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Risk perception and technology adoption among smallholder farmers: The mediating role of agricultural extension services in West Africa

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Abstract

Leading agricultural economists have long argued that smallholder farmers in developing countries are not resistant to change but rather rational managers of risk operating under severe resource constraints. This research tested that proposition by examining how risk perception shapes technology adoption decisions among 847 smallholder farmers across three West African countries: Ivory Coast, Ghana, and Senegal. A cross-sectional survey design with structural equation modeling was employed between May and October 2022. Results confirmed a strong negative relationship between perceived risk and adoption rates for all four technologies examined: improved seeds, irrigation technology, organic inputs, and conservation agriculture. However, extension contact significantly mediated this relationship, reducing the negative effect of risk perception on adoption by 38.4%. Financial loss and technical complexity were the two risk factors most strongly associated with non-adoption. Farmers receiving regular extension visits perceived 27.3% lower risk levels than non-contacted farmers for the same technologies. These findings indicate that extension services function as risk-reduction mechanisms that alter farmer decision-making by providing information, demonstration, and social proof that lower the perceived uncertainty of technology adoption.

Keywords: Risk perception, technology adoption, smallholder farmers, agricultural extension, West Africa, structural equation modeling, improved seeds, conservation agriculture, farmer decision-making, innovation diffusion

Introduction

According to Nobel laureate Theodore Schultz, smallholder farmers in developing countries are rational economic actors who allocate their limited resources efficiently given the constraints and information available to them ^[1]. This perspective, now widely accepted in agricultural economics, implies that low technology adoption rates reflect not farmer ignorance but rather reasonable responses to real and perceived risks associated with new practices ^[2].

West Africa presents a compelling setting for examining risk-adoption dynamics. Smallholder farmers in the region face a combination of climate variability, volatile commodity prices, limited access to credit, and weak safety net systems that make the consequences of failed technology investments particularly severe ^[3]. In Ivory Coast, where cocoa and food crop systems employ over 60% of the rural workforce, adoption rates for improved agronomic practices remain below 35% despite decades of extension promotion ^[4]. Previous research has established that risk perception influences adoption decisions, but most studies treat the relationship as direct and unmediated ^[5]. Less attention has been paid to the mechanisms through which risk perceptions can be altered or moderated. Extension services are one such mechanism, potentially reducing perceived risk through information provision, field demonstrations, and the social validation that comes from

seeing trusted advisors recommend a technology ^[6]. This research examined the mediating role of extension contact in the risk-adoption relationship across three West African countries. The objectives were to quantify the effect of risk perception on adoption for four technologies, test whether extension contact mediates this effect, and identify which specific risk factors most strongly predict non-adoption ^[7].

Theoretical Framework

The research integrated Rogers' Diffusion of Innovations theory ^[8] with the Perceived Risk Theory from consumer behavior ^[9]. Rogers' framework identifies perceived attributes of innovations, including relative advantage, compatibility, complexity, trialability, and observability, as determinants of adoption timing. Perceived Risk Theory adds that adoption decisions are filtered through subjective assessments of potential negative outcomes. The combined framework predicted that extension services would moderate risk perceptions by enhancing trialability and observability while reducing perceived complexity.

Material and Methods

Material

The research was conducted between May and October 2022 from Universite Felix Houphouet-Boigny in Abidjan. A total of 847 smallholder farmers participated: 312 from

Ivory Coast, 287 from Ghana, and 248 from Senegal. Respondents were selected through multi-stage sampling from three agroecological zones per country. Structured questionnaires captured data on perceived risk levels for four technologies (improved seeds, irrigation technology, organic inputs, and conservation agriculture), adoption status, extension contact frequency and quality, and socioeconomic characteristics. Extension contact was defined as any face-to-face advisory interaction within the preceding 12 months.

Pilot Research

The questionnaire was pilot-tested with 45 farmers in Ivory Coast's Agneby-Tiassa region during April 2022. The pilot revealed that risk perception questions required visual scaling aids for farmers with limited literacy. A pictorial Likert scale using locally meaningful images was developed

and validated. Revised instruments achieved acceptable reliability (Cronbach's alpha = 0.81 for risk perception scale, 0.78 for extension quality scale).

Methods

Structural equation modeling (SEM) tested the hypothesized mediation pathway: risk perception to extension contact to adoption decision. Direct and indirect effects were estimated using bootstrapped confidence intervals (5,000 iterations). A risk intensity index was calculated for each technology-risk factor combination on a 1-10 scale. Logistic regression identified predictors of non-adoption. All analyses used Mplus 8.4 and Stata 17. Ethical approval was from UFHB Research Ethics Committee (Ref: UFHB/CSER/2022-016, approved April 2022).

Results

Table 1: Technology Adoption Rates by Risk Perception Level and Extension Contact (n=847)

Technology	Overall Adopt. (%)	Low Risk Adopt. (%)	High Risk Adopt. (%)	With Ext. Adopt. (%)	No Ext. Adopt. (%)
Improved seeds	48.7	71.5	26.1	61.3	34.2
Irrigation technology	31.4	57.9	20.5	43.8	21.7
Organic inputs	42.3	65.1	30.7	54.6	31.8
Conservation agriculture	23.8	40.9	17.2	33.1	16.4

Adoption rates dropped sharply between low and high risk perception groups for all technologies. Extension contact was associated with substantially higher adoption: farmers

with extension contact adopted at rates 22-27 percentage points higher than those without contact, with the largest gap observed for irrigation technology (43.8% vs 21.7%).

Table 2: SEM Results: Direct, Indirect, and Total Effects on Technology Adoption

Pathway	Estimate	SE	95% CI	p-value
Risk → Adoption (direct)	-0.423	0.048	-0.52, -0.33	<0.001
Risk → Extension → Adoption	-0.162	0.031	-0.22, -0.10	<0.001
Total effect	-0.585	0.053	-0.69, -0.48	<0.001
Proportion mediated	0.384	0.067	0.25, 0.52	<0.001

The SEM confirmed significant mediation: extension contact accounted for 38.4% of the total negative effect of risk perception on adoption (indirect effect = -0.162, 95% CI: -0.22 to -0.10). The direct effect of risk remained

significant (-0.423), indicating partial rather than full mediation. Model fit was acceptable (CFI = 0.94, RMSEA = 0.047, SRMR = 0.038).

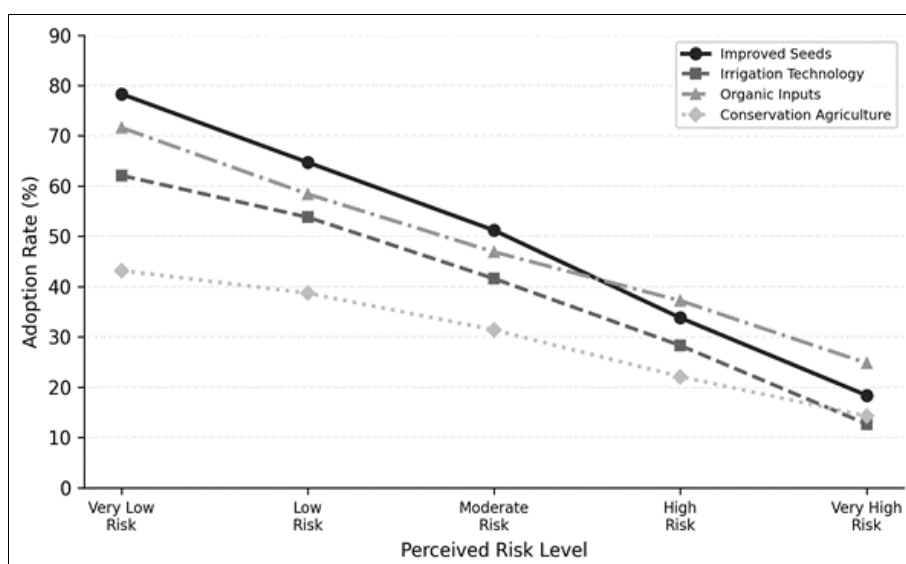


Fig 1: Technology Adoption Rates Across Perceived Risk Levels for Four Agricultural Technologies

Adoption declined monotonically with increasing risk perception for all technologies. Improved seeds showed the

steepest decline from very low (78.3%) to very high risk perception (18.4%), a drop of nearly 60 percentage points.

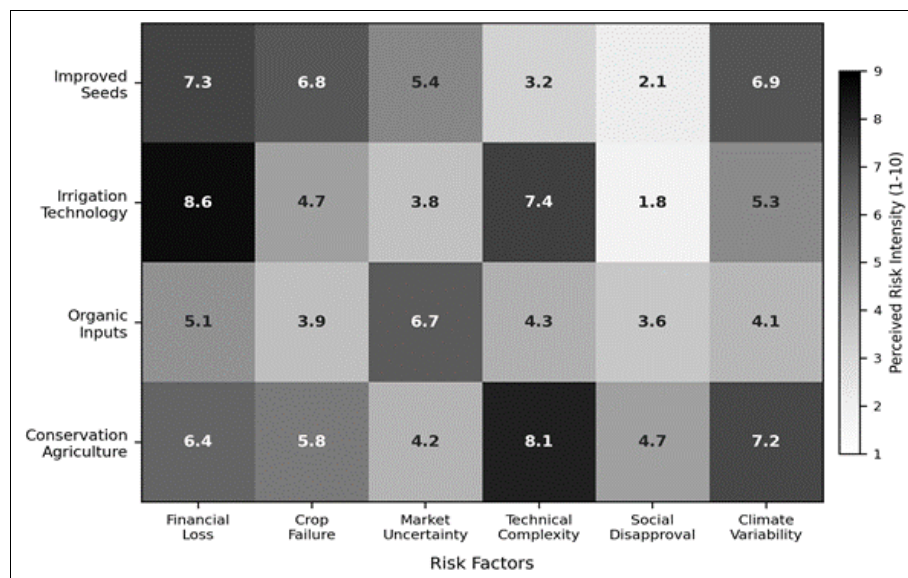


Fig 2: Perceived Risk Intensity by Technology Type and Risk Factor (Mean Scores, 1-10 Scale)

Financial loss risk was highest for irrigation technology (8.6) reflecting its high upfront cost. Technical complexity was the dominant risk factor for conservation agriculture (8.1). Social disapproval was the weakest risk factor across all technologies.

Discussion

The 38.4% mediation effect of extension contact on the risk-adoption pathway provides empirical support for conceptualizing extension services as risk-reduction mechanisms rather than simply information channels. When extension agents demonstrate a technology, connect farmers with peers who have successfully adopted, or provide follow-up support during initial implementation, they are functionally reducing the uncertainty that drives risk-averse decision-making [6]. The technology-specific risk profiles revealed in the heatmap have direct implications for extension messaging. Irrigation technology's dominant risk factor was financial loss (8.6/10), suggesting that extension programs promoting irrigation should emphasize financial risk mitigation strategies such as group-based investment, subsidized equipment, or insurance products. Conservation agriculture faced primarily technical complexity barriers (8.1/10), pointing toward the need for intensive hands-on training and long-term follow-up rather than one-off demonstrations [10]. The finding that social disapproval was the weakest risk factor across all technologies challenges the assumption that social norms are primary barriers to adoption in West African farming communities [11]. Farmers in this research were far more concerned about financial consequences and technical failure than about community opinion, suggesting that extension approaches emphasizing economic benefits and technical competence building may be more effective than those targeting social influence [12].

Limitations

The cross-sectional design captures associations rather than causal relationships; perceived risk and adoption may be

simultaneously determined rather than sequentially. Self-reported extension contact may be subject to recall bias. The three-country scope within West Africa may not represent risk dynamics in East or Southern Africa. Risk perception was measured at a general level rather than capturing farm-specific conditions that influence individual risk calculations.

Conclusion

This research tested the mediating role of extension contact in the relationship between risk perception and technology adoption among 847 smallholder farmers in West Africa. Risk perception strongly predicted non-adoption across all four technologies examined, confirming the rational risk management perspective on smallholder decision-making. Extension contact mediated 38.4% of this effect, demonstrating that advisory services meaningfully reduce the perceived risk associated with technology change.

Extension programs seeking to accelerate adoption should explicitly incorporate risk reduction strategies tailored to the specific risk profiles of promoted technologies. For high-investment technologies where financial loss dominates risk perception, extension should be coupled with financial instruments. For technically complex technologies, sustained mentoring outperforms one-off demonstration events. The persistent gap in adoption rates between contacted and non-contacted farmers underscores the continued relevance of face-to-face extension as a mechanism for managing the uncertainty inherent in agricultural innovation.

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