



ELIMINATING FOOD LOSS, ELEVATING FARMERS USING AGTECH

May 2023

Acknowledgements

Contributors

Aparna Bhaumik, Allina Tiwari, Shivangi Sharma, Vikramjeet Sharma, Debaranjan Pujahari, Anagha Wankhede.

We would like to thank **Hemendra Mathur** (Venture Partner, Bharat Innovation Fund) for contributing his valuable insights and advice that helped shape this perspective.

Disclaimer

This report has been produced by a team from Sattva Consulting as a product for the Sattva Knowledge Institute (SKI). The authors take full responsibility for the contents and conclusions. Any participation of industry experts and affiliates who were consulted and acknowledged here, does not necessarily imply endorsement of the report's contents or conclusions.

This report only provides the findings of our limited search and is based on information acquired through conducting interviews of the organizations named/featured/attributed in the report, publicly available information on such organizations, and publicly accessible documents/information that may have been submitted/filed/reported by these organizations. SKI has not conducted any independent searches of any information or data presented in the report or on the organizations named/featured/attributed in the report, nor have we conducted searches using any specialized diligence software/tools/vendors/third parties/regulators. SKI does not comment on, nor has it reviewed the compliance status of the organizations mentioned in this report, which remains the sole responsibility of the users of the report.

This report is provided for information purposes only. No advice or services are being offered or provided by Sattva Media and Consulting Private Limited ("Sattva") or SKI in or pursuant to this publication. This report is not a substitute for professional advice or availing services. Users of this document should seek advice or other relevant assessments regarding the appropriateness of recommendations referred to in this report and should consult their advisors before making any decisions. Sattva and SKI accept no liability and will not be liable for any loss or damage arising from any use of this report, howsoever arising.

To quote this primer, please mention: Sattva Knowledge Institute, *Eliminating Food Loss, Elevating Farmers using Agtech*, May 2023. Use of the report's figures, tables or diagrams, must fully credit the respective copyright owner where indicated. Reproduction must be in original form with no adaptations or derivatives. For use of any images in the report please contact the respective copyright holders directly for permission.

This work is licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License:

Attribution - You may give appropriate credit, provide a link to the licence, indicate if any changes were made.

Non-Commercial - You may not use the material for commercial purposes.

Share A Like - If you remix, transform, or build upon the material, you must distribute your contributions under the same licence as the original.



To view a copy of this license, visit <http://creativecommons.org/licenses/by-nc-sa/4.0/>

About Sattva Knowledge Institute

Sattva Knowledge Institute (SKI), established in 2022, is our official knowledge platform at Sattva. The SKI platform aims to guide investment decisions for impact, shedding light on urgent problems and high potential solutions, so that stakeholders can build greater awareness and a bias towards concerted action. Our focus is on offering solutions over symptoms, carefully curating strong evidence-based research, and engaging decision-makers actively with our insights. Overall, SKI aims to shift intent and action toward greater impact by influencing leaders with knowledge. All of our content proactively leverages the capabilities, experience and proprietary data from across Sattva.

Design: Usha Sondhi Kundu; cognitive.designs@gmail.com





CONTENTS

1	Executive Summary	06
2	40% of Food Losses Happen at the Post-harvest Stage	07
3	Agtech Interventions as Key to Solving the Challenge of PHFL	08
4	How Can Funders Accelerate Agtech Startups to Reduce PHFL?	19
5	References	23

Executive Summary

40% of the food produced globally tends to be lost during the post-harvest value chain. In India, inefficient post-harvest management practices lead to massive post-harvest food losses that impact farmer incomes. Emerging technologies like robotics, artificial intelligence, blockchain, machine learning, analytics, IoT and others carry the potential to address the inefficiencies across the value chain that can lead to a reduction of PHFL, contributing to a more resilient food system and increased farmer incomes.

Several challenges need to be overcome to effectively drive innovation and efficiency across the post-harvest value chain. **Poor harvesting practices** are impacted by early or delayed harvesting, lack of access to machinery that can assess moisture and quality, and low farm mechanisation. **Poor produce handling** is exacerbated by improper cleaning and foregoing processes, like sorting and grading, that can lead to volume and quality loss. **Lack of storage and transportation facilities** or non-scientific storage practices are estimated to cause most of the losses in the value chain. **Lack of food processing facilities** (with only 7% of perishables being processed in India) indicate a significant value loss. **Inadequate market linkages, lack of market and price information**, limited access to multiple buyers at the farmgate cause distress selling and indirect food losses.

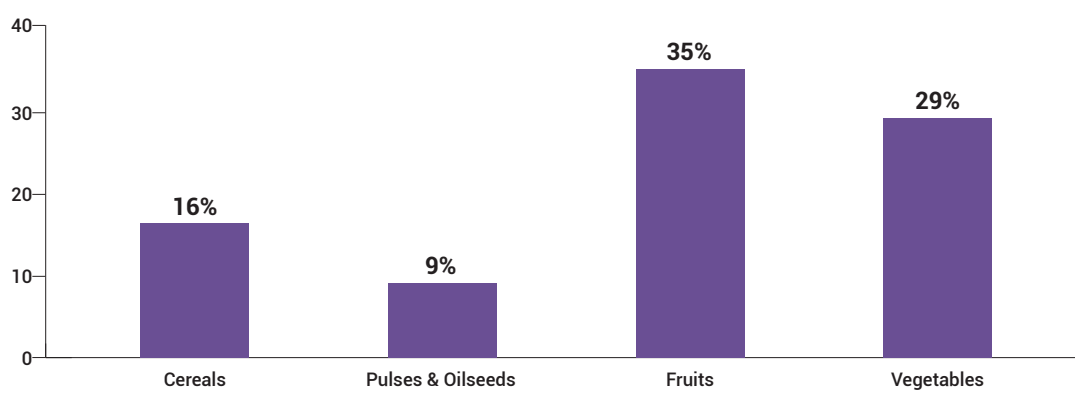
This perspective explores **agtech interventions that have the potential to address these challenges**, and the opportunities that exist to encourage further innovation in this space. The **role of funders** in creating an enabling ecosystem for agtech to flourish and drive innovation and efficiency is also explored.

The **core principles** that have successfully reduced post-harvest food losses and increased farmers income include a focus on data-driven solutions, improved quality and shelf-life technologies, and shortened supply chains with better market linkages. In light of these principles, **the priority areas** that seek funder interest involve trust-building between farmers, FPOs, and agtech startups to accelerate technology adoption; strengthening farmers' and FPOs' capacity and awareness of technology benefits at different stages of the value chain; improve their access to finance and credit for equipment and tech-enabled services; establishing on-farm and decentralised agtech services; and customising technological solutions to fit the landholding and financial context of small and marginal farmers.

40% of Food Losses Happen at the Post-Harvest Stage

Around one-third of the food produced globally tends to be wasted. **Out of this, 40% of the loss occurs in the post-harvest value chain** (Gunasekera et al. 2017). In India, inefficient post-harvest management practices and infrastructure lead to a significant loss of food.

Figure 1: Post-harvest food losses across crops








Source: NABCONS 2022

Additionally, there is a significant **loss of value** for the average Indian farmer that can be addressed and with the appropriate intervention there is a potential to increase farmer incomes. The value of post-harvest food losses in India for just fruits and vegetables that farmers are unable to sell is estimated to be around INR 63,000 crores every year (US\$7.7 million) (Mahapatra & Pandey 2018). Globally, the value of grain loss is estimated to be around \$60 billion (McKinsey & Company 2021).

Addressing post-harvest food losses (PHFL) becomes key in building resilient food systems, with a growing food demand, which calls for **an increase of 56%** from 2010 food production levels (Slathers et al. 2020). It deserves urgent attention especially in India, which is not only one of the largest food producers in the world, but is also home to the largest proportion of undernourished people.

Post-harvest losses are categorised into two types based on how they occur (Grolleaud 2002). **Direct losses** happen at the production and post-production stages due to inefficient post-harvest management (PHM) practices (elaborated below in *Table 1*). **Indirect losses** occur due to farmers' inability to find buyers in time. Indirect losses are largely due to inadequate market linkages.

Table 1: Categorising post-harvest food losses: Direct and indirect losses

Category	Stage	Factors Causing Losses	Sub-issues
Direct Losses	Production	 Poor harvesting practices	Harvest timing, moisture content, harvesting technique
	Post-production	 Poor produce handling	Pre-cooling, packaging, ripening, awareness and access to moisture meters, refractometers
		 Lack of storage facilities and transportation	Cold storage, warehousing, quality control assessment, infrastructure, roads, transport systems
		 Lack of processing	Grading, sorting, secondary processing
Indirect Losses		 Inadequate market linkages	Packaging, branding, market information, wholesale and retail marketing

Other than the broad categorisation offered above, post-harvest food losses can also be looked at in terms of **weight loss due to spoilage, quality loss, nutritional loss, seed viability loss, and commercial loss** (Kumar et al. 2017). Mostly, post-harvest food losses in developing countries like India majorly occur due to two things; a lack of knowledge or training of farmers and lack of adequate technologies at the farm level.



















Agtech Interventions as Key to Solving the Challenge of PHFL

Technology in agriculture (or “agtech”) can revolutionise post-harvest management systems in India. Innovative solutions across various stages of the agricultural value chain can help farmers and other stakeholders in the agricultural ecosystem tackle both volume and value losses by improving quality, storage, logistics, and access to markets, among other things.

In each of these stages, technology can be leveraged to drive efficiency and change. At present, in India, there are multiple startups that have come up with innovative ideas for each of the above-mentioned supply chain steps. Further, existing solutions (warehousing and transportation logistics) have also incorporated technology, optimising their impact and reducing losses.

Based on our previous categorisation, we have segregated the available technological solutions that have been adopted by various Agtech players in India as well.

Table 2: Technologies and agtech players tackling PHFL in India

Factors causing losses	Technologies available	Agtech Players in India
Poor harvesting practices	Quality monitoring and traceability, instant on-field quality assessment, real-time farm monitoring and agronomy advisory, Artificial intelligence (AI)-based robot for agriculture, advanced machinery for harvesting	    
Poor produce handling	Advanced machinery for drying, threshing, sorting, grading, packing, benchmarking, smart machines that grade, sort and pack fruits and vegetables using AI	 
Lack of storage facilities and transportation	Cold storage solutions to transport perishables, climate-smart deeptech solutions for motor controls, IoT, and energy storage, Pan-India warehousing network, features like routing, efficient and accurate delivery systems	     
Lack of processing	Climate-clean micro food processing units	
Lack of market linkages	Financial forecasting and real-time mandi prices, connecting producers of food directly with retailers, restaurants, and service providers using in-house applications, user-friendly online mobile application that digitises the physical mandis, artiyas (commission agents), loaders, mills, and middlemen	   

The following sections unpack challenges across the identified value chain stages, and look at the technologies required to accelerate solutions in that particular space, with a focus on select interventions. The following criteria have been kept in mind for selecting the five agtech interventions relevant for the five value chain stages that need to be targeted to reduce post-harvest losses:

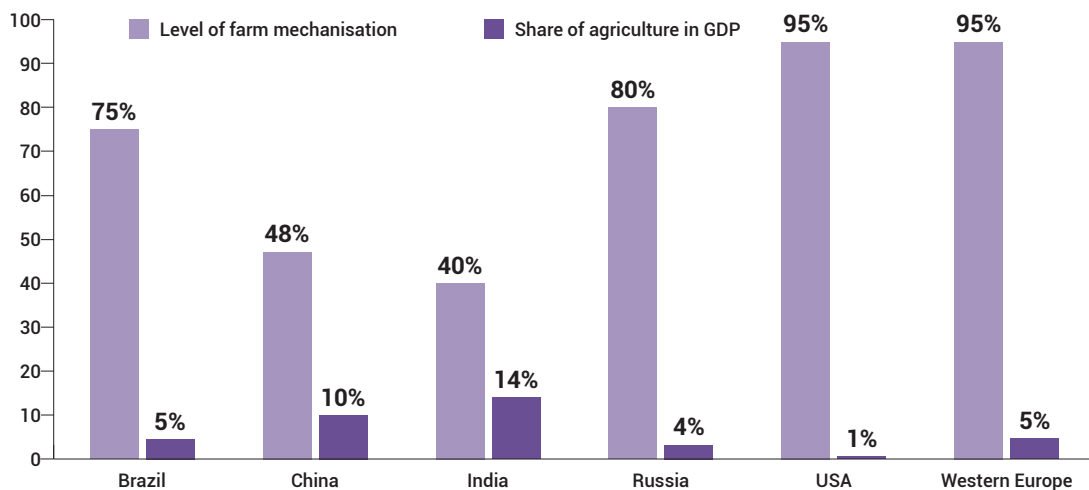
Figure 3: Challenges that require agtech interventions



Poor Harvesting Practices

THE PROBLEM: Harvesting is a critical operation in the value chain that impacts the crop quality. If the crop is not mature enough, or has high moisture content, chances are that early harvesting will lead to direct and cause loss in quality, weight, volume and thereby value of the product. However, delay in harvesting can be equally risky as it may lead to shattering losses. A study conducted in Punjab found that quantity lost during late-stage harvesting was 57% higher than loss during early-stage harvesting, due to shattering of grains (Shah et al. 2013).

Figure 4: Level of farm mechanisation and share of agriculture in GDP



Source: FICCI and Grant Thornton 2022

While the share of agriculture in GDP in India is higher compared to other countries (Table 3), the level of farm mechanisation remains surprisingly low at 40%. This also indicates that most smallholder farmers do not have access to proper technology for harvesting their produce. The situation is further exacerbated by the fact that not a lot of harvesting equipment available is suited for small and marginal landholdings. The low penetration of harvesting equipment, lack of knowledge on best practices and inability to afford machinery makes farmers dependent on cheap agricultural labour. However, during peak harvesting season, there are high chances of labour shortage as well, leading to a risk of losses due to shattering.

THE SOLUTION: In Myanmar, a study revealed that combine harvesting was able to cut down losses by 3% to 7% by weight (Lyu 2022). Accelerating farm mechanisation amongst smallholder farmers, along with flexible models such as pay-per-use, that eases adoption of technology can solve critical challenges in harvesting practices that cause food losses. It can minimise premature or late harvesting. Furthermore, increased mechanisation can lead to increased farmer incomes by 30% to 50% (ibid.). Leasing farm equipment to smallholder farmers, and increasing their availability near farms has gained much traction in the last decade.

Success Story

TAFE (Tractors and Farm Equipment) is a Chennai-based company that is currently India's second-largest tractor manufacturer. TAFE seeks to assist farmers to increase their farm productivity and output by integrating farming practices, popularising cost-effective soil and water management initiatives, and reducing the cost of farm inputs through farm mechanisation solutions through JFarm (TAFE n.d.).

JFarm was established in 1964 with the objective of increasing farmer incomes and improving farm productivity to meet growing food needs. JFarm's integrated farming services take a balanced approach to nutrient management by focusing on low-cost inputs, farm mechanisation, soil and water management practices, crop and seed selection, advanced crop production and protection technologies.

Around 2018, TAFE launched its JFarm Services App, (JFarm n.d.) a free platform that connects farmers who want to rent out their equipment. JFS is a farmer-to-farmer digital platform that enables access to affordable farm equipment. The app links farmers looking for farm equipment with farmers who own tractors via the Custom Hiring Centers (CHCs) near the farm gate. By promoting a just and open rental process, JFS leveraged digital technology to empower and generate additional revenue for farmers. It also improved farm productivity by increasing access to affordable farm machinery.

IMPACT: Currently, JFarm Services operates **across sixteen states and has partnered with nine state governments.** It has enabled access to affordable farm mechanisation for over 30 lakh farmers in India. Additionally, JFS has expanded to leverage the platform to connect FPOs who want to sell and buy produce as well as inputs. At present, they have been able to connect over 400 FPOs.





Poor Produce Handling

THE PROBLEM: Poor produce handling refers to poor practices during the stages of primary processing that include threshing, cleaning, drying, sorting, grading and others that are conducted at the farm level, usually by smallholder farmers themselves. The crop is still at the stage where weather-related vagaries could contaminate it if not handled properly, resulting in losses. Manual threshing can lead to incomplete separation of grain from husk or chaff, spillage and grain breakage (Kumar et al. 2017).

Improper cleaning may lead to insect infestation and mould growth during storage. Mould growth is also a risk that needs to be mitigated at the drying stage before the grain goes for storage. Additionally, the traditional method of natural drying (grains being left in the field or out in the open) makes it susceptible to being eaten by insects or birds.

For perishables, mainly fruits and vegetables, a key activity in the primary processing phase is cleaning, sorting and grading of produce. Fruits and vegetables need to be cleaned in order to prevent food-borne illnesses and ensure the quality of produce. Further, the produce has to be sorted, which involves the separation of rotten, damaged and diseased produce from the healthy stock. This process ensures that no secondary contamination can take place. Similarly, grading or categorisation of produce according to quality and maturity parameters is another important stage during handling, that can determine the shelf life of the produce and fetch a good market price for farmers if done correctly.

THE SOLUTION: For non-perishables, farm machinery for cleaning, threshing and drying is recommended as it minimises the risk of compromising crop quality. Technologies like solar drying, vacuum sealing, and hermetic storage bags can help increase the shelf life of produce. Solar drying is estimated to lead to an additional 22% increase in the market price of the commodity (Gunasekera et al. 2017). Additionally, robotics and AI-powered technology can help in quality management and assessment and lower the risk of spoilage and decay.

Many agtech startups in India work in ensuring quality management at the production level itself to minimise risk for farmers. Leveraging robotics and AI for crop inspection and spraying to keep pests in control (Niqorobotics), modular greenhouse technologies with full stack services are some of the solutions available within this space.

Success Story

Agrograde is a Maharashtra-based agtech startup that works to improve the marketability and profitability of fruits and vegetables by leveraging AI for the sorting and grading of produce (Agrograde n.d.). Through the AI-based system, Agrograde can detect the size, colour, foreign objects, surface quality, defects, diseases, and shape for a variety of commodities for grading.

Agrograde identified two problems – the inappropriate handling of fresh produce without an understanding of data and quality, and the trust deficit in the supply chain that led to losses. By enabling an efficient and transparent trading process, the startup has been able to address both issues. Additionally, the supply chain required tech-enabled infrastructure to solve the issue of quality that essentially governs the price and profitability of the product.

Agrograde designed affordable solutions that are meant for Indian varieties and environmental conditions. They also operate with a pay-per-use model that increases the affordability of their products for smallholder farmers.

By combining custom-built computer vision and machine learning (ML) algorithms, Agrograde's solutions can assess the quality, grade, sort, and generate a quality report. Their ML models are trained over a vast proprietary dataset, which helps provide accurate and reliable results that enable data-driven decision-making.

The Agrograde grading and sorting machine is a patent-pending device that sorts, grades and packs fruits and vegetables by assessing for size, quality, grade, shape, and defects using multiple cameras and sensors and generating results. While the pay-per-use model for this machine is popular with aggregators in certain geographies, traders and FPOs prefer to buy the machine and operate it to increase the marketability of the produce, while reducing their operating expenses as the machines improve their efficiency significantly.

IMPACT: Agrograde currently covers nine fruits and vegetables ranging from apples and oranges to onions and potatoes. Their solutions are being used in Maharashtra for onion and potato. Agrograde has worked with over 13 FPOs and traders aggregating produce from more than 2000 farmers to reduce handling of produce, improve marketability, and reduce operating costs. It has signed 23 LOIs under the SMART project (Initiative of World Bank, Govt. of Maharashtra and VSTF) to empower FPOs with post-harvest technologies.

With their solution, Agrograde has been able to **reduce by 74% the labour costs** required for sorting and grading. Further, they have achieved **an increase in the number of orders received by users by 25%** due to increase in marketability of the produce. Agrograde users were able to demand up to **20% higher margins** than the market with the use of this technology.



Lack of Storage and Transportation

THE PROBLEM: Poor storage conditions, lack of storage capacity, and inability to access or afford storage solutions are some of the major challenges smallholder farmers face while storing their produce. Studies have pointed to storage as the main stage where maximum post-harvest losses take place (Kumar et al. 2017). For example, a study reported that around 5-7% of maize produced in India was lost during storage (FICCI 2022).

Table 3: Cold Storage Infrastructure Overview in India

Type of Infrastructure	Infrastructure Requirement	Infrastructure Created	Investment Potential INR Crores	% Gaps
Pack-house	70,080	249	66,339	99%
Cold Storage (Bulk)	341,64,411 Metric Ton	318,23,700 Metric Ton	2,600	9%
Cold Storage (Hub)	9,36,251 Metric Ton		1,260	1,260
Reefer Vehicles	61,826	9,000	15,848	85%
Ripening Chamber	9,131	812	3,328	91%

Source: Gupta et al. 2021

Especially for perishables, storage techniques determine the quality of produce and shelf life. By adhering to accurate temperature and humidity standards, the shelf life of mature and undamaged produce can be extended (Kiaya et al. 2014). However, while there are technologies and solutions available in the market, their reach has been a major challenge. The market for cold storage is particularly scattered and disorganised, which has led to low uptake amongst farmers. 75% of India's cold storage units store mainly a single commodity, potatoes (MoFPI 2016).

A WRI study noted that majorly storage and transportation are the two stages where most of the losses take place in the value chain (Agarwal et al. 2021). Transport is hence another roadblock that leads to major losses; poor road infrastructure, and improper modes of transportation lead to contamination, high spillage, and risk of theft. For instance, a study revealed that for groundnuts in India, 2% of the produce is lost just during transportation. For fresh produce, this statistic is more concerning. A study of the mango value chain in India found that 10-15% of loss happened at the transport stage (FAO 2018).

THE SOLUTION: Studies have revealed that scientific storage practices can reduce post-harvest food losses by 6% (Ali et al. 2015).

When it comes to perishables and fresh produce, multiple interventions focusing on cooling and cold storage solutions have achieved the desired impact. Up-and-coming trends in cold storage and chain, including pre-cooling technologies, reefers, ripening chambers IQF, and others have the potential to reduce post-harvest losses. It is estimated that transporting fresh produce in refrigerated containers and closing the cold chain gap can reduce losses by around 35% (Maheshwar et al. 2006). However, operating costs for cold storage units in India can be double (\$60 per cubic metre) than that in developed countries (\$30 per cubic metre), making them an expensive venture. There is a need for decentralised storage systems that can harness the power of renewable energy, thereby lowering the cost of operations, and cater to Indian farmers better (Kumar et al. 2022).

For foodgrains, the usage of silo storage and scientific storage mechanisms can help bring down losses by almost 10% (Bahri et al. 2020). A few storage players in India, including Arya and StarAgri, have been successful in establishing a seamless link between the storage of produce and selling it to buyers at a good price, solving the challenges of PHFL at multiple stages of the value chain (Claus 2022).

Success Story

Arya.ag, India's largest grain commerce platform, has been able to reduce post-harvest losses and value losses for farmers by lowering distress sales through **enabling farmgate storage and finance options** for farmers and farmer producer organisations. Arya's business model has a keen focus on transparency and assurance of quality, quantity and payments.

Currently, Arya works across 21 states and 425 districts by leveraging warehousing and storage solutions and integrating them with financial options and market linkages, enabling a complete post-harvest value chain intervention (Jha 2022).

Arya's digital warehouses located near the farmgate allow farmers and FPOs to store their produce and get access to finance and working capital through Arya's integrated financial services Aryadhan, a non-banking financial corporation (NBFC). This allows farmers to store their grain safely in scientific storage, minimising volume and quality loss due to traditional storage, while value loss is also avoided by eliminating the risk of distress sales. The stored produce is then used as collateral to get loans that can allow farmers and FPOs to plan for the next season.

Digital storage allows real-time monitoring of the scientifically stored produce. Arya has been able to facilitate the reach of technologies like AI/ML and IoT to farmers through their integrated services. In Telangana, UNR Farmer Producer Company was able to utilise Arya's services efficiency to increase their income from INR 9 million to INR 12 million. Similarly, BBWS Farmers Producer Company achieved an additional income of INR 9 million by leveraging Arya's tech-enabled storage solutions (Das 2022).



IMPACT: Through their network of 10,942 warehouses, Arya.ag has worked with over 650,000 farmers, 500 FPOs and 8,000 agri enterprises (Arya ag n.d.). For farmers, their business model has been able to ensure a growth of 15-25% in their value realisation. Arya's financial solutions, geared to prevent distress sales by leveraging storage, have over 40% first-time borrowers who are accessing working capital through a formal channel, of which 10% are women. The impact of Arya.ag has been massive, effectively championing storage solutions, along with integrated financial services, to reduce post-harvest losses and increase farmer income.



Lack of Processing

THE PROBLEM: The Problem: Only 7% of India's perishable produce is processed, despite the processing industry being one of the largest in India.

While there are major stages of post-harvest food losses that occur up till this stage, there is a significant value loss that happens when facilities of processing are not available for farmers closer to the farmgate. This leads them to miss out on the opportunity to increase income through value addition (Ganesh et al. 2018).

ELEVATING FARMERS USING AGTECH

The major problem at this stage is the absence of processing facilities closer to the farmgate. While there are losses that occur during processing as well, especially when it comes to traditional ripening practices and inappropriate processing of crops, the challenge of lack of processing infrastructure is far higher. PRS India found a gap of 91% between the required ripening chambers and the actual availability on the ground (Kodidala et al. 2018).

THE SOLUTION: Having the option to process crops near the farmgate would allow farmers to tackle the perishability of their produce, and would reduce distress sales. Farmers that are bound to sell produce quickly before they start rotting (especially when it comes to fruits and vegetables) can instead have the option of selling to food processors, or processing the crops themselves by leveraging models of agripreneurship.

The food processing industry in India comprises 2.5 million enterprises, which are unregistered and informal, and contributes to 74% of the employment in the industry (Gunasekara et al. 2017). While the government has recognised the need to develop this industry further, the schemes available only apply to medium and large processors. Schemes are also available for farmer producer groups to venture into food processing, but it has not yet taken off.

Agtech startups such as S4S Technologies have tried to address the problem of post-harvest food losses through food processing. By sourcing directly from farmers at the village level and employing food processing, S4S Technologies has been able to successfully reduce post-harvest food losses.

Success Story

S4S Technologies launched operations in 2019 to address the problem of PHFL by providing a near-farmgate food processing platform and transforming food losses into value-added products. Their farmgate solutions enable landless women and farmers to become micro-entrepreneurs and **increase their income by 60-110%** (S4S technologies n.d).



Their business model rests on village-level sourcing and providing the right combination of technology, market and finance to women micro-entrepreneurs, who process the crops into value-added products. The products are then supplied to retailers in the food and beverage industry. **The processing of excess vegetables and fruits that would have otherwise rotten is the intersection where S4S is able to reduce both direct and indirect losses at the same time.**

The women entrepreneurs work as aggregators that buy crops like ginger, garlic, carrot and beetroot from farmers and utilise S4S solar-powered technology to dry them. The startup then purchases these dried vegetables from the aggregators and supplies them to institutional clients. The technology works on a rent-based model to prioritise

affordability. Currently, their solar-powered dryer can process more than 45 different kinds of food categories including fruits and vegetables, pulses and grains, nuts, spices, tea, coffee, milk, and alternate proteins.

IMPACT: To date, S4S Technologies have facilitated the creation of 1200 microentrepreneurs with assured additional income, and have facilitated market linkages for 60,000 smallholder farmers across Maharashtra, Odisha and Tamil Nadu. Their solution has an additional goal of being energy efficient with a minimum carbon footprint. To this end, S4S has been able to save 37,000 mt of CO2 emissions annually by utilising solar-powered technology for drying and food processing.

The potential impact that S4S Technologies, a relatively new startup can accelerate has been recognised by the Government of India, alongside Gates Foundation, USAID, UKAID and others who have funded them.



Lack of Market Linkages

THE PROBLEM: While smallholders face many challenges with market linkages, a major problem that leads to both food losses and value losses is the lack of market and price information, with limited access to multiple buyers at the farmgate. The inability to sell at the correct time may lead to the produce rotting, getting contaminated, and becoming unfit for sale. Similarly, selling too soon without following adequate post-harvest processes can lead to volume losses due to a reduction in quality.

While there are storage solution providers, processors, and retailers within the agriculture markets, very few have been able to directly work with farmers. This has led to farmers being unable to leverage the price increment that happens at the value-addition stage or enjoy the benefits of a shorter supply chain.

THE SOLUTION: The Indian government has made many strides in improving agriculture markets for farmers. Different laws have made headway in allowing for private players to penetrate the market, while others have moved towards digital and decentralised marketing structures.

Supply chain tech, and essentially agtech players that work in improving market linkages are responsible for US\$12 billion market potential (Madan et. al. 2020). Multiple inefficiencies have been addressed through agtech when it comes to improving the supply chain.

Agtech has been used to address multiple inefficiencies in the supply chain. Resolving information asymmetry, establishing better price discovery mechanisms, enabling out-of-market transactions and digital marketplaces are a few critical interventions that have helped reduce post-harvest losses while simultaneously leading to an increase in farmer incomes. Ninjacart, DeHaat, Bijak, Waycool, and Origo are some major startups that have had an impact over the last few years.

Success Story

WayCool's supply chain technology is focused on connecting farmers' outputs to retailers through a comprehensive tech stack called CENSA. The organisation procures and manages fresh produce from farmers and FPO, and provides end-to-end services, ensuring transparency and intelligence at every stage.

One particular case study allows a deeper insight into WayCool's impact in reducing post-harvest losses and increasing farmer incomes.

SITUATION: Tomato is one of the four major commodities procured and managed by WayCool.

Around 15 tonnes of tomatoes are procured daily from 26,000 farmers in the organisation's network. Due to heavy rains hampering the regular procurement, WayCool was unable to procure from the traditional tomato-growing belt of Karnataka and Tamil Nadu.

INTERVENTION: Coimbatore was selected as the alternative geography for tomato procurement by WayCool. However, Coimbatore generally grows the Shivam variety which has few modern trade takers due to its low shelf-life (37% of WayCool's revenue is generated from modern trade; e-commerce and quick-commerce). WayCool chose to conduct a pilot by sowing and procuring the Saaho variety which has a longer shelf life compared to Shivam.

IMPACT: While growing the Saaho variety costs 38% higher than Shivam, the yield is 29% higher, and the farmers were able to earn 56% higher gross revenue. This led to an 86% higher net profit for the farmers that season. Additionally, WayCool was able to reduce the volume loss of tomatoes by 5-10% in the Saaho variety as compared to 30-40% for Shivam.

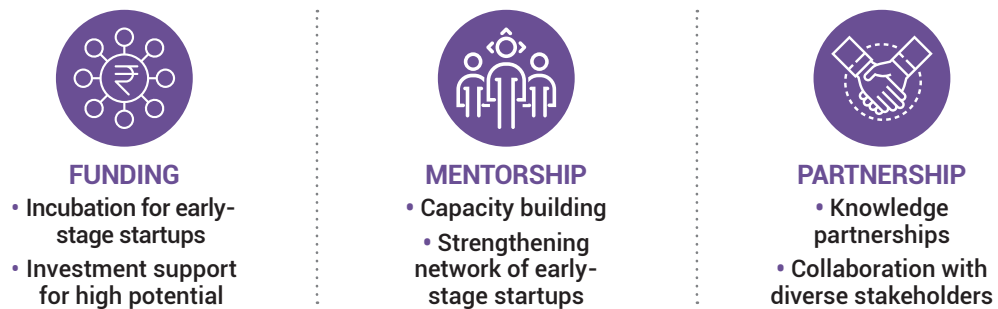
WayCool's phygital business model connects over 200,000 farmers and 165,000 retailers, and enables the movement of over 2000 tonnes of food per day. By taking a demand-led approach to the food value chain, the organisation has been able to successfully address the information asymmetry faced by farmers. **Their approach has ensured higher income for farmers as well as a reduction in food losses across the value chain.**



How Can Funders Accelerate Agtech Startups to Reduce PHFL?

Funders, especially foundations and social enterprises are actively working to incubate and accelerate startups in the agriculture ecosystem. The role of funders in the agtech ecosystem can be categorised into three buckets:

Figure 5: Role of foundations and other funders in boosting agtech interventions



Multiple foundations in India have played an enabling role for agtech startups. The Bill and Melinda Gates Foundation (BMGF) and Tata Trusts are two prominent foundations in this space. BMGF focuses on enabling access of smallholder farmers to digital technologies which can increase their income. Tata Trusts founded Social Alpha with the purpose of incubating and accelerating startups solving complex problems. Multiple agtech startups working to reduce PHFL, including AgNext, and Tan90, have received funding through the India Agritech Incubation Network (IAIN) powered by Social Alpha. A focus on the aspect of reducing post-harvest food losses through the enabler of technology will also enable focus across multiple goals; building resilient food systems, improving farmer incomes and contributing to the following SDGs:

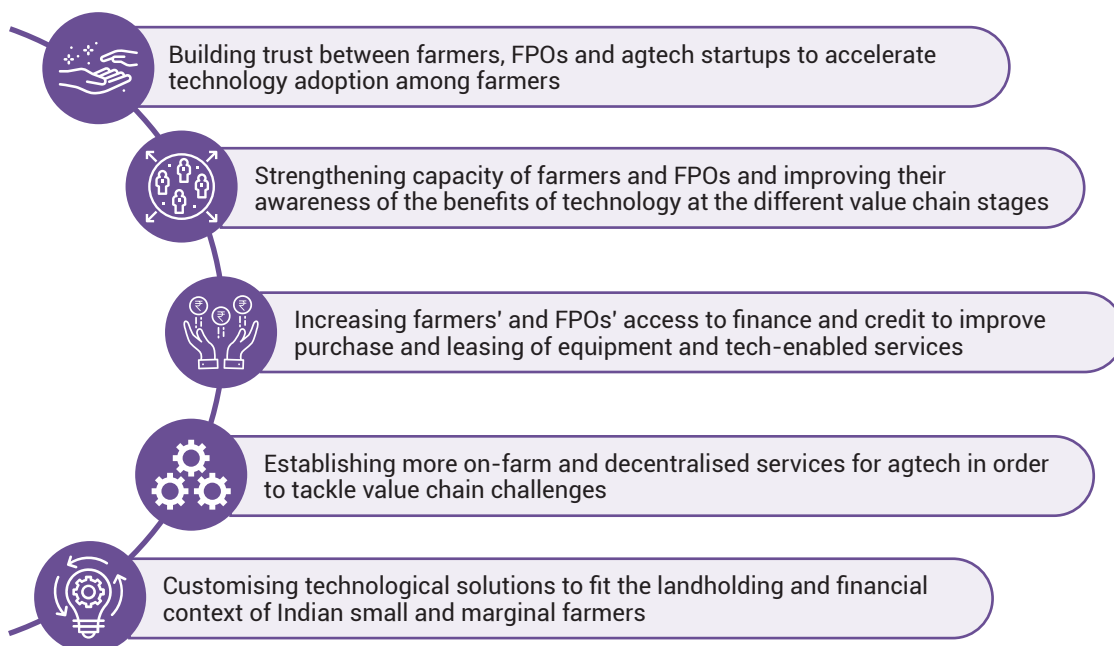
Figure 6: SDGs related to reducing PHFL and increasing farmer incomes through agtech interventions



A key driver that has emerged from the case studies above, is the focus on technology adoption by farmers and the development of an entrepreneurial spirit for them to derive greater value within this space. Startups have found success in driving technology adoption among farmers and farmer groups by creating an enabling ecosystem for them. However, they need to leverage support from foundations that have experience in building awareness and on-ground capacity to increase service adoption by farmers. While agtech's market potential stands at US\$24 billion, the market penetration is lower than 1% (Madan et al. 2020). This is where funders and startups can work together to achieve the maximum impact.

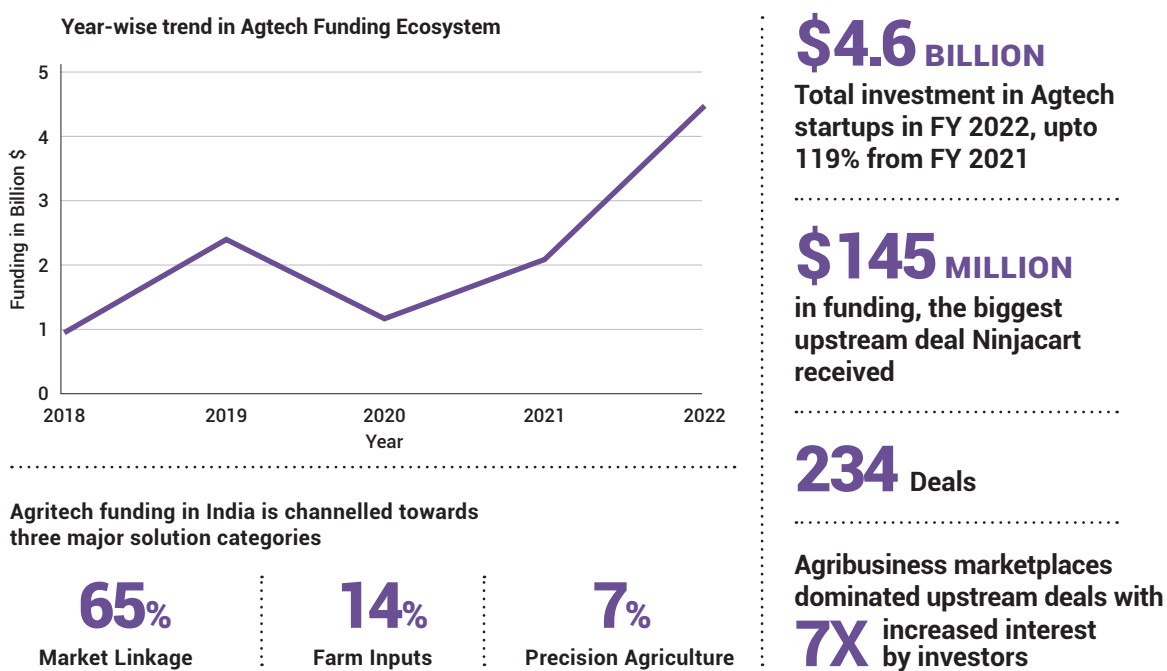
ELEVATING FARMERS USING AGTECH

Figure 7: Focus areas for funders to enable agtech growth



Agri-tech funding in India has grown four times since 2016, with nearly 65% of the investment being towards supply chain tech and output market linkage, and financial services (Madan et. al. 2020). However, other areas highlighted in this perspective will also require investments to unlock solutions that can reduce post-harvest food losses.

Figure 8: Technology landscape of Indian agriculture



Source: Siwal 2023

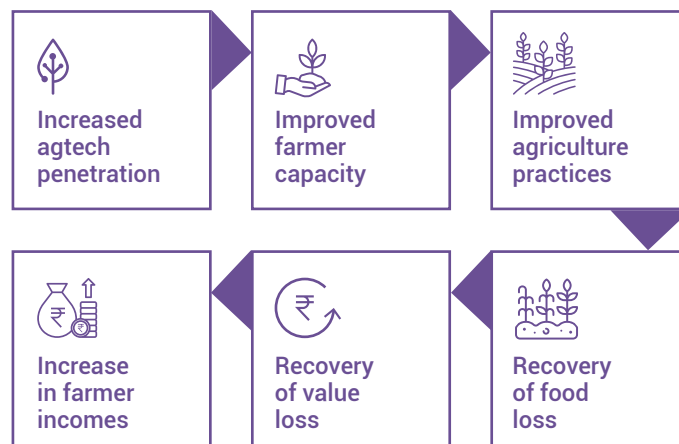
The Government of India has made significant strides in creating an enabling environment for agtech in India as well. Following are some of the policies that have fostered the growth of agtech interventions in the ecosystem:

- **Enabling cold chain infrastructure:** A total of INR 196.5 crores have been allocated to the Integrated Cold Chain and Value Addition Infrastructure, a scheme whose objective is to provide seamless cold chain and preservation infrastructure facilities from farm gate to the consumers. The development of new-age technologies that can improve the shelf life of horticulture, meat, dairy, fish and other perishable commodities, are covered under this scheme (PIB 2022).
- **Accelerating food processing and micro enterprises:** The government has multiple schemes in place to promote the growth of the food processing industry and reduce post-harvest value loss. Under the Pradhan Mantri Sampada Yojana, there are three schemes that:
 - enable creation and expansion of processing infrastructure;
 - encourage a group of entrepreneurs to set up food processing units based on a cluster approach that link producer groups through supply chain tech and
 - promote manufacturing of food that meets safety and quality guidelines (ibid.).
- **Promoting infrastructure, agripreneurship and agtech innovation:** The Agriculture Infrastructure Fund, for which the Government of India has already mobilised INR 30,000 crores, has a special focus on infrastructure development at the post-harvest stage (PIB 2023). In order to reduce post-harvest food losses, the scheme will focus on building marketing infrastructure, logistics infrastructure including cold chain, and direct priority sector lending towards innovation. The scheme envisions PPP models to attract investments, and the direct investment is expected to further accelerate the growth of entrepreneurs leveraging innovative technologies (Agricoop n.d.).
- **Building a database for customised solutions:** The Agri Stack or the India Digital Ecosystem for Agriculture (IDEA) has been under construction since 2020. It aims to create a National Digital Agriculture Ecosystem by building a dynamic, public, and open database of farms, farmers, and crops. This unified platform will utilise advanced technologies to offer customised, end-to-end solutions, enhancing efficiency, productivity, and income for farmers (PIB 2022).

In conclusion, accelerating agtech adoption by farmers requires a deeper understanding of the Indian smallholder's context. Funders working in the Indian agriculture space have been pivotal in guiding startups through incubation and acceleration. A focus on creating solutions geared to Indian smallholder farmers' specific challenges will allow agtech to move forward with a purpose-driven mindset and unlock immense potential.

ELEVATING FARMERS USING AGTECH

Addressing the challenge of post-harvest food losses will allow the following goals to be achieved:



It is worth emphasising the potential of addressing post-harvest value losses through agtech interventions. Not only does agtech have the maximum potential to address the challenge, but additionally, it will speed up much-needed improvements in agriculture practices and farmer capacities, enabling the enhancement of farmer incomes.

References

- Agarwal, M, Agarwal, S, Ahmad, S, Singh, R and Jayahari, KM 2021, *Food Loss and Waste in India: The Knowns and the Unknowns*, World Resources Institute India.
- [Agrograde.com](#) n.d. viewed on April 3, 2022.
- Ali, J, Sharma, A and Rani, P 2015, 'Overview of Grain Drying and Storage Problems In India.', *International Journal of Engineering Research and General Science*, vol. 3, no. 5, September-October.
- [Arya.ag](#) n.d., viewed on March 17, 2023.
- Bahri, V 2020, *Foodgrain storage losses in India: Waste not, want not*, Trade Promotion Council Of India.
- Boxall, RA 2001, 'Post-harvest losses to insects—a world overview', *International Biodeterioration & Biodegradation*, vol. 48, nos. 1–4, pp 137-152.
- Claus, C 2022, *Arya.ag announces a four-fold jump in its profits in H1FY23*, Food Infotech, viewed on March 20, 2023.
- Chowdhary, S 2022, 'Food Producer Organisations: Farmers reap bumper gains', *Financial Express*, viewed on March 17, 2023.
- Department of Agriculture, Cooperation & Farmers' Welfare [Agricoop] n.d., *Scheme Guidelines for CENTRAL SECTOR SCHEME of Financing facility under 'Agriculture Infrastructure Fund'*, viewed on March 22, 2023.
- Down To Earth 2018, *Point of no agri-returns Part 2: Every year, farmers lose Rs 63,000 crore for not being able to sell their produce*, viewed on March 18, 2023.
- Food and Agriculture Organization 2018, *Food loss analysis: causes and solutions - Case study on the mango value chain in the Republic of India*, FAO Rome. p. 58.
- Ganesh, U, Shankar, M, Banerji, S, Mahadevan, K, Borthakur, S, Thukral, C and Yadav, S 2018, 'Reducing Post-harvest Losses in India: Key Initiatives and Opportunities', *Intellectap*.
- Grolleaud, M 2002, *Post-harvest losses: discovering the full story. Overview of the phenomenon of losses during the post-harvest system*, FAO, Rome, Italy.
- Gunasekera, D, Parsons, H and Smith, M 2017, 'Post-harvest loss reduction in Asia-Pacific developing economies', *Journal of Agribusiness in Developing and Emerging Economies*, vol. 7, no. 3, pp. 303-317.
- Gupta, K, Garg, T, Kumari, A, & Kumar, S 2021. 'Enabling Cold-chain Infrastructure Development in India: Evolution and Assessment of Policies and Institutional Mapping.' *Alliance for an Energy Efficient Economy*.
- India Maize Summit 2022, *Maize Vision 2022: A Knowledge Report*, FICCI India.
- [Jfarmservices.in](#) n.d. viewed on March 20, 2023.
- Jha, R 2022, *How Arya.ag's post harvest solutions have empowered lakhs of Indian farmers*, *Plunge Daily*, viewed on 18 March 2023.
- Kiaya, V 2014, 'Post-harvest losses and strategies to reduce them: Technical Paper on Postharvest Losses', *Action Contre la Faim (ACF)*, vol. 25, pp.1-25.
- Kodidala, S 2018, *Food processing Infrastructure in India*, PRS Blog, PRS Legislative Research, viewed on 19 March, 2023.

ELEVATING FARMERS USING AGTECH

- Kumar, D and Prasanta, K 2017, '[Reducing Postharvest Losses during Storage of Grain Crops to Strengthen Food Security in Developing Countries](#)', *Foods (Basel, Switzerland)* vol. 6, no. 1.
- Kumari, P 2022, 'A Sustainable Solution for Post-Harvest Management in India', *Energy Review*, vol. 4, no. 5.
- Lyu, S 2022, '[BRIEF - Role of Mechanisation in Reducing Food Loss and Waste in China](#)', United Nations Economic and Social Commission for Asia and the Pacific, Thailand.
- Madan, A, Putrevu, R, Khurana, S, Goenka, S, Sinha, D and Mor, H 2020, '[Agritech-towards transforming Indian Agriculture](#)', EY, viewed on 3 April, 2023.
- Maheshwar, C and Chanakwa, TS 2006, 'Postharvest Losses Due To Gaps In Cold Chain In India-A Solution', *Acta Horticulturae*, 712, 777-784.
- McKinsey & Company, 2021, '[How to Reduce Postharvest Crop Losses in the Agricultural Supply Chain](#)', viewed on March 10, 2023.
- Ministry of Agriculture & Farmers Welfare [MoA&FW] 2022, '[Digital Technology in Agriculture](#)', viewed on March 19, 2023.
- MoA&FW 2023, '[Agriculture Infrastructure Fund crosses Rs.30,000 crore mark of capital mobilization for projects in agriculture sector for creation of post-harvest management infrastructure and community farming assets](#)', viewed on March 21, 2023.
- Ministry of Food Processing Industries, Government of India [MoFPI] 2016, '[Opportunities in Cold Chain Sector in India](#)', viewed on March 18, 2023.
- MoFPI 2022, '[Infrastructure Under PMKSY](#)', viewed on March 21, 2023.
- MoFPI 2023, '[Notes on Demands for Grants, 2023-2024](#)', DEMAND NO. 45.
- NABCONS 2022, '[Study to Determine Post-Harvest Losses of Agri Produces in India](#)', MOFPI, New Delhi.
- Pokhrel, B 2021, 'Review on post-harvest handling to reduce loss of fruits and vegetables', *International Journal of Horticulture and Food Science*, pp. 48-52.
- S4S Technologies n.d., '[Impact](#)', viewed on March 27, 2023.
- Shah, D 2013, '[Assessment of pre and post harvest losses in tur and soyabean crops in Maharashtra](#)', Agro-Economic Research Centre Gokhale Institute of Politics and Economics.
- Siwal, P 2023, '[Technology landscape of Indian agriculture](#)', Sattva Knowledge Institute, viewed on 20 March, 2023
- Stathers, T, Holcroft, D and Kitinoja, L 2020 'A scoping review of interventions for crop postharvest loss reduction in sub-Saharan Africa and South Asia', *Nature Sustainability*, vol. 3, pp. 821-835.
- [Tafe.com](#) n.d., viewed on March 25, 2023.
- Tiwari, A Harishchander, H and Rane, M V, 2022, 'Cold Storage in India for Small Farmers - Current Status and Challenges', *International Refrigeration and Air Conditioning Conference*, Paper 2472.
- [Waycool.in](#) n.d. viewed on April 3, 2023.
- [Waycool.in](#) n.d., '[Case Study](#)', viewed on April 3, 2023.



