Learning Brief

December 2021

# How can solar-powereddecentralised food processing increase value chain efficiency, inclusiveness and resilience?

Insights from S4S Technologies' experience in India during the COVID-19 pandemic

# Contents



# Executive Summary


**Like in many developing countries, the growth of India's food processing sector is hampered by efficiency challenges**. Recently, these challenges have been exacerbated by the COVID-19 pandemic, which further disrupted the value chain by impeding interactions between market actors.

**This learning brief aims to explore the advantages and drawbacks of renewable energy-powered decentralised food processing units, as compared to traditional centralised systems relying on grid electricity.**The study is based on both quantitative and qualitative data collected over a period of 6 weeks, between November 2020 and January 2021, and draws of the experience of S4S Technologies, an agricultural processing platform serving shelf-stable, nutrition-rich, and convenience foods to industrial kitchens and packaged food companies, which operates both centralised and decentralised facilities.

**The study found that decentralised food processing has the potential to reduce reliance on travel and transportation, increasing operational flexibility, and improving energy efficiency and cleanliness, thus contributing to increased value chain efficiency, inclusiveness and resilience**. While centralised processing allows for economies of scale and better resource and information management, decentralisation increases efficiency by minimising long-distance movements. Decentralised processing also has a greater social and environmental impact. This model is more easily scalable, and its flexibility makes it more resilient than centralisedprocessing. Finally, food processing can be optimised by drawing on the strength of both models.

**However, scaling the use of off-grid processing units faces a number of challenges and requires a common effort from partners across the ecosystem**.For instance, off-grid processing and food companies require capital to scale up their business models. There is little awareness of the economic potential of processing among smallholders, and those interested in investing in the technology often lack access to finance, market linkages and training on how to run a successful business and adhere to food safety standards.Addressing these challenges is resource intensive and thus requires contributions from government and donor agencies, finance institutions, NGOs, off-takers and off-grid processing equipment suppliers alike.

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# 1 Introduction

## 1.1 Context

**Like in many developing countries, the growth of India's food processing sector is hampered by efficiency challenges.** Food processing is the transformation offresh agricultural products into foodand ingredients suitable for consumption, cooking or storage, and includes activities such as drying, grinding, and packaging. Outputs are consumed by the fast-moving consumer goods (FMCG) and food service industries. One of the largest in the world, India's food processing sector is expected toreach $535 billion by 2025.[1] More than40,000 organised companies and over 230,000 small and medium enterprises (SMEs) are involved in food processing in the country.[2]Mostfresh produce is sourced from the country's 120 million smallholder farmers.[3]However, processing ispoorly integrated. Once harvested by farmers,products go through five to eight successive market players before reaching the FMCG and food services industries.This has a negative impact on the environment by leading to transport-related greenhouse gas emissions andmakes the whole value chain inefficient with up to 40% of post-harvest losses, added logistics costs, and less income for farmers.[4]

**These challenges have been exacerbated by the COVID-19 pandemic, which further disrupted the value chain by impeding interactions between market actors.** On March 24, 2020, the country entered a total lockdown. For six months, only essential travel was allowed. This hada negative impact on the value chain. Restricted movement of labour reduced the availability of workforce during the harvest season, leading to lower production and available fresh produce supply for processors. In addition, imports and exports were disrupted and demand from local retailers and restaurants decreased, leading to supply-demand imbalances and increased price volatility. This resulted in lower profit, job losses and reduced incomes throughout the value chain. Small informal businesses and farmers in particular were gravely affected and their resilience capacity acutely reduced.[5]

**However, decentralising food processing has the potential to increase value chain efficiency, inclusiveness and resilience**. This hypothesis was the driving force behind the development of S4S Technologies' business model. The company is one of the firsts in the country to supply solar-powered dryers. By eliminating reliance on centralised energy sources and enablingprocessing to take place at farm gate,equipment that generates off-grid energy for productive uses can thus address these value chain weaknesses, while having a positive impact on the environment by reducing the need for transport and substituting polluting energy sources, and benefitting vulnerable market players. However, decentralised food processing is still in its infancy, andthere is a need to better understand both the benefits and challenges that come with this model.

**Based on S4S Technologies' experience, this learning brief aims to explore the advantages and drawbacks of renewable energy-powered decentralised food processing units,as compared to traditional centralised systems relying on grid electricity.** This study was developed by S4S based on a data-driven analysis of the pros and cons of centralised and decentralised food processing. Conducted during the COVID-19 pandemic, the research draws on the company's experience in operating both centralised and decentralised food processing units,and tests how the two can be impacted by external shocks.Thestudy throws light on how agricultural and food industries can look at both processing methodologies in regular and emergency situations and has helped S4S to re-assess and strengthen its supply chain during scale-up. Lessons were drawn that can be used to support the growth of an efficient, inclusive and resilient food processing industry in India and other developing countries.

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[1] Invest India. "Food Processing Industry in India - Statistics & Overview | Invest India." Investindia.gov.in, 2018

[2] Ministry of Food Processing Industries. "Annual Report 2019-20." Government of India, 2020.

[3] WBCSD. "Impact of COVID-19 on Smallholder Farmers – Insights from India." World Business Council for Sustainable Development (WBCSD), 2 June 2020

[4] Intellecap. Reducing Post-Harvest Losses in India: Key Initiatives and Opportunities. Rockefeller Foundation, Feb. 2018.

[5] Ibid.

## 1.2 S4STechnologies' business model

**Established in 2011, S4S Technologies a decentralised agricultural processing platform serving shelf-stable, nutrition-rich, and convenience foods to industrial kitchens and packaged food companies.** The company's preservative-free, lightweight, fully traceable, ready-to-use vegetables replace fresh supplies in these industrial applications. In doing so, S4S saves customers time, purchase hurdles, and daily cooking efforts, while still delivering products at a competitive price. S4S serves over 850 small and large customers and processes 25,000 tons of produce annually.

**At the heart of the S4S business model is the solar-powered, decentralised food dehydration system operated by women entrepreneurs**. S4S works with over 800 women entrepreneurs in 23 villages in Maharashtra and Odisha to convert produce into non-perishable products at farm level by enabling them to access and operate a solar dryer, which allow them to process up to 100kg per day. Micro-entrepreneurs often are smallholder producers, who take on processing as an additional income-generating activity.

**The non-perishable produce is then made fit for the customer at the central factory located in Aurangabad, Maharashtra.** Dehydrated products are graded, sorted, and packaged before being supplied to S4S's industrial clients. S4S's business model is summarised in Figure 1 below.

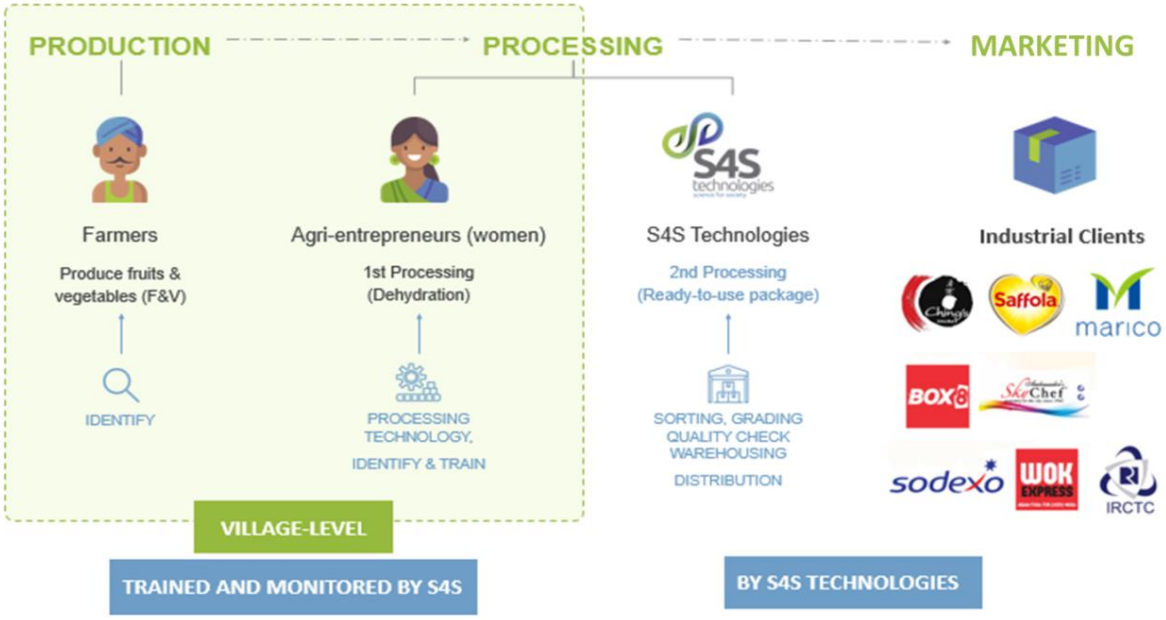


Figure 1: S4S Technologies' business model

# 2 Methodology

The study was carried outover a period of six weeks, between November 2020 and January 2021, and based on a mixed-methods approach.Data was collected through key informant interviews at the central factory and 11decentralised facilitiesin order to map which type of supply chain carried what opportunities and challenges. The study focused on the processing of ginger and onion for the centralised facility, and ginger only for the decentralised ones.

Quantitative data was collected on the number of days of operation, overall throughput, cost of throughput per kilogrampre- and post-pandemic, and energy costs. This allowedS4S to assessthe difference in performance between the two processing methods in a quantified manner.In addition, a qualitative assessment was conducted on regulatory challenges and associated cost and time, logistics and manpower aspects, as well as climate impact.

# 3 Findings

The data collected enabled S4S to identify differences in operation and performance between centralised and decentralised processing facilities.The findings enabled the company to draw some key lessons on the pros and cons of solar-powered, decentralised processing,summarised in **Error! Reference source not found.**,

Table 1. Pros and cons of decentralised processing

| Parameter | Decentralised | Centralised |
|---|---|---|
| Ease to set up | ⊕ New units can be established in only three days and have a lower investment cost per unit<br>⊕ Regulatory requirements are easy to meet and the administrative procedure is simple | ⊖ Setting up a new facility or equipment requires several months and require higher upfront investment<br>⊖ Regulatory requirements and administrative procedures are complex |
| Efficiency | ⊕ Lower post-harvest losses<br>⊕ Lower capital expenditure and overheads<br>⊖ Lower economy of scale<br>⊖ Less control over quality | ⊕ Higher economy of scale<br>⊕ More control over quality<br>⊖ Higher post-harvest losses<br>⊖ Higher capital expenditures and overheads |
| Employment opportunities | ⊕ Creates job opportunities in remote areas<br>⊕ Higher incomes for micro-entrepreneurs (~INR 6,500/month)<br>⊕ Better job quality and accessibility | ⊕ More labour intensive<br>⊖ Lower income for wage workers (~ INR 5,000/month)<br>⊖ Lower job quality |
| Environmental impact | ⊕ Reduces emissions by reducing food waste and transportation | ⊖ Greater emissions due to food waste and transportation |
| Resilience | ⊕ Breakdowns lead to less value chain disruption<br>⊕ Greater modularity enables to quickly adapt to changes in crop availability and prices<br>⊕ Easier to operate in case of travel restrictions<br>⊕ Lower contamination risks in case of pandemics | ⊖ Breakdowns lead to greater delays and profit losses<br>⊖ Set-up cannot be modified to address market changes<br>⊖ Travel restrictions can lead to unavailability of labour and halt operations<br>⊖ Higher workforce concentration increases contamination risks in case of pandemics |

**Decentralised processing units are easier to establish.** Indeed, regulatory aspects in a decentralised set-up are simple and easy. In comparison, setting up a centralised factory requires to abide by multiple laws and filings on food, pollution, and labour, which is costly and complex to implement. As a result, accessing the necessary resources to set up a centralised unit is more difficult. In addition, increasing processing capacity can be done more quickly. A decentralised unit is modular, easy to install and can be set up in only three days. In comparison, the turnaround time is much longer for centralised units. Capacity cannot be increased incrementally, and ordering and installing the processing equipment takes at least a few months. As a result, decentralised processing constitutes a more scalable model.

**While centralised processing allows foreconomies of scale and better resource and information management, decentralisation increases efficiency by minimising long-distance movements.** Indeed, larger plants have the advantage of benefitting from economies of scale. For instance, S4S found that in its centralised factory, employees were able to share equipment. Utilities like vegetable cutters were used 24 hours per day, againstonly one hour in decentralised settings. In addition, logistics and manpower are better defined. In decentralised set-ups' operations are more fragmented, and lack information systems, which does not enable them to optimise resource allocation and lead to wasted time.However, near farm gate processing reduces long-distance movement of raw materialsfrom farmers to processors. This decreases logistics costs, but also wastage in the supply chain, asthe limited shelf-life of agricultural produce and handling by multiple middlemen means that long-distance movement is likely to lead to the damage of goods, andpost-harvest loss rates up to 40%.[6]Overall, S4S found that savings on wastage and transportation increased margins by 15% as compared to centralised processing. These cost savings also benefit the end customers, who do not have to absorb the wastage cost, but also the farmers, who can improve their margin by up to 3%.

**Decentralised processing provides better work opportunities.**Indeed,itgenerates quality work opportunity for rural populations, and women in particular. While centralised processing facilities generate employment opportunities, these only benefit people located in the vicinity of a factory. Wage workers from centralised processing plants can make up to INR 25 per hour, orINR 5,000 per month for 25 full days of work[7], but spend time and money travelling to their place of work.In addition, processing activities conducted in centralised facilities often requires heavy lifting. In comparison, decentralised units can provide economic opportunities for people who live in remote areas with little economic activity. S4S found that by processing 2,500kg of ginger or onion, a micro-entrepreneur would earn a net income of INR 6,500 per month,or INR 65 per hour as decentralised processing only requires about four hours of active work per day. This not only results in a higher income than for wage workers, but represented a 50% to 200% increase in income for micro-entrepreneurs as compared to their previous economic activities – which were usually limited to agricultural production. In addition, decentralised processing operations are lessphysically strenuous, which make them more accessible to women. Decentralised processing does not require entrepreneurs to travel, and provides them with the flexibility to choose their own schedule, and the lower level of effort required frees time and enables them to engage in other income generating activities.While centralised processing is more labour intensive and thus has the potential to create more jobs at once, decentralised processing is more inclusive, and leads to higher quality, better paid jobs.

**Decentralised processing is moreenvironmentally-friendly.**Indeed, food wastage is estimated to contribute to about 8% of greenhouse gases (GHG) emissions.[8]Similarly, even when food does reach the processing plant and end customer, transportation and refrigeration also generates emissions through their reliance on fossil fuels.As shown in Table 2, by reducing both post-harvest losses and transportation, our studyfound thatthe

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[6]Intellecap. Reducing Post-Harvest Losses in India: Key Initiatives and Opportunities. Rockefeller Foundation, Feb. 2018.

[7] Eight hours per day

[8]FAO. Food Wastage Footprint & Climate Change. 2015.

existing processing capacity of S4S decentralised unitscontribute to a reduction of 0.16Mt $CO^2$ e. In addition, decentralised processing units'energy requirements can be met by renewable energy sources.As compared to drying units using coal basedelectricity, S4S' decentralised units are estimated to avoid2 kg of $CO^2$ efor each kilogramme of food processed that otherwise could have been wasted[9].

**Table 2. Summary of findings**

| Parameter | Quantity | Reduction in $CO^2$ emissions (Kg) |
|---|---|---|
| Reduction in food losses (in kg of produce)* | 37,800 | 79,380 |
| Saving through minimal logistics** | 7,560 | 6,804 |
| Processing saving as a result of avoiding coal based energy base (in kWh of energy replaced)*** | 37,800 | 75,600 |
| Total | | 161,784 |

* 1Kg of food waste in our landfills sends 2.1Kg of $CO_2$ into the atmosphere[10]

** 1 kWh of energy generated from coal based sources emits 1.01 Kg of $CO_2$[11]

**The flexibility of the decentralised processing modelmakesitmore resilient.**For instance,with decentralised processing, the consequences of breakdowns are less severe: if one facility runs into some technical issue, it only affects a small volume of production while other units remain operational.Incomparison, in a centralised system, any breakdown leads to revenue loss as the processing is to be completely halted. Decentralisation thus increases reliability of supply. Moreover, decentralised food processing units provide more production flexibility. Larger central factories have a fixed set up dedicated to the processing of a specific category of crops (e.g. fruits and vegetables, or pulses) and set of products, which cannot be modified. In comparison, in a decentralised unit, the set up can easily be changed and minor addition or deletion of equipment sets can enable to process up toten categories of crops, and a total of over 45 different products.This can enable for a more diversified production, which can protect crop specific shocks, such as decreased supply or raw materials due to poor harvests,or changing prices.

[9] EPA. "Sustainable Management of Food". 2021

[10] ibid

[11] EIA, "How much carbon dioxide is produced per kilowatthour of U.S electricity generation?". 2021

**Box 1. Impact on resilience to the COVID-19 crisis**

The modularity of decentralised units could be critical in mitigating the impact of the pandemic on processing activities. One of the consequence of the crisis has been the unavailability of some types of fresh produce, which leave centralised units unable to operate, since they cannot process other crops.In comparison,if the impact of the crisis were to persist and seriously disrupt the supply chain, decentralised units could easily change their set up and process new products.

In addition, decentralised units can be more easily operated in case of travel restrictions. During the pandemic, micro-entrepreneurs were less impacted by restrictions and able to work from their farm or home, which made them less likely to get contaminated. During the restriction period, decentralised processing was the only livelihood opportunity available, and shiftedfrom an additional income activity to a main one. Women entrepreneurs were supported by other family members who were unable to engage in other activities. As a result, the number of processing batches per month increased, and the cost of production fell by 18%. In comparison, centralised food processing had to operate at lower capacity in order to reduce contamination risks, and comply with COVID regulations. As a result, the capacity utilisation was 13% less in centralised settings, and the cost of production increased by 23%. These benefits can also apply to other emergency settings in which ability to travel is impacted - such as political unrest or climatic events like floods.

**Finally, food processing can be optimised by drawing on the strength of both models.**After identifying the benefits and drawbacks of decentralised processing, S4S identified ways to incorporate some of the advantages of centralised processing to their decentralised model, and scale down centralised operations. Based on these learning, the company piloted a new Common Facility Center (CFC) model, which consists of aggregating decentralised units to enable five to ten women to work together at an entrepreneur's house, thus allowing for a better utilisation of shared assets. Operated by women self-help groups, these units can process up to one tonne of cropsper day. This is ten times more produce than current decentralised facilities, but fifty times less than traditional centralised facilities. These units have been found to carry benefits of both and are being rapidly accepted. S4S plans to double down its capacity with this new model which came as the outcome of this study.

# 4 Conclusion and recommendations

This comparative study has found that decentralised food processing has the potential toreduce reliance on travel and transportation, increasing operational flexibility, and improving energy efficiency and cleanliness, thus contributing to increased value chain efficiency, inclusiveness and resilience.Over the years,the role of smallholder farmers has only been as producers, and not as processors, which was due to unavailability of energy. Decentralised technologies now make this viable.

However, scaling the use of off-grid processing units,especially the CFC model that S4S piloted faces a number of challenges, including access to finance, lack of awareness about the technology, lack of skills and knowledge, and the development of adequate market linkages. Addressing these barriers requires a common effort from partners across the ecosystem.Stakeholders including government and donor agencies, finance and microfinance institutions,off-takers, NGOs and solar energy equipment distributors can partner to promote and facilitate the adoption of decentralised processing:

- **Off-grid processing equipment suppliers and food processing companies should be provided with financing to support the scale-up of decentralised processing.**Piloting and scaling decentralised processing unitsrequires significant investments. Companies still need to test and improve their business models to improve access for last-mile customers, but have limited access to finance.The system needs a balanced flow of capital at various stages, including early-stage grants to subsidise the development and piloting of decentralised processing units, as well as debt financing to support scale-up and working capital.
- **Access to finance for rural entrepreneurs should also be facilitated to enable them to invest in off-grid processing units.** Indeed, access to finance remains a key hurdle for

entrepreneurs, as off-grid technologies represent a significant investment cost, and rural communities have very limited financial means. Financial institutions such as banks, microcredit institutions and credit and saving groups can look at differentiated financing models for farmers to take up processing activity that ensures additional income.

- **Awareness of smallholder farmers about technologies available for value addition at farm gate should be improved.**Currently, most of the farmers have little knowledge of decentralised processing technologies, and of the economic opportunity that it represents, which is a key barrier for adoption and driving the demand for decentralised processing units. Information about decentralised, affordable and renewable energy based technologies should be provided through exhibitions, demonstrations and online channels.

- **To maximise the income of farmers and make processing feasible at farm gate, micro-entrepreneurs should be provided with regular training and capacity building.** The decentralised production model requires entrepreneurs to have the knowledge and skills necessary to operate the processing equipment and run a profitable business. In particular, even if the decentralised units are less regulated, it is still crucial to adhere to best food handling practices. All the required set-ups from hygiene perspective (like hand gloves, head nets, sanitizers etc.) should be provided in the package. Standard Operation Procedures for each product should be developed and transferred to the farmer.

- **Micro-entrepreneurs should be supported in securing a profitable off-take market before investing in processing.**Most of the time, farmers are ignorant of the market demand and end up investing in processing of produce with limited market potential and are seasonal in nature.They often have limited access to information about sale prices, which leads to mismanagement of costs. Efforts should be made to improve access to market information, and connect micro-entrepreneurs with off-takers.
- **Primary production challenges should be addressed to ensure that entrepreneurs engaged in processing have access to sufficient supply**. For instance, due to the seasonality of agricultural production, a key issue faced by processing entrepreneurs is the availability of raw agricultural produce throughout the year. Providing and standardising storage options at village level could reduce difficulties associated with the storage of produce for farmers for long periods before processing, and ensure that processing entrepreneurs are able to access quality inputs at all times.