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Seasonal Digital Coordination in Hani Terrace Farming: A Longitudinal Field Study of WeChat–SMS Infrastructure in Rural Yunnan, China

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Article

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Abstract

Background: Rice terrace farmers in remote mountainous areas have long struggled to access agricultural information easily, coordinate collective efforts, and address shared resource dilemmas for which straightforward remedies are lacking. While mobile-based communication systems seem to provide a frugal solution to these structural barriers, systematic field data documenting real-world adoption patterns, realized economic gains, and emergent friction remains limited. This empirical gap is particularly acute for the ethnic minority farming systems of Southwest China, where traditional social structures, land management, and linguistic traditions differ significantly from those in the African and South Asian contexts typically examined in the current literature.

Methods: We tracked 300 Hani terrace farmers over 12 months (January–December 2025) in rural Yunnan Province, using a mixed-methods design that combined structured platform logs, monthly interaction records, coordination event documentation, information flow assessments, and an obstacle register spanning five data instruments. Quantitative data were analyzed descriptively, and qualitative obstacle narratives were thematically coded.

Results: Platform membership grew nearly eightfold, from 37 to 295 members, representing 98.3% adoption by December. Forty coordination events yielded combined economic savings of ¥28,040 (mean ¥701 per event; median ¥300), with labor coordination accounting for the largest share (32.5%). Information delivery accelerated by up to 350-fold for market prices, and trust scores for market and weather data doubled from 2 to 4 on a five-point scale. However, active participation averaged only 23.7% across the year, and 45% of the 40 recorded obstacles were only partially resolved.

Conclusions: WeChat and SMS platforms can work as real coordination infrastructure in smallholder terrace farming, but their benefits are bunched in particular seasons, concentrated in specific functions, and contingent on social and institutional conditions

that technology alone cannot create. Design implications, policy recommendations, and directions for future research are discussed.

Keywords: *digital agriculture; agricultural coordination; information asymmetry; social capital; frugal innovation.*

Introduction

Walking through one of the Hani villages in Yunnan during the rice-planting season, the scale of the coordination problem becomes clear. In terraced fields, this labor-intensive farming method requires sowing or harvesting within a relatively short period to ensure a rice harvest. In remote mountainous areas, where workers have migrated in search of employment and find it difficult to travel back and forth within a short timeframe, the question of how to manage terraced fields efficiently under normal circumstances becomes a matter of the utmost importance. Information is available; there are those who know the irrigation schedule and those who check market prices in the city; however, getting it to those who need it, at the right time, is extremely difficult. Mobile communication platforms do not magically solve this problem, but they do alleviate some of its structural constraints, and this shift is worthy of careful study.

Researchers have reported the wider application of mobile phones in rural agriculture. For example, Jensen [1] showed that mobile phone usage by the South Indian fishing industry to access price information reduced price dispersion, waste production, and improved market efficiency. Similarly, Fafchamps and Minten [2] documented the benefits of SMS-based advisory services for Indian farmers. The expansion of mobile phone usage in sub-Saharan Africa, lowering communication costs and improving access to information, markets, and services, evidenced the enhancement of economic welfare and development in the agricultural settings Aker and Mbiti [3]. However, these studies failed to integrate the role of social and cultural context that shapes how these mobile service platforms are actually used. This research gap motivates the present investigation.

The Hani people of Yunnan Province have been cultivating terraced rice fields for more than 1,300 years. In 2013, their lands were inscribed on the UNESCO World Heritage List in recognition of the technical sophistication of their gravity-fed irrigation systems and the meticulous community management that ensures their continued operation [4]. For the Hani people, farming is, at its core, a collective endeavor: planting schedules are coordinated among dozens of families, irrigation water is distributed through customary agreements, and labor is exchanged through “huzhu” networks that blend reciprocity with social obligation. These traditional mechanisms have worked for centuries, but they are facing increasing pressures. The rural population is aging, young people are migrating to cities, the weather has become less stable, and market prices fluctuate in ways that cannot be monitored through weekly market visits.

In this regard, WeChat, China’s leading social messaging platform, which has more than 1.3 billion monthly active users as of 2024 [5], has a feature rarely offered by agricultural guidance systems designed specifically for this purpose: a feature that already exists. Farmers who own smartphones use WeChat to communicate with their families. Repurposing it for agricultural coordination requires no new infrastructure, institutional approval, or significant training. This is what Prabhu [6] call frugal innovation, that is, not a new technology, but a creative use of existing technology. The SMS messaging system applies the same logic to farmers who do not own smartphones or have reliable data connections.

The thing that researchers do not know, and what this study seeks to uncover, is how this appropriation has evolved, which coordination functions does the platform perform effectively, and which does it perform poorly? Who participates actively, and who benefits without participating? What economic gains are realized, and when? What obstacles arise, and how does the community respond to them? These questions that cannot be answered through a cross-sectional survey. They require a sustained presence in the field, systematic documentation, and a willingness to report on failures as well as successes. This study presents the results of a 12-month longitudinal study involving

300 farmers from the Hani terraced fields in Yuanyang County, tracking the dynamics of platform adoption, economic outcomes, information flow, and patterns of barriers over the course of a full agricultural cycle. This study aims to achieve two objectives: the first is empirical, to provide accurate field evidence on a phenomenon that has not been sufficiently documented, and the second is theoretical, to contribute to ongoing discussions regarding the adoption of agricultural information and communication technologies (ICT), information asymmetry, and the co-evolution of technology and social practices in smallholder farming systems.

Materials and Methods

Study Site and Population

The study was conducted in a group of villages inhabited by the Hani ethnic minority in Yuanyang County, Honghe Hani and Yi Autonomous Prefecture, Yunnan Province, China (approximately 23° N, 102° E; elevation 1,400–1,800 meters above sea level). The Hani were chosen for their well-established rice field terraces and remote, high-altitude location. Moreover, the mobile network coverage and villagers' familiarity with mobile devices, using SMS and WeChat to some extent, and there was no prior official intervention in agriculture information and communication technology that could influence the assessment, made the Yuanyang villages an optimal area for conducting this study. In this study, three hundred farmers from Yuanyang Hani terraced fields were selected by community organizers using purposive chain sampling. The eligibility criteria were as follows: participants should be actively engaged farmers in rice terrace fields for no less than three years, have a mobile phone, and be willing to participate for 12 months in this study. Participants' ages ranged between 26 and 68, with a mean of 45.5 years old, with 61.3% male and 38.7% female. The gender distribution reflects the documented gender-based patterns of agricultural labor in the region. All participants provided a signed consent to use their data for study purposes, and personal data were anonymized prior to analysis and displayed to a third party.

Intervention Design

The system was designed to use two methods that work together to coordinate farmers' work time and communicate with each other.

2.2.1. WeChat Group Platform:

The main WeChat group was established in Jan 2025 and managed by five members of farmers who were selected by interviewing them and considering farmers' suggestions. The group leaders selected for their previous community activities established a trustworthy, digital literacy, and willingness to perform day-to-day duties and follow up with tasks through updating, posting, and responding to coordination requests. The WeChat group supports posting, images, videos, texts, voice messages, and documents, with at least one post a day. The daily post protocol requires at least one substantive agriculture post, weather update, market price, or coordination request to keep the group active during low-activity days.

SMS messaging system

For older farmers who did not have smartphones or lived in areas with low connectivity, a supplementary text message list was sent to ensure that the main information was delivered to all participants. The SMS system was used for urgent alerts, weather warnings, pest control guides, and request coordination that needed to reach everyone quickly. The two systems were different as they served different segments of the community and addressed different types of information needs.

Implementation phases

First Phase: The first two months were allocated for interviewing the community, recruiting participants, and initial assessment of the project. Phase two, from months 3 to 12, was for active coordination, daily posting for weather, prices, labor, and volunteer requests, incident logging, and archiving all types of data. Phase three, months 13 to 15, involved gathering and completing all bending tasks, questionnaires submitted by participants, and the study was concluded.

Data collection and organization

Data were organized in five tables for the next data analysis.

Supplementary Table 1: **Participant Demographic Profile:** Demographic data for all 300 participants were collected at baseline and included age, gender, household size, terrace area (mu), and type of main crop (monoculture of red rice versus mixed cropping: red rice, lotus roots, and legumes), and self-assessed digital technology proficiency on a scale of 1 to 5.

Supplementary Table 2: **Monthly Platform Interaction Log:** Recorded the total number of active platform members, total messages, labor requests, general inquiries, and market inquiries every month for 12 months.

Supplementary Table 3 – **Record of Coordination Success and Impact:** Documents all coordination events that resulted in practical actions, date, type of request, resolution mechanism, response time, and estimated economic benefit in Chinese yuan (RMB).

Supplementary Table 4 – **Comparison of Information Flow:** Evaluate four types of information (market prices, weather warnings, technical support, and coordination of rituals/celebrations), and compare traditional and digital delivery methods, changes in speed, and changes in the level of trust (on a 5-point scale).

Supplementary Table 5 – **Record of Obstacles and Friction:** Document all obstacles, noting the date, type of problem, description, attempted solution, and outcome.

Data Analysis

Descriptive statistics were employed to analyze the data in supplementary tables 1-3 and visualized using Python tools matplotlib and pandas [7]. Temporal trends in the two system engagements (WeChat and SMS messaging) were assessed using time series plots and growth calculations. Economic benefits and savings were analyzed using distributional statistics and cumulative trajectory modelling. The data in Supplementary Tables 3–5 were thematically coded. The obstacle types were grouped into eight

domains: logistics, agricultural, and infrastructure, social, resource, information, health and safety, and policy. The resolution outcomes were divided into four categories: resolved success, partial repair, partial solution, and cross-tabulated with obstacle categories. The trust level changes were visualized on logarithmic and linear scales, and information flow transformation was assessed through comparative analysis of delivery speed, which was standardized to hours. All analyses were conducted using Python 3.10 programming language.

Results

Enrolled participants' demographics, digital skills, and crop data analysis

The 300 framers who participated in this study were mostly ordinary and typical members of their local community and representative participants, which is this study's requirement. Participants' mean age was 45.4 years (SD = 10.2; range: 26–68), and the largest age cluster fell in the 40–49 age range (n= 117, 39.0%), while farmers under 30 were notably sparse (n=5, 5.0%) (Figure 1A). The distribution between participants' gender shows that male frequency was higher, with 61.3% male (n = 184), 38.7% compared to female (n = 116), which reflects the traditional gender division of agricultural labor in the region (Figure 1B). The average number of family members of participants was 4.1 people, and the average area of agricultural terraces was 9.8 mu (approximately 0.65 ha). Regarding digital skills among participants, which were self-assessed on a five-point scale, most were concentrated around the average level. The most common score level was score 3 (n = 90, 30.0%), and the distribution was approximately bell-curve shaped, with a slight skew toward lower skills: 16.3% rated themselves at score1 (the lowest), while only 9.7% reported advanced proficiency (score5; Figure 1C). In this study, it was observed that farmers with low digital skills could not adopt the platform and needed guidance to use it through an information bridge designed to address this lack. The crop composition was largely dominated by growing red rice as the main crop, with 77.7% of participants (n = 233), while the remaining 22.3% (n = 67) engaged in mixed farming systems combining red rice, lotus

roots, and legumes (Figure 1D). Farmers diversified their sources of income and tackled somewhat more complex coordination needs, given that the harvest cycles of lotus roots and legume cultivation interact significantly with the red rice planting schedule.

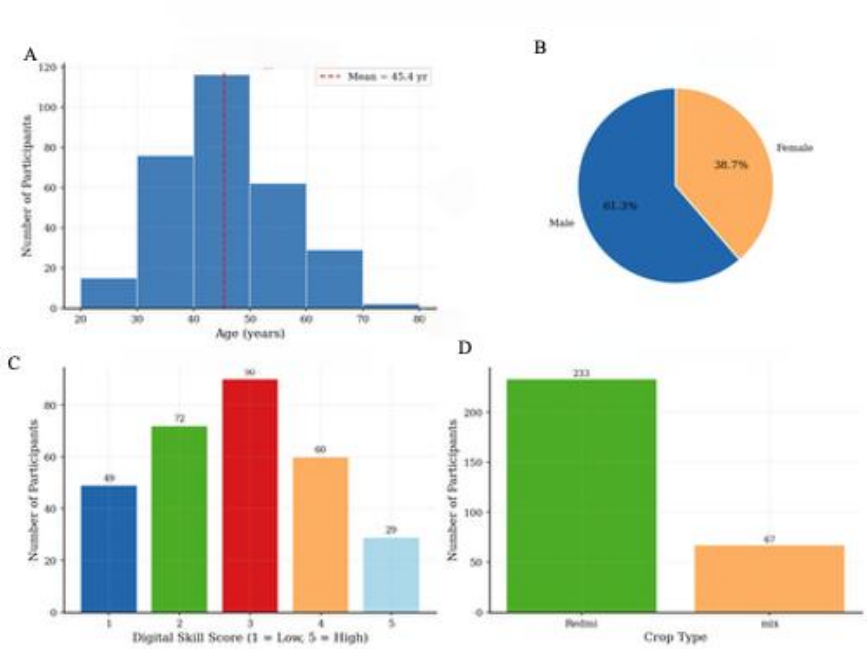


Figure 1. *Demographic profile, digital skills, and crop system of study participants (n = 300). (A) age distribution with mean reference line (45.4 years), (B) gender distribution, (c) digital technology skill level distribution (1 = minimal, 5 = advanced), and (D) primary crop type (Red rice monoculture and Mixed red rice + lotus root + legumes).*

Platform enhanced performance growth and activities

The number of farmers who participated in this study grew steadily. The group started in January with 37 members and ended up in December with 295 members, with a 7.97-fold increase representing 98.3% of the total registered members (Figure 2A). However, the platform performance growth featured three phases:

Phase I Slow pickup (January–March): From 37 in January to 90 members in March (+143%), driven by initial recruitment through “Information Bridge” farmers and early adopters.

Phase II: Steady growth (April–August): The platform members grew from 90 to 124 members (+38%), as the spring planting season contributed to increased demand for

labor, information, and news, and other services. Moreover, word spread among households that had experienced the benefits of coordination.

Phase III: Peak growth and stabilization (September–December): the farmer members grew from 124 to 295 members (+138%); the fall harvest season of red rice appears to have been the turning point that attracted the vast majority of the remaining members.

However, we noticed that April was a turning point in participation level because April is the busiest time and farmers need better coordination. The data showed that they joined the platform because they needed it for labor exchange, information, and real work, not merely for communication or chatting. We created an active membership that was defined as posting at least one message per month that provides important and useful information for the platform community. The total number of messages throughout the year was 2,108, with a clear seasonal pattern featuring two peaks. The highest number of message peaks was in April (279 messages), followed by September (258 messages), which correlated with the planting season in April and the harvesting season in September. The lowest number of messages was posted in December (n= 107 messages), reflecting a decline in engagement during the off-season (Figure 2B). This reflects the correlation between message volume and agricultural production cycles, rather than with the platform's growing member base, and confirms that the group functioned as a task-oriented coordination tool rather than a social chat channel. The analysis of request types shows that requests for labor coordination dominated throughout the year, accounting for 578 requests (27.4% of total messages) and peaking sharply in September (145 requests) (Figure 2C). Market inquiry requests peaked in October, after the harvest. Meanwhile, requests for general advice remained relatively stable from month to month, indicating a sustained technical curiosity that was not closely tied to the agricultural calendar.

In contrast, the active members peaked in September, reaching 65 members (28.3% of the total), while the second peak was in September, but the annual average was only 23.7%. The decline in active members in August (12.1%) coincided with the

peak of farm work, a period when farmers were more present in the fields and using their phones less (Figure 2D). During these periods, the Information Bridge farmers effectively became the platform's editorial team, broadcasting information on behalf of a largely silent audience.

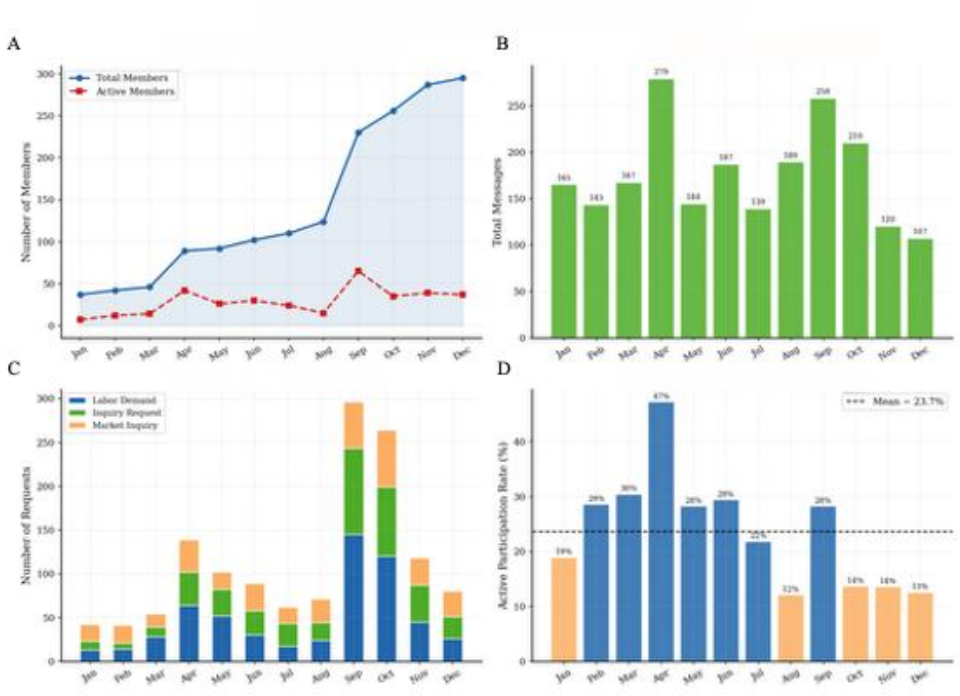


Figure. 2. *Monthly platform engagement and activities metrics: (a) Growth trends for total and active members; (b) Volume of monthly messages; (c) Breakdown of request types by month (stacked bar chart); (d) Monthly active engagement rate with a reference line for the annual average (23.7%). (Figure file: fig2_platform_engagement.png, submitted separately)*

The platform delivered economic benefits

The total number of coordination events was 40, resulting in documented economic savings totaling ¥28,040 over 11 months, spanning February to November, with no events recorded in January or December (Table 1. The distribution of cost savings per event was heavily right-skewed, as the mean-to-median ratio of 2.34 indicates that a small number of high-value events, such as a bulk supply coordination event and an irrigation drought prevention intervention, each generating savings of ¥4,500, substantially increased the overall average. In contrast, approximately 60% of all events resulted in savings ranging from ¥60 to ¥400 (Figure 3A). Although these amounts may

appear modest in absolute terms, this amount of savings represents meaningful economic gains for households cultivating fewer than 10 mu of registered farmland. For such households, saving approximately ¥300 from a single labor exchange can constitute a significant reduction in production costs.

Table 1. The economic values of the platform

Statistic	Value
Total events documented	40
Total aggregate savings	¥28,040
Mean savings per event	¥ 701(SD=¥892)
Median savings per event	¥300
Minimum savings	¥60
Maximum savings (single event)	¥ 4500
Events with savings >¥1000	8(20.0%)

The mean-to-median ratio of 2.34 signals that a handful of high-value events, bulk supply coordination at ¥4,500, and irrigation drought prevention intervention also at ¥4,500 pulled the aggregate figure upward considerably. Most of the transactions (about 60%) fell within the range of 60 to 400 Chinese yuan. These are modest amounts in absolute terms, but for households that cultivate less than 10 mu of the registered land, saving 300 Chinese yuan in a single labor exchange is no small feat.

Monthly savings were heavily concentrated in the growing season. June (¥7,500) and August (¥7,000) together accounted for 52% of the annual total. The five-month window from April to August contributed ¥21,910 (78.1%) of all savings, while the post-harvest months (September–November) added ¥5,210 and the early-season months (February–March) only ¥1,920 (Figure 3B). The implication for evaluation design is direct: a study conducted outside the April–August window would capture less than a quarter of the platform's economic value.

Labor coordination was the most common coordination type (13 events, 32.5% of the total). Representative examples included eight households collectively hiring each other for rice harvesting (¥800 saved per household) and a six-person transplanting group completing 8 mu of seedlings in a single day (¥820 in labor costs avoided). Machinery sharing, technical advice, and irrigation coordination each contributed three events (Figure 3C). Single event categories–bulk supply purchasing and pest disease prevention–generated the largest per-event savings, although their infrequency limited their aggregate contribution.

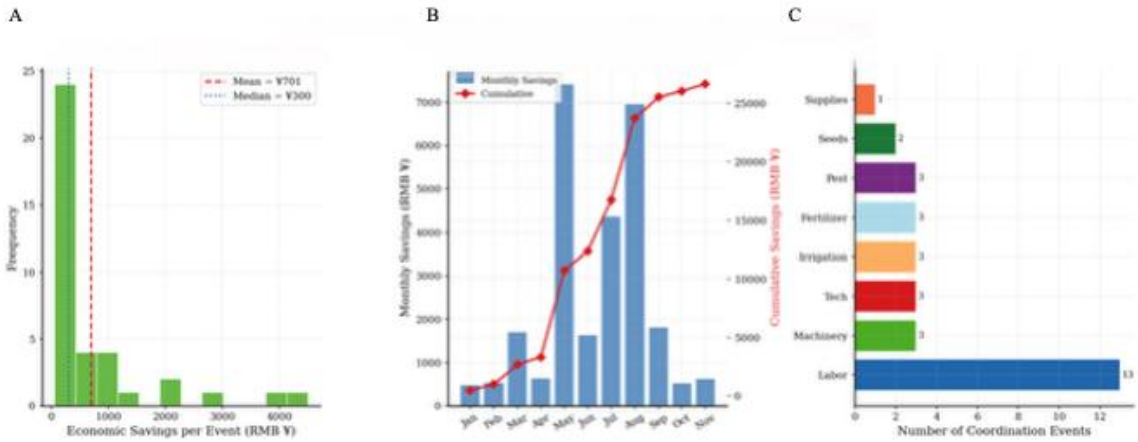


Figure. 3. *Economic impact of platform-mediated coordination: (a) distribution of economic savings per coordination event (n = 40); mean (¥701) and median (¥300) reference lines shown; (b) monthly and cumulative economic savings trajectory; (c) coordination request type frequency.*

Platform improved the Information flow and trust among participants

Before the platform, getting a market price meant waiting for market day, roughly seven hours after prices were set. A weather warning was transmitted by word of mouth, taking approximately two hours to reach most households. Technical advice required walking to find a village elder, which could take the better part of a day. These were not catastrophic failures in the information infrastructure; rather, they were simply the

normal friction costs of rural communications in a scattered, mountainous community. After the launch of the platform, these timelines collapsed, as shown in Table 2.

The 350-fold acceleration in market price reporting (from approximately 7 hours to approximately 1 minute) was the most surprising transformation. This platform has enabled farmers to make sales decisions in real time rather than being bound by prices set days in advance. The delivery of weather warnings improved from approximately two hours to near-instantaneous delivery via SMS and showed a 200-fold improvement in the prevention of crop damage. The significance of this improvement became tangibly apparent on June 20, when a hailstorm damaged crops. The warning came too late, while the damage was real. This incident directly led to the establishment of a direct line of communication with the Meteorological Office, demonstrating how platform issues can drive organizational development rather than merely exposing a vulnerability.

Technical support demonstrated the most significant operational change, where the response time dropped from 48 hours (which previously required in-person travel to consult an expert) to approximately 30 minutes via group chat, a 96-fold improvement (Figure 4A). On July 11, a farmer posted photos of insect larvae that turned out to be beneficial rather than pests; identifying the species took 30 min, preventing the unnecessary use of pesticides. This kind of immediate access to experts is qualitatively different from anything the traditional system could offer.

Table 2: Speed of information flow among the participants.

Information Type	**Traditional Method**	**Digital Method**	**Speed Improvement**	**Trust: Before → After**
Market Prices	Wait for market day (~7h)	Daily WeChat updates	350×	2→4

Weather Warnings	Word of mouth(~2h)	Bulk SMS Broadcast	200×	2→4
Technical Support	Visit elder in person(~48h)	Group chat Q&A	96×	3→4
Ritual Coordination	Village committee meeting(~24h)	WeChat coordination	24×	3→3

Regarding the trust level, it was assessed on a five-point scale, and the data analysis showed that it was significantly for market and weather information (from 2 to 4), shifting from distrust to genuine trust (Figure 4B). According to our observations, three mechanisms appear to underlie this shift. First, messages on the platform carry the sender's identity, allowing reputation to be tracked over time. Second, rapid delivery reduces distortion through intermediaries, as fewer hands handle the information, which reduces the chances of it being altered or forgotten. Third, multiple farmers can verify the information simultaneously within the group, creating a form of distributed fact-checking. The level of trust in ritual coordination remained constant at 3, which makes sense that ritual information is relational and embodied in ways that digital verification cannot easily address.

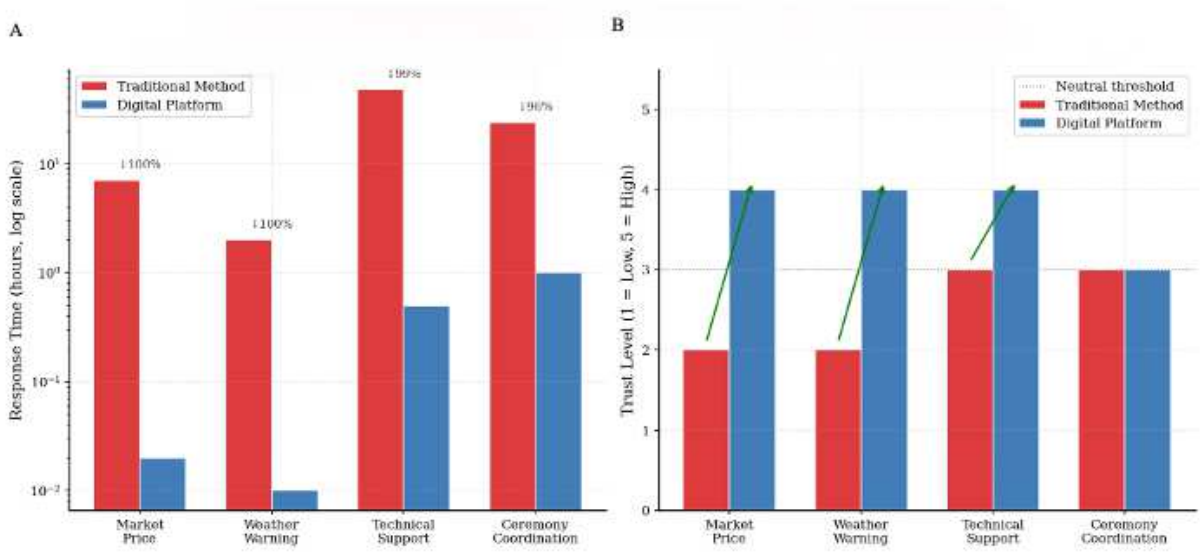


Figure 4. *Digital transformation of agricultural information flow: (a) Comparison of information delivery speed between traditional and digital methods (log scale; percentage reductions annotated); (b) Level of confidence in the information before and after platform adoption (1 = very low, 5 = very high).*

Features of the platform obstacles

Forty cases of obstacles were recorded over ten months (January through October), while no cases were recorded in November or December (Table 3).

Table 3: Obstacle records of the platform

Outcome Category	**n**	**Percentage**
Resolved (fully addressed)	13	32.5%
Success (effectively managed)	9	22.5%
Partial solution	10	25.0%

Partial repair	8	20.0%
Satisfactory resolution (Resolved + Success)	22	55.0%
Incomplete resolution (Partial solution + Partial repair)	18	45.0%

The obstacles incidents were addressed by the participants and the admins of the platform and resulted in a satisfactory resolution (resolved + success) of 22 obstacles, while incomplete resolutions (partial solution + partial repair) were 18 obstacles (Figure 5A).

The recorded obstacle incidents process resulted in nine thematic areas (Figure 5B). Information obstacles were the highest (9), accounting for 22.5%, which included the spread of misinformation, such as false rumors about fertilizer prices, the promotion of counterfeit products, and misidentification of pests, as well as information gaps outside the growing season. Infrastructure obstacles (7 in number, accounting for 17.5%) included network connectivity failures in lower-tier areas, equipment compatibility issues, and power outages. Similarly, social obstacles (7 in total, accounting for 17.5%) ranged from conflicts over irrigation schedules and disputes regarding grain drying areas to digital divide issues affecting elderly farmers who were unable to use WeChat apps. The temporal distribution peaked in May (number of cases = 5) and August (number of cases = 5), two periods marked by intense activity (Figure 5C). The platform delivers its maximum value precisely when coordination complexity is at its highest, but this very complexity generates the greatest amount of friction. These two dynamics are not coincidental; rather, they are two sides of a single, intense coordination effort.

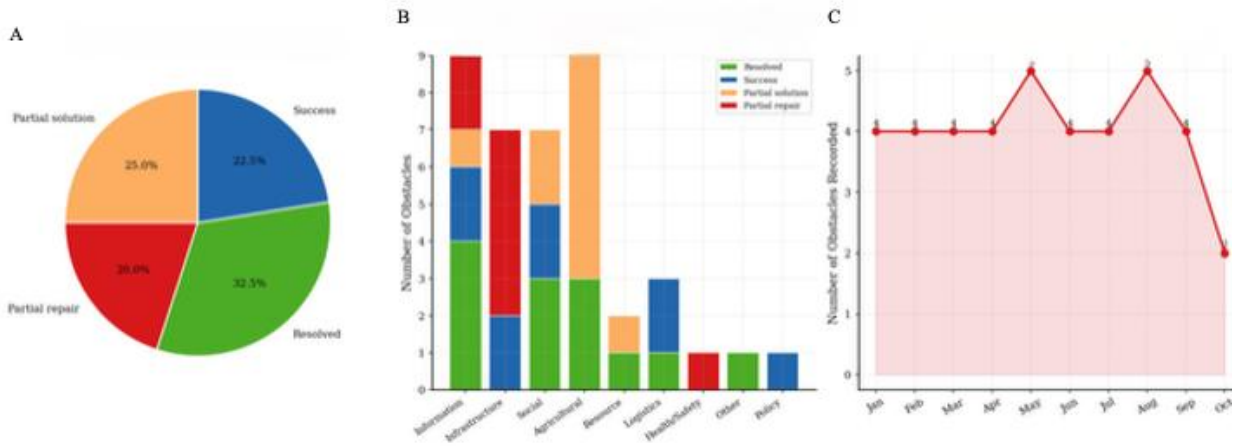


Figure 5. *Obstacle and friction analysis: (A) resolution outcome distribution (n = 40), (B) obstacle category and resolution outcomes (stacked bar) and (C) monthly distribution of obstacles recorded.*

The qualitative analysis revealed that it was not the obstacles themselves that stood out, but rather the community's responses. When network connectivity was lost during a critical weather warning, farmers established a hybrid backup protocol combining SMS and WeChat within days. When misinformation about fertilizer prices spread, "Information Bridge" farmers developed practices for verifying evidence through photos. When older farmers struggled with WeChat interfaces, younger neighbors provided verbal relay services, a peer-mediated digital inclusion strategy consistent with community-based technology diffusion models [8], but more creative and faster than those models typically predict

Discussion

This study's results are broadly consistent with other farmer-digital adoption studies in that the respondent profile is middle-aged, male-dominated, and characterized by relatively modest education and digital capability, which is typical of many rural farmers' settings rather than a study-specific anomaly [9]. Similar work on farmers' acceptance of digital technologies also reports average farmer ages in the mid-40s and

substantial heterogeneity in education and digital readiness, reinforcing the idea that adoption barriers are structural and not just local to this site [10]. The concentration of respondents around digital skill Level 3, with fewer farmers at the highest level, is important because recent evidence shows that digital literacy is a strong enabler of adoption and service use among farmers. A 2025 study on agricultural social services in China found that higher digital literacy significantly increased adoption, and the effect remained robust after controlling for selection bias and endogeneity [11]. This supports the interpretation that low-skilled farmers need mediation, training, or facilitation before they can meaningfully engage with the platform, which is consistent with the “Information Bridge” idea.

Studies on farmer acceptance of digital technologies repeatedly show that perceived usefulness and facilitating conditions matter more than technological complexity, and that support from institutions or peer networks strengthens adoption pathways [12]. Mixed-cropping households likely face more coordination demands, more scheduling trade-offs, and more information needs than red-rice-only households; therefore, the platform may be especially valuable for them if it helps synchronize production, labor allocation, and harvest timing [13].This means that mixed cropping should not be treated as a minor demographic detail; it is a practical indicator of higher informational complexity and a potentially stronger demand for decision support. Compared with other studies, the present findings suggest that farmer adoption of digital platforms is strongly shaped by immediate seasonal needs and the presence of trusted intermediaries. Prior research on agricultural digitalization has shown that farmers are more likely to use information services when those services are timely, practical, and aligned with the agricultural calendar, particularly during planting and harvest periods [14].

The rapid membership growth observed in this study around seasonal turning points therefore appears to reflect need-based adoption rather than simple interest in communication [15]. In addition, the wide gap between total membership and active

posting resembles patterns reported in digital farmer networks, where a small set of active users or peer leaders supports information flow for a much larger passive audience [16]. This suggests that Information Bridge farmers functioned as intermediaries who translated platform access into usable coordination benefits, similar to the role of trusted channels reported in mobile agricultural advice studies [17]. Accordingly, low posting frequency should not be interpreted solely as weak engagement but also as evidence of a functional communication structure adapted to seasonal labor demands and differentiated user roles.

The seasonal pattern in message volume is consistent with prior studies showing that farmer communication intensifies when information is directly linked to production tasks, especially during planting and harvesting periods. In other words, digital groups used by farmers tend to function most actively when coordination needs are highest, rather than maintaining a steady social-chat rhythm throughout the year [18]. The labor-coordination requests dominated the message flow also fits well with research on rural digital networks and farmer-to-farmer communication, which shows that practical, time-sensitive exchanges are usually the primary reason farmers participate in such platforms. The sharp September peak in labor requests suggests that the platform was especially valuable when work pressure was highest, reinforcing the idea that the group served as an operational tool for synchronizing field activities [19].

The market inquiry peak after harvest is also meaningful because it matches the period when farmers shift from production to marketing and income realization. This is consistent with studies showing that farmers seek market information most actively when output becomes available for sale and price uncertainty increases [20]. In contrast, the relatively stable pattern of general advice requests suggests that technical curiosity is present year-round, but it is not the main driver of platform use [21]. Taken together, these patterns suggest that the platform's value lies in its ability to support seasonal decision-making, labor organization, and market transition, rather than in maintaining continuous social interaction.

Compared with other studies, the present findings indicate that the economic value of farmer coordination platforms is highly seasonal and strongly concentrated in periods of intensive agricultural activity. Previous research on rural digital and cooperative interventions has shown that the greatest gains often arise from a small number of high-value coordination events rather than from frequent low-value exchanges [22]. Therefore, the pronounced right skew in savings per event in this study is not unusual, but it does suggest that aggregate benefit is disproportionately driven by exceptional events such as bulk purchasing and irrigation coordination. In addition, the concentration of savings between April and August aligns with broader evidence that the economic value of digital coordination tools rises sharply during planting and harvest seasons, when labor shortages and timing pressures are greatest [23]. These results imply that platform evaluation should be conducted over a full agricultural cycle, because shorter observation windows would likely underestimate the platform's contribution to household welfare and production efficiency.

Compared with earlier work, the findings suggest that the platform dramatically reduced the friction costs of rural information exchange. Studies on SMS-based agricultural information have shown that farmers benefit from timely market and weather messages; however, the effects are often modest and depend on whether the advice is familiar, trusted, and actionable [24]. In this study, the shift from hours to minutes for price reporting and from hours to near-instant weather warnings indicate a much larger operational change than simple message delivery because it enabled real-time decision-making inside the local communication network. The market-price result also aligns with work on price-information systems, which shows that smallholders often rely on delayed, informal, and imperfect channels, which can lead to poor sales timing and reduced bargaining power [25]. The panic sale documented in this study is particularly important because it illustrates a known vulnerability in rural information systems: when prices circulate slowly or inaccurately, farmers may act on rumors rather than verified data. At the same time, the platform's ability to correct misinformation

within hours suggests that digital coordination can do more than speed up communication — it can also improve information validation and reduce the damage from rumor-driven behavior [26]. The weather-warning result is also consistent with prior studies, but this study shows both the promise and the limits of fast information channels. Research on SMS Agri-met advisories has found that farmers are more likely to comply when messages concern familiar agricultural cycles, while weather-related advice can be harder to translate into action [27]. The hailstorm example fits this pattern well: even near-instant communication may come too late if the warning system is not connected early enough to an authoritative source or if the event develops too quickly. The creation of a direct communication line with the Meteorological Office is therefore an important institutional outcome, because it shows that the platform did not merely transmit information faster; it also pushed the local system toward a more integrated early-warning structure.

The technical-support result is consistent with broader evidence that digital farmer platforms are most valuable when they shorten the path between a problem and an expert response. In many rural settings, the traditional system depends on travel, personal contact, and delayed consultation; therefore, a shift from 48 h to approximately 30 min represents not only faster communication but also a different problem-solving structure [28]. The larvae example is especially strong because it shows how rapid expert input can prevent unnecessary pesticide use, which is exactly the kind of practical efficiency that prior studies of digital extension systems emphasize. The increase in trust for market and weather information also fits with earlier research showing that farmers trust information more when it is transparent, attributable, and repeatedly confirmed. When messages carry identifiable senders, farmers can evaluate credibility over time rather than treating information as an anonymous rumor [29]. The explanation about fewer intermediaries is also well grounded: each additional relay can introduce delay, distortion, or selective memory; therefore, direct group delivery naturally improves reliability [30]. The distributed fact-checking effect observed in this study is

particularly important because it suggests that trust is not only generated by the sender but also by collective verification among peers [31].

The fact that ritual coordination remained stable at 3 is also interpretable in light of how digital systems work. Ritual information is often embedded in social relations, customary practice, and embodied participation, so it is less likely to be transformed by a messaging platform than by the market, weather, or technical advice [32]. This contrast shows that the platform did not universally change all forms of information equally; instead, it improved information types that are factual, time-sensitive, and verifiable. Compared with other studies on digital agriculture and rural information systems, the findings show that obstacles are not simply technical breakdowns; they are often produced by the same conditions that make the platform valuable in the first place. Prior research generally shows that rural digital systems face three recurring barriers: weak infrastructure, uneven digital literacy, and misinformation [33]. The results fit that pattern, but they go further by showing that the community did not remain passive in the face of these problems. Instead, users created practical workarounds, which suggests a more active and resilient form of collective adaptation than is usually captured in adoption studies [34].

The clustering of obstruction cases in May and August is especially important because it matches the periods of highest coordination demand. This suggests that friction rises when the platform is under the greatest pressure, not when it is idle. In other words, the same seasonal intensity that increases the platform's value also exposes its vulnerabilities. This pattern is consistent with broader studies of agricultural coordination systems, where periods of peak labor demand often reveal hidden weaknesses in communication, infrastructure, and scheduling [35]. The examples of community responses are one of the strongest parts of this section. The hybrid SMS–WeChat backup protocol is a clear sign of institutional learning, because it shows that farmers did not treat the loss of connectivity as a dead end; they built redundancy into the communication system [26]. Likewise, the practice of verifying fertilizer-price

rumors through photos shows that users were not just consuming information but actively validating it [36]. These behaviors are consistent with community-based diffusion theory but in this case show something more dynamic: peer learning here was not slow or linear but fast, improvisational, and deeply contextual. The response to the digital divide is also worth emphasizing because it shifts the interpretation of inclusion. Instead of relying only on formal training, younger neighbors informally mediated access for older farmers through verbal relay and interface assistance. This is important because it shows that digital inclusion can emerge through social relationships rather than only through top-down capacity building [37]. Compared with other studies, the findings suggest that rural communities can compensate for technical exclusion with locally organized support networks, although this also means that access may remain uneven and dependent on kinship or neighborhood ties [38].

Recommendations

The following five recommendations are derived directly from the data.

Design the platform in accordance with the agricultural calendar: The platform's value was not distributed evenly throughout the year but was concentrated in specific seasons and functions. The platform's features, such as labor matching tools, price alert protocols, and technical advisory channels, should be clearly aligned with the most critical coordination functions at each agricultural stage. Seasonal "coordination calendars," equipped with readily available expert resources and automated reminders, can significantly enhance the platform's value.

Invest in infrastructure reliability before capabilities: Connectivity and energy stability are essential requirements, not luxuries. Hybrid SMS/WeChat systems, offline data caching, and solar-powered charging stations are better suited to resource-constrained rural contexts than sophisticated but fragile technologies. The goal is to provide a minimum level of reliable and effective connectivity, not a maximum number of features.

Supporting digital platforms with institutional infrastructure: Conflict resolution mechanisms, information verification protocols, and community governance structures are not optional add-ons to digital coordination; they are the social infrastructure that makes digital coordination sustainable. Village committees, networks of lead farmers, and agricultural extension services should be explicitly integrated into platform management from the outset.

Multi-faceted evaluation: Adoption rates are not the only factor to consider. Evaluation frameworks must include the quality of engagement (not just the volume of messages), economic outcomes (broken down by event type and season), problem-resolution rates, and indicators of cultural and social impact. A platform that achieves a 98% adoption rate but resolves only 55% of its issues is not considered a complete success.

Building coordination skills alongside digital literacy skills: Training programs should address not only device operation but also communication standards, information verification practices, conflict management in digital contexts, and social protocols for coordinating collective resources. The "information bridge" model, which employs trusted community members as platform moderators and digital literacy champions, appears to be particularly effective in socially cohesive communities with high levels of trust and warrants broader implementation and evaluation.

Limitations

The research studies on ethnicities in China have always faced some limitations. As it is the age of technology, and in China the digital economy has grown to a large scale, a number of research participants were hesitant to share their personal details of the online transition. The farmers think that their accounts will be compromised if they provide details related to their payment. Although this was not the concern of all the farmers, some have shown concern over it. The data collection in rural areas is not easy,

as many researchers approach the farmers, it is difficult to interview the farmers directly in detail, and they just share part of their online system of payment.

Conclusion

After a year of monitoring 300 farmers from the Hani Terraces throughout a full growing season, a picture has emerged that falls neither into the category of excessive optimism nor that of excessive pessimism regarding the technology. The platform has been successful, membership has grown to near-universal coverage, coordination efforts have yielded real economic savings, the flow of information has accelerated and become more reliable, and the community has adapted creatively to the obstacles it faced. However, these benefits were concentrated within a specific time period, were unevenly distributed among households and types of activities, and depended on a level of social cohesion and institutional capacity that cannot be assumed in other contexts.

The total savings of ¥28,040, 350-fold acceleration in the availability of market prices, and doubling of trust in information are real gains and of great importance to the households that benefited from them. The same is true of the 45% rate of unresolved documented obstacles and the persistent digital divide that has left older farmers and those with low skill levels dependent on others to access the platform. Both the gains and the gaps are part of the story, and any honest account of the impact of agricultural information and communication technology must include both.

This study, in addition to its empirical findings, employs a longitudinal methodology that pays close attention to temporal dynamics. Agricultural platforms do not provide a constant value throughout the year; their activity peaks during periods of high demand for coordination, while it declines during periods of stagnation. They also build trust in reliable information more quickly than social media or by providing greater value. These dynamics are not apparent in cross-sectional or short-term studies, yet they are essential for designing, deploying, and evaluating platforms that effectively serve smallholder farmers.

As mobile phone connectivity continues to expand in rural agricultural communities across the Global South, the need for rigorous, longitudinal, and culturally grounded field studies will increase. The Hani Terraces system, with its long-standing coordination traditions, UNESCO-recognized landscape, and practical use of a messaging system to solve problems that have persisted for generations, is an inspiring model of what community-embedded digital coordination can achieve and a clear illustration of what it cannot achieve on its own.

References

1. Jensen, R. The digital provide: Information (technology), market performance, and welfare in the South Indian fisheries sector. *The quarterly journal of economics* **2007**, *122*, 879-924.
2. Fafchamps, M.; Minten, B. Impact of SMS-based agricultural information on Indian farmers. *The World Bank Economic Review* **2012**, *26*, 383-414.
3. Aker, J.C.; Mbiti, I.M. Mobile phones and economic development in Africa. *J. Econ. Perspect.* **2010**, *24*, 207-232.
4. Zhan, G.; Jin, Z. Hani rice terraces of honghe-the harmonious landscape of nature and humans. *Landscape Research* **2015**, *40*, 655-667.
5. Tencent. *Tencent Annual Report 2024*; Tencent Holdings Limited: 2024.
6. Prabhu, J. Frugal innovation: doing more with less for more. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* **2017**, *375*, doi:10.1098/rsta.2016.0372.
7. Hunter, J.D. Matplotlib: A 2D Graphics Environment. *Computing in Science & Engineering* **2007**, *9*, 90-95, doi:10.1109/MCSE.2007.55.
8. Rogers, E.M.; Singhal, A.; Quinlan, M.M. Diffusion of innovations. In *An integrated approach to communication theory and research*; Routledge: 2014; pp. 432-448.
9. Wang, H.; Mao, Y.; Zhou, M.; Li, X. Farmers' Digital Literacy and Its Impact on Agricultural Green Total Factor Productivity: Evidence from China. *Sustainability* **2025**, *17*, 9255.
10. Abdelaziz, F.; Abay, K.A. Digital literacy training to promote diffusion of digital agricultural tools to smallholder farmers: evidence from a randomized intervention in Egypt. *Food Policy* **2026**, *141*, 103108, doi:https://doi.org/10.1016/j.foodpol.2026.103108.
11. Wang, Y.; Xu, G.; Cao, J.; Chen, Y.; Wu, J. Does digital literacy affect farmers' adoption of agricultural social services? An empirical study based on China Land Economic Survey data. *PLoS One* **2025**, *20*, e0320318, doi:10.1371/journal.pone.0320318.

12. Gouroubera, M.W.W.; Gouthon, M.; Segnon, A.C.C.; Dosso, F.; Togbévi, Q.F.; Moumouni-Moussa, I.; Zougmoré, R.B. Understanding farmers' acceptance of digital technologies: a meta-analytic structural equation modeling approach based on the technology acceptance model. *Frontiers in Sustainable Food Systems* **2026**, *Volume 10 - 2026*, doi:10.3389/fsufs.2026.1723715.
13. Sakarya, I.E.; Rohmer, S.U.K.; van Lieshout, R.N.; Van Woensel, T. Quadratic optimization for sustainable agriculture: A study of mixed cropping systems. *Omega* **2026**, *143*, 103539, doi:https://doi.org/10.1016/j.omega.2026.103539.
14. Miine, L.K.; Akorsu, A.D.; Boampong, O.; Bukari, S. Drivers and intensity of adoption of digital agricultural services by smallholder farmers in Ghana. *Heliyon* **2023**, *9*, e23023, doi:10.1016/j.heliyon.2023.e23023.
15. Fakhraddine, M.; Zerrad, N.; Berhili, H.; Morchid, M. Digital transformation in Moroccan agriculture: Applications, used technologies, impacts on marketing, limitations, and orientations for future research. *Smart Agricultural Technology* **2025**, *11*, 100978, doi:https://doi.org/10.1016/j.atech.2025.100978.
16. Lasdun, V.; Harou, A.P.; Magomba, C.; Guereña, D. Peer learning and technology adoption in a digital farmer-to-farmer network. *J. Dev. Econ.* **2025**, *176*, 103496, doi:https://doi.org/10.1016/j.jdeveco.2025.103496.
17. Mulungu, K.; Kassie, M.; Tschopp, M. The role of information and communication technologies-based extension in agriculture: application, opportunities and challenges. *Information Technology for Development* **2025**, *31*, 1117-1146, doi:10.1080/02681102.2025.2456232.
18. Albizua, A.; Bennett, E.M.; Larocque, G.; Krause, R.W.; Pascual, U. Social networks influence farming practices and agrarian sustainability. *PLoS One* **2021**, *16*, e0244619, doi:10.1371/journal.pone.0244619.
19. Izuchukwu, A.; Erezi, E.; David Emeka, E. Assessing the impact of farmer-to-farmer communication networks on knowledge sharing and adoption of sustainable agricultural practices in Africa. *Int. J. Agric. Earth Sci* **2023**, *9*, 58-76.
20. Marion, P.; Lwamba, E.; Floridi, A.; Pande, S.; Bhattacharyya, M.; Young, S.; Villar, P.F.; Shisler, S. The effects of agricultural output market access interventions on agricultural, socio-economic, food security, and nutrition outcomes in low- and middle-income countries: A systematic review. *Campbell Systematic Reviews* **2024**, *20*, e1411, doi:https://doi.org/10.1002/cl2.1411.
21. Erekalo, K.T.; Gemtou, M.; Kornelis, M.; Pedersen, S.M.; Christensen, T.; Denver, S. Understanding the behavioral factors influencing farmers' future adoption of climate-smart agriculture: A multi-group analysis. *Journal of Cleaner Production* **2025**, *510*, 145632, doi:https://doi.org/10.1016/j.jclepro.2025.145632.
22. Ambler, K.; de Brauw, A.; Herskowitz, S.; Pulido, C. Viewpoint: Finance needs of the agricultural midstream. *Food Policy* **2023**, *121*, 102530, doi:https://doi.org/10.1016/j.foodpol.2023.102530.

23. Sun, X.; Ma, Y. Sharing and Co-Creating Value: Innovation in Platform-Based Agricultural Service Models Driven by Service Demand Collaboration—A Case Study of the JN Life. *Sustainability* **2025**, *17*, 1215.
24. Camacho, A.; Conover, E. The impact of receiving SMS price and weather information on small scale farmers in Colombia. *World Development* **2019**, *123*, 104596, doi:https://doi.org/10.1016/j.worlddev.2019.06.020.
25. Claude, S.J.; Ngigi, M.W.; Majiwa, E. Determinants of market participation and its effect on profit margins among smallholder wheat producing farmers in Rwanda. *Discover Agriculture* **2025**, *3*, 38, doi:10.1007/s44279-025-00184-w.
26. Zhu, Z.; Dai, Z.; Jiang, Y.; Wu, B.; Zhang, S.; Ma, X.; Wang, X.; Feng, Y. Bridging the knowledge gap: how farmers' digital literacy affects their ability to receive and understand meteorological warnings and emergency guidance during extreme weather events in China's Guanzhong Region. *Climate Risk Management* **2026**, *53*, 100837, doi:https://doi.org/10.1016/j.crm.2026.100837.
27. Sharma, U.; Chetri, P.; Minocha, S.; Roy, A.; Holker, T.; Patt, A.; Joerin, J. Do phone-based short message services improve the uptake of agri-met advice by farmers? A case study in Haryana, India. *Climate Risk Management* **2021**, *33*, 100321, doi:https://doi.org/10.1016/j.crm.2021.100321.
28. Kaiser, N.; Barstow, C.K. Rural Transportation Infrastructure in Low- and Middle-Income Countries: A Review of Impacts, Implications, and Interventions. *Sustainability* **2022**, *14*, 2149.
29. Rust, N.A.; Stankovics, P.; Jarvis, R.M.; Morris-Trainor, Z.; de Vries, J.R.; Ingram, J.; Mills, J.; Glikman, J.A.; Parkinson, J.; Toth, Z.; et al. Have farmers had enough of experts? *Environ Manage* **2022**, *69*, 31-44, doi:10.1007/s00267-021-01546-y.
30. Liu, M.; Shi, P.; Wang, J.; Wang, H.; Huang, J. Do farmers get a greater return from selling their agricultural products through e-commerce? *Rev. Dev. Econ.* **2023**, *27*, 1481-1508, doi:https://doi.org/10.1111/rode.12968.
31. Drolsbach, C.P.; Solovev, K.; Pröllochs, N. Community notes increase trust in fact-checking on social media. *PNAS Nexus* **2024**, *3*, pgae217, doi:10.1093/pnasnexus/pgae217.
32. Johannessen, L.E.F. Interaction rituals and technology: A review essay. *Poetics* **2023**, *98*, 101765, doi:https://doi.org/10.1016/j.poetic.2023.101765.
33. Nxumalo, G.S.; Chauke, H. Challenges and opportunities in smallholder agriculture digitization in South Africa. *Frontiers in Sustainable Food Systems* **2025**, *Volume 9 - 2025*, doi:10.3389/fsufs.2025.1583224.
34. Calzolai, S.; Timpanaro, G.; Grasso, A.; Vindigni, G. Digital technologies and social inequalities in agriculture and rural contexts: a gap-oriented systematic mapping review. *Journal of Rural Studies* **2026**, *125*, 104199, doi:https://doi.org/10.1016/j.jrurstud.2026.104199.

35. Feuerbacher, A.; McDonald, S.; Dukpa, C.; Grethe, H. Seasonal rural labor markets and their relevance to policy analyses in developing countries. *Food Policy* **2020**, *93*, 101875, doi:https://doi.org/10.1016/j.foodpol.2020.101875.
36. Rossi, S.; Gemma, S.; Borghini, F.; Perini, M.; Butini, S.; Carullo, G.; Campiani, G. Agri-food traceability today: Advancing innovation towards efficiency, sustainability, ethical sourcing, and safety in food supply chains. *Trends Food Sci. Technol.* **2025**, *163*, 105154, doi:https://doi.org/10.1016/j.tifs.2025.105154.
37. Smit, A.; Swart, J.; Broersma, M. Understanding digital citizenship in everyday life: tensions between digital inclusion policies and disadvantaged citizens' experiences. *Information, Communication & Society* **2025**, 1-19, doi:10.1080/1369118X.2025.2571396.
38. Park, S.; Freeman, J.; Middleton, C. Intersections between connectivity and digital inclusion in rural communities. *Communication Research and Practice* **2019**, *5*, 139-155, doi:10.1080/22041451.2019.1601493.