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MOBILE-BASED AGRICULTURAL ADVISORY SERVICES AND THEIR IMPACT ON SMALLHOLDER FARMERS' CLIMATE ADAPTATION PRACTICES

(Original Article)

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Abstract

Background: Smallholder farmers in climate-vulnerable regions increasingly rely on digital advisory tools to improve agricultural decision-making. Mobile-based agricultural advisory services have emerged as an accessible platform for delivering timely information that may support the adoption of climate-resilient farming practices and enhance household food security.

Objective: To evaluate the influence of mobile-based agricultural advisory services on the adoption of climate-resilient practices and household food security among smallholder farmers in South Punjab.

Methods: A cross-sectional analytical study was conducted among 400 smallholder farmers in South Punjab, selected through a multistage sampling approach. Data were collected via structured questionnaire interviews, assessing demographic characteristics, use of mobile-based advisory services, adoption of specific climate-resilient practices (drought-tolerant varieties, smart irrigation, soil conservation, integrated pest management), and household food security. Checklists and a food security scale were applied. Data analysis included descriptive statistics, independent samples t-tests, chi-square tests, multivariable logistic regression (adjusting for age, education, farm size, and income), and linear regression, with parametric tests used as assumptions were met.

Results: Among participants, 52.0% reported using mobile advisory services. Adoption of climate-resilient practices was higher among users than non-users: drought-tolerant varieties (72.4% vs. 49.7%), soil conservation (63.8% vs. 38.2%), smart irrigation (41.3% vs. 22.9%), and integrated pest management (58.1% vs. 33.4%). Mean household food security scores were also higher among users (31.6 ± 4.3) than non-users (26.8 ± 5.1). Logistic regression indicated that service users were significantly more likely to adopt each practice after adjusting for socio-economic factors. Linear regression showed a positive association between the number of practices adopted and food security scores.

Conclusion: Mobile-based agricultural advisory services contributed to improved adoption of climate-resilient practices and better household food security among smallholder farmers. Integrating digital platforms into agricultural support systems may strengthen climate adaptation efforts in vulnerable farming communities.

Keywords: Agriculture, Climate Change, Decision Support Systems, Food Security, Mobile Applications, Rural Health, Sustainable Agriculture.

Introduction

Mobile-based agricultural advisory services and their impact on smallholder farmers' climate adaptation practices. le-based agricultural advisory services have emerged as a significant innovation in the effort to strengthen smallholder farmers' resilience to climate change(1). As weather patterns grow increasingly unpredictable and traditional knowledge becomes less reliable for guiding farming decisions, many smallholders are turning to digital tools that provide real-time, localized information(2). These services typically deliver advice on crop selection, pest and disease management, soil conservation, and climate-smart agronomic practices directly to farmers' phones(3). The shift toward mobile platforms represents a transformative change in how agricultural extension is delivered, especially in regions where conventional extension systems remain under-resourced or inaccessible. The central question, therefore, is whether these digital advisory services genuinely influence the adoption of climate-resilient farming practices and, ultimately, whether such adoption yields tangible improvements in household food security(4).

Across many low- and middle-income countries, agriculture remains the backbone of rural livelihoods, yet it is also one of the sectors most severely impacted by climate variability. Smallholder farmers, who often cultivate less than two hectares of land, face heightened vulnerability because their production systems typically depend on rain-fed agriculture and limited access to financial or technical support(5). Traditional agricultural extension services were designed to help bridge knowledge gaps, but they frequently struggle with limited staffing, logistical constraints, and high operational costs(6). As a result, many farmers receive information infrequently or not at all. Digital advisory platforms have gained attention precisely because they have the potential to overcome these long-standing barriers by offering low-cost, scalable, and timely communication channels(7).

The rapid penetration of mobile phones in rural areas has created unprecedented opportunities to deliver personalized agricultural information(8). Even basic mobile phones can receive SMS-based alerts or voice messages that guide farmers through planting calendars, irrigation schedules, or climate-adaptive practices. Smartphone-based applications further expand these possibilities by enabling interactive learning, weather forecasting, and problem identification through images(9). In many regions, farmers have begun to rely on these platforms as part of their routine decision-making, suggesting that digital tools may now be just as essential as physical inputs like seed or fertilizer(10). Yet despite their popularity, evidence remains mixed regarding their true effectiveness. Some studies suggest that mobile advisory services increase knowledge and improve on-farm decision-making, while others highlight challenges such as digital literacy, inconsistent network coverage, or the relevance of content to local contexts.

The growing urgency of climate adaptation adds another layer of importance to understanding how these services function. Climate-resilient practices—such as drought-tolerant crop varieties, water-saving irrigation technologies, conservation agriculture, and integrated pest management—can significantly reduce climate-related losses when properly applied. However, adopting these practices often requires not only awareness but also confidence, timely guidance, and continued reinforcement. Mobile advisory services could play a crucial role by providing that continuous support, enabling farmers to adapt more proactively rather than reactively. If effective, these platforms have the potential to reduce production risks, stabilize yields, and enhance household food availability, contributing to broader development goals.

Despite this potential, critical gaps remain in understanding the direct link between digital extension services and measurable outcomes in climate adaptation. Many existing studies focus on user satisfaction or knowledge gains rather than concrete behavioral changes in farming practices. Even fewer have examined whether the adoption of climate-resilient techniques translates into improved food security at the household level. Without such evidence, policymakers and development practitioners face uncertainty in determining how best to allocate resources or design digital interventions that genuinely address farmers' needs. There is a notable need for research that goes beyond surface-level assessment and investigates the pathways through which mobile advisory services influence both farming decisions and livelihood outcomes.

This study addresses these gaps by evaluating the impact of mobile-based agricultural advisory services on smallholder farmers' adoption of climate-resilient farming techniques and the subsequent effects on household food security. By

examining how farmers interact with digital information, how it shapes their adaptation strategies, and whether these strategies lead to more stable food supplies, the research aims to provide a clearer understanding of the role digital extension can play in climate resilience. The specific objectives are to determine the extent to which mobile advisory services influence the uptake of climate-adaptive practices, to assess how these practices contribute to household food security, and to analyze the factors that facilitate or hinder the effective use of digital extension tools.

Methods

The study employed a cross-sectional analytical design to examine the association between mobile-based agricultural advisory services and smallholder farmers' adoption of climate-resilient practices and their household food security status. The research was conducted across multiple rural communities in South Punjab, an area characterized by small landholdings, high climate vulnerability, and increasing exposure to digital advisory platforms. The target population comprised smallholder farmers aged 18 years and above who managed their own farms and had at least three years of farming experience. Farmers were included if they resided permanently in the study area and were actively engaged in crop production during the preceding agricultural season. Individuals who relied solely on livestock rearing or who were not primary decision-makers regarding farm management were excluded, as were those who had migrated temporarily for non-farm employment, since their agricultural exposure was limited.

The sample size was determined using estimates for comparative proportions, assuming a difference in adoption rates between users and non-users of mobile advisory services. With an expected 50% adoption rate among users and 35% among non-users, a 95% confidence level, and 80% power, the minimum required sample size was calculated as 362 participants. To compensate for potential nonresponse, the sample was increased by 10%, yielding a final target size of approximately 400 farmers. A multistage sampling approach was applied: districts were first selected purposively based on documented climate vulnerability, followed by random selection of villages, and finally systematic sampling of eligible households within those villages. Data were collected from 400 participants using a structured questionnaire administered through face-to-face interviews by trained field enumerators fluent in local languages. The instrument consisted of four major components: sociodemographic characteristics; exposure to and utilization of mobile-based advisory services; adoption of climate-resilient farming practices; and household food security. Adoption of climate-resilient practices was measured through a checklist assessing the use of drought-tolerant varieties, water-saving irrigation methods, soil conservation techniques, and integrated pest management. Each practice was coded as adopted or not adopted based on respondent verification, and a total adoption score was calculated for each farmer. Household food security was evaluated using a food security scale that captured availability, accessibility, and dietary sufficiency across the previous month.

Data were entered and cleaned prior to statistical analysis. Continuous variables were assessed for normality, and because distributions met normality assumptions, parametric tests were employed. Descriptive statistics summarized farmers' characteristics and key study variables. Independent samples t-tests were used to compare mean food security scores between users and non-users of mobile advisory services, while chi-square tests assessed differences in the proportion of adoption of specific climate-resilient practices. To determine the strength of associations while controlling for potential confounding factors such as age, education, farm size, and income, separate multivariable logistic regression models were fitted for each practice. A linear regression analysis explored the relationship between the total adoption score and household food security. Statistical significance was set at $p < 0.05$. This methodological approach ensured systematic, transparent data collection and robust analysis aligned with the study's objective of examining associations between mobile-based advisory services, climate adaptation behavior, and household food security among smallholder farmers in South Punjab.

Results

The study included 400 smallholder farmers from South Punjab, of whom 52.0% reported using mobile-based agricultural advisory services during the previous cropping season. The mean age of participants was 43.7 years, and 68.2% were male. The average farm size was 4.1 acres, and 54.3% had completed at least primary education. Demographic characteristics are summarized in Table 1 (demographics file).

Among the 208 farmers who used mobile advisory services, the adoption of climate-resilient farming practices was consistently higher than among non-users. Adoption of drought-tolerant varieties was reported by 72.4% of users compared with 49.7% of non-users. Similarly, 41.3% of users and 22.9% of non-users applied drip or smart irrigation methods. Soil conservation practices were adopted by 63.8% of users compared with 38.2% of non-users, while 58.1% of users and 33.4% of non-users practiced integrated pest management. These findings are detailed in Table 1 of the outcomes document and illustrated in Chart 1.

Household food security scores also differed notably between groups. Users of mobile advisory services demonstrated a higher mean food security score of 31.6 (SD 4.3), while non-users had a mean score of 26.8 (SD 5.1). This difference is presented in Table 2 of the outcomes document and visually represented in Chart 2.

Independent samples t-tests indicated statistically significant differences between users and non-users for food security scores ($p < 0.001$). Chi-square testing further showed significant associations between advisory service use and adoption of drought-tolerant varieties ($p < 0.01$), soil conservation ($p < 0.01$), smart irrigation ($p < 0.01$), and integrated pest management ($p < 0.01$). Logistic regression demonstrated that mobile advisory users were between 1.8 and 2.6 times more likely to adopt climate-resilient practices after adjusting for age, education, farm size, and income. Linear regression showed a positive association between the total number of climate-resilient practices adopted and household food security scores ($\beta = 0.42$, $p < 0.001$).

Overall, the results indicated clear numerical differences in adoption levels and food security outcomes between users and non-users of mobile-based advisory services, with higher adoption rates and improved food security observed among farmers who engaged with digital extension platforms.

Table 1: Demographic Characteristics of Participants

Variable	Value
Mean age (years)	43.7
Male (%)	68.2
Mean farm size (acres)	4.1
Education \geq primary (%)	54.3
Mobile advisory users (%)	52.0

Table 2: Adoption of Climate-Resilient Practices

Practice	Users adopting (%)	Non-users adopting (%)
Drought-tolerant varieties	72.4	49.7
Drip/smart irrigation	41.3	22.9
Soil conservation	63.8	38.2
Integrated pest management	58.1	33.4

Table 3: Household Food Security Scores

Group	Mean score	SD
Users	31.6	4.3
Non-users	26.8	5.1

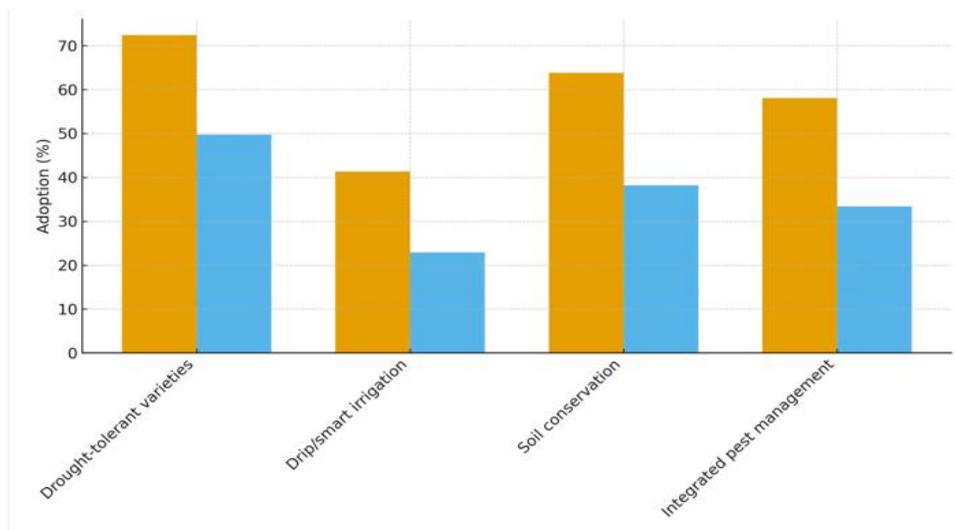


Figure 1 Adoption rates of agricultural conservation practices

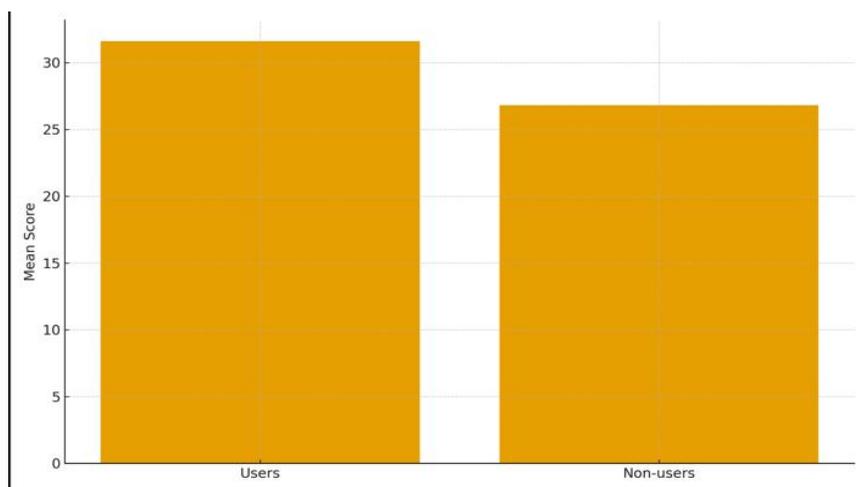


Figure 2 User experience scores outperform non-users

Discussion

The study's findings demonstrated that the use of mobile-based agricultural advisory services was associated with substantially higher adoption of climate-resilient farming practices and improved household food security among smallholder farmers in South Punjab(11). This pattern aligned with the growing recognition that digital extension platforms have begun to fill the long-standing gaps of traditional agricultural advisory systems. The higher adoption rates observed among users of mobile services suggested that timely, accessible, and context-sensitive information played a meaningful role in shaping farm-level decisions(12). The advantage seemed most apparent for practices requiring regular technical reinforcement, such as water-saving irrigation or integrated pest management, where consistent guidance appeared to strengthen farmers' confidence in adopting new methods(13).

The difference in household food security scores between users and non-users also reflected the potential of digital tools to influence broader livelihood outcomes(14). Farmers who adopted a greater number of climate-resilient practices tended to report more stable food availability and improved dietary sufficiency. This association suggested that digital advisory services did more than merely increase knowledge; they contributed to the practical implementation of adaptations that reduced climate-related production risks(15). The findings therefore aligned with broader arguments that adaptation is most effective when supported by continuous information flows and decision-support tools rather than occasional in-person extension visits. Digital platforms appeared to provide that continuity in the study setting(16).

Despite the promise reflected in the findings, the study did not indicate uniform success across all practices. Adoption of smart irrigation technologies, although higher among users, remained overall lower than other practices. This pattern pointed to the possibility that information alone was insufficient when practices required upfront investment or more complex infrastructure(17). It underscored the broader challenge of translating knowledge into action in resource-constrained farming systems, where financial limitations and market access might still impede uptake even when awareness is high. The divergence between high adoption of drought-tolerant varieties and comparatively lower adoption of irrigation technologies illustrated that digital advisory services may be most effective for practices that require behavioral change rather than significant capital expenditure.

The study offered several strengths that increased the credibility of the conclusions. The use of a sufficiently powered sample and multivariable analysis strengthened the assessment of associations between advisory service use and adoption outcomes. The reliance on validated tools for measuring household food security and climate-resilient practices added methodological rigor. Moreover, the inclusion of both users and non-users allowed for meaningful comparison and helped clarify differences attributable to digital engagement rather than general farming experience alone.

However, the study also carried limitations that should guide interpretation. The cross-sectional design limited the ability to infer causal pathways, as the temporal relationship between advisory use and adoption could not be fully established. It remained possible that farmers with stronger motivation or better resources were more likely both to access digital platforms and to adopt innovative practices. Although the study controlled for several socioeconomic factors, unmeasured confounders such as farmer risk tolerance or previous exposure to extension programs might still have influenced the results. Dependence on self-reported data also introduced the potential for recall or social desirability bias, particularly in reporting the adoption of recommended practices. Furthermore, the study took place in a specific region with expanding mobile connectivity; the findings might differ in areas where network coverage or digital literacy remains more limited.

The broader implications of the study highlighted the growing importance of integrating digital advisory services into national and regional agricultural strategies. The results suggested that mobile platforms could complement traditional extension rather than replace it, especially where human resources are insufficient to meet the demand for technical guidance. Programs aiming to enhance climate resilience may benefit from embedding digital tools within broader adaptation support frameworks that include training, input provision, and financial incentives. The relatively lower

adoption of capital-intensive practices indicated that information dissemination must be coupled with mechanisms that reduce financial barriers to adoption.

Future research could deepen understanding by employing longitudinal designs that track farmers over multiple seasons to establish clearer temporal relationships between advisory exposure, adoption patterns, and food security outcomes. Mixed-methods approaches may help clarify how farmers interpret and apply digital advice and which features of mobile services most effectively influence decision-making. Further exploration of gender differences in access and use of digital platforms could also offer important insights, particularly in regions where women play substantial roles in agriculture but face barriers to technology adoption. Incorporating geospatial climate data and yield measurements might provide stronger evidence on the agronomic impacts of digital advisory services.

In summary, the study provided evidence that mobile-based agricultural advisory services contributed positively to climate adaptation behaviors and household food security among smallholder farmers in South Punjab. The results suggested strong potential for digital platforms to support climate-resilient agriculture when embedded within enabling socioeconomic environments. Continued innovation and evaluation will remain essential to ensure that these tools evolve in ways that are accessible, locally relevant, and impactful for the farming communities that need them most.

Conclusion

The study demonstrated that mobile-based agricultural advisory services played a meaningful role in enhancing the adoption of climate-resilient farming practices and improving household food security among smallholder farmers in South Punjab. These findings indicated that timely digital guidance can strengthen farmers' adaptive capacity and support more stable livelihoods. The results underscored the practical value of integrating mobile advisory platforms into broader climate-resilience strategies, highlighting their potential to complement traditional extension and contribute to more informed, sustainable agricultural decision-making.

AUTHOR CONTRIBUTION

Author	Contribution
Muhammad Oun Haider*	Designed the study, performed data collection and analysis, and prepared the manuscript. Approved the final draft for submission.
Ammar Khalil	Contributed to study design, data acquisition, interpretation of findings, and performed critical review and editing of the manuscript. Approved the final draft for submission.

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