Analysis of factors promoting the usage of electronic National Agriculture Market in Rajasthan, India

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Information and communication technology (ICT) can improve the value and supply chain for agriculture. The post-harvest value chain is still extensive in India, and farmers frequently do not get a reasonable share of the profit. Despite greater procurement by the state and federal Government agencies as well as players in the private sector, the vast majority of farmers continue to get the short end of the stick. The present study focuses on the factors promoting the usage of the electronic National Agriculture Market (e-NAM) in Rajasthan, India. The significant *P*-values in KMO and Bartlett's test indicate that researchers can proceed with the factor analysis. Using principal component analysis, it was found that the well-known functionalities of e-NAM included virtual highlights, capacity-building amenities, e-bidding design features, value-addition modules and e-logistics features, which encouraged stakeholders to sell their products across the Indian states using digital platforms in order to achieve higher prices compared to traditional markets. The supply chain has been shortened due to e-NAM, which connects the physical markets of multiple states on a virtual stage using ICT.

Keywords: Agriculture, electronic market, factor analysis, information and communication technology, principal component analysis.

INFORMATION and communication technology (ICT) has been widely adopted in India, which paves the way to provide farmers with prompt and affordable information services and facilitates coordination of agricultural agents[1]. The effective use of ICT in agriculture empowers the stakeholders with cutting-edge methods to increase agricultural productivity and profitability, as important information is provided in a timely and user-friendly manner that is easy to obtain and reasonably priced[2]. ICT tools are used to deliver crucial information quickly in an approachable format that is simple to get and competitively priced[3]. A significant potential to overcome the shortcomings of Agricultural Product Marketing Committees (APMCs) in the traditional marketplaces is provided by the integration of ICT in agriculture marketing. The Government of India recognized the value of electronically mediated farm markets and inaugurated an electronic National Agriculture Market (e-NAM) on 14 April 2016 in Rajasthan[4]. The Small Farmers' Agri-Business Consortium (SFAC) administers e-NAM, a pan-Indian electronic trade portal entirely supported by the Union Government. Through the establishment of a centralized online platform for agricultural commodity price discovery, the e-NAM portal connects the existing APMCs/ Regulated Marketing Committee (RMC) market yards, submarket yards, private markets and other unregulated markets aiming to unify all national agricultural markets[5]. In 2023, the e-platform encompassed 1361 marketplaces spread across 23 Indian states and 4 Union Territories (UTs). To be eligible for assistance through the e-NAM, three criteria must be met for the state APMCs are, holding a single trading license, implementing a single market fee levy point, and offering provision for e-auction/e-trading for price discovery as facilitated by the State Agriculture Marketing Department[6]. Currently, the e-NAM platform accommodates the trading of approximately 209 commodities, encompassing food grains, oilseeds, fruits, vegetables, spices and flowers. One of the distinctive features of e-NAM is its capability to assess the valuation of these commodities, which significantly enhances price discovery and provides real-time trading opportunities for stakeholders. Suppliers and buyers worldwide have access to more marketplaces and a centrally controlled platform for trading goods due to e-NAM. It also offers online analysis of price trends, arrival, trading activity and projections, collects market fees in one place, and supports trading based on the actual demand and supply of the commodity. This eliminates the requirement for the commodity to be physically present in the mandis. It also facilitates inter-mandi and inter-state business and maintains automatic digital bookkeeping of transactions[7]. The platform has approximately 1.78 crore registered stakeholders, including 1.74 crore farmers and 2.40 lakh traders[8]. In India's rural areas, there were 238 million smartphone users in 2019 and 299 million in 2020, increasing by 25.6%, according to a study by the Internet and Mobile Association of India[9]. This shows that more farmers in rural regions are acquiring smartphones, which they can use to access e-NAM[9]. The Indian Government of India has started a number of projects to increase internet

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access in rural areas, such as Bharat Net, which aims to give high-speed broadband connectivity to all Gram Panchayats (village-level administrative units) in the country. As of January 2021, 144,676 Gram Panchayats have been connected to Bharat Net, according to a report of the Ministry of Electronics and Information Technology, GoI[10]. Additionally, the private sector is also implementing a strategy to increase internet access in rural areas. According to a report by the *Economic Times*[11], one of India's top telecom service providers has launched the 'Digital Udaan' initiative to teach internet usage and digital literacy to people in rural areas. This initiative has trained over 1.5 million people in digital skills across 28,000 Indian villages[11]. Therefore, the focus of the present study has been on how much of the digital mandi's resources are used by e-NAM beneficiaries. This study aimed to understand how much the farmers and traders in Rajasthan's Tonk and Dausa districts use the e-NAM facilities.

Material and methods

A study was undertaken in the Dausa and Tonk districts of Rajasthan on the factors encouraging the use of e-NAM in order to ensure that registered farmers and traders from the Mandawari and Niwai APMCs may easily utilize the facilities. Most APMC markets in Rajasthan are linked to the e-NAM digital market via SFAC, i.e. 145 APMCs are linked to e-NAM. Two APMCs that joined e-NAM in the second phase in 2017, viz. Niwai mandi in the Tonk district and Mandawari mandi in the Dausa district were chosen at random for the study. Between 2019 and 2020, data were collected from registered farmers and traders in a cross-sectional manner to analyse their level of usage of the e-NAM platform and its provisions. Face-to-face interviews were conducted with randomly selected 100 respondents, consisting of 25 farmers and 25 traders from each APMCs. Respondents were asked to evaluate the facilities of e-NAM on a three-point scale, from extremely needed to extremely not, based on the aforementioned factors required. To determine the relationship between the factors, the collected responses were subjected to factor analysis. The main goal of factor analysis is to represent the covariance relationship between numerous variables in terms of a small number of underlying incoherent and random values known as factors.

Factor analysis is a data reduction approach that identifies hidden patterns in a group of variables to simplify identifying relationships[12]. Using factor analysis, the significant components that allow the adoption of e-NAM from the study region were identified. With exploratory factor analysis (EFA), one can examine the relevant variables to develop a theory or model from a sizable collection of latent dimensions, frequently represented by a collection of objects[13,14]. The rule of thumb for EFA is that the sample size should be 100 or above. Correlation matrix is one of EFA's most widely used statistical methods to determine the correlation between variables[15]. The correlation loadings were classified by Hair *et al.*[16] as 0.30 = minimum, 0.40 = relevant and 0.50 = practically. Various checks must be performed to determine whether the sample is adequate and whether the data are suitable for factor analysis before the constructs can be extracted[17]. According to Burton and Mazerolle[17], measures of sampling adequacy assess how strongly an item correlates with other items in the EFA correlation matrix[17]. The Kaiser–Meyer–Olkin (KMO) analysis is used to determine the suitability of the sampling[18]. According to Netemeyer *et al.*[19], a KMO correlation of 0.60–0.70 or higher is deemed sufficient for assessing the output of an EFA. Principal components analysis (PCA) is a popular method to extract factors, and when there is no prior theoretical foundation or model, PCA can be employed[20]. Researchers must choose how many constructs to rotate after the extraction step. In comparison to other phases, factor retention is more crucial. Hayton *et al.*[21] have justified why this choice is so crucial. First, there is evidence that these decisions are robust across options[22]. Second, the effectiveness of EFA depends on the ability to distinguish between large and minor factors in order to strike a compromise between parsimony and effectively capture the underlying connections[23]. For factor retention, Kaiser's criteria (eigenvalue > 1 rule) and scree test were generally used for factor analysis[18,24]. Factor rotation will help provide a more understandable and clear answer by boosting high-item loadings and decreasing low-item loadings. The varimax rotation, a widely utilized rotational approach for EFA, was introduced by Thompson and often yields a clear and straightforward structure. Therefore, it is being utilized in this study[19].

Results and discussion

The examination of the socio-economic characteristics of farmers and traders utilizing the e-NAM platform (as shown in Table 1) revealed that a predominant proportion, around 53% of farmers and 24% of traders, fell within the range of middle-aged, i.e. 35–50 years. These individuals were the primary users of the e-NAM mandis. Notably, a significant number of them, about 58% of farmers and 64% of traders were situated relatively nearby, within a distance of 2–13 km from the e-NAM mandi, where they engaged in digital commodity transactions. Furthermore, the study indicated that a substantial portion, 94% of farmers and 62% of traders, were involved in the exchange of wheat and mustard respectively, both within and outside the state borders, aiming to secure better prices for their produce. Most beneficiary farmers and traders had primary and secondary educational qualifications (42% and 58% respectively). In a study conducted to determine the extent of utilization of ICT in agricultural marketing by Saini and Jirli[4], discovered that a higher percentage of middle-aged

(35–50 years) individuals residing in close proximity (2–13 km) to digital mandis were actively and extensively utilizing these platforms for the exchange of their agricultural commodities.

The KMO test was used to determine the suitability of the samples for EFA for exploratory factor analysis (Table 2). A value of 0.618 indicates that the sample is highly significant for factor analysis. Furthermore, the significant *P*-value for Bartlett's test of sphericity indicates that the observed correlation matrix for the utilization patterns of e-NAM mandi facilities significantly deviates from an identity matrix, supporting the underlying assumption of non-sphericity in the data. As a result, researchers are justified in proceeding with the factor analysis, confident in the appropriateness of the dataset for exploring underlying latent factors influencing the usage patterns within the e-NAM mandis.

PCA was employed to extract factors that underlie the promotion of e-NAM facility usage. Factor extraction was guided by Kaiser's criteria, wherein factors with eigenvalues greater than 1 were retained, indicating their significance in explaining the variance in the data. Additionally, the scree test, a graphical approach, was employed to identify the inflection point on the curve formed by plotting eigenvalues (*y*-axis) against components (*x*-axis). This method helps in determining the optimal number of factors to retain for the e-NAM facilities dataset. Through the process of factor retention in Kaiser's criteria (Table 3) and scree plot (Figure 1), five components have been preserved in decreasing order of eigenvalues from one to five, which explains 65% of cumulative variance indicating variability in the usage pattern of e-NAM facilities by beneficiaries.

Table 4 shows the factor loadings within the rotated component matrix, which were obtained through the utilization of Varimax rotation with Kaiser normalization. This rotation was executed to determine the correlations between e-NAM mandi facilities and the five extracted components. Accumulation of e-NAM facilities on a component occurred when the correlation value exceeded 0.5, allowing the assessment of the correlations between these components and the facilities offered by e-NAM mandis. The five extracted components are virtual facilities, capacity building facilities, e-bidding, value addition and e-logistics.

Factors related to the virtual facility

The elements that contribute to the virtual facility components include engaging in commodity transactions via the digital platform, accessing mandis through mobile applications, and conducting transactions through mobile apps. These elements have respective factor loadings of 0.847, 0.712 and 0.518. Notably, these factors are positively correlated and collectively contribute to the formation of this particular component. A similar study by Aker *et al.*[1] showed that mobile apps can facilitate information exchange within social networks, potentially lowering the cost of information search for farmers and traders. According to a study, the global internet-of-things (IoT) in the agricultural market is anticipated to increase from US$ 5.6 billion in 2020 to US$ 12.7 billion by 2025, at a compound annual growth rate of 17.9% throughout the forecast period[25]. This indicates that the adoption of IoT in agriculture is increasing rapidly. Jha *et al.*[26] also highlighted that artificial intelligence (AI) has the potential to transform the agricultural

Table 1. Socio-economic profile of farmers and traders of e-NAM digital market

Parameters	Observation (%)	
	Farmers (n = 50)	Traders (n = 50)
Age (years)		
<35	4	10
35–50	53	24
>50	43	16
Distance of e-NAM mandi from farm (km)		
<2	20	18
2–13	58	64
>13	22	10
Transaction of commodity		
Wheat	94	58
Mustard	66	62
Bajra	32	42
Seasamum	10	12
Gram	22	14
Educational qualification		
No schooling	16	0
Primary education	42	20
Secondary education	34	58
Undergraduate	8	20
Postgraduate	0	2

Table 2. Kaiser–Meyer–Olkin (KMO) and Bartlett's test

KMO measure of sampling adequacy	0.618
Bartlett's test of sphericity (approximate chi-square)	185.859*
Degrees of freedom (d*f*)	66

*Significant at p-value < 0.000.

Table 3. Total variance explained by extracted components of facilities of e-NAM mandis using principal component analysis

Component	Total	Initial eigenvalues	
		Percentage of variance	Cumulative percentage
1	2.678	22.318	22.318
2	1.578	13.147	35.464
3	1.417	11.808	47.273
4	1.097	9.145	56.418
5	1.047	8.723	65.141
6	0.887	7.388	72.529
7	0.723	6.027	78.555
8	0.674	5.614	84.169
9	0.594	4.947	89.116
10	0.546	4.551	93.667
11	0.390	3.247	96.915
12	0.370	3.085	100.000

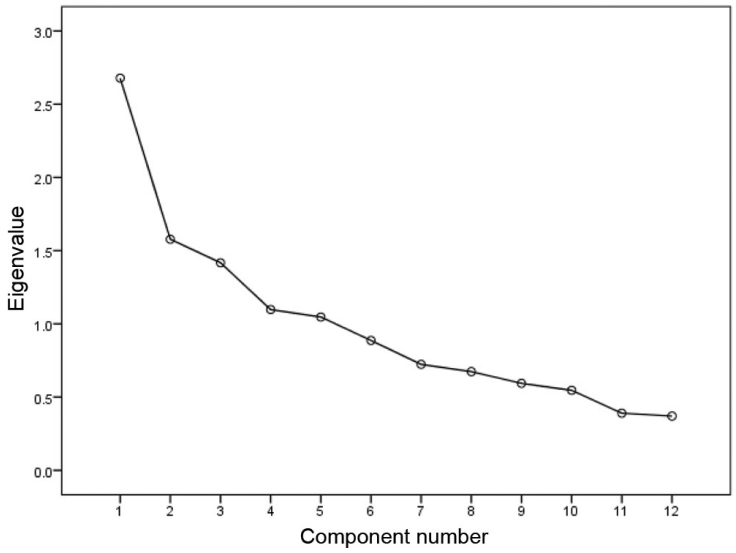

Figure 1. Scree plot of extracted components of facilities of e-NAM mandis with their eigenvalues.

Table 4. Extraction of factors using Varimax with Kaiser normalization of factor loadings

	Rotated component matrix				
Facilities of e-NAM mandis utilized by beneficiaries	Virtual facility	Capacity-building facility	e-Bidding facility	Value-addition facility	e-Logistics
Transaction of commodity on digital platform	0.848				
Access mandi through mobile app	0.712				
Payment of transaction through mobile app	0.518				–0.516
Training in APMCs		0.744			
e-Modules tutorials		0.713			
Avail price information on mobile phone		0.600			
Invoice generation			–0.733		
Immediate money transaction			0.639		
Visit mandi through ICT medium			0.619		
Quality assessment of commodity				0.833	
Grading and sorting of commodity				0.600	
Hired transportation					0.800

sector by improving yield, reducing costs and increasing efficiency.

Factors related to capacity-building facility

According to a press release from the Ministry of Agriculture and Farmers' Welfare (MoA&FW), GoI, e-NAM offers various capacity-building initiatives to farmers and other stakeholders, including training programmes, webinars and workshops that will assist them in comprehending the advantages and effectively utilizing the platform[27]. This component arises from training received in APMCs, e-module tutorials, and the availability of price information on mobile devices, each having factor loadings of 0.744, 0.713 and 0.600 respectively. Supporting this, a study conducted by the World Bank highlighted that ICT devices and services exerted a notable influence on the advancement of stakeholders within the agriculture sector[2].

Factors related to the e-bidding facility

The fundamental components in an e-bidding facility with a factor loading of –0.733, 0.639 and 0.619 respectively, are invoice generation, immediate money transaction and visiting mandis through ICT, each of which contributes to the development of the components. Chand[28] also explained the potential of e-bidding in agricultural marketing across India for eliminating the intermediates and getting remunerative prices for the farmers[28,29]. An e-bidding platform offered by e-NAM allows farmers to sell their goods to the highest bidder and ensures that transactions are efficient and transparent, which can help farmers receive fair prices for their goods[30].

Factors related to the value addition facility

The factors influencing value addition facility are quality assessment, grading and sorting of commodities with a

factor loading of 0.833 and 0.600 respectively. A similar study conducted on reforms of agricultural marketing indicated the importance of value addition of the produce for providing quality services to the consumers in order to improve the value-chain management of agriculture[5,31]. The Indian Council for Research on International Economic Relations (ICRIER), New Delhi reported that e-NAM offers value-added services, including grading, sorting, packaging and transportation, that help farmers produce high-quality goods and obtain higher market prices[32].

Factors related to the e-logistics facility

The important factors in e-logistics facility, with a factor loading of 0.800 and –0.516 respectively, are hired transportation and payment of transactions through mobile apps[33,34].

Assessing the potential of e-NAM as a solution to resolving farmer issues

According to the study by ICRIER, e-NAM has increased competition by bringing together buyers and sellers from various regions of the country, enabling farmers to sell their produce at a higher price, leading to a 1.5–2% increase in the prices that farmers receive for their products[32]. MoA&FW, GoI, reported that e-NAM has allowed farmers to sell their produce directly to the buyers, reducing the cost of intermediary fees by 50% for commission agents and 25–30% for traders[27]. A study by the Institute for Social and Economic Change found that e-NAM has aided farmers in reaching out to distant markets and increasing their income by allowing them to sell their goods in places with a greater demand than the local mandis[35]. According to a report by the National Institution for Transforming India (NITI Aayog), New Delhi, e-NAM has enabled farmers to learn about the current prices in various mandis (wholesale markets) and better decide how to sell their produce. It also provides transparency in the trading process by displaying market prices and transaction data[30]. By minimizing paperwork and transportation time, e-NAM has streamlined the trading process and increased efficiency. A report by MoA&FW, GoI, mentions that e-NAM has cut down on paperwork and transit time by 50% and 22% respectively[27]. These advantages might not be immediate or widespread, but they do indicate that e-NAM may have the ability to improve the situation of Indian farmers in the long run (Table 5).

Table 5. Assessing the potential of e-NAM as a solution to resolving farmers' issues

Potential of e-NAM	Reference
Increased competition among market stakeholders	32
Reduced intermediaries in the supply chain	27
Access to a larger market beyond the local mandis	35
Transparency in the supply chain	30
Efficiency in trade	27

Conclusion

The present study offers insights into the factors that can be used to encourage stakeholders in the supply chain to use e-NAM. Several e-NAM characteristics were observed, including virtual features, capacity-building facilities, e-bidding components, value-addition elements and e-logistics, information accessibility, platform trust, usability and perceived benefits. The study also assessed the factors facilitating e-NAM usage in Rajasthan. The findings of this study can be utilized to examine the adoption rate and usage pattern among stakeholders in other states and identify areas for improvement and further promotion of e-NAM, which can increase agricultural productivity and farmers' income. This study highlights the value of digital literacy among farmers and can be utilized to develop initiatives that encourage the same, like training programmes and awareness campaigns. The study can also be used to enhance the usability and information content of the digital platform to increase interactivity, speed, efficiency and global connectivity with customized navigations.

Policy implications of this study

According to a report by the Food and Agriculture Organisation of the United Nations, technology can significantly increase agricultural output while reducing poverty and hunger[36]. The findings of the present study could help policymakers formulate guidelines and legislation for farmers to adopt new technologies like virtual markets, blockchains, AI and IoT in marketing structures for the effective and seamless operation of mandis. The second recommendation would be to strengthen rural infrastructure. According to a report by the World Bank, rural infrastructure can aid in reducing poverty and fostering economic development, such as roads, electricity and internet connectivity, to ensure that farmers have access to the necessary resources and technologies[37]. Finally, by establishing a supportive legislative environment and offering financial incentives to private businesses that invest in agriculture, governments can encourage the private sector to invest in the agricultural supply chain.

Conflict of interest: None.

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