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SUPPLY CHAIN AND LOGISTICS MANAGEMENT PRACTICES OF AGRICULTURAL AND FOOD PROCESSING BUSINESSES IN NAGPUR DISTRICT

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ABSTRACT

Agricultural and food-processing supply chains link farms with procurement, transport, storage, processing, markets, retailers, and consumers. Efficiency in perishables is of great importance because delay, poor handling, inadequate storage, and price fluctuations can lead to lower quality and farmers' income. This secondary data study provides an assessment of the practices of the supply chain in the Nagpur district, Maharashtra, covering various aspects of production, market infrastructure, storage, processing, participation, and trends in arrival prices. Nagpur generated approximately 664,449 tonnes of food grains, including pulses, rice, wheat, soybeans, sugarcane, and cotton, in 2024-25. The Nagpur APMC has an integrated market of 140 acres and has individual commodity yards, warehouses, cold-storage units, weighbridges, auction halls, and processing units. The FCI's Ajni complexes offer a storage space of 85,500 tonnes. The main challenges are small available storage space, lack of a cold chain, orange price fluctuations, reliance on intermediaries, and processing of oranges and perishables. Key recommendations are decentralized collection, grading & packing; providing traceability; refrigerated transport; coordination among farmers and processors; and integrated logistics planning.

KEYWORDS : *Agricultural Supply Chain, Food Processing, Logistics Management, Nagpur District, Kalamna Market, Post-Harvest Management.*

1. INTRODUCTION

Supply-chain management is the coordination of the movement of materials, information, and finance from suppliers to consumers. It links input suppliers, farmers, aggregators, transporters, agricultural produce market committees, warehouses, processors, wholesalers, and retailers to consumers in the agriculture and food business. Agricultural commodities are particularly difficult, as they are subject to seasonal, perishable, weather-dependent, and quality-changing factors. The logistics, therefore, have to deal with the issues of cost and delivery time and, at the same time, ensure that the product is fresh and safe and that moisture, temperature, traceability, and shelf life are maintained.

Value added through efficient logistics is being able to provide the appropriate quality and quantity of produce to the appropriate market at the appropriate time. Harvesting, sorting, grading, packaging, pre-cooling, storage, and transportation all take place under scientific conditions and help to minimize losses while keeping the process more consistent. The poor handling, however, can lead to wastage, distress sales, irregular supply of raw material, and unstable prices. Production planning,

stock management, transportation, information sharing, and collaboration among autonomous market participants and institutions are therefore needed for successful management.

The agricultural supply chains in the Nagpur district have a diversified production system, a large city market, food-processing activities, and extensive road, rail, and air connectivity, including MIHAN, making it an appropriate area for studying the agricultural supply chains. Rice, wheat, pulses, soybeans, cotton, sugarcane, vegetables, and citrus fruits are cultivated in the district. Some of the important orange-producing areas are Katol, Narkhed, Kalmeshwar, and Saoner, where orange, soybean oil, soy food, and cattle feed industries can be developed.

The main organized wholesale market in the district is Kalamna, under the control of Nagpur APMC, which covers 211 villages. While farmers have good infrastructure and production, they do not always have storage facilities, processors rely on intermediaries, perishables do not have a cold-chain system in place, and seasonal harvests reduce prices. The study thus evaluates the capabilities of Nagpur as a logistics hub, market practices, and supply chain constraints.

2. Objectives of Research

1) To conduct the study on the structure of the supply chain of agriculture and food processing industries of the Nagpur district.
2) To investigate the agriculture raw-material base of the district with the latest production data on crops.
3) To assess the warehousing, cold storage, wholesale market, and processing infrastructure.
4) To study the role of traders, commission agents, and processors in the APMC of Nagpur.
5) To study the correlation between the market arrivals and agricultural prices at Kalamna market.
6) To map out the key gaps in the supply chain and make recommendations for enhancing the efficiency of supply chain logistics and value addition, as well as access to markets.

3. Hypotheses of Research

- **H_{01}:** The foodgrain production is highly skewed in a single major category as indicated by a Herfindahl–Hirschman Index of 0.50 and above in Nagpur.
- **H_{11}:** The foodgrain production base of Nagpur is reasonably diversified with a Herfindahl–Hirschman Index < 0.50.
- **H_{02}:** There is sufficient market-accessible APMC warehouse capacity in the district at least equal to 10% of annual food grain production.
- **H_{12}:** Less than 10% of food grain production is available in the marketable APMC warehouse capacity.
- **H_{03}:** The effect of the increase of the commodity in the Kalamna market is not significant in the reduction of the price of the market.
- **H_{13}:** The more commodities are brought to the market in Kalamna, the lower the prices will be for selected agricultural commodities.

The 10% storage threshold is only a clear analytical standard for this paper and not a statutory standard of the government.

4. Research Methodology

The study is descriptive and analytical in nature, and it is totally secondary data-oriented, having the Nagpur district as a geographical study area. Information was collected from Maharashtra crop estimates for 2024-25, Nagpur APMC records, MSME industrial profiles, parliamentary warehousing data, district profiles, administrative data, and published research on the prices of the Kalamna market. Analytical methods include percentage analysis, growth rates, storage-to-production ratios, employment and investment averages, the Herfindahl–Hirschman Index, and reported arrival-price regressions. The foodgrain diversification index (HHI) is used to assess the diversification of foodgrain consumption, and the storage ratio is defined as the ratio between foodgrain warehouses and foodgrain production in the current year. Limitations of the study include no survey at the firm level

and different data years as well as missing details on cold storage capacity. The analysis separates total district storage from market-accessible APMC capacity of private enterprises, as the FCI facilities primarily support public foodgrain operations.

5. Theoretical Framework

The theoretical framework is based on the concept of integrated supply-chain theory in the agro-food processing systems of Nagpur. This is a theory that considers procurement, production, inventory, transportation, and distribution as interrelated functions. Efficiencies in production can be offset by poor grading, packaging, storage, or processing efficiencies. Thus, there is a need for coordination between farmers, farmers' traders, transporters, processors, and retailers for effective integration.

The agri-food supply chain structure differentiates fresh products from processed products. Oranges and vegetables need fast transportation, pre-cooling, ventilated packing, refrigerated transportation, and continuous quality management. Rice, wheat, pulses, and soybeans have longer storage times but require a reliable supply, drying, cleaning, testing, and scientific storage.

The perishability theory and time value theory can be attributed to the fact that the value of food decreases with delay and inappropriate temperatures in cold storage. Cost savings are not the only concern; responsive logistics is equally crucial. First-expiry-first-out inventory control and real-time monitoring practices help to ensure quality.

Fragmentation amongst small producers can be decreased via supply-chain coordination. Farmer-producer organizations, collection centers, contracts, shared forecasts, and digital information aid in better consolidation, bargaining power, and planning. Traceability also enables certification, recall, and compliance with export requirements. Overall digital lot identification, QR codes, laboratory testing, and temperature records can significantly decrease uncertainty, waste, handling errors, and supply chain risks for Nagpur processors and can help them meet premium domestic and international market standards.

6. Data Analysis and Interpretation

6.1 Agricultural raw-material base

Table 1
Selected agricultural production indicators, Nagpur district, 2024–25

Commodity group	Area in official dataset	Production in official dataset	Converted production
Total foodgrains	3,532.49 “00” ha	6,644.49 “00” tonnes	664,449 tonnes
Total cereals	2,001.36 “00” ha	3,711.25 “00” tonnes	371,125 tonnes
Rice	985.51 “00” ha	2,014.73 “00” tonnes	201,473 tonnes
Wheat	987.32 “00” ha	1,648.79 “00” tonnes	164,879 tonnes
Total pulses	1,531.13 “00” ha	2,933.24 “00” tonnes	293,324 tonnes
Total oilseeds	943.38 “00” ha	777.47 “00” tonnes	77,747 tonnes
Soybean	917.26 “00” ha	753.88 “00” tonnes	75,388 tonnes
Sugarcane	23.78 “00” ha	1,255.97 “00” tonnes	125,597 tonnes
Cotton	2,108.75 “00” ha	4,842.05 “00” bales	484,205 bales

Note: Area and production figures were multiplied by 100. Cotton production is reported in bales of 170 kilograms rather than tonnes.

Source: Author’s calculations from Government of Maharashtra final advance estimates.

Pulses constituted approximately 44.15% of foodgrain production, followed by rice at 30.32%, wheat at 24.81% and other cereals at 0.72%. The resulting HHI is:

$$HHI = (0.4415)^2 + (0.3032)^2 + (0.2481)^2 + (0.0072)^2 = 0.3485$$

The number of categories that are well-represented is about 2.87. Food grain diversification is moderate, as indicated by the result. This facilitates several processing stages, such as dal milling, ready-to-cook products, and cereal-pulse mixtures, as well as rice and flour milling.

The production of oilseed is, however, very concentrated. Soybean accounted for about 96.97% of total oilseed production. So, in addition to having a sizable local resource in soy, the soy business also faces the associated risks of weather, pricing, and procurement. Reducing this vulnerability might be achieved through diversifying the source of oilseed supplies or by establishing longer-term contracts with growers.

Though not a food product, cotton production generates a need for aggregation, moisture testing, ginning, and transportation of cotton bales. Sugarcane is a potential resource for local processing like jaggery. Grains, pulses, oilseeds, cotton, vegetables, and oranges mix well and have opportunities for similar logistics but have different handling and storage needs.

6.2 Wholesale-market and logistics infrastructure

Table 2
Selected logistics facilities of Nagpur APMC

Facility or indicator	Available infrastructure
Total market land	140 acres
Villages within market jurisdiction	211
Market-linked dry warehouse capacity	5,300 MT
Cold-storage facilities	4 units
Weighbridges	4
Licensed processing units in market area	65
Auction halls	12 grain, 5 fruit, 4 chilli and 5 vegetable halls
Chilli-drying platforms	3
Farmer-hostel capacity	180 beds
Listed shops and agent blocks in principal categories	1,366
Method of sale	Open auction

Source: Nagpur Agricultural Produce Market Committee.

Nagpur has some commodity markets that are organized, providing the city with a significant aggregating advantage. Within a general market complex are activities related to grain, fruit, chili, and other vegetables. Market participants' movements are minimized between a number of unrelated areas by way of warehouses, weighing facilities, banks, roads, and auction halls.

The stated capacity of the APMC warehouse is 5300MT, which includes 1000MT godowns and a 3300MT warehouse at the main market yard. It is just 11% of the annual foodgrain production of 664,449 tonnes.

$$5{,}300/664{,}449\times100=0.80\%$$

So, the market-accessible dry storage capacity can be less than 1% of food grain production at a given time. Annual output is naturally disposed of in several inventory cycles, and not all produce is sold through Nagpur APMC. However, the ratio suggests that there is low buffering capacity, especially when harvesting is concentrated.

The APMC also offers a produce-pledge facility under which a farmer/eligible person can avail a loan of up to 75 percent of the market value of his/her produce for a period of 180 days at a fixed rate. This can be a useful practice for farmers to help prevent the need for immediate distress sales; however, limited warehouse space makes this difficult.

According to the parliamentary data, there are two FCI storage complexes in Ajni, one that has a capacity of 52,118 MT and the other that has 33,382 MT. They have a combined capacity of 85,500 metric tons. With APMC capacity, the total capacity of district-located identified dry stores is 90,800 MT,

which is equivalent to 13.67% of food grain production. FCI capacity is not, however, totally adequate commercially for private enterprise for procuring and distributing; it can only be used for government procurement and distribution.

The APMC lists four cold-storage centers but gives no details on the storage capacity of any individual or combination. The limited number of assessments of the cold chain that can be done is a restriction. The information for oranges, vegetables, dairy products, and frozen foods is less useful than that for chambers, operating temperature, utilization, pre-cooling, electricity reliability, and refrigerated-vehicle availability.

6.3 Food-processing enterprise base

Table 3
Manufacture of food products and beverages in Nagpur, June 2012

Indicator	Food and beverage sector	Total registered industrial units	Sector share
Enterprises	1,294	10,228	12.65%
Employment	10,542	106,119	9.93%
Investment	₹15,848 lakh	₹148,349 lakh	10.68%
Average employment per food enterprise	8.15 workers	—	—
Average investment per food enterprise	₹12.25 lakh	—	—

Source: Author's calculations from the Ministry of MSME industrial profile.

The small enterprises' base in Nagpur city included food products and beverages. However, the average of about 8.15 workers and ₹12.25 lakh investment per enterprise suggests that many enterprises were small. Laboratory testing, modern packaging, refrigerated transport, and enterprise-resource-planning (ERP) systems are some of the most common constraints that small processors encounter in their raw-material forecasting.

The district profile indicates that there are some established companies in the country engaged in snack manufacture, dairy, spices, biscuits, etc., indicating the organized processing experience in Nagpur. Meanwhile, the district's official profile tells us that there is considerable unexploited potential in the processing of oranges and also in making protein using rice, soybeans, pulses, and millets.

6.4 Changes in market participation

Table 4
APMC market functionaries

Financial year	Commission agents	Traders	Change in traders from 2022–23
2022–23	919	1,899	—
2023–24	906	1,589	–16.32%
2024–25	904	1,557	–18.01%

Source: Nagpur APMC.

The commission agent category showed a decrease of 1.63%, and the trader category showed a decrease of 18.01% during the period. This can be due to license consolidation, business exits, and shifts in the market participation or towards alternative procurement channels. The secondary data are non-causative data.

More than 900 commission agents survived to prove the importance of intermediated trade today. Long chains can also lead to a loss of price transparency and delay in information flow, but intermediaries can facilitate aggregation, financing, quality assessment, and buyer matching. Digital

auctions and direct processor procurement should not replace and remove intermediaries, as many small farmers are reliant on intermediaries' knowledge of markets and their short-term credit facilities.

6.5 Arrival and price behaviour in Kalamna market

Warade and Chakravorty used the data of tomatoes, potatoes, onions, and red chili collected at monthly intervals from 1997–98 to 2016–17. Their results are useful to understand the effects of seasonality and concentration.

Table 5
Arrival-price indicators for major commodities in Kalamna

Commodity	Cuddy–Della arrival-instability index	Price-instability index	Effect of an additional 100 tonnes of previous-month arrivals on current price
Tomato	68.15	63.35	–₹12.16 per quintal, significant at 10%
Potato	49.52	42.14	+₹0.32, statistically insignificant
Onion	48.82	71.54	–₹3.21 per quintal, significant at 5%
Red chilli	94.91	29.73	–₹10.64 per quintal, significant at 10%

Source: Warade and Chakravorty (2018).

The results revealed that the higher the number of arrivals, the lower the current price of tomatoes, onions, and red chili. The chili (red) showed the highest arrival instability, and the onion showed high price instability. This is seen as a weak temporal coordination, and in this case the arrivals are large volumes in short time periods, and storage, processing, and market diversion may be inadequate.

This can be partially alleviated during processing. The tomatoes can be turned into puree, into sauce, and/or into dehydrated products; the chilies can be scientifically dried and powdered; the low-grade oranges can be processed into orange juice, orange concentrate, peel oil, and pectin. This processing, however, is subject to quality standards, packaging, and assured demand.

7. Findings of the Study

Nagpur is endowed with a significant and diversified base of farm raw materials, with food grain production of over 664,000 tonnes during 2024-25.

Pulses were the highest category of foodgrains, and rice and wheat also provided substantial amounts, providing opportunities for food processing in a variety of ways.

Soybeans accounted for almost 97% of oilseed production, providing raw-material benefits for soybean-processing industries but exposing the commodity processors to commodity-concentration risk.

Kalamna offers a comprehensive wholesale-market system consisting of commodity-specific yards, auction halls, warehouses, weighbridges, shops, banks and processing licences.

Only 1.80% of the foodgrain production of the district was stored in the APMC warehouse. With identified FCI facilities, total district-located dry storage remained at 13.67%, and most of the FCI capacity is not ordinary private commercial storage.

There are 4 cold storages reported at APMC; however, the capacity and utilisation details are not published, so a good cold chain assessment cannot be carried out.

In 2012, food products and beverages represented about 12.65% of the total number of registered industrial enterprises documented and over 10,500 jobs.

This shows that the wholesale market participation structure is becoming transformed, as evidenced by the reduction of APMC traders by around 18% from 2022-23 to 2024-25.

The findings from market-arrival research confirm that there are statistically significant negative relationships between the arrivals and prices for tomato, onion and red chilli.

Even though Nagpur is renowned for oranges, the district government has continued to acknowledge that there is inadequate capacity for orange processing.

8. Discussion

The agricultural base, the big city population and the strong multimodal connectivity are the key strengths of Nagpur in the supply chain. It is centrally located in MIHAN and has an airport, railway network and main roads that facilitate distribution in India and could be suitable for air cargo of high-value products. The integrated layout of Nagpur APMC, separate commodity yards, weighbridges and auction halls help to minimise some of the transaction and handling costs. But for end-to-end integration, there's a need for timely information on arrivals, demand, storage, transport and retail prices.

A big challenge is the warehouse. Due to inadequate storage facilities in APMC, farmers are compelled to sell their produce quickly, or a private storage facility is needed by the farmers and traders. Decentralised warehouses in important production talukas and warehouse receipt financing would help lower the first-mile costs, congestion and distress sales.

There is a need for more planning for perishables logistics. A district cold-chain inventory should include information on pack houses, pre-cooling units, refrigerated vehicles, ripening chambers, storage capacity and utilisation. Collection, grading and primary processing of oranges should be near the orchards in Katol, Narkhed and Kalmeshwar. The premium fruits can be marketed fresh; the lower-quality ones can be processed; the leftover material can be turned into a valuable by-product.

The key elements of the processor-farmer coordination should include farmer-producer organisations, procurement schedules, quality standards, transparent pricing and fair risk sharing. The market arrivals, prices, warehouse vacancies and transport needs can be integrated into digital platforms. Processors also need to implement traceability, digital inventory and demand forecasting.

Strategies to evaluate performance include farm-to-market time, handling losses, order fulfilment, capacity utilisation, rejection rates, inventory turnover, energy consumption, and farmers' share of consumer prices. These indicators help to evaluate logistics projects and the sustainable value chain's competitiveness as a whole by commercial results rather than the amount of infrastructure being built.

9. Hypothesis Testing

Three main hypotheses were tested, and results were found. First, the HHI for pulses, rice, wheat and other cereals was calculated as 0.3485, which is less than the operational HHI of 0.50. Hence, H_{01} was rejected and H_{11} was accepted; hence, it can be inferred that there is a reasonably diversified foodgrain-production base in Nagpur. Second, the capacity of the warehouse in Nagpur APMC (5300 metric tonnes) was only around 0.80% of the district's food grain production, which is less than the critical threshold level of 10% as determined by the analysis. Thus, the null hypothesis (H_{02}) was rejected and the alternative hypothesis (H_{12}) was accepted, and it was found that the APMC storage is not sufficient in the market to accommodate the agricultural production in a year. Thirdly, the negative effect of the previous month's market arrivals statistically on the tomato, onion and red chilli prices was significant. At the 10% significance level, the tomatoes and red chillies and, at the 5% level, the onion were rejected as part of H_{03}. For potato, however, the potato coefficient was positive but not statistically significant, and so H_{03} was not rejected for potato. Overall H13 was supported for tomato, onion and red chilli but not for potato, indicating that the increase in market arrivals during the seasons resulted in low prices for the perishables.

10. Conclusion

Nagpur has good base conditions to develop a good agricultural and food-processing supply chain. It is characterised by a diversified production base, an integrated wholesale market, a developed processing sector and an existing road, rail and air transport network. These factors help the district to act as a concentration, processing and distribution centre for eastern Maharashtra as well as the

Vidarbha region. However, the study reveals that the development of logistics has not been able to track agricultural potential. There is a small capacity of APMC warehouses as compared to the annual foodgrain production, and there is no public information on the capacity and utilisation of the market cold storages. The price-arrival results show that the arrival of concentrated loads can lead to lower farmer prices. This district is also under-utilising its orange-processing potential. Improvement-based on coordination, not any single infrastructure. The development of decentralised collection and grading centres should take place in close proximity to production areas. Matters of warehouse-receipt finance and scientific storage and assaying should be increased. Cold-chain mapping should be able to point out gaps in capacity at the commodity level. Unsuitable practices for perishables should be replaced with refrigerated transport and reusable plastic crates. Processors to coordinate procurement with farmer organisations, and digital systems to give market forecasts, batch traceability and real-time inventory data. Nagpur can transform from a predominantly production and trading hub to a value-adding agri-food logistics hub. This transition will require the linkage of farmers to APMCs, warehouses, processors, transporters, research institutions, and retailers, with the establishment of clear information flow, proper infrastructure, and mutually beneficial trade agreements.

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