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RESEARCH PAPER

Factors influencing farmers decision to participate in e-auction: A case of Electronic National Agriculture Market (e-NAM) in Punjab, India

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Abstract: This study aimed to analyze farmers' perceptions and the factors influencing their decision to participate in e-auctions in Punjab. Primary data were collected through interviews with 250 farmers and analyzed using logistic regression and SMOTE Tomek techniques. The study revealed that the average age of the farmers was 46 years, and the average annual income was ₹ 5.2 lakh. Only 12.40 percent of farmers were aware of e-NAM. While 68.80 percent of farmers knew about the electronic quality assaying process, only 36.00 percent could interpret the assaying report, and just 20.40 percent considered the assaying report for price determination.Majority of farmers (90%) reported selling Basmati rice through e-NAM, followed by cotton (84.80%), potato (76.40%), kinnow (28.80%), and green peas (16.80%). All farmers checked commodity prices before bringing their produce to the market, primarily relying on commission agents (100%) for price information, followed by fellow farmers (98.40%) and media/social media (18%). Most farmers (94.40%) owned a smartphone, while 5.60% had a simple phone. All farmers indicated that the open auction method was used at APMC, with the price determination process taking 3 to 5 minutes (60%) or more than 5 minutes (39.2%).After being informed about the e-auction process of e-NAM, 89.6% of farmers preferred e-auction over open auction. Payment settlements were mainly handled by commission agents, with cash being the preferred method, and payments were typically received within 3 to 5 days after the sale. Major constraints faced by farmers in using e-NAM included lack of guidance, fear of losing commission agents' assistance, absence of grading facilities, and complexities in the selling process. Key parameters predicting farmers' preference for open auction over e-auction were their loan sources, family background, education, family size, annual income, and age.

Key words: Commission Agent, E-auction, E-NAM, Market, Price

Introduction

The agricultural sector in India plays a vital role, contributing approximately 20 per cent to the country's GDP and serving as a significant source of employment opportunities in rural areas (Siddayya *et al*., 2016). The growth of this sector has shown fluctuations, with an increase from -0.2 percent in 2014-15 to 6.3 percent in 2016-17, followed by a decline to 2.9 percent in 2018-19 (Chaitra *et al*., 2020). However, the issue of price transparency has persisted, often concealed within closed-door negotiations, causing uncertainty for farmers (Poolsingh *et al*., 2022). Moreover, the agricultural markets in India grapple with challenges such as information asymmetry, collusion among traders, improper weighment, payment delays, and inadequate infrastructure. Weak market integration and poor institutional arrangements have resulted in volatile commodity prices that adversely impact farmers (Chand, 2016). In 2004, the National Farmers Commission recommended the establishment of regulated markets accessible to farmers within a 5-kilometer radius, equivalent to an approximate market area of 80 square kilometers. Nevertheless, the current nationwide average market area covered by regulated markets stands at a staggering 487.40 square kilometers, and the availability of commodity-specific markets with necessary infrastructure remains scarce (Siddayya *et al*., 2016a).

Farmers make crucial decisions regarding crop planning, credit requirements, and investments based on market information. However, small holder producers often lack timely access to market-related information (Satapathy and Mishra 2020), forcing many to sell their produce immediately after harvest due to the absence of proper storage facilities, the need for cash to repay debts and labor wages, and financial requirements for social ceremonies and children's education (Sahu *et al*., 2004). India incurs substantial losses, with 30-35 percent of its agricultural production going to waste due to inadequate supply chain and logistics management (Saini *et al*., 2023).

Efficiency in the agricultural marketing system necessitates robust infrastructure facilities, transaction transparency, and the accountability of market officials. This ensures higher market arrivals, efficient price discovery, and reduced price volatility (Acharya 2007). To address these persistent challenges, it is imperative to enhance marketing resources for farmers to secure fair prices and support the growth of the agricultural sector (Sharma and Patil, 2018). The fragmentation of states into multiple marketing areas, each governed by separate Agricultural Produce Market Committees (APMCs), has led to issues such as the imposition of multiple market fees, the need for various licenses to trade in different APMCs and States, and licensing barriers that foster conditions of monopoly. Additionally, inadequate infrastructure in APMCs, limited adoption of technology, and information asymmetry remain persistent problems (Patil, 2021). Urgent reforms are necessary to address these market inadequacies (Chand, 2006).

The corner stone of farmers' success lies in obtaining remunerative prices, as increased production alone cannot improve their income unless they receive favorable prices for the crops they cultivate (Raju, 2020). The central government has periodically intervened in the agricultural marketing system to enhance its functionality across the nation, proposing various reforms. Recognizing the pressing need to address the challenges within the existing agricultural marketing system, the Union Government initiated the implementation of a Central Sector Scheme on April 14, 2016. This scheme is designed to promote the National Agriculture Market, which operates through a unified electronic platform known as the Electronic National Agricultural Market, or e-NAM (Pool singh *et al*., 2021). This platform is anticipated to be a transformative force in the country's agricultural marketing ecosystem (Patil, 2021). e-NAM enables traders from any State to participate in the purchase of agricultural commodities from any State in India.

The linking of agricultural markets across the country is expected to influence farmers' price realization in several ways. E-tendering is set to enhance transparency, reduce trader cartelization in intra-market transactions, and increase competitiveness through a higher number of buyers (Venkatesh *et al*., 2021). The full benefits of linking agricultural markets in the country and placing them on an electronic platform will be realized when a single trading license is valid nationwide, allowing farmers to sell their produce in any market across the country (Chand, 2016). However, as of now, only about 15% of APMC markets are linked, and the farmers' participation rate hovers around 13% (Venkatesh *et al*., 2021). There is an information gap regarding a comprehensive understanding of e-NAM, including farmers' perspectives, the factors influencing their participation in e-NAM, awareness levels, constraints within e-NAM, and the role of middlemen in the agricultural marketing system. This research paper aims to critically examine farmers' perceptions, the role of middlemen, and the factors influencing farmers' participation in e-NAM.

Material and methods

The research area for this study comprises farmers of the Bathinda district of Punjab who engage in selling their produce through e-NAM and mandi analysts of the Bathinda district. Out of 79 e-NAM APMCs in Punjab, Bathinda APMC was selected purposively for the study. A total of 250 farmers who sold their produce through e-NAM were selected randomly from the farmers list provided by Bathinda Mandi Analyst. Mandi analyst of e-NAM (APMC) was also selected for the official schedule of Bathinda mandi.

Primary data was collected from various stakeholders of e-NAM like farmers and e-NAM officials (Mandi analyst). The questionnaire included both closed and open-ended questions. Secondary data was collected from the e-NAM website, newspaper articles, and research papers.The survey was collected using a structured questionnaire during March and April 2023.

Percentages and frequency distributions were calculated to summarize the data and provide an overview of the characteristics and experiences of the farmers. The findings from the data analysis were interpreted and presented using tables, and discussed about the research objectives.

For the independent variables like age (years), annual income, land holding, loan from cooperative banks, loans from commercial banks, loans from commission agents, loans from money lenders, loans from relatives, loans from friends, loan-free, family background, education, size of the family, types of phones farmers have, a distance of villages from mandi and the dependent variable auction they prefer (After making farmer understand about e-action), logistic regression was conducted using the Python stats library to compare which independent variables affects the most to the dependent variable.

A statistical modeling technique called logistic regression is used to estimate the likelihood of a binary outcome based on one or more predictor factors. It is frequently used in many different disciplines, including social sciences, machine learning, and statistics. The logistic function, also known as the sigmoid function, is a key component of logistic regression. It maps any real-valued number to a value between 0 and 1, which represents the probability of the event occurring.

The logistic function is defined as:

$\sigma(z) = 1 / (1 + e^{(-z)})$

where $\sigma(z)$ is the output of the sigmoid function and z is the linear combination of input features and their respective weights.In logistic regression, the linear combination of input features and their respective weights is computed as:

$$z = \beta_o + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_p x_p$$

where z represents the linear combination, β_o is the intercept term, β_1, β_2, , ..., β_p are the coefficients or weights associated with the features x_1 x_2 , ..., x_p.

SMOTE Tomek is a hybrid sampling method that combines the Tomek Links algorithm and the Synthetic Minority Oversampling Technique (SMOTE). By employing SMOTE to oversample the minority class and Tomek Links to undersample the majority class, it seeks to address the issue of unbalanced datasets. Combining these two factors results in a dataset that is more evenly distributed, which can help machine learning algorithms perform better.

Results and discussion

The socio-economic profile of the respondents is represented in Table 1. The majority of farmers fall into the age group of 41-50, accounting for 51.60 per cent followed by 51-60 (26.40%) and 31-40 (22.00%), and the average age of farmers was 46.09 years. All farmers surveyed were only male. The majority of the farmers (86%) had completed their schooling up to 10th standard and all the farmers were married. The average landholding size of the farmers was 5.15 acres. The majority of the farmers (44.80%) were marginal landholders followed by small (2.5 to 5 acres), medium (5 to 10 acres), and large (>10 acres) land holders by 27.20 per cent, 19.20 per cent and 8.80 per cent respectively. The average family size of the farmers was 6.4 members and the average annual income was ₹ 5,22,800.

Table 1. Socio-economic profile characteristics of farmers

Particulars	Category	Percentage
Age (Years)	31-40	22.00
	41-50	51.60
	51-60	26.40
	Average age	46.09
Gender	Male	100.00
	Female	0.00
Education	Illiterate	0.40
	≤10th	86.00
	12th	11.60
	Graduate	2.00
Marital Status	Single	0.00
	Married	100.00
Landholding (Acres)	Marginal (<2.5)	44.80
	Small (2.5-5)	27.20
	Medium (5-10)	19.20
	Large (>10)	8.80
	Average land holding	5.15
Size of the family	Small (1-4)	4.40
	Medium (5-7)	77.60
	Large (>7)	18.00
	Average family size	6.40
Annual income (₹)	1 Lakh to 2 Lakh	21.60
	2 Lakh to 3 Lakh	8.00
	3 Lakh to 4 Lakh	21.20
	4 Lakh to 5 Lakh	29.60
	More than 5 Lakh	19.60
Average annual income	5,22,800	

Table 2. shows Farmer's awareness of e-NAM and other processes of e-NAM. Farmers' awareness about e-NAM. The study found that only 12.40 per cent of the farmers were aware of the e-NAM. Even though the surveyed farmers were practically engaged in e-NAM or selling their products through e-NAM but were not familiar with the term e-NAM. The awareness about e-NAM could be enhanced through various ways such as social media, newspapers, magazines, and others.

Despite e-NAM offering various features like checking commodity prices and enabling online payments, farmers did not report any utilization of the platform for any purposes other than the sale of commodities (Kalamkar *et al*., 2019). Farmers generally had limited knowledge about e-NAM, likely due to their reliance on commission agents for market transactions, who primarily handled the e-NAM process on their behalf (Bandhavya *et al*., 2022). Patil (2021) also reported that despite of e-NAM being operational for five years in Haryana, only 22 percent of farmers were about e-NAM. Raju *et al*. (2022) reported that the farmers who completed their graduation were aware of e-NAM and the farmers with 10th/diploma showed a lack of information about the e-NAM platform.

Table 2. Farmers awareness and other processes of e-NAM

Particulars	Category	Percentage
Farmer's Awareness about e-NAM	Yes	12.40
	No	87.60
Source of Entry token	Through Commission agent	100.00
	By yourself	0.00
Farmers assaying process at APMC	Farmers' awareness about the quality assaying process at APMC	68.80
	Ability to interpret the assaying report of the produce	36.00
	Consideration about the assaying report for price determination of the produce	20.40

Commission agents not only provide information about market prices but also assist farmers in obtaining the necessary entry tokens to participate in trading activities. The study found that all the farmers (100.00%) took their entry tokens through commission agents. Farmers' reliance on commission agents for market transactions, often without their physical presence due to simultaneous field responsibilities, resulted in commission agents predominantly handling the e-NAM procedures (Bandhavya *et al*., 2022).

The majority of the farmers (68.80%) were aware of the electronic quality assaying process of the APMC. Only 36.00 per cent of the farmers were able to interpret the assaying report of the produce. Only 20.40 per cent had ever considered the assaying report for price determination of the produce. Therefore, from this table, it is concluded that awareness about the assaying process at APMC is less, and utilization of this assaying process amongst the farmers is even less. Therefore, there is a necessity to create more awareness about the quality assaying process at e-NAM among the farmers to safeguard them from getting exploited. The successful implementation of e-NAM in selected APMCs required essential infrastructural facilities, including quality testing, e-auction, and weighing, with weighing facilities generally meeting 'good' to 'satisfactory' standards (Kalamkar *et al*., 2019). Patil (2021) found that in Haryana, only 38.50% of farmers were aware of the electronic quality assaying process at APMCs, with just 7.75% able to interpret the assaying report, and among those, only 4.50% had ever considered it for price determination, highlighting a significant need for increased awareness and utilization of this process to protect farmers from exploitation (Patil, 2021).

Fig. 1 shows the type of commodity sold by farmers through e-NAM. The majority of the farmers (90.00%) reported that they sold Basmati rice through e-NAM followed by cotton (84.80%), potato (76.40%), kinnow (28.80%), and green peas (16.80%). Basmati rice is a high-value commodity, and the widespread utilization of e-NAM for its trade reflects the platform's success in providing a reliable and efficient market place to farmers. Common rice and wheat are the major commodities cultivated by the farmers in the region but they are sold to the government agencies through the *e-kharif* platform at Minimum Support Price. By leveraging e-NAM, potato farmers and traders can potentially access a larger market, negotiate better prices, and streamline the trading process.

Table 3. shows the farmers' pro-activeness towards the price information. The data reveals that every farmer (100%) diligently examines commodity prices before transporting their produce to the APMC. This practice is primarily driven by the considerable expenses associated with transportation, loading

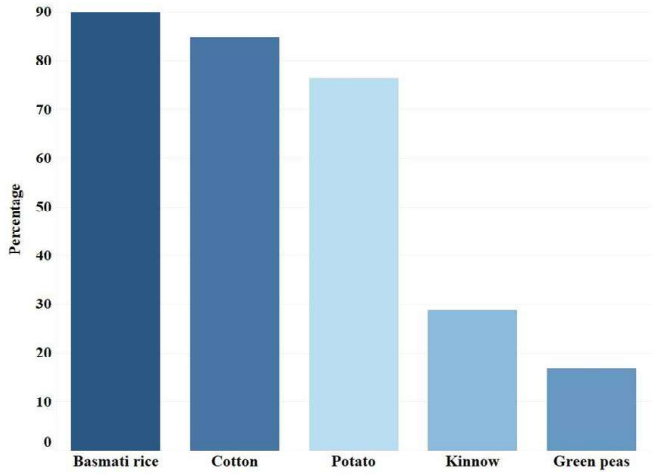

Fig 1. Type of commodity sold by farmers through e-NAM

and unloading, and labour charges. As a result, farmers consistently make it a habit to verify commodity prices before heading to the APMC for marketing purposes.

The study revealed that commission agents and fellow farmers were the primary sources of information for farmers regarding commodity prices. All the farmers (100.00%) opined that they usually ask commission agents to obtain price-related information at the APMC. Farmers often exchange information and experiences with each other. Approximately 98.40 per cent of the respondents reported that they rely on fellow farmers to gather information about commodity prices. This highlights the importance of peer-to-peer information sharing within the farming community. Approximately 18 per cent of the respondents reported relying on social media platforms, and messaging apps like WhatsApp, newspapers, and other media channels for price-related information. Surprisingly, none of the respondents reported using the option of calling the Kisan Call Center (KCC) to obtain price information. The KCC is a toll-free helpline service that provides agricultural-related information and advice. Also, none of the respondents reported using the e-NAM app for accessing price-related information. Patil (2021) found that around 81.25 per cent of the farmers checked the commodity prices before bringing their produce to the e-NAM APMC in Haryana. While, e-NAM offers multiple functionalities such as checking commodity prices, facilitating commodity sales, and online payments, farmers did not utilize the platform for any other purposes beyond selling their produce through commission agents at APMCs in Gujarat (Kalamkar *et al*., 2019).

Table 3. also shows the Types of phones available to the farmers. Interestingly, all the farmers surveyed possessed a mobile phone, either a smart phone or a simple phone. The results showed that, around 94.40 per cent of the farmers owned a smartphone, while 5.60 per cent of the farmers possessed a simple phone. This indicates that a significant number of farmers have access to mobile technology, enabling them to benefit from various digital initiatives introduced by the government and non-governmental organizations. The wide spread availability of phones among farmers highlights the potential

Table 3. Farmers' pro-activeness towards commodity prices and information sources

Particulars	Category	Percentage
Percentage of farmers checking the commodity price before bringing their produce to the market	Yes	100.00
	No	0.00
Sources of information regarding the price of a commodity	Commission agents	100.00
	Fellow farmers	98.40
	WhatsApp/Other social media/ Newspaper/Media /other	18.00
	Calling KCC	0.00
	E-NAM application	0.00
Types of phones available with the farmers	Smartphone	94.40
	Simple phone	5.60

of digital platforms to enhance agricultural practices and facilitate access to vital information and resources. Patil (2021) reported that all the farmers in Haryana owned either a simple phone (51.50%) or a smartphone (48.50%).

Farmers' opinion towards the method of bidding followed at APMC is shown in Table 4. All the farmers opined that the open auction method of bidding is followed while auctioning their produce at APMC. The trader who wins the bid will put the bidding price information on the e-NAM portal in their office. E-Auction does not happen during trading. Bidding is the point where the price discovery mechanism happens. It is one of the crucial activities in the APMC. One of the biggest features of e-NAM over the traditional APMC system is Online Bidding. One of the biggest drawbacks of the traditional APMC System was that only a few Traders registered under that particular APMC used to bid through an open Auction system in the APMC but e-NAM networks all the existing APMCs through a single portal as a unified national Market, so that traders from different APMCs across the nation can participate in the trade.

In the current auction process, traders inspect agricultural produce physically, place bids, and, if successful, receive a receipt from APMC officials. This receipt initiates the weighing and billing process, followed by payment by cheque or cash. Traders oppose this method as they prefer physical verification, despite the scheme's emphasis on essential electronic procurement for online commodity information (Kalamkar *et al*. 2019).

Table 4. also shows the time taken in the open auction method of sale to decide the price of the agricultural commodities. The opinion of the majority of farmers (60.00%) was that it typically took 3 to 5 minutes in an open auction to determine the price of their produce. In contrast, 39.20 per cent of farmers indicated that it took more than 5 minutes, while a smaller fraction, 0.80 per cent reported that the process usually took 1 to 3 minutes. Patil (2021) reported that in Haryana, 47.00 per cent of farmers reported within one minute and 51.25 per cent reported 3 to 5 minutes and only 1.75 per cent mentioned it took more than 5 minutes. Farmers and traders anticipate that e-NAM auctions, unlike the quick physical auctions in APMC markets, may be time-consuming

Table 4. Information about the bidding and auction process

Particulars	Category	Percentage
Farmers' opinion towards the method of bidding followed at APMC	Open auction	100.00
	e-Auction	0.00
Time taken in open auction to decide the price of farmers produce	Less than 1 minute	0.00
	1- 3 minute	0.80
	3-5 minutes	60.00
	More than 5 minutes	39.20
Awareness about e-auction among farmers	Yes	2.40
	No	97.60
Auction they prefer (After making farmers understand about e-action)	Open auction	10.40
	e-auction	89.60

and could pose challenges in settling payments on the same day (Kalamkar *et al*., 2019).

With respect to the awareness about the e-auction among farmers, only 2.40 percent were about this. The results highlight a significant lack of awareness among the farmers regarding e-auction. After informing farmers about the e-auction process of e-NAM, 89.60 percent of the farmers opined that they would prefer an e-auction in place of an open auction. This suggests that there is a notable change in farmers' preferences once they understand the concept and benefits of e-auction as it offers advantages such as convenience, efficiency, and improved market access.

Table 5 reveals about the source of payment settlement for the farmers. All the farmers (100.00%) opined that commission agents were the persons who settled their transactions and made payments to them. None of the farmers reported that they got payment either from traders or e-NAM. There is difficulty in ensuring online payments on the same day of trade and requires at least 15 days to arrange money, primarily due to traders needs more time to arrange funds for larger quantity of daily purchases, resulting in a delay in payment to farmers compared to commission agents. Therefore, farmers are completely dependent on the commission agent for money, Commission agent makes payments to farmers in cash (Bandhavya, Singh, 2022).

With respect to the farmers' preference towards the different methods of payment, the majority of the farmers (72.00%) reported that they would prefer the cash method of payment for settling their transactions. E-payment was preferred by 59.20 percent of the farmers, whereas 10.80 percent of the farmers preferred payments through cheques.

Payment Settlement is one of the most important events for the farmers in this whole trading procedure at APMC. At the end of the day, farmers want a quick and safe payment settlement for their produce.There is a delay in payment by traders due to challenges faced by tenant farmers in obtaining loans from banks, highlighting the need for cash payments to farmers (Bandhavya *et al*., 2022).

All the farmers reported that it took around 3 to 5 days to get their payments either through cash, e-payment, or cheque

Table 5. Information about payment settlement

Particulars	Category	Percentage
Source of payment settlement for farmers	e-NAM	0.00
	Commission agent	100.00
	Traders	0.00
Preference for the method of Payment by farmers	Cash	72.00
	e-Payment	59.20
	Cheque	10.80
Number of days taken to receive the payment	e-Payment	3 to 5
	Cash	3 to 5
	Cheque	3 to 5

mode. It reflects a consistent pattern in the payment processing for these farmers, indicating that they generally experienced a relatively quick turnaround in accessing their funds.

The majority of farmers (95.20%) reported obtaining loans from commercial banks. This indicates that commercial banks were the primary source of loans for the farmers. Similarly, an equal percentage of farmers (95.20%) also reported obtaining loans from cooperative banks. Cooperative banks are often established to serve specific communities or groups. A significant portion of farmers (34.00%) reported obtaining loans from commission agents. Only a small percentage of farmers (0.80%) reported obtaining loans from money lenders. Money lenders typically provide loans at high-interest rates. A very small percentage of farmers (0.40%) reported obtaining loans from friends. This indicates that borrowing from friends is not a common practice among the farmers. Similarly, only a small percentage of farmers (0.40%) reported obtaining loans from relatives. This suggests that, borrowing from relatives is not a prevalent source of credit for the farmers. A notable percentage of farmers (5.20%) reported being loan-free, indicating that they are financially stable for their agricultural activities.Commission agents still play a major role in lending financial services to the farmers. Farmers also find it easy to approach the commission agents because they provide a loan facility without taking any security, and will be available at any time over the phone, especially during emergencies.

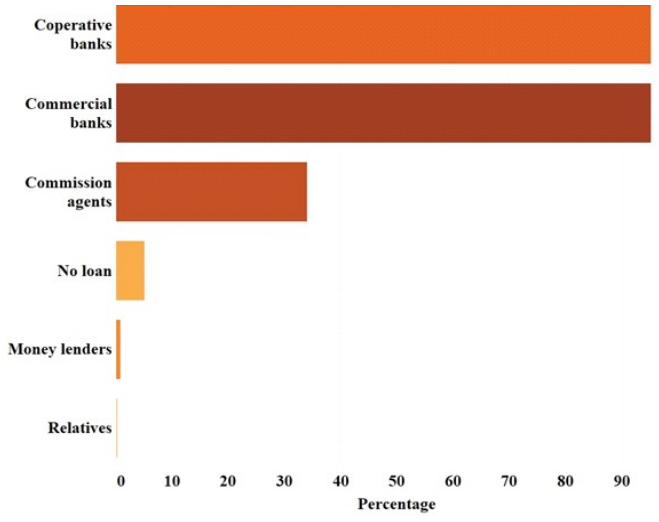

Fig. 2 Profile of farmer's indebtedness

Table 6. Farmers' reasons to sell their produce through commission agents

Particulars	Percentage
Take responsibility for selling the produce	100.00
Provides credit facility to purchase inputs/emergency fund	76.80
Immediate Cash Payment	100.00
Provides Unloading facility	100.00
Provides Weighing facility	100.00
Provides Cleaning facility	100.00
Provides Bagging facility	100.00
Provides Hospitality at his Shop	100.00
Take responsibility for Dispute settlement	100.00

Singh *et al* (2008) found that among institutional sources, commercial banks extended approximately 72 percent of the loans, while cooperatives accounted for roughly 28%. In contrast, among non-institutional sources, commission agents emerged as the primary credit provider. The study by Singh *et al.* (2017) found that large farmers tend to borrow loans from commercial banks and institutional sources whereas, agricultural labor households heavily relied on non-institutional agencies due to their limited collateral.

Table 6 provides information about the Farmers' reasons to sell their produce through commission agents. During the survey, it was found that the relationship between a commission agent and a farmer is paramount. These relationships exist for decades and are passed on from generation to generation. It was found that the commission agents play a central role in the marketing of agricultural produce. Right from production to marketing, farmers are dependent on commission agents for cash and other resources. Commission agent plays the role of the bank for farmers and provides easy and collateral-free loan facility to farmers. The table shows that the commission agent provides multiple facilities to farmers at APMC. Hence, farmers are dependent upon the commission agents for selling their produce. The major reasons as expressed by the farmers for dependency on commission agents for selling their produce were that the commission agent takes the responsibility of selling their produce (100.00%), immediate cash payment (100.00%), provides unloading facility (100.00%), weighing facility (100.00%), cleaning facility (100.00%), bagging facility (100.00%), takes responsibility of dispute settlement (100.00%), provides hospitality at his shop (100.00%), provides credit facility for purchasing the farm inputs (76.80%). For decades, farmers have relied on intermediaries to sell their produce in traditional markets, and transitioning to the online platform of e-NAM has proven to be challenging for them (Patnaik, 2018).

Bandhavya *et al.* (2022) reported that farmers' limited physical presence at markets, leading to commission agents handling e-NAM procedures, coupled with their dependency on commission agents for finances due to challenges faced by tenant farmers in obtaining bank loans, highlights the need for reforms to reduce farmers' reliance on intermediaries and enhance their direct engagement in e-NAM processes and financial transactions.

Table 7. provides information about the constraints faced by farmers in using the e-NAM platform. All the farmers reported facing the constraint of not having proper guidance or a help desk to assist them in using the e-NAM platform, fear of losing assistance from commission agents if they start marketing on their own, absence of grading facility within the APMC, complicated selling process at e-NAM. Understanding the content displayed on the computer and projector screens in the auction hall, and difficulty in understanding or interpreting the assaying report were the constraints faced by 98.80 percent and 97.80 per cent of the respondents in the E-NAM. Singh *et al*. (2021) also reported technical illiteracy as a major problem in this study. Farmers who were technologically illiterate or had low educational levels could not understand and operate the e-NAM platform on smartphones and laptops Nitesh (2018).

Table 7. Constraints faced by Farmers in e-NAM

Particulars	Percentage
No Guidance or help desk	100.00
Fear of losing assistance from commission agents	100.00
Absence of grading facility in APMC	100.00
The selling process is more complicated than before	100.00
Farmers do not understand the content displayed on the computer and projector screen in the auction Hall.	98.80
Farmers do not understand/interpret the Assaying Report	97.80
There is a chance of receiving less price due to the quality assaying process in e-NAM	96.00
Traders Collusion/trade malpractices	43.60
Delay in Online Payment	39.20
Labour problem for loading/unloading	16.00
The market is far away	12.40
Less Physical Space available at APMC	11.20
Server problem/Internet problem	0.80

About 96 per cent of the farmers were apprehensive of receiving lower prices due to the quality assaying in e-NAM. As farmers bring their produce without grading, they were worried about getting lower prices for their produce. Bandhayya *et al.* (2022) reported that due to the absence of a mechanism to collect representative samples, there was dissatisfaction among the farmers about the e-NAM quality assaying process. Traders' collusion or trade malpractices was the problem reported by 43.60 percent of the farmers. This might be due to the fact that currently traders from other APMCs are not participating in online bidding as they are accustomed to the old practice of physical verification of the produce and it may take some time to bring trust among the traders in the e-NAM quality assaying process.

Approximately 39.20 percent of the respondents reported facing delays in receiving online payments. This indicates that the digital payment process within the e-NAM platform may have room for improvement in terms of efficiency and timeliness. Raju (2020) found that the farmers in the Duggiral market of Andhra Pradesh faced technical glitches in e-NAM software. Few farmers experienced a delay in online payments by 15 days, which discouraged farmers from trading in e-NAM.

Labor-related problems during loading and unloading of the produce, longer distance of APMCs from the village, limited physical space in the APMC, and server or internet problems while using e-NAM were reported by 16.00 percent,

Table 8. Result of Logistic regression

		Precision	Recall	F1-score	Accuracy	ROC
Before upsampling	E-auction	0	0	0	0.91	0.47
	Open auction	0.91	1	0.95		
After upsampling	E-auction	0.18	0.57	0.28	0.72	0.63
	Open auction	0.94	0.74	0.83		

12.40 percent, 11.20 percent, and 0.80 percent of the farmers, respectively. The labor fees as prescribed by the government in APMCs might be regulated regularly and in the future, the government may think of increasing the number of e-NAM APMCs to provide marketing facilities in the vicinity of villages. Insufficient space can impact farmers' ability to bring and display their produce effectively, potentially affecting their trading opportunities on the e-NAM platform. There is a need to increase the market infrastructure facilities in the APMC. Kumar (2020) identified a monopoly of lorry owners' associations for transporting commodities. It is suggested that multiple affordable transportation options should be seamlessly integrated into the e-NAM platform to move commodities efficiently. Kalamkar (2019) reported that farmers in Gujarat faced some constraints in e-NAM such as difficulties in the online transaction process, a perceived complexity in the sale process compared to traditional methods, delays in receiving online payments, challenges in price discovery, and a perceived inadequacy in sorting facilities.

Table 8. provides the results of logistic regression analysis, including precision, recall, F1-score, accuracy, and ROC metrics for predicting the outcomes of e-auction and open auction. The results for e-auction before up-sampling indicate that the logistic regression model did not predict any instances correctly, resulting in precision, recall, and an F1-score of 0. However, the accuracy of the model is reported as 0.91, which means that the model accurately predicted the open auction instances. The ROC value of 0.47 suggests a relatively low discriminatory power of the model in distinguishing between e-auction and open auction. After upsampling, the logistic regression model shows improvement in predicting e-auction instances, as reflected in precision, recall, and F1-score values higher than 0.

Table 9. Feature importance results obtained from regression analysis

Parameters	â Value
Loan free	4.96
Loan from Relative	4.58
Loan from Friends	4.58
Loan from Moneylenders	4.58
Family background	3.45
Loan from a Cooperative bank	2.52
Loan from Commercial bank	2.52
Education	2.04
Size of the family	1.51
Annual income	0.50
Age (years)	0.46
What kind of phone do you possess	0.40
Total Land (Acres)	0.08
Loan from Commission agent	0.03
Distance of mandi from village	0.02

However, the values for e-auction still indicate relatively low performance compared to open auctions. The accuracy of the model is reported as 0.72, suggesting an overall improvement in prediction accuracy after upsampling. The ROC value of 0.63 indicates better discriminatory power of the model compared to before upsampling.

Table 9. provides the feature importance results obtained from a regression analysis. The β value of 4.96 indicates that the "loan-free", β value of 4.58, the "Loan from Relative", and "loan from Friends" also have a β value of 4.58, "Loan from Money lenders" also have a β value of 4.58, has the highest importance in predicting the outcome or dependent variable in the regression model. With a â value of 3.45, the "Family background" parameter holds substantial importance in the model. The β value of 2.52 for "Loan from Cooperative Bank" indicates its moderate importance in the model. Similar to the previous parameter, "Loan from Commercial bank" also has a β value of 2.52, signifying its moderate importance. With a â value of 2.04, the "Education" parameter holds a moderate level of importance in the model. This indicates that the level of education of the individuals being analyzed has a moderate influence on the predicted outcome. The parameter "Size of the family" has a β value of 1.51, suggesting its relatively moderate importance in the model. With a β value of 0.50, the "Annual income" parameter holds a lower level of importance in the model. The parameter "Age (years)" has a β value of 0.46, indicating its relatively lower importance in the model. With a β value of 0.40, the "Kind of phone do you possess" parameter holds a relatively lower level of importance. The β value of 0.08 for "Total Land (Acres)" indicates its minimal importance in the model. The parameter "Loan from Commission agent" has a β value of 0.03, signifying its very minimal importance in the model. With a β value of 0.02, the "Distance of mandi from village" parameter holds the least importance in the model.

Conclusion

The findings of the study highlight important insights regarding the awareness, preferences, challenges, and constraints faced by farmers in adopting e-NAM for their agricultural marketing activities. The awareness about e-NAM among farmers was found to be relatively low, with only 12.40 percent of farmers being aware of the platform. Many farmers relied on commission agents for market transactions, and this dependence limited their understanding and utilization of e-NAM features. However, after being educated about e-auction, a significant percentage of farmers expressed a preference for e-auction over traditional open auction methods. The type of commodities sold through e-NAM reflected a focus on high-value products like Basmati rice, indicating the platform's

success in providing a reliable marketplace for such goods. Farmers reported actively checking commodity prices before heading to the APMC, relying primarily on commission agents and fellow farmers for price information.

The availability of smartphones among the majority of farmers highlighted the potential for digital platforms to enhance agricultural practices and access to vital information. The payment settlement process was largely mediated by commission agents, with cash being the preferred method, and most farmers reported receiving payments within 3 to 5 days. Farmers' indebtedness primarily involved loans from commercial and cooperative banks, with commission agents playing a significant role in providing loans without the need for collateral. Commission agents also offered various facilities to farmers, including unloading, weighing, cleaning, and bagging.

Despite the benefits of e-NAM, farmers faced various constraints, such as the lack of guidance, fear of losing commission agent assistance, absence of grading facilities, and complexities in the selling process. Technical literacy, the understanding of auction reports, and concerns about lower prices due to quality assessment were also significant issues. The most important parameters in predicting farmers' preference for open auction over e-auction are related to their loan sources, family background, education, family size, annual income, and age. These factors collectively shape their decision-making in the agricultural marketing process.

Policy makers should prioritize awareness and education campaigns to inform farmers about the platform's advantages and offer digital literacy training. Establishing information centers at Agricultural Produce Market Committees (APMCs) can provide real-time support. Quality assurance measures should be improved, with a focus on transparency and the efficiency of online payments. Encouraging e-auction methods, investing in market infrastructure, expanding access to formal credit sources, ensuring rural connectivity, and fostering inclusivity are all crucial. The relationship between farmers and commission agents remains central, but efforts should be made to reduce dependence on intermediaries and empower farmers to participate more actively in e-NAM processes.

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