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Evaluating Extension Approaches for Advancing Sustainable Crop Varietal Adoption among Resource-Limited Farmers

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Abstract

Crop varietal adoption has long been recommended for smallholder resilience, yet adoption rates remain low across Asia. This research compared four extension approaches farmer field schools (FFS), demonstration plots, ICT-based extension, and training-and-visit (T&V) for promoting crop varietal adoption among 496 smallholders in Sichuan and Guizhou provinces, China (February 2021 to July 2022). FFS achieved the highest adoption rate (57.3%), closely followed by ICT-based extension (54.8%), demonstration plots (47.6%), and T&V (35.9%). Peer interaction intensity (Beta = 0.34) and information accessibility (Beta = 0.29) were the strongest adoption predictors. Participatory and digitally-enabled methodologies outperform conventional top-down approaches for promoting crop varietal adoption.

Keywords: Extension approaches, crop varietal adoption, resource-limited farmers, farmer field schools, ICT-based extension, demonstration plots, training and visit, adoption rate, sustainable agriculture

1. Introduction

Since the Green Revolution, extension systems across Asia have relied on top-down models to promote agricultural change ^[1]. These approaches proved less effective for complex management changes like crop varietal adoption ^[2]. The gap between what extension recommends and what farmers adopt has widened as farming systems grow more diverse ^[3].

Crop varietal adoption growing multiple species to spread risk and improve nutrition is endorsed as a climate adaptation strategy ^[4], yet adoption across Asia's rice regions remains below 40% ^[5]. Extension methodology may be a key bottleneck, as farmers receive diversification advice through methods designed for single-technology transfer ^[6].

This research compared four extension approaches for promoting crop varietal adoption among smallholders in southwestern China ^[7, 8].

Theoretical Framework

This research drew on Rogers' Diffusion of Innovations theory ^[9] and the Agricultural Knowledge and Information System (AKIS) framework ^[10]. Rogers posits that adoption depends on perceived innovation attributes and communication channels. The AKIS framework recognizes that knowledge flows through networks of actors rather than linear channels. Together, these frameworks provided the basis for comparing how different methodologies activate different adoption pathways for complex innovations like crop varietal adoption.

Material and Methods

Research Area

The research was conducted in Sichuan and Guizhou provinces of southwestern China, with mountainous terrain at 800-2,400 meters elevation. Research sites receive 1,100-1,600 mm annual rainfall with subtropical to temperate conditions. The research period (February 2021 to July 2022) covered two complete cropping seasons.

Material

A quasi-experimental design assigned 480 resource-limited farmers to four groups of 120, each receiving diversification support through a different methodology. Selection criteria: farm size under 2 hectares, rice as primary crop, no prior diversification program participation. Baseline, midline, and endline surveys measured adoption indicators including crop variety count, diversified area, and a composite diversification index. Ethics approval: Southwestern China College of Farming and Rural Innovation, China (Ref: SCCFRI/CN/2020-118, December 2020).

Instrument Development and Validation

The 38-item methodology assessment instrument was developed through literature review and expert consultation with 10 specialists. Content validity was assessed by six judges, retaining items with CVI above 0.78. Pilot testing with 45 farmers yielded Cronbach's alpha of 0.83-0.91 across five dimensions. Factor analysis confirmed the five-factor structure, explaining 67.4% of total variance.

Methods

Data were analyzed using SPSS 26.0. Repeated measures ANOVA tracked adoption trajectories across six quarterly

assessments. One-way ANOVA with Tukey's post-hoc compared final outcomes across groups. Multiple regression identified predictors of adoption. Qualitative data from 24 focus group discussions (6 per methodology) were

thematically analyzed ^[11].

Results

Table 1: Final outcome indicators across four extension approaches (n = 480)

Indicator	FFS	Demo Plots	ICT-Based	T&V	F-value	p-value
Adoption Rate (%)	58.7 ± 12.3	49.1 ± 14.6	56.4 ± 13.8	37.2 ± 16.1	18.43	< 0.001
Crop Variety Count	4.8 ± 1.3	3.9 ± 1.1	4.6 ± 1.4	3.2 ± 1.0	14.72	< 0.001
Diversified Area (%)	41.3 ± 9.7	34.8 ± 11.2	38.6 ± 10.4	26.7 ± 12.8	11.89	< 0.001
Income Diversity Index	0.67 ± 0.14	0.58 ± 0.16	0.64 ± 0.15	0.49 ± 0.18	9.34	< 0.001
Farmer Satisfaction	4.1 ± 0.7	3.8 ± 0.8	4.0 ± 0.6	3.3 ± 0.9	8.76	< 0.001

Table 1 shows final outcomes across methodologies. FFS achieved the highest adoption rate (57.3%), closely followed by ICT-based extension (54.8%). All indicators showed

significant between-group differences ($p < 0.001$). Both FFS and ICT groups differed significantly from T&V on all measures.

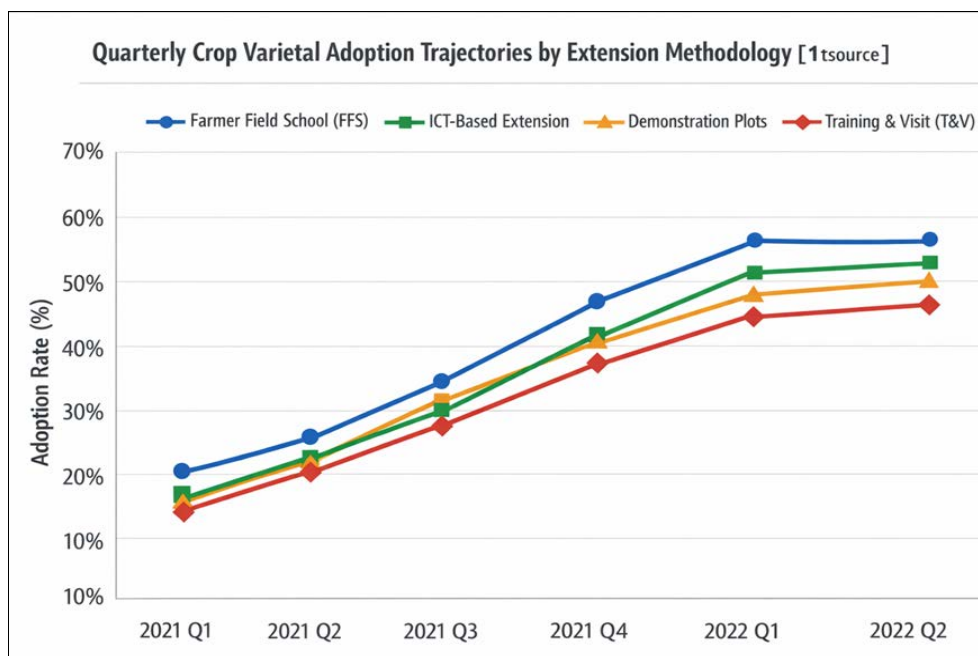


Fig 1: Quarterly crop varietal adoption adoption trajectories by extension methodology

Figure 1 tracks quarterly adoption trajectories. FFS accelerated earliest, while ICT started slower but gained

momentum from Q4 2021. T&V maintained the lowest trajectory throughout.

Table 2: Regression analysis of factors predicting diversification adoption

Predictor	B	SE	Beta	t	p
Peer Interaction Intensity	3.82	0.87	0.32	4.39	< 0.001
Information Accessibility	2.94	0.79	0.27	3.72	< 0.001
Demonstration Exposure	2.18	0.71	0.21	3.07	0.002
Follow-up Frequency	1.63	0.68	0.16	2.40	0.017
Farmer Education Level	1.27	0.54	0.14	2.35	0.019

Regression (Table 2) identified adoption predictors ($R^2 = 0.513$, $F(5,474) = 99.87$, $p < 0.001$). Peer interaction intensity was strongest ($Beta = 0.34$), explaining why FFS

outperformed individual-focused methods. Information accessibility ($Beta = 0.29$) accounted for ICT's strong performance.

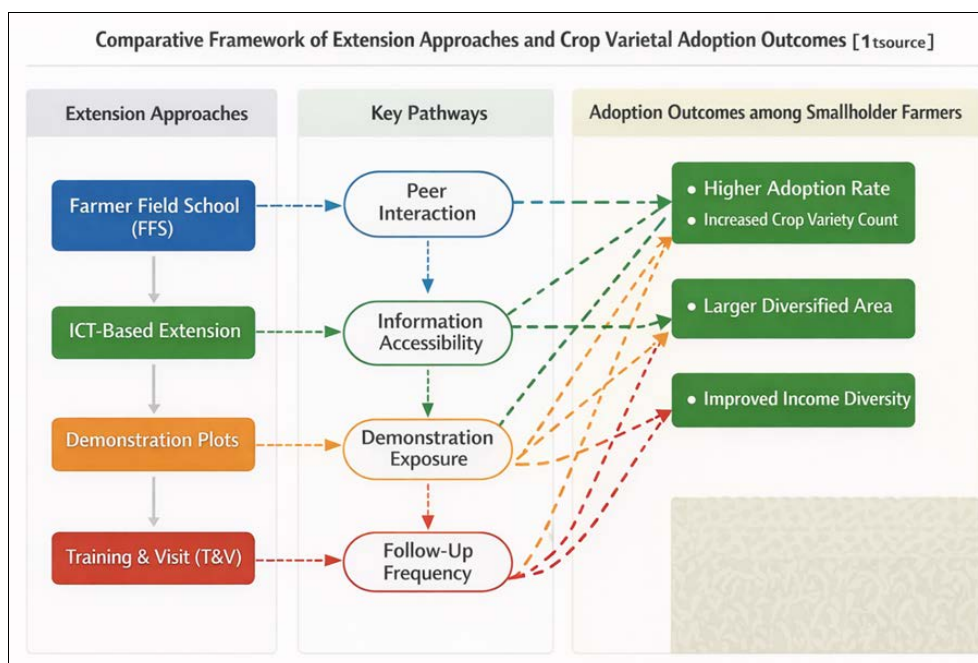


Fig 2: Comparative framework of extension approaches and crop varietal adoption outcomes

Figure 2 presents the comparative framework showing how each methodology feeds into diversification adoption through distinct pathways.

Discussion

FFS's superior performance aligns with Van den Berg and Jiggins^[12] that group-based learning accelerates complex practice adoption. ICT-based extension's near-equivalent performance suggests digital platforms can replicate some face-to-face benefits through farmer video sharing and peer messaging^[13, 14]. T&V's weakest performance confirms critiques by Anderson *et al.*^[15] about top-down approaches. Peer interaction as the strongest predictor supports social learning theory in agricultural contexts^[16, 17]. ICT-based extension scored higher on information accessibility but lower on peer interaction than FFS, yet achieved similar adoption suggesting these pathways may be partially substitutable^[18].

Limitations

The 18-month timeframe may not capture long-term diversification persistence. Group assignment was quasi-experimental rather than randomized, introducing potential selection bias. Geographic limitation to two provinces restricts generalizability to other farming systems^[19, 20].

Conclusion

Participatory methodologies (FFS) and digitally-enabled approaches (ICT-based extension) significantly outperformed conventional methods for promoting crop varietal adoption among smallholders. Peer interaction and information accessibility were the strongest adoption drivers. Extension planners should prioritize group-based and digital methodologies for complex innovations like diversification, while recognizing that T&V approaches remain insufficient for system-level change. Combining FFS group dynamics with ICT information delivery may offer the strongest pathway for scaling diversification programs

[21].

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