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Role of Digitalization, e-NAM and Artificial Intelligence in Reducing Price Risk for Smallholder Farmers

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INTRODUCTION

One of the most pressing challenges facing Indian agriculture today is price risk, particularly for smallholder farmers who cultivate limited landholdings and possess minimal market power. Price volatility directly affects farm incomes, discourages investment, and threatens livelihood security. Smallholder farmers often face uncertainty due to seasonal production cycles, climatic variability, market imperfections, and dependence on intermediaries. In response to these challenges, digitalization, the electronic National Agriculture Market (e-NAM), and Artificial Intelligence (AI) have emerged as important tools for improving market access, enhancing price discovery, and supporting informed decision-making. International organizations such as the Food and Agriculture Organization (FAO) and the World Bank recognize digital agriculture as a key driver of inclusive growth and income stability for small-scale farmers (FAO, 2022; World Bank, 2021).

Price Risk and Its Impact on Smallholder Farmers

Price risk refers to uncertainty in the prices farmers receive for their produce between the time of production and sale. In India, agricultural price volatility is largely driven by seasonal gluts, inadequate storage infrastructure, weak market integration, and limited access to reliable market information. Smallholder farmers are disproportionately affected because they lack the financial capacity to delay sales or absorb price shocks.

Studies indicate that most small farmers sell their produce immediately after harvest due to liquidity constraints, resulting in distress sales at prices well below seasonal averages (Broll et al., 2012). This income instability not only affects household consumption but also reduces farmers' ability to invest in improved seeds, irrigation, and modern inputs. Consequently, addressing price risk is essential for strengthening farm resilience and ensuring sustainable agricultural development.

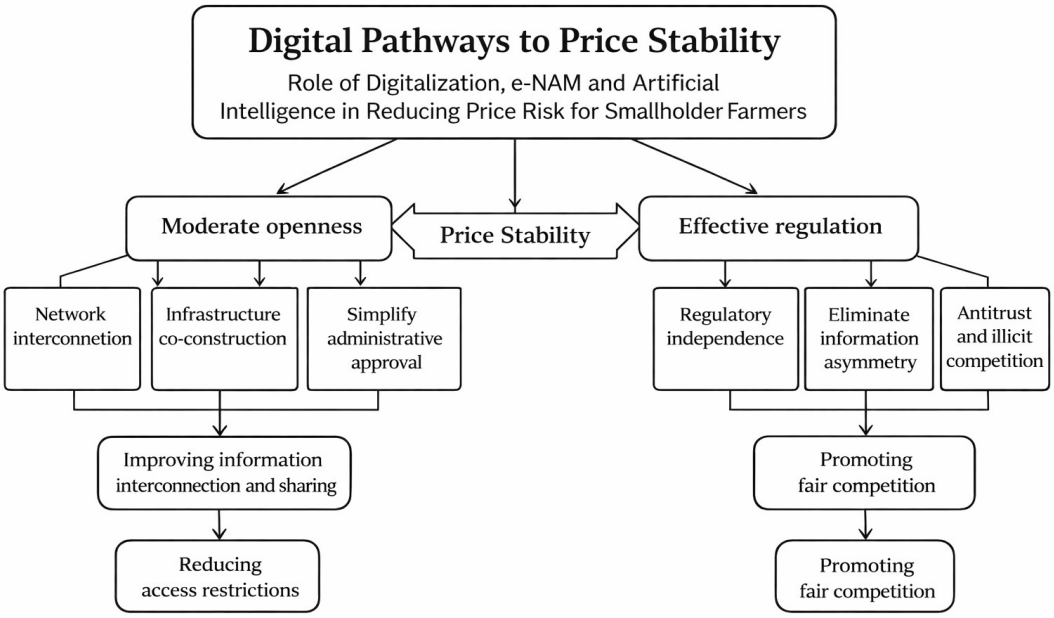

Figure. Conceptual Framework of Digital Pathways to Price Stability for Smallholder Farmers

Digitalization in Agriculture: Improving Access to Information

Digitalization in agriculture involves the use of Information and Communication Technologies (ICTs) such as mobile phones, internet services, and digital platforms to deliver agricultural information and services. Digital tools have significantly reduced the information gap between farmers and markets by enabling access to real-time data on prices, weather, crop advisories, and government schemes.

According to the FAO (2022), digital agriculture improves farmers' decision-making capacity by providing timely and location-specific information. Mobile-based applications and SMS services help farmers plan production and marketing activities more efficiently. For smallholder farmers, digitalization reduces dependence on local traders for price information and increases transparency in market transactions.

Role of ICTs in Reducing Information Asymmetry

Information asymmetry has historically disadvantaged farmers in agricultural markets, allowing traders and commission agents to dominate price discovery. ICT-based interventions address this imbalance by enabling farmers to access market prices across different mandis and regions.

Empirical evidence suggests that access to real-time price information improves farmers' bargaining power and market participation (World Bank, 2021). Digital platforms also support electronic payments and record-keeping, reducing transaction costs and delays. By improving transparency and accountability, ICTs play a critical role in mitigating price risk and enhancing income stability for smallholder farmers.

Contribution of e-NAM to Price Risk Reduction

Prior to e-NAM, agricultural markets in India were fragmented, with limited inter-state trade and significant price variation across regions. e-NAM addresses these inefficiencies by enabling farmers to access a broader range of buyers beyond their local mandis, thereby improving price realization.

e-NAM reduces price risk by promoting competition among buyers and increasing transparency in transactions. Features such as electronic weighment, quality assaying, and online payments enhance trust and efficiency in market operations. By reducing the role of intermediaries, e-NAM allows farmers to retain a larger share of the consumer price. Reports of Government of India, 2023, indicate that farmers participating in e-NAM benefit from improved price discovery and reduced transaction costs. For smallholder farmers, even marginal price improvements contribute significantly to household income and financial stability.

Artificial Intelligence

AI-Based Price Forecasting and Market Intelligence: Artificial Intelligence represents a major advancement in the use of digital technologies in agriculture. AI systems analyse large datasets—including historical prices, weather conditions, demand patterns, and logistics information—to generate predictive insights. In agricultural marketing, AI helps farmers anticipate price trends and identify optimal selling periods. The World Bank (2021) highlights AI-based price forecasting as a critical tool for managing market uncertainty. By providing early warnings of price declines or favorable market conditions, AI enables farmers to make informed decisions regarding storage, timing of sales, and market selection.

AI-driven price forecasting models use machine learning algorithms to analyse historical and real-time data. These models help predict short-term and medium-term price movements, allowing farmers to reduce losses due to unfavorable price fluctuations. Market intelligence systems powered by AI provide real-time information on prices across markets, arrival volumes, and demand trends. Such platforms enhance transparency and reduce information asymmetry, strengthening farmers' bargaining power (FAO, 2022).

Decision Support Systems for Crop and Market Planning: AI-enabled decision support systems integrate production and marketing decisions by recommending suitable crops, varieties, and marketing strategies based on expected demand and price trends. These systems help align farm output with market requirements, reducing the likelihood of oversupply and price crashes. FAO (2022) emphasizes that decision support tools are particularly beneficial for smallholder farmers, as they simplify complex data into actionable insights. When combined with digital platforms like e-NAM, these systems improve overall market efficiency.

AI in Pest Detection and Yield Stability: AI applications in pest detection and crop monitoring indirectly contribute to price stability by reducing yield losses. Research conducted at Dr. YSR Horticultural University, Andhra Pradesh, demonstrated that convolutional neural network models such as VGG-16 achieved high accuracy in detecting major insect pests in brinjal crops (Sai Kumar et al., 2021).

Early pest detection enables timely intervention, preventing crop losses and ensuring stable market supply. Yield stability reduces sudden price fluctuations caused by supply shocks, benefiting both farmers and consumers.

YouTube as a Digital Extension Tool

Digital platforms such as **YouTube** have emerged as complementary agricultural extension tools. Studies indicate that video-based content improves farmers' understanding of crop practices, pest management, and marketing strategies (Raghuprasad et al., 2022).

Research conducted in Telangana found that farmers perceived agricultural YouTube videos as moderately effective,

particularly when content quality and clarity were high. Although YouTube cannot replace formal extension services, it enhances knowledge dissemination and peer-to-peer learning.

Challenges in Adoption of Digital and AI Technologies

Despite their potential, the adoption of digitalization, e-NAM, and AI faces several challenges. Limited digital literacy, poor internet connectivity in rural areas, and lack of awareness restrict effective utilization. High initial costs and concerns regarding data reliability also hinder adoption among smallholder farmers.

FAO (2022) stresses the need for institutional support, training, and inclusive design to ensure equitable access to digital technologies. Without addressing these constraints, the benefits of digital agriculture may remain unevenly distributed.

Policy Implications and Way Forward

Policy interventions should focus on strengthening rural digital infrastructure and promoting farmer-centric digital literacy programs specially for the smallholders. Integrating AI tools with government initiatives such as e-NAM and extension services can enhance their effectiveness. The World Bank (2021) recommends public–private partnerships and support for Farmer Producer Organizations (FPOs) to scale digital solutions. Simplified interfaces, local-language content, and trust-building mechanisms are essential for widespread adoption.

CONCLUSION: TECHNOLOGY AS AN ENABLER OF INCOME STABILITY

Digitalization, e-NAM, and Artificial Intelligence are redefining agricultural marketing in India by reducing price risk and empowering smallholder farmers. These technologies improve access to market information, enhance price discovery, and support informed decision-making.

While challenges remain, evidence from global and national studies suggests that AI-driven digital agriculture can significantly contribute to income stability and sustainable development. With appropriate policy support and inclusive implementation, technology can transform smallholder farmers from price takers into informed market participants.

Declaration: The insights presented in this article are derived from collective scholarly deliberations facilitated through interactive academic engagement. They emphasize the growing importance of digitalization—particularly platforms such as e-NAM and applications of artificial intelligence—in mitigating price risk and enhancing price stability for smallholder farmers. The discussion underscores the urgency of leveraging digital pathways to strengthen market integration, improve price discovery, and promote economic resilience within agricultural systems.

The views expressed are personal and represent collective reflections emerging from group discussions, brainstorming sessions, and interactive academic activities conducted by Assistant Professor (Contractual) Sachin Rathour, RVSKVV, Gwalior.

SOURCE

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