chain from these two solutions would be limited because they would handle smaller volumes compared to other solutions.

*Figure 14: Impact assessment matrix for the five technology solutions*[25]




## B2B platform

The B2B platform would connect intermediaries to institutional players and processors, and facilitate sales and relevant value-added services for all parties.

### Key functionality of B2B platform

The B2B platform would serve a wide range of perishable and non-perishable crops and provide exhaustive information about products on the platform, including crop variety, volume, time of harvest, quality, source of origin, etc. To support the presence of key information, quality assessment and traceability would be integrated as important value-add services. Quality assessment would set up standardised parameters and offer tech solutions to determine physical and chemical quality of produce, while traceability solutions would make the movement of produce from farmgate through supply chain transparent, providing easier access to the source information. In addition, logistics and warehousing would be offered to improve transportation efficiency, and tech solutions would be deployed in storage space to control quality. Last, but not the least, various payment and financing options would be provided for business players to support smoother transactions.

A detailed list of key functionalities of the platform, key enablers, as well as potential third-party tech partners is below.

#### Overview of key functionality, enabler and potential tech partners for B2B platform[26]

| Functional area | What functionalities it would provide | What are the key enablers | Potential third-party tech partner |
|---|---|---|---|
| **Buyer-Supplier matching** | • The platform would service a wide range of produce, including fresh produce and non-perishable produce.<br>• It would offer exhaustive information about produce, e.g., physical and chemical characteristics, source, etc.<br>• It would connect intermediaries and institutional buyers at the | • The platform could provide incentives in the initial development phase to traders to list their produce sales on the platform and also to provide their produce requirements.<br>• It could get big buyers from different regions on board to enable fast development of platform. | NA |

| | | | |
|---|---|---|---|
| | national level, to serve nation-wide demand and supply centres.<br><br>• It would provide quality and delivery assurance and hold all parties accountable.<br><br>• It would have feedback mechanisms to gather data on highly-rated and poorly-rated farmers/aggregators and buyers, and closely moderate platform interactions. | • It could ensure details for deal requirement are listed, such as buyer expectations of quality and volume.<br><br>• It could build a user-friendly front-end for sales and demand listing, and a powerful backend centred on big data analytics and management. | |
| **Quality assessment** | • It would be source location-based to allow information on the quality of produce to be available at the last mile.<br><br>• It would be cost-efficient to deploy.<br><br>• Technologies would be easy to deploy at scale, and have high usability, even for low-literacy users.<br><br>• Information on quality metrics and pricing would be transparent, both for farmers and buyers. | • It could institutionalise quality-linked price incentives and SOPs for quality assessment, aligned with Indian government's standards, especially for export produce.<br><br>• Rapid prototypes of quality assessment tools for different kinds of crops could be developed and tested.<br><br>• It could organise showcases of usage to raise awareness in sector. | • Amvicube<br>• Raav Techlabs<br>• AgNext<br>• Intello Labs |
| **Traceability** | • The solution would make information available on origin and movement of produce through low-cost technologies.<br><br>• The data made available through the solution would be interoperable, for value chain players to improve sourcing model, and for financial institutions and other players to develop financing solutions on the back of this data, etc. | • It could optimise information access through better packaging, such as attaching a barcode for consumer to scan and obtain source information. Thus, it would improve consumer willingness to pay for premium and encourage traceability integration in value chains.<br><br>• Efforts could be made in improving awareness of ethical production and supply chain transparency. | • SourceTrace<br>• Aspagteq<br>• TraceX<br>• IBM Food Trust |
| **Logistics and ware-housing** | • It would provide logistics and warehouse services with temperature and moisture regulation mechanisms for suppliers and buyers.<br><br>• It would be powered by an AI-based logistics optimization model for | • Utilisation of infrastructure could be increased to improve return from heavy capital investment and move to an OPEX model.<br><br>• It could leverage IoT solution such as sensor and digital devices to monitor environment | • Ecozen<br>• Superplum<br>• INI farms<br>• a2zgodaam.com<br>• Godaam Innovations |

| | | | |
|---|---|---|---|
| | improved shipment coordination and cost-effective transportation.<br><br>• It would be an open platform that allows warehouse owners to list their warehouses, and enables buyers and intermediaries to book storage spaces via the platform. | of produce, thus ensuring quality of produce and improving service. | |
| **Financial service** | • Various business digital payment options would be provided by the platform, including credit card, online bank transfer, UPI, digital wallets, and so on.<br><br>• Diverse financing options against receivables would be available based on the needs of different value chain players, e.g., advance payments for farmers, PO financing for aggregators, etc.<br><br>• Options to purchase different financial products, such as forward contracts, futures, etc., would be provided. | • Integration of various payment options to platform for business would be essential.<br><br>• Investment in strong IT infrastructure would streamline digital transaction and ensure transaction security.<br><br>• It could invest in developing various financing products to enable the delivery of diverse financial services via the platform.<br><br>• It could institutionalise smart contract solutions to ensure automatic payment management and reduce risks. | • Different credit card service providers, such as Mastercard, Visa, and so on<br>• Different e-wallet and UPI payment providers such as Google Pay, PhonePe, and so on |

### Examples of existing practices for B2B platforms

There are different existing offerings of B2B platforms in the market. Some examples include NCDEX, NeML, AgriBazaar and Ninjacart. Yet their functionality maturity is low to medium and could be further optimised.[27]

NCDEX is a leading player in commodity derivatives and offers services such as buyer-supplier matching, warehousing solutions with NCDEX-recognised warehouses and digital space reservation system, quality sampling and testing, financial services with derivatives and financing options with warehouse receipts. Nevertheless, it has potential to further enlarge its commodity portfolio, which currently covers only 20-25 crops, and could further improve its value-added service offerings. For example, tech solutions could be deployed to better regulate the storage environment and reduce moisture-regulation issues in warehouses. Moreover, transportation services could be integrated with the platform to support logistics coordination and warehousing solutions. Furthermore, quality testing requirements and services could be extended to all crops on the platform instead of only limited crops. Also, it would add value if traceability could be integrated with the platform, to satisfy buyers' and consumers' need in source tracing.[28]

NeML is another leading player among B2B platforms, which has pioneered initiatives like e-Pledge, e-marketing and provides an online trading platform for both non-perishable and perishable produce. In addition to the commodity spot exchange function, it also provides logistics services with a cold storage network and quality certification (for fresh produce). Moreover, the company supports financial inclusion by facilitating credit to smallholders against commodities stored in NeML and Bank approved warehouses, using its unique e-pledge mechanism. However, there is scope for NeML to further optimise its functionalities. It could potentially expand

its coverage of different crops beyond the current 20 types of non-perishable crops and 20 types of fresh produces. Its functionalities for non-perishable crops, in particular, could be further enhanced by providing quick technological quality assessment tools and smart logistics services. Traceability solutions could also be integrated to meet buyers' demand on produce source tracing.[29]

AgriBazaar is an online agri-marketplace with over 1 lakh users. It offers a trading portal of a wide spectrum of crops, covering more than 80 types of commodities. Besides, it offers services in logistics from sourcing locations to distribution centres. It provides a variety of logistics and warehousing solutions, including silo storage and temperature-controlled storage systems. For quality assessment, an AI-based commodity testing app has been developed to help sellers assess the quality of the produce, with the help of photographs of produce and analysis by R&D team. Moreover, AgriBazaar owns a payment platform, i.e. AgriPay, which enables digital payments, credits, and other financial services. The potential for improvement in its functionality lies mainly in its buyer-supplier matching model and traceability solutions. Given that AgriBazaar currently sourcing both from farmers and aggregators, it could improve its effectiveness by creating differentiated models for each sourcing segment. Furthermore, traceability solutions, which are currently unavailable on the platform, could be integrated to create better transparency of produce origin for buyers and end consumers.[30]

Ninjacart positions itself as a supply chain company for fresh produce and focuses on connecting producers directly with retailers, restaurants and service providers. It offers a powerful logistics network to guarantee fresh produce delivery from sourcing to business within 12 hours. Additionally, quality assessment is completed at the collection centres of Ninjacart. The platform has also launched a food traceability system called "FootPrint" to capture and help users trace end-to-end footprint of products. Moreover, it facilitates fast digital payments, which enables sellers to receive payments within 24 hours. Nevertheless, like AgriBazaar, Ninjacart has potential to further improve, by evaluating whether and how to source from farmers and aggregators at the same time, and by considering a different solution focus and operation model for different sourcing partners. For example, when sourcing directly from smallholder farmers, solutions to cover the last-mile-delivery from smallholder farmers to the Ninjacart collection centre would be important, instead of asking farmers to bring produce to appointed collection centres, which would be potentially costly for farmers and demotivate them. [31]

*Figure 15: Select examples of existing practices of B2B and functionality maturity assessment*

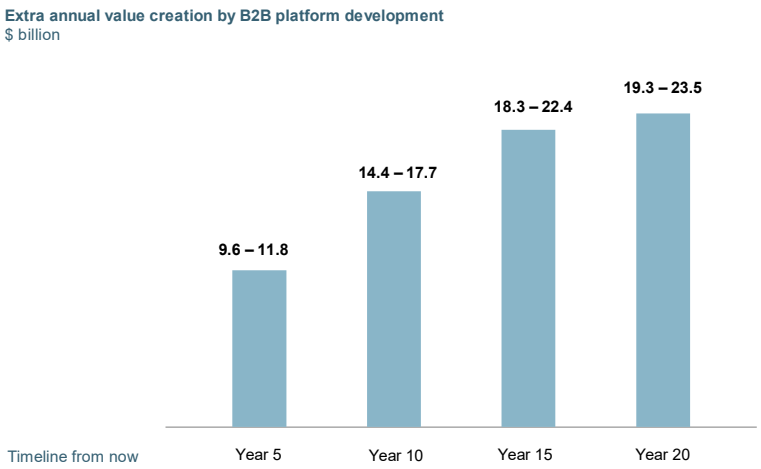
| Examples | Description | Assessment of functionality maturity |
|---|---|---|
| NCDEX | National Commodity & Derivatives Exchange Limited (NCDEX) is India's largest Agricultural commodity exchange. The platform has a broad based bouquet of permitted commodities aggregating to a total of 23, forming an important component of India's global trade. | Low |
| NeML | NCDEX e-Markets Limited (NeML), a subsidiary of NCDEX, has pioneered initiatives like Mandi Modernization Program (MMP), e-Pledge, and e-marketing. NeML provides online trading platform for both non-perishable and fresh produces. The company also helps in financial inclusion by facilitating credit to smallholders against commodities stored in NeML and bank approved warehouses using its e-pledge mechanism. | Low |
| agribazaar | AgriBazaar is an online agri-marketplace to connect farmers, traders, banks, enterprises and governments in India, with over 1lakh users and 33,000 listed auctions as of June 2020. It also provides services like warehousing, financing, crop advisory, etc. | Medium |
| ninjacart | Ninjacart is India's largest fresh produce supply chain company that connects producers of food directly with retailers, restaurants, and service providers using in-house applications that drive end to end operations. Their supply chain is equipped to move 1400 tonnes of perishables from farms to businesses, every day, in less than 12 hours. | Medium |

## Potential value creation of B2B platform

B2B platforms, with their full functionality, can create significant value, much of which can be retained by farmers. In a mature state (20 years from now), B2B platforms can be expected to create an additional value of $19 – 24 billion, with an estimated CAGR of around 5% from the fifth to the twentieth year. Value at the farmer's side would improve due to overall value chain growth and greater transparency of market information facilitated by the B2B platform. Along with being able to directly absorb the value through FPO or other aggregators,

farmers would also realise a higher income potential as a result of a higher market demand and greater transparency in information conveyed by intermediaries on produce variety, volume, etc. Combined with further levers to support farmers, especially Farmer Aggregation and Mandi Automation solutions, additional value created for farmers annually could be $34 –42 billion in 20 years.[32]

*Figure 16: Impact estimation for B2B platform development*




## Mandi Automation solution

The Mandi Automation would be a digital portal of the current APMC system, connecting smallholder farmers to intermediaries or institutional buyers/processors/unorganised retailers and traders to institutional buyers/processors/unorganised retailers.

### Key functionality of Mandi Automation solution

In addition to being a pan-India trading portal for a wide range of crops, the Mandi Automation solution would offer logistics and warehousing solutions to support produce storage and transportation between sellers and buyers, quality assessment of the physical and chemical characteristics of the produce, source tracing of the produce, and financial services for fast payment and financing.

### Existing practice of Mandi Automation solution - eNAM

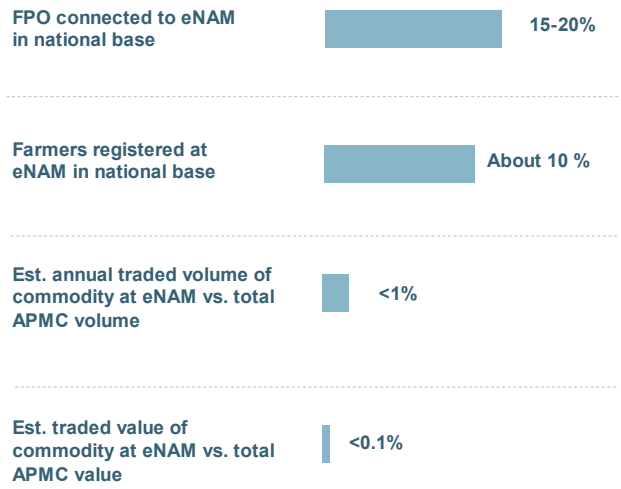
National Agriculture Market, also called eNAM, is a solution developed by the government for Mandi Automation

It is a pan-India electronic trading portal which networks the existing APMC mandis to create a unified national market for agricultural commodities. Farmers can opt to trade directly on their own through a mobile app or through registered commission agents. Traders and exporters can procure quality products in bulk, at a single place, and ensure transparent financial transactions. The platform covers trading of 175 commodities, including 26 types of cereals and food grains, 14 types of oilseeds, 31 types of fruits, 50 types of vegetables, 16 types of spices and 38 types of other crops. It is linked with 1,000 markets (APMCs) in 18 states and 3 union territories, with over 45 lakh farmer memberships as of March 2021. The implementation of eNAM is led by Small Farmers Agribusiness Consortium (SFAC) under the aegis of Ministry of Agriculture and Farmers' Welfare, Government of India. [33]

However, eNAM presently faces multiple challenges in evolving to the next stage, especially in trading volumes and value. eNAM is operating at a large scale, with 1,012 FPOs, 1.66 crore farmers, 1,31 lakh traders and 73,151 commission agents registered as of May 2020, according to the Ministry of Agriculture & Farmers' Welfare. However, traded volume and value are still below the expected scale. Regarding trading volume, in total 3.43 Crore MT commodities and 38.16 Lakh numbers (Bamboo & Coconut) have been traded on eNAM from 2016 to 2020 according to the reported data, with estimated average traded volume per year to be 0.8-1 Crore MT,

which is estimated to be less than 1% of the total traded volume in APMCs. In addition, around Rs. 1 lakh crore commodities have been traded on eNAM from 2016 to 2020 based on reported data, with estimated average traded value per year of Rs. 0.2-0.3 lakh crore. The scale is estimated to be less than 0.1% versus the total traded value in AMPCs. Moreover, it underlines the disproportionately low volume of high value crops traded via eNAM.[34]

*Figure 17: Analysis of eNAM performance*




To scale up to the next level, eNAM needs to get more farmers and buyers on board by improving its functionality and by delivering incentive support.

eNAM faces challenges to increasing its scale, and the number of farmers, traders and institutional buyers on board remains insufficient for the following reasons:

- **Farmers adopt the usage of eNAM slowly**
    - Farmers are unwilling to bear the high transportation cost of produce to APMCs.
    - Farmers in rural areas have difficulties adopting digital payment.
    - No clear price benefits are seen from selling through eNAM.
- **Traders and institutional buyers are resistant to switch to eNAM**
    - Traders and institutional buyers are resistant to adopt a digital channel.
    - Traders and institutional buyers prefer end-to-end responsibility to take care of produce in sales and transportation, to ensure quality.
    - Quality assaying at the APMC takes a long time and is not fully trusted due to subjective judgement.
    - It's difficult to complete cash payment in eNAM which is always preferred by farmers.
    - Institutional buyers prefer to procure from traders to improve efficiency. Foreign institutional buyers also tend to procure from traders to avoid the restriction of MSP.

To address these challenges, the functionality of eNAM needs to be further optimised, and stronger government support is needed to get more sellers and buyers on board:

- **Government support could be strengthened to increase enrolment**
    - The government could subsidise farmers to use eNAM for trading.
    - In-person skill and tool trainings could be provided to farmers to get them on board.
    - Digital payment adoption by farmers could be improved through government investment.

- Traders and buyers, especially big traders and buyers, could be incentivised to adopt usage of eNAM in procurement.
- Government could introduce initiatives and actions to support development of eNAM and its functionality, such as making the process of handling commodities in APMCs more standardised and transparent to ensure quality, and improving awareness about ethical production to encourage buyers to adopt traceability measures.

- **Functionality of eNAM needs optimisation**
  - Functional areas of buyer-supplier matching, logistics and warehousing, quality assessment, traceability and financial service could be improved to satisfy farmers' and buyers' needs.
  - Emerging technology solutions could be integrated to support functionality optimisation.

Regarding functionality optimisation, eNAM has the potential to upgrade its functionality with technological interventions to better serve the need of farmers, traders and institutional buyers:

Opportunity for improvements to eNAM[35]

Case analysis based on secondary research + Existing advantages ● Potential to improve

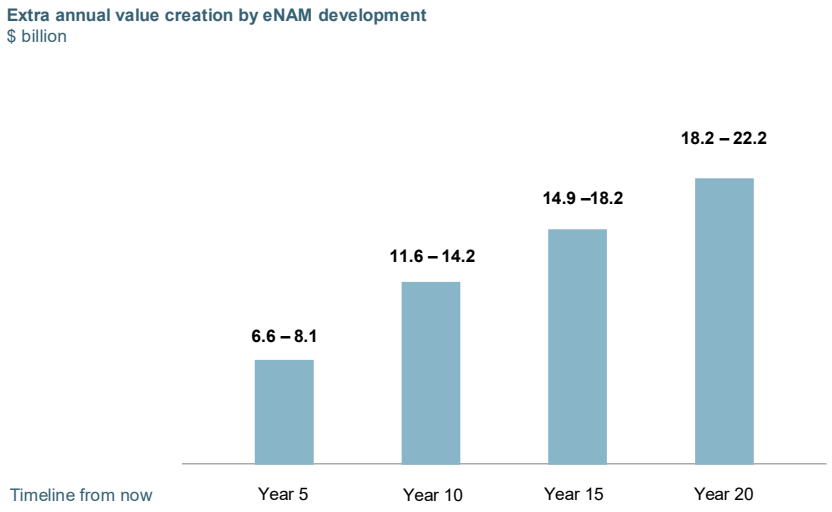
| Functional area | eNAM functionality today | Opportunities to improve |
|---|---|---|
| **Buyer-Supplier matching** | + Platform **connects farmers to traders or institutional buyers**, and also **traders to institutional buyers**<br>+ It allows suppliers to list their different **produce sales information on the platform**, including crop variety, volume, etc.<br>+ It offers **transparent trading prices** of crop in different APMC. | • Develop AI solution in platform to **automatically aggregate small volume produce sales for big traders and institutional buyers on their demand** to satisfy buyers' need and improve pricing for farmers.<br>• List complete **produce information on platform** to facilitate purchase requests from buyers, e.g. farm origin, detailed quality assessment, etc.<br>• **Provide AI-based demand** and **price forecasting.** |
| **Logistic & Ware-housing** | + Warehousing and logistics solutions are provided by APMC after commodities reach APMC.<br>● **Limited transportation solutions** are provided to farmers from farm to APMC. | • Provide **shared load aggregation service** to connect various smallholder farmers and transport their produce to APMCs, including frontend app for farmer request, backend route calculation and truck coordination system etc.<br>• **Invest in setting up logistics and storage facilities** to monitor temperature and moisture. |
| **Quality assessment** | + Quality assessment is **completed at APMC** based on the **physical characteristics** of the produce and **quality parameters are listed** on platform.<br>● Quality assaying can take **long time**. | • Offer **tech solutions of quality assessment for both physical and chemical characteristics**, e.g. image-based AI solution, infrared spectroscopy combined with machine vision analytics, to increase assessment speed and make assessment more objective. |
| **Traceability** | ● Limited traceability service is provided. | • Provide technological **traceability solution,** starting origin tracing from the farm gate. |
| **Financial service** | + Digital payment is facilitated with debit card, internet banking, etc. and | • Offer farmers **various financial service options** in digital payment, short-term |

| | | |
|---|---|---|
| | financing services is provided with warehouse receipt. | financial credit, crop insurance, payment guarantee, payment on delivery, etc. |

### Potential value creation of Mandi Automation solution / eNAM

At a mature state, eNAM would bring significant value to not only farmers, but also traders and institutional buyers on the platform. Annual extra value generated 20 years from now is expected to be $18-22 billion, with an estimated CAGR of 5% from Year 5 to Year 20 By then, with the further improvements in its functionality and government support, it is expected that eNAM would cover 50-60% of trade volume in the APMC system. It would bring value to farmers by improving value captured by farmers through the APMC system via better buyer-supplier connecting, transparent and fair quality assessment, lower cost to transport produce to the APMC and so on. Combined with further levers to support farmers, especially with Farmer Aggregation solution and B2B platform, the extra annual value created for farmers could be $34 –42 billion in 20 years.[36]

*Figure 18: Impact estimation for Mandi Automation / eNAM development*




## Farmer Aggregation solution

The Farmer Aggregation solution would contribute to efficient aggregation of produce from smallholder farmers and transportation to intermediaries or larger buyers including institutional buyers, processors and unorganised retailers.

### Key functionality of Farmer Aggregation solution

To ensure fair value captured by farmers, the Farmer Aggregation solution would need to provide complete functionality to address pain points of farmers, intermediaries and institutional buyers. Apart from creating linkages among smallholder farmers, intermediaries and institutional buyers, a user-friendly front-end for farmers is important to allow easier access for farmers and high usage frequency. Its logistics would especially focus on shared load aggregation service in order to collect small volumes of produce from diverse locations at low cost and in a time-efficient manner. In addition, quick and standardised quality assessment would play an important role to remunerate farmers fairly. Also, traceability solutions and financial services would add value to both sellers and buyers. A detailed view of key functionalities is shown below.

#### Overview of key functionalities for Farmer Aggregation solution[37]

| Functional area | Details of key functionalities |
|---|---|

| | |
|---|---|
| **Buyer-Supplier matching** | • The platform would **link smallholder farmers to intermediaries or institutional buyers** to facilitate direct sales from smallholder farmers.<br>• The platform would provide **information about production and facilitate purchase requests** from buyers, e.g. crop, volume, region, time for purchase, etc.<br>• **User-friendly front-end** would be provided to farmers to list sales information, select aggregators by regions and prices, and book transportation vehicles for produce. |
| **Logistic & Ware-housing** | • The platform would provide **shared load aggregation service** to connect various smallholder farmers and aggregate their produce.<br>• The platform would offer **logistics options near the farm** which provide **low-temperature and moisture-regulated** space. |
| **Quality assessment** | • **Standardised parameters** would be used for quality assessment. The solution grades produce and remunerates farmers accordingly.<br>• **Option for image-based AI solution** would be provided to assess produce quality quickly based on physical characteristics. |
| **Traceability** | • **A traceability solution would be offered to summarise source information of produce**, including date and place of origin, farmer profiling, etc. |
| **Financial service** | • The platform would offer farmers **fast** and **various payment options,** including digital payment and cash payment if needed. |

## Examples of existing practices for Farmer Aggregation solutions

While there are not many existing Farmer Produce Aggregation solutions in India, some examples include Mastercard Farmers Network and Loop. Functionality maturity of the existing examples is assessed to be low, since the solutions are still in the initial development phase and most functions are under exploration. There is a need to optimise the overall functionality of these solutions in order to scale up the model.

*Figure 19: Select examples of existing practices of Farmer Aggregation and functionality maturity assessment*

| Examples | Description | Assessment of functionality maturity |
|---|---|---|
| mastercard | Mastercard Farmer Network (MFN) is an agriculture platform that digitizes marketplaces, payments, workflows, and farmer transaction histories, by connecting buyers, suppliers, agtechs, and banks with FPOs/farmers digitally.<br>MFN has been running a pilot in Andhra Pradesh for 2018-2020 and it is reported that 24,000 farmers are using the platform in the state as of October 2020. | Low |
| Loop | Loop is a shared transport service for farmers launched by Digital Green in 2015 to improve smallholder farmers' access to markets and to help farmers realize higher income from sale of their vegetables. The pilot began in August 2015 and until mid January 2016, the project has been operational in 2 districts (Samastipur and Muzaffarpur of Bihar) and has helped more than 1,000 farmers.<br><br>Loop picks up farmers' produce based on their requests through a mobile app, pools bookings from farmers and matches them to nearby carriers, delivers the produce to market, and pays farmers after produce is sold at wholesale markets. | Low |

Mastercard Farmer Network is an online agriculture platform that connects smallholder farmers to buyers in order to sell their produce. As of October 2020, 24,000 farmers reported that they had used the platform. This platform makes the option for digital payment available. However, it provides limited solutions for logistics, quality assessment and traceability, so far.[38]

Loop is a shared transport service that supports farmers to flexibly book requests for selling their produce, to pool bookings together, and to arrange nearby carriers to pick up and deliver the produce to market. The pilot began in 2015 and helped more than 1,000 farmers in Samastipur and Muzaffarpur of Bihar. In addition, it offers

digital payment options to farmers and sends sales receipts by text message to farmers. However, the platform provides limited quality assessment and traceability solutions.[39]

### Opportunity for improvements to Farmer Aggregation solutions[40]

Case analysis based on secondary research + Existing advantages ● Potential to improve

**Example 1: Mastercard Farmer Network**

| Functional area | Functionality today | Opportunities to improve |
|---|---|---|
| **Buyer-Supplier matching** | ● It connects farmers with buyers, inputs suppliers, FPOs and banks or financial institutions. The farmers can list their produce and prices through a digital agent, and the buyers can enter their requirements as well. | Extend coverage of crops served on platform to satisfy various need of farmers and buyers. |
| **Financial service** | + Digital payment options are offered. | NA |
| **Logistics & Ware-housing** | ● Plans are in place for the platform to offer logistics support. | Support farmers to transport their produce through last-mile logistics services. |
| **Quality assessment** | ● Limited services are provided. | Offer technological quality assessment solutions at the farm gate to assess physical and chemical quality of produce and remunerate farmers based on quality. |
| **Traceability** | ● Limited services are provided. | Offer ttraceability solutions to summarise source information of produce, including date and place of origin, farmer profiling, etc. |

**Example 2: Loop**

| Functional area | Functionality today | Opportunities to improve |
|---|---|---|
| **Buyer-Supplier matching** | ● It helps smallholder farmers to access markets and to connect with preferred aggregators of their choice. Currently the platform only services the vegetables segment. | Service additional perishable and non-perishable segments on the platform |
| **Financial service** | + Digital payment options are provided and the platform sends farmers receipts by text message when sales are completed. | NA |
| **Logistics & Ware-housing** | + It allows farmers to book transportation directly via Loop app. Produce will be picked up by closest available vehicles and driven to buyers. | NA |
| **Quality assessment** | ● Limited services are provided. | Offer technological quality assessment solutions at the farm gate to assess the physical and chemical quality of the produce and remunerate farmers based on the quality assessed. |
| **Traceability** | ● Limited services are provided. | Offer ttraceability solutions to summarise source information of produce, including date and place of origin, farmer profiling, etc. |

## Hyperlocal Connect solution

The Hyperlocal Connect solution focuses on facilitating direct fresh produce sales in local markets between farmers and consumers.

### Key functionalities of Hyperlocal Connect solution

Hyperlocal Connect would provide a user-friendly fresh produce sales and purchasing experience to both farmers and consumers via desktop and mobile. Key product information including prices, volume, produce sources, quality, etc. would be provided via platform. In addition, a fast and low-cost delivery solution would be enabled to transport the products from farmers to consumers. Easy-to-use and fast tech solutions in quality assessment as well as traceability would be offered via platform. Moreover, the platform would support various forms of payment. To facilitate usage for local farmers and consumers, selection of multiple local languages would be available on the platform.

### Overview of key functionality for Hyperlocal Connect solution[41]

| Functional area | Details of key functionality |
|---|---|
| **Buyer-Supplier matching** | • The platform would provide a **user-friendly experience to farmers for selling and to consumers for purchasing produce**, available in **desktop** as well as **mobile** versions.<br>• It would focus on various kinds of **fresh produce from local farmers** on the platform.<br>• It would provide consumers with **basic information on** prices, sources, and physical characteristics of products.<br>• It would provide farmers with **suggestions about the market value** of the products, which would help them in product pricing. |
| **Logistics & Ware-housing** | • The solution would build a **smart logistics network** to gather produce from farmers and find the quickest and lowest-cost route to deliver products to consumers.<br>• It would have **moisture- and temperature-regulated storage space in logistics facilities** to ensure products do not get spoilt before reaching consumers.<br>• It would offer a **cold and dry warehousing solution** to farmers if they have need to store their produce for longer time.<br>• It would provide **quick, smooth and accurate delivery of products** with **low delivery fees**. |
| **Quality assessment** | • It would offer farmers **easy-to-use and fast tech solutions to perform quality assessment** of produce.<br>• It would conduct **simple product review of physical appearance when collecting products** from farmers to ensure basic product quality.<br>• Quality assessment results would be uploaded with product information to the platform. |
| **Traceability** | • It would offer farmers **incentives and technological solutions to record the source of the produce**, including details like farm activities, farmer profiling, etc., especially for organic produce. |
| **Financial service** | • It would provide **various forms of payments** like debit card, credit card, e-wallet, cash on delivery, etc. |
| **Other value-added service** | • The platform would be available in **multiple local languages** to facilitate usage for local farmers and consumers. |

## Examples of existing practices for Hyperlocal Connect solutions

Existing Hyperlocal Connect solutions are still at a nascent stage and examples include Kalgudi and Farmerprice. Their functionalities are at an early stage of maturity, and would require improvement to reach their potential.

*Figure 20: Select examples of existing practices of Hyperlocal Connect and functionality maturity assessment*

| Examples | Description | Assessment of functionality maturity |
|---|---|---|
| Kalgudi | Kalgudi is a free-to-use AI-based agricultural platform that connects farmers and micro-entrepreneurs to consumers in India and abroad. The platform is available in local languages with some features that are offline-enabled for remote areas where connectivity is poor.<br>Kalgudi's core agriculture services help farmers and FPOs in farm management, information dissemination, training, extensions and facilitates transactions with digital assistance. In just a few months after launch, Kalgudi has reached 300 FPOs, each with 200-300 member farmers and 500 women's self-help groups from Andhra Pradesh who sell their good directly to consumers. | Low |
| | Farmerprice is a Farmer to Consumer platform, which allows farmers to do direct marketing of their produces to consumer and retailers without middleman or intermediary. It offers complete traceability of the product to the consumer and has both online and offline payment options. The technology is a mobile application built for Android and supports 2 languages – English and Tamil. | Low |

Kalgudi is an agriculture platform that connects farmers to Indian and international consumers for the sale of their produce. The platform covers both fresh and non-perishable produce and offers detailed product descriptions. In addition, it partners with India Post to provide product shipment services and offers end-to-end traceability information to consumers. Furthermore, the platform includes an RBI approved payment gateway and supports multiple local languages. Nevertheless, there is scope for Kalgudi to further optimise its functionalities by expanding its fresh produce coverage (given the low availability of fresh products on the platform) by improving logistics efficiency, (given the current delivery time of 5-10 days), by integrating quality assessment with the platform; and by offering a range of payments methods.[42]

Farmerprice is an online digital tool that provides farmers with a platform to sell their agricultural products to end consumers. At the same time, it provides farmers with information about farm input and quality produce services. It enables traceability of products because of its direct purchase model from farmers or the nearest shops. Moreover, it allows both online and offline payment for users. However, the app is still at an initial launching stage and has very few users. It is crucial for the tool to optimise its overall functionality in order to acquire more customers. The business model needs to be refined in order to meet customer demand. [43]

Opportunity for Hyperlocal Connect solution functionality (Kalgudi as analysis example)[44]

Case analysis based on secondary research + Existing advantages ● Potential to improve

| Functional area | Functionality today | Opportunities to improve |
|---|---|---|
| **Buyer-Supplier matching** | + It is an AI-based agricultural platform that provides a **farmer-to-consumer** portal and connects farmers, micro-entrepreneurs and consumers in India and abroad.<br>● The direct farmer-to-consumer e-portal specialises in **fruits, vegetables, spices, snacks, and other regional specialities**. However, the variety available is still very limited.<br>+ They provide **product descriptions** including packing processes, production/manufacturing processes, ingredients, and nutrients for products sold on their platform. | • **Fresh fruit and vegetables** still account for a small proportion of products sold through the platform. This proportion could be **increased** to meet local consumers' needs.<br>• It could provide farmers with **suggestions about market value** of the products to help them in product pricing. |

| | | |
|---|---|---|
| | + **Price negotiation option** is offered for bulk order. | |
| **Logistic & Ware-housing** | + Produce is **delivered directly from the farm field** to the consumers.<br>+ The platform works with **various transporters** including India Post for product shipment. Some **shipping cost is absorbed by the buyer,** depending on shipping territory and weight of products.<br>● It usually takes 5-10 days to reach the buyers. | • **Cooperation with partners to build in temperature-regulated transportation facilities** could be considered, to improve ability to sell fresh fruits and vegetables.<br>• It could invest in **logistics network capability** to improve delivery efficiency. |
| **Quality assessment** | ● Limited quality assessment service is provided. | • It could offer farmers **easy-to-use and fast tech solutions to perform quality assessments**, especially of fresh produce.<br>• Quality assessment **results** could be **uploaded** with product information to the platform.<br>• It could facilitate transport partners to conduct **product review of physical appearance when collecting products**. |
| **Traceability** | + It provides **end-to-end traceability** of the product by showcasing the producers, farm activities, inputs used, and processing of every order. | NA |
| **Financial service** | ● It provides an RBI approved payment gateway with 100% secure payments supporting NEFT and RTGS. | • It could provide **various forms of payments** to both farmers and consumers like debit card, credit card, e-wallet, cash on delivery, etc. |
| **Other value-added service** | + The platform is available in local languages with some features that are offline-enabled for remote areas where connectivity is poor.<br>+ The platform also offers service of inputs sales, output sales, etc. | NA |

## Online Retail solution

The Online Retail solution would connect retailers and consumers in order to provide a purchase channel for both perishable and non-perishable food.

### Key functionality of Online Retail solution

A highly functional Online Retail solution would provide consumers with a user-friendly way to get their groceries online. It would cover a wide range of products and provide exhaustive information about them. At the same time, it would manage a smart logistics network to offer quick, smooth, accurate product delivery with low fees, while simultaneously ensuring product quality. Moreover, it would offer quality assessment and traceability solutions to ensure transparency of supply chain and product information. Flexible payment methods including cash and digital payment would be supported on the platform.

### Overview of key functionality for Online Retail solution[45]

| Functional area | Details of key functionality |
|---|---|
| **Buyer-Supplier matching** | • The platform would provide a **user-friendly experience** to consumers to purchase **produce**, available in both **desktop** and **mobile** versions.<br>• It would cover a **wide range of products** including perishable and non-perishable items.<br>• It would provide **key information about products** on quality, price, source and nutrition.<br>• It would **source** produce from the supplier **efficiently**, even in a multi-vendor sourcing model, to ensure sufficient stock and good quality of produce. |
| **Logistics & Ware-housing** | • The platform would have **moisture- and temperature-regulated storage space** in warehouses and logistics facilities to ensure products do not get spoilt.<br>• It would manage a **smart logistics network** to gather produce from one or multiple suppliers and to find the quickest and lowest-cost route to transport the produce.<br>• It would provide **quick, smooth and accurate delivery of products** with **low delivery fees**. In addition, it would offer options for **time slot for delivery** and **self-pickup**. |
| **Quality assessment** | • The platform would leverage technological solutions to perform **quality assessment** for both the **physica**l and **chemical characteristics** of the products.<br>• It would list quality assessment results and provide product information for consumers. |
| **Traceability** | • It would use technological solutions to **trace the source of the produce from the farm-gate level**, especially for organic produce.<br>• It would list sourcing information of all products. |
| **Financial service** | • It would provide **various forms of payments** like cash on delivery, debit card, credit card, e-wallet, etc. |

### Examples of existing practices for Online Retail solutions

There are a number of existing players of Online Retail solutions in India, including several fast-growing examples such as BigBasket, Grofers, JioMart and Zopnow. Although they are still operating at a limited scale, they have demonstrated high maturity in their functionality offerings.

*Figure 21: Select examples of existing practices of Online Retail and functionality maturity assessment*

**Existing practices of Online Retail solution** (selective examples)

| Examples | Description | Assessment of functionality maturity |
|---|---|---|
| bigbasket | Founded in 2011, BigBasket is India's largest online food and grocery store. It has over 18,000 products and more than 100 brands in its catalogue. They have products ranging from fresh fruits and vegetables, rice and dals, spices and seasonings to packaged products, beverages, personal care products, meats, etc. and are currently operational in over 20 Indian cities. | High |
| GROFERS | Grofers is one of India's largest online supermarket in the grocery space. The company uses its in-house technology platform to manage a network of over 5,000 partner stores that enable the company to run a lean supply chain – from manufacturers straight to customers in 27+ cities in India. Grofers utilizes its supply chain to deliver over 25 million products to customers every month. | High |
| JioMart | JioMart is an Indian online grocery store that provides 50000+ grocery and daily essentials from nearby store. It is started as a joint venture between Reliance Retail and Jio Platform. The online store which was launched in December 2019 and piloted in April 2020, has now launched in over 200 cities and towns in India and has over 2.5 lakh order daily from India as of June 2020. | Medium |
| zopnow | Zopnow, founded in 2011, is a technology platform for online groceries that connects consumers from hypermarkets online. It operates in 9 cities including Delhi, Faridabad, Ghaziabad, Noida, Mumbai, Gurgaon, Pune, Mumbai and Bengaluru. The company's vision is to offer fresh groceries, fast and easy at customer's doorstep. | Medium |

BigBasket and Grofers are the leading players in the area and are both in operation in over 20 cities in India. They offer a large range of products to consumers, from fresh products to non-perishable products. Also, they have invested in improving delivery service to ensure efficiency and quality. In addition, various forms of payment are supported on the platform. Even though JioMart and Zopnow have gaps in their functionality and user size compared to the leading players, their scale is expanding rapidly. Despite relatively high functional maturity versus other solution models, existing Online Retail solutions could still optimise quality assessment and traceability functions, to satisfy the needs of consumers about product quality. Several opportunities to improve their functionality have been identified below in depth, using BigBasket as analysis example.[46]

## Opportunity for Online Retail functionality (BigBasket as analysis example)[47]

Case analysis based on secondary research + Existing advantages ● Potential to improve

| Functional area | Functionality today | Opportunities to improve |
|---|---|---|
| **Buyer-Supplier matching** | + It is an e-grocery platform, sourcing farm-fresh products directly from farmers or mandis and supplying to end consumers.<br>+ It covers a **wide range of products** including fruits and vegetables, food grains, oils and masala, bakery, beverages, snacks and other kitchen and household goods.<br>+ It provides information on the **price of the product, nutritional facts and physical characteristics** about the product to the consumer. | NA |
| **Logistics & Ware-housing** | + It works on an **inventory model,** wherein it buys products from leading suppliers and stores these products in | NA |

| | | |
|---|---|---|
| | warehouses, or small godowns, and does not use retail outlets.<br>+ It offers **subscription-based delivery** and allows customers to place their orders and request for delivery at their homes at their preferred time.<br>+ It leverages data science to build **route optimisation models** to ensure on-time delivery. | |
| **Quality assessment** | ● Limited quality assessment services are provided. | • It could build in **quality assessment tools** to constantly monitor produce quality and reduce wastage after procurement.<br>• It could provide **quality assurance labels** for all products. |
| **Traceability** | ● It provides information on the **country of origin** of the product and from which **supermarket or grocery supplies** it was sourced. | • The platform could provide **traceability features** for the products **at farm-gate level** to indicate where the product is coming from, especially for the organic products. |
| **Financial service** | + It provides **multiple ways to make payment,** including debit/ credit card, e-wallet payment, online banking and cash on delivery. | NA |
| **Other value-added service** | + It uses ML and analytics to help customers save time by **creating a list of items most likely to be purchased** on the basis of system intelligence. | NA |

## Impact generated by the five technology solutions

In a mature state, the technology solutions are expected to generate significant impact and nearly double farmer income from crop cultivation.

Assuming that these solutions reach maturity, 20 years from now, their combined value creation per year is projected to be $62 to 76 billion. 50-60% of the marketable volume in the sector is expected to be traded via online platforms, which will translate to a crop value of about $200 billion per year. Online platforms are expected to create 35% additional value in the sector through quality transparency, disintermediation, and improved market coordination.

Farmers are expected to retain around 50-60% of the additional value created, i.e. $34 to 42 billion. According to industry expert inputs and market report estimations on impact of agricultural technology solutions on farmers, around 75 to 91 million farmers are expected to benefit from the technology solutions once they reach a mature state. This would account for 35-43% of farmers in India in year 20.

Over the 20-year term, we expect farmers to see increased crop cultivation incomes of INR 31k – 38k due to additional value capture, which is 70-80% of the current farmer incomes from crop cultivation (estimated at INR 45k – 50k). This would mean an almost doubling of farmer incomes from crop cultivation over a 20-year term.[48]

*Figure 22: Key impact statistics from the technology solutions in the mature state*

**$62 – 76 billion** value would be created from the 5 technology solutions per year

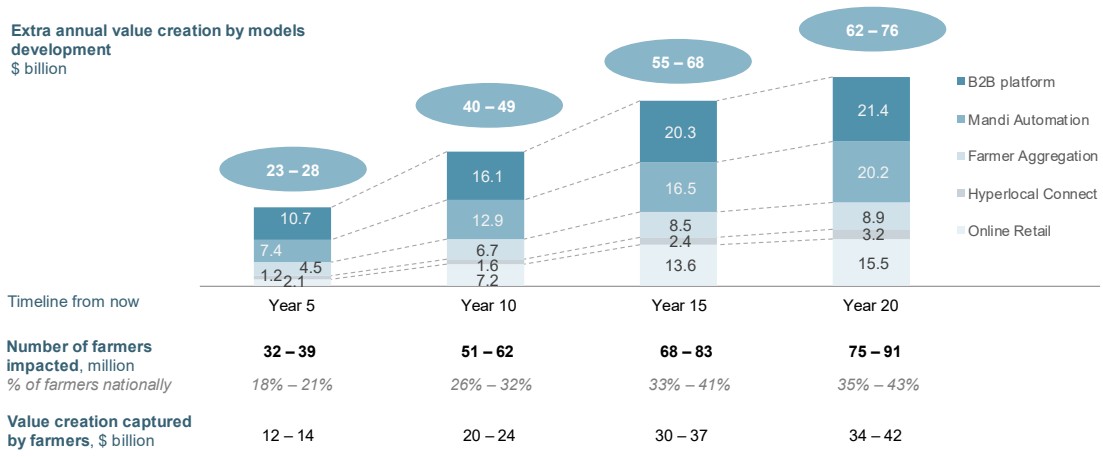
**$34 – 42 billion** value would be captured by farmers per year

**75 – 91 million** farmers would benefit from the technology solutions

**70% – 80%** farmer income increase in crop cultivation

Among the 5 technology solutions, B2B platform and Mandi Automation solution would be the main value drivers, contributing to more than half of the total extra value created. Online Retail is expected go through fast development (est. CAGR of 13% to 15% from year 5 to year 20) and is likely to be the third largest value contributor (20-25% of total value creation), due to the global transition of consumer behavior toward e-grocery adoption, and to the increasing number of players and investors in the Indian market. Farmer Aggregation and Hyperlocal Connect solutions would experience stable growth with a CAGR of 5% to 7% from year 5 to year 20. They would bring a smaller portion of value due to more limited market size and lower market readiness.

*Figure 23: Key impact statistics from the technology solutions in the mature state*




## Next steps to scale up the technology solutions

To accelerate the timeline to reach scale and maturity of solutions, investments from different players could be made.

| Solution | Current stage | Support needed | Key actors |
|---|---|---|---|
| **B2B Platform** | Pilot | • Extend services to additional crop segments<br>• Improve functionalities<br>• Integrate support services across key functions<br>• Scale up geographically | Private sector players |

| | | | |
|---|---|---|---|
| **Mandi Automation** | Pilot | • Incentivize more farmers, traders and buyers to come on board<br>• Extend solution functionality, including logistics and warehousing, quality assessment, traceability and so on | National government |
| **Farmer Aggregation** | Pilot | • Incentivize more farmers, traders and buyers to come on board<br>• Invest in improvement of existing solutions and development of new solutions<br>• Improve transportation solutions for farmers | National government |
| **Hyperlocal Connect** | Nascent | • Improve solutions for buyer-supplier matching and quality assurance<br>• Explore efficient operating models, especially in logistics<br>• Conduct pilots | State and local government |
| **Online Retail** | Emerging | No support needed | Private sector players |

To ensure that the investment leads to success, collaboration and commitment to long-term substantial support from different actors would be required.

- **Technology companies** and **AgriTech players** would need to cooperate closely on developing technology solutions. Big Tech companies will have to commit on building best-in-class B2B buyer supplier matching platforms based on learnings from the e-Commerce industry. In addition, they would need to help emerging AgriTech players providing solutions in quality assurance, traceability etc., with enhancing their solutions through AI, machine learning, etc. AgriTech players, themselves, would need to rapidly improve their functionality offerings and pilot their solutions in the field, to iterate their tech solutions through several sprints.

- **Agricultural business** would need to support aggressively emerging Tech Platforms by transacting on them at scale. They could actively integrate fast-growing and promising technological interventions to bring changes to the current ecosystem.

- **Government** would also play an important role to support development of solutions. The Ministry of Agriculture would need to invest in enhancing capabilities and adoption of eNAM in consultation with NGOs, agribusinesses, and technology companies. State government could take the lead to facilitate on-the-ground implementation of pilots to accelerate learning and improvement.

- **Donors** would provide sustained funding for pilot and scale-up of integrated platforms in different commodities and markets. Since they have higher appetite to take on long-term investments without expectation of quick impact or returns, we expect that they would be key participants in the technological transformation of the F2F space.

- **Agricultural social organisations** could help implement the solution in both pilot and scale-up phases, leveraging close relationships and collaboration with farmers and FPO, to accelerate testing and deployment of projects.

With active involvement and strong collaborations from stakeholders in different domains, transformation of the ecosystem is possible in the near future. A shared agenda could be drafted by various stakeholders to develop a common vision and highlight key action points, in order to guarantee success of the solution deployment.

# Conclusion

This report represents an effort to understand the challenges in the Farmgate to Fork ecosystem and develop solutions with technologies to improve value creation of the system and value captured by farmers. Several key points can be drawn from the effort to date, including:

- **Agriculture is the cornerstone for Indian economy, but smallholder farmers, who account for 86% of the farmers in India and contribute significant value to the economy, are capture minimal value.** Value capture for smallholder farmers is hindered by poor visibility of demand from buyers, exploitative intermediation, limited quality assurance, limited access to efficient and low-cost logistics, and low bargaining power of smallholders.
- **Technology is the key to unlock the changes in the Farmgate-to-Fork ecosystem and support the goal of doubling farmer incomes.** Technology can rapidly deploy solutions to address the key challenges in the Farmgate-to-Fork ecosystem, and India is well-prepared to harness technological power with its high infrastructure readiness, evolving agri-tech innovation landscape, and increasing investor activity.
- **Technology solutions with buyer-supplier matching as a central function can connect different actors in value chain. In addition, integrated value-add services in logistics & warehousing, quality assessment, traceability and financial service have high potential to create impact on farmer incomes.** Five technology solutions for the Farmgate to Fork ecosystem, --the B2B platform, Mandi Automation solution, Farmer Aggregation solution, Hyperlocal Connect solution and Online Retail solution – are expected to deliver significant value to the ecosystem and nearly double farmer incomes from crop cultivation.
- **Existing technology solutions still have gaps in functionality and would need continuous efforts from multiple actors to optimise overall functionality and bring users on board.** Functionality maturity of existing practices in B2B, Mandi Automation, Farmer Aggregation, and Hyperlocal Connect is assessed to be low or medium, while leading practices in Online Retail solution have more advanced functionality to.

As a next step, stakeholders from different domains need to develop a shared vision and commit to long-term support to transform the Farmgate-to-Fork ecosystem with technology interventions. Key actors must invest in integrating best practices and best-in-class technologies into these solutions, in rapid piloting and scale-up of ideas, in coordination among value chain actors, and in sustained funding support to ensure long-term success.

We encourage and invite more stakeholders to join us in building impactful and viable solutions for the Farmgate-to-Fork ecosystem, and we look forward to working together to create meaningful change by harnessing the power of technology.

# Annex: Methodology notes

## Impact of technology solutions for the Farmgate-to-Fork ecosystem

The exercise of sizing the potential impact of the five technology solutions is a directional analysis. Estimations of the technology solution impact on price, supply and farmer number in mature state depend on applicability of technology on different crops, maturity of the technology, as well as other factors such as value chain actor adoption, government regulation and efforts on behalf of the stakeholders to scale the technologies – all of which are difficult to predict accurately. Estimation was completed with available public information and industry expert inputs and assumptions were applied where proven figures were not available. Most of these technologies are still in a nascent or pilot phase, where there are very limited use cases with solid performance statistics. Therefore, assumptions were developed with closely comparable domestics and international cases

as well as by Indian agriculture and technology experts with an optimistic mind-set. Estimation could be potentially influenced by unpredictable future changes in macro- and micro-environment.

Key functions applied to calculate the impact of technology solution are:

Extra Value Impact at mature state = (Base Price * (1+Technology solution impact on Price [%])) * (Base Supply x (1+Technology solution impact on Supply [%])) – (Base Price * Base Supply)

Extra Value Impact in Year X = Extra Value Impact at mature state x Technology solution roll-out degree in Year X [%]

Key assumptions for the valuation include:

- Base price and base supply are the values of all crop in India in 2020, for which data from Agricultural & Processed Food Products Export Development Authority (APEDA), Area and Production Statistics from Ministry of Agriculture and Farmers Welfare (DAC), Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) was leveraged. Values were firstly calculated in different crop level and summed up to crop segment level.
- Technology solution impact on price, supply and farmer number at mature state was estimated based on available domestics and international use cases, challenges of related functional areas in value chain, and technology applicability by crop. Literature and case studies were utilised to generate the estimation, and expert opinion and closest comparable estimations were used where no literature was available. General impact from solution by crop segment, functional areas and demand centre was estimated to be 5-25%. Technology applicability was assumed to vary from 15-90% depending on degree of crop commercialisation and technology features.
- Roll-out degree of solution was assessed based on maturity of existing practices in the solution area and potential growth driven by market demand and different actors. Literature research and inputs from agriculture and technology experts were applied to deliver the estimation.

# Endnotes

[1] Smallholder farmers are defined as farmers owning <2 hectares of land.

[2]Handbook of Statistics on Indian States 2016-17, Reserve Bank of India, 2017, https://rbi.org.in/Scripts/AnnualPublications.aspx%3Fhead%3DHandbook%20of%20Statistics%20on%20Indian%20States; Accessed 20 Jan 2021; TechnoServe India analysis

[3]Agricultural Statistics at a Glance 2019, Govt. of India, 2020, https://eands.dacnet.nic.in/PDF/At%20a%20Glance%202019%20Eng.pdf; Indian Tea Association, https://www.indiatea.org/tea_growing_regions; All accessed 20 Jan 2021; TechnoServe India Analysis.

[4] Employment in agriculture (% of total employment), ILOSTAT database, International Labour Organisation, https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS; Report of the Committee on Doubling Farmers' Income, Volume II "Status of Farmers' Income: Strategies for Accelerated Growth", Ministry of Agriculture & Farmers Welfare, August 2017, https://agricoop.gov.in/sites/default/files/DFI%20Volume%202.pdf; All India Report on Agriculture Census 2015-16, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, 2020, http://agcensus.nic.in/document/agcen1516/ac_1516_report_final-220221.pdf; All accessed on 20 Jan 2021; TechnoServe India Analysis.

[5] Analysis includes crops only – excludes agricultural allied sectors (i.e., livestock, forestry, fishing)

[6] A U-shaped domestic recover scenario is estimated to happen with high probability as COVID-19 may very possibly lead to a stop-start economy and slightly slow recovery time through the end of 2021, which could trigger a U-shaped economic slowdown and recovery.

[7] Agri Exchange database, Agricultural & Processed Food Products Export Development Authority, http://apeda.in/agriexchange/India%20Production/India_Production_State_Wise.aspx, https://agriexchange.apeda.gov.in/indexp/genReport_combined.aspx#content; Statewise and item-wise estimates of value of output from agriculture and allied sectors (2011-12 to 2015-16), Ministry of Statistics and Program Implementation, 2018, http://mospi.nic.in/sites/default/files/publication_reports/Final1Brochure_30july2018.pdf; FAOSTAT, Food and Agriculture Organisation, http://www.fao.org/faostat/en/#data/QC; Farmers' Income in India: Evidence from Secondary Data, Thiagu Ranganathan, Centre for Development Studies, 2015, https://www.researchgate.net/publication/303314984_Farmers'_Income_in_India_Evidence_from_Secondary_Data. All accessed 20 Jan 2021; TechnoServe India analysis.

[8] Agricultural value projections are calculated as projected supply (MT) multiplied by projected farm gate price (INR). The numbers represent the difference between baseline and COVID-19 supply, where negative values indicate a reduction.

[9] Agri Exchange database, Agricultural & Processed Food Products Export Development Authority, http://apeda.in/agriexchange/India%20Production/India_Production_State_Wise.aspx, https://agriexchange.apeda.gov.in/indexp/genReport_combined.aspx#content; Ministry of Statistics and Program Implementation, 2018, http://mospi.nic.in/sites/default/files/publication_reports/Final1Brochure_30july2018.pdf;

FAOSTAT, Food and Agriculture Organisation, http://www.fao.org/faostat/en/#data/QC. All accessed 20 Jan 2021; TechnoServe India analysis.

[10] Summary of Economic Survey 2020-21, Ministry of Finance, 2021, https://pib.gov.in/PressReleasePage.aspx?PRID=1693232#:~:text=India%20is%20expected%20to%20emerge,two%20years%20as%20per%20IMF.&text=The%20Survey%20says%2C%20India's%20GDP,fall%20in%20the%20second%20half. Accessed 20 Feb 2021.

[11] COVID-19 Livelihoods Survey, Azim Premiji University, 2020, https://cse.azimpremjiuniversity.edu.in/wp-content/uploads/2020/06/Compilation-of-findings-APU-COVID-19-Livelihoods-Survey_Final.pdf. Accessed 25 Feb 2021.

[12] Analysis of cotton uses example from fabric production in Maharashtra and scales all costs, margins and prices to reflect the production of about 2m fabric. Analysis of Paddy uses example from Bihar. Data analysis is conducted by TechnoServe India.

[13] We hold the view that intermediation in itself is not a problem in agricultural value chains. In recent years, the view that intermediaries are an unnecessary middle layer in value chains and must be removed for value chain efficiency has gained widespread acceptance. However, it is important to assess the value of intermediaries in each value chain uniquely and understand their role in solving for value chain constraints, before recommending decisive steps to remove them. Often, value capture is not impeded by intermediaries, but by unnecessary intermediary layers, information loss, lack of pricing and demand transparency, etc. Solutions that make intermediation more transparent and systematic must therefore be considered, as removing intermediaries altogether might not behoove all value chains.

[14] Innovation with a Purpose: The role of technology innovation in accelerating food systems transformation, WEF prepared in collaboration with McKinsey & Company, January 2018, http://www3.weforum.org/docs/WEF_Innovation_with_a_Purpose_VF-reduced.pdf, accessed 20 Jan 2021; Compendium on Emerging Technologies on Agriculture, Telangana State Agricultural University; TechnoServe India analysis.

[15] AI4AI: Artificial Intelligence for Agriculture Innovation – Next Steps about Working Group Set-up Plan (Presentation), World Economic Forum and Government of Telangana, October 2020.

[16] Compendium on Emerging Technologies on Agriculture, Telangana State Agricultural University; Working Group inputs and TechnoServe India analysis.

[17]Digital India Report, McKinsey Global Institute, 2019, https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/digital%20india%20technology%20to%20transform%20a%20connected%20nation/digital-india-technology-to-transform-a-connected-nation-full-report.ashx; Internet Trends report, Mary Meeker, 2019, https://www.bondcap.com/report/itr19/; National Strategy for Artificial Intelligence, NITI Aayog, June 2018, https://niti.gov.in/writereaddata/files/document_publication/NationalStrategy-for-AI-Discussion-Paper.pdf; All accessed 20 Jan 2021; TechnoServe India analysis.

[18] eNAM website, https://enam.gov.in/web/; Telangana's Year of AI — 2020 and Beyond, Information Technology Electronics & Communications Department, Government of Telangana State, 2020, https://it.telangana.gov.in/wp-content/uploads/2021/01/Telangana-Year-of-AI-2020-Report.pdf; Karnataka tomato growers to get crop, price forecasts from IBM using AI, ML, The Hindu: Business Line, 2019, https://www.thehindubusinessline.com/economy/agri-business/karnataka-

tomato-growers-to-get-crop-price-forecasts-from-ibm-using-ai-ml/article26358330.ece; Government of Karnataka inks MoU with Microsoft to use AI for digital agriculture, Microsoft News Center India, 2017, https://news.microsoft.com/en-in/government-karnataka-inks-mou-microsoft-use-ai-digital-agriculture/. All accessed 20 Feb 2021.

[19] The Farmers Produce Trade and Commerce (Promotion & Facilitation) Act, Ministry of Law and Justice, 2020, http://egazette.nic.in/WriteReadData/2020/222039.pdf; The Farmers (Empowerment & Protection) Agreement on Price Assurance and Farm Services Act, Ministry of Law and Justice, 2020, http://egazette.nic.in/WriteReadData/2020/222040.pdf; Essential Commodities (Amendment) Act, Ministry of Law and Justice, 2020, http://egazette.nic.in/WriteReadData/2020/222038.pdf; Pradhan Mantri Fasal Bima Yojana (Feb'16), Ministry of Agriculture & Farmers Welfare, https://pmfby.gov.in/; Union Budget of 2019-20, Ministry of Finance, 2020, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1605030; All accessed 20 Jan 2021.

[20] At the time of the writing of this report, there has been pushback to the three acts - the Farmers Produce Trade and Commerce (Promotion & Facilitation) Act, the Farmers (Empowerment & Protection) Agreement on Price Assurance and Farm Services Act and the Essential Commodities (Amendment) Act (also called collectively as the FARM Acts) from a few states. As a result, the Supreme Court of India has paused the implementation of these laws since January of 2021, and has ordered the formation of a committee to look into farmers' grievances, before assenting to their nationwide deployment.

[21] Producer characteristics for crops include size of landholdings, seasonality of production, etc. Market characteristics include nature of demand and typical demand centres, typical length of supply chain, etc.

[22] Compendium on Emerging Technologies on Agriculture, Telangana State Agricultural University; Working Group inputs and TechnoServe India analysis. Some solutions are categorized under same number since their application of technology and impact are very similar

[23] The volume includes volume traded within APMC and volume traded outside Mandis while recorded as APMC trading.

[24] Based on Working Group inputs and TechnoServe India analysis.

[25] Based on Working Group inputs and TechnoServe India analysis.

[26] Based on Working Group inputs and TechnoServe India analysis.

[27] Analysis on functionality of NCDEX, NeML, AgriBazaar and Ninjacart is based on information gathered from secondary research.

[28] NCDEX website, https://www.ncdex.com/; NCDEX Warehousing & Logistics, NCDEX, https://ncdex.com/downloads/Research/casestudies-conceptpaper/Warehousing-and-Logistics.pdf; NCDEX starts warehousing reforms to strengthen quality checks, Business Standard, 2014, https://www.business-standard.com/article/pti-stories/ncdex-starts-warehousing-reforms-to-strengthen-quality-checks-114031801014_1.html. Accessed 1 March 2021; Expert inputs and TechnoServe India analysis.

[29] NeML website, https://neml.in/NEMLWebsite/; ReMS website, http://www.remsl.in/; FFresh website, https://ffresh.neml.in/. All accessed 1 March 2021; Expert inputs and TechnoServe India analysis.

[30] AgriBazaar website, https://www.agribazaar.com/home. Accessed 3 March 2021; Expert inputs and TechnoServe India analysis.

[31] Ninjacart website, https://ninjacart.in/. Accessed 3 March 2021; Expert inputs and TechnoServe India analysis.

[32] Agri Exchange database, Agricultural & Processed Food Products Export Development Authority, http://apeda.in/agriexchange/India%20Production/India_Production_State_Wise.aspx; Area and Production Statistics, Ministry of Agriculture and Farmers Welfare, https://aps.dac.gov.in/Public/Report.htm; FAOSTAT, Food and Agriculture Organisation, http://www.fao.org/faostat/en/#data/QC. All accessed 20 Jan 2021; WEF Working Group input, TechnoServe India analysis.

[33] eNAM website, https://enam.gov.in/web/. Accessed 1 March 2021.

[34] "38 new mandis integrated with eNAM; The pan-India electronic agri-produce trading portal reaches milestone of 1000 mandis across 18 States & 3 UTs", PIB Delhi, May 2020, https://pib.gov.in/PressReleasePage.aspx?PRID=1624083#:~:text=In%20last%204%20years%20the,crore%20on%20e%2DNAM%20platform. Accessed 5 March 2021.

[35] eNAM website, https://enam.gov.in/web/. Accessed 1 March 2021.

[36]Agri Exchange database, Agricultural & Processed Food Products Export Development Authority, http://apeda.in/agriexchange/India%20Production/India_Production_State_Wise.aspx; Area and Production Statistics, Ministry of Agriculture and Farmers Welfare, https://aps.dac.gov.in/Public/Report.htm; FAOSTAT, Food and Agriculture Organisation, http://www.fao.org/faostat/en/#data/QC. All accessed 20 Jan 2021; eNAM website, https://enam.gov.in/web/. Accessed 1 March 2021; WEF Working Group input, TechnoServe India analysis.

[37] Based on Working Group inputs and TechnoServe India analysis.

[38] "Mastercard's Technology Platform 'MFN' to Help Farmers Connect Directly with Buyers, Input Suppliers & Financial Institutions", Krishi Jagran, October 2020, https://krishijagran.com/agriculture-world/mastercard-s-technology-platform-mfn-to-help-farmers-connect-directly-with-buyers-input-suppliers-financial-institutions/. Accessed 10 March 2021.

[39] Loop website, https://getloopapp.com/. Accessed 10 March 2021; Expert inputs and TechnoServe India analysis.

[40] "Mastercard's Technology Platform 'MFN' to Help Farmers Connect Directly with Buyers, Input Suppliers & Financial Institutions", Krishi Jagran, October 2020, https://krishijagran.com/agriculture-world/mastercard-s-technology-platform-mfn-to-help-farmers-connect-directly-with-buyers-input-suppliers-financial-institutions/. Accessed 10 March 2021; Expert inputs and TechnoServe India analysis.

[41] Based on Working Group inputs and TechnoServe India analysis.

[42] Kalgudi Consumer Store website, https://kalgudi.com/. Accessed 10 March 2021; Expert inputs and TechnoServe India analysis.

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[44] Kalgudi website, https://store.kalgudi.com/store/home. Accessed 10 March 2021; Expert inputs and TechnoServe India analysis.

[45] Based on Working Group inputs and TechnoServe India analysis.

[46] Big Basket website, https://www.bigbasket.com/; Grofers website, https://grofers.com/; Zopnow website, https://zopnow.in/; Jiomart website, https://www.jiomart.com/. Accessed 4 March 2021. Expert inputs and TechnoServe India analysis.

[47] Big Basket website, https://www.bigbasket.com/. Accessed 4 March 2021. Expert inputs and TechnoServe India analysis.

[48] Agri Exchange database, Agricultural & Processed Food Products Export Development Authority, http://apeda.in/agriexchange/India%20Production/India_Production_State_Wise.aspx; Area and Production Statistics, Ministry of Agriculture and Farmers Welfare, https://aps.dac.gov.in/Public/Report.htm; FAOSTAT, Food and Agriculture Organisation, http://www.fao.org/faostat/en/#data/QC. All accessed 20 Jan 2021; eNAM website, https://enam.gov.in/web/; "Market value of online grocery across India in 2018 and 2019 with a forecast until 2024", Statista, April 2020, https://www.statista.com/statistics/1115613/india-online-grocery-market-value/#:~:text=Market%20value%20of%20online%20grocery%20in%20India%202018%2D2024&text=The%20market%20value%20of%20online,billion%20Indian%20rupees%20in%202024; "India's online grocery market may clock $3 billion sales in 2020", The Economic Times, May 2020, https://economictimes.indiatimes.com/internet/indias-online-grocery-market-may-clock-3-billion-sales-in-2020/articleshow/75875861.cms. Accessed 5 March 2021; WEF Working Group input, TechnoServe India analysis.