Research Article:

USE OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) ACROSS THE VEGETABLE VALUE CHAIN IN CHITWAN, NEPAL

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ABSTRACT

Integration of Information and Communication Technology (ICT) is essential for enhancing agricultural value chains, with improved efficiency, stronger coordination, and timely access to reliable information. This study examined ICT use across the vegetable value chain in Chitwan, Nepal, focusing on device ownership, platform utilization, perceived benefits, challenges, and digital literacy among input suppliers, farmers, collectors, wholesalers, retailers, and consumers. Data were collected from 134 farmers and 58 other value chain actors using a semi-structured interview schedule and analyzed through frequency calculation. Results revealed universal ownership of mobile phones, radios, and televisions, but farmers' access to smartphones and the internet was lower than that of other actors. Farmers mainly used ICT for crop calendars and real-time market prices, while other actors extensively employed ICT for market communication, logistics, and price negotiation. Although 73.13% of farmers reported improved decision-making, only 37.31% observed higher income. Key challenges among farmers included lack of training, language barriers, and irrelevant content. No actors had received formal ICT training, and farmers' digital literacy was lower than that of input suppliers and wholesalers. The study highlights a critical need for targeted ICT training, localized content, and improved extension services to enhance digital literacy and facilitate effective ICT adoption, thereby increasing the associated benefits within the vegetable value chain.

सारांश

कृषि मूल्य श्रृङ्खला सुदृढ गर्न सूचना तथा सञ्चार प्रविधि (आईसीटी) अत्यावश्यक छ। यस अध्ययनले चितवन जिल्लामा तरकारी मूल्य श्रृङ्खलामा सूचना तथा सञ्चार प्रविधि प्रयोगको अवस्थालाई उजागर गर्ने प्रयास गरेको छ । यस अध्ययनले उपकरण स्वामित्व, प्लेटफर्मको उपयोग, लाभप्रतिको धारणा, चुनौतीहरू र डिजिटल साक्षरतामा ध्यान दिइएको छ । सामग्री आपूर्तिकर्ता, किसान, सङ्कलक, थोक व्यापारी, खुद्रा व्यापारी तथा उपभोक्तासहितका सरोकारवालाहरूलाई समेटी २०२५ मा १३४ जना किसान र ५८ जना अन्य मूल्य श्रृङ्खला सरोकारवालाबाट अर्ध-संरचित अन्तर्वार्ता फाराम प्रयोग गरी तथ्याङ्क सङ्कलन गरिएको थियो । उक्त तथ्याङ्कलाई आवृत्ति गणनाद्वारा विश्लेषण गरिएको थियो । अध्ययनको नतिजाले सबै सरोकारवालाहरूसँग मोबाइल फोन, रेडियो र टेलिभिजन भए तापनि स्मार्टफोन र इन्टरनेटमा किसानहरूको पहुँच न्यून देखाएको थियो । किसानहरूले मुख्यतया बाली पात्रो र समसामयिक बजार मूल्यका लागि आईसीटी प्रयोग गरेका थिए भने अन्य सरोकारवालाले बजार सञ्चार, ढुवानी र मूल्य वार्ताका लागि आईसीटी प्रयोग गरेका थिए । करिब ७३.१३% किसानहरूले निर्णय क्षमता सुधार भएको बताएका थिए तर ३७.३१% ले मात्र आम्दानी बढेको अनुभव गरेका थिए । किसानहरूले प्रशिक्षण अभाव, भाषागत समस्या र अप्रासङ्गिक सामग्रीलाई मुख्य चुनौतीका रूपमा पहिचान गरे । कुनै पनि सरोकारवालाले औपचारिक आईसीटी तालिम पाएका थिएनन् र किसानहरूको डिजिटल साक्षरता इनपुट आपूर्तिकर्ता र थोक व्यापारीभन्दा कम थियो । यस अध्ययनले लक्षित

आईसीटी तालिम, स्थानीय सामग्री विकास र विस्तार सेवाको सुदृढीकरणद्वारा डिजिटल साक्षरता वृद्धि गरी प्रभावकारी आईसीटी अपनत्वलाई प्रोत्साहन गर्न आवश्यक रहेको छ, जसले तरकारी मूल्य श्रृङ्खलाभित्र लाभ बढाउन सहयोग पुऱ्याउनेछ ।

Keywords: Adoption, extension, farmer, training

INTRODUCTION

The agriculture sector has become increasingly information-driven, requiring diverse scientific and technological inputs for effective decision-making (Avşar & Mowla, 2022; Tao et al., 2021). Timely and reliable information supports agricultural development by improving production planning, post-harvest management, marketing efficiency, and cultivation practices (Le et al., 2020; Liu et al., 2021). With the growing use of ICTs across all stages of the agricultural value chain, stakeholders gain access to accurate and up-to-date data that enhances food security, profitability, and environmental sustainability (El jaouhari et al., 2024; Janssen et al., 2017). ICT applications enable precision farming, low-carbon production techniques, and real-time monitoring in production and processing, while also reducing waste, optimizing logistics, and strengthening decision-making across the supply chain (El Bilali & Allahyari, 2018; Sharma et al., 2020). At the consumption stage, ICTs facilitate traceability, agro-e-commerce, and circular economy practices (Liu et al., 2021).

Emerging technologies such as blockchain, big data, IoT, AI, and cloud computing are increasingly integrated to improve coordination among value chain actors. Input suppliers benefit from ICT-enabled logistics, inventory systems, e-vouchers, and digital land platforms that enhance access and transparency (McLaren & Stanley, 2017; Smale et al., 2015). Farmers adopt GPS, sensors, drones, and mobile applications for precision agriculture, yield forecasting, and post-harvest loss reduction (Heege, 2015; Wolfert et al., 2017). They also access mobile-based financial services such as M-PESA (Baumüller, 2018; Kikulwe et al., 2014) and digital extension platforms that provide timely agronomic advice (Aker, 2011; Cole & Fernando, 2012). Traders and collectors use ICTs for logistics coordination and harvest pooling, lowering transaction costs (Miller et al., 2013). Wholesalers rely on market information systems such as M-Farm and Reuters Market Light to improve traceability, certification, and market access (Baumüller, 2015; Liu Tong et al., 2015). Retailers increasingly connect directly with consumers through farm-to-consumer models, which enhance transparency and trust (Karippacheril et al., 2017; Talavera et al., 2017). Collectively, these innovations improve the efficiency and resilience of agri-food systems while contributing to climate change mitigation through decarbonized production (El jaouhari et al., 2024).

Despite these advances, agricultural value chains in developing countries still face information gaps that limit inclusiveness and efficiency (Van Campenhout, 2022). Early ICT interventions that focused mainly on price information produced mixed results due to structural barriers such as weak transport infrastructure and limited trader access (Aker, 2010; Fafchamps & Minten, 2012; Jensen, 2007). While traders are often perceived as exploitative, studies show they play a critical intermediary role, with the problem being too few traders rather than too many (Sitko & Jayne, 2014). More recent ICT innovations that improve information flows, such as signaling farmgate prices to traders, have enhanced competition and farmer incomes (Ochieng & Baulch, 2020). Input markets also struggle with counterfeit products, but e-verification and crowdsourced rating systems have strengthened trust, quality assurance, and adoption of improved technologies (Bagamba et al., 2021; Bold et al., 2017; Gilligan et al., 2019). Thus, the success of ICT interventions depends not only on technological adoption but also on addressing structural and institutional constraints.

The Agriculture Development Strategy (ADS) of Nepal (2015–2035) emphasizes that the modernization of the agricultural value chain depends on information infrastructure and information and communication technology (ICT) systems, not just on traditional view of physical infrastructure (like roads and facilities). It advocates integrating digital tools with traditional agricultural development to enhance connectivity, efficiency, and market access. ADS highlights the critical role of ICT in transforming Nepalese agriculture aiming to support the transition from subsistence-oriented farming to commercial agribusiness. It underscores that ICT strengthens efficiency, competitiveness, and market connectivity across the agricultural value chain, while positioning information infrastructure and ICT as foundational components of its framework for accelerating agricultural growth (MoAD, 2016).

The implementation of ICT Policy (2072), Digital Framework Nepal, and initiatives such as the Project for Agriculture Commercialization and Trade (PACT) and Agriculture Management Information System (AMIS) under MoALD have significantly expanded farmers' access to ICT tools in Nepal (Mishra et al., 2024). Agricultural applications like Smart Krishi, Krishi Ghar, IFA Krishi, and digital payment platforms such as eSewa and mobile banking are supporting farm management and transactions. Call centers operated by universities and government institutions, along with scheduled programs like *Krishi Karyakram* broadcast via radio and TV, are effectively reaching farming communities. Modern platforms such as Facebook, TikTok, and YouTube facilitate information sharing, while WhatsApp and Viber provide cost-effective communication. Additionally, agricultural websites are enhancing awareness of new innovations and best practices.

Vegetables are an important subsector of Nepalese agriculture, contributing 14.46% to the agricultural GDP in FY 2080/81 (2023/24) (MoALD, 2024). Vegetable productivity is severely affected by the low extension coverage, untimely availability of information from traditional extension services, as well as the moderate level of satisfaction among farmers with their existing access to information (Niraula et al., 2023). ICT is important for highly perishable fresh vegetables that are sensitive to timeliness in supply, susceptible to damage in transit and require a quick response at the supply end (Chung et al., 2013). ICT can play a vital role to reduce information gaps and strengthen linkages among actors in the value chain, including farmers, traders, input suppliers, and consumers (Waqar et al., 2018).

Previous studies on ICT and agriculture have largely focused on farmers (Dhungana, 2024; Mishra et al., 2023; Mishra, 2024; Singh & Aryal, 2023), leaving its application among other value chain actors understudied. Moreover, empirical evidence on the use of ICT across different stages of the vegetable value chain remains limited. This study will assist policymakers and extension agencies in designing targeted interventions to improve efficiency, information flow, and overall value chain performance. The study includes an assessment of device ownership and ICT access by value chain actors, platform utilization patterns by value chain actors, learning about the integration of ICT in agriculture, use of ICT across the different stages by value chain actors, use of ICT and related platforms across the stages, perceived benefits from the use of ICT by value chain actors, challenges in the use of ICT by value chain actors, self-rated digital literacy by value chain actors, training on the use of ICT in agriculture, support desired by value chain actors in the use of ICT, and the effectiveness of current extension services in promoting the use of ICT.

RESEARCH METHODS

The research was conducted in Chitwan district, a major vegetable-producing region in central Nepal (MoALD, 2024). Further, Bharatpur Metropolitan (ward number 4, 5, 6, 8, 11, 12) were purposively selected due to their accessibility to vegetable markets, prominence in vegetable farming, availability of input suppliers and growing exposure to ICT such as smartphones, mobile applications, and digital market information systems.

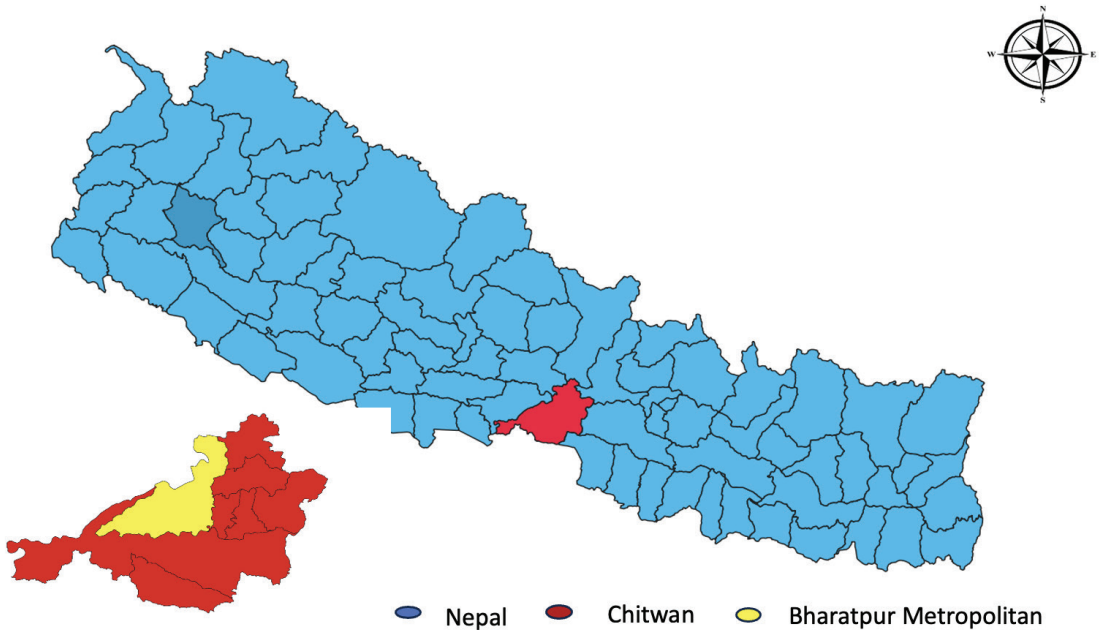

Fig. 1. Map of Nepal showing the study area

A total of 783 farm households were considered the population for the study. To calculate sample size, we used the formula (Daniel, 1999);

$n = N*X / (X + N - 1)$,

Where,

$X = Z_{\alpha/2}^2 *p*(1-p) / MOE^2$,

and $Z_{\alpha/2}$ is the critical value of the Normal distribution at α/2, MOE is the margin of error, p is the sample proportion, and N is the population size.

A simple random sampling technique was employed to select farming households. In addition to farming households, the study included other key stakeholders within the vegetable value chain selected using snowball sampling technique. These stakeholders were agricultural input suppliers, collectors, wholesalers, retailers, and consumers. A total of 192 respondents were selected, with 134 farmers, 12 input suppliers, 5 collectors, 10 wholesalers, 11 retailers and 20 consumers. In June-August 2025, semi-structured interview schedule was carried out to gather the information from the respondents, similarly, 5 Focus Group Discussion (FGDs) and 10 Key Informant Interviews (KIIs) were carried out to validate and compliment the information gathered through interview schedule. FGDs were carried out in a group of 6-8 members including both male and female. Similarly, KIIs were carried out with executives of agricultural cooperatives, ICT service providers, progressive farmers, local representatives and extension workers. The qualitative insights from FGDs and KIIs were not analyzed separately but were used to support, explain, and enrich the interpretation of survey results. Secondary data were gathered from reports of Agriculture Development Office (ADO) Chitwan, Prime Minister Agriculture Modernization Project (PMAMP) Chitwan, and other published research papers from different authors. Frequency calculation was the sole means to present the findings.

RESULTS AND DISCUSSION

Socio-demographic characteristics of the respondents

The socio-demographic characteristics of the value chain actors reveal notable variations across gender, age, education, ethnicity, and income levels (Table 1 and Table 2). Male dominance was evident among input suppliers (83.3%), collectors (100%), wholesalers (80%), and farmers (59.7%). In contrast, a higher proportion of females was observed among consumers (60%) and retailers (45.5%). Most actors were within the age group of 41–59 years. This age group was dominant among input suppliers (66.7%) and collectors (80%). Farmers were almost evenly distributed between ≤40 years (47.8%) and 41–59 years (47.8%), indicating participation from both younger and middle-aged groups. Wholesalers (40%) and retailers (54.5%) were primarily middle-aged (41–59 years), while consumers were mostly concentrated in the 41–59 years group (70%), with 10% aged ≥60 years.

In terms of education, 66.7% of input suppliers had higher secondary education and 25% were graduates. Farmers had a more diverse profile, with 37.3% having secondary education, 29.9% higher secondary, and 28.3% with only primary education or no formal education. Collectors mostly had secondary (60%) or higher secondary education (40%). Among wholesalers and consumers, 50% and 60% had higher secondary education, respectively, while 40% of consumers had graduate degrees. Retailers, however, had comparatively lower educational attainment, with 72.7% educated only up to the secondary level.

Table 1. Socio-demographic characteristics of the value chain actors (input suppliers, farmers and collectors)

Variables	Input supplier (n=12)	Farmer (n=134)	Collector (n=5)
Gender			
Male	10 (83.3)	80 (59.7)	5 (100)
Female	2 (16.7)	54 (40.3)	0 (0)
Age			
≤40	4 (33.3)	64 (47.8)	1 (20)
41–59	8 (66.7)	64 (47.8)	4 (80)
≥60	0 (0)	6 (4.4)	0 (0)
Education			
Illiterate	0 (0)	6 (4.4)	0 (0)
Primary	0 (0)	32 (23.9)	0 (0)
Secondary	1 (8.3)	50 (37.3)	3 (60)
Higher secondary	8 (66.7)	40 (29.9)	2 (40)
Graduate	3 (25)	6 (4.5)	0 (0)
Ethnicity			
Brahmin	7 (58.4)	60 (44.7)	2 (40)
Chhetri	1 (8.3)	26 (19.4)	3 (60)
Janajati	4 (33.3)	40 (29.9)	0 (0)
Dalit	0 (0)	8 (6)	0 (0)
Annual Income (NPR)			
<500,000	0 (0)	26 (19.4)	0 (0)
500,000–1,000,000	5 (41.7)	42 (31.3)	3 (60)
>1,000,000	7 (58.3)	66 (49.3)	2 (40)

Source: Field survey, 2025

Note: Figures in parentheses indicate percentage

The dominance of Brahmin and Chhetri groups was observed in most activities. Brahmins constituted the majority among input suppliers (58.4%), farmers (44.7%), wholesalers (60%), and consumers (40%). Chhetris were 60% among collectors and wholesalers (30%). Similarly, Janajatis among farmers (29.9%), retailers (36.4%), and consumers (40%). Dalit representation was observed only in farming (6%).

Annual income levels varied across actors. A majority of input suppliers (58.3%) and wholesalers (60%) earned above NPR 1,000,000 annually. Similarly, 49.3% of farmers earned above NPR 1,000,000, while 19.4% earned less than NPR 500,000. Among collectors, 60% earned between NPR 500,000 and 1,000,000. Retailers also showed similar trends, with 63.6% earning between NPR 500,000 and 1,000,000. Among consumers, 50% earned between NPR 500,000 and 1,000,000, while 20% earned below NPR 500,000.

Table 2. Socio-demographic characteristics of value chain actors (wholesalers, retailers, and consumers)

Variables	Wholesaler (n=10)	Retailer (n=11)	Consumer (n=20)
Gender			
Male	8 (80)	6 (54.5)	8 (40)
Female	2 (20)	5 (45.5)	12 (60)
Age			
≤40	6 (60)	5 (45.5)	4 (20)
41–59	4 (40)	6 (54.5)	14 (70)
≥60	0 (0)	0 (0)	2 (10)
Education			
Illiterate	0 (0)	0 (0)	0 (0)
Primary	1 (10)	3 (27.3)	0 (0)
Secondary	3 (30)	5 (45.4)	0 (0)
Higher secondary	5 (50)	3 (27.3)	12 (60)
Graduate	1 (10)	0 (0)	8 (40)
Ethnicity			
Brahmin	6 (60)	4 (36.4)	8 (40)
Chhetri	3 (30)	3 (27.2)	4 (20)
Janajati	1 (10)	4 (36.4)	8 (40)
Dalit	0 (0)	0 (0)	0 (0)
Annual Income (NPR)			
<500,000	0 (0)	1 (9.1)	4 (20)
500,000–1,000,000	4 (40)	7 (63.6)	10 (50)
>1,000,000	6 (60)	3 (27.3)	6 (30)

Source: Field survey, 2025
Note: Figures in parentheses indicate percentage

Farming experience of farmers

Table 3 presents the farming experience of the farmers. Results showed that 29.85% had 1-5 years, 22.39% had 6-10 years, 25.37% had 11-15 years, and 22.39% had 16 and more years of experience.

Table 3. Farming experience of farmers (n=134)

Experience (years)	Frequency
1-5	40 (29.85)
6-10	30 (22.39)
11-15	34 (25.37)
≥16	30 (22.39)

Source: Field survey, 2025
Note: Figures in parentheses indicate percentage

Farm size of farmers

Table 4 presents the farm size of the farmers. Results showed that 47.77% of the farmers cultivated more than 0.5 ha, while 37.31% farmed 0.25-0.50 ha, and only 14.92% had less than 0.25 ha.

Table 4. Farm size of farmers (n=134)

Farm size (ha)	Frequency
<0.25	20 (14.92)
0.25-0.50	50 (37.31)
>0.50	64 (47.77)

Source: Field survey, 2025
Note: Figures in parentheses indicate percentage

Farmers access to institutional support

Table 5 presents farmers' access to institutional support. Farmers demonstrated strong institutional engagement, with 97.01% membership in agricultural cooperatives, 91.04% have regular contact with extension workers, and 88.05% have access to credit.

Table 5. Farmers access to institutional systems (n=134)

Indicator	Frequency
Cooperative membership	130 (97.01)
Extension contacts	122 (91.04)
Credit access	118 (88.05)

Source: Field survey, 2025
Note: Figures in parentheses indicate percentage

Device ownership and ICT access by value chain actors

Table 6 presents the device ownership and access to ICT by value chain actors. Mobile phones, radio and TV were owned by all value chain actors. Access to smartphones was lower among farmers (89.55%) than other actors (100%). Similarly, internet connections were reported by 89.55% of farmers compared to 100% access among other actors. Access to tablets was lower among all actors. These findings align with Kimani and Minishi-Majanja (2024), which reported that mobile phones are widely used among value chain actors, while access to smartphones and tablets is more limited among farmers. This is because smartphones and tablets are relatively more expensive, require higher digital skills, and depend on stable internet connectivity, factors that remain limited among smallholder farmers. Mobile phones, on the other hand, are more affordable, easier to operate, and function well even with basic network coverage, making them the most accessible ICT tool for value chain actors.

Table 6. Device ownership and ICT access by value chain actors

Device/Service	Input supplier	Farmer	Collector	Wholesalers	Retailer	Consumer
Mobile Phone	100	100	100	100	100	100
Smartphone	100	89.55	100	100	100	100
Radio	100	100	100	100	100	100
Television	100	100	100	100	100	100
Computer	100	59.7	100	100	100	100
Tablet	16.66	35.82	40	10	18.18	40
Internet connection	100	89.55	100	100	100	100

Source: Field survey, 2025

Note: Figures in parentheses indicate percentage

Platform utilization patterns by value chain actors

Table 7 presents the platform utilization patterns by value chain actors. Results showed that mobile SMS, phone calls, and social media (Facebook, TikTok, WhatsApp, Viber) were widely used by all actors. Among farmers, 86.6% used Facebook, and 83.6% used YouTube. However, agricultural websites were rarely accessed (29.85%), showing preference for easy-to-use platforms over specialized sites. The result is similar to the findings of Raja MadhuShekar et al. (2023).

Table 7. Platform utilization patterns by value chain actors

Platform	Input supplier	Farmer	Collector	Wholesaler	Retailer	Consumer
Mobile SMS	100	98.50	100	100	100	100
Phone call	100	100	100	100	100	100
Mobile apps	100	88.05	0	100	100	0
Facebook	100	86.56	0	100	100	0
YouTube	100	83.58	0	100	100	0
WhatsApp	100	79.10	100	100	100	0
Viber	100	79.10	100	100	100	0
TikTok	100	86.56	100	100	100	100
Agricultural websites	50	29.85	0	0	18.18	0

Source: Field survey, 2025

Note: Figures in parentheses indicate percentage

Learnt about integration of ICT in agriculture

Table 8 presents the learning source about integration of ICT in agriculture. Results revealed that, most farmers (79.1%) reported self-learning, with media (22.38%) as another major source. None cited extension workers, training, or NGOs. This indicates lack of formal capacity-building interventions and reliance on informal learning.

Table 8. Learnt about integration of ICT in agriculture

Sources	Input supplier	Farmer	Collector	Wholesaler	Retailer	Consumer
Extension workers	0	0	0	0	0	NA
Fellow farmer	0	23.88	0	0	0	NA
Training	0	0	0	0	0	NA
I/NGO	0	0	0	0	0	NA
Self	100	79.10	80	100	100	50
Media	50	22.38	20	20	27.27	50

Source: Field survey, 2025

Note: Figures in parentheses indicate percentage; NA indicate response not applicable for the particular question

Use of ICT across the different stages by value chain actors

Table 9 highlights how ICT is applied across production, post-harvest management, and marketing by different value chain actors. The results revealed distinct use-pattern, with farmers using ICT for agronomic guidance and price information (Ayim et al., 2022; Goal & Gustira, 2020; Kamala et al., 2019; Sethy & Mukhopadhyay, 2020), while traders, wholesalers, and retailers using ICT for market coordination, logistics, and negotiation (El Bilali et al., 2019; Liu et al., 2021; Zhang et al., 2016).

Among farmers, use of ICT was highest for crop calendars (76.1%), followed by accessing real-time market prices (46.3%), pest and disease management (23.9%), and soil management tips (19.4%). Only 4.5% of farmers used ICT for weather forecasts and to decide harvesting time. Use of ICT for advisory services on irrigation scheduling and fertilizer/pesticide were completely absent. Results highlight that use of ICT is primarily confined to planning and market-related decisions rather than input optimization. The low use of ICT for services on weather, irrigation, and input recommendations highlights either the absence of localized content or limited farmer awareness.

Use of ICT to access new technologies was reported by all of the input suppliers (100%), and 66.7% were using ICT for obtaining real-time market prices, while 58.3% were using ICT for booking logistics and 91.7% were using for customer feedback. However, only 8.3% tracked delivery or logistics in real time.

Collectors showed strong dependency on ICT for transport and market coordination, as all (100%) used ICT for booking logistics and price negotiation, while 80% tracked deliveries and 40% used ICT for grading, sorting and packaging.

Table 9. Use of ICT across the different stages by value chain actors

Application	Input supplier	Farmer	Collector	Wholesaler	Retailer	Consumer
Locate input suppliers	NA	19.40	NA	NA	NA	NA
Compare input prices	NA	26.86	NA	NA	NA	NA
Recommendation on inputs	NA	13.43	NA	NA	NA	NA
Weather forecasts	NA	4.47	NA	NA	NA	NA
Crop calendar	NA	76.11	NA	NA	NA	NA
Irrigation advice	NA	0	NA	NA	NA	NA
Fertilizer/pesticide schedules	NA	0	NA	NA	NA	NA
Soil testing/ management tips	NA	19.40	NA	NA	NA	NA
Pest/disease management	NA	23.88	NA	NA	NA	NA
Access to new technology	100	31.34	NA	NA	NA	NA
Decide harvesting time	NA	4.47	NA	NA	NA	NA
Grading/sorting techniques	NA	10.44	40	40	0	NA
Packaging and storage tips	NA	13.43	40	40	0	NA
Book transport/logistics	58.33	0	100	100	0	NA
Track delivery/manage logistics	8.33	0	80	70	0	NA
Real time market price	66.66	46.26	100	80	81.81	30
Market communication	100	97.01	100	100	100	30
Advertise online	100	11.94	40	60	90.90	NA
Price negotiation	100	59.70	100	100	100	0
Payment	100	89.55	100	100	100	100
Feedback	91.66	16.41	80	40	0	0

Source: Field survey, 2025

Note: Figures in parentheses indicate percentage; NA indicate response not applicable for the particular question

Wholesalers also showed significant use of ICT, with 100% using it for market communication, price negotiation, and logistics booking. Similarly, 80% used ICT for accessing real-time prices, 70% for tracking delivery and 40% used ICT for grading and packaging. These results highlight that ICT provides wholesalers with significant market power, enabling them to streamline supply chains and maintain control over pricing and distribution through improved communication, pricing, and logistics management (Ceynowa et al., 2023; Song et al., 2021).

Retailers showed significant use of ICT for price negotiation (100%), market communication (100%), and advertising (90.9%). However, they did not use ICT for grading, storage, or logistics. Their adoption of online advertising highlights the growing role of ICT in direct-to-consumer marketing models.

Consumers primarily used ICT for transparency, with 30% reported checking real-time prices and using platforms for communication. This reflects consumer reliance for price information and trust.

Use of ICT and related platform across the stages

Table 10 presents the use of ICT and related platforms across the stages. The results reveal that value chain actors use a wide range of ICT tools and digital platforms at different stages of agricultural production, post-harvest, and marketing.

At the input stage, traditional approaches like phone calls and modern platforms such as Facebook, WhatsApp, Viber and TikTok were used to locate input suppliers and compare prices. Recommendations on input use were mostly obtained through phone calls, WhatsApp, and Viber reflecting trust in direct, personalized communication.

For production-related decisions, like information on weather forecasts were gathered through both traditional media **(**TV, radio**)** and modern platforms **(**Facebook, mobile apps**)**. Crop calendars and soil management tips were accessed mainly through agricultural websites, Facebook, TikTok, YouTube, and phone calls**,** suggesting reliance on both formal and informal channels. Similarly, pest and disease management information was gathered through social media (Facebook, TikTok, YouTube, WhatsApp, Viber) along with phone calls, and agricultural websites**,** reflecting a combination of peer-to-peer learning and expert resources.

Information on irrigation, fertilizer/pesticide schedules, and new technologies**,** were accessed through Facebook, TikTok, YouTube, and phone calls**,** with some dependence on TV and websites**,** indicating that audiovisual content is increasingly preferred for practical demonstrations.

In the harvesting and post-harvest stages, decisions on harvesting time were accessed through TV, radio, and Facebook**,** while information related to grading, sorting, packaging, and storage was accessed through Facebook, TikTok, YouTube, TV, and agricultural websites.

For marketing and logistics, traditional phone calls remained the most dominant tool, especially for booking transport, tracking delivery, and accessing real-time market prices. WhatsApp, Viber mobile SMS, and mobile apps also played significant roles in enhancing coordination and efficiency. Market communication and price negotiation involved use of phone calls, WhatsApp, Viber, Facebook, TikTok, and mobile SMS. Online advertisement was on TikTok and Facebook**,** which are widely used platforms. Finally, payment with Mobile Apps (eSewa and Mobile Banking) and feedback was primarily facilitated through phone calls, WhatsApp, Viber and mobile SMS**,** indicating a preference for direct and instant communication.

Table 10. Primary ICT and related platform across the stages

Stages	ICT and related platform
Locate input suppliers	Phone call, Facebook, WhatsApp, Viber, TikTok
Compare input prices	Phone call, WhatsApp, Viber
Recommendation on inputs	Phone call, WhatsApp, Viber
Weather forecasts	Facebook, TV, Radio, Mobile Apps
Crop calendar	Agricultural websites, Facebook
Irrigation advice	Facebook, TikTok, YouTube, Phone call
Fertilizer/pesticide schedules	Facebook, TikTok, YouTube, Phone call
Soil testing/ management tips	Facebook, TikTok, YouTube, Phone call
Pest/disease management	Facebook, TikTok, YouTube, Phone call, WhatsApp, Viber, Agricultural websites
Access to new technology	Facebook, TikTok, YouTube, TV, Agricultural websites
Decide harvesting time	TV, Radio, Facebook
Grading/sorting techniques	Facebook, TikTok, YouTube, TV, Agricultural websites
Packaging and storage tips	Facebook, TikTok, YouTube, TV, Agricultural websites
Book transport/logistics	Phone call, WhatsApp, Viber, mobile SMS, Mobile Apps
Track delivery/manage logistics	Phone call, WhatsApp, Viber, Mobile SMS, Mobile Apps
Real time market price	Phone call, WhatsApp, Viber, Mobile SMS
Market communication	Phone call, WhatsApp, Viber, TikTok, Facebook, Mobile SMS
Advertise online	TikTok, Facebook
Price negotiation	Phone call, WhatsApp, Viber, Facebook, Mobile SMS
Payment	Mobile Apps
Feedback	Phone call, WhatsApp, Viber, Mobile SMS

Source: Field survey, 2025

Perceived benefits from the use of ICT by value chain actors

Table 11 presents the perceived benefits from the use of ICT as stated by value chain actors. For farmers, major benefits included better decision-making (73.13%), time saving (64.17%), and improved market access (41.79%), but only 37.31% reported higher income and 4.47% reduced post-harvest losses. However, all the wholesalers and retailers (100%), reported benefit in income, better decision making and time saving. This suggests that farmers face barriers in affordability, digital literacy, relevance, and infrastructure, which limit the translation of ICT use into tangible economic benefits. This result is similar to the findings of previous studies (Buragohain, 2020; Modi & Sharma, 2025; Narmilan et al., 2020), which reported that ICT helps farmer make better decisions, save time, and access markets more easily. However, the proportion of farmers reporting direct increases in income or significant reductions in post-harvest losses is much lower (Modi & Sharma, 2025; Naik & Navaneetham, 2024).

Table 11. Perceived Benefits from the use of ICT by value chain actors

Benefit	Input supplier	Farmers	Collector	Wholesaler	Retailer	Consumer
Higher income	83.33	37.31	100	100	100	NA
Reduced input cost	0	16.41	NA	NA	NA	NA
Reduced post-harvest loss	0	4.47	NA	0	0	NA
Better decision making	91.66	73.13	60	100	100	30
Time saving	83.33	64.17	60	100	100	30
Improved access to market	25	41.79	60	90	100	30

Source: Field survey, 2025

Note: Figures indicate percentage; NA indicate response not applicable for the particular question

Challenges in the use of ICT by value chain actor

Table 12 presents the challenges in the use of ICT by value chain actors. Farmers were the only group reporting significant challenges, including lack of training (61.19%), language barriers (20.89%), poor internet access (13.43%), and high costs (11.94%). Sigdel et al. (2022) also reported similar challenges among farmers. Other value chain actors, except consumers, reported no barriers in most categories, except for irrelevant content, which was identified as a challenge by 18.18%-20.89% of respondents.

Table 12. Challenges in the use of ICT by value chain actor

Challenge category	Input supplier	Farmer	Collector	Wholesaler	Retailer	Consumer
Cost of devices	0	11.94	0	0	0	0
Poor internet	0	13.43	0	0	0	0
Lack of training	0	61.19	0	0	0	0
Language barriers	0	20.89	0	0	9.09	0
Irrelevant content	25	20.89	20	20	18.18	0
Distrust in digital sources	0	7.46	0	0	0	0

Source: Field survey, 2025

Note: Figures indicate percentage

Self-rated digital literacy by value chain actors

Table 13 presents the self-rated digital literacy of value chain actors. The majority of farmers (68.65%) rated themselves at a medium level of literacy, while only 20.91% reported a high level. In contrast, all wholesalers and input suppliers (100%) rated themselves as highly literate. This finding underscores the persistent capacity gaps at the production stage, despite the widespread availability of digital devices.

Table 13. Self-rated digital literacy levels among value chain actors

Rating	Input supplier	Farmer	Collector	Wholesaler	Retailer	Consumer
Low	0	10.44	0	0	0	0
Medium	0	68.65	30	0	50	20
High	100	20.91	70	100	50	80

Source: Field survey, 2025

Note: Figures indicate percentage

Training on the use of ICT in agriculture

Table 14 presents the formal training received by value chain actors in the use of ICT. None of the actors had received formal ICT training. This systemic neglect explains farmers' reliance on self-learning and contributes to ineffective ICT utilization.

Table 14. Formal training received by the value chain actors in the use of ICT

Response	Input supplier	Farmer	Collector	Wholesaler	Retailer	Consumer
Yes	0	0	0	0	0	NA
No	100	100	100	100	100	NA

Source: Field survey, 2025

Note: Figures indicate percentage; NA indicate response not applicable for the particular question

Support desired by value chain actors in the use of ICT

Table 15 presents the support desired by value chain actors in the use of ICT. Farmers expressed high demand for training in Mobile Apps (91.04%), pest alerts (83.58%), and video-based learning (86.56%). Input suppliers prioritized market linkage information (100%), while consumers desired transparent market information (100%). These findings suggest that training and content relevance are crucial to bridge adoption gaps.

Table 15. Desired support mentioned by value chain actors in the use of ICT

Indicator	Input supplier	Farmer	Collector	Wholesaler	Retailer	Consumer
Mobile Apps training	0	91.04	0	0	0	NA
Market linkage info	100	85.07	100	100	90.90	100
Government scheme awareness	66.66	95.52	90.9	60	45.45	NA
Real time disease/pest alerts	0	83.58	0	0	0	NA
Video based learning	0	86.56	0	0	0	NA
Digital literacy training	0	10.44	0	0	0	NA

Source: Field survey, 2025

Note: Figures indicate percentage; NA indicate response not applicable for the particular question

Effectiveness of current extension services in promoting use of ICT

Table 16 presents the responses of value chain actors regarding the effectiveness of current extension services in promoting the use of ICT. A large majority of farmers (80.59%) rated extension services as ineffective in this regard. Likewise, all input suppliers, collectors, wholesalers, and retailers (100%) expressed similar dissatisfaction. Thapa et al. (2025) also highlighted institutional weaknesses in mainstreaming digital agriculture, including insufficient resources, limited readiness of extension workers, and inadequate capacity to integrate digital tools effectively.

Table 16. Response to existing efforts in promoting the use of ICT

Response	Input supplier	Farmer	Collector	Wholesaler	Retailer	Consumer
Very effective	0	0	0	0	0	0
Moderately effective	0	17.91	0	0	0	0
Ineffective	100	80.59	100	100	100	0
Don't know	0	1.50	0	0	0	100

Source: Field survey, 2025

Note: Figures indicate percentage

CONCLUSION

Results revealed that the widespread use of mobile phones, radios, and televisions among all value chain actors highlights a key access to information. However, a noticeable gap exists in smartphone usage and internet access, with farmers lagging behind other actors. This indicates a significant barrier for utilizing modern platforms. Patterns of platform use revealed a preference for accessible and user-friendly social media platforms like Facebook, TikTok, WhatsApp, and Viber among all actors. This implies that future ICT efforts should focus on these popular platforms. The low access to specialized agricultural websites among farmers indicates a need for different delivery methods, potentially linked to current social media platforms. Farmers mainly use ICT for crop calendars and checking market prices, emphasizing their focus on essential information. However, the limited use of ICT for important farming tasks like irrigation scheduling, fertilizer and pesticide recommendations, and detailed weather forecasts reveals a lack of relevant and user-friendly applications tailored to these needs. Other value chain actors,

such as input suppliers, collectors, wholesalers, and retailers, primarily use ICT for real-time market communication, logistics coordination, price negotiation, and online advertising. While farmers see benefits like better decision-making and time savings with ICT, advantages such as increased income and reduced post-harvest losses remain limited for them. This suggests that access to information alone is not enough; effective training and integration of ICT into production and post-harvest management are vital for economic gains. A major challenge in ICT use is the total lack of formal ICT training among all value chain actors, leading to a heavy reliance on self-learning. This contributes directly to farmers' lower self-rated digital literacy compared to other actors, and it influences challenges such as language barriers, irrelevant content, and, for farmers, even distrust in digital information. The strong demand for Mobile Apps training, market linkage information, pest alerts, and video-based learning, especially from farmers, clearly highlights where targeted interventions are most needed.

Therefore, future efforts should focus on developing and sharing context-specific and user-friendly ICT tools and platforms that meet the needs of different value chain actors. Such platforms should include localized language options, relevant agricultural content, and practical features to ensure usability, especially for farmers with limited digital skills. At the same time, extensive digital literacy training programs should be designed and implemented for all value chain actors, with special emphasis on farmers, who face the biggest gaps. These training initiatives should not only cover technical skills, such as operating devices and navigating digital platforms, but also how to interpret and apply information to enhance agricultural decision-making and productivity. Additionally, boosting the capacity of extension services is crucial for effectively promoting and integrating ICT into everyday agricultural practices. Extension personnel should have both digital skills and knowledge to encourage farmer participation, provide timely support, and connect technology availability with practical use.

AUTHOR CONTRIBUTIONS

Author A: Conceptualization; Validation; Formal analysis; Investigation; Data curation; Visualization; Writing-original draft.

Author B: Writing-original draft; Writing-review and editing.

Author C: Conceptualization; Methodology; Software; Validation; Formal analysis; Investigation; Data curation; Writing-original draft; Writing-review and editing; Visualization.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest regarding this publication.

ETHICS APPROVAL

Ethical approval for this study was obtained from the Institutional Review Board (IRB) of Nepal Polytechnic Institute, Purbanchal University, Nepal. All participants were informed about the objectives of the study, assured of confidentiality, and provided written informed consent prior to participation.

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