Address for correspondence:
Dr. J. Jeya Ani
Assistant Professor,PG &
Research Department of
commerce, St. Xavier's College
(Autonomous), Palayamkottai
Email: anijeyasxc@gmail.com

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Digital Transformation in Agriculture: Bridging the Gap Between Traditional Markets and The Digital Economy

Dr. J. Jeya Ani
Assistant Professor, PG & Research Department of commerce,
St. Xavier's College (Autonomous), Palayamkottai

Abstract

Agriculture, a cornerstone of developing economies, continues to rely heavily on traditional marketing systems such as mandis, local traders, and commission agents. These traditional structures often lack transparency, result in farmer exploitation, and limit income opportunities. The pace with which the digitisation has overtaken the world is phenomenal. In recent years, technological revolution has created a chance to modernize agricultural markets. With the rapid spread of digital economy, mobile applications, and fintech solutions, farmers now have access to tools such as real-time price updates, online trading platforms, mobile-based advisory services, and secure digital payment systems. This growth may be attributed to availability of affordable data services, proliferation of feature phones as well as 'budget smart phones', and the rise of innovative digital services. Digitalisation helped them to cut down the role of intermediaries, make the market more efficiency, and make pricing more fair. However, adoption remains uneven due to digital literacy gaps, barriers in infrastructure, and trust deficits in online systems, particularly in rural areas.

This paper explores how digital transformation can bridge the gap between traditional agricultural markets and the digital economy. Using secondary sources and survey-based findings, the study applies reliability testing (Cronbach's Alpha = 0.82) and regression analysis to evaluate factors influencing farmers' adoption of hybrid models. Results indicate that digital literacy, price transparency, and trust in digital payments significantly impact adoption, explaining 52% of the variance. The findings highlight that a hybrid mandi–digital system is more sustainable than fully replacing traditional markets. Policy support, rural digital literacy, and strengthened agri-startup ecosystems are recommended as enablers of inclusive agricultural growth.

Keywords: Agriculture; Digital Transformation; Traditional Markets; Digital Economy; e-NAM; Hybrid Models; Farmer Empowerment

Introduction

Agriculture remains the backbone of most developing economies, employing a significant share of the rural workforce and contributing substantially to national income. Despite this importance, agricultural marketing continues to depend heavily on traditional market structures such as local mandis, commission agents, and village traders. These traditional market arrangements are opposed by many since they are not very clear and farmers don't have negotiating power, use of unfair trade practices and the prevalence of exploitative tactics that reduce the income levels. Farmers frequently encounter problems including delayed payments, price changes, and post-harvest losses, which limit their profitability due to lack of transparency and excessive transaction costs (Chand, 2012).

The pace with which the digitisation has overtaken the world is phenomenal. In recent years, technological revolution has created a chance to modernize agricultural markets. With the rapid spread of digital economy, mobile applications, and fintech solutions, farmers now have access to tools such as real-time price updates, online trading platforms, mobile-based advisory services, and secure digital payment systems. Therefore, an important aspect of the new trend is that along with the target of yield increase, awareness is up with regard to concepts like adaptive research and sustainability. There is a growing conviction that if development to be durable, it should be sustainable. The priority has become not just sustainable agriculture, but sustainable livelihoods based on agriculture, not only for present population but for people in the future as well. In India, Electronic National Agricultural Market (e-NAM) and private agri-tech sites like Ninjacart, DeHaat, and AgroStar have shown how digital platforms may connect farmers directly with purchasers which include consumers, merchants, retailers and wholesalers.

This growth may be attributed to availability of affordable data services, proliferation of feature phones as well as 'budget smart phones', and the rise of innovative digital services. Digitalisation helped them to cut down the role of intermediaries, make the market more efficiency, and make pricing more fair. However, adoption remains uneven due to digital literacy gaps, barriers in infrastructure, and trust deficits in online systems, particularly in rural areas.

Against this backdrop of digitalisation, the present study examines how digital revolution can bridge the gap between traditional agricultural markets and the digital economy. It seeks to identify the major problems faced by farmers in adopting digital platforms, assess the role of factors such as price transparency, digital literacy, infrastructure, and trust in digital payments, and propose strategies in creating a potential shift from traditional to balanced hybrid system. By addressing these questions, the study contributes to ongoing debates on agricultural modernization, rural digitalization, and farmer empowerment in an era of global economic change.

Research Questions
1. What challenges exist in traditional agricultural marketing systems?
2. How can digital transformation enhance transparency and efficiency?
3. What factors influence farmers' adoption of digital agricultural platforms?
4. What strategies can ensure inclusive integration of traditional and digital markets?

Review of Literature
Acharya (2006) highlighted the inefficiencies of traditional agricultural markets in India, pointing out that intermediaries and commission agents capture a disproportionate share of value, leaving farmers with low returns. His study revealed that small and marginal farmers, lacking access to storage and credit, often engage in distress sales immediately after harvest. Although the APMC Act was intended to regulate markets and protect farmers, in practice it reinforced trader dominance, limiting competition and price discovery. Acharya argued for cooperative marketing societies, institutional reforms, and policy interventions that provide fairer terms of trade for farmers. His work remains relevant today as digital platforms aim to solve the very issues he identified—lack of transparency, farmer exploitation, and weak bargaining power.

Chand (2012) examined agricultural development policies in India, emphasizing that although MSPs and procurement systems offer some protection, they do not benefit the majority of farmers. He found that the restrictive nature of APMC markets suppresses competition and discourages private investment. Chand advocated for liberalized policies, contract farming, and direct farmer-to-consumer linkages to empower farmers and promote efficiency. Importantly, he argued that transparency and fair competition are critical for inclusive agricultural growth. While his study predates large-scale digital adoption, it anticipated how technology could reduce information asymmetry and support reforms.

Madan (2017) reported that variables such as education, farm size, experience in mobile usage, extension participation, achievement motivation, innovativeness, e-readiness, possession of electronic gadgets, degree of IT savviness and information cost had positive and significant relationship and the age had negative and significant relationship with knowledge level, extent of adoption, attitude and mobile message management of the respondents, respectively.

Kshetri's (2018) focused on how mobile payments improve financial inclusion throughout rural economies. He argued that digital payment systems reduce transaction costs as well as improve security to build trust among users. Thus they particularly matter to groups like farmers who are marginalized. He did study digital payments adoption and he highlighted just how social trust and community networks shape it. Informal institutions accelerate the rate at which people adopt digital payments. In agriculture, digital payments lessen dependence upon cash and record transactions with transparency, which are critical for the building of creditworthiness.

Verhoef as well as colleagues (2019) examined just how markets do change and do improve from a mix of digital and customary systems. Digital tools should work alongside old ways, they suggested, reaching people, providing information, and making things run more smoothly instead of getting rid of them. For example, because trusted local networks combine within digital platforms, they can bring together the best of both worlds, dependability and modern efficiency.

The FAO's (2021) report on digital agriculture noted global case studies that reduced post-harvest losses and improved supply chain efficiency. Smallholder farmers using mobile applications, e-marketplaces, along with digital advisory platforms accessed markets directly beyond improved income stability, it found. The report stressed that digital agriculture also provides support for environmental sustainability because it optimizes the use of resources and reduces the amount of waste.

The World Bank's (2017) report highlighted just how technology reshapes farmer access to certain markets and services. The study showed that ICT tools facilitate access to credit, crop insurance, and institutional networks, thereby improving resilience against risks. However, the report emphasized that ICT adoption is constrained by poor connectivity in rural areas and low levels of digital literacy. The World Bank concluded that successful digital agriculture requires not only technology but also institutional support and rural infrastructure development.

Objectives of the Study
1. To analyze limitations of traditional agricultural markets.
2. To examine the role of digital platforms in agricultural transformation.

3. To identify the influence of digital literacy, transparency, and digital payments on adoption.
4. To propose sustainable strategies for bridging traditional and digital markets.

Methodology

Research Design: Descriptive and analytical in nature.
Sample Size: 300 farmers from rural regions of Tirunelveli (representing small, marginal, and medium farmers).
Sampling Technique: Stratified random sampling (to ensure representation across landholding sizes).
Data Collection: Structured interview schedule using a 5-point Likert scale covering factors such as price transparency, digital literacy, trust in digital payments, infrastructure, and market access.
Statistical Tools Used: Cronbach's Alpha for reliability testing, Multiple Regression Analysis for factor influence. Hypothesis Testing (t-test and p-value) for validation.

Hypotheses

1. H1: Price transparency has a significant positive influence on farmers' adoption of digital agricultural platforms.
2. H2: Digital literacy significantly affects the likelihood of farmers adopting digital agricultural markets.
3. H3: Trust in digital payments significantly contributes to the adoption of digital agricultural systems.
4. H4: Access to rural infrastructure (electricity, internet, storage, and logistics) significantly impacts farmers' adoption of digital agriculture.
5. H0 (Null Hypothesis): There is no significant relationship between the independent variables (price transparency, digital literacy, trust in digital payments, and infrastructure access) and the dependent variable (farmers' adoption of digital agriculture).

Data Analysis and Interpretation
Reliability Test

Scale	Cronbach's Alpha	No. of Items
Farmer Perceptions on Digital Integration	0.82	5

With $\alpha = 0.82$, the questionnaire is highly reliable ($\alpha > 0.7$).

The reliability test was conducted using Cronbach's Alpha (α) to measure the internal consistency of the questionnaire items. In this study, the 5-point Likert scale included factors such as price transparency, digital literacy, trust in digital payments, infrastructure, and market access. The result was $\alpha = 0.82$, which is well above the commonly accepted threshold of 0.70

This indicates that the items included in the questionnaire are highly reliable and consistent, meaning farmers responded in a stable and coherent manner across different constructs. In simpler terms, the reliability test confirms that the responses are dependable and not random, which allows the study to proceed confidently with further statistical analysis.

Regression Analysis

Model	R	R²	Adjusted R²	Std. Error
1	0.743	0.552	0.541	0.471

Regression analysis was applied to determine the extent to which independent variables (price transparency, digital literacy, digital payment trust, and infrastructure access) influence the dependent variable (adoption of digital agriculture by farmers).

The model produced an R = 0.743, showing a strong correlation between independent variables and adoption behaviour. The R² = 0.552 means that the four independent variables explain 55.2% of the variation in adoption. This is statistically meaningful because it demonstrates that more than half of farmers' decisions to adopt digital platforms can be explained by these four factors. Adjusted R² = 0.541 adjusts for the number of predictors, confirming the robustness of the model even with multiple variables.

Each independent variable was tested using t-values and p-values. Since all p-values are below 0.05, they are statistically significant predictors.

Coefficients

Variable	B	Beta	T	Sig. (p)
Constant	1.012	–	4.05	0.000
Price Transparency	0.298	0.335	4.29	0.000
Digital Literacy	0.362	0.401	4.77	0.000
Digital Payments Trust	0.211	0.249	3.18	0.002
Infrastructure Access	0.184	0.205	2.95	0.004

All four factors significantly influence adoption ($p < 0.05$).

Hypothesis Testing

Hypothesis	Result
H1 Price transparency positively influences adoption.	Accepted
H2 Digital literacy significantly influences adoption	Accepted
H3 Trust in digital payments significantly influences adoption	Accepted
H4 Infrastructure access significantly influences adoption	Accepted

Interpretation
1. Digital Literacy ($\beta = 0.401$, $p < 0.01$) is the strongest predictor, confirming that farmers with higher technological knowledge are more likely to adopt digital markets.
2. Price Transparency ($\beta = 0.335$, $p < 0.01$) is also a key driver, showing that visible and fair pricing motivates adoption.
3. Trust in Digital Payments ($\beta = 0.249$, $p < 0.01$) reflects increasing confidence in fintech solutions among rural communities.
4. Infrastructure Access ($\beta = 0.205$, $p < 0.01$) adds an important dimension: without electricity, mobile networks, and logistics, adoption remains limited.
5. The model's $R^2 = 0.552$ indicates that over half of the variability in adoption is explained by these four factors.

Findings
1. Digital Literacy as the Strongest Predictor
Regression results show digital literacy ($\beta = 0.401$, $p < 0.01$) is the most influential factor.
Farmers with basic smartphone and app knowledge are far more likely to adopt digital platforms.
2. Price Transparency Encourages Adoption
Price transparency ($\beta = 0.335$, $p < 0.01$) significantly drives digital adoption.
Farmers prefer platforms that provide real-time, unbiased price information, reducing their dependence on middlemen.
3. Trust in Digital Payments is Growing
Digital payment trust ($\beta = 0.249$, $p < 0.01$) indicates rising confidence in UPI, mobile wallets, and banking apps.
Farmers who used digital payments reported fewer delays in receiving money compared to traditional mandi systems.
4. Infrastructure Access as a Structural Enabler
Infrastructure access ($\beta = 0.205$, $p < 0.01$) shows that reliable electricity and mobile connectivity play a vital role.
Farmers in regions with poor infrastructure reported more barriers to adopting digital tools.
5. Model's Strength ($R^2 = 0.552$)
The four factors together explain 55.2% of the variance in digital adoption.
This confirms that adoption is influenced not by a single factor but by a combination of literacy, transparency, financial trust, and infrastructure.
6. Small vs. Medium Farmers
Small farmers showed higher reliance on traditional mandis but expressed willingness to adopt digital systems if training and infrastructure were provided.
Medium farmers had higher digital adoption rates, suggesting resource advantages.

7. Generational Divide

Younger farmers were more digitally inclined compared to older farmers, reflecting a generational gap in technology use.

Suggestions
1. Enhance Digital Literacy Programs
Government and NGOs should conduct farmer training workshops on using mobile apps, digital payment systems, and online platforms.
Incorporating digital education into agricultural extension services will empower farmers to adopt digital markets more effectively.
2. Improve Price Transparency Mechanisms
Expand platforms like e-NAM (Electronic National Agriculture Market) to cover more crops and regions.
Ensure that farmers receive real-time price updates through SMS, WhatsApp alerts, or mobile apps in local languages.
3. Build Trust in Digital Payments
Strengthen financial literacy campaigns to educate farmers about the safety of UPI, mobile wallets, and banking apps.
Collaborate with banks and fintech companies to provide secure, low-cost, and farmer-friendly payment solutions.
4. Strengthen Rural Infrastructure
Invest in last-mile internet connectivity, electricity, and cold storage facilities.
Establish more digital service centres in rural areas so farmers can access online platforms even without smartphones.
5. Promote Hybrid Market Systems
Encourage a blend of traditional mandis and digital platforms rather than complete replacement, as many farmers still rely on face-to-face transactions.
Support cooperative marketing societies that integrate digital tools with physical marketplaces.
6. Supportive Policy Interventions
Introduce subsidies for smartphones, internet data, and digital transaction charges for small and marginal farmers.
Formulate policies that ensure fair play in e-markets, preventing digital monopolies or exploitation by large traders.
7. Inclusive Digital Ecosystem
Design user-friendly apps in regional languages with audio–visual features for illiterate farmers.
Ensure that women farmers and vulnerable groups are equally included in digital adoption initiatives.

Conclusion
The study on Digital Transformation in Agriculture: Bridging the Gap Between Traditional Markets and the Digital Economy reveals that while traditional mandis continue to play a central role in

agricultural trade, digital platforms are emerging as powerful enablers of transparency, efficiency, and inclusivity. After listening to 300 farmers, the findings confirm that digital literacy, price transparency, trust in digital payments, and access to infrastructure are the most significant factors that influence adoption. Among these, digital literacy emerged as the strongest predictor, showing that knowledge and confidence in using technology are critical for digital transformation.

The regression model revealed that four key factors collectively explain over 55% of the variance in adoption, indicating that multiple interconnected factors shaped digital adoption. These scores showed that digital adoption is shaped by a combination of interconnected factors and structural disparities where small farmers and older-generation farmers remain more reliant on traditional systems, while medium farmers and younger-generation farmers are more open to digital tools.

The study concludes that a hybrid market model—integrating both digital and traditional systems offers the most sustainable pathway forward. To achieve this, policymakers must invest in infrastructure, digital literacy programs, and secure financial systems to ensure inclusive adoption. Without addressing the digital divide in rural areas, digital platforms risk benefiting only a privileged few, reinforcing inequalities rather than resolving them.

Ultimately, bridging traditional and digital markets is not just a technological transition but a socio-economic transformation that requires education, trust-building, supportive infrastructure, and inclusive policies. If implemented effectively, digital transformation can empower farmers, reduce exploitation, and strengthen rural economies by connecting them to wider and fairer markets.

Conflicts of interest
The authors declare that there are no conflicts of interest regarding the publication of this paper.

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