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FOOD PROCESSING – THE MISSED OPPORTUNITY

India, with its vast agricultural base, has always been a major player in global food production. However, the potential for value addition through food processing remains largely untapped. Food processing in India is an emerging sector, vital not only for enhancing food security but also for contributing to the country's economic growth, creating jobs, and ensuring nutritional standards are met.

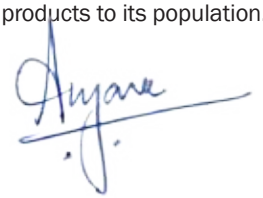
India's food processing industry is currently one of the largest in the world, encompassing a wide range of activities, from agricultural raw material processing to the production of ready-to-eat foods. Despite being the second-largest producer of food, India processes only a fraction of its agricultural output. According to reports, less than 10% of fruits and vegetables and about 20-25% of milk and meat products are processed. This underutilization represents a missed opportunity for the country to increase its export potential and improve domestic food distribution systems.

The government has recognized the significance of this sector and, over the years, has introduced numerous initiatives to promote food processing. Schemes such as the Pradhan Mantri Kisan Sampada Yojana (PMKSY), which offers financial assistance for setting up processing units and cold chain infrastructure, and the Food Processing Fund for promoting food-based businesses, are steps in the right direction. Additionally, the creation of Food Parks across the country is helping improve infrastructure and connectivity for food businesses.

Despite these positive strides, several challenges continue to hinder the full potential of the food processing sector. The lack of adequate cold chain infrastructure remains a major bottleneck, especially for perishable goods like fruits, vegetables, and dairy products. High wastage rates and inadequate storage facilities lead to significant losses in the supply chain. Furthermore, regulatory hurdles, lack of skilled labour, and the complexity of the supply chain add to the difficulties faced by the industry.

To ensure sustained growth, India must focus on improving infrastructure, especially in rural areas, and invest in technology and research to enhance the quality and shelf-life of processed foods. Strengthening public-private partnerships can also play a key role in driving innovation and ensuring that food processing reaches all segments of society.

The food processing industry, thus holds immense promise for India's economic development. With the right policies, investments, and innovations, India can become a global leader in food processing, reducing food waste, enhancing food security, and boosting exports while providing healthier, value-added products to its population.



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FOOD PROCESSING

India's Gateway to Growth, Global Reach, and Economic Prosperity

India's food processing sector plays a pivotal role in the national economy – it contributes significantly to our country's GDP, employment and exports, but most importantly, it augments the market value of agricultural produce and significantly reduces perishability and wastage of fresh produce.

Our nation holds the distinction of being the world's largest producer of milk and is one of the leading producers of fruits and vegetables (F&V). It certainly holds immense potential to, rather a competitive advantage, to harness its raw agricultural produce into processed foods, catering to both domestic and international markets. The sector has witnessed remarkable expansion in recent years, fuelled by changing consumer preferences & aspirations, urbanization, increasing disposable incomes, and growth of organized retail. Additionally, it has paved the way for making available sorts of ingredients for both household and commercial use. The diverse demand spectrum indeed presents a myriad of opportunities for this sector. According to a report by Ministry of Food Processing Industry (MOFPI), the Indian food industry output is anticipated to reach a size of US$ 535 billion by FY 2025-26.

According to a report by Ministry of Food Processing Industry (MOFPI), the Indian food industry output is anticipated to reach a size of US$ 535 billion by FY 2025-26.

Today, India is one of the fastest growing economies and the food processing sector stands as one of the largest sectors covering a variety of our country's produce. The Government of India also supports the sector with various initiatives. The Ministry of Food Processing Industries (MoFPI) has implemented various schemes like Pradhan Mantri Kisan SAMPADA Yojana (PMKSY), PM Formalisation of Micro food processing Enterprises (PMFME) Scheme and Production Linked Incentive Scheme for Food Processing Industry (PLISFPI), offering financial, technical, and business aids to establish food processing enterprises. Establishment of Mega Food Parks, integrated cold chain and infrastructure facilities, offering incentives, strengthening Indian food brands for global visibility, adopting latest technology, supporting clusters and groups such as FPOs/SHGs, creation of backward and forward linkages, or even permitting FDI, the Indian food processing sector is

About the **AUTHOR**

Mr. Manish Bandlish is Managing Director, Mother Dairy Fruit & Vegetable Pvt Ltd.

poised to reach new heights.

Fulfilling Domestic and International Demands at the same time

Given our country's extensive production base, we have the potential to fulfil both domestic and international demands with products like value-added dairy products, value-added F&V products, frozen vegetables & snacks, canned fruits and vegetables, etc.

Let's take a look at the domestic aspect first. It is rightly said that a robust food processing industry is crucial for addressing our nation's food and nutritional security challenges. Processed foods provide convenience, enhanced shelf life, ease of transportation to remote regions, and enhanced accessibility. Furthermore, it creates greater opportunities for farmers to achieve better prices and access to larger markets. We boast the largest and the youngest population and the consumption of food is only poised to grow. Over the year's we have seen how the demand has increased for processed foods. For instance, the pandemic lockdown increased awareness especially in dairy, RTE/RTC, and value-added F&V segments. We have witnessed various techniques like canning, dehydration, individual quick frozen, etc. being employed to increase the shelf life of seasonal produce.

The recent editions of World Food India and Indusfood have paved the way for providing international market linkages for the food & beverage (F&B) sector and provided a strong impetus to India's F&B exports.

As the demand for convenient food options continues to rise, processing of produce like milk and F&V presents substantial opportunities for product innovation. Products like value-added dairy products, fruit pulps, purees, pickles, etc. are amongst the fastest growing segments. As a country, we have great R&D facilities and expertise. We can foster innovation by creating new products while enhancing existing ones, thereby ensuring superior food safety and extended shelf-life. Our regional culinary heritage also offers immense scope for value-addition and for mass market availability.

In the international market too, there's growing demand for processed F&V. For instance, countries like the USA, Germany, France, Canada and Netherlands bet big on imports of processed fruits. Notably, the share of processed food exports in agri-food exports increased substantially from 13.7% in 2014-15 to 23.4% in 2023-24. This global demand for processed fruits and vegetables is only projected to rise across all regions.

Through our horticulture brand Safal, we are cognizant of this fact. Over the last few decades, we have successfully established a strong presence in around 40 countries. Safal has pioneered in exporting fresh fruits, IQF vegetables, pulps & concentrates and preserved gherkins across various parts of the globe. We have state-of-the-art facilities in Bengaluru, Karnataka and Ranchi, Jharkhand which process tropical fruit pulps & concentrates, catering to reputed multinationals. Given our agricultural strength, we are well poised to penetrate further into global markets. To cater to the growing demand, Safal is also in the process of setting up two more processing plants in Gujarat and Andhra Pradesh.

Global Participation to Showcase our Strength

Over the last few years, the Government of India has taken several initiatives aimed at enhancing infrastructure and involved multiple stakeholders to facilitate improved interactions between farmers, processors, distributors, and retailers. One of the key initiatives has been organizing trade fairs and exhibitions to showcase our comprehensive farm-to-fork model to both domestic and global audience. The recent editions of World Food India and Indusfood have paved the way for providing international market linkages for the food & beverage (F&B) sector and provided a strong impetus to India's F&B exports.

Moreover, Indian F&B companies have strengthened their participation in global food exhibitions. Be it SIAL, Paris or Gulfood in Dubai, these exhibitions pave the way for the companies to showcase their innovations, latest advancements, etc. and provides an opportunity to connect with global buyers and expand their reach, all while solidifying the country's position as a key player in the international food industry.

Tapping the Untapped Potential

According to a study conducted on the level of food processing in India have indicated that it is 21.1% for milk, 4.5% for fruits, and 2.7% for vegetables, which shows the immense potential this sector holds. The global landscape of F&V processing, coupled with an in-depth analysis of its dynamics in India, unveils a plethora of opportunities within the sector. A rich raw material base, strong demographics & rising disposable incomes, advancements in technology and structural shift in consumption patterns will reshape the processing landscape (both domestically and internationally) positively.

The role of government policies and initiatives has been key in the sector's success as it holds vast potential for expansion across the entire value chain, from production and processing to storage, distribution and marketing. Setting up establishments like Makhana Board and National Institute of Food Technology in Bihar would assist in improving production, processing, and value addition for more agricultural produce while creating skilling, entrepreneurship and employment opportunities.

Let us come together as an industry, share best practices, knowledge, experiences and adopt innovative techniques & latest technologies. Let's initiate dialogues & discussions, incentivize and promote research & innovation, and pledge to orchestrate a new chapter in the remarkable transformation of the Indian food processing industry. With right investments in technology, infrastructure and R&D, it has the potential to not only reduce wastage and increase efficiency but also significantly boost farm incomes, contributing to the overall prosperity of our farmers. Our country's dairy sector has been instrumental in establishing an ecosystem that benefits all the stakeholders and is well poised to make India 'Dairy to the World'. The time is right for us to create a lasting impact with our food processing sector and make our country 'The Food Basket to the World'.

Meat the Future

REDEFINING FOOD SAFETY AND QUALITY IN FOOD PROCESSING

About the **AUTHOR**

Mr. Abhay Parnerkar, is the CEO of Godrej Foods Ltd.

In a world where what we eat defines how we live, the conversation around meat safety and quality has become more critical than ever. For Indian households, meat is not just a source of protein—it is a family bonding exercise, and, often, a celebratory feast. Think of the tender Nihari simmered to perfection or a rich pot of Biryani, its fragrant layers enveloping succulent meat, with each dish an ode to tradition and togetherness.

However, the journey of meat from farm to fork is far from straightforward, especially in a country where wet markets dominate the landscape, and consumers wrestle with concerns over freshness, hygiene, and quality.

India's meat and poultry sector is one of the fastest-growing segments of the food industry, with revenue in the processed meat market amounting to US$2.89bn in 2025. The market is expected to grow annually by 4.89% (CAGR 2025-2030). With an increasing demand, this is where innovation, trust, and modern food processing step in to bridge the gap between tradition and health. Let us take a closer look at how the meat (poultry) industry is evolving to ensure safety and deliver unparalleled quality—straight to your plate.

Farm to Table: The Science Behind Safe Meat

Every great meal starts with great ingredients, and for meat, that journey begins long before it reaches your kitchen. The process starts at the farm, where science meets care to ensure that the poultry is raised in pristine conditions.

At Godrej Foods Ltd., we prioritize antibiotic-free meat; the chickens are raised in stress-free environments, fed on nutrient-rich, high-quality organic diets, and are free from harmful additives or growth hormones. Our farming practices ensure minimal human intervention, fostering health-

ier and happier birds—a crucial factor in producing tender, succulent meat.

The journey does not end at the farm. At the processing plant, and throughout the product's life cycle, a stringent cold chain system is maintained to ensure ideal temperatures, preserving the meat's freshness and safety until it reaches your hands.

One of the standout benefits of modern meat processing is the ability to cut out the middleman. At Godrej, our farm-to-table model ensures a direct supply chain, minimizing the risks of contamination that arise from handling by multiple intermediaries. This streamlined process not only ensures higher safety standards but also offers better value to the consumer, delivering fresher and higher-quality meat products.

Smart Processing: Hygiene Meets Innovation

When it comes to meat processing, we leave nothing to chance. Traditional wet markets, while familiar, often lack regulatory oversight and expose meat to a cocktail of contaminants—from harmful bacteria to improper handling practices. Studies have indicated that meat from wet markets is often contaminated with

Traditional wet markets, while familiar, often lack regulatory oversight and expose meat to a cocktail of contaminants—from harmful bacteria to improper handling practices.

pathogens such as *Salmonella* and *E. coli*, with prevalence rates ranging from 25% to 88%, depending on processing conditions.

Modern food processing facilities like ours eliminate these risks. The processing facilities employ a globally benchmarked practices, such as air- and water-chilling systems, to rapidly reduce meat temperature post-slaughter. This prevents bacterial growth and preserves the meat's natural tenderness and flavour. According to a USDA study, improper handling during processing such as that in wet markets, can lead to bacterial growth rates doubling every 20 minutes at temperatures between 4 °C and 60 °C (*Source: USDA Food Safety Report*).

One of the biggest advantages of organized meat processing is ***complete backward and forward traceability***, ensuring that every step—from the chick stage to the consumer's plate—is monitored for quality and safety. This system allows tracking of the bird's health, feed, and farm conditions, while also maintaining strict hygiene during processing, storage, and distribution. With batch numbering and cold chain management, consumers can trust that the meat they purchase is safe, fresh, and free from contamination.

IQF & Beyond

Using advanced techniques such as Individual Quick Freezing (IQF), we ensure that the meat is frozen at peak freshness, locking in nutrients and flavour. This process freezes meat at extremely low temperatures (-40°C) within minutes, preventing the formation of large ice crystals that could damage the cellular structure of the meat. IQF is used to freeze individual pieces of meat and poultry, ensuring that the products remain fresh and free from freezer burn.

Meat texture is another key factor to be considered. We often encounter chicken being too tough or rubbery. This is a common issue with chicken from local butcher shops, as there is no established process to cool down the chicken and ensure its tenderness (post processing). In regulated entities that process chicken, the body temperature of the chicken is typically reduced to 4 degrees Celsius or lower. This freezing method results in smoother and more tender meat.

Additionally, hygienic packaging ensures that the meat remains untouched by human hands after processing. From airtight seals to clear labelling with nutritional information and usage guidelines, every step is designed to give consumers peace of mind.

Busting Myths: Frozen vs. Fresh

Frozen meat has long been subject to myths that it is less nutritious or somehow "not fresh." However, science tells a different story. By freezing meat immediately after processing, we preserve its nutritional content and keep harmful bacteria at bay. According to a report by the International Institute of Refrigeration (IIR), properly frozen meat can maintain its nutritional value for up to six months, while "fresh" meat begins to lose its quality after just a few hours at room temperature (*Source: IIR Report, 2021*).

Be it the water used for cleaning, containers for meat storage, or units for disposing of body parts and blood, there is often a lack of established cleaning processes or schedules in wet market local shops. This contamination can lead to cases of stomach upset, dysentery, and more. Even after boiling wet market chicken, some germs may persist. In contrast, fresh chilled chicken or packed chicken from reputable brands is stored, cut, and processed in conditions that are 100% safe, clean, and hygienic.

The Challenges of Tradition: Why We Need Change

Despite advancements in meat processing, consumer awareness remains a challenge. Many households rely on traditional methods of meat preparation, such as washing meat with turmeric and salt, to combat potential contamination. While these methods can be effective, they are no substitute for sourcing meat from hygienic and regulated sources. Moreover, consumer perception remains a hurdle. Many still believe that frozen meat is less fresh than wet market options. The Food Safety and Standards Authority of India (FSSAI) has intensified market raids to crack down on unhygienic practices. Previous inspections revealed that majority of local butcher shops fail to meet basic hygiene standards.

Towards a Safer Plate: Collective Efforts in Meat Safety

The modern meat industry is at a crossroads. Whether it is understanding the benefits of frozen meat, checking labels for certifications, or supporting brands that prioritize transparency, every small step contributes to a safer food ecosystem.

As we continue to innovate, the goal remains clear: to provide every household with meat that is not only fresh and flavourful but also safe and trustworthy. After all, when it comes to the food we serve our families, there should be no compromise.

Food Processing: A Sunrise Sector

Food processing is one of the most promising industries in India, contributing significantly to economic growth, employment generation, and value addition to agricultural produce. With a growing population, rapid urbanization, and changing consumption patterns, food processing has emerged as a crucial sector that bridges the gap between agricultural production and consumer demand. Recognized as a 'sunrise sector,' food processing holds immense potential for improving farmers' income, reducing post-harvest losses, and enhancing food security.

The Indian food processing industry has witnessed substantial growth, averaging an annual growth rate of around 8.3% from 2015-2023. It contributes over 11.2% to the Gross Value Added (GVA) in manufacturing and over 12.5% to the GVA in the agriculture sector (2022-23). Despite its progress, India lags behind several developed nations in food processing, highlighting the need for further investment and policy intervention.

About the **AUTHOR**

Dr Prabodh Halde, Chairman, All India Food Processors' Association Western Region

India's Agricultural Landscape

India is one of the world's largest agricultural producers, with a vast diversity of crops due to its varied agro-climatic conditions. The country ranks first in milk production, second in fruits and vegetables, and third in fish and egg production. Despite this, a significant portion of the produce is wasted due to a lack of infrastructure and processing capabilities.

The potential for food processing in India is immense, as it can convert 40% of perishable agricultural produce into higher-value products, ensuring better returns for farmers while providing safe and nutritious food to consumers.

Food Processing: The Engine of Agricultural Growth

Food processing plays a pivotal role in fuelling agricultural growth through value addition. By transforming perishable raw materials into processed food products with longer shelf life, the industry reduces wastage and ensures a steady market for farmers. It also creates 12

One of the primary goals of food processing is to make food safe, edible, and hygienic.

million rural employment opportunities and enhances export potential.

The sector enhances agricultural profitability by offering 50%-200% better pricing for processed goods compared to raw produce. Additionally, food processing supports allied industries such as logistics, packaging, and retail, contributing to overall economic growth.

India vs. Global Food Processing Standards

Compared to developed nations, India has a relatively low level of food processing. While the U.S. processes 70% of its food, China processes 25%, and the Philippines processes 80%, India processes only about 11% of its total produce.

A significant challenge is post-harvest wastage, with India losing approximately ₹92,000 crores annually due to inadequate cold storage and transportation facilities. Increasing the food processing percentage can help mitigate these losses and boost farmer incomes.

Primary Function : Ensuring Hygiene, Safety, and Edibility

One of the primary goals of food processing is to make food safe, edible, and hygienic. The industry employs various techniques such as pasteurization, freezing, dehydration, and sterilization to eliminate pathogens and extend shelf life.

Food processing also plays a vital role in fortifying foods, improving nutritional value by adding essential vitamins and minerals. Fortified rice, iron-enriched wheat flour, and probiotic dairy products are examples of how food processing contributes to public health.

Recent Advancements in Food Processing

The food processing industry has seen significant technological advancements, including:

- High-Pressure Processing (HPP): Enhances food safety without compromising nutrition.
- Pulsed Electric Fields (PEF): Improves food shelf life and extraction of bioactive compounds.
- Ohmic Heating: Accelerates food sterilization while retaining nutrients.
- Cold Plasma Technology: Provides non-thermal sterilization for fresh produce.
- Smart Packaging: Extends shelf life and ensures food quality.

These innovations enhance food safety, reduce wastage, and improve processing efficiency, making Indian food products more competitive in global markets.

Myths About Food Processing

Despite its benefits, food processing faces several misconceptions:

- Processed food is unhealthy: Many processed foods retain nutritional value, while fortification enhances public health.
- Food preservatives are harmful: Many natural preservatives, such as salt, vinegar, and ascorbic acid, are safe and used for centuries.
- Food processing removes nutrients: Advanced technologies ensure minimal nutrient loss, with some processes enhancing bioavailability.
- Packaged foods are always artificial: Many packaged foods use natural ingredients with safe preservation techniques.

Government Initiatives for Food Processing Growth

The Ministry of Food Processing Industries (MoFPI) has implemented several initiatives to promote the sector:

- World Food India: A global platform showcasing India's food industry to attract investment and foster international collaboration.
- Production Linked Incentive (PLI) Scheme: Offers Rs.10,900 crores in incentives to food processing companies for scaling up operations and exports.
- Mega Food Parks Scheme: Establishes modern infrastructure with 42 operational parks to support food processing clusters.

- Operation Greens: Stabilizes supply chains for perishable fruits and vegetables.
- Pradhan Mantri Kisan Sampada Yojana (PMKSY): Supports food processing projects, cold chain infrastructure, and value addition.
- Startup India Initiatives: Encourages food tech startups, providing funding and mentorship.
- 100% FDI in Food processing sector
- NIFTEM initatives

As India moves towards self-reliance with 'Make in India' and 'Atmanirbhar Bharat,' food processing will play a crucial role in reducing post-harvest losses, enhancing food security, and boosting the economy.

Suggestions for Strengthening the Sector

To unlock the full potential of food processing, India should focus on:

- Harmonizing Central and State Policies: Coordinating policies across different levels of government for seamless implementation.
- Strengthening Nodal Agencies: Establishing a single-window clearance system for approvals and funding.
- Digital Mapping of Agro Clusters: Identifying processing zones to streamline logistics and reduce transportation costs.
- Market Research and Export Guidance: Assisting entrepreneurs in identifying global trends and expanding overseas.
- Encouraging Public-Private Partnerships: Leveraging private sector expertise to boost food processing infrastructure.

Revolutionising Indian Economy

Food processing is undeniably a sunrise sector in India, poised to drive economic transformation, rural empowerment, and agricultural modernization. With its vast potential for value addition, job creation, and export growth, food processing is emerging as a key pillar of India's economic strategy. The sector bridges the gap between farm and fork, ensuring better incomes for farmers while providing consumers with safe, nutritious, and diverse food options.

By investing in modern infrastructure, adopting cutting-edge technology, and strengthening policy frameworks, India can harness the full potential of food processing. Strategic government support, coupled with private sector participation, can unlock unprecedented opportunities, making India a global hub for processed food exports.

As India moves towards self-reliance with 'Make in India' and 'Atmanirbhar Bharat,' food processing will play a crucial role in reducing post-harvest losses, enhancing food security, and boosting the economy. This sunrise sector is not just about economic gains—it is about ensuring sustainability, nutrition, and a brighter future for India's agricultural and industrial landscape. With the right focus and initiatives, food processing is set to revolutionize the Indian economy and establish the country as a global food powerhouse. With the right policy support, investment, and infrastructure, India can position itself as a global leader in food processing.

By reducing food wastage, ensuring consumer safety, and empowering farmers, food processing holds the key to a Rs.1000,000 crore industry in the coming years. Recognizing its importance, the government must prioritize this sector as a growth engine for the economy, creating a robust ecosystem that benefits all stakeholders.

With focused interventions and technological advancements, India can achieve its vision of becoming a global food hub, fulfilling the goals of 'Make in India' and 'Atmanirbhar Bharat' in the food processing sector.

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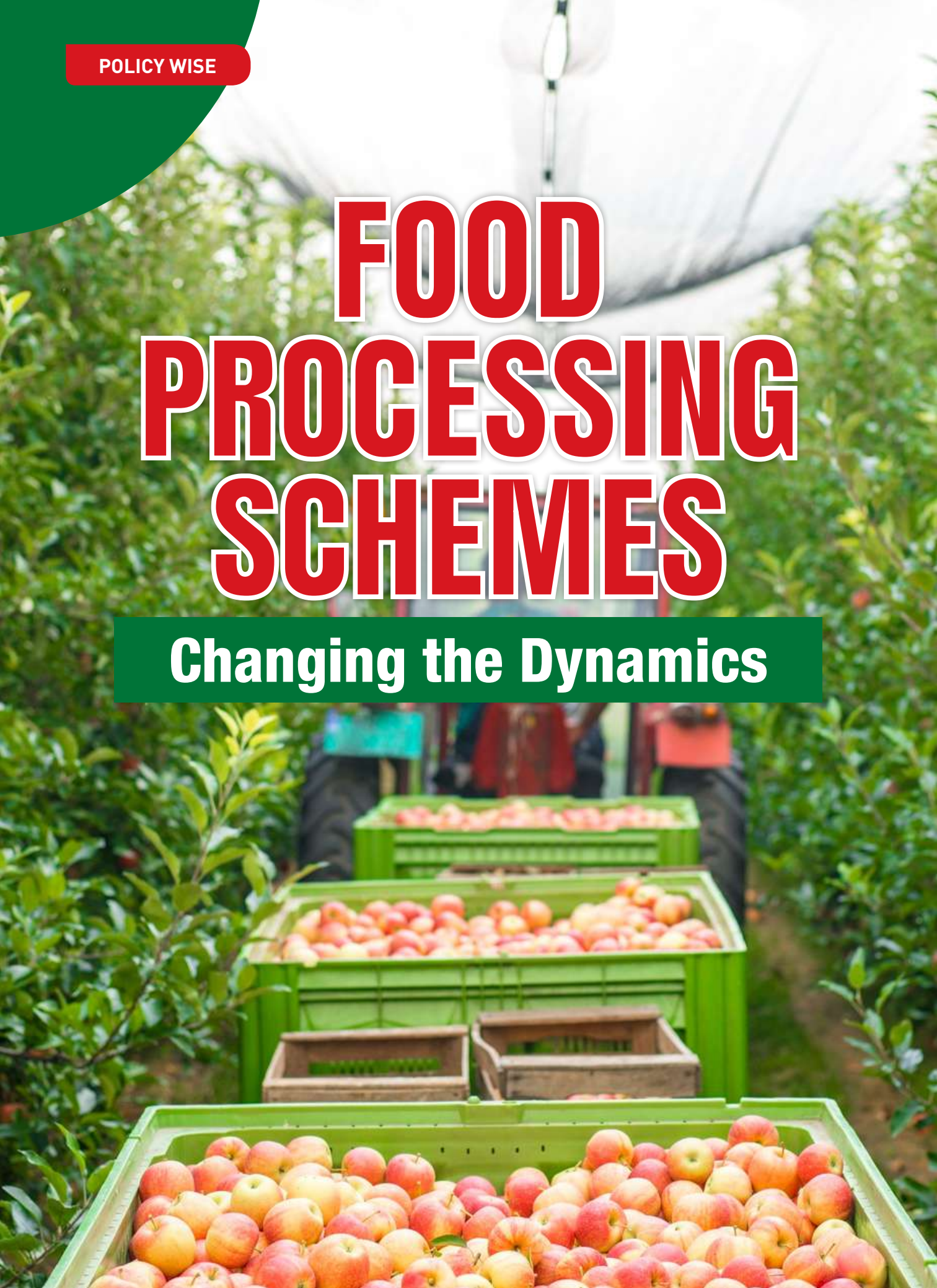

India is the largest producer of milk and spices and one of the leading producers of fruits and vegetables, poultry, and meat. India has access to several natural resources that provides it with a competitive advantage in the food processing sector. Due to its diverse agro-climatic conditions, it has a wide-ranging and large raw material base suitable for food processing industries.

The food processing industry in India is one of the largest employers within organised manufacturing, accounting for 12.41 per cent of total employment in the organised sector. The food processing sector has grown substantially, averaging an annual growth rate of around 7.3%, during 2015-2022. The sector has contributed 10.54% of the Gross Value Added (GVA) in Manufacturing and 11.57% of GVA in Agriculture sector in 2020-21. In the fiscal year FY24, the value of agri-food exports, which includes processed food exports, reached USD 46.44 billion, constituting roughly 11.7 per cent of India's total exports. Notably, the share of processed food exports within agri-food exports has risen from 14.9 per cent in FY18 to 23.4 per cent in FY24.

The growing consumption of food is expected to reach US$ 1.2 trillion by 2025-26, owing to urbanization and changing consumption patterns. According to the Viksit Bharat@2047 report, India's food processing sector will grow significantly, reaching US$ 1,100 billion by FY35, US$ 1,500 billion by FY40, US$ 1,900 billion by FY45, and US$ 2,150 billion by FY47.

The food processing industry in India is one of the largest employers within organised manufacturing, accounting for 12.41 per cent of total employment in the organised sector.

Indian Potential

India was a global leader in milk production contributing approximately 25% to global milk production, in 2022-23. The country ranked second in vegetables and fruits and egg production and fifth in meat production, respectively, in 2022-23.Additionally, India is the largest producer of spices in the world, with 11.26 million tonnes of major spices produced in 2022-23. The food processing industry in India is still in its early stages, contributing less than 10% to the total food output. According to a Deloitte study on Level of Food Processing in India, processing levels were at 2.7% for vegetables, 4.5% for fruits, 15.4% for fishery, 21.1% for milk, and 34.2% for meat in 2020-21.

A strong food processing industry is essential to tackle food and nutritional security issues. Processed food offers convenience, extended shelf life, easy transport to remote areas, and improved accessibility, serving as a valuable source of nourishment. Additionally, it offers farmers increased opportunities for better price realization and expanded selling prospects.

POLICY PUSH

Pradhan Mantri Kisan Sampada Yojana

To foster growth in the food processing sector, the Indian government has initiated several key programs, including the Pradhan Mantri Kisan Sampada Yojana (PMKSY). The Ministry of Food Processing Industries (MoFPI) has been implementing a Central Sector umbrella scheme – Pradhan Mantri Kisan Sampada Yojana (PMKSY) since 2017-18. The PMKSY is one of the important interventions by the Government in Food Processing sector and it has made substantial contribution in strengthening Food Preservation and Processing Infrastructure of the country.

PMKSY is a comprehensive package of component schemes, which aimed at creation of modern infrastructure with efficient supply chain management from farm gate to retail outlet. Under the component schemes of PMKSY, viz. Mega Food Parks (discontinued w.e.f. 01.04.2021), Integrated Cold Chain and Value Addition Infrastructure, Creation of Infrastructure for Agro Processing Clusters, Creation/ Expansion of Food Processing and Pres-

The PMKSY is one of the important interventions by the Government in Food Processing sector and it has made substantial contribution in strengthening Food Preservation and Processing Infrastructure of the country.

ervation Capacities, Creation of Backward and Forward Linkages (discontinued w.e.f. 01.04.2021) and Operation Greens, financial support in the form of grants-in-aid/ subsidy is provided for setting up of food processing projects to encourage investments in both on-farm and off-farm preservation and processing infrastructure across the country.

1217 food processing projects have been approved with total project cost of Rs. 31308.24 crore including MoFPI grants-in-aid/ subsidy of Rs. 8698.18 crore thereby attracting private investment of Rs. 22610.06 crore under the above mentioned component schemes of PMKSY since their inception to 2024-25 (till 30.06.2024). Out of 1217, 651 projects have been completed thereby creating preservation and processing Infrastructure of 48.91 LMT/annum and 183.523 LMT/ annum respectively.

Under the Capacity Building component of Pradhan Mantri Formalisation of Micro Food Processing Enterprises (PMFME) scheme, trainings for both farmers and micro level entrepreneurs are being conducted on the thematic area "Value addition of the products to reduce the post-harvest losses." Under PMFME scheme, 76 Common Incubation Centres have been approved across the country so that the farmers can utilize these facilities to process their produce by reducing the post-harvest losses. As of 31 October 2024, 1,079 PMKSY projects have been completed.

Production Linked Incentive Scheme for Food Processing

The Production Linked Incentive Scheme for Food Processing (PLISFPI), launched in 2021, seeks to cultivate globally competitive food processing leaders by facilitating branding and marketing initiatives in international markets. By mandating the use of domestically grown agricultural products (excluding additives, flavours, and edible oils) in the manufacturing process, the scheme has substantially increased local raw material procurement, benefiting underdeveloped and rural areas while supporting farmers' incomes. Furthermore, the emphasis on local production of raw materials for processed food has generated additional off-farm employment opportunities, significantly contributing to the economic development of rural regions.

The scheme has significantly contributed to the country's overall growth and development by scaling up domestic manufacturing, enhancing value addition, boosting the domestic production of raw materials, and creating employment opportunities. The scheme supports large companies, millet-based products, innovative and organic products, as well as small and medium enterprises, while also promoting Indian brands globally. According to data reported by the scheme's beneficiaries, an investment of Rs. 8,910 crore has been made across 213 locations. As of 31 October 2024, the scheme has reportedly generated employment of over 2.89 lakh.

Under the PLI scheme, a significant proportion of beneficiaries are MSMEs, with 70 MSMEs directly enrolled and 40 others contributing as contract manufacturers for larger companies. Collectively, these initiatives have strengthened SMEs by fostering innovation, improving competitiveness, expanding market access, generating employment opportunities, and supporting the broader value chain in the food processing industry.

Under the Production Linked Incentive Scheme for Food Processing Industries (PLISFPI), the Government provides

financial incentives to promote Indian food brands abroad, supporting branding and marketing activities for Indian-branded consumer food products in global markets. Beneficiaries are reimbursed 50% of their expenditure on branding and marketing abroad, capped at 3% of their annual food product sales or Rs. 50 crore per year, whichever is lower. Applicants are required to spend a minimum of Rs. 5 crore over five years to qualify.

By 31 October 2024, 171 applications had been approved under this scheme.

Pradhan Mantri Formalisation of Micro Food Processing Enterprises

To provide comprehensive support—including technical, financial, and business assistance for establishing or upgrading micro food processing enterprises—the Pradhan Mantri Formalisation of Micro Food Processing Enterprises (PMFME) scheme was launched in 2020. The scheme aims to enhance the competitiveness of existing individual micro-enterprises in the unorganized segment of the food processing industry and promote formalization of the sector. The Scheme primarily adopts One District One Product (ODOP) approach to reap the benefit of scale in terms of procurement of inputs, availing common services and marketing of products. It provides the framework for value chain development and alignment of support infrastructure. The ODOP are identified by States / UTs based on the agriculture production, raw material availability, perishability of the product etc.

Ministry of Food Processing Industries (MoFPI) extends financial assistance as grant-in-aid to various institutions/ universities, Public funded organizations and recognized R&D laboratories both in public and private sector, to promote and undertake demand driven R&D work in the Food Processing Sector for product and process development, design and development of equipment, improved storage, shelf-life, packaging etc.

Under the scheme, financial assistance as grant-in-aid is given to Private organizations/ Universities/institutions/ R&D laboratories and Council of Scientific & Industrial Research (CSIR) recognized R&D units in private sector to the tune of 50% of equipment cost in general areas and 70% in difficult areas and to various Universities, Indian Institute of Technology (IITs), Central/ State Government Institutions, Government funded organizations to promote and undertake demand driven R&D work in food processing sector for product & process development, design and development of equipment, improved storage, shelf-life, packaging etc. R&D projects of Government organizations/ Institutions are eligible for 100% grant-in-aid for the cost of equipment, consumables and expenditure related to Research Fellows, etc.

As of 31 October 2024, the scheme has received 407,819 applications, with loans totalling Rs.8.63 thousand crore sanctioned to 108,580 applicants. Additionally, the programme has successfully trained 672 Master Trainers, 1,120 District Level Trainers, and 87,477 beneficiaries across 36 states and union territories.

India›s food processing sector is a dynamic and rapidly evolving industry and has been playing a critical role in the country›s economic landscape. This sector is essential for enhancing agricultural productivity, creating employment opportunities, and ensuring food security. With policy push and schemes, the government is enabling the sector to achieve its true potential.

'PACKAGING PLAYS AN EXTREMELY CRUCIAL ROLE IN THE FOOD PROCESSING INDUSTRY'

In today's competitive food processing industry, packaging plays a crucial role in preserving product quality, ensuring safety, and enhancing consumer appeal. In an interaction with Agriculture Today, SN Venkataraman, Chief Executive – ITC Packaging & Printing Business discusses about the significance of packaging and its impact on the food processing sector.

How important is packaging in the food processing industry?

Packaging is central to food processing , to preserve its nutritional , taste and textural qualities and also the face on the retail shelf. It acts as a critical line of defence, preserving food quality and safety against contamination and spoilage. Convenience has also become a main priority for consumers. Features like resealable bags and easy-to-open containers greatly influence purchasing decisions. Moreover, packaging is critical for marketing and branding. In India, over 60% of retail sales come from food and groceries, and consumers typically decide within just 13 seconds. In such a short time, eye-catching packaging can make all the difference in attracting buyers. Hence, more than anywhere else packaging plays an extremely crucial role in deciding the sales of the product in the food processing industry.

What are the recent innovations that have happened in the packaging sector in food business? How receptive have been the Indian companies towards it?

Recent innovations in the food packaging sector include:

Sustainable Packaging: Today's Gen-Z consumers are conscious about the packaging material used in their purchases. Hence, there is a significant shift being made by the brands towards Paper based packaging and recyclable plastic packaging ,to reduce environmental impact.

Convenience & Shape : Consumers are gravitating towards products that come with packaging which eases the use. For example, ID Vada batter pouch etc

Delivery friendly Packaging for QSR : With the rise of food delivery services in the country, Heat retention of the product and protecting from contamination is the need, ITC has innovated and launched our B2C brand Ecobyte – This range of packaging solutions are Oil and Grease resistant, heat-sealable, anti-microbial, recyclable and heat retentive.

Connected Packaging: Technology is omnipresent, that holds true for packaging as well. Digital packaging solutions are widely used for consumer engagement, track and trace and anti-counterfeit feature. Example for promotional activity, use of Augmented Reality (AR) is a trend in the market. ITC packaging's range of Pacconnect is a seamless end-

to-end solution in this space.
Indian companies have shown a positive response to these trends, particularly in sustainable packaging. The introduction of EPR (Extended Producer Responsibility) guidelines is driving this shift. Many start-ups and established conglomerates are embracing practices like Paperization and Recycling initiatives, including the collection of used packaging, to align with these trends.

What is the extent of R&D that is happening in the segment?
Primary packaging in food processing industry is majorly plastics-based owing to its versatility, functionality and cost. Specialty films with superior barriers properties and also light-weight are being introduced, apart from treated and coated films. Work is also happening in conjunction with sustainability drivers in developing new laminates based on mono-materiai structures. Thrust on paper-based structures are driving coatings that enhance the properties like barrier and strength of substrates, to make recyclable and compostable packaging.

ITC packaging has pioneered in this arena of coatings with our proprietary solutions such as Bioseal, Oxyblock and Germfree. For instance, poly coatings in tea envelopes are now replaced by Bioseal coated paper.

How does ITC keep abreast with the innovations happening in the segment? What are the changes that ITC has brought out in the packaging space?
ITC Packaging is committed to staying at the forefront of packaging innovations, particularly in sustainable packaging. Life Science Technology Center (LSTC) at Bangalore is engaged in molecular research on various materials to launch cutting edge packaging solutions that are accessible and affordable. ITC packaging has launched its initiative called Innovpack, to partner with consumer brands, to create recyclable/compostable solutions that do not compromise the runnability and strength. We also enable brands for use of Recycled content in packaging and structurally value engineer the packaging to reduce the virgin plastics. Furthermore, ITC is leading the way in introducing PFAs-free packaging solutions in India, demonstrating its commitment to environmentally friendly practices. Through these efforts, ITC not only enhances its packaging offerings but also sets a benchmark for sustainability in the industry, ensuring that it remains a leader in innovation and responsible packaging solutions.

Government should establish clear and enforceable regulations on recyclable packaging that promote sustainable packaging

What are the transformational changes you would like to see in the packaging business?
Automation & Efficiency: Embrace digitalisation and automation in production to optimize efficiency and reduce waste and meet global standards for quality. This would not only streamline operations but also lower costs and improve response times to market demands.
Sustainable Practices: Focus on renewable sources of energy has still room to improve in this sector as it is one of the energy intensive industries. There is a long way to travel from linear to a circular economy, when we look at this sector.

Packaging is central to food processing , to preserve its nutritional, taste and textural qualities and also the face on the retail shelf.

What role should government play in encouraging safe and smart choices by the food businesses?
Although Governments have been actively involved in shaping the food and packaging regulations, areas of focus are:
Regulatory Frameworks: Government should establish clear and enforceable regulations on recyclable packaging that promote sustainable packaging.
Recycling : Promote the growth of recycling infrastructure, specially for plastics
Incentives for Innovation and R&D : Offering financial incentives, such as tax breaks or grants for businesses that adopt new technologies aimed at enhancing food safety and sustainability, which will encourage companies to invest in smarter practices.

From a career point of view, does the packaging sector offer a lucrative choice? Are you satisfied with the current level of skill set?
India is a young nation with more than 65% of its population under the age of 35, who are all active consumers. So, it is not a surprise, that packaging is the fifth largest sector in the economy and is one of the fastest growing sectors. For a new product to be launched, you need trained manpower starting from graphic design – design software usage – prepress workflows – materials knowledge – applied packaging expertise – press operations – converting operations – quality assurance – packing line expertise etc and more. You also need to be in tune with broader trends impacting the way consumers buy - focus on customisation and convenience - necessity for sustainable packaging - convenience and affordability. So, it's a very attractive career choice and one less impacted by recessionary trends. We need the standards at various educational institute serving industry to be raised and the curriculum to reflect the latest trends in automation and technology and not just the basics . This will require close Industry – Educational Institutes interaction and exchanges.

REVOLUTIONIZING FOOD PROCESSING WITH SOLAR INNOVATION

THE JOURNEY OF RAHEJA SOLAR FOOD PROCESSING

The Indian food processing sector has witnessed remarkable growth over the years, contributing significantly to the nation's economy. With an annual growth rate of 7.3% between 2015 and 2022, this industry has played a crucial role in enhancing agricultural value addition, reducing post-harvest losses, and creating employment opportunities. At the heart of this transformation is Raheja Solar Food Processing (RSFP), a pioneer in sustainable food preservation through solar dehydration technology.

RSFP designs and manufactures cutting-edge solar dryers that help farmers preserve their produce, reduce wastage, and increase profitability.

Addressing a Global Challenge: Post-Harvest Losses

Raheja Solar Food Processing (RSFP), solves one of the most pressing challenges in agriculture—post-harvest food loss. India, despite being one of the largest agricultural producers, faces a significant issue of food wastage due to inadequate storage and processing facilities. By leveraging solar-powered dehydration, no farmer's hard work should go to waste.

While pursuing his B.E. in Mechanical Engineering, ***Varun Raheja***, a passionate nature enthusiast, was deeply moved by the hardships faced by farmers and the alarming waste of precious crops. In 2018, at just 20 years old, he teamed up with his mother, ***Mrs. Babita Raheja***, who is committed to empowering underprivileged women.

Together, they founded ***Raheja Solar Food Processing Private Limited (RSFP)*** to tackle the shocking impact of food loss and uplift struggling farmers. Inspired by his love for nature and an unshakable desire to create change, he launched RSFP in Madhya Pradesh.

Seeing the pain of farmers losing their harvest to inefficient preservation methods, Varun, as the Co-founder and Director, developed a sustainable solution—Raheja solar dryers. These dryers became a beacon of hope, helping farmers preserve their crops, reduce waste, and secure better incomes.

Solar Drying: A Sustainable Solution for Farmers

RSFP designs and manufactures cutting-edge solar dryers that help farmers preserve their produce, reduce wastage, and increase profitability. Unlike conventional drying methods that are time-consuming and prone to contamination, our scientifically designed solar dryers offer a more efficient, hygienic, and sustainable solution. These dryers not only extend the shelf life of fresh produce but also help in retaining their natural colour, taste, and nutritional value—aligning perfectly with the needs of health-conscious consumers.

However, their mission extends beyond just providing equipment. They actively engage with farmers, training them on optimal solar drying techniques, guiding them on high-demand products, and offering a buyback policy that ensures they have a steady market for their dried produce. This decentralized approach empowers rural communities, especially women-led self-help groups (SHGs), by providing them with an independent and sustainable source of income.

From Solar-Dried Innovation to Market-Ready Products

Beyond manufacturing solar dryers, they have created a product line that embodies their sustainability vision. Using their solar-powered dehydration technology, RSFP produces natural, preservative-free dried fruits, vegetables, and herbs that cater to both B2B and B2C markets. The process ensures that the produce

retains maximum nutrition while achieving an extended shelf life without the need for artificial additives.

One of their flagship brands, ***Barefruit***, is dedicated to offering 100% natural, solar-dried snacks made from farm-fresh fruits. These products contain no preservatives, no additives—just pure, sun-dried goodness, providing a guilt-free snacking option for conscious consumers.

Innovation and Recognition

Our journey has been marked by continuous innovation and significant milestones. RSFP gained national recognition when they were featured on Shark Tank India, showcasing their commitment to sustainable food processing and farmer empowerment. Their efforts have not only led to business growth but have also inspired other agritech start-ups to adopt eco-friendly solutions for post-harvest management.

Through strategic partnerships with government initiatives, research institutions, and private organizations, they continue to expand the reach and impact. By integrating ***smart technology*** such as remote monitoring for solar dryers, precision airflow mechanisms, and angularly optimized designs, they ensure that their solutions remain at the forefront of innovation in food processing.

By combining traditional wisdom with modern technology, they are building a ***sustainable food ecosystem***—one that reduces post-harvest losses, uplifts rural communities, and promotes eco-friendly food processing

RSFP isn't just a company; it's a movement of hope, sustainability, and empowerment. It's a reflection of Varun's vision to care for both nature and society, creating lasting change in the lives of small and marginal farmers.

Today, RSFP proudly supports over 60,000 farmers across India, building a thriving micro-food processing ecosystem that bridges these communities with the broader economy.

ENSURING INCOME AND FOOD SECURITY FOR SMALL AND MARGINAL WOMEN FARMERS

Over the years, agriculture as a whole in the Global South has witnessed two important trends- a gradual shift to family farming with majority of farmers being small and marginal and feminisation of agriculture with greater participation of women in agriculture. In India itself, small and marginal farmers constitute almost 90% of the total holdings contributing to almost 50% of total output with almost 70% of farm labourers being women.

With limited access to resources whether its land, machinery, extension services, inputs, credit and markets, it has left a devastating effect on the lives and livelihood. Women and youth are the worst affected. Being small and marginal also makes women farmers more susceptible to climate shocks. While men are able to move to the non-farm sector, women are not able to access such coping strategies. As a result, even after toiling so hard, farmer families go hungry.

The Self-Employed Women's Association (SEWA) is a trade union of poor, self-employed women in the informal sector of India. It has an urban and rural membership of 3.4 million, of which two-thirds are rural.

According to World Food Program (WFP), of the 343 million people who are extremely hungry, almost 60% are women and girls. Also, low farm productivity, climate change and water scarcity and structural inequities in areas like finance and infrastructure faced by small and marginal farmers, discourages their children to look at farming as a viable livelihood option, leading to a cycle of migration, social distress and poverty. The challenge for policy makers, international development institutions and CBOs is how can we convert small farm holders into entrepreneurs and in the process create a vibrant farming ecosystem where farmer family don't have to go hungry.

Farmers as Entrepreneurs

One of the challenges that SEWA faced with its members who are dependent on agriculture is that why farmer families go hungry even after putting so much of toil in their fields? The other was that with major climate changes, farming has been riskier with droughts

About the **AUTHORS**

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and floods occurring quite frequently. In order to challenge the existing status quo, SEWA launched an innovative business model called 'RUDI' for small and marginal farmers with the objective of providing direct market linkages to get better price for their products and value addition activities by setting up processing centres managed by rural women. It is designed as a local decentralised supply chain model managed by farmers and the landless. The target was to internally rotate the scarce funds of the rural producers in a way that fetches maximum benefit and brings about positive changes in their lives and to provide multi-user facilities. This in turn reduces incidental expenses and build-up an integrated value chain in order to enhance the efficiency of agricultural activities, to reduce the hardships of the producers, processors and to create multiple em-

According to World Food Program (WFP), of the 343 million people who are extremely hungry, almost 60% are women and girls.

ployment opportunities and an efficient supply of agro-products to rural members.

By encouraging women farmers to become entrepreneurs, the model also works towards ensuring economic development of the villages and above all to make them "Self-Reliant". Since 2000, the focus has been on enhancing financial stability and prosperity for its members through the transition to green technology and into the green economy in what is termed as building 'climate resilience'. SEWA help build the skills, capacity, and confidence of workers to have livelihood security and resources to withstand the changing physical landscape and the significant increase of climate and economic shocks.

Decentralised Value Chain Models for Livelihood Security

Based on its members needs and demand, over the years SEWA has been experimenting and innovating ways for value addition and creation to its large member base where mainstream markets have failed.

RUDI Dal Mill, Ahmedabad

The RUDI Dal Mill, located in Kavitha village, near Ahmedabad Gujarat, is a pioneering initiative of integrating women into the agricultural value chain, fostering local economic growth, and promoting community self-reliance. Established on April 8, 2022, it is Gujarat's first dal mill operated and managed entirely by women, marking a significant step in rural development and empowerment.

A few of the members collectively envisioned a solution where rural women could not only process locally grown produce but also gain financial independence and develop management skills. Based on a Business Plan that the women together developed, with an initial

capital of INR 200,000, they set up a mini–Dal Mill processing unit in their village. The RUDI Dal Mill employs a detailed and systematic approach to process various types of dals, ensuring high-quality products through a blend of traditional and mechanical methods. The women package and market their processed lentils, pulses and other produce under the RUDI brand name.

For these first-time women entrepreneurs, there were significant hurdles. Being new to mechanical processing activities, they had to rapidly learn operations and machinery usage. Generating profits required bulk processing, needing consistent raw material supply and market demand - both of which have been suboptimal initially. Intermittent electricity issues and the general fear of failure added to their challenges. The RUDI Dal Mill initiative, supported by SEWA, has brought transformative economic and social changes to Kavitha village, directly benefiting the women managing the mill and the wider community. Below is an assessment of its impact categorized under economic and social growth.

Economic Impact on Women and Community

Increased Income and Financial Independence: Income from the mill has improved the economic stability of their families, supporting essential needs like education, healthcare, and savings for future goals.

Profit Sharing for Long-term Growth: The mill operates on a profit-sharing model where SEWA's initial investment is repaid through earnings. This ensures financial autonomy for the mill and fosters a sustainable growth cycle.

Market Creation for Local Farmers: By sourcing raw dal locally, the mill provides farmers with a fair and consistent market, reducing their dependency on exploitative intermediaries.

Additional Revenue Streams : Future plans to utilize by-products, such as dal husk for body scrubs and ubtan, aim to further diversify income and reduce waste.

Regional Economic Ripple Effect: Beyond the women employed, the mill indirectly supports other economic activities, such as transportation, packaging, and local retail partnerships, fostering a broader economic uplift in the region.

Social and Leadership Growth

Empowerment Through Skills and Confidence: The women underwent a 45-day training program that equipped them with technical skills, operational expertise, and managerial confidence. This training has empowered them to independently manage all aspects of the mill. By taking on leadership roles, these women now serve as role models, inspiring others in the community to pursue entrepreneurship.

Challenging Traditional Gender Roles: The mill's success has challenged societal norms by positioning women as key economic contributors and decision-makers. This shift has not only elevated their status within their families but also within the larger community.

Building Collaborative Networks: The collective management of the mill has fostered a spirit of collaboration and mutual support among the women. The bonds created through this shared enterprise have strengthened community ties and set a precedent for cooperative initiatives.

Leadership in Local Development: The women's involvement in the mill has transformed them into active participants in the village's economic development. Their decision-making and problem-solving skills have earned them respect and recognition as leaders in the community.

Social Upliftment: The RUDI Dal Mill initiative has improved community morale by showcasing the potential of women-led enterprises to drive social and economic progress. The project has spurred discussions about gender equality and the importance of investing in women's education and entrepreneurship.

Way Forward

While not yet profitable, the project instilled entrepreneurial spirit and self-confidence in the women. Crucially, this initiative provides an alternative source of income for the women, whose main livelihood of agriculture is highly unreliable due to factors like weather, climate change, market fluctuations, land constraints and input costs and quality. An additional revenue stream enhances the food security of their families.

The way ahead involves securing reliable raw material sources in good quantity, expanding the customer base, and potentially exploring product diversification. With their newfound talents and SEWA's continued mentorship, these women are resilient and ambitious for growth.

Kamala

Kamala is a women-led business which integrates small, marginal farmers and landless rural women workers into an innovative food chain system – right from procuring the ingredients directly from the marginal farmers, to processing these into traditional, nutritious delicacies for self-consumption and marketing to consumers. In the process, the landless women laborers become the owners, planners, managers and marketers. Priority is given to local procurement and nutritive values over variety and appearance. Imbibing SEWA's founder,

RUDI Impact

- Ensured food and livelihood security to 16,000 small and marginal farmers
- Farmers are getting 10-15% more than locally offered market prices
- 2,75,000 Households have access to quality products at affordable prices ensuring food security and stability
- 50,000 urban customers benefiting daily through availability of nutritious food through RUDI's 'Kamla Café's'

Elaben Bhatts economy of nurturance, Kamlaa serves homemade meals, nutritious snacks and bakery products with a thrust on the traditional.

From Farm to Fork

The activity started as a lunch service for office-goers. Initially, SEWA members cooked nutritious lunch on demand and the office-goers collected their food. The women would visit the commercial buildings nearby and provide them coupons. As the lunch options became popular, a seating arrangement was made and the menu expanded over the years. The Ahmedabad experience was replicated in five districts of Gujarat (Anand, Mehsana, Patan, Surendranagar and Sabarkantha) in 2019. In the Ahmedabad centre, about 75 women are engaged in the activity.

Impact

Since Kamala's inception in 2015, around 500 women have been trained in processing, marketing and redistributing nutritious food in Ahmedabad and nine districts of Gujarat. It has in the process created employment opportunities for over 267 rural women, earning an average monthly income of INR 12,000. Besides this Kamala has been able to demonstrate the following impact on the lives of the women members

- Generating livelihood and employment opportunities at each stage of production, making them self-reliant and financially independent
- Ensuring fair returns to the marginal farmers for their modest produce
- Establishing an enterprise led, owned, and managed by landless women laborers
- Building an integrated value chain which enhances the efficiency of agricultural activities
- Reducing hardships of the producers & creating employment opportunities for the processors
- Strengthening local production and distribution of Smart Food
- Ensuring food security for rural households and providing an ideal, healthy alternative of good taste, nutrition and convenience with traditional snacks processed using whole and coarse food grains and millets

The RUDI model's has demonstrated the ability of women to take ownership and control of their enterprises to build scalable and sustainable businesses in spite of myriads of challenges that they face- both socially and culturally. The decentralised model allows opportunities for cost efficiency through aggregation and collectivisation leading to better access to quality inputs and output markets, helps improve risk mitigation through improved decision making of farmers and localised solutions, and allows women to collectively develop coping mechanisms against climate shocks through access to climate advisories, insurance and other wrap around solutions against climate shocks.

Since its inception, the RUDI model has been able to demonstrate its effectiveness in multiple ways-

- Provide steady returns to farmers and ensures food security to households
- Provides multiple employment opportunities to the rural women producers and youth through involvement in procurement, processing, packaging, marketing and management of agricultural products
- Rotate scarce rural capital within the villages, thereby strengthening the rural economy
- Introduce green technologies and financial mechanisms or small and marginal producers to incorporate climate resilience solutions

This is a scalable and replicable model that provides poor women farmers the necessary tools, equipment's and knowledge that ensures livelihood security and food security so that farmers don't have to stay hungry.

Ancient Roots
ROUTE TO A HEALTHY LIFE

Arpita Ankit Patel, envisions a healthy society powered by the age old wisdom. A homemaker-turned-entrepreneur, she transformed her passion for health and nutrition into Ancient Roots, where she introduced a line of cookies, snacks, and pre-mixes using millets and jaggery, free from palm oil and preservatives

Launched in 2020, Ancient Roots today has an impressive line up of Health cookies (Wheat, millets, and jaggery delights), Multigrain Snacks (Protein-packed Chevda, Gathiya, and Sev), Pancake Mixes (Fiiber and protein-rich) and Chai Masalas (Flavorful blends for every brew).

Recognized with The India Awards 2023 for Intriguing Food Products Start-Up of the Year, Ancient Roots aims for continued growth by introducing new, healthy snacks with eco-friendly packaging and expanding globally.

A Passionate Dream

A commerce graduate and a diploma holder in nutrition, Arpita was constantly intrigued by the magical secrets of ancient healing & wellbeing.

"After my certification as a nutritionist, I realized that we never take stock of the ingredients of any popular product before purchasing it. Most of the time we make impulsive purchases based on marketing gimmicks & flashy packaging. However most of the modern products are laced with artificial ingredients such as preservatives, flavoring agents, binders and taste enhancers which are really bad for growing kids & adults alike.

After I became a mother, I didn't want my children & family to consume those things but at the same time I didn't want them to be devoid of the joys of having treats such as cookies, pancakes etc. So I started developing these in my own kitchen and surprisingly my kids loved it and I received positive feedback about it from friends and family," says Arpita.

Initially it was really challenging for Arpita to make sustaining products without preservatives, refined sugar, flour etc , but she stayed true to her commitment towards eating healthy and serving healthy. "Once my creations picked up, Naturally making sure that it reaches to the masses was the next step & that led to the birth of - Ancient Roots."

Market Expansion

The turning point came with the PMFME Scheme, providing crucial financial support. This funding enabled Arpita to purchase processing machinery, boosting production capacity from 50 kg to 600

Advice for youngsters looking to start a business on their own

Decide what you want, make a plan and work on that every single day. You will receive a lot of unsolicited advice too but your journey is different from others. Believe in your dreams and work towards it ceaselessly and yeah don't forget to amass friends and build a great team on the way because you will never find the right team, you always have to build a right team.

kg per day. This upgrade propelled Ancient Roots into a new growth phase, enhancing both output and market reach. She has currently expanded to o key cities of Ahmedabad, Mumbai, Jaipur, Baroda, and Surat."

"I still remember the day when the new machines came in and it took us countless trials to perfect the process but we eventually could achieve it. Ensuring smooth production, managing manpower, scouting for the perfect ingredients , I would say that the challenges are many but the satisfaction of doing something right towers all of that.

Ancient Roots innovates with healthier ingredients like millets and jaggery, ensuring recipes are nutritionally sound. The enterprise uses vacuum-sealed packaging to maintain product quality. Sustainability is central, with eco-friendly sourcing and active CSR initiatives, including community support, employee

welfare, and educational programs.

Ancient Roots is committed to replacing maida and refined sugar with healthier alternatives, supporting local agriculture, creating jobs, and fostering sustainable practices. The eco-friendly packaging and nutritious products enhance global export potential, positioning Ancient Roots as a leader in sustainable and health-conscious food processing.

Recognized with The India Awards 2023 for Intriguing Food Products Start-Up of the Year, Ancient Roots aims for continued growth by introducing new, healthy snacks with eco-friendly packaging and expanding globally. With a focus on health trends and sustainability, the enterprise is set to drive innovation in the global health food market, contributing to economic growth through job creation and increased exports.

Ancient Roots innovates with healthier ingredients like millets and jaggery, ensuring recipes are nutritionally sound.

BASTAR FOOD FIRM

EMPOWERING TRIBAL WOMEN AND YOUTH

Brought up in Bastar, Chattisgarh, Shaikh Raziya's journey towards entrepreneurship was purely coincidental. A post graduate in microbiology, she was preparing for the UPSC examination, when she realized that it was not her calling. Upon returning to her village, she started her own enterprise and offered food consultancy services for a few food processing firms.

Raziya procures mahua from around 300 tribal women in 10 districts of Chattisgarh and Madhya Pradesh.

Towards Empowering Rural Women and Youth

Raziya was also working for Sarda Ram Krishna Sevashram, where she saw a clear view of the lives of Adivasi women in Bastar. Women and youth in these tribal areas faced huge unemployment and the young boys found joining naxalite groups, as the easiest option for gainful employment. This dismal situation led her to search for alternate solutions.

She discovered the potential of a food-based enterprise in Bastar, as it can derive value from locally available forest minor produce. This led to the establishment of Bastar Food Firm and Consultancy Services (BFFCS) in 2017.

Journey of BFFCS

By the end of 2020, Raziya established a manufacturing unit. She started formulating recipes using mahua flowers. Considering its inimitable health benefits and its abundance in forests, she started formulating recipes using mahua flowers. The first branded product, Mahua ladoo became a roaring success in the market. Currently, they have 20 value-added products of mahua as well as other forest minor products. The products were designed for every segment of customers, from babies to the geriatric, like mahua cookies, daliya, mahua tea, wild honey, rasam powder, energy bars, dheki rice, tamarind sauce, etc.

Raziya procures mahua from around 300 tribal women in 10 districts of Chattisgarh and Madhya Pradesh. She shares short videos on Standard Operating Procedures (SOPs) for collecting and handling raw material with the tribal community through officials of the Department of Forests, so that the quality of the raw material is maintained while it is collected or cultivated. Other than mahua, we also procure dheki rice, tamarind, millets, turmeric, and chillies. These raw materials are processed in the processing unit. Quality is given utmost priority and it is made sure that there is no compromise on the quality of the raw materials as well as finished products.

Last year they exported 12 tons of mahua and this year they are expecting to export around 70 tons to London and 15 tons are for the domestic market. Domestic marketing is done mainly through digital marketing platforms as the target customers are mostly urban population.

Market Outreach

Bastar Foods production has increased from 30 kg/day to 100 kg/day and the monthly sales have seen a growth from Rs. 58,000 to Rs. 1,70,000. She started her enterprise with Rs 200 and currently the total turnover is Rs 25 lakh.

The products now reach Andhra Pradesh, Telangana, Delhi, Maharashtra, and beyond, including international markets like London. She employs 8 full-time staff and has established a network of 500 farmers.

Madhuca Longifolia popularly known as Mahua in major of northern India belongs to family Sapotaceae. It is popular for its sweet flowers with an intoxicating sweet fragrance. Mahua flowers have many potential health benefits, including their antioxidant, antibacterial, and anti-inflammatory properties. They are also used in traditional Ayurvedic medicine to treat a variety of conditions. Tribal people use *mahua* flowers for curing of skin diseases, headache, pitta and bronchitis. Flower juice is supplemented to lactating women for augmentation of breast milk.

Bastar Food Firm has revolutionized Mahua flower use, contributing significantly to Southern Chhattisgarh's food processing sector.

Skill Development

Raziya aims to integrate tribal women's native knowledge about forest minor produce and traditional recipes with technology. She trains these women in hygienic food processing practices, food loss and other food handling aspects. She teaches them the recipes of her products also. Along with raw materials collected or cultivated by them, like

"I have messages for both aspiring women entrepreneurs and policy makers. To women entrepreneurs I would say that taking up entrepreneurship in itself is a difficult task and being a woman adds to the challenge. But, with focus and determination it is very doable. Convincing others to believe in your ideas may be difficult initially. Believe in yourself and show them what you are capable of. Make sure you are impacting lives through your enterprise, and that should be your measure of success.

I would like policy makers to craft effective strategies that support women entrepreneurs in taking up digital tools. Scaling up can be done only if enterprises have a strong digital footprint. However, many micro-entrepreneurs lack the knowledge, capacity and resources to use digital tools. So, even small steps like conducting digital marketing courses in the local language would be a great support to entrepreneurs. "

mahua, tamarind and wild honey, BFFCS also procures finished products if they meet the quality standards. To date she has trained around 3000 women from various districts in Chattisgarh. Around 300 women have taken up value addition activities after receiving the training. These women can either market their products to BFFCS or sell them through the Madhuvania brand of Chattisgarh government which promotes the sale of products from forest minor producers.

Challenges that Inspired

Financial support was a major challenge for her. "Initially I didn't get a loan. My enterprise was completely bootstrapped and I invested Rs 10 lakhs from my savings to begin with. Recently I got Rs 15 lakhs as loan with a 35% subsidy under a scheme of the Ministry of Food Processing Industries," Raziya recollects.

Team management was also an important impediment for her. She felt that aligning the objectives of the team members with those of the organization was difficult at times.

"Working with the government sector is another challenge. I think it is hard to convince it of a woman's idea than a man's idea. Convincing bank and forest department officials was tough initially", she reminisces.

Travelling is costly as well as risky in forest areas like Bastar and is another challenge. Obtaining adequate quantity of quality raw materials and penalty from e-commerce websites like Amazon are also major issue. "Bastar being a remote village, delivery personnel find it difficult to pick up products from us on time; this delays product delivery to customers. But ultimately, we have to pay the penalty even though it is not our fault," she says.

"COVID-19 also created several challenges, as we were not able to export or market our products domestically. Yet we didn't shut down our unit completely. As a service, we started distributing mahua-based products free of cost to COVID-19 patients, for which we got very positive feedback from them. During the pandemic we also conducted online trainings and consultancy services. All these challenges have served as learning experiences for me".

Recognition

- Motwani Jadeja Foundation International Fellowship (2019)
- Women Transforming India Awards by NITI Aayog (2019)
- Successful Women Entrepreneur Award by National Institute of Food Technology, Entrepreneurship and Management (2021)

Future Path

Bastar Food Firm has revolutionized Mahua flower use, contributing significantly to Southern Chhattisgarh's food processing sector. Through innovation, sustainable practices, and community support, the firm bridges traditional and modern food practices, empowering local farmers and enhancing market reach.

Bastar Food Firm is poised for continued growth and impact. By expanding market presence, pioneering new products, and upholding eco- friendly practices, the firm is dedicated to shaping a healthier, inclusive, and sustainable future for the food processing industry. Raziya's dedication and determination has indeed given a strong livelihood opportunities for the underprivileged community.

MEGA FOOD PARKS
AGGREGATING THE SURPLUS

The food processing industry in India has witnessed rapid growth in the recent past, with the sector emerging as one of the most promising industries. The food processing industry in India had reached a value of US$ 336.4 billion in 2023 and is expected to reach US$ 735.5 billion, at a CAGR of 8.8% during 2023-2032, according to IMARC (International Market Analysis Research and Consulting Group).

Food processing has immense potential to contribute significantly to the GDP of India. Food processing has been recognized as one of the priority industries in the "Make in India" policy initiative for the promotion of domestic manufacturing and attracting investments. The industry, besides being relevant for ensuring economic growth, provides opportunities for gainful employment, thus supporting the livelihood of millions of people across the country. Recent statistics reveal that the sector has achieved an AAGR of around 7.26% in the past seven years, thus transforming it into a vital segment of the country's economy.

Currently, India is processing less than 10 % of its agricultural output, thus, presenting immense opportunities for increasing these processing levels and leading to investments in this sector.

Underutilised Raw Materials

The area under horticultural crops has expanded to 28.98 million hectare in 2023-24, up from 28.63 million hectare in the second advance estimates and 28.44 million hectare in 2022-23. India's fruit production is expected to increase by 2.29 per cent in 2023-24, reaching an estimated 112.73 million tonne. The rise is driven by higher yields in crops like mango, banana, lime/lemon, grapes, and custard apple. The overall vegetable production for 2023-24 is projected to be around 205.80 million tonne, showing a balanced trend. Tomato production is estimated to increase by 4.38 per cent, reaching 213.20 lakh tonne, compared to 204.25 lakh tonne last year.

Currently, India is processing less than 10 % of its agricultural output, thus, presenting immense opportunities for increasing these processing levels and leading to investments in this sector. Presently, India's share of high value and value-added agricultural produce within the

export basket stands at less than 15%, however, India has a strategic geographical location which gives it a unique advantage when it comes to exports. The country has convenient connectivity to Europe, Middle East and Africa from the western coast, and Japan, Singapore, Thailand, Malaysia, Korea, Australia and New Zealand from the eastern coast.

It was on 10th July 2012 when India's first Mega Food Park - Srini Food Park, was inaugurated by the then union agriculture minister Sharad Pawar at Chittoor in Andhra Pradesh – the largest fruits and vegetables cluster in India. From seed to shelf, Srini Food Park facilitates end-to-end food processing with beneficial forward and backward linkages.

Limited Infrastructure Access

The lack of adequate infrastructure is one of the most pressing challenges for India's food processing sector. For instance, there is a significant issue with cold chain and storage facilities, with more than 30% of agricultural produce lost due to inadequate cold chain infrastructure. The NITI Aayog has estimated annual post-harvest losses to be around Rs. 90,000 crore.

Additionally, poor connectivity and the absence of all-weather roads lead to erratic supply chains, making it difficult to transport perishable goods efficiently. This situation increases costs and reduces the overall quality of food products.

Small Enterprises often lack access to the latest technology and modern processing equipment. This limitation negatively impacts their ability to compete effectively with larger firms that can invest in advanced machinery and processes. The high costs associated with upgrading facilities further exacerbate this issue, restricting innovation and efficiency in production.

There are also numerous regulatory hurdles that complicate compliance with quality standards, especially for exports. The diversity of regulations under different ministries creates confusion and inconsistencies in food safety specifications and guidelines. Ensuring adherence to international quality standards is challenging, which can limit the ability to export processed food products effectively.

Small scale of operation at the level of farmers limit them from give them little or no access to storage facilities that can maintain the quality of produce. The best alternative for them would be to work as a cluster and depend on a common aggregator/location that can give them the advantage of the scale of operation.

Mega Food Parks

Ministry of Food Processing Industries has been implementing Mega Food Park Scheme (MFPS), a component scheme under the Pradhan Mantri Kisan Sampada Yojana (PMKSY), to create modern infrastructure for the food processing sector along the value chain from farm to market. Under the scheme, Ministry has approved 41 Mega Food Park (MFP) projects. Out of this, 24 MFP projects are operational and remaining 17 projects are under implementation.

The Mega Food Park Scheme is designed to connect agricultural production

with markets, integrating farmers, processors, and retailers to maximize value addition, reduce wastage, boost farmers' incomes, and generate employment, particularly in rural areas.

The scheme follows a "cluster" approach, focusing on the development of state-of-the-art infrastructure within a clearly defined agricultural or horticultural zone. This infrastructure supports the establishment of modern food processing units on industrial plots within the park, ensuring a seamless and well-organized supply chain. Each Mega Food Park comprises essential supply chain infrastructure, including collection centres, primary processing centres, central processing centres, cold storage facilities, and approximately 25-30 fully developed plots for entrepreneurs to set up their food processing units.

This integrated framework ensures efficient processing, storage, and transportation of agricultural produce, enhancing the sector's overall efficiency.

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Success Models

Several mega food parks have assisted farmers to experiment and diversify their agricultural practices. All operational food parks are contributing in a big way to reducing wastage of agriculture and horticulture produced through more than 2.5 lakh tonnes capacity of modern cold and ambient warehousing that has been created in these projects.

Patanjali's Food & Herbal Park in Haridwar is considered a successful example of a Mega Food Park (MFP) in India. Gujarat Agro Infrastructure mega food park is poised to attract a total investment of nearly Rs. 650 crore, significantly benefitting many farmers. Similarly, the Himalayan Mega Food Park aids apple growers in Uttarakhand, with its apple juice concentrate facility, while the Cremica Food Park, transforms the prospects of tomato farmers in Himachal and neighbouring regions through a world-class pulping facility. These success stories, underscore the profound and expanding influence of Mega Food Parks in shaping the agribusiness landscape.

Mega food parks are evolving into job hubs for prominent Indian and global food brands, facilitating the export of food products worldwide. Leveraging India's inherent strengths and renewed government focus, these parks position India as a major global sourcing hub and a substantial consumption market. The Mega Food Parks, through common infrastructure facilities and induction of advanced technologies, have improved the production and the processing sector of India. In addition to positively impacting employment and exports, MFPs have reduced food wastage and increased farmer incomes.

MAKING MARKETS WORK FOR SMALLHOLDERS

PALLADIUM STRENGTHENING ODISHA'S AGRICULTURE & FOOD PROCESSING SECTOR

About the **AUTHOR**

Amit Patjoshi, CEO, Palladium India

Unlocking Growth: Transforming India's Agri-Food Sector

India is one of the world's largest producers of agricultural commodities, ranking second in fruits and vegetable production. However, the country faces significant post-harvest losses, estimated at nearly 30-40% of perishable produce annually, resulting in an economic loss of approximately $14-15 billion each year. One of the largest producers of agricultural and horticultural crops in India is Odisha. With its ten agro-climatic zones, diverse soil types, and vast coastline, 7th in production of vegetables, the state holds immense potential for food processing. In FY 2023-24, agriculture and allied sectors in the state grew by 3.5%, contributing 20.4% to the Gross State Value Added (GSVA) and employing nearly 48% of the workforce. Despite these strengths, challenges such as lack of adequate storage, inadequate processing infrastructure, and market access barriers restrict Odisha's ability to fully leverage its agri-food sector for export and value-added production, highlighting the need for robust interventions in food processing and value addition.

To bridge these gaps, Palladium has been at the forefront of strengthening Odisha's food processing ecosystem by driving strategic initiatives such as the PM Formalization of Micro Food Processing Enterprises (PMFME) scheme and the Promotion and Stabilization of Farmer Producer Organizations (PSFPO) project. These interventions have empowered small-scale food enterprises and farmer groups, improving access to markets, enhancing processing capabilities, and unlocking investment potential.

Odisha's Food Processing Landscape: Opportunities and Growth

The food processing sector is a crucial bridge between India's abundant agricultural produce and the evolving demands of consumers, holding the key to mitigating crop losses while driving farmer incomes and enhancing India's agricultural exports. With an expected Compound Annual Growth Rate (CAGR) of 11%, Odisha's food processing sector presents substantial investment opportunities. Key areas include:

- Maize: Processing into flour, flakes, meal, oil, and starch derivatives.

The food processing sector is a crucial bridge between India's abundant agricultural produce and the evolving demands of consumers, holding the key to mitigating crop losses while driving farmer incomes and enhancing India's agricultural exports.

- Fruits and Vegetables: Value-added processing of mango, banana, and indigenous produce.
- Dairy: Expansion into butter, cheese, and traditional milk-based sweets.
- Rice: Processing, bran oil extraction, and biomass power generation.
- Cashew: Processing and product diversification.
- Seafood Processing: Brackish water fisheries sector growing at a CAGR of 12.02%.

Odisha is home to several unique agri-products with high market potential, including GI-tagged Kandhamal Haldi (turmeric), Koraput Arabica Coffee, Simlipal Wild Honey, and Kuchinda Chili. The state is also India's largest producer of jackfruit and paddy straw mushrooms, providing a strong foundation for value-added processing and exports.

Story of Impact: Chocolaca: Sweet Taste of Transformation

Founded in 2021 by sisters Shanta and Rita, Chocolaca specializes in Beans-to-Bar chocolate using exclusively organic ingredients. Under PM-FME, Palladium helped them secure a loan of $17,302. This financial support, combined with Palladium's expertise in strategic planning and facilitating credit-linked financial assistance helped the sisters in acquiring advanced machinery. This led to an increase in their annual turnover from $5,732 in FY 2021-22 to an impressive $46,140 till March 2024.

Driving Change through agribusiness growth

PMFME: Empowering Micro Food Enterprises

The PMFME scheme, launched by the Ministry of Food Processing Industries (MoFPI), Govt of India aims to formalize and enhance two lakh micro food processing enterprises nationwide. Palladium plays a crucial role in providing credit-linked support and capacity-building initiatives, enhancing market expansion opportunities for micro-enterprises, FPOs, and self-help groups, and supporting infrastructure development, including incubation centres for skill-building. A major milestone under this initiative is that over 1950 micro food enterprises and 26,000 SHG members in Odisha, have benefitted from PMFME, significantly improving business formalization and income generation. Under the initiative, Odisha also showcased its vast food processing potential and investment opportunities at World Food India 2024, reinforcing its commitment to attracting

Odisha's rapid progress in food processing and agri-exports provides a scalable model for other states looking to enhance value addition and market competitiveness.

Story of Impact:Odisha Mangoes reaching Global Markets

Madanamohana Farmer Producer Cooperative Society Limited (MFPCSL) has set a remarkable benchmark by successfully exporting Odisha's farm produce to international markets. Through collaboration with the Directorate of Horticulture (DoH), Government of Odisha,Agricultural and Processed Food Products Export Development Authority (APEDA), the National Cooperative Development Corporation (NCDC), and Palladium, the FPC has opened new global opportunities for the farmers of Ostapal village in Dhenkanal.

The export of 1,202 kg of premium-quality Dasari and Amrapali mangoes, along with 500 kg of fresh vegetables-such as bitter gourd and ladyfinger-to Dubai, Italy, and Qatar, showcases the excellence of Odisha's agricultural outputs. The FPC is trained to maintain robust, end-to-end quality systems while ensuring strict adherence to export guidelines and international quality standards. ensuring compliance with global regulations.

Building on its success, the FPC aims to expand its membership base, focus on exporting cashew, and invest in advanced machinery for cashew processing and enhance organic farming practices to further tap into global markets.

investors. This momentum was further strengthened during the Utkarsh Odisha – Make in Odisha Conclave 2025, where the state government signed 17 MoUs with various investors to promote agri-food processing industries and securing investments worth Rs. 739 crore in the food processing sector, strengthening the state's agri-value chain and fostering rural economic growth.

Further, Odisha has been making significant strides in agriculture and food processing through various government initiatives and recent developments aimed at strengthening the sector. The Odisha Food Processing Policy 2022 was introduced to boost private sector investments across the value chain, fostering growth and innovation in food processing. To further enhance the ecosystem, the state has initiated the development of two exclusive industrial parks equipped with fully developed infrastructure, creating a conducive environment for food processing enterprises. Additionally, the implementation of schemes like Shree Anna Abhiyan (previously known as Odisha Millet Mission) have had a profound impact in facilitating processing and value-addition of crops like millets. Recognizing the critical need for post-harvest infrastructure, Palladium has been working closely with the Government of Odisha in recently launching

a new cold storage policy aimed at improving storage facilities, reducing food wastage, and enhancing supply chain efficiency. These strategic initiatives highlight Odisha's commitment to positioning itself as a leading hub for food processing and agri-business, offering a scalable model for other states in India.

PSFPO: Strengthening Farmer-Led Processing and Market Access

The PSFPO project, funded by the Gates Foundation, supports Farmer Producer Organizations (FPOs) in enhancing their business and integrating them into profitable markets. Palladium has played a key role in this transformation by strengthening the ecosystem through market-driven training, business planning, and private sector engagement. It has also facilitated value chain development by establishing processing units and linking them to domestic and international supply chains, including the Odisha Jackfruit Mission and export-oriented mango and vegetable value chains. Additionally, Palladium has enhanced market access by signing 78 MoUs with buyers and exporters, integrating over 180 FPOs directly with institutional buyers, and reducing dependency on intermediaries, ultimately ensuring better price realization and sustainability for smallholder farmers. A landmark achievement under the PSFPO project was the export of over 36 MT of mangoes, fresh vegetables, and other fruits from Odisha to the Middle East and Europe in FY 2024-25. These exports, facilitated by FPO-led aggregation and quality control, resulted in a 40%-100% higher price realization for farmers.

Enhancing Agri-Exports: The Odisha Export Pathshala Initiative

To further strengthen Odisha's export potential, Palladium, in collaboration with NABARD, launched the Odisha Export Pathshala initiative, a first-of-its-kind event in the state aimed at transforming its agricultural export landscape. The pioneering program equips Farmer Producer Organizations (FPOs) with essential knowledge and skills to access global markets, addressing critical gaps in export readiness. Through specialized export training and industry exposure, it educates FPOs on quality compliance, documentation, and export procedures, ensuring they meet international standards. The initiative also fosters direct market linkages by facilitating interactions with key trade facilitation agencies such as APEDA and the Spices Board, helping FPOs establish strong buyer connections. Additionally, it enhances post-harvest management and value chain development by improving infrastructure and financial accessibility, ensuring long-term sustainability in agricultural exports. As Odisha's first dedicated export-focused initiative for FPOs, the Odisha Export Pathshala stands as a groundbreaking and replicable model for boosting agri-exports across India.

Through this initiative, Odisha has identified key commodities for export, including cashew, coffee, floriculture products, medicinal plants, millets, mangoes, vegetables, and spices. By building robust post-harvest infrastructure and strengthening supply chains, the initiative is positioning Odisha as a major player in India's agricultural exports.

The Road Ahead: Policy and Innovation for a Resilient Future

Odisha's rapid progress in food processing and agri-exports provides a scalable model for other states looking to enhance value addition and market competitiveness. To further accelerate this growth, several key strategies can be implemented. The adoption of advanced technologies such as AI, IoT, and blockchain can improve traceability and efficiency in supply chains. Strengthening Farmer Producer Organizations (FPOs) through market-oriented production, quality standardization, and direct farmer-buyer linkages can enhance their competitiveness. Infrastructure development, including the expansion of cold storage facilities, food parks, and logistics, will facilitate seamless transportation and reduce post-harvest losses. Additionally, policy and convergence support, improved access to finance, and reduced tariff barriers can boost export competitiveness. Sustainability initiatives, such as promoting eco-friendly packaging and minimizing waste in food processing, will further ensure long-term growth and resilience in the sector.

GI TAG: A GUARANTEE OF AUTHENTICITY

Nagpur Oranges, Naga Mircha, Darjeeling Tea, Alphonso Mango have one thing in common - an identity due to their geographic origin. We might have known the respective agriculture produce by these names, however it is heartening to know that now they are bound by a tag protecting their identity and sale.

Union Minister of Commerce & Industry, Shri Piyush Goyal has set a target of reaching 10,000 Geographical Indication (GI) Tags by 2030, at the GI Samagam in New Delhi.

What is a GI tag?

A geographical indication (GI) is a certification that identifies a product belonging to a specific geographical zone. It also implies that this product has been made from traditional processes, has a high standard & solid reputation because of its location and has a specific set of qualities that sets it apart from other similar products. GI tags were introduced in a bid to counteract the cheap counterfeits which not only tarnished the reputation of the originals but also affected the income of the genuine producers.

The GI tag can be earned by products across multiple categories such as handicrafts, manufactured goods, foodstuff, natural products, and agricultural produce.

For instance, Nagpur oranges are a variety of mandarin oranges that are widely cultivated in Nagpur and Vidharbha regions of Maharashtra. Renowned for its distinct taste, juicy pulp, and vibrant colour, Nagpur oranges have a pockmarked exterior and are not exactly round. Similarly some popular GI tagged agriculture produce include Basmati Rice. Prized for its unique aroma and long grains, it is grown in select regions of India and Pakistan. Often called as the "Champagne of Teas," Darjeeling Tea is known for its delicate flavour and grown in West Bengal, India. Nendran Bananas is a premium variety from Kerala, famous for its use in chips and desserts. Alphonso Mangoes are celebrated for their rich taste, these mangoes hail from Maharashtra.

These GI tags not only enhance the global marketability of these products but also ensure fair value for the farmers and producers.

How does GI tag benefit Farmers?

An important benefit while selling products with GI tag is the better price recovery. The special price is for the special attributes of the product. That is it is for the distinct sweetness of Marayoor jaggery, or the spice of the Appemidi mango pickle – qualities that can help producers set their products apart from competitors and build brand equity.

GI tags lend the products a badge of legitimacy, allowing the producers to value their generational skills, unique ingredients, and region-specific delicacies at higher rates. For instance, after obtaining the GI tag, Darjeeling tea saw its price being raised to fivefold. The boards indicated that this premium positioning enables local producers to tap niche markets in the domestic and global markets. provides local employment and livelihood opportunities.

The idea is that producers will be able to better manage prices and even command a premium, not just within India, but also when exporting to other countries. The opportunity of a higher income allows much potential for growth of rural economies. As part of these standards, the product can be traced back to its place of origin as well, offering greater transparency. With perishables, it becomes really important to be able to know exactly where the food or ingredient is from, in the case of disease outbreaks and so on.

GI Tag in India

As of March 31, 2024, there were 635 Geographical Indication (GI) tagged

products in India. These products include agricultural products, handicrafts, food items, and manufactured goods. Close to 200 agriculture products have received GI tags. Darjeeling Tea was the first product in India to receive a Geographical Indication (GI) tag in 2004.

A few foods that received the GI status in 2022 and 2023 include the Mithila makhana (from Bihar), Tandur red gram (Telangana), Raktsey Karpo apricot (Ladakh), Alibag white onion (Maharashtra), and Mancurad mango (Goa).

States such as West Bengal, Tamil Nadu, Kerala, Nagaland and Karnataka (to name just a few) have put India on the 'GI map' with produce such as Seeraga Samba Rice, Chikmagalur Arabica Coffee, Vengurla Cashew, Assam Karbi Anglong Ginger, Banganapalle mangoes and Bhalia wheat

While Basmati is well-known all over the world, other varieties of rice such as Wayanad Jeerakasala, and Wayanad Gandhakasala from Kerala have got the GI tag too. There is also the Kalanamak rice from Uttar Pradesh, Joha rice from Assam, and the Katarni rice from Bihar.

As of March 31, 2024, there were 635 Geographical Indication (GI) tagged products in India.

Union Minister of Commerce & Industry, Shri Piyush Goyal has set a target of reaching 10,000 Geographical Indication (GI) Tags by 2030, at the GI Samagam in New Delhi. The number of authorized users for GI tags increased from 365 to 29000 and the number of patents granted increased from 6000 to 100000, in the last 10 years.

The Registrar of Geographical Indication located in Chennai takes care of all GI application and the cost of application for the registration for goods is INR 5000. The period of GI protection is for ten years which can be renewed. The first application received by the Geographical Registry was for Darjeeling Tea filed by Tea Board of India dated 27 October 2003. Darjeeling tea owns its unique tea qualities to special weather and soil conditions of Darjeeling hills of Eastern India. After thorough examination of the application and completing all formalities, Darjeeling tea became the first registered geographical indication of India on 29th October 2004 (Tea Board of India).

GI Logo & Slogan
अतुल्य भारत की अमूल्य निधि
Invaluable Treasures of Incredible India

Challenges

Even though products labelled with GI tags adhere to superior quality standards, geographical indications (GIs) encounter various challenges in India. The challenges include the lack of awareness among producers and farmers regarding the registration process, post-GI schemes, and subsidies. Moreover, there is insufficient infrastructure resources to promote and market GI-tagged products. Additionally, GI-tagged products have a limited presence in domestic and international markets due to ineffective marketing strategies, the absence of postproduction control, and unethical market practices.

In an increasingly industrialized and standardized food market, GI labels may assure consumers of a more genuine, unique, and higher quality food, while offering producers an opportunity to differentiate their products and perhaps obtain higher prices. Geographical indication registration encourages community ownership and therefore it helps in proper distribution of the economic benefits accrued from commercialization of the commodity across a wider section of people in that territory. It also gives an upper edge to producers as they unlock value by capitalizing on consumer's desire for typical quality product.

Bridging the Gap

The Impact of PMGSY on Agricultural Transformation in Rural India

The Pradhan Mantri Gram Sadak Yojana (PMGSY), launched in the year 2000 by the Government of India, is a flagship rural road-building program aimed at providing single connectivity to the unconnected villages thereby giving access to the broader road network. This ambitious initiative addresses the infrastructural bottlenecks that have historically constrained economic opportunities in India's rural heartland. By providing all-weather roads to previously isolated villages, PMGSY has not only improved access to markets, healthcare, and education but has also become a transformative force for agricultural development.

Agriculture, the backbone of rural livelihoods, has long struggled with challenges such as limited access to modern inputs, labour market inefficiencies, and poor market integration. PMGSY tackles these barriers by reducing transportation costs, enabling better mobility of goods, services, and labour, and fostering rural-to-urban and rural-to-rural market connectivity. Improved road infrastructure encourages the adoption of modern agricultural technologies, diversification into higher-value crops, and commercialization of farm produce, especially in remote areas that were previously disconnected.

The PMGSY roads have played a pivotal role in revolutionizing agriculture in rural India by addressing one of the most critical bottlenecks: connectivity.

This transformative impact underscores the critical role of infrastructure in shaping rural economies. By connecting farmers to resources and markets, PMGSY has catalyzed a shift toward more productive and sustainable agricultural practices, paving the way for rural economic development and poverty alleviation.

About the **AUTHORS**

Amit Shukla is the Joint Secretary and K.M.Singh is the Director respectively in Rural Connectivity Division of the Ministry of Rural Development.

The Journey of PMGSY: Transforming Rural Connectivity

The primary objective of PMGSY was to provide all-weather road connectivity to unconnected rural habitations based on population norms as per the Census 2000. The scheme prioritized habitations with populations of 500+ in plain areas and 250+ in hilly, tribal, or desert areas. Recognizing the evolving needs of rural India, additional verticals were introduced to upgrade and consolidate ex-

isting road networks, ensuring seamless transportation for goods and services.

The evolution of the Pradhan Mantri Gram Sadak Yojana (PMGSY) can be seen as a progressive journey addressing the connectivity challenges faced by rural India. Each phase of the program represents a critical step toward enhancing accessibility, strengthening infrastructure, and fostering socio-economic development.

PMGSY-I (2000): The Foundation Stage

- ***Objective***: Provide all-weather road connectivity to unconnected rural habitations.
- ***Focus***: Accessibility to essential services like education, healthcare, and markets.
- ***Impact***: Built a foundation for rural connectivity, addressing the basic transportation needs of isolated villages

PMGSY-II (2013): Capacity Building

- ***Objective***: Upgrade and enhance the durability of existing road networks.
- ***Focus***: Strengthen inter-village and inter-district connectivity for regional development.
- ***Impact***: Improved the quality of rural roads, ensuring better transportation of goods and services.

PMGSY-III (2019): Targeted Connectivity

- ***Objective***: Upgrade 1,25,000 km of through routes and major rural links.
- ***Focus***: Link Gramin Agriculture Markets (GrAMs), schools, and healthcare facilities.
- ***Impact***: Transformed rural transportation networks, boosting agricultural and economic activity.

PMGSY-IV (2024): Expanding Horizons

- ***Objective***: Connect 25,000 new habitations that have emerged due to population growth.
- ***Focus***: Strengthen connections to important facilities along the alignment such as farm clusters, cold storage units, warehouses, and markets.
- ***Innovations***: Use of climate-resilient and sustainable road construction techniques.
- ***Impact***: Ensures long-term benefits for farmers and underserved communities, paving the way for resilient rural economies.

The evolution of the Pradhan Mantri Gram Sadak Yojana (PMGSY) can be seen as a progressive journey addressing the connectivity challenges faced by rural India

The journey of PMGSY reflects its continuous evolution to meet the dynamic needs of rural India, showcasing its transformative impact on rural connectivity and livelihoods.

Transformative Impact of PMGSY on Rural India

Several impact assessment studies have been done by various agencies such as the Asian Development Bank, World Bank, Development Monitoring and Evaluation Office (DMEO) (2020) of NITI Aayog, Birla Institute of Technology & Science (2016) etc.. The findings of the different studies suggest that PMGSY has been instrumental in the social-economic development of Rural India.

These evaluations have confirmed that the ***PMGSY*** has been a cornerstone of rural transformation in India, significantly improving the lives of millions of people across the nation. By providing all-weather road connectivity to previously unconnected or underserved rural habitations, the program has brought profound changes in social, economic, and developmental aspects of rural India. Some of the dimensions of these changes are listed below:

a. *Enhanced Access to Essential Services*

- ***Education***: Improved road connectivity has enabled children in remote villages to access schools and colleges more easily, leading to higher enrolment rates and better educational outcomes.
- ***Healthcare***: Faster and more reliable transportation to healthcare facilities has improved access to medical care, reducing maternal and

infant mortality rates and addressing health emergencies effectively.

b. *Economic Upliftment*

- ***Agriculture***: PMGSY has transformed rural economies by providing farmers better access to markets. This has encouraged crop diversification, increased adoption of modern farming practices, and enhanced income through the commercialization of agricultural produce.
- ***Employment Opportunities***: Improved connectivity has facilitated mobility, allowing rural workers to access jobs in nearby towns and non-agricultural sectors.
- ***Reduction in Transportation Costs***: Lower costs and travel times for goods and services have boosted trade and economic activities in rural areas.

c. *Social and Regional Integration*

- ***Improved Mobility***: Villages are no longer isolated; better roads have fostered greater interaction among communities and improved access to social networks.
- ***Women's Empowerment***: Enhanced road connectivity has increased women's participation in education, employment, and community activities by making travel safer and more accessible.

d. *Strengthened Infrastructure and Rural Development*

- ***Sustainable Growth***: The adoption of climate-resilient construction techniques in later phases has ensured the durability of rural infrastructure, contributing to long-term development.
- ***Regional Development***: By connecting remote areas, PMGSY has reduced regional disparities and integrated rural communities into the broader economic framework.

e. *Spill over Benefits*

- ***Improved Rural Enterprises***: Easier access to markets and raw materials has supported the growth of small businesses and rural enterprises.
- ***Development of Allied Sectors***: Connectivity has boosted sectors like animal husbandry, forestry, and fisheries by enabling access to better resources and markets.

PMGSY: A Catalyst for Agricultural Transformation

As given above, one of the crucial sectors, which has witnessed the impact of Pradhan Mantri Gram Sadak Yojana (PMGSY), is the agriculture sector. The

PMGSY roads have ***played a pivotal*** role in revolutionizing agriculture in rural India by addressing one of the most critical bottlenecks: connectivity. By linking remote villages to markets and essential services, PMGSY has empowered farmers, transformed agricultural practices, and boosted rural economies.

a. *Enabling Market Access and Commercialization:*

- ***Improved Market Linkages***: Farmers now have better access to local and regional markets, allowing them to sell their produce at competitive prices and reduce dependency on intermediaries.
- ***Increased Commercialization***: Connectivity has encouraged farmers to move from subsistence farming to market-oriented production, fostering higher incomes and economic stability.

b. *Enhancing Agricultural Productivity*

- ***Access to Modern Inputs***: Improved roads have facilitated the timely delivery of critical agricultural inputs like seeds, fertilizers, pesticides, and machinery, enabling higher yields.
- ***Adoption of Advanced Practices***: Easier transportation of resources and information has encouraged the use of high-yield variety seeds, modern irrigation methods, and climate-resilient technologies.

c. *Diversification and Intensification*

- ***Crop Diversification***: Better connectivity has enabled farmers to transition to high-value crops such as fruits, vegetables, and pulses, boosting profitability.
- ***Labor-Intensive Practices***: Improved access to labor markets has supported the adoption of labor-intensive farming practices, especially in remote areas where mechanization is limited.

d. *Reducing Post-Harvest Losses*

- ***Faster Transportation***: All-weather roads have reduced travel time, enabling farmers to transport perishable goods like fruits, vegetables, and dairy products more efficiently.
- ***Access to Storage Facilities***: Improved connectivity to warehouses and cold storage units has minimized post-harvest losses and enhanced the quality of agricultural produce.

e. *Supporting Allied Agricultural Activities*

- ***Boost to Allied Sectors***: Livestock, fisheries, and agro-based industries have benefited from better access to inputs, markets, and services, increasing rural incomes.
- ***Rural Enterprises***: Road connectivity has facilitated the growth of agri-businesses like food processing units and input supply chains, creating additional revenue streams for farmers.

f. *Bridging the Urban-Rural Divide*

- ***Integration into Value Chains***: Farmers in remote areas can now connect with larger agricultural value chains, accessing buyers and services previously out of reach.
- ***Participation in E-Agriculture***: Connectivity has enabled access to mobile-based advisory services, weather forecasts, and online marketplaces, modernizing the agricultural ecosystem.

Impact Evaluation and Findings

An evaluation of Centrally Sponsored Schemes in the Rural Development Sector, including Pradhan Mantri Gram Sadak Yojana was carried out by the Development Monitoring and Evaluation Office (DMEO) of NITI Aayog in 2020.

Findings:

i. The scheme is well aligned with India's international goals and is seen to contribute to SDGs (Sustainable Development Goals) 2 & 9 as it addresses the issues of poverty, hunger and infrastructure for growth.

ii. Roads constructed under PMGSY have been observed to create positive impacts at both at level of the household and the community.

iii. The roads have been observed to increase access to market and livelihood opportunities, and health and education facilities.

iii. PMGSY is noted to build the foundations for long-lasting poverty reduction in rural India. Improved rural connectivity provides a long-term and sustained boost in the living standards of rural populations as it allows households to accumulate wealth and human capital.

Impact Evaluation of Pradhan Mantri Gram Sadak Yojana, 2018 conducted by World Bank

Findings:

- The crops taken to the markets for sale from PMGSY roads increased by 8%.
- Farmers selling food grains traveled 7.2 to 9.8 Km farther for the higher price of crops
- The rate of primary employment in the non-farm sector increased by about 13%
- The share of people with primary employment outside their habitation increased by 8%
- The share of babies delivered at home decreased by 30% in connected habitations

The PMGSY has blossomed beyond its initial objective of providing road connectivity; it has become a transformative force driving rural development in India. By bridging the urban-rural divide, it has created new economic opportunities, enhanced the quality of life, and laid the foundation for a more inclusive and prosperous India. The PMGSY has been instrumental in unlocking the agricultural potential of rural India by providing vital road connectivity. It has enhanced productivity, enabled market access, and supported diversification, laying the groundwork for a sustainable and prosperous agricultural sector. As PMGSY continues to evolve, it holds the potential to further accelerate rural growth and reduce poverty.

PALM OIL FARMING

A TRANSFORMATIVE ECONOMIC FORCE FOR INDIA

India is at a critical point on its journey towards agricultural self-reliance. As the world's largest importer of palm oil, the country faces a dual challenge: balancing the affordability of edible oils for consumers while reducing its heavy reliance on imports, which imposes a significant economic burden. The government's initiatives, led by the National Mission on Edible Oils – Oil Palm (NMEO-OP) and National Mission on Edible Oils – Oilseeds (NMEO-Oilseeds), aim to boost domestic oilseed production, empower rural communities, and promote sustainable growth, ultimately advancing the vision of Atmanirbhar Bharat in edible oils.

On October 3, 2024, the Union Cabinet approved the NMEO-Oilseeds, which will be implemented from 2024-25 to 2030-31 with a financial outlay of ☐10,103 crore. The programme will focus on enhancing the production of key primary oilseed crops such as rapeseed-mustard, groundnut, soybean, sunflower, and sesame, along with improving extraction efficiency from secondary sources like cottonseed, rice bran, and tree-borne oils. It targets an increase in primary oilseed production from 39 million tonnes (2022-23) to 69.7 million tonnes by 2030-31. Together with NMEO-OP (Oil Palm), the target is to boost domestic edible oil production to 25.45 million tonnes by 2030-31, meeting around 72% of India's projected domestic requirement of 35.5 million tonnes.

Palm Oil's Role in India's Economic Framework

In 2024, palm oil accounted for 38% of India's edible oil consumption, making it an integral part of millions of people's daily diets. However, this dependence on imports creates vulnerabilities. Currently, 57% of the country's edible oil demand is met through imports, with palm oil alone constituting 59% of this total. This reliance costs India approximately $15 billion annually, straining the economy and exposing it to global price fluctuations. Cooking oil prices, for instance, surged by 65% over the past year due to higher import duties and market volatility.

India's palm oil strategy is unique compared to global giants as it focuses on small-scale farmers rather than large plantations.

To address these challenges, the NMEO-OP aims to transform domestic production. The mission plans to increase oil palm cultivation by 16.71 lakh hectares, with 8.50 lakh hectares expected to produce fruit by 2029-30. This is projected to yield 170 lakh tonnes of Fresh Fruit Bunches (FFBs) and boost Crude Palm Oil (CPO) production to 28.11 lakh tonnes by 2029-30.

Boosting Production, A Game-Changer for Farmers

India's palm oil strategy is unique compared to global giants as it focuses on small-scale farmers rather than large plantations. This model holds immense potential for rural job creation and income generation. For instance, the Mega Oil Palm Plantation Drive engaged over 10,000 farmers across 12,000 hectares in 15 states from July to September 2024. With reliable yields of 4–5

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tonnes per hectare annually, palm oil cultivation promises economic stability for participating farmers.

However, a key challenge is the four-year gestation period before oil palms begin delivering consistent returns. To address this, the NMEO-OP provides subsidies for saplings, fertilisers, and irrigation, along with a Viability Gap Payment (VGP) mechanism to support farmers during price dips. Promoting intercropping—growing secondary crops alongside oil palms—offers farmers interim income and improves soil health.

To ensure success, the Solvent Extractors Association of India (SEA) has recommended increasing the NMEO-OP budget from Rs. 10,000 crore to Rs. 25,000 crore over the next five years. This enhanced funding would strengthen farmer education, improve seed quality, modernise agricultural practices, and develop processing and storage infrastructure.

Strengthening the Value Chain

Palm oil's economic impact extends beyond farming to a broader value chain, encompassing transportation, warehousing, and processing industries. However, the availability of discounted refined palm oil imports slows this progress. To counter this, the SEA has proposed raising import duties on refined palm oil (RBD Palmolein) from 12.5% to 15% and restricting duty-free imports of finished products such as soap noodles and stearic acid that undermine local industries.

In a recent development, Hindustan Unilever Limited (HUL) announced the acquisition of the palm undertaking of Vishwatej Oil Industries in Telangana as part of its palm localisation strategy. HUL plans to set up sapling nurseries, fruit collection centres, and a state-of-the-art palm oil mill, while introducing global best practices in sustainable agriculture. This initiative aligns with India's NMEO-OP and aims to strengthen local supply chains.

Additionally, SEA advocates for uniform import duties on all crude edible oils to level the playing field for domestic producers. It has also called for government-backed private partnerships in oilseed extension programmes and the establishment of

Palm oil's economic impact extends beyond farming to a broader value chain, encompassing transportation, warehousing, and processing industries.

model farms to encourage best practices and innovation.

Consumer Preferences and Sustainability

India's approach to palm oil farming is uniquely aligned with consumer preferences and sustainability goals. For the first time, the Union Agriculture Ministry is conducting a nationwide survey on edible oil consumption patterns through the "My Gov" platform. This data-driven initiative seeks to capture consumer preferences and edible oil consumption trends. The insights gained will guide policy decisions and enable farmers to cultivate demand-driven crops, effectively bridging the gap between consumer needs and agricultural production.

Globally, palm oil supplies between 35% and 40% of the world's vegetable oil demand on just under 6% of the land used to produce all vegetable oils. To get the same amount from alternative oils like soybean, coconut, or sunflower oil you would need anything between 4-and-10 times more land, which would just shift the problem to other parts of the world and threaten other habitats, species and communities. Because of its high yield, palm oil requires around *one-ninth* the land of substitutes like rapeseed, olive and soybean. To keep pace with growing food demand would require 36 million hectares of additional Oil Palm land, whereas soybean, the second most popular oil crop, would need 204 million more hectares. On top of this, producing palm oil takes significantly less amount of fertiliser, pesticides and energy inputs.

Environmental sustainability forms a key pillar of India's palm oil strategy. Under the NMEO-OP, the focus is on achieving environmental benefits such as low water usage, enhanced soil health, and the productive use of fallow crop areas. Regions like the Northeast, with their favourable climatic conditions, are well-suited for large-scale cultivation. However, challenges such as inadequate infrastructure and high transportation costs must be addressed through targeted investments and subsidies, says SEA.

Long-term sustainability also requires investments in research and development. Innovations like climate-resilient seedlings, high-density planting techniques, and public-private partnerships can improve productivity, according to the SEA. Furthermore, practices such as soil conservation and biodiversity preservation are essential to maintaining ecological balance.

A Roadmap for Transformation

India's palm oil journey represents more than just an agricultural mission—it is a blueprint for inclusive growth, economic resilience, and environmental sustainability. By placing farmers at the centre of its strategy, prioritising sustainability, and fostering collaboration between the government and industry, India can achieve self-reliance in edible oils. This transformation promises to strengthen the economy, empower rural communities, and create thousands of jobs across the value chain.

With the right policies, investments, and partnerships, palm oil farming has the potential to revolutionise India's agricultural and economic landscape—driving prosperity from farm to table.

WHY ARE BIOLOGICAL COMPANIES STRUGGLING FOR INVESTMENT, AND WHAT ARE THE EXPECTATIONS OF INVESTORS?

In recent years, the agricultural biologicals sector has witnessed significant growth. The global market was estimated at $16.7 billion in 2024 and is projected to reach $31.8 billion by 2029. This surge underscores the increasing demand for sustainable agricultural solutions.

However, early-stage startups, particularly those in pre-seed and seed stages, face substantial challenges in securing investment. While more established companies like Switch Bioworks, Elicit Plant, Solasta, Agospheres, Biotalys, Micropep, Catalera, Botanical Solution, and BioConsortia successfully obtained funding in 2024, emerging enterprises often struggle to attract similar attention. This disparity is partly due to investors' heightened expectations and a preference for ventures with proven technologies or those nearing revenue generation.

Current Investment Trends in Agricultural Biologicals

Geographically, Europe-focused venture capitalists (VCs) are leading the way in funding biological companies. Looking ahead to 2025, there is cautious optimism that U.S. investors will increase their participation, particularly as interest rates decline. However, uncertainties related to tariffs, the farm economy, and government agency (EPA) budgets persist, which could impact investment decisions.

The investment landscape has changed significantly. The willingness to fund biological companies at the high levels seen 3-5 years ago has diminished. Investors today possess more profound industry knowledge, making them more selective. They are increasingly drawn to companies with well-defined business models, clear paths to market impact, and solid financial planning.

From an industry perspective, biologicals are thriving, particularly in nitrogen use efficiency, nitrogen fixation, and biocontrol.

The Challenges of Building a Successful Biologicals Business

Succeeding in the biological sector demands patience, effort, and strategic focus. Investors often have unrealistic expectations regarding market development, leading to an oversaturated and unsustainable market. Moving forward, I hope to see more realism in investor sentiment, which will benefit the entire industry by fostering sustainable growth and innovation.

Additionally, recent failures in agri-biological investments have made investors more cautious. To attract funding, companies must demonstrate:

- Quality-driven research & development
- Efficient spending and cost management
- Clear and executable go-to-market strategies

Companies that meet these expectations will have a higher chance of securing funding, thereby improving the overall quality of investments in the sector.

Regulatory Barriers and Their Impact on Investment

My experience raising investment for Bionema has reinforced one of the most critical issues in this sector: the lengthy and costly regulatory approval process for biopesticides. While venture capital investors are interested in biological solutions, many are deterred by the extended timelines required to bring products to market. Unlike conventional

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agrochemicals, biopesticides require approximately £5-8 million per product for global registration, which is manageable for companies like Bionema. Still, the real challenge is the time needed for regulatory approval. This process often delays market entry by 5-7 years in the EU, 2-3 years in NA and 12 months in Brazil after biopesticides regulatory reform, making it difficult for investors to commit to early-stage funding.

Instead of investing in Series A or Series B rounds, I have observed greater interest from agrochemical multinationals in acquiring or licensing biological technologies. While this demonstrates the commercial viability of biologicals, it also signals a reluctance among large corporations to invest in the sector's long-term growth. If the biological industry is to thrive and compete with synthetic chemicals, substantial investment will be required to accelerate development and commercialisation.

Moreover, biopesticide regulations must be harmonised globally to streamline approvals and reduce market entry barriers. The fragmented regulatory environment forces companies to undergo separate and costly registration processes in different regions, further discouraging investment. Unless regulatory agencies align their frameworks, the biological sector will struggle with slow growth and limited funding.

Key Areas of Growth in Agricultural Biologicals

From an industry perspective, biologicals are thriving, particularly in nitrogen use efficiency, nitrogen fixation, and biocontrol. New application methods like planter box technologies are experiencing significant growth and scaling.

For farmers, return on investment (ROI) remains the key driver. In the current economic climate, growers are seeking efficiency-enhancing solutions, including:

- Fertilizer replacements
- Yield enhancers
- Abiotic stress mitigation products

As growers become more educated about biologicals, their adoption rates are increasing rapidly, leading to further investment in these technologies.

While venture capital investors are interested in biological solutions, many are deterred by the extended timelines required to bring products to market.

Investor Expectations for the Future

Historically, venture capital has played a key role in funding biologicals and will continue to do so. However, some investors have overly enthusiastic expectations regarding short-term returns. As VCs gain a deeper understanding of the sector, we expect them to invest more targeted and strategically.

Private equity firms are taking a more cautious, sustainable approach to investment. These firms focus on long-term flexibility and adaptability, recognising the rapidly evolving nature of the AgBio industry.

The Reality of Raising Capital in 2025

The current investment climate in biorationals mirrors the broader agricultural market's bearish trend. However, market growth in this sector, driven by:

- Public and grower demand for sustainable agriculture
- Stricter regulatory policies limiting chemical options

Farmers are expected to increase their adoption of biologicals, but only for science-backed solutions with proven efficacy that deliver real value.

Finding new capital to fund early-stage biological companies will remain challenging in 2025. Investors are becoming more critical and selective, favouring companies that:

- Have a proven technology platform
- Are generating (or near generating) revenue
- Have a clear pathway to profitability

As a result, securing seed funding or Series A investment will be challenging over the next 1-2 years.

The Long-Term Future of BioAg Investment

Despite the current challenges, biologicals attract significant interest, mainly from companies traditionally focused on agrochemicals and fertilisers. These corporations recognise the growing regulatory and consumer-driven shift toward sustainable agricultural solutions. However, we have seen a slight decline in mergers and acquisitions (M&A) activity and the closure of some companies in this sector. This highlights the difficulty of sustaining a BioAg business—balancing high investment costs with the need for consistent financial returns. Despite this, the long-term strategic value of biologicals is undeniable. The agricultural industry is undergoing a significant shift, and biologicals will be crucial in this transformation. Investors may remain cautious, but their interest in scalable, science-backed solutions will persist.

Final Thoughts

While securing investment remains a significant challenge for early-stage biological companies, those focusing on innovation, strategic planning, and strong financial models will continue attracting funding. Realism in investor expectations is key to building a sustainable and impactful BioAg industry.

The future of biologicals is bright, but companies must prove their value with solid science, strong business cases, and a clear go-to-market strategy.

DIGITAL TRANSFORMATION IN AGRICULTURE

The Role of Women in Agri-Tech Startups

Dr. Yukti Gill is the MD & Co-Founder of Satyukt Analytics

Advanced technologies create major digital changes within agricultural industries by enhancing productivity and sustainability and building resilience. The agricultural industry advances because new agri-tech startup companies emerge while innovative women entrepreneurs lead many of these businesses. The leadership of these professionals pushes technology development while creating inclusive growth opportunities for the industry.

Women entrepreneurs are progressively establishing agri-tech startups that introduce new approaches and advanced answers to agricultural problems.

Modern Technology in Agriculture

Modern digital technologies apply precision agriculture through a combination of satellite data with advanced technology and machine learning to deliver Software as a Service (SaaS) solutions to the sector. The innovative technologies let farmers check their crops by distance and they reduce environmental harm as they improve resource efficiency for superior results.

The agricultural industry gains from precise farming systems enabled by satellite imagery together with predictive analytics to achieve sustainability and productivity efficiency despite climate change limitations on resources.

Women Leading the Charge in Agri-Tech

Over the ages, women have continuously participated in agricultural work

yet society has failed to recognize their essential contributions. Women entrepreneurs are progressively establishing agri-tech startups that introduce new approaches and advanced answers to agricultural problems. These leaders have responded to problems which include supply chain inefficiencies and resource management alongside climate resilience.

Female entrepreneurship means startups create sustainable farming systems along with innovative environmental tools to battle climate change while ensuring production security. These entrepreneurs utilize modern tools to develop beneficial solutions that accommodate women farmers with their specific obstacles.

Challenges Faced by Women in Agri-Tech

Women who make major contributions to agri-tech encounter various obstacles that prevent them from moving forward. Their restricted access to land and constrained funding opportunities as well as scarce technology resources prevents women entrepreneurs from successfully innovating their firms and expanding operations. Women find their ability to participate critically limited during agricultural decision-making processes by societal traditions together with gender stereotypes.

The World Economic Forum reports how agritech businesses should use gender-inclusive technologies to empower female agricultural producers. Through such actions, companies build stronger business profiles and gain new customers.

The Impact of Women-Led Agri-Tech Startups

Through their leadership, the agricultural_technology startups operated by women are actively advancing the transformation of the farming industry. The combination of sustainable methods with digital solutions makes these businesses improve production output and environmental preservation.

Companies employing precision farming methods together with innovative processes achieve better productivity rates and open new market opportunities. The technological improvements enhance policy accuracy so it becomes both effective and target-specific and outcome-focused.

The complete realization of digital transformation potential in agriculture requires building an inclusive framework that enables support for female business owners in the sector.

Fostering an Inclusive Agri-Tech Ecosystem

The complete realization of digital transformation potential in agriculture requires building an inclusive framework that enables support for female business owners in the sector. Agri-tech businesses should enable women entrepreneurs through funding services, mentoring programs, and specialized training that focuses on their specific requirements.

Government agencies and commercial institutions must develop policies and organizational programs regarding gender representation that boost equality in the business sector. The Empowering Women in Agrifood (EWA) program by EIT Food operates through its unique platform which delivers exceptional support for female business leaders launching sustainable food system innovations.

Way Forward

Digital agriculture development creates possibilities for establishing sustainable food systems that resist changes. Agri-tech woman entrepreneurs lead the current change by implementing beneficial innovations that serve farmers alongside consumers and environmental needs. Improving the leadership roles of these individuals enables us to establish an agriculturally progressive environment that welcomes everyone.

RISE OF AGRI BLOCKCHAIN IN TRANSFORMING AGRICULTURE

Agriculture is the backbone of many economies worldwide, particularly in countries like India, where approximately 58% of the rural population depends on it for livelihood. As technology advances along with time starting from manual ploughing to Tillers and Tractors, natural manure to chemical fertilizers, biotechnology, usage of drones etc. have brought revolutionary growth in the agriculture industry. However, the sector faces significant challenges, including lack of transparency, inefficiencies in supply chains, and inadequate access to credit.

Agri Blockchain—a revolutionary technology poised to address these challenges by enhancing traceability, reducing fraud, and increasing efficiency in agricultural transactions.

Blockchain Technology

Blockchain technology is the latest one which gives a new dimension for the upliftment of the agriculture field. It helps to grow the agriculture economy through digital identity, secures property rights and establishes better communication of farming practices. The new generation must adopt this new technology to improve productivity and meet the needs of the increasing population.

Blockchain technology is developed on Distributed Ledger Technology (DLT). This DLT system allows built-in trust to be established as blockchain technology facilitates peer-to-peer connections. Once some information is written and approved on the blockchain, it becomes part of the ledger and non- corruptible forever.

As this technology grows to the furthermore levels, the running cost will come down compared to other virtual data storage options including Amazon and Google, which mainly runs on periodic fees for storage of data while blockchain technology users need to pay a one-time storage fee as it uses DLT. Blockchain technology reduces the need for middlemen in transactions, making data more transparent and unalterable once uploaded. This blockchain technology allows users to establish a digital identity, which will help them in the future to access various opportunities, including financial services, social benefits, healthcare, education, political and legal rights, gender equality, etc. The practical applications of Blockchain in Agriculture field as of now

Agri Blockchain—a revolutionary technology poised to address challenges in agriculture by enhancing traceability, reducing fraud, and increasing efficiency in agricultural transactions.

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identified are in Food safety- Food supply chain, Agri-inputs- distribution and delivery of Agri subsidies with transparency and Land Title registration.

Application of Blockchain in Agriculture:

Food Production

When smart farming is applied on the farms utilizing IoT technologies, the local fields are monitored with the help of UAVs (unmanned aerial vehicles), various sensors (temperature, pH, soil moisture, humidity, light), and machine learning systems. IoT devices and sensors help in data generation with the purpose of enhancing farmers' decisions and management on crop growth. The blockchain has its place within farming by optimizing water, labour, and fertilizer needs in such a way that it eliminates difficulty. Sensor data is collected and analyzed using machine learning to create a meaningful application out of it. Numerous high-value use cases, such as Crop Identification, Crop Quality Recommendations, Crop Yield Prediction, Grow Score (Automated Crop Growth Factor), and Crop Demand Prediction, can be fuelled by predictive models. The combination of blockchain and IoT will assist farmers and other stakeholders in terms of making better decisions.

Insurance

The risk for food security is increased thanks to the climatic evolution that endanger agricultural production. Extreme weather events trigger both, crop and livestock production, and there is global warming expected to worsen weather conditions in the future. If there is a loss incurred because of the bad weather, farmers are able to instantly receive the crop insurance claim amount due to the automated resources provided by the blockchain. Due to the robust and dependable characteristics of the blockchain ecosystem, information pertaining to the assets of smart weather stations will be efficiently retrieved by insurance companies or relevant authorities. They can use smart contracts to access the specific information needed through a direct inquiry to the blockchain. Once the request for an Insurance claim is accepted, the amount requested is directly sent to the wallet of the farmers' accounts. Thus, there is going to be a fast and easy way in which a blockchain based system will aid farmers in obtaining their compensation. In this case, farmers lose this amount in case no loss is suffered as they must pay before the cropping cycle and when there is loss they stand to be paid.

India is likely to have the world's largest implementation of blockchain technology for Governance once it is operational.

Supplychain

Blockchain exists in various fields and helps track transactions increasing transparency among stakeholders in the food supply chain. The wider adoption of this technology allows to control and prevent a clear need to improve food safety in the food supply chain. It secures the preservation and organization of information that encourages the creation and utilization of data-oriented solutions that enhance intelligent farming and intelligent index based agricultural insurance. Also, they can lower the costs associated with transactions and thus enhance the ability of farmers to access the market and create additional income opportunities. It brings matters of trust and transparency in the food supply chain ecosystem enhancing food safety for all.

Cost Efficient

Blockchain technology can definitely reduce transaction costs. Blockchain technology may offer appropriate answers for a variety of issues that traders and customers encounter. By preserving information security, it may securely and irrevocably link the data of every facet of planting and harvesting agricultural products. Compared to conventional monitoring methods, it might make supply chain management more effective. Each link in the supply chain, including the manufacturer, the origin, the shipping firm, the destination, the warehouse, multimodal transportation, and, lastly, the customers. It offers a digital payment option with no fees when it comes to payment options. Households produce a large number of agricultural products. These participants are excluded from the market because traditional e-commerce is unable and unwilling to provide services for them due to their tiny scale and low transaction volume.

Market Scenario

An analysis by Markets and Markets projects that the global blockchain technology market for agriculture will expand at a compound annual growth rate (CAGR) of 48.37%, from USD 60 million in 2020 to USD 429 million by 2025. Numerous other industries have also adopted the blockchain, frequently with

impressive outcomes. The Marco Polo Network's use of blockchain technology to modernize the import/export industry is a prime example. They have developed a platform that enables importers and exporters to monitor their shipments across the globe and ensures payment upon fulfilment of certain requirements. Renault is one of the companies spearheading the adoption of blockchain technology in the automotive sector. To cope with the stringent laws governing the European auto industry, they have implemented blockchain technology. They have been able to lower noncompliance expenses overall. The IBM Food Trust is a prime example of how blockchain technology is being used in the agriculture sector. They have established a cooperative network that encompasses all parties involved in the food supply.

In India, the demand for Agri Blockchain is also rising, with initiatives like the Digital India program fostering a conducive environment for technological innovations.

The Indian Landscape

In India, approximately 150 million farmers contribute to the agricultural sector, with the potential for Agri Blockchain to significantly enhance their productivity and profitability. The Indian Government is actively investigating the potential of blockchain technology after realizing its potential. The Ministry of Agriculture and Farmers' Welfare has initiated pilot projects aimed at implementing blockchain for various agricultural applications, including crop insurance, supply chain management, and market linkages. In the recent past years, due to the initiation taken by the Government of India to have a bank account for every citizen in the country and most of them use mobile phones that are linked-up to their bank accounts, for the farmers the adoption of blockchain technology in agriculture will become more widespread. For now, BanQu, a blockchain software company, had given digital identities to thousands of people in India. BanQu has set a target to uplift 10 crores people, from extreme poverty using blockchain technology, which allows farmers to directly connect with buyers and get financial capital quickly.

Government Initiatives

A pan-Indian blockchain structure, termed IndiaChain, is the ambition of the Indian Government. In November 2017, India's think tank NITI Aayog initiated a blockchain architecture for public data in India. The NITI Aayog has also disclosed that they wish to create in addition to the national data analytics portal, a reservoir of knowledge that can be accessed by various Government organizations in near future. India may be the first of the major economies to establish a nationwide network of blockchains for the purpose of enabling the Government once IndiaChain is fully functional. India is likely to have the world's largest implementation of blockchain technology for Governance once it is operational.

The Indian Government has launched several schemes aimed at digitizing agriculture, which indirectly supports the implementation of Agri Blockchain:

Digital India Initiative: This flagship program is aimed at transforming India into a technologically enabled knowledge economy and society. It supports the use of technology in various sectors, including agriculture.

Pradhan Mantri Fasal Bima Yojana (PMFBY): This crop insurance scheme aims to provide financial support to farmers in the event of crop failure. Blockchain integration may improve claims processing's transparency.

e-NAM (National Agriculture Market): This online trading platform aims to create a unified national market for agricultural commodities. Blockchain can ensure that transactions on this platform are secure and transparent.

Best Practices from Around the World: The Global Success Stories

- **IBM Food Trust**: This initiative uses blockchain to provide end-to-end visibility in the food supply chain. Companies like Walmart and Nestlé have adopted it, resulting in reduced food waste and improved traceability.
- **Provenance:** Based in the UK, Provenance leverages blockchain technology to track the journey of products from source to consumer. This practice has increased consumer trust and allowed brands to command premium prices.

- **Agri-Ledger**: This initiative in Haiti uses blockchain to provide farmers with a digital identity and access to financial services, enhancing their ability to secure loans and manage transactions.

Indian startups like Agri Chain and Block Agri are exploring similar models, focusing on providing transparency and traceability in agricultural supply chains. These best practices can be adapted to local contexts, ensuring that farmers benefit from increased market access and financial inclusion.

Challenges in Implementing Agri Blockchain the Major Obstacles are

- **Digital Literacy**: A significant portion of the rural population lacks digital literacy, which is crucial for adopting blockchain technologies.
- **Infrastructure Deficiencies**: Poor internet connectivity and inadequate technological infrastructure in rural areas hinder the implementation of Agri Blockchain.
- **Resistance to Change**: Traditional practices are deeply rooted in the agricultural sector, making stakeholders hesitant to adopt new technologies.

Overcoming Challenges in India

- **Capacity Building**: Initiatives aimed at improving digital literacy among farmers can foster acceptance of blockchain technology. Training programs can equip farmers with the necessary skills to utilize these platforms.
- **Investment in Infrastructure**: The Government and private sector should collaborate to improve internet connectivity and technological infrastructure in rural areas, ensuring that farmers can leverage blockchain effectively.
- **Incentives for Adoption**: Providing financial incentives or subsidies for farmers who adopt blockchain technology can motivate them to embrace these innovations.

Role of Financial Institutions in Facilitating Agri Blockchain

- Providing Credit Access: By utilizing blockchain to assess the creditworthiness of farmers, financial institutions can offer loans based on real-time data and transparent transactions.
- Enhancing Insurance Services: Blockchain can streamline crop insurance claims, making the process quicker and more transparent, which could encourage more farmers to take out insurance policies.
- Financing Blockchain Startups: Banks can invest in Agri Blockchain startups that are innovating in the agricultural space, thereby fostering growth and innovation

Innovative Ideas for the Way Forward

- Smart Contracts for Transactions: Implementing smart contracts can automate transactions between farmers and buyers, ensuring timely payments and reducing the chances of disputes.
- Blockchain for Supply Chain Finance: Financial institutions can utilize blockchain to offer supply chain financing solutions, ensuring that farmers get paid promptly while allowing buyers to manage their cash flow.
- Collaborative Platforms: Developing collaborative platforms that connect farmers, banks, and tech providers can foster a supportive ecosystem for Agri Blockchain, driving innovation and adoption.

Agri Blockchain has the potential to revolutionize the agricultural sector by enhancing transparency, improving efficiency, and increasing financial access for farmers. The Indian Government's initiatives and the growing global trend toward digitalization create a favorable environment for its adoption. While challenges exist, they can be overcome through concerted efforts involving capacity building, infrastructure development, and collaboration among stakeholders. The successful implementation of Agri Blockchain in India will not only empower farmers but also transform the agricultural landscape into a more sustainable, efficient, and profitable sector.

HOW SOIL HEALTH HELPS FARMERS TACKLE CLIMATE CHANGE

Soil is vital for both people and the planet. Soil is an important source of food and medicine, it filters and purifies our water, reduces flooding and plays a crucial role in the fight against climate change. Soil is one of the most ubiquitous – and underappreciated - substances on Earth. Soil has historically been the most overlooked asset in improving agriculture and mitigating climate change. Despite being the source of 95% of the food we produce, there is a lack of detailed understanding of the role soil can play in both agriculture and combating climate change. So, it is vital that we focus on soil health and farm more sustainably in order to ensure food security for the future.

Agriculture is in a unique position. Investing in soil health should be widely embraced as a readily scalable and proven method of reducing global emissions, closing the global yield gap and improving the resilience of agriculture against climate change.

The UN's Food and Agriculture Organization (FAO) estimates that 30 percent of the world's soils are now degraded. While a report by the European Commission estimates that between 60 and 70 percent of its soils are unhealthy.

There are multiple human-made threats to soil health. These include deforestation, urbanization, agricultural intensification, soil compaction, acidification, salinization, pollution, landslides, wildfires and soil erosion. According to the FAO, soil erosion poses a major threat to global food security and could compromise the wellbeing of at

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least 3.2 billion people globally.

Soil Health in India

Good soil health is crucial not only for high-value crop production but also for sustaining ecosystem services. Over 99.7% of our food comes from the soil. However, soil health degradation worldwide has reduced agricultural productivity, water availability, and the health of forest and pasture ecosystems. This decline has also impacted on human nutrition, with around 66% of the global population being malnourished. Additionally, approximately 3 billion tonnes of soil are eroded / degraded annually by water and wind in India. Therefore, soil health is vital for the wellbeing of humans, wildlife, and various ecosystems.

Agriculture in India faces significant challenges due to poor soil health. Most soils have low nutrient levels, with an average soil organic carbon (SOC) of around 0.54%. Land degradation affects about 30% of the country's geographical area, leading to nutrient deficiencies that impact local nutrition. Nutrient depletion and improper/imbalanced fertilizer use reduce crop productivity.

The Impact of Soil Degradation on Productivity

Feeding the world population, 7.3 billion in 2015 and projected to increase to 9.5 billion by 2050, necessitates an increase in agricultural production of approximately 70% between 2015 and 2050.

Soil carbon sequestration is gaining attraction among farmers, researchers, and policymakers as a viable solution for creating a more sustainable agricultural system.

Soil degradation spreads at an alarming rate, **endangering** land fertility and negatively affects the incomes of agricultural producers by reducing crop yields, lowering livestock productivity and, by extension the world's food supply. Global food security, ecosystem health, and sustainable development are all at **risk** from soil degradation, which is a result of both human and natural factors.

Soil degradation can be physical (e.g., decline in structure, crusting, compaction, erosion, anaerobiosis, water imbalance), chemical (e.g., acidification, salinization, elemental imbalance comprising of toxicity or nutrient deficiency), biological (depletion of SOC pool, reduction in soil biodiversity, decline in microbial biomass-C), or ecological (e.g., disruption in elemental cycling, decline in C sink capacity).

The degradation of our soils, due to human activities, today, can harm our well-being. It causes the extinction of species and accentuates climate change.

Soil Degradation has far-reaching negative consequences on reduction in ecosystem functions and services of interest to humans and conservation of nature including landslides, flooding, desertification, water contamination, and a drop in food production worldwide. Meanwhile, the agriculture sector faces a variety of direct implications daily such as soil salinization, soil acidification, organic matter loss, depleting SOC pool, soil compaction, loss of land quality and productivity, loss of arable land, pollution, clogging of waterways and loss of biodiversity.

Strategies for Soil Quality Restoration and Environmental Degradation Risks Reduction

The strategy is to produce "more from less" by reducing losses and increasing soil, water, and nutrient use efficiency.

- Reducing soil erosion.
- Creating a positive soil/ecosystem by enriching Organic carbon.
- Improving availability of nutrients to the crops
- Site-specific techniques of restoring soil quality include conservation agriculture & integrated nutrient management incorporating the 4Rs (Right source, Right rate, Right time, Right place) principles of Balanced

Crop Nutrition ensures maximum yield and improved plant health, enhances production, farm profitability, environmental protection, and sustainability.

- Use of Biofertilizers or microbial bioinoculants increases soil biodiversity and enhances the microbial process, nutrient availability, enhance soil fertility, protect plants from pathogens, and improve soil health with minimal environmental impact.
- Use Cover Crops- reduces erosion, increases organic matter, creates macropores, enhances soil aggregation, and supports beneficial fungi. Legume cover crops also fix nitrogen in the soil.
- Continuous vegetative cover such as residue mulch and cover cropping, green manure, and compost, can enhance soil organic matter.
- Reduce Pesticide Use-Broad-spectrum insecticides harm beneficial insects. Enhancing biodiversity supports beneficial organisms and improves pest control
- Crop Rotation- diverse crop rotations break pest and disease cycles, manage weeds, reduce nutrient excesses and improve overall crop health.
- Controlled animal grazing at appropriate stocking rates.

Soil Carbon Sequestration- A Pathway to Sustainable Agriculture and Climate Change Mitigation

Soil carbon sequestration has emerged as a pivotal strategy in the fight against climate change. By capturing atmospheric carbon dioxide (CO_2) and storing it in the soil, this process not only helps mitigate greenhouse gas emissions but also enhances soil health and agricultural productivity. Soil carbon sequestration is gaining attraction among farmers, researchers, and policymakers as a viable solution for creating a more sustainable agricultural system.

Benefits of Soil Carbon Sequestration:

- Climate Change Mitigation: The primary benefit of soil carbon sequestration is its potential to reduce atmospheric CO_2 levels. Soils can act as a significant carbon sink, offsetting a portion of the CO_2 emissions from fossil fuels and other sources. This helps mitigate the impact of climate change by reducing the greenhouse effect and global warming.
- Improved Soil Health: Increasing soil organic carbon enhances soil structure, water retention, and nutrient availability. This leads to healthier soils that support robust plant growth and higher crop yields. Improved soil health also makes soils more resilient to erosion, drought, and other environmental stresses.
- Enhanced Agricultural Productivity: By fostering healthier soils, carbon sequestration practices can boost agricultural productivity. Higher soil organic matter levels improve soil fertility, leading to better crop performance. Additionally, resilient soils can maintain productivity even under adverse weather conditions.
- Biodiversity Promotion: Practices that promote soil carbon sequestration, such as cover cropping and reduced tillage, also support greater biodiversity. Diverse plant species and healthy soils provide habitats for beneficial insects, microbes, and other organisms, contributing to a more balanced and resilient ecosystem.

Feeding the world population, 7.3 billion in 2015 and projected to increase to 9.5 billion by 2050, necessitates an increase in agricultural production of approximately 70% between 2015 and 2050.

Soil health and soil life are closely linked to agricultural methods and management systems. Managing soil health and life is essential for soil productivity, beneficial soil biota, soil protection, and stabilization. However, excessive use of chemicals and conventional farming practices negatively impact soil health. Intensive farming further depletes soil, threatening future food production leading to climate change.

To sustainably increase soil fertility, stabilization, health, and biodiversity, we must enhance the soil's physical, chemical, and biological properties. This approach will also improve global food security. Sustainable soil management practices offer long-term benefits for soil health, ecosystem functioning, greenhouse gas emission control, and climate change mitigation.

COLD CHAIN
CUTTING THE LOSSES

Cold chain infrastructure is a critical component of modern supply chains, ensuring the preservation and quality of perishable goods from production to consumption. The cold chain logistics sector in India is experiencing significant growth, driven by the increasing demand for temperature-sensitive products, advancements in technology, and supportive government initiatives.

Market Overview

India's cold chain infrastructure has seen considerable growth over the past decade, driven by rising demand for perishable goods and government initiatives aimed at reducing food wastage. As of 2023, the Indian cold chain market was valued at INR 2.05 trillion and is projected to grow to INR 5.06 trillion by 2028, at a compound annual growth rate (CAGR) of 18.25%. This growth is largely attributed to sectors such as agriculture, pharmaceuticals, and food processing, which require robust cold chain solutions to maintain product quality and safety.

India's cold chain infrastructure is still in a developmental phase, characterized by uneven distribution and inadequate capacity to handle the country's growing demand for temperature-sensitive goods. Key challenges include high energy consumption, lack of standardization, and significant initial investments in infrastructure. As of 2022, cold chain storage accounted for approximately 44.64% of the total market share and is expected to grow significantly as more modern storage facilities are established across the country. Cold chain logistics constituted 55.36% of the market share in 2022 and is crucial for maintaining the

integrity of the cold chain from production to consumption points.

However, with increasing awareness and governmental initiatives, there is a growing focus on enhancing the cold chain infrastructure. Programs and subsidies provided by the Ministry of Food Processing Industries (MoFPI) and other bodies are encouraging private sector participation and investment in this sector. Initiatives like the Pradhan Mantri Kisan SAMPADA Yojana and the Integrated Cold Chain and Value Addition Infrastructure scheme have been pivotal in promoting the establishment of advanced cold chain facilities across the country.

Importance in the Food Processing Sector

In the food processing sector, the cold chain plays a pivotal role by extending the shelf life of perishable products, reducing waste, and ensuring food safety. Efficient cold chain systems help in maintaining the nutritional value and taste of products, which is critical in meeting consumer expectations for quality and freshness.

Additionally, maintaining the cold chain ensures food safety by inhibiting the growth of harmful bacteria and pathogens. This is particularly important as consumers increasingly demand high-quality, fresh, and nutritious food products. An efficient cold chain system supports these demands by preserving the sensory and nutritional attributes of perishable items from the point of origin to the point of consumption.

Moreover, an effective cold chain supports the food industry's economic growth by minimizing post-harvest losses, which can significantly impact farmers' incomes and the overall supply chain's efficiency. By facilitating better storage and transportation conditions, the cold chain infrastructure can create surplus production that is suitable for export, further boosting the agricultural economy.

Key Trends in Cold Chain

Technological Integration: The adoption of advanced technologies such as the Internet of Things (IoT), blockchain, and predictive analytics is revolutionizing the cold chain logistics sector. These technologies provide real-time monitoring, enhance supply chain transparency, and improve operational efficiency.

In the food processing sector, the cold chain plays a pivotal role by extending the shelf life of perishable products, reducing waste, and ensuring food safety.

Sustainability Efforts: There is a growing emphasis on sustainability, with companies investing in eco-friendly refrigeration solutions and renewable energy sources. These efforts are aimed at reducing the carbon footprint of cold chain operations and ensuring energy efficiency.

Challenges

One of the primary challenges is the inadequate infrastructure for cold chain logistics. There is a significant shortage of specialized temperature-controlled warehouses and refrigerated vehicles tailored to India's diverse climatic conditions. The reliability of electricity and the need for alternative power sources are critical for ensuring uninterrupted cold storage operations. These infrastructure gaps lead to high spoilage rates and inefficient logistics operations.

High Operational Costs

The cost of setting up and maintaining cold chain infrastructure is substantial. This includes the capital expenditure (CAPEX) for cold storage facilities and the operational expenditure (OPEX) for energy consumption and maintenance. High operational costs can deter investments and limit the expansion of cold chain services, especially in rural and underserved areas.

Technological Disparities

While advanced technologies such as IoT, AI, and blockchain are transforming cold chain logistics globally, their adoption in India remains limited. The technological gap leads to inefficiencies and higher losses due to suboptimal monitoring and management of temperature-sensitive products.

Regulatory and Compliance Issues

Navigating the regulatory landscape can be complex, with varying standards and compliance requirements across different regions. Ensuring regulatory compliance, particularly for pharmaceuticals and food products, is essential but can be cumbersome and costly.11

Regulatory Hurdles

Navigating the complex regulatory landscape poses challenges for the cold chain logistics sector. Streamlined regulatory processes and stringent quality standards are necessary to ensure compliance and maintain product integrity.

Opportunities

Government Initiatives

Programs such as the Pradhan Mantri Kisan Sampada Yojana (PMKSY) and the National Logistics Policy provide financial assistance and incentives for developing cold chain infrastructure. These initiatives are expected to significantly enhance the sector's capabilities and efficiency.

Public-Private Partnerships

Encouraging public-private partnerships can facilitate the expansion and modernization of cold chain infrastructure, particularly in underserved areas. These collaborations can leverage combined resources and expertise to build a robust and efficient cold chain network.

Strategic Recommendations

Infrastructure Investment

Substantial investment in standardized cold storage facilities and renewable energy sources is essential to modernize the cold chain infrastructure. Public-private partnerships should be encouraged to achieve this goal.

Technology Adoption

The integration of IoT, blockchain, and predictive analytics should be accelerated to improve real-time monitoring, supply chain transparency, and operational efficiency.

Regulatory Reforms

Simplifying regulatory processes and providing financial incentives can reduce operational delays and encourage private sector investment. Ensuring compliance with stringent quality standards through regular inspections is also crucial.

The adoption of advanced technologies such as the Internet of Things (IoT), blockchain, and predictive analytics is revolutionizing the cold chain logistics sector.

Skill Development

Developing specialized training programs for cold chain professionals is vital to enhance technical expertise. Expanding access to training facilities in rural areas can bridge the skill gap and create a well-equipped workforce.

Collaborative Initiatives

Fostering collaboration among stakeholders, including government agencies, logistics companies, and technology providers, is essential for addressing common challenges and driving innovation. International collaborations can provide access to global best practices and advanced technologies.

Future Prospects and Developments

The future of cold chain infrastructure in India looks promising, with anticipated advancements in technology and a robust policy framework supporting its expansion. Innovations in IoT and data analytics are expected to optimize cold chain operations, while sustainable practices will address the high energy demands of the industry.

Moreover, the rise of e-commerce and the increasing demand for quick, reliable delivery of perishable goods underscore the need for a robust cold chain infrastructure.

Governmental initiatives, such as those from the National Centre for Cold-chain Development (NCCD) and the National Horticulture Board (NHB), are poised to drive further development. The focus will likely remain on building a resilient, efficient, and sustainable cold chain that can support the country's ambitious goals in food processing and agricultural productivity.

The cold chain logistics sector in India has immense potential for growth. By addressing the existing challenges and leveraging opportunities through strategic investments and collaborations, India can ensure the safe and efficient handling of temperature- sensitive products, ultimately benefiting the economy and public health.

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