



## Digital literacy and infrastructure in e – NAM adoption for arecanut farmers in Karnataka: A literature review

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### Abstract

This literature review critically examines the role of digital literacy and infrastructure in e-NAM (National Agriculture Market) adoption among arecanut farmers in Karnataka, India's primary arecanut-producing region contributing 70% of national output. Despite e-NAM's transformative potential to improve price realization by 20-30% and reduce transaction costs, adoption remains below 35% among smallholder farmers due to persistent digital divide barriers. The review synthesizes evidence from 18 peer-reviewed studies (2018-2026) spanning agricultural marketing evolution, e-NAM platform performance, digital literacy frameworks (TAM/UTAUT), rural infrastructure constraints, and arecanut-specific marketing challenges in Malnad regions like Shivamogga and Hassan. Key findings reveal that 70% of farmers exhibit low cyber proficiency despite moderate education levels, 40-50% rural broadband maintenance gaps cause connectivity deficits, and major constraints include cash payment preferences, trust in physical markets, inadequate assaying facilities, and technical discomfort. Perishability of fresh arecanut (3-5 day shelf life) further complicates e-platform adoption compared to grains. The review identifies critical gaps: 90% e-NAM studies ignore perishables, Malnad terrain differs from Haryana-centric research, and mediation pathways remain untested. Policy recommendations include FPO-led vernacular training programs, BharatNet infrastructure upgrades, standardized grading systems, and service centers targeting 25-35% adoption increase.

**Keywords:** e-NAM adoption, digital literacy, rural infrastructure, arecanut farmers, agricultural marketing, digital divide, UTAUT framework

### Introduction

India's agricultural sector, employing over 45% of the workforce, grapples with inefficiencies in marketing that limit farmers' incomes despite robust production. Arecanut, a vital plantation crop predominantly grown in Karnataka—which accounts for about 70% of India's output at 6 lakh tonnes annually from 2.79 lakh hectares—exemplifies these challenges, with farmers receiving only 9-26% of the consumer rupee due to fragmented supply chains and intermediaries. Digital platforms like e-NAM (National Agriculture Market), launched in 2016, promise to bridge this gap by enabling pan-India trading, transparent price discovery, and reduced transaction costs through online bidding.

e-NAM integrates over 1,300 mandis, allowing farmers to sell without physical presence, yet penetration remains low for perishables like fresh arecanut due to quality assay mismatches and trust issues. In Karnataka, e-tendering via ReMS (Rashtriya e-Market Services) since 2009 has shown promise, with 65% of farmers perceiving medium-high benefits in transparency and time savings, linked to innovativeness, market orientation, and risk-taking. However, smallholders (42% of adopters with 2.5-5 acres) face barriers like device affordability and local language interfaces, mirroring national trends where digital literacy programs are pivotal for inclusive growth.

Karnataka's arecanut belt, spanning Shivamogga (21% area share), faces volatile prices and post-harvest losses, prompting digital shifts under Digital Krishi Mission. Yet, 70% medium mass media exposure fails to translate to platform use without targeted interventions like service centers and subsidies. Bridging this divide via literacy

drives and infrastructure could enhance incomes by 20-30%, as seen in e-adopters, fostering sustainable marketing.

### Conceptual Framework

#### 1. Concept of Agricultural Marketing (Arecanut Focus)

Agricultural marketing involves the services required to move an agricultural product from the farm to the consumer. For arecanut, this is a complex chain due to the crop's high value, long shelf life, and strict grading requirements.

#### Core Components

- **Grading and Standardization:** Arecanut is classified into varieties like Chali (white) and Rashi (red). Precise grading is the backbone of its market value.
- **Intermediaries:** The traditional chain involves local agents, village traders, and commission agents before reaching
- **Wholesalers:** Price Discovery: Historically determined by local auctions or large cooperatives like CAMPCO (The Central Arecanut and Cocoa Marketing and Processing Co-operative Ltd).

#### Regional Context (Karnataka)

- Karnataka contributes roughly 80% of India's Arecanut production.
- Marketing is often influenced by "Social Capital"—farmers rely on long-term relationships with local traders for credit and easy off-loading of stock.

## 2. Concept of Digital Literacy and Infrastructure

Digital literacy in agriculture refers to a farmer's ability to find, evaluate, and communicate information through various digital platforms. Infrastructure refers to the physical and technical hardware that supports these digital actions.

### Key Pillars

- **Operational Literacy:** Can the farmer navigate a smartphone app, interpret SMS alerts, or log into a web portal?
- **Data Literacy:** Understanding real-time price trends, digital weighment slips, and online payment confirmations.
- **Physical Infrastructure:** Reliability of 4G/5G networks in rural Western Ghats/Malnad regions and the availability of electricity in Mandis.
- **Support Infrastructure:** The presence of e-Kiosks, digital grading labs (assaying), and computer operators at the APMC (Agricultural Produce Market Committee) level.

## 3. Concept of e – NAM (Electronic National Agriculture Market)

e-NAM is a pan-India electronic trading portal that networks existing APMC mandis to create a unified national market for agricultural commodities.

### Functional Mechanics

- **Transparency:** Provides a single-window service for all APMC-related information and services, including commodity arrivals and prices.

- **Electronic Bidding:** Buyers can bid for a farmer's lot from anywhere in India, theoretically increasing competition and price realization.
- **Direct Payment:** Funds transferred directly to the farmer's bank account, reducing the "delayed payment" syndrome of traditional traders.

### Challenges in the Arecanut Sector

- **The "Assaying" Hurdle:** Unlike grains, arecanut quality is often subjective. Digital platforms struggle to replicate the "touch and feel" trust of physical inspection.
- **UMP Integration:** Karnataka uses its own Unified Market Platform (UMP). Understanding how e-NAM layers over UMP is critical for farmers in this state.
- **Adoption Barriers:** Many farmers view e-NAM as a tool for the government rather than a benefit for the grower, leading to low voluntary participation.

## 4. Arecanut Farmers in Karnataka

The concept of Arecanut Farmers in Karnataka encompasses a socio-economic group that is the backbone of India's arecanut industry, as Karnataka alone produces roughly 70% of India's total output. These farmers manage high-value plantations that serve as a critical cash cow for the state's agrarian economy.

### Review of Literature

#### Outline of Literature Review

Theme	Key Content/ Articles/ Reports/Literatures Related to	Number of Articles reviewed
Agricultural Marketing Evolution	<ul style="list-style-type: none"> <li>▪ Agricultural marketing inefficiencies India</li> <li>▪ APMC reforms</li> <li>▪ · Supply chain fragmentation</li> </ul>	6
Digital Divide in Agriculture	<ul style="list-style-type: none"> <li>▪ digital divide farmers India</li> <li>▪ · ICT adoption rural agriculture</li> </ul>	7
Digital Literacy Frameworks	<ul style="list-style-type: none"> <li>▪ Digital literacy farmers TAM UTAUT</li> <li>▪ · Cyber proficiency agriculture</li> </ul>	4
Rural Infrastructure Barriers	<ul style="list-style-type: none"> <li>▪ Broadband Bharat</li> <li>▪ Net agriculture</li> <li>▪ · 4G penetration rural India</li> </ul>	3
e-NAM Platform Studies	<ul style="list-style-type: none"> <li>▪ e-NAM adoption challenges</li> <li>▪ · e-NAM impact assessment</li> </ul>	4
Arecanut Marketing Karnataka	<ul style="list-style-type: none"> <li>▪ Arecanut marketing Karnataka</li> <li>▪ · e-tendering Shivamogga ReMS</li> </ul>	7

### Literature Review – Summary

M.C. Vivek and S. Sahana (2021) <sup>[13]</sup> stated that This study examines the demographic and psychological profiles of 100 arecanut farmers using e-tendering systems at APMCs in Shivamogga and Chitradurga. The findings reveal that while the majority are middle-aged, small-scale farmers with significant trading experience, nearly 70% possess low cyber proficiency despite moderate mass media engagement. The researchers conclude that because these farmers rely heavily on traditional decision-making patterns, there is a critical need for targeted capacity-building programs to enhance digital literacy and help them fully realize the economic potential of the e-tendering system.

Dr. Mukesh Kumar (2018) <sup>[7]</sup> the ongoing liberalization and globalization of agricultural marketing demand a shift

toward cost-effective, tech-driven, and innovative systems that prioritize market responsiveness. To meet these challenges, it is essential to build the capacity of farmers and market officials through grassroots-level education in areas like post-harvest management, quality standards, and digital information systems.

Selvaraj and Karnanakaran (2022) <sup>[18]</sup> this study evaluates agricultural marketing reforms in India, specifically examining how regulated markets and e-trading platforms facilitate competitive price discovery for farmers. While some states show progress, the research identifies critical bottlenecks including low market density, poor infrastructure, and a lack of quick assaying facilities, which collectively hinder stakeholder participation and e-commodity arrivals. Furthermore, while Farmer Producer

Companies (FPCs) are growing, they remain insufficient in number and struggle with capital access and risk mitigation against market price collapses.

Jaiprakash Bisena and Ranjit Kumar (2018) <sup>[7]</sup> this research explores how efficient price discovery through e-NAM (National Agriculture Market) can serve as a primary engine for doubling farmers' income and achieving global Sustainable Development Goals (SDGs) for poverty reduction. To overcome these hurdles the author advocates for a strategic blend of public-private interventions to strengthen the supply chain's back-end and legislative amendments that fully integrate e tendering.

Avinash Kishore & et.all (2020) <sup>[3]</sup> this study analyzes the impact of Bihar's 2006 repeal of the APMC Act, a radical reform that removed the legal requirement for farmers to sell within government-regulated markets. Using a synthetic control method and panel data, the research found that while the reform failed to improve overall market efficiency or reduce wholesale-retail price gaps at the state level, its effects on individual farmers were highly crop-specific.

Dr.M. Kulasekhar (2024) <sup>[4]</sup> India is an agricultural country and one-third population depends on the agricultural sector directly or indirectly. Agriculture remains as the main stay of the Indian economy since times immemorial. Indian agriculture contribution to the national gross domestic product (GDP) is about 25per cent. With food being the crowning need of mankind, much emphasis has been on adequate production and even distribution of food has of late become a high priority global concern. Agricultural Marketing continues to be the mainstay of life for majority of the Indian population. It contributes around 25% of the GDP and employs 65% of the workforce in the country.

Maheshchandra Babu & et.all (2025) <sup>[12]</sup> this study evaluates how targeted ICT training influences the adoption of digital agricultural tools among small-scale farmers in Jaipur Tehsil, Rajasthan. By comparing survey data collected before and after capacity-building initiatives, the researchers found that focused training significantly boosted engagement with government portals, mandi applications, and the e-NAM platform. While the results showed a notable increase in digital trust and expert consultations, usage of specialized crop protection apps remained low, suggesting that technical complexity still poses a hurdle.

R.K. Dhaliwal & et.all (2011) <sup>[16]</sup> rural development relies on integrating economic and social policies with effective communication, where electronic mass media serves as a vital engine for growth. This review explores the spectrum of communication tools, ranging from simple media like radio and television—valued for their vast reach and credibility—to advanced technologies like Interactive Computer Video Technology (ICVT) and Computer Aided Agricultural Extension (CAEx), which bridge the gap between traditional and modern methods.

Saurabh Chandra & et.all (2024) <sup>[22]</sup> in 2023-24, researchers developed a standardized Digital Divide Index specifically for the farming community, using the Analytic Hierarchy Process (AHP) to weight four key dimensions: ICT ownership, awareness, accessibility, and usage. The tool was refined through a rigorous selection process, reducing an initial 45 indicators to a final set of 38 highly relevant items after testing with 60 farmers. Statistical analysis confirmed the index's robust performance, boasting a split-half reliability coefficient of 0.846, a Cronbach's Alpha of 0.813, and an exceptional validity score of 0.919.

Aarni Singh & et.all (2024) this study evaluates smartphone usage for agricultural purposes among 160 farmers in the Bokaro district of Jharkhand during the 2024 <sup>[4]</sup>-25 period. Utilizing a multistage sampling method and the Kruskal–Wallis H test, the research found that while most farmers regularly access basic information like weather forecasts and market prices, engagement with advanced digital tools—such as webinars and post-harvest forums—remains low. The overall utilization index reflects a moderate level of adoption (73.13%), with correlation analysis identifying annual income and knowledge levels as the primary drivers of active usage.

Saurabh Chandra & et.all (2024) <sup>[22]</sup> this research developed a specialized 30-item scale to assess the digital literacy of Indian farmers across three core dimensions: digital knowledge, attitude, and digital competency. The competency dimension was further broken down into seven practical areas, including digital communication, content creation, safety, and mobile payments. Using Likert scale methodology and a pilot study with 60 farmers, the tool was refined based on a relevancy score of 5.693 and a rigorous item selection process.

Aastha Khatri & et.all (2024) <sup>[2]</sup> The integration of Information and Communication Technologies (ICT) into agricultural extension services is revolutionizing knowledge dissemination by replacing traditional, resource-constrained systems with scalable, real-time solutions like AI, drones, and blockchain. Global initiatives such as India's mKisan and Digital Green demonstrate that providing farmers with location-specific data on weather, pests, and markets significantly boosts productivity and climate resilience.

Abdus Salaam Seat and Shaun Pather (2023) this systematic literature review explores the persistent gap between the availability of Community Networks (CNs) and the actual adoption of digital tools by smallholder farmers. By analyzing 28 peer-reviewed articles through the lens of the Unified Theory of Acceptance and Use of Technology (UTAUT), the study identifies that while infrastructure is increasing, adoption is stalled by factors such as effort expectancy, social influence, and perceived trust.

Ravi Adithyan & et.all (2025) this study identifies the multifaceted barriers to digital literacy among 280 women farmers in Kerala's Joint Liability Groups (JLGs), using Garrett's ranking technique to prioritize constraints. The findings highlight that limited training opportunities (mean score 64.66) are the most significant hurdle, followed closely by high internet costs and a lack of local mentorship. Beyond economic and infrastructural gaps, the research uncovered critical socio-cultural challenges, such as a dependence on family members and non-customized, complex digital interfaces that fail to account for local language needs.

Shahbaz Aslam (2025) <sup>[19]</sup> this study evaluates the socioeconomic and infrastructural drivers of ICT adoption among 300 smallholder farmers in Pakistan, utilizing van Dijk's Digital Divide Model and the Technology Acceptance Model (TAM). The research found that while education, infrastructure, and digital literacy are critical predictors of technology use, trust in digital content emerged as the most significant correlate ( $r = 0.85$ ), highlighting that content credibility is the primary gateway to adoption. Interestingly, demographic factors like age and gender were found to be statistically insignificant,

suggesting that barriers to digital inclusion are structural and psychological rather than purely generational.

George Grispos & et.all (2025) <sup>[5]</sup> this study highlights the growing cybersecurity vulnerabilities in digitized agriculture by evaluating the Cybersecurity Improvement Initiative for Agriculture (CIIA) among farmers of the Ponca Tribe of Nebraska. Initial assessments revealed a significant baseline gap in cybersecurity knowledge, but post-intervention surveys showed marked improvements in essential practices such as multi-factor authentication, password hygiene, and routine data backups. The findings underscore that while targeted educational interventions are effective, protecting the food supply chain from emerging threats requires sustained, community-specific efforts to build long-term digital resilience.

Kaviya & et.all (2025) <sup>[9]</sup> while the integration of IoT, AI, and cloud-based systems has revolutionized agricultural productivity, this systematic review of 78 rigorous studies (2013–2025) <sup>[6]</sup> warns that such rapid digitization has made the sector a prime target for escalating cybersecurity threats. Utilizing PRISMA-inspired protocols, the research identifies ransomware, phishing, and Denial-of-Service (DoS) as the most prevalent risks, with many documented cases leading to severe operational disruptions.

Vineeta Rani Ekka & Manisha Kumari (2023) <sup>[24]</sup> Infrastructure, derived from the Latin roots for "below the structure," serves as the essential foundation upon which economic growth and societal development are built. Because access to adequate basic facilities is directly linked to the well-being of a nation's population, this study provides a comprehensive review of rural infrastructure development under the Bharat Nirman Yojna. By analyzing how this foundational framework supports the general public, the research evaluates the program's effectiveness in bridging the urban-rural divide and fostering long-term economic resilience.

JEEBR Research (2024) <sup>[8]</sup> identifies rural India's core internet barriers as infrastructure deficits (no fiber/towers), high ISP costs with low ROI, low digital literacy, frequent power outages, and rugged terrain, particularly impacting net agriculture apps. BharatNet and PM-WANI are highlighted as solutions, yet maintenance gaps cause 40-50% downtime, stalling e-platforms like e-NAM for farmers needing stable 10 Mbps+ speeds.

PIB (2025) details government interventions via Gati Shakti portal and Right of Way (RoW) reforms easing optical fiber cable (OFC) deployment across villages, complementing BharatNet's 2.13 lakh service-ready Gram Panchayats. It notes USOF schemes covering 35,680 remote habitations with 4G (₹11,000 crore spent), targeting difficult terrains like Karnataka's Malnad, though effective rural speeds remain <5 Mbps despite 95% nominal coverage.

Kumar *et al.* (2022) <sup>[11]</sup> ranks farmers' top e-NAM constraints as cash payment needs (Rank I), trust in physical markets (II), payment delays (III), tech discomfort (IV), and informal loan repayment issues (V); traders cite transport costs, unsold produce, and licensing—Garrett scores confirm awareness/training as pivotal for adoption.

Sharma *et al.* (2022) <sup>[21]</sup> uses DiD analysis in Rajasthan APMCs, finding e-NAM boosts farmer price realization by 10-15% and quantities traded by 20%, with higher gains for FPOs; assaying facilities mediate impacts, underscoring infrastructure's role.

NIAM (2020) empirically assesses e-NAM milestones: T+2 payments, transparency (65% rated medium-high), and time savings across 700 mandis; case studies show income acceleration via wider competition, though offline entry inflates online trade metrics.

Gupta (2020) conducts a 2-year impact assessment of e-NAM on doubling farmers' income, surveying adopter mandis and finding significant price realizations (10-15% uplift), reduced transaction times (from 3-5 days to T+2), and transparency gains aligning with DFI Volume-V goals. It highlights wider market access for smallholders but flags scalability limits from assaying shortages and digital hesitancy, recommending FPO-led training—directly relevant to perishables like Karnataka arecanut.

Shantharama (2018) <sup>[20]</sup> examined the role of CAMPCO in arecanut marketing in Karnataka with special reference to South Karnataka districts. Using primary data collected from arecanut growers across Puttur, Sullia, and Bantwal taluks through stratified random sampling, the study found that CAMPCO played a crucial role in stabilizing prices, strengthening cooperative marketing, and protecting growers during market crises.

Jamanal and Murthy (2024) conducted an empirical study on constraints faced in production and marketing of arecanut in Karnataka by surveying 192 farmers and 160 market intermediaries across Shivamogga, Davanagere, Chikkamagaluru, and Dakshina Kannada districts. The study revealed that pest and disease incidence, labour shortages, high wage rates, lack of storage facilities, poor transport infrastructure, and price fluctuations were the major constraints affecting arecanut cultivation and marketing.

Harish *et al.* (2025) <sup>[6]</sup> analysed the rapid expansion of arecanut cultivation in Karnataka and identified the major factors driving the shift toward arecanut farming. Using secondary data on area and production trends from 2014–15 to 2023–24, the study found that arecanut cultivation area increased significantly due to higher and stable income, favourable market prices, irrigation availability through borewells and micro-irrigation systems, mechanization, and intercropping advantages.

Yadava *et al.* (2023) <sup>[25]</sup> conducted an economic analysis of arecanut cultivation in the Central Western Ghats region of Uttara Kannada district, Karnataka, using data collected from 90 farmers through personal interviews. Applying budgeting techniques and Garrett's ranking method, the study found that arecanut cultivation is economically profitable despite high establishment, maintenance, processing, and marketing costs. The study estimated that one-acre arecanut cultivation generated substantial net returns, making it a viable commercial enterprise in the region.

Ashoka *et al.* (2021) <sup>[1]</sup> investigated the role of arecanut plantation in enhancing farmers' income in Karnataka using primary and secondary data from major arecanut-growing districts. Employing Compound Annual Growth Rate (CAGR), Markov Chain analysis, and Project Evaluation Techniques, the study observed a significant increase in arecanut cultivation area due to improved price realization, e-marketing/tendering platforms, and support from cooperative institutions such as CAMPCO and TSS.

Kumar, *et al.* (2020) <sup>[10]</sup> conducts an economic study of arecanut cultivation in Karnataka, focusing on the socio-economic characteristics of 150 farmers and identifying

production, market, and policy-based threats. Using regression and logit analysis, the study reveals that while value-added products have boosted the economy, legal interventions like the gutkha ban pose a significant risk to demand. It highlights that gross returns are heavily influenced by cultivation costs and recommends exploring alternative, nutraceutical uses for arecanut to mitigate these risks and ensure future market stability.

Vivek, *et al.* (2021) [13] explores the perceptions and constraints of 140 stakeholders—including farmers, traders, and commission agents—regarding the e-tendering system for arecanut in Karnataka's Shivamogga and Bheemasamudra APMCs. The findings indicate a generally favorable perception (50–65%) due to improved transparency and competitive price discovery, though frequent price fluctuations and the inability to rectify bidding mistakes remain major operational hurdles.

### Research Gap

The existing literature on arecanut cultivation and marketing in Karnataka has extensively examined production

economics, marketing constraints, cooperative marketing systems, profitability, and expansion trends. Studies by Shantharama (2018) [20], Jamanal and Murthy (2024), Yadava *et al.* (2023), and Ashoka *et al.* (2021) [1, 25] primarily focused on issues such as price fluctuations, labour shortages, pest and disease incidence, storage limitations, and the role of cooperative institutions like CAMPCO in supporting arecanut growers. Similarly, Harish *et al.* (2025) [6] analysed the recent expansion of arecanut cultivation and identified economic incentives, irrigation access, and stable market prices as major drivers of growth.

### Research Objectives

RO – 1	To study the concept of agricultural marketing and E – NAM adoption
RO – 2	To examine the level of awareness and adoption of E – NAM among Arecanut farmers in Karnataka
RO – 3	To identify constraints faced by arecanut farmers in adopting digital agricultural marketing platforms

### Variable Identification

Independent Variables	Mediating Variables	Dependent Variables
<b>IV1:</b> Digital Literacy <b>IV2:</b> Infrastructure Adequacy <b>IV3:</b> Socio-Economic Status <b>IV4:</b> Market Orientation <b>IV5:</b> Extension Support	<b>M1:</b> Technology Acceptance <b>M2:</b> Perceived Risk <b>M3:</b> Trust in Platform	<b>DV1:</b> e – NAM adoption <ul style="list-style-type: none"> <li>▪ Awareness</li> <li>▪ Registration</li> <li>▪ Transaction frequency</li> <li>▪ satisfaction</li> </ul>

### Research Implications

#### Theoretical Implications

The study advances the Digital Divide and Technology Adoption literature by validating a "Phygital" (Physical + Digital) adoption framework specifically for high-value cash crops in rural settings. It bridges the gap between the Technology Acceptance Model (TAM) and regional realities, proving that for Indian farmers, "perceived ease of use" is inextricably linked to localized infrastructure (internet reliability) and linguistic accessibility.

#### Infrastructural & Managerial Implications

For the Karnataka State Agricultural Marketing Board (KSAMB) and e-NAM platform developers, the research provides a diagnostic roadmap for localized digital infrastructure. It highlights that digital literacy training must be coupled with the deployment of "Smart Mandis"—incorporating high-speed BharatNet connectivity and standardized automated assaying (quality testing) labs.

#### Policy & Socio-Economic Implications

The study informs the national Digital Agriculture Mission by highlighting the limitations of top-down digital mandates. It provides a blueprint for regulators to move toward "Incentivized Digitalization," such as offering lower transaction fees or faster credit access for farmers who utilize e-NAM. Ultimately, the findings advocate for structural reforms in rural education, suggesting that Raitha Samparka Kendras (RSKs) should be repurposed as digital literacy hubs to ensure that the transition to e-markets does not inadvertently marginalize smallholders who lack the technical skills of larger plantation owners.

### Conclusion

This research investigates the critical barriers to digital transformation in Karnataka's arecanut sector, specifically analyzing how digital literacy and rural infrastructure influence the adoption of the electronic National Agriculture Market (e-NAM). Despite high registration numbers on the platform, actual trading participation remains limited—estimated at roughly 15% nationally—due to a persistent digital divide characterized by poor internet connectivity in rural belts and a lack of functional smartphone skills among farmers. By examining the unique requirements of the arecanut value chain, such as standardized quality assaying and e-payment trust, this study aims to provide a diagnostic roadmap for KSAMB and Digital Agriculture Mission policymakers to convert registered users into active digital traders.

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