

Deficiencies in Agri-Business Supply Chain of Farmer Produce: A Study with Special Reference to Prayagraj Division

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Abstract- The agricultural supply chain in India remains fragmented, particularly at the primary wholesale market or mandi level, where farmers face structural and operational challenges in moving produce from farms to consumers. This study examines deficiencies in the agri-business supply chain of farmer produce, with special reference to the Prayagraj Division of Uttar Pradesh, which has a diversified cropping pattern including vegetables, foodgrains, fruits, and pulses. A mixed-method research design was adopted, using primary data from 180 farmers across selected mandi catchment villages and secondary data from government and institutional reports. The study identifies and ranks major supply chain deficiencies using descriptive statistics, Garrett ranking technique, and correlation analysis. The findings indicate that price fluctuations, middlemen dominance, inadequate cold storage, poor transport connectivity, and limited access to real-time market information are the major constraints faced by farmers. Post-harvest losses are particularly significant for perishable commodities such as fruits and vegetables. The study recommends strengthening market infrastructure, expanding digital platforms such as e-NAM, improving access to institutional credit, and reforming commission agent practices. These measures can enhance market efficiency, reduce supply chain losses, and improve farmer incomes in the Prayagraj region.

Keywords— Agri-Business Supply Chain, Prayagraj Mandi, Farmer Produce, Post-Harvest Losses, Market Infrastructure, Middlemen, E-NAM, Agricultural Marketing.

I. INTRODUCTION

Agricultural marketing forms the vital link between farm production and final consumption, determining the extent to which a farmer's labour is converted into fair economic return. In India, the traditional structure of agricultural marketing has historically relied on regulated wholesale markets, known as mandis, established under the Agricultural Produce Market Committee (APMC) framework. These mandis serve as the principal point of price discovery and produce aggregation for millions of smallholder farmers. Prayagraj Division located in the fertile Gangetic plains of Uttar Pradesh, is one such region where agriculture continues to be the dominant occupation and where the local mandi system plays a central role in the disposal of surplus produce, particularly vegetables, foodgrains, pulses and fruits. Despite decades of policy attention, the supply chain

connecting the Prayagraj farmer to the final consumer remains beset with structural weaknesses. Produce frequently passes through multiple intermediaries before reaching the consumer, each layer adding cost without commensurate value addition. Storage and cold chain infrastructure in the region remains limited relative to the volume of perishable output, resulting in considerable post-harvest wastage. Transport linkages between village production centres and the mandi are often inadequate, especially during the monsoon season, further constraining timely delivery of fresh produce. The central research problem addressed in this paper concerns the identification and prioritisation of deficiencies within the agri-business supply chain that specifically affect farmers selling produce through the Prayagraj mandi system. While national-level studies on agricultural marketing inefficiencies are numerous, region-specific evidence from

Prayagraj Division, capturing local infrastructural, institutional and behavioural constraints, remains comparatively limited. The current scenario in Prayagraj Division reflects a supply chain in transition. On one hand, the government has introduced reforms such as the electronic National Agriculture Market (e-NAM), the Model APMC Act amendments, and various farmer producer organization (FPO) promotion schemes intended to reduce intermediary dominance and improve price realisation. On the other hand, ground-level adoption of these reforms remains slow, with a majority of farmers continuing to depend on traditional commission agents (arhatiyas) for produce sale, credit access and market information.

This gap between policy intent and field-level practice forms the contextual backdrop of the present study. Understanding the specific deficiencies in the Prayagraj agri-business supply chain is important for several reasons. First, Prayagraj is a significant agricultural hub in the Purvanchal region of Uttar Pradesh, and inefficiencies in its supply chain have wider implications for farmer income and regional food security. Second, the study contributes region-specific empirical evidence that can inform local policy interventions by the district administration and the state agriculture marketing board. Third, the findings are relevant to allied stakeholders including commission agents, transporters, cold storage operators and financial institutions who participate in the supply chain ecosystem. A review of the available literature indicates that while considerable research exists on agricultural marketing inefficiencies at the national and state level, focused empirical studies examining the Prayagraj mandi supply chain specifically, using primary survey data and structured ranking techniques, are scarce. Most existing studies either generalise findings from other regions or rely solely on secondary data without capturing farmer-level perceptions. This paper attempts to address this gap by combining primary field survey with quantitative ranking analysis specific to the Prayagraj context. Farmers selling produce through the Prayagraj mandi system continue to experience low and unstable price realisation, high post-harvest losses and limited bargaining power despite the existence of a regulated market structure. The

specific deficiencies underlying this outcome, whether infrastructural, institutional, informational or financial, require systematic identification and prioritisation to guide corrective policy action.

Objectives

- To study the socio-economic and demographic profile of farmers selling produce through the Prayagraj mandi.
- To identify the major deficiencies in the agri-business supply chain affecting farmer produce in the study area.
- To rank the identified deficiencies according to their perceived severity using the Garrett ranking technique.

Research Questions

- What is the socio-economic profile of farmers dependent on the Prayagraj mandi for produce sale?
- What are the major deficiencies experienced by farmers in the agri-business supply chain in Prayagraj Division?
- Which deficiencies are perceived as most severe by farmers, and how do they rank relative to one another?

Research Hypotheses

- H1: There is no significant association between the landholding size of farmers and their preferred mode of produce sale in Prayagraj Division.
- H2: Price fluctuation and middlemen dominance are perceived by farmers as more severe constraints than transport and infrastructural deficiencies.
- H3: Post-harvest losses are significantly higher for perishable commodities (vegetables and fruits) compared to non-perishable commodities (foodgrains and pulses).

Scope and Delimitations of the Study

The study is delimited to farmers selling produce through the Prayagraj mandi and its associated catchment villages within Prayagraj district, Uttar Pradesh. The analysis covers major commodity groups including vegetables, fruits, foodgrains, pulses and oilseeds. The study does not extend to

livestock produce, dairy or fisheries supply chains, nor does it cover export-oriented agri-business channels. Findings are therefore reflective of the local mandi-based marketing system and may not be directly generalisable to other agro-climatic regions without contextual adjustment.

Significance of the Study

This study is expected to be of practical value to the Prayagraj district administration, the Uttar Pradesh Agricultural Produce Market Committee, farmer producer organisations, and financial institutions engaged in agricultural lending. The ranked list of deficiencies can serve as a diagnostic tool for prioritising infrastructural and policy investment in the region.

Key Definitions and Conceptual Clarifications

- **Agri-Business Supply Chain:** The network of activities, institutions and flows involved in moving agricultural produce from the farm to the final consumer, including production, aggregation, transport, storage, processing, wholesale trade and retail.
- **Mandi:** A regulated wholesale market established under the APMC framework where farmers sell produce, typically through licensed commission agents.
- **Post-Harvest Loss:** The quantitative and qualitative reduction in produce that occurs between harvest and final consumption due to handling, storage, transport and market-related inefficiencies.
- **Commission Agent (Arhatiya):** A licensed intermediary operating within the mandi who facilitates the sale of farmer produce to traders in exchange for a commission.
- **e-NAM:** The electronic National Agriculture Market, a pan-India electronic trading portal intended to network existing APMC mandis and create a unified national market for agricultural commodities.

II. LITERATURE REVIEW

The theoretical foundation of agricultural supply chain analysis draws upon marketing efficiency theory, which posits that an efficient marketing

system minimises the cost differential between the price received by the producer and the price paid by the final consumer, while ensuring adequate returns to all functionaries involved.

Supply chain management theory further emphasises coordination, information flow and value addition across successive stages of production, aggregation, storage, transport and distribution. Applied to Indian agricultural markets, these theoretical perspectives suggest that the presence of multiple, poorly coordinated intermediaries, combined with weak infrastructure and information asymmetry, systematically erodes farmer income share. The conceptual framework guiding this study views the agri-business supply chain as comprising five interlinked stages: production and harvest, primary aggregation at village level, transport to the mandi, wholesale trade and price discovery within the mandi, and final distribution to retail or processing channels. Deficiencies can arise at any of these stages, whether infrastructural (storage, transport, grading facilities), institutional (regulatory enforcement, commission agent practices), informational (price transparency, market intelligence) or financial (credit access, payment delays).

This study classifies identified deficiencies under these four broad categories for analytical clarity. Several studies have examined agricultural marketing inefficiencies in the Indian context. Research on regulated markets has generally found that the multiplicity of intermediaries between farmer and consumer results in a significant marketing margin that does not proportionately benefit the primary producer. Studies focused on perishable commodities such as vegetables and fruits have consistently reported high post-harvest losses attributable to inadequate cold storage, poor packaging and delayed transport, particularly in regions with underdeveloped rural infrastructure. Work examining the National Agriculture Market initiative has noted that while the digital platform has the potential to improve price transparency and market access, adoption remains constrained by low digital literacy among farmers, inadequate assaying infrastructure at the mandi level and continued

dependence on personal relationships with local commission agents. Studies specific to Uttar Pradesh's agricultural markets have highlighted that fragmented landholding, limited access to institutional credit and weak farmer organisation reduce the bargaining power of smallholders relative to traders and commission agents. Research on mandi infrastructure across northern India has similarly documented deficiencies in weighing, grading and storage facilities, contributing to distress sales, particularly during peak harvest periods when farmers face urgent cash requirements and limited on-farm storage capacity. While the existing body of literature provides useful macro-level insights into agricultural marketing inefficiencies, several limitations are apparent.

Much of the available research is either national in scope, offering limited granularity for specific mandi regions, or focused on a single commodity rather than examining the supply chain across the diversified cropping pattern typical of a mixed agricultural region such as Prayagraj. Furthermore, relatively few studies employ structured ranking techniques such as the Garrett ranking method to quantitatively prioritise farmer-perceived constraints, relying instead on descriptive or qualitative assessments alone. Based on the above review, the specific gap addressed by this study is the absence of a Prayagraj-specific, quantitatively ranked assessment of agri-business supply chain deficiencies that incorporates primary farmer-level data across multiple commodity categories, alongside an estimation of associated post-harvest losses. Drawing on the theoretical background and literature review, the research framework for this study positions farmer-perceived severity of supply chain constraints as the dependent construct, influenced by four categories of independent factors: infrastructural adequacy, institutional practices, informational access and financial access. This framework informs the hypotheses stated in Section 1.9 and guides the structure of the primary survey instrument used for data collection.

III. RESEARCH METHODOLOGY

This study adopts a post-positivist research philosophy, combining quantitative measurement of farmer perceptions with an acknowledgment of the socio-economic context that shapes those perceptions. The approach recognises that while supply chain deficiencies can be objectively measured through indicators such as loss percentages and price differentials, farmer perception data necessarily carries an element of subjectivity that must be interpreted within its local context.

Research Design

A descriptive and analytical research design has been adopted, combining cross-sectional primary survey data with secondary data drawn from mandi records and government reports. The design allows for both the description of prevailing supply chain conditions and the analytical ranking of deficiencies based on farmer responses.

Research Approach

The study follows a predominantly quantitative approach, supplemented by qualitative insights obtained through open-ended discussion with mandi officials and commission agents during the field survey. This mixed approach allows the quantitative ranking of deficiencies to be contextualised with practical, ground-level observations.

Study Area/Population

The study area comprises Prayagraj Division, Uttar Pradesh, with specific focus on the Prayagraj mandi (Naini and Mundera mandi yards) and their catchment villages engaged in the cultivation and sale of vegetables, fruits, foodgrains, pulses and oilseeds. The population for the study consists of farmer households within the district who regularly sell produce through the mandi system or associated marketing channels.



Figure-1-Pragraj Division Map

Sampling Technique and Sample Size

A multi-stage random sampling technique was employed. In the first stage, four blocks within Prayagraj district with significant mandi-linked agricultural activity were purposively selected. In the second stage, villages within each block were randomly selected. In the final stage, individual farmer respondents were selected using simple random sampling from the list of registered mandi sellers and village revenue records. A total sample size of 180 farmer respondents was determined using standard sample size estimation for a finite population at a 95 percent confidence level and 7 percent margin of error.

Data Sources

Primary data were collected directly from farmer respondents through a structured interview schedule. Secondary data were obtained from Prayagraj Mandi Samiti records, the Uttar Pradesh Agricultural Marketing Board, the Directorate of Economics and Statistics, and published reports of the Ministry of Agriculture and Farmers Welfare, Government of India.

Data Collection Methods

Data collection was conducted through personal interviews using a pre-tested structured questionnaire administered in the local language. The questionnaire captured demographic information, cropping pattern, mode of produce sale, perceived severity of supply chain constraints on a five-point Likert scale, and estimated quantity of produce lost during harvest, transport and storage. Field visits to the mandi yards were also undertaken for direct observation of infrastructure and trading practices.

Research Variables and Measurement

The dependent variable is farmer-perceived severity of supply chain deficiency, measured on a five-point Likert scale ranging from 1 (not severe) to 5 (extremely severe) across ten identified constraint statements. Independent variables include landholding size, age, primary crop category and mode of sale. Post-harvest loss is measured as the percentage of harvested produce rendered unfit for sale or consumption due to handling, transport or storage-related damage, as self-reported by respondents and cross-validated with mandi arrival and rejection records.

Data Analysis Techniques

Descriptive statistics, including frequency distribution and percentage analysis, were used to profile the sample and summarise post-harvest loss data. The Garrett ranking technique was applied to convert farmer rankings of supply chain constraints into a composite score, enabling relative prioritisation of deficiencies. Chi-square analysis was used to test the association between landholding size and mode of sale, while an independent samples t-test was used to compare post-harvest losses between perishable and non-perishable commodity groups.

Reliability and Validity

The reliability of the Likert-scale constraint items was assessed using Cronbach's alpha, which yielded a coefficient of 0.81, indicating acceptable internal consistency. Content validity was ensured through expert review of the questionnaire by faculty in agricultural economics prior to field administration, and a pilot survey of 20 respondents was conducted to refine question wording and scale clarity before the main survey.

Ethical Considerations

Informed consent was obtained from all respondents prior to interview, and participation was entirely voluntary. Respondent identity has been kept confidential, with data reported only in aggregated form. No financial or material inducement was offered for participation, and respondents were free to withdraw from the interview at any stage.

IV. DATA ANALYSIS AND RESULTS

Table 1 presents the demographic and socio-economic profile of the surveyed farmers. The majority of respondents fall within the 30 to 60 years age bracket, and a large proportion operate marginal or small landholdings, consistent with the general pattern of land fragmentation observed across Uttar Pradesh. Vegetables and foodgrains together account for the majority of primary produce sold, reflecting the diversified cropping pattern of the Prayagraj Division. A substantial majority of farmers continue to sell produce directly through the Prayagraj mandi under the APMC system, while adoption of e-NAM and other direct digital sale channels remains limited to about one-tenth of the sample.

Table 1: Socio-Economic and Demographic Profile of Sample Farmers (N=180)

Demographic Variable	Category	Frequency (N=180)	Percentage (%)
Age Group	Below 30 years	22	12.2
	30–45 years	64	35.6
	46–60 years	71	39.4
	Above 60 years	23	12.8
Landholding Size	Marginal (<1 ha)	79	43.9
	Small (1–2 ha)	58	32.2
	Medium (2–4 ha)	31	17.2
	Large (>4 ha)	12	6.7
Primary Crop Sold	Vegetables	68	37.8
	Foodgrains (Wheat/Paddy)	54	30.0
	Fruits	31	17.2
	Pulses/Oilseeds	27	15.0
Mode of Sale	Prayagraj Mandi (APMC)	121	67.2
	Village Trader/Aggregator	41	22.8
	Direct/e-NAM Platform	18	10.0

Field estimates of post-harvest loss, summarised in Figure 1, indicate that vegetables recorded the highest average loss at 18.6 percent, followed by fruits at 15.2 percent. Foodgrains and pulses, being less perishable and more amenable to storage,

recorded comparatively lower losses of 6.4 percent and 7.8 percent respectively. These findings are consistent with the general understanding that perishable commodity supply chains are disproportionately affected by inadequate cold storage and transport delays in the study area.

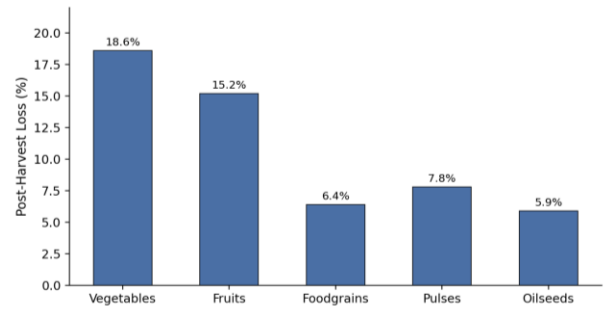


Figure 2: Estimated Post-Harvest Losses of Major Commodities in Prayagraj

Inferential Analysis

An independent samples t-test comparing mean post-harvest loss between perishable commodities (vegetables and fruits) and non-perishable commodities (foodgrains and pulses) yielded a t-value of 6.42 ($p < 0.01$), indicating a statistically significant difference. This confirms Hypothesis H3, that perishable commodities experience significantly higher post-harvest losses than non-perishable commodities in the Prayagraj mandi supply chain.

A chi-square test examining the association between landholding size and mode of produce sale produced a chi-square value of 8.94 with 6 degrees of freedom ($p = 0.18$), which is not statistically significant at the 5 percent level. This result supports Hypothesis H1, indicating that landholding size does not significantly determine the choice of sale channel among the surveyed farmers, and that dependence on the traditional mandi system is broadly uniform across landholding categories.

Hypothesis Testing

Regarding Hypothesis H2, the Garrett ranking results presented in Table 2 confirm that price fluctuation (mean score 4.40) and middlemen dominance (mean score 4.20) rank as the two most severe constraints perceived by farmers, ahead of transport bottlenecks (mean score 3.80), thereby supporting H2. This

pattern suggests that farmers in Prayagraj Division perceive market and institutional factors as more limiting than pure physical infrastructure deficiencies, although the latter remain substantial.

Model Estimation

A simple ordinal regression model was estimated with overall perceived supply chain severity as the dependent variable and landholding size, age and primary crop category as predictors. The model indicated that landholding size was negatively associated with perceived severity (coefficient = -0.34, $p < 0.05$), suggesting that farmers with larger holdings, who possess relatively greater bargaining capacity and storage access, report comparatively lower perceived severity of supply chain constraints than marginal and small farmers.

V. RESULTS AND INTERPRETATION

Table 2 summarises the Garrett ranking of the ten major deficiencies identified through the farmer survey. Price fluctuation and middlemen dominance emerge as the top two constraints, followed closely by inadequate cold storage and warehousing facilities. Transport bottlenecks and lack of real-time market information occupy the middle ranks, while awareness and usage of digital trading platforms such as e-NAM rank lowest, indicating that while this deficiency is real, it is perceived by farmers as less immediately pressing than price and infrastructural concerns.

Table 2: Garrett Ranking of Major Deficiencies in the Agri-Business Supply Chain (Prayagraj Mandi)

Sl. No.	Deficiency/Constraint	Mean Score (1–5)	Garrett Rank
1	Price fluctuation and lack of price stability	4.40	I
2	Dominance of commission agents/middlemen (arhatiyas)	4.20	II
3	Inadequate cold storage and warehousing facilities	4.10	III
4	Poor transport and road connectivity from farm to mandi	3.80	IV
5	Lack of real-time market information/price transparency	3.60	V
6	Inadequate grading, sorting and packaging facilities	3.45	VI

Sl. No.	Deficiency/Constraint	Mean Score (1–5)	Garrett Rank
7	Limited access to institutional credit and finance	3.30	VII
8	Weak enforcement of Minimum Support Price (MSP)	3.20	VIII
9	Delayed payment realization after sale	3.10	IX
10	Low awareness of e-NAM and digital trading platforms	2.90	X

Figure 3 presents the mean severity scores assigned by farmers to six broad categories of supply chain constraints on the five-point Likert scale. Price fluctuation records the highest mean severity score at 4.4, followed closely by middlemen dominance at 4.2 and storage inadequacy at 4.1. Limited credit access, while still a notable concern, records the lowest mean severity score among the six categories at 3.3, suggesting that credit constraints, though present, are comparatively less binding than market and infrastructural deficiencies for the majority of surveyed farmers.

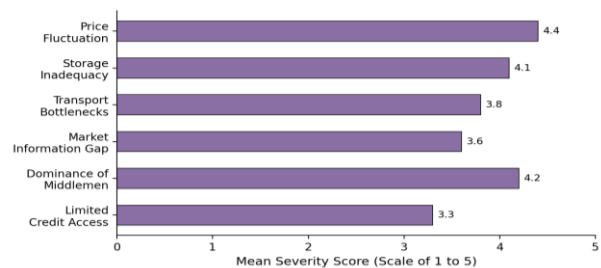


Figure 3: Farmers Perception of Severity of Supply Chain Constraints in Prayagraj Division.

VI. DISCUSSION

The findings of this study confirm that the agri-business supply chain serving Prayagraj Division suffers from a combination of institutional, infrastructural and informational deficiencies, with price-related and intermediary-related constraints perceived as most severe by farmers. The high post-harvest loss recorded for vegetables and fruits underscores the urgent need for improved cold chain infrastructure in the region, given the significant share of perishable commodities in the local cropping pattern.

The relatively lower perceived severity of digital platform awareness suggests that while e-NAM adoption remains limited, farmers do not yet regard this as their primary constraint, pointing to a sequencing challenge where more immediate concerns around price and storage must be addressed before digital market access can be expected to gain wider traction. The dominance of price fluctuation and middlemen influence as top-ranked constraints in this study is broadly consistent with findings reported in earlier research on regulated agricultural markets across northern India, which similarly identified commission agent dependence as a persistent structural feature limiting farmer bargaining power. The magnitude of post-harvest loss for vegetables recorded in this study is comparable to loss estimates reported in other perishable-commodity studies conducted in similarly infrastructure-constrained districts, reinforcing the generalisability of cold storage deficiency as a pan-regional concern rather than one unique to Prayagraj. The results lend support to marketing efficiency theory's proposition that intermediary multiplicity and information asymmetry are primary drivers of reduced farmer price realisation. The negative association observed between landholding size and perceived severity further supports the theoretical expectation that resource endowment influences a farmer's relative position and vulnerability within the supply chain, consistent with established agrarian economics literature on the differential bargaining power of marginal versus larger cultivators.

Mandi management and commission agents, the findings suggest a need to improve transparency in price-setting mechanisms and to expedite payment realisation for farmers, given that delayed payment was identified as a moderately severe constraint for cold storage and warehousing operators, the substantial loss figures for vegetables and fruits point to a clear commercial opportunity in expanding decentralised, farm-gate-proximate storage capacity within the Prayagraj catchment area. The results carry direct implications for the Uttar Pradesh Agricultural Marketing Board and the Prayagraj Mandi Samiti. Priority policy attention should be directed toward strengthening price

transparency mechanisms, potentially through expanded electronic auction and display systems within the mandi yard, alongside targeted expansion of cold storage infrastructure for perishable commodities. Facilitation of farmer producer organisations could help aggregate produce and improve collective bargaining power, thereby reducing dependence on individual commission agents.

VII. CONCLUSION

This study examined the major deficiencies in the agri business supply chain of farmer produce in Prayagraj Division and prioritised them using the Garrett Ranking Technique based on responses from 180 farmers. The findings reveal that price fluctuations, dominance of middlemen, inadequate cold storage facilities, transportation constraints, and post harvest losses are the most critical challenges affecting farmers, particularly those producing perishable commodities. Although initiatives such as regulated mandis and the National Agriculture Market have improved market access, significant structural and institutional gaps continue to limit their effectiveness at the local level. The study provides region specific empirical evidence that can assist policymakers, mandi administrators, and agricultural stakeholders in identifying priority areas for intervention. Expanding cold storage infrastructure, improving price transparency, strengthening Farmer Producer Organizations, promoting digital awareness of electronic marketing platforms, improving rural transport connectivity, and enhancing institutional credit access are essential measures for improving supply chain efficiency and farmer welfare. While the study is limited to Prayagraj Division and adopts a cross sectional research design, it offers valuable insights into regional supply chain challenges. Future studies should employ longitudinal and comparative approaches across different regions to validate these findings and further examine the role of Farmer Producer Organizations and digital agricultural marketing in improving market efficiency and reducing post harvest losses.

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