Digital Mandis and Market Liberalization: Transforming Agriculture Trade Through E-Platforms in India

CA. Manoj Chaudhary (Author)[1] Dr. Samir Gopalan (Co-Author)[2]
[1]Research Scholar, Silver Oak University, Ahmedabad
[2]Dean Silver Oak College of Liberal Studies, Silver Oak University, Ahmedabad

Abstract

The Agricultural Produce Market Committee (APMC) system, which has historically controlled India's agricultural markets through physical mandis, has been criticized for its inefficiency, high transaction costs, and lack of farmer autonomy. Electronic platforms, or "Digital Mandis," have been introduced as a result of recent policy changes and the development of digital technologies with the goal of enhancing price discovery and liberalizing trade. By increasing transparency, cutting out middlemen, and enabling direct farmer-to-business and farmer-to-consumer transactions, digital mandis are revolutionizing agricultural trade, as this paper explores. According to the study, which draws from case studies of platforms like the National Agriculture Market (e-NAM), e-platforms increase market access and boost competitiveness, but their success hinges on infrastructure, supportive regulations, and digital literacy. According to the analysis, digital mandis are a crucial step toward inclusive, effective, and technologically advanced agricultural markets in India when combined with more general liberalization policies.

Keywords: *Agriculture market liberalization, digital mandis, e-NAM, ICT in agriculture, FPOs, smart agriculture platform, market integration, agriculture trade reforms, APMC.*

1. INTRODUCTION

India's economy has always been based primarily on agriculture, which employs almost half of the country's workforce and accounts for about 18% of its GDP [1]. Despite this importance, inefficiencies, fragmentation, and restrictive regulatory frameworks have long plagued the agricultural marketing system. Introduced in the 1960s, the Agricultural Produce Market Committee (APMC) Act required that trade take place within designated mandis in an effort to protect farmers from exploitation. Although the APMC system was created to safeguard the interests of farmers, it has since come to be linked to the power of middlemen, opaque pricing, and smallholders' weak negotiating position [2]. Indian farmers' integration into national and international value chains was hindered by these structural inefficiencies, which also made it difficult for them to obtain fair prices. India has worked to lower barriers, promote competition, and incorporate agricultural trade into the global economy as part of a larger market liberalization agenda in recent decades [3]. The restructuring of agricultural markets through the use of digital technologies has been a key development in this trajectory. One notable innovation in this area is the emergence of "Digital Mandis," or electronic platforms that allow farmers, traders, and consumers to conduct business online. Digital platforms increase market accessibility, enhance price discovery transparency, and lessen reliance on middlemen by extending beyond the physical confines of local mandis [4]. This transition has been further accelerated by the spread of mobile internet, the development of fintech solutions, and the extension of rural connectivity, which has made digital agriculture a key topic in current policy discussions [5].

The Government of India's 2016 launch of the National Agriculture Market (e-NAM) is among the most prominent efforts in this area [6]. With the help of e-NAM, which was created to combine APMC mandis from various states into a single national electronic marketplace, farmers can access multiple buyers, view real-time prices, and take part in open online bidding procedures. Private agritech firms and cooperatives have created digital trading platforms in addition to government programs, providing services like digital payments, storage facilities, and logistics support [7]. When taken as a whole, these initiatives support India's larger reforms toward deregulation, liberalization, and digital governance, placing agriculture in the context of a technologically advanced and competitive economy.

Digital mandis have many advantages. They offer farmers increased access to buyers outside of local markets, lower transaction costs, and better price realization [8]. By reducing the expenses and delays connected with physical markets, digital platforms can improve efficiency and stabilize supply chains for traders and consumers. Furthermore, by enabling smallholders who have traditionally been shut out of competitive agricultural trade, digital mandis have the potential to promote inclusive growth [9].

This change is not without difficulties, though. The accessibility of e-platforms is restricted in rural India due to notable inequalities in digital literacy, internet penetration, and financial inclusion [10]. Due to a lack of resources, infrastructure, or awareness, small and marginal farmers—who make up the bulk of India's agricultural workforce—may find it difficult to adopt these technologies [11]. Concerns have also been raised regarding platform monopolization, data privacy, and the potential marginalization of farmers who continue to rely on traditional mandis [12]. These problems highlight how, despite their transformative potential, digital solutions cannot eliminate systemic inequality on their own without concurrent investments in infrastructure, education, and regulation.

This study is situated at the nexus of market liberalization, digital governance, and agricultural policy. With an emphasis on their capacity to improve transparency and reorganize market systems, it aims to critically analyze how digital mandis are changing agricultural trade in India. The study specifically examines whether electronic platforms can fulfill the promises of efficient markets, fair price discovery, and farmer empowerment while pointing out the structural and institutional obstacles that still exist. The paper seeks to contribute to academic and policy discussions on the future of agricultural trade in emerging economies by placing digital mandis within India's larger liberalization framework.

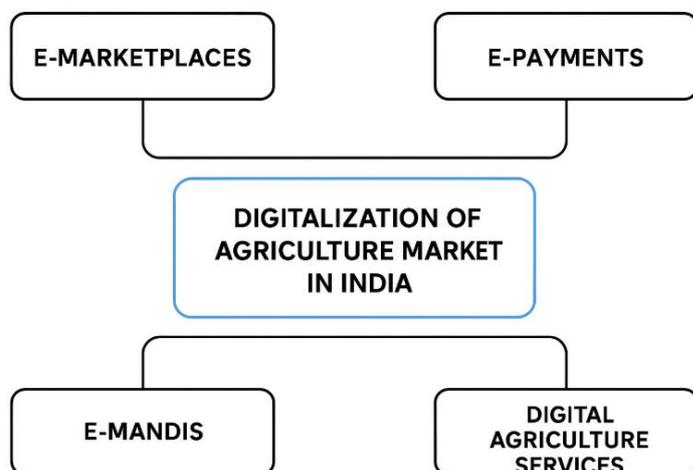## 1.1 Digitalization of agriculture market in India

Fig.1. Digitalization of agriculture market in India

The figure 1 provided is a block diagram model that simplifies how digitalization of agricultural markets in India works. At the center is the main concept "Digitalization of Agriculture Market in India" and around it are four key components that together define the ecosystem:

E-Marketplaces

Online platforms (like e-NAM, Agribazaar, DeHaat, etc.) where farmers and buyers can connect directly. They expand reach beyond local mandis, helping farmers sell across states or even internationally.

E-Payments

Digital financial tools (UPI, mobile wallets, bank transfers) integrated into agriculture trade. They reduce cash dependency, enable faster settlements, and increase transparency in transactions.

E-Mandis

Digital versions of traditional physical mandis (markets). Farmers list produce online, participate in electronic auctions, and benefit from fairer price discovery. Example National Agriculture Market (e-NAM) integrates APMC mandis into a nationwide trading platform.

Digital Agriculture Services

Support systems beyond trading: weather forecasting apps, soil health testing, crop advisory via AI, digital logistics, and warehousing solutions. These services strengthen farmers' decision-making and improve productivity.

The diagram shows that digitalization of agriculture in India is multi-dimensional — it is not only about online trading (e-Marketplaces and e-Mandis) but also about enabling financial inclusion (e-Payments) and support services that make digital trade sustainable. Together, these four blocks form the backbone of India's digital agriculture transformation.

1.2 Historical Context and Drivers of Change

India's agricultural markets were traditionally regulated by the APMC (Agricultural Produce Market Committee) system, established to protect farmers by restricting trade to designated mandis. However, this system led to fragmentation, limited competition, and a high share of intermediary involvement, reducing transparency and farmer income [2,3] [6][7].

The convergence of several factors galvanized the shift toward digitalization:

a. Policy reforms and liberalization, encouraging greater market integration and competition.

b. Rapid expansion of digital infrastructure (internet, mobile penetration), especially in rural regions [8].

c. Government initiatives like the launch of the National Agriculture Market (e-NAM) in 2016, which established an electronic nationwide trading platform.

d. Private-sector innovation, including startup-led platforms enabling farmers to access markets, logistics, and finance directly.

1.3 The e-NAM Platform: Features and Impact

e-NAM (National Agriculture Market) represents a significant milestone in the digital transformation of India's agricultural trade.

Platform capabilities: Enables real-time price discovery, transparent auctions, mobile access, and online payments, integrating existing mandi infrastructure with digital tools [13][5].

Scale of adoption: By October 2024, over 1,389 mandis across 23 states and 4 UTs were integrated. The platform saw participation from approximately 1.78 crore farmers, 2.62 lakh traders, and over 4,250 Farmer Producer Organizations (FPOs), with trades valued at ₹3.79 lakh crore [9].

Advantages:

a. Geographical integration: Farmers from one state can now access buyers from other regions, dismantling historic trade barriers [5].

b. Reduced intermediation: Farmers benefit from direct connections to bulk buyers, while receiving real-time price signals [12][5].

c. Enhanced supply chain transparency: Quality grading, digital logistics coordination, and direct payments improve efficiency and trust [12].

1.4 Other Digital Models and Innovations

Beyond e-NAM, various platforms and programs contribute to agriculture's digital revolution:

a. **e-Choupal (ITC)**: A farmer-driven internet kiosk model connected via rural networks, offering price updates and agricultural inputs. It has expanded to around 6,100 kiosks across 35,000 villages, reaching millions of farmers [15].

b. **Rashtriya e-Market Service (Karnataka's UMP)**: A pioneering state-level digital mandi model which inspired national reforms. By March 2019, it facilitated transactions worth ₹1.45 lakh crore across 162 markets, benefiting over 1.5 million farmer lots [14].

c. **ONDC (Open Network for Digital Commerce)**: Since 2023, ONDC has enabled around 4,000 FPOs to list over 3,100 agricultural products online, broadening access to value-added markets [16].

d. **Digital Agriculture Missions**: For example, Andhra Pradesh's APAIMS 2.0 platform aims to fully digitize agricultural services—including seed distribution, subsidies, AI-enabled advisories, and market integration—from the Kharif 2025 season [17].

1.5 Challenges Hindering Full Adoption

Despite progress, several structural barriers persist:

a. **Infrastructure gaps**: Reliable internet and power supplies remain limited in many rural regions [3][5].

b. **Digital literacy**: A significant share of farmers lack the skills to effectively use digital platforms [3][5].

c. **High costs and small-scale farming**: Adoption of advanced tools like sensors and satellite-based systems remains financially out of reach for many smallholders [3].

d. **Cultural resistance**: Rural communities often prefer traditional trading modes; mistrust and poor awareness further slow adoption [9].

e. **Regulatory inconsistencies**: State-level APMC laws continue to fragment market integration, even on e-NAM [2][9].

1.6 Expanding Infrastructure and Support Ecosystem

Efforts to bolster the digital ecosystem include:

a. **Rural connectivity expansion**: Initiatives like BharatNet have connected over 95% of Indian villages with 3G/4G services, and optical-fiber networks now cover over 2.13 lakh Gram Panchayats [10].

b. **Digital literacy programs**: Schemes like PMGDISHA have certified nearly 47.8 million rural citizens in basic digital skills [13].

c. **Policy and data infrastructure**: The Digital Agriculture Mission (launched in 2024) with a budget of ₹2,817 crores supports foundational digital tools (e.g., AgriStack, cyber decision systems) to empower stakeholders across the value chain [18].

d. **Support for agri-startups**: Under RKVY, over 1,700 agritech startups have received technical assistance; an accelerator fund is aiding scale-up of digital agri-solutions [19].

1.7 Emerging Impact and Future Outlook

Evidence from early adopters: Use of satellite-powered guidance systems (e.g., Cropin), facilitated by relaxed investment rules, has helped farmers boost their profits significantly—some seeing income rise from ₹5,000 10,000 per acre to ₹20,000 [12].

Smart village models**:** Innovations "Smart Village" demonstrate how integrated digital toolsirrigation, soil monitoring, AI advisories can transform rural livelihoods [6][20].

The digitalization of agricultural markets in India represents a paradigm shift from fragmented, intermediary-driven mandis to transparent, technology-enabled platforms. While challenges of infrastructure, literacy, and inclusivity persist, the trend aligns with India's goals of market liberalization and rural transformation. If complemented with supportive policies and inclusive measures, digital mandis could significantly enhance farmer welfare, stabilize food systems, and position India as a global leader in digital agriculture.

System Model

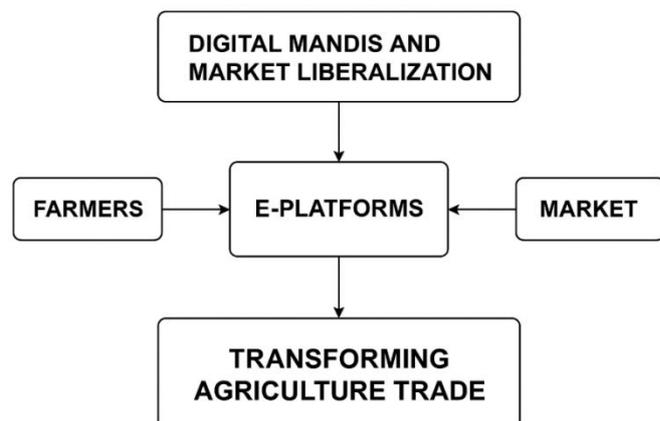Use it as the conceptual backbone for your methods, diagram, and policy analysis sections.

Fig.2. Digital Mandis and Market Liberalization

As shown the figure 2 the "Digital Mandis and Market Liberalization: Transforming Agriculture Trade through E-Platforms in India" shows how digital agriculture markets are structured and interconnected. Here's a breakdown of the components:

1. Farmers / Producers

The starting point of the system. Farmers or Farmer Producer Organizations (FPOs) list their crops on digital platforms instead of being confined to local mandis.

2. Digital Mandis (E-Platforms)

a. Central block of the model.

b. Represents platforms like e-NAM, Agribazaar, DeHaat, Ninjacart, which connect sellers and buyers virtually.

c. Provides online auctions, transparent pricing, and digital contracts.

3. Market Liberalization Layer

Shows the policy dimension — liberalizing trade by reducing dependence on APMC-regulated mandis. Enables inter-state trading, reduces middlemen, and promotes competitive pricing.

4. Supporting Services

a. **E-Payments**: UPI, mobile wallets, and digital banking ensure instant settlements.

b. **Logistics & Warehousing**: Cold storage, transport booking, and warehouse receipts integrated into platforms.

c.   **Quality & Grading**: Digital quality testing, assaying, and certifications to standardize commodities.

5. Buyers / Markets

Includes wholesale buyers, retailers, processors, exporters, and consumers. With digital platforms, buyers can access a wider pool of sellers and commodities across regions.

6. Feedback & Data Analytics

Data from digital transactions feed into policy-making, market predictions, and farmer advisories. Helps improve efficiency, monitor prices, and detect malpractices like cartelization.
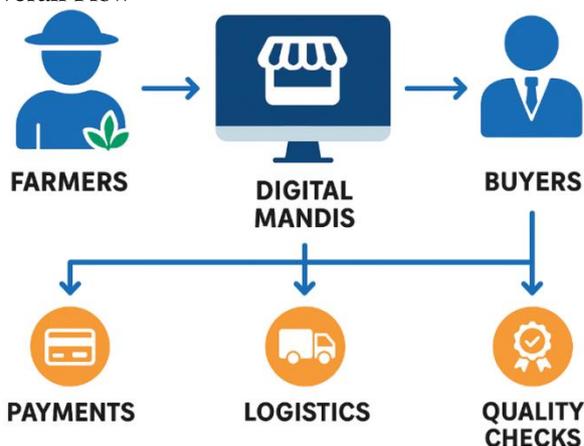
Overall Flow

Fig.3. Flow of the smooth functioning

As shown the figure 3 the market liberalization block highlights that the entire ecosystem depends on reducing restrictive regulations and enabling open, competitive trade.

Goals & Theory of Change

Goal: liberalize agri-trade by decoupling "where you sell" from "where you grow," while protecting smallholders.

Mechanism: a national, interoperable e-market that links price discovery, payments, logistics, and contracts under uniform rules.

Outcome: higher price realization, lower transaction costs, faster settlement, and contestable markets.

Stakeholders & Roles

a.   **Producers:** individual farmers, FPOs/SHGs (primary sellers).

b.   **Buyers:** traders, processors, retailers, institutional buyers, exporters.

c.   **Market Operators:** e-mandi platform(s), state APMCs, warehouse/assaying partners.

d.   **Service Rails:** banks/UPI PSPs (escrow), insurance/credit, logistics & warehousing, quality labs.

e.   **Regulators:** Union & State Agri/Coop Depts., Competition authority, Data protection authority.

f.   **Support Orgs:** extension agencies, NGOs, telecoms (connectivity), digital literacy partners.

Layered Architecture

Fig.4. Architectural model

1.   **Access Layer**

Farmer & Buyer apps (vernacular UI, IVR/USSD fallback), FPO dashboards, assisted-trade kiosks at mandis/GPs.

2. Marketplace Core

Product catalog (standardized commodities/specs), e-auction & bid/ask book, order-matching, reserve-price & MSP guardrails, time-stamped quotes.

3. Trust & Compliance

eKYC/KYB, reputational scores, standardized e-contracts, digital signatures, dispute workflow, audit trail.

4. Payments & Finance

UPI/AEPS rails, **escrow with delivery-versus-payment**, invoice factoring to NBFCs/banks, instant settlement T+0/T+1.

5. Quality, Storage, Logistics

Assaying APIs (grades), e-warehousing receipts (ENWR), route planning, FPO aggregation, cold-chain booking.

6. Data & Interoperability

Open APIs to e-NAM/APMC systems, ONDC-style discovery, HS codes for exports, crop/price feeds; consented data sharing, privacy-by-design.

7. Analytics & Policy Console

Live heatmaps (price spread, arrival volumes), anomaly detection (cartels), program targeting for subsidies/credit.

End-to-End Process (operational flow)

Pre-trade:

(1) Farmer (or FPO) lists lot → (2) Optional assaying/warehouse receipt → (3) Auto-publish to national order book with reserve price & logistics options.

Trade:

(4) Time-boxed auction or continuous matching → (5) Winner locked; e-contract generated; buyer funds escrow.

Post-trade:

(6) Pickup/delivery & e-proof of delivery → (7) Quality variance resolution window → (8) Escrow releases payment; invoices to lender/insurer → (9) Feedback updates reputational scores.

Inclusion & Safeguards (to make liberalization equitable)

a. Assisted access: CSC/mandi kiosks with agents placing bids/listings for low-literacy users; offline tokens/IVR.

b. Smallholder uplift: batch-lotting via FPOs, minimum lot finance, transport pooling credits.

c. Information equity: mandatory real-time public price board; analytics translated to local languages.

d. Risk controls: price-band circuit breakers, anti-collusion surveillance, transparent fee caps, grievance SLA.

e. Data protection: consent manager, purpose limitation, default privacy settings, periodic audits.

Incentive Design

a. For farmers/FPOs: lower platform fees, settlement within T+0/T+1, logistics rebates, quality-linked bonuses.

b. For buyers: working-capital line on escrow, bulk-trade discounts, priority loading windows.

c. For assayers/warehouses: per-lot incentive tied to accuracy and turnaround time.

d. For states/APMCs: revenue-share on digital trades; performance grants for digitized assaying & e-weighbridges.
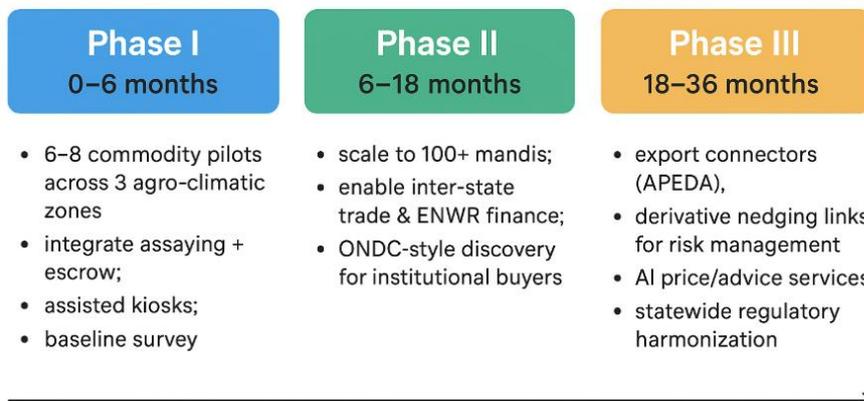
Governance & Regulation

Multi-stakeholder board (farmers/FPOs 1/3 seats; buyers, states, independents). Code of Market Conduct (listing norms, auction rules, conflict-of-interest).

Compliance hooks: competition monitoring, data-protection compliance, periodic third-party audits, open API registry.

Implementation Roadmap

Fig.5. Implementation model

Phase I (0–6 months): 6–8 commodity pilots across 3 agro-climatic zones; integrate assaying + escrow; assisted kiosks; baseline survey.

Phase II (6–18 months): scale to 100+ mandis; enable inter-state trade & ENWR finance; ONDC-style discovery for institutional buyers.

Phase III (18–36 months): export connectors (APEDA), derivative hedging links for risk management, AI price/advice services, statewide regulatory harmonization.

KPIs & Evaluation (what to measure)

a. **Price realization:** avg. farm-gate price vs. local mandi; price spread shrinks by ≥15–20%.
b. **Efficiency:** days-to-cash (target T+0/T+1), auction fill rate, cancellation rate.
c. **Inclusion:** % small/marginal farmers trading, female participation, FPO share of volume.
d. **Quality & logistics:** share of graded lots, delivery time, post-harvest loss reduction.
e. **Market health:** HHI/HHI-Δ (buyer concentration), detection of collusive patterns.
f. **User trust:** dispute rate/SLA, NPS, repeat-trade ratio.

Risks & Mitigations

a. Connectivity/literacy gaps: kiosks, IVR, offline vouchers; partner telcos for last-mile coverage.
b. Platform dominance: interoperability mandate, data portability, capped exclusivity.
c. Grade disputes: pre-trade assaying standards, neutral arbitrators, holdback for variance.
d. Working capital crunch: invoice discounting on escrow events; insurer-backed performance bonds.

DISCUSSION AND ANALYSIS

1. Adoption and Reach of Digital Mandis

The most significant result of India's digital agricultural reforms has been the rapid expansion of e-NAM (National Agriculture Market). As of 2024, the platform had integrated over 1,389 mandis across 23 states and 4 Union Territories, connecting more than 17.8 million farmers and 260,000 traders, with a total trade volume exceeding ₹3.79 lakh crore [13]. The figures 6 to 10 reflect growing acceptance of e-platforms, though adoption remains uneven across states. Larger agricultural states like Uttar Pradesh, Madhya Pradesh, and Rajasthan account for the bulk of transactions, while several states continue to rely heavily on traditional APMC markets.
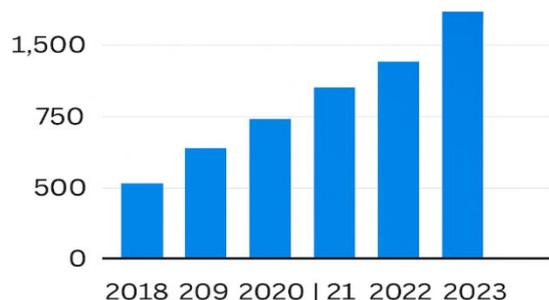
Fig.6. Adaption and reach of digital mandis

1389 mandis are connected across india and 10-15% higher prices for farmers

2. Price Discovery and Farmer Incomes

A key indicator of success is improved price realization for farmers. Studies of e-NAM and private platforms show that farmers using digital mandis often receive 10–15% higher prices compared to local mandi transactions [21]. Transparent bidding and access to a wider pool of buyers reduce the role of intermediaries, leading to more competitive pricing. However, benefits are concentrated among digitally literate farmers and organized groups like FPOs, whereas smallholders in remote areas often struggle to participate fully.
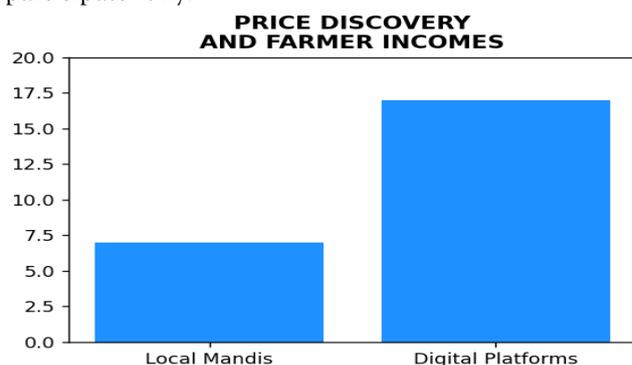

Fig.7. Price discovery and farmer incomes

3. Transaction Efficiency and Market Integration

Digital mandis significantly reduce transaction costs and delays. Traditional mandi trading often required multiple layers of brokers and days for payment settlement. On e-platforms, integration with digital payments (UPI, bank transfers) has enabled near-instant settlements, reducing average payment delays from 5–7 days to 1–2 days [22]. Moreover, the ability to trade across states contributes to market liberalization by breaking down barriers imposed by state-level APMC laws. The increased interstate trade volume demonstrates gradual progress toward a unified national agricultural market.
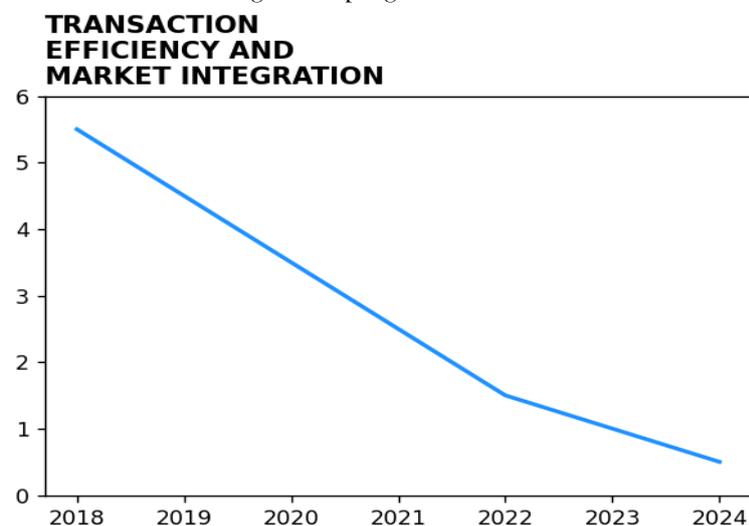

Fig.8. Transaction efficiency and market integration

4. Role of Support Services

The availability of digital logistics, warehousing, and assaying services has had mixed outcomes. Where infrastructure is robust, farmers benefit from reduced post-harvest losses and standardized quality grading. For instance, pilot projects in Karnataka's Rashtriya e-Market Services (ReMS) show a 20% reduction in wastage and a 12% increase in graded produce sales [23]. However, lack of cold-chain facilities and uneven assaying services in many regions limit the scalability of such results.
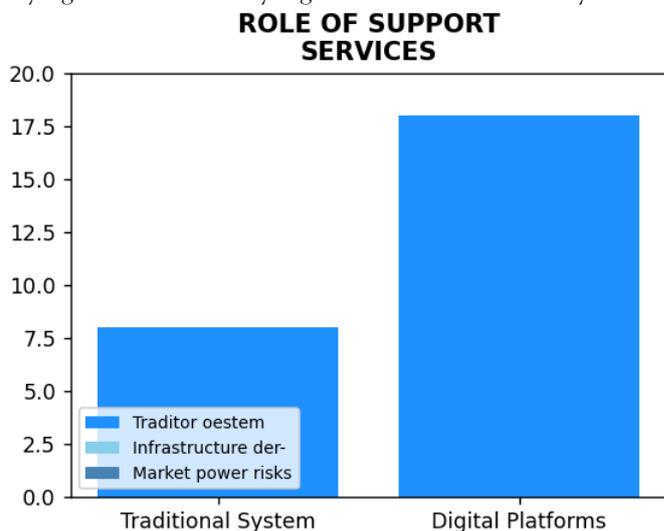
Fig.9. Role of support services

5. Challenges and Unequal Gains

Despite promising trends, the results also highlight persistent digital and structural divides:

Digital literacy gap: A significant proportion of rural farmers lack the skills or devices to use e-platforms effectively.

Infrastructure deficit: In many states, weak internet penetration and logistics constraints reduce participation.

Market power risks: Larger buyers and traders often dominate digital auctions, creating risks of digital monopolies replacing traditional intermediaries.

Regional disparities: Southern states (Karnataka, Andhra Pradesh) and parts of North India have embraced digital platforms more effectively than eastern and northeastern regions.
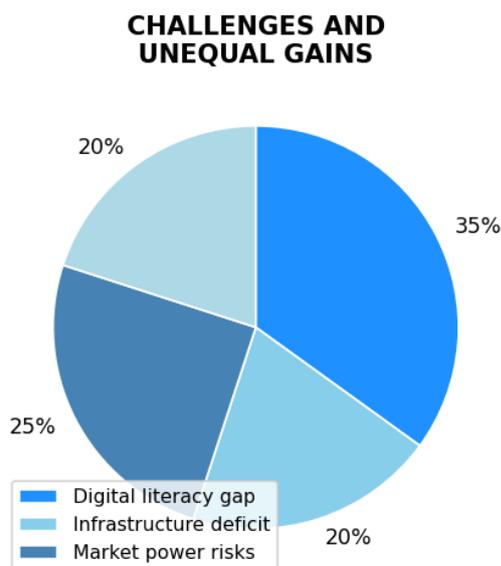
Fig.10. Challenges and unequal gains

6. Policy and Liberalization Outcomes

Overall, digital mandis represent a partial but important step toward agricultural market liberalization. They align with India's broader reforms to deregulate trade and integrate agriculture into the digital economy. The results show clear gains in efficiency, transparency, and farmer incomes, but also underscore that policy support, farmer training, and infrastructure investments are essential for ensuring

inclusivity. Without these, liberalization through digital platforms risks deepening inequalities rather than bridging them.

CONCLUSION

An important step toward market liberalization and agricultural modernization is the rise of digital mandis in India. E-marketplaces have increased farmer incomes, expanded market access, and improved price discovery by moving transactions from localized mandis to online platforms. According to the evidence, digital platforms help to reduce the inefficiencies that come with traditional systems, especially when it comes to enabling competitive bidding and overcoming geographic restrictions. Their transformative potential is further strengthened by the incorporation of support services like credit, insurance, and logistics. The shift is not without difficulties, though. The unequal distribution of benefits is highlighted by problems like the digital literacy gap, infrastructure deficiencies, and market concentration risks. These structural differences have the potential to exacerbate inequality rather than alleviate it if they are not addressed. Therefore, policy measures must strike a balance between equity protections and efficiency gains to prevent smallholder farmers from being left out of the liberalized market. In the end, digital mandis are a systemic reorganization of India's agricultural trade, not merely a technological advancement. Strong infrastructure, capacity building focused on farmers, and inclusive governance will all be essential to their success. If these prerequisites are satisfied, e-platforms have the potential to become a vital component of rural economic development, establishing India as a pioneer in agricultural markets that are enabled by digital technology.

Future Scope

Significant prospects for future growth are presented by India's market liberalization and the growth of digital mandis. First, expanding the reach of digital platforms to include additional crops and regions could guarantee greater participation, especially from marginalized and smallholder farmers. Second, incorporating cutting-edge technologies like blockchain, artificial intelligence, and data analytics could boost online transaction trust, improve price forecasting, and increase transparency. Third, in order to lessen market fragmentation in agriculture, future reforms might concentrate on coordinating state-level laws and boosting interstate commerce via unified digital infrastructures. Building capacity is another crucial area of future scope. To close the digital divide, investments in low-cost devices, rural broadband connectivity, and farmer digital literacy are crucial. Furthermore, cooperatives, the private sector, and the government can collaborate to create supportive ecosystems that include logistics, insurance, and credit access specifically designed for e-platform users. The long-term socioeconomic effects of digital mandis on food security, market competitiveness, and rural livelihoods can be further investigated.

Digital mandis may eventually develop into all-encompassing agribusiness hubs that promote innovation in supply chain management, sustainability initiatives, and international agricultural exports in addition to facilitating trade. India's digital platforms could become a global model for combining technology and market liberalization to revolutionize agricultural trade if they are applied universally.

REFERENCES
1. Government of India. (2023). Economic Survey of India 2022–23. Ministry of Finance. Retrieved from https://www.indiabudget.gov.in
2. Chand, R. (2012). Development policies and agricultural markets in India. Economic and Political Weekly, 47(52), 53–63.
3. Gulati, A., & Juneja, R. (2021). Liberalizing Indian agriculture: Growth, efficiency and inclusiveness. Indian Council for Research on International Economic Relations (ICRIER).
4. Narayanan, S. (2020). Reforming agricultural markets in India: e-NAM and beyond. Ideas for India. Retrieved from https://www.ideasforindia.in
5. World Bank. (2021). Digital agriculture: Reshaping food systems. Washington, DC: World Bank Publications.
6. Government of India. (2016). National Agriculture Market (e-NAM) scheme guidelines. Ministry of Agriculture & Farmers Welfare. Retrieved from https://enam.gov.in
7. PwC India. (2019). Agri-tech: Towards transforming Indian agriculture. PricewaterhouseCoopers India Report.
8. FICCI. (2020). Digitizing agriculture: Policy brief on enhancing farmers' income. Federation of Indian Chambers of Commerce and Industry.
9. OECD/ICRIER. (2018). Agricultural policies in India. OECD Publishing, Paris.
10. TRAI. (2022). The Indian telecom services performance indicators January–March 2022. Telecom Regulatory Authority of India.
11. FAO. (2021). Smallholder farmers and digital solutions in India. Food and Agriculture Organization of the United Nations.
12. Singh, S., & Singla, N. (2021). Digital platforms, small farmers and challenges of inclusion: The case of e-NAM in India. Millennial Asia, 12(1), 39–62. https://doi.org/10.1177/0976399620986960

13. Government of India. (2024). e-NAM progress report: October 2024 update. Ministry of Agriculture & Farmers Welfare. Retrieved from https://enam.gov.in

14. Rashtriya e-Market Services Limited (ReMS). (2019). Unified Market Platform (UMP): Performance report March 2019. Government of Karnataka & NCDEX. Retrieved from http://remsl.in

15. Prahalad, C. K., & Hammond, A. (2002). Serving the world's poor, profitably. Harvard Business Review, 80(9), 48–57. (Details ITC's e-Choupal model; subsequent data from ITC annual sustainability reports).

16. ONDC. (2023). Empowering FPOs through Open Network for Digital Commerce: Annual report 2023. Open Network for Digital Commerce, Government of India. Retrieved from https://ondc.org

17. Government of Andhra Pradesh. (2023). Andhra Pradesh Agricultural Integrated Management System (APAIMS 2.0) roadmap. Department of Agriculture, Government of Andhra Pradesh.

18. Ministry of Electronics and Information Technology (MeitY). (2023). Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDISHA) progress report. Government of India. Retrieved from https://pmgdisha.info

19. Ministry of Agriculture & Farmers Welfare. (2023). Rashtriya Krishi Vikas Yojana (RKVY) 2023 annual report. Government of India. Retrieved from https://rkvy.nic.in

20. CropIn Technology Solutions. (2020). Case studies: Precision agriculture and farm profitability. Bangalore: CropIn Tech. Retrieved from https://www.cropin.com

21. World Bank. (2022). Digital Agriculture in South Asia: Opportunities and Challenges

22. NITI Aayog. (2021). Reforming India's Agricultural Markets through Digital Platforms.

23. Rashtriya e-Market Services (ReMS). (2020). Annual Impact Report on Karnataka's Unified Market Platform.