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Digital interventions and operational challenges in green chilli (*Capsicum annuum*) marketing supply chain in Varanasi district of Uttar Pradesh

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Abstract

The present study was undertaken to examine the role of digital interventions and the operational challenges associated with the marketing supply chain of green chilli (*Capsicum annuum*) in Varanasi district of Uttar Pradesh. The study aimed to analyse the adoption of digital technologies in procurement, transportation, and market linkages, as well as to identify the major constraints affecting effective digital integration within the supply chain. The investigation was based on both primary and secondary data collected during the agricultural year 2025-2026. A combination of purposive and random sampling techniques was employed for the selection of respondents. A total of 110 green chilli growers along with wholesalers, retailers, consumers, and producers were selected from the selected villages of Chhapra block. The collected data were analysed using suitable statistical tools including Likert scale analysis and Garrett ranking technique. The findings revealed that marginal and small farmers continued to depend heavily on intermediaries, although the adoption of digital platforms had gradually increased across all farm categories. Digital technologies were observed to contribute towards reduced transportation delays, improved online booking facilities, and enhanced market accessibility. However, the impact of digital interventions on transportation cost reduction and elimination of middlemen remained comparatively limited among marginal farmers. The major constraints identified in digital adoption included poor internet connectivity, inadequate infrastructure, lack of knowledge, insufficient government support, and limited training opportunities. Respondents suggested improvement in internet facilities, provision of training programmes, subsidies, and establishment of digital training centres for strengthening supply chain efficiency. The study concluded that digital interventions possessed considerable potential to improve green chilli marketing, provided infrastructural and institutional barriers were effectively addressed.

Keywords: Green Chilli, digital interventions, supply chain management, marketing efficiency, operational challenges

Introduction

Green chilli (*Capsicum annuum*) was recognised as one of the most important commercial vegetable crops cultivated in India due to its significant contribution to agricultural income, nutritional security, and employment generation. The crop was widely grown across several states of the country because of its high market demand, adaptability to diverse agro-climatic conditions, and extensive utilisation in culinary and processing industries. In Uttar Pradesh, particularly in the Varanasi district, green chilli cultivation was considered an important source of livelihood for small and marginal farmers. However, the marketing supply chain of green chilli was characterised by several operational inefficiencies, including price fluctuations, inadequate market information, poor storage facilities, transportation constraints, and the involvement of multiple intermediaries, which adversely affected farmers' profitability. In recent years, digital interventions such as mobile-based advisory services, digital marketplaces, online payment systems, and information and communication technologies were increasingly adopted to improve supply chain efficiency and market accessibility. These technological interventions were

observed to enhance communication, reduce information asymmetry, strengthen market linkages, and facilitate better decision-making among stakeholders. Despite these advancements, several operational challenges related to digital literacy, internet connectivity, infrastructure limitations, and limited awareness among farmers continued to hinder the effective implementation of digital technologies in the green chilli marketing supply chain in the study area.

Research methodology

The selection of the district, block, villages, and respondents was carried out through the application of both purposive and random sampling techniques. Varanasi district was purposively selected with the intention of reducing logistical difficulties and minimising time-related constraints during the course of the study. Among the various blocks within the district, Chhapra block was deliberately chosen owing to the comparatively higher concentration of farmers engaged in green chilli cultivation. Thereafter, a comprehensive list of villages within the selected block was prepared, and five per cent of the villages possessing a

relatively larger population of green chilli growers were selected through random sampling techniques.

Subsequently, a complete list of green chilli cultivators from the selected villages was compiled and classified into five categories on the basis of operational landholding size, namely marginal (below 1 hectare), small (1.01-2.00 hectares), semi-medium (2.01-4.00 hectares), medium (4.01-10.00 hectares), and large (above 10 hectares). From this sampling frame, a total of 110 farmers were selected using proportionate random sampling methods. In addition, 10 wholesalers, 5 retailers, 10 consumers, and 5 producers were selected in order to examine digital interventions and operational challenges prevailing in the study area. Primary data were collected through direct personal interviews with the aid of a well-structured interview schedule, whereas secondary data were obtained from books, research journals, government reports, and official records maintained at

district and block headquarters. The collected data were analysed using suitable statistical tools and techniques, and the findings of the study pertained to the agricultural year 2025-2026.

Analytical Tools

- **Likert scale:** A Likert scale is a rating scale used to assess opinions, attitudes, or behaviors. To collect data, you present participants with Likert-type questions or statements and a continuum of possible responses, usually with 5 or 7 items. Each item is given a numerical score so that the data can be analysed quantitatively.
- **Garrett Ranking:** Per cent position = $100 (R_{ij} - 0.5) / N_j$

Results and discussion

Table 1: Distribution of respondents based on procurement methods.

Sr. No.	Category	Direct Selling	Through Agents	Digital Platforms
1	Marginal	16	28	20
2	Small	14	18	18
3	Semi-medium	11	10	12
4	Medium	7	5	8
5	Large	4	1	4

Table 1: The present table shows the distribution of respondents based on procurement methods adopted by Green Chilli (*Capsicum annuum*) farmers across different landholding categories. It was observed that a majority of marginal farmers relied on agents (28), followed by digital platforms (20) and direct selling (16), indicating continued dependence on intermediaries despite growing digital adoption. Small farmers also showed higher dependence on agents (18) and digital platforms (18), with relatively lower engagement in direct selling (14). Semi-medium farmers demonstrated a more balanced distribution across all methods, with a slight preference for digital platforms (12). Medium and large farmers exhibited a greater inclination towards direct selling and digital platforms compared to agents, reflecting better market access and bargaining power.

Table 2: Distribution of respondents based on impact on middlemen reduction.

Sr. No.	Category	Reduced	Not Reduced
1	Marginal	18	28
2	Small	16	16
3	Semi-medium	10	8
4	Medium	7	3
5	Large	4	0

Table 2: The present table shows the distribution of respondents based on the impact of digital technology on the reduction of middlemen among Green Chilli (*Capsicum annuum*) farmers. It was observed that a majority of marginal farmers reported that middlemen had not been reduced (28), while only 18 indicated a reduction, suggesting limited effectiveness of digital tools in eliminating intermediaries for smallholders. Among small farmers, the responses were equally divided, with 16 respondents each reporting reduction and no reduction,

indicating a transitional stage in market practices. Semi-medium farmers showed relatively better outcomes, with more respondents (10) experiencing reduction compared to those who did not (8). Medium and large farmers demonstrated a stronger impact, with most respondents reporting a reduction in middlemen, particularly all large farmers (4).

Table 3: Distribution of respondents based on transport facilities improvement.

Sr. No.	Category	GPS Use	Online Booking	Reduced Delay
1	Marginal	15	20	22
2	Small	14	18	20
3	Semi-medium	10	12	13
4	Medium	7	8	8
5	Large	3	4	4

Table 3: The present table shows the distribution of respondents based on improvements in transport facilities through digital technology among Green Chilli (*Capsicum annuum*) farmers. It was observed that marginal farmers reported the highest benefits in terms of reduced delay (22), followed by online booking (20) and GPS usage (15), indicating that digital tools had significantly enhanced transportation efficiency for smallholders. Small farmers also experienced similar improvements, with reduced delay (20) and online booking (18) being the most prominent benefits. Semi-medium farmers showed moderate adoption across all aspects, while medium and large farmers reported comparatively lower usage levels. Among the different parameters, reduced delay emerged as the most significant improvement across all categories, highlighting the effectiveness of digital technology in streamlining logistics. GPS usage, although beneficial, was less widely adopted compared to other aspects.

Table 4: Distribution of respondents based on response of respondents transportation cost reduction.

Sr. No.	Category	Reduced	Not Reduced
1	Marginal	20	26
2	Small	18	14
3	Semi-medium	12	6
4	Medium	7	3
5	Large	3	1

Table 4: The present table shows the distribution of respondents based on their perception of transportation cost reduction through digital technology among Green Chilli (*Capsicum annuum*) farmers. It was observed that a majority of marginal farmers reported that transportation costs had not been reduced (26), while 20 respondents indicated a reduction, suggesting limited impact among this group. In contrast, small farmers showed a more positive response, with 18 respondents reporting reduced costs compared to 14 who did not. Semi-medium farmers demonstrated a stronger impact, with twice as many respondents (12) experiencing cost reduction compared to those who did not (6). Medium and large farmers also reported notable benefits, with a majority indicating reduced transportation costs.

Table 5: Constraints in Digital Adoption

Sr. No.	Constraints	Garrett Score	Rank
1	Poor Internet	16.34	I
2	Poor Infrastructure	16.34	I
3	Lack of Knowledge	14.85	II
4	Lack of Govt. Support	14.11	III
5	Lack of Training	13.86	IV
6	Limited Credit Access	13.12	V

Table 5: The table presented the ranking of constraints in digital adoption among Green Chilli (*Capsicum annuum*) farmers based on Garrett scores. It was observed that poor internet connectivity and poor infrastructure jointly ranked first, each with a Garrett score of 16.34, indicating that these were the most critical barriers hindering the adoption of digital technologies. Lack of knowledge ranked second with a score of 14.85, highlighting limited awareness and understanding among farmers. Lack of government support was ranked third (14.11), followed by lack of training (13.86), suggesting gaps in institutional and capacity-building efforts. Limited access to credit (13.12) was ranked fifth, indicating financial constraints in adopting digital tools. High cost, with the lowest score of 11.39, was ranked sixth, implying it was a relatively less severe constraint compared to others.

Table 6: Suggestion to improve supply chain management using digital technology.

Sr. No.	Factors	Total Score	Rank
1	Improve Internet	78	I
2	Training	77	II
3	Subsidy	66	III
4	Awareness	60	IV
5	Digital Training Centers	70	V
6	Subsidized Apps	62	VI
7	Market Linkage Support	56	VII

Table 6: The present table shows the suggestions for improving supply chain management using digital technology based on total scores and rankings. It was observed that improving internet connectivity ranked first with the highest score (78), indicating that better digital infrastructure was considered the most critical requirement by respondents. Training was ranked second (77), highlighting the need to enhance farmers' skills and capacity to effectively use digital tools. Digital training centers, with a score of 70, were also emphasized as an important support mechanism, though ranked fifth, suggesting a need for localized training facilities. Subsidy (66) and subsidized apps (62) were ranked third and sixth respectively, reflecting financial support requirements for adopting digital technologies. Awareness (60) and market linkage support (56) were ranked fourth and seventh, indicating relatively lower but still significant importance.

Conclusion

The present study concluded that digital interventions had emerged as an important mechanism for improving the marketing supply chain of green chilli (*Capsicum annuum*) in Varanasi district. The findings indicated that the adoption of digital technologies such as online marketing platforms, mobile-based advisory services, GPS facilities, and online transportation booking systems had positively influenced market accessibility, communication efficiency, and transportation management among farmers. It was observed that marginal and small farmers still relied considerably on intermediaries for the disposal of their produce, whereas medium and large farmers demonstrated greater utilisation of direct selling and digital platforms due to comparatively better market exposure and bargaining capacity. Digital interventions were found to reduce transportation delays and improve logistical coordination; however, their effectiveness in reducing transportation costs and eliminating middlemen remained limited, particularly among marginal farmers. The study further revealed that infrastructural deficiencies, especially poor internet connectivity and inadequate digital infrastructure, constituted the most severe barriers restricting wider adoption of digital technologies. In addition, lack of knowledge, insufficient training, limited institutional support, and restricted access to credit adversely affected farmers' ability to effectively utilise digital tools within the supply chain. The suggestions provided by respondents highlighted the urgent need for strengthening internet connectivity, organising regular training programmes, establishing digital training centres, and extending financial support through subsidies and subsidised digital applications. Overall, the study demonstrated that digital technologies possessed substantial potential to enhance transparency, efficiency, and market integration in the green chilli supply chain. Nevertheless, sustainable improvement in digital adoption and operational efficiency required coordinated efforts from government agencies, extension institutions, and market stakeholders to address infrastructural, educational, and financial constraints prevailing in the study area.

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