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Determinants, Knowledge and Constraints of Electronic National Agriculture Market (eNAM) Adoption in Tamil Nadu

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HIGHLIGHTS

- Education, social participation and digital literacy significantly influence farmers' participation in e-NAM.
- Knowledge levels are higher among e-NAM farmers and traders than non-e-NAM farmers.
- Phase-wise analysis shows higher knowledge in the payment and e-bidding stages of e-NAM.
- Financial, behavioural and infrastructural constraints limit e-NAM adoption among the stakeholders.

ARTICLE INFO

Keywords: Digital literacy, e-NAM, Logistic regression, Competition, Participation, Market infrastructure.

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ABSTRACT

The study aimed to analyse the factors influencing stakeholders' participation in the Electronic National Agriculture Market (e-NAM) using primary data collected from 390 respondents, comprising 150 e-NAM farmers, 150 non-e-NAM farmers, and 90 traders in Tiruvannamalai district of Tamil Nadu in 2025. A logistic regression model was used to identify the determinants of participation, while Garrett's ranking method was used to highlight the major constraints. The results revealed that social participation, education level, digital literacy and distance to markets are significant determinants of participation, whereas landholding, age, experience and income were found to be non-significant. Knowledge levels were higher among e-NAM farmers and traders compared to non-e-NAM farmers. Garrett's ranking technique revealed that immediate cash requirement, low digital literacy, technical difficulties, and poor market infrastructure were the major constraints of farmers, whereas traders highlighted competition among traders and non-uniform mandi policies as key challenges. The results suggest that awareness programmes, improved market infrastructure, standardised mandi practices and timely payments are essential to enhance e-NAM participation.

INTRODUCTION

Agriculture continues to play an important role in the Indian economy. It makes up 18% of GDP and employs about 45% of the workforce (Gupta et al., 2025). The traditional agricultural marketing system faces several inefficiencies, which create significant challenges. Farmers' price realization is greatly affected by issues like information asymmetry, fragmented markets, trader collusion, improper weighing practices, delayed payments and inadequate infrastructure (Swain et al., 2022; Patil et al., 2024). These structural inefficiencies not only reduce market function effectively, but also make it harder for farmers to make marketing decisions. Weak market linkages and inadequate institutional arrangements, such as the absence of farmer producer organisations (FPOs), limited cooperative support, poor credit access and insufficient extension services make farmers' income less stable and make them more vulnerable (Chand, 2016; Mohanraj et al., 2024). Small and marginal farmers are the most affected, because they often

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have to sell their crops right after harvest to pay off debts, which leads to distress sales and exposure to seasonal price changes.

Government of India launched the Electronic National Agriculture Market on 14 April 2016 as a nationwide online trading portal integrating Agricultural Produce Market Committees (APMCs). The platform is managed by the Small Farmers Agribusiness Consortium under the Ministry of Agriculture and Farmers Welfare to improve price transparency, reduce the role of intermediaries, and create a unified national agriculture market. As of June 2025, 1,522 mandis across 23 states and 4 Union Territories had been integrated into e-NAM, covering 247 commodities and registering approximately 1.83 crore stakeholders, of which farmers account for nearly 97.85% (e-NAM, 2025). Tamil Nadu stands out in terms of implementation with 213 integrated mandis and about 4.86 lakh registered stakeholders. However, the adoption and effective utilisation of e-NAM remain uneven across stakeholders. Previous studies have predominantly concentrated on farmers' awareness and perception, with limited attention on multi-stakeholder operational knowledge throughout transaction stages. Existing studies indicate that insufficient awareness and inadequate digital literacy are barriers to farmers' participation (Singh et al., 2021; Kumar et al., 2024). Weak market infrastructure and a lack of institutional support affect the platform's efficiency, especially for traders and intermediaries (Gautam et al., 2022).

Previous research has not adequately linked socio-economic characteristics with participation behaviour, nor have they examined functional knowledge across various phases of e-NAM transactions and compared users and non-users of e-NAM. This creates a critical gap in understanding the behavioural, informational and infrastructural constraints affecting adoption. It is hypothesised that socio-economic factors significantly influence farmers' participation, knowledge levels and adoption of e-NAM. To address these gaps, the present study aims to analyse the socio-economic determinants influencing farmers' participation in e-NAM, examine phase-wise functional knowledge among e-NAM farmers, non-e-NAM farmers and traders and assess the major constraints hindering adoption of the platform. The success of any policy initiative depends on the adoption behaviour and perception of its stakeholders (Badodiya et al., 2010). The findings of this study are expected to provide policy insights for improving the efficiency and inclusiveness of digital agricultural markets in India.

METHODOLOGY

The present study was conducted purposively in Tiruvannamalai District of Tamil Nadu due to its substantial agricultural arrivals and active participation in digital agricultural marketing through the e-NAM platform. The district comprises seven Agricultural Produce Market Committees (APMCs), of which Cheyyar and Chetpet mandis were selected based on their higher volume of online transactions and active stakeholder participation. The sampling frame was constructed using official records obtained from APMCs comprising 76 villages integrated into the market. The total population consisted of 1,200 farmers and 90 traders. The sample size was determined using Slovin's formula (Kabo-Bah & Bannor 2025).

$$N = \frac{N}{(1+N(e^2))}$$

Where, n = sample size, N = total population e = margin of error

For 5% margin of error, the required sample size was 300 farmers and 73 traders. A total of 390 respondents were selected to capture diverse stakeholder perspectives, including 150 e-NAM farmers, 150 non-e-NAM farmers and 90 traders. An explanatory research design was adopted to estimate the factors influencing the participation and adoption behaviour of respondents in e-NAM. Explanatory research designs were particularly useful in examining emerging phenomena such as digital agricultural platforms, where structured empirical evidence was evolving (Stebbins, 2001).

Primary data were collected during September and October, 2025 using a structured and pre-tested questionnaire. The 30-item knowledge assessment tool was validated by a panel of five subject-matter specialists for content validity and subsequently pre-tested with 20 farmers to ensure reliability and clarity of the instrument. The questionnaire covered socio-economic characteristics, functional knowledge across the e-NAM phases and challenges faced by stakeholders. Secondary data were collected from official reports, e-NAM database and APMCs records. Respondents were informed about the purpose of the study prior to data collection.

The binary logistic regression model was employed to estimate the determinants influencing participation in e-NAM, where the dependent variable was dichotomous and examined the probability of participation as influenced by independent variables (Raghavendra et al., 2023; Gautam et al., 2022). The logistic function was expressed as

$$\text{Logit}(P) = \ln\left(\frac{p}{(1-p)}\right) = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3\ldots\ldots\beta_nX_n$$

Where, β_0 = Intercept or constant term, β_1 to β_n = Coefficients representing the effect of independent variables on the likelihood of participation in e-NAM, $\left(\frac{p}{(1-p)}\right)$ = Odds ratio

The selection of explanatory variables was based on a comprehensive review of literature on agricultural technology adoption and e-NAM studies (Raju et al., 2022; Praneeth et al., 2023; Patil et al., 2024; Kumar et al., 2024). Distance to the market was included as an important factor, as earlier studies have shown it to be a key determinant of participation in e-NAM (Raghavendra et al., 2023). Additionally, a pilot survey was conducted among farmers in the study area, during which farmers themselves identified age, education, landholding size, farming experience, annual income, social participation, distance to market and digital literacy as the major factors influencing their participation in e-NAM. The variables were thus validated both empirically through literature and practically through direct farmer responses, ensuring contextual relevance and farmer-justified selection of determinants. Model fit was assessed using log-likelihood, Bayesian Information Criterion, Akaike Information Criterion and pseudo R^2 values.

Garrett's ranking analysis was used to rank the constraints faced by respondents in the adoption of e-NAM platform (Kumar et al., 2024). Each respondent was asked to rank the problems, and the per cent position was calculated as:

$$\text{Per cent Position} = \frac{100(R_{ij-0.5})}{N_j}$$

Where, R_{ij} = rank assigned by the j^{th} respondent for the i^{th} constraint, N_j = total number of constraints ranked by the j^{th} respondent.

RESULTS

The socio-economic characteristics of the farmers indicate that farmers were predominantly middle-aged with considerable farming experience. The average landholding size was 3.57 acres, reflecting the dominance of small and marginal farmers in the study area. The respondents exhibited moderate levels of education and digital literacy, which influence their participation in digital agricultural marketing platforms. The findings indicate relatively low social participation among the respondents.

Factors influencing farmers' participation in e-NAM

The results of the binary logistic regression model (Table 1) revealed that education, social participation and digital literacy had a significant positive influence on participation in e-NAM ($p<0.05$), while distance to markets showed a significant negative effect ($p<0.001$). Age, landholding size, farming experience and annual income were found to be non-significant.

The model fit statistics (Table 2) confirmed that the model had good explanatory power, with McFadden Pseudo R^2 of 0.408 and Nagelkerke R^2 of 0.560, suggesting a satisfactory model fit.

Knowledge levels of respondents

The knowledge level of respondents (Table 3) on e-NAM was assessed using a structured set of 30 questions regarding the functioning of e-NAM. Each response was assigned a score of one, resulting in a maximum obtainable score of 30. The classification of respondents based on their knowledge levels was done using mean (14.41) and standard deviation (7.92). Although the standard deviation was relatively large, reflecting the heterogeneous knowledge levels across diverse stakeholder groups, the mean ± standard deviation classification method was retained as it is widely adopted in agricultural knowledge assessment studies (Raju et al., 2022; Praneeth et al., 2023). The findings indicated that knowledge levels varied considerably across different stakeholder groups. Among e-NAM farmers, a majority (52.66 per cent) possessed medium knowledge, while 42 per cent showed high knowledge levels. Traders showed relatively higher knowledge with 63.33 per cent in the medium category and 22.33 per cent had high levels of knowledge. Non-e-NAM farmers showed lower knowledge levels, with 62 per cent falling under low knowledge category.

Table 1. Logistic regression estimates for farmers' participation in e-NAM

Variables	Coefficient (β)	Odds Ratio	p-value
Age (X_1)	0.08	1.08	0.256^{ns}
Education(X_2)	1.26	3.51	0.029*
Landholding size (X_3)	0.55	1.72	0.410^{ns}
Farming experience (X_4)	0.05	1.05	0.282^{ns}
Annual Income (X_5)	0.02	0.99	0.615^{ns}
Social Participation (X_6)	2.23	9.25	0.015**
Distance (X_7)	-0.31	0.73	0.008**
Digital Literacy (X_8)	2.98	19.61	0.014**

ns = non-significant, * = 5% significance, ** = 1% significance

Table 3. Knowledge classification of respondents on e-NAM (%)

Knowledge Level	e-NAM farmers	Non-e-NAM farmers	Traders
Low (≤6.49)	5.33	62.00	13.33
Medium (6.49-22.23)	52.66	34.00	63.33
High (≥22.23)	42.00	4.00	23.33

Mean = 14.41; Standard Deviation = 7.92

Phase-wise functional knowledge of e-NAM

The phase-wise functional knowledge of respondents (Table 4) indicated that e-NAM farmers and traders exhibited moderate to high levels of knowledge across different phases of the e-NAM process, whereas non-e-NAM farmers showed comparatively lower levels of knowledge. For non-e-NAM farmers, the phase-wise knowledge assessment was based on their awareness and understanding of e-NAM procedures rather than actual participation in the platform. Among the various phases, the highest knowledge levels were observed in the payment phase, with 70 per cent among e-NAM farmers and 73.33 per cent among traders. This was followed by the e-bidding phase, where knowledge levels were 68.33 per cent among e-NAM farmers and 73.33 per cent among traders. Moderate knowledge levels were observed in the gate entry, sale agreement and gate exit phases for both e-NAM farmers and traders. Non-e-NAM farmers exhibited consistently lower knowledge levels across all phases, ranging from 23.33 per cent to 31.66 per cent. The lowest knowledge levels were observed in the sale agreement phase, followed by the assaying phase.

Table 4. Phase-wise knowledge of respondents in e-NAM (%)

Phases	e-NAM farmers	Non-e-NAM farmers	Traders
Gate Entry	54.66	26.00	49.33
Assaying	48.00	24.66	46.66
e-Bidding/Auction	68.33	30.00	73.33
Sale Agreement	54.44	23.33	58.88
Payment	70.00	31.66	73.33
Gate Exit	58.66	26.66	60.66

Values represented mean percentage knowledge scores across activities

Table 2. Model fit comparison

Model	Log-Likelihood	AIC	BIC	McFadden Pseudo R^2	NagelkerkeR^2
Model (intercepts only)	-37.45	-	-	-	-
Model (with predictors)	-22.16	68.32	93.45	0.408	0.560

Constraints faced by farmers and traders in e-NAM

The constraints faced by farmers and traders in e-NAM are presented in Figure 1 and 2. The results highlighted that financial, behavioural, technical and infrastructural factors influenced stakeholders' participation in e-NAM. The major constraint for the farmers was the need for immediate cash payments, followed by a strong preference for face-to-face selling and distrust in online transactions. Difficulties in repaying informal loans through digital platforms and issues related to e-NAM were identified as the major constraints. Infrastructural constraints such as inadequate grading facilities and lack of storage were relatively less identified challenges, while market-related constraints such as price reduction due to digital grading of the produce and longer auction duration were ranked lower.

For traders, higher competition from traders outside the region was identified as the major constraint, followed by non-uniform policies across mandis and limited infrastructural facilities, such as inadequate computers and a lack of technical staff. Technical issues, including system slowdown and difficulties in digital payment processes, were also reported. Difficulty in assessing quality without physical inspection was observed as an important constraint.

DISCUSSION

Education enhances the understanding of market dynamics and utilisation of digital platforms, while social participation facilitates information exchange and the collective decision-making process (Panda et al., 2019; Yadav et al., 2023). These findings support the diffusion of innovations theory, which emphasises the importance of communication channels and social systems in the technology adoption process. Digital literacy appears to be the most important factor, suggesting that familiarity with digital tools and platforms is essential for effective participation in e-NAM. Farmers with higher exposure to mobile applications, internet services and social media are equipped to access market information and complete online transactions. These findings are consistent with earlier studies, which reported that digital awareness significantly enhances the adoption of e-NAM (Klerkx & Rose, 2020; Raju et al., 2022; Niranjan et al., 2023; Praneeth et al., 2023; Patil et al., 2024; Godara et al., 2024; Kumar et al., 2024).

The negative influence of distance to market indicates that physical accessibility continues to affect participation in digital platforms. Farmers located farther from markets face higher transaction and information costs, which reduce their participation

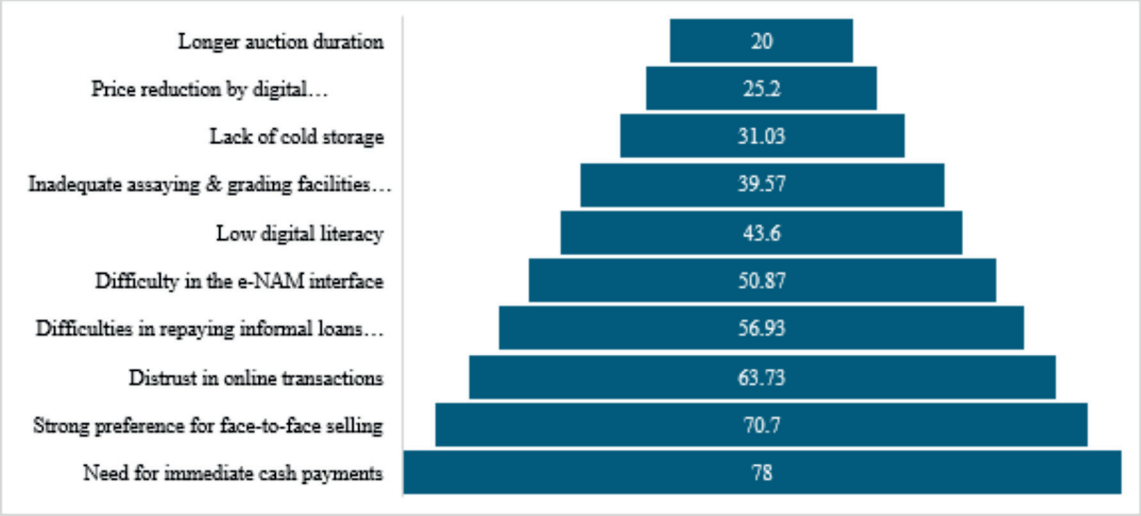

Figure 1. Constraints faced by farmers in e-NAM

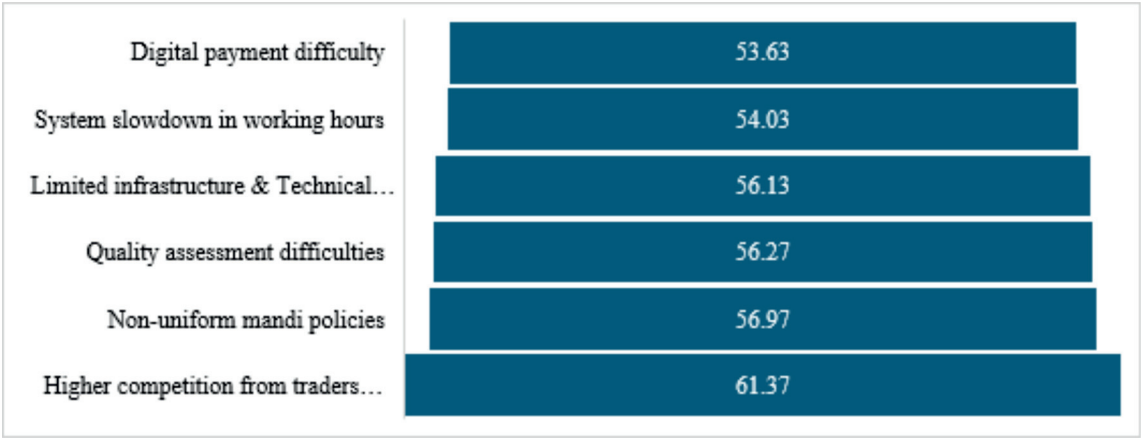

Figure 2. Constraints faced by traders in e-NAM

in digital platforms. This observation aligns with transaction cost theory and previous studies which explain that increased costs discourage participation in market activities (Fafchamps & Minten, 2012; Raghavendra et al., 2023).

The phase-wise knowledge of the e-NAM platform improves operational understanding across different transaction stages. Higher knowledge levels among e-NAM farmers and traders suggest that frequent interaction with the platform enhances familiarity with processes such as bidding and payment. Non-e-NAM farmers exhibit lower knowledge levels, indicating limited exposure and awareness. The comparatively higher knowledge in payment and e-bidding phases reflects the importance of these stages in actual transactions, while lower knowledge in assaying and gate exit procedures highlights gaps in technical understanding of the digital platforms. These findings are aligned with the results of Raju et al. (2022).

The financial, behavioural and infrastructural factors continue to limit the adoption of e-NAM. The need for immediate cash payments and preference for face-to-face selling indicate the persistence of traditional marketing practices and trust-based transactions. Distrust in online transactions and difficulties in loan repayment reflect behavioural and financial barriers. Technical challenges, such as difficulty in online processes and low digital literacy, reduce farmers' confidence in using digital platforms, while infrastructural limitations, such as inadequate grading facilities and a lack of storage facilities, affect the operational efficiency of the platform. These findings are consistent with Kumar et al. (2024); Nelson et al. (2025).

For traders, market-oriented and institutional constraints such as increased competition from outside traders and non-uniform mandi policies significantly influence participation. Technical challenges in digital platforms, including system slowdown and difficulties in digital payment processing, further hinder their engagement. These findings suggest that improving digital literacy, strengthening infrastructure, ensuring policy uniformity and building trust in digital transactions are essential for enhancing the effectiveness of e-NAM.

From an extension perspective, the identified constraints call for targeted interventions. Extension agencies should organise regular digital literacy training camps at the village level, focusing specifically on smartphone usage, online payment processes and e-NAM registration procedures. Establishing farmer help desks at mandis would assist in resolving technical difficulties during transactions. Facilitating linkages between farmers and formal credit institutions would address the immediate cash payment barrier effectively. For traders, harmonisation of mandi policies across APMCs and provision of adequate digital infrastructure, such as computers and reliable internet connectivity, are essential prerequisites. Capacity-building programmes involving both farmers and traders on a common platform would further foster mutual trust and improve the overall efficiency of the e-NAM platform.

CONCLUSION

The study highlights that socio-economic factors significantly influence farmers' participation in e-NAM. Education, social participation and digital literacy enhance adoption, while distance to markets continues to limit participation. Higher knowledge levels among e-NAM users indicate that digital platforms improve operational understanding across transaction stages. Financial dependence on immediate cash, preference for traditional marketing practices and the infrastructural limitations restrict effective adoption. The findings highlight that strengthening digital literacy, improving market infrastructure, and ensuring policy uniformity are essential for enhancing participation in e-NAM. The study emphasises the importance of behavioural and institutional factors in digital agricultural marketing and suggests that targeted extension interventions and capacity building efforts are necessary to improve the efficiency and inclusiveness of e-NAM.

DECLARATIONS

Ethical approval and consent to participate: Informed consent was obtained from all respondents prior to data collection.

Competing interests: The authors declare that they have no competing interests.

Conflict of interest: The authors declare that there is no conflict of interest regarding the publication of this paper. All authors have critically reviewed, revised, and approved the manuscript and take full responsibility for its content.

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