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Digital Marketplaces for Farm-to-Consumer Trade: A Comparative Review of E-Commerce Platforms, Architectures, and Adoption Barriers in Agricultural Supply Chains

Shivani Dhabadge[1], Pratik Salke[2], Yagnika Patel[3], Anand Kasar[4], Sainath Kedase[5]

[1]Assistant Professor, Department of MCA, ASM's Institute of Business Management & Research, Pune, Maharashtra, India.
Email: shivanidhabadge@asmedu.org
[2]MCA Student, Department of MCA, ASM's Institute of Business Management & Research, Pune, Maharashtra, India.
Email: mca25.pratiksalke@asmedu.org
[3]MCA Student, Department of MCA, ASM's Institute of Business Management & Research, Pune, Maharashtra, India.
Email: mca25.yagnikapatel@asmedu.org
[4]MCA Student, Department of MCA, ASM's Institute of Business Management & Research, Pune, Maharashtra, India.
Email: mca25.anandkasar@asmedu.org
[5]MCA Student, Department of MCA, ASM's Institute of Business Management & Research, Pune, Maharashtra, India.
Email: mca25.sainathkedase@asmedu.org

Abstract – In most developing economies, farm produce still reaches consumers through a long relay of commission agents, traders and wholesalers, and each of them keeps a share of the price. Buyers end up paying more, while growers are left with a thin margin. Wider internet access and cheaper smartphones have opened another route: web and app-based marketplaces where farmers sell directly to households, retailers and institutional buyers. This paper draws on two independent studies of agricultural e-commerce and reads them together as one consolidated review. It traces how digital trade moved from general retail into farming, sets out the stakeholder roles and technical building blocks a farm-to-consumer platform needs, and compares deployed systems, from large state-backed markets such as India's eNAM and China's Pinduoduo to smaller ventures such as Harvest Port, Farmigo, AgriChain, Fresh Shop, Procurant and iTradeNetwork, with a community-oriented "Farmer Gateway" concept built on cooperative storage and last-mile vending points. Recurring obstacles are identified, including patchy rural connectivity, low digital and financial literacy, distrust of online payment, language exclusion and weak regulatory support. The strategies proposed across the literature are then summarised: offline-capable applications, tiered pricing, multilingual interfaces, cooperative-led training, and blockchain- or AI-assisted transparency tools. The review closes with research gaps, chiefly the shortage of comparative, cross-regional evaluation needed to guide inclusive digital agricultural trade.

Key Words: *E-commerce, Agricultural Supply Chains, Digital Marketplaces, Farm-to-Consumer Trade, Rural Development, Farmer Empowerment, Digital Inclusion, Cooperative Platforms, Supply Chain Digitalisation, Policy Intervention.*

1. INTRODUCTION

For a large part of the population in developing countries, farming is still the main source of income. Yet the way produce travels from field to plate has barely changed. Between the grower and the person who finally eats the food there is usually a string of commission agents, village traders and wholesale-market staff. Every one of them keeps a portion of the price, so the farmer receives only a fraction of what the consumer pays, and the consumer does not necessarily get fresher or cheaper food in return. Spoilage makes matters worse. Without dependable cold storage or quick transport, a noticeable share of the harvest never reaches a paying customer at all.

This review looks at two independent studies that arrive at the same suggested fix: an online marketplace where farmers can list, price and sell their produce directly. The first study surveys how agricultural e-commerce has developed worldwide and leans on established programmes such as eNAM and Pinduoduo. The second proposes a cooperative-based "Farmer Gateway" meant to shorten the vegetable supply chain between growers and residents of nearby housing societies. One is broad and policy-minded, the other narrow and concerned with implementation, so together they complement each other.

The rest of the paper is organised as follows. Section 2 describes the traditional chain and where it fails. Section 3 traces the move of e-commerce into agriculture, and Section 4 reviews the academic literature on adoption and design. Sections 5 to 7 cover platform architecture, a comparison of existing systems and three national case studies. Sections 8 and 9 discuss adoption barriers and possible remedies, and Sections 10 and 11 close with research gaps and conclusions.

2. THE TRADITIONAL SUPPLY CHAIN AND ITS WEAKNESSES

The conventional chain follows a familiar order. Input suppliers equip the farmer for cultivation, the harvest is sorted and packed, distributors or wholesalers carry it to market, retailers such as grocery stores buy their stock from them, and consumers make the last purchase. Cold storage and warehousing sit between distribution and retail to slow down spoilage, although coverage is patchy, especially away from big cities.

Three weaknesses keep appearing. The first is the sheer number of hands involved. Each intermediary adds a margin, which pushes retail prices up while pulling farm-gate prices down. The second is opacity: growers seldom know what their

produce is fetching elsewhere, so they tend to accept whatever the local trader offers. The third is delay. Slow collection, transport or storage lowers quality and adds directly to post-harvest loss, which hits vegetables and fruit hardest. Fig -1 contrasts this arrangement with a direct digital chain. Taken together, these problems make the case for technology-supported trade that reduces the distance, in steps and in time, between producer and buyer.

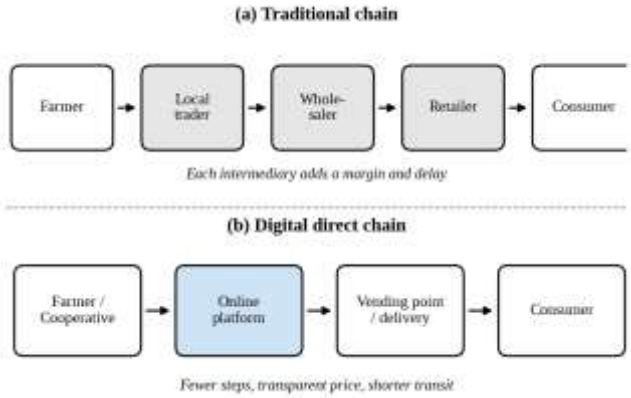


Fig -1: Traditional chain versus direct digital chain (conceptual schematic drawn by the authors)

3. DIGITAL TRANSFORMATION OF AGRICULTURAL TRADE

3.1 Growth of E-Commerce Across Sectors

Over roughly two decades e-commerce has become central to global trade, changing retail, travel, electronics and financial services before anything else. Companies such as Amazon, Alibaba and Flipkart showed that logistics, payments, inventory and customer support can all be run digitally at very large scale [1]. Comparable growth has been documented in Europe as well [22]. Once the model was proven, other sectors followed, including agriculture, which had long been slow to go online.

3.2 Entry into Agriculture

Farming has traditionally depended on manual labour, scattered landholdings and informal, face-to-face markets. Better internet access and cheaper smartphones now allow farmers to advertise and sell directly to consumers, wholesalers, retailers and institutional buyers through dedicated platforms [2]. Because prices and listings are visible to many participants at once, the resulting market is usually more competitive and open than a traditional mandi or a roadside trader, and it pulls production, harvesting and sales into one tighter value chain [3]. Digital channels also drew fresh attention during the pandemic period, when physical markets were disrupted [9].

3.3 Main Benefits

Studies point to a similar list of gains from moving agricultural trade online. Farmers can reach markets beyond their local mandi [6]. Live listings improve price transparency, letting growers compare offers and bargain from a stronger position [7]. Faster transactions and better-coordinated logistics cut the time produce spends in transit or storage, which reduces post-harvest loss. Buyers, for their part, get fresher produce, more competitive prices and clearer information about where their food came from. Much of this rests on smoother handling of orders, packing, transport and delivery, which AI- and IoT-based coordination tools increasingly support [8].

4. LITERATURE REVIEW

Research on agricultural e-commerce covers platform design, cooperative models, supply-chain innovation and regional case studies. Early work by Alyoubi on developing countries identified weak infrastructure and low digital literacy as lasting brakes on adoption [10]. Goyal argues that digital markets improve rural welfare mainly when they are trusted, local and sensitive to context [11]. Mishra and Williams reach a similar view: rural e-commerce projects work when they fit existing business habits and social norms, and fail when an outside template is dropped in unchanged [12].

Case studies stress the technical back end. Kim et al. describe the OpenFarm information system and treat logistics coordination and data interoperability as preconditions for a working platform [13]. Zhong et al. study data-driven vegetable supply chains and find that traceability and demand forecasting are what actually reduce waste and misallocated stock [14]. Kumar and Kushwaha review India's digital agriculture push and report steady adoption alongside problems of scale and an uneven user experience [15]. Batte and Ernst, working with farmers in the United States, found that age, education and internet quality strongly predict whether a farmer uses a digital sales channel at all [16].

Another group of studies looks at cooperatives and technology-based intermediation. Hu and Luo show that farmer-run digital cooperatives can take over part of the logistics and market-knowledge burden that individual growers would otherwise carry, which strengthens their hand against private traders [17]. On the infrastructure side, Zhang and Liu explain how blockchain record-keeping makes supply-chain transactions harder to falsify and easier to trust [18]. Singh and Maheshwari survey the AI tools that sit beneath farm-to-consumer platforms, such as product categorisation, demand forecasting and personalised recommendations [19]. Sharma and Gupta describe the gaps still open in Indian logistics, platform reliability and buyer engagement [20], while Gadde takes a wider industry view of how removing intermediaries changes pricing and distribution [21]. Smith and Johnson [23] and Lee and White [25] also examine technology-enabled empowerment of farmers and direct farmer–consumer platforms, respectively. The main studies are listed in Table -1.

Table -1: Summary of the literature surveyed

Author(s)	Focus area	Key finding
Alyoubi (2015) [10]	E-commerce in developing economies	Infrastructure and literacy gaps limit adoption
Goyal (2010) [11]	Digital markets and rural welfare	Gains need localised, trusted platforms
Mishra & Williams (2006) [12]	Rural business integration	Adoption needs fit with local practice
Kim et al. (2015) [13]	OpenFarm case study	Interoperability and logistics are key
Zhong et al. (2015) [14]	Vegetable supply-chain data	Traceability and forecasting cut waste
Kumar & Kushwaha (2022) [15]	India's digital agriculture	Growing, but scalability lags
Batte & Ernst (2007) [16]	U.S. farmer adoption	Age, education, internet drive uptake
Hu & Luo (2019) [17]	Digital farmer cooperatives	Improve access and bargaining power
Zhang & Liu (2020) [18]	Blockchain in supply chains	Builds transactional trust
Singh & Maheshwari (2023) [19]	AI in farm-to-consumer platforms	Aids sorting, forecasting, personalisation

Author(s)	Focus area	Key finding
Sharma & Gupta (2021) [20]	E-commerce in Indian agriculture	Logistics and engagement gaps remain
Gadde (2014) [21]	Intermediary dynamics	Digital platforms reshape pricing

Overall, the literature covers individual design decisions and country-level adoption patterns well. Both source studies, however, point to the same shortfall: few works compare several deployed platforms side by side. Without such comparisons it is hard to say how far findings travel across regions, or whether a pilot can grow into a national programme.

5. PLATFORM ARCHITECTURE AND STAKEHOLDERS

5.1 Stakeholder Roles

In both source studies a farm-to-consumer platform revolves around four roles. Farmers are the main suppliers and the intended beneficiaries; they may sell straight to buyers or pass produce through a cooperative that handles listing, storage and dispatch for them. Cooperatives, where they exist, run the shared server, the product database and the physical storage, and they act as a collective seller looking after members' interests. Shipping or logistics partners carry goods the farmer does not deliver personally, which widens the market radius. Consumers, whether households or businesses that use farm produce as an input, form the demand side that pays for the whole system, and their reviews, ratings and location data also guide how the platform is run. Seen together, the four roles form a loop: supply, storage, movement and demand each feed information back to the others, and the platform's job is to keep that loop short, visible and trustworthy.

5.2 Technical Infrastructure

Three technical layers make up a workable platform. The application server hosts the storefront and back-end logic, keeps listings and orders in sync, and has to stay responsive at demand peaks, since outages quickly erode user trust [29]. The payment gateway handles the money side. Because trust in online payment is often the weakest point for first-time users, it should offer several channels (cards, mobile wallets, bank transfer), encrypt traffic with TLS/SSL and follow data-security standards such as PCI DSS [10]. The third layer is shipping and logistics, which decides how produce physically reaches the buyer. Good implementations combine local delivery partners and GPS tracking and, where possible, low-emission transport [4], [7]. Table -2 summarises these layers. The three layers depend on one another: a fast storefront is of little use if payment fails at checkout, and secure payment does not help if the produce cannot be delivered while it is still fresh.

Table -2: Technical requirements of a farm-to-consumer e-commerce system

Requirement	Specification	Function
Application server	Hosting, domain, database	Runs storefront and order logic
Payment gateway	Cards, wallets, bank transfer	Processes and secures payments
Shipping channel	Cooperatives, logistics, GPS	Moves produce to the buyer

5.3 Cooperative Vending-Point Model

One source study proposes a variation worth singling out, the "Farmer Gateway". Farmers pool their produce through a cooperative that pays a fixed return no matter how market prices swing from day to day, and that plans supply using sales history and buyer preferences. Instead of home delivery, produce goes to community vending points inside housing societies. This removes a layer of last-mile courier cost and lets residents pick up fresh vegetables close to home. The design also expects patchy rural connectivity: an offline mode lets a farmer keep recording listings and transactions without a signal and sync them later. The model shows that direct farm-to-consumer trade need not mean doorstep delivery. A shared local access point can cut out intermediaries at a lower running cost.

6. COMPARATIVE OVERVIEW OF EXISTING PLATFORMS

Many platforms of different size and philosophy already operate in this space. Table -3 collects the systems discussed across both source studies, together with the limitation most often linked to each.

Table -3: Selected farm-to-consumer platforms and their limitations

Platform	Core approach	Principal limitation
eNAM (India)	National auction linking mandis	Needs local digital readiness [4], [11]
Pinduoduo (China)	Social group-buying from growers	Suits dense urban demand [5], [15]
OpenFarm (S. Korea)	IoT and data-driven yield planning	Needs sensor and data infrastructure [13]
Harvest Port	Farm services and equipment market	Limited coverage, cost barrier
Farmigo	Curated local produce orders	Fixed pickup, limited regions
AgriChain	Harvest-to-buyer traceability	Needs continuous internet
Fresh Shop	Online grocery-retailer orders	Seasonal gaps, weak farmer link
Procurant	Cloud-based whole-chain visibility	No direct farmer-to-buyer link
iTradeNetwork	End-to-end procurement and compliance	Intermediaries still involved

Most of these systems fall into three groups. Large state- or platform-backed systems such as eNAM and Pinduoduo achieve scale and good price discovery, but their success depends on local digital readiness and, in Pinduoduo's case, on dense demand. Smaller purpose-built tools, namely Harvest Port, Farmigo, AgriChain and Fresh Shop, each solve a narrow problem well, yet they tend to be limited by geography or season, or remove intermediaries only in part. Enterprise systems such as Procurant and iTradeNetwork give strong visibility along the whole chain, but they were never built to link an individual farmer with an individual consumer, so intermediaries stay in place further down the line.

7. GLOBAL CASE STUDIES

7.1 eNAM, India

India's Electronic National Agricultural Market, launched in 2016, brings existing regulated wholesale markets (APMC mandis) onto a single online trading platform. Online auctions and standardised quality grading let a farmer reach buyers beyond the nearest mandi, which weakens the fragmentation that once allowed local traders to set prices with little

competition. More than a thousand mandis have been connected so far [4]. Goyal observes that the added price transparency has reduced some of the hold that exploitative middlemen used to have [11], although the benefit to any one farmer still depends heavily on local infrastructure and on how comfortable that farmer is with the platform.

7.2 Pinduoduo, China

Pinduoduo grew through social, group-buying commerce. Consumers form purchasing groups over social media and place bulk orders, which lets the platform negotiate lower unit prices and assure participating farmers of predictable demand. Kumar and Kushwaha cite it as an example of how platform design, integrated logistics and mobile-first access together can close market gaps that an ordinary website would leave open [15]. The approach suits markets with heavy social-media use and short delivery distances, which helps explain why it has been harder to copy in more dispersed rural regions elsewhere.

7.3 OpenFarm, South Korea

OpenFarm combines Internet-of-Things (IoT) sensing of soil moisture, weather and harvest readiness with data analytics, so that farmers can plan production against expected demand. Kim et al. describe how the resulting yield forecasts flow straight into logistics planning and buyer matching, shortening lead times and cutting spoilage for smallholders in a fast-moving market [13]. The price is a heavier technology requirement than a plain marketplace, since sensors and data pipelines add costs that a listing-only site avoids.

8. ADOPTION BARRIERS

8.1 Infrastructure Gaps

Unreliable internet, intermittent electricity and poor roads limit how well any digital marketplace can work in rural areas, and the smallholders a platform is meant to serve feel these gaps most. Closing them usually calls for public investment or a public–private partnership rather than a fix at the platform level alone [19]. Rural connectivity problems have been discussed at length elsewhere [24].

8.2 Trust and Digital Literacy

Many farmers are unfamiliar with online identity checks, worry about payment fraud, or simply feel uneasy trading with someone they cannot see. Each of these lowers the willingness to try a new platform. The usual remedies in the literature are seller-review systems, secure payment gateways, responsive customer support and interfaces designed for different literacy levels [20], along with practical training that helps farmers take up new technology [26].

8.3 Cost, Language and Scalability

Subscription or transaction fees may be too high for small farmers even where connectivity is not a problem [27]. Interfaces offered only in a dominant national language shut out people who are more at ease in a regional tongue. Singh and Maheshwari link this directly to platform loyalty and satisfaction [19], and the role of multilingual interfaces is examined further in [28]. As the user base grows, the infrastructure must scale without slowing down, which favours cloud-based back ends over fixed on-premises servers [29].

8.4 Policy and Regulatory Gaps

Technology alone is not enough, and a supportive regulatory setting matters just as much. Vague rules, the absence of subsidies for going digital, and agricultural laws written before e-commerce existed all limit how far a platform can grow. Across the literature reviewed here, the interventions recommended most often are tax incentives, simpler compliance requirements and targeted digital-literacy programmes.

9. STRATEGIES TO ADDRESS THE BARRIERS

Several remedies appear often enough in both source studies to count as good practice rather than one-off ideas. An offline-capable app lets a farmer keep recording listings and orders when the network drops and sync when the signal returns, which deals with the infrastructure gap instead of assuming it away. Free or low-cost basic tiers, with paid features reserved for higher-volume sellers, keep the platform usable for the smallest farmers while still bringing in revenue from those who can pay [27]. Multilingual, local-language interfaces and support for assistive technology reach users that a single-language design would leave out [28].

Trust is best built through cooperative-run training and community outreach, not a generic help page, because first-time digital users need it before they risk real income on an unfamiliar system [17]. Behind all this, cloud-based and horizontally scalable infrastructure keeps performance steady as adoption grows [29]. Blockchain record-keeping and AI-driven demand forecasting can add transparency and planning accuracy that neither a simple listings site nor a purely manual cooperative could deliver by itself [18], [19]. Because these measures reinforce one another, they work best as a package planned together with cooperatives, technology providers and local authorities, rather than as separate add-ons introduced one at a time.

10. FUTURE RESEARCH DIRECTIONS

Four gaps stand out. First, AI and predictive analytics for demand forecasting and dynamic pricing have been tested on only a few flagship platforms. Second, blockchain traceability has been shown to work in principle but has seldom been evaluated at the scale of a national marketplace [18]. Third, behavioural research on why farmers and rural consumers adopt or reject a given platform is thinner than the technical work on platform design. Fourth, hardly any sustainability studies weigh the environmental footprint of e-commerce logistics against the food waste it prevents, even though that trade-off is central to calling digital agricultural trade a truly sustainable alternative. Cross-regional comparison, which tests the same design choices under different infrastructure and cultural conditions, would help turn the scattered evidence reviewed here into guidance that applies beyond a single country or platform. Longitudinal studies that follow the same farmers for several seasons after they join a platform would be equally valuable, because most evidence so far comes from short pilots and one-off surveys.

11. CONCLUSION

Both studies reach a similar conclusion from different directions. Digital marketplaces can shorten the distance between farmer and consumer, raise the share of the final price that reaches the grower, and give buyers fresher produce at a transparent price, but only when the platform suits the infrastructure, literacy and trust levels of the community using it. Large state-backed systems such as eNAM show what is possible at national scale. Leaner cooperative designs such as the Farmer Gateway show that the same disintermediation can be achieved with a lighter technical footprint, using shared vending points and offline-tolerant apps instead of assuming fast connectivity everywhere. Neither approach alone removes the lasting barriers of rural infrastructure, digital literacy, cost and language. Those will need coordinated effort from

governments, technology providers, cooperatives and financial institutions. With that support, digital farm-to-consumer trade can plausibly become a lasting contributor to rural incomes, affordable food and more resilient supply chains.

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