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Perceived usefulness and ease of use as predictors of farmer engagement with mobile extension applications

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Abstract

Technology acceptance in agriculture is often assumed rather than tested extension agencies develop mobile applications expecting farmers will use them, but uptake frequently falls short of projections. This research applied the Technology Acceptance Model (TAM) to examine whether perceived usefulness and perceived ease of use predicted farmer engagement with mobile extension applications in Madagascar. A cross-sectional survey was administered to 213 smallholder farmers across Analamanga, Vakinankaratra, and Itasy regions who had been exposed to at least one mobile extension application between January and September 2022. Structural equation modeling tested the TAM framework with digital literacy, age, education, and social influence as external variables. Perceived usefulness ($\beta = 0.47, p < 0.001$) and perceived ease of use ($\beta = 0.38, p < 0.001$) together explained 54.3% of variance in behavioral intention to use mobile extension apps. Young farmers under 35 scored significantly higher on both perceived usefulness (mean = 3.9) and ease of use (mean = 4.1) compared to farmers over 50 (means = 2.6 and 2.2 respectively, $p < 0.001$). Digital literacy mediated 27.4% of the relationship between education and perceived ease of use. Only 38.1% of farmers who expressed high behavioral intention translated this into regular app usage beyond three months. The gap between intention and sustained use suggests that TAM captures initial acceptance but may under predict long-term engagement in resource-constrained agricultural settings.

Keywords: Technology acceptance model, perceived usefulness, ease of use, mobile extension, farmer engagement, digital agriculture, app adoption, smallholder farmers, Madagascar agriculture, ICT extension

Introduction

Technology acceptance refers to the psychological and behavioral processes through which individuals decide to adopt, continue using, or abandon a new technology [1]. In agricultural extension, mobile applications have been promoted as a way to deliver timely advisory content to farmers in areas where face-to-face extension is sparse. Madagascar, where the extension agent-to-farmer ratio exceeds 1:5,000 in most regions, has seen at least 14 mobile extension applications launched since 2015, yet sustained user engagement rarely passes 20% of registered farmers [2, 3].

Davis's Technology Acceptance Model offers a tested framework for understanding this pattern. TAM proposes that perceived usefulness (the degree to which a person believes using a technology will improve performance) and perceived ease of use (the degree to which use is seen as effortless) are the two primary determinants of technology adoption behavior [4]. While TAM has been applied across sectors from banking to healthcare, its application in smallholder agricultural contexts remains limited, and results from developed-country settings may not transfer directly to environments with lower digital literacy and infrastructure constraints [5, 6]. This research tested whether the TAM framework applies to mobile extension application engagement among Malagasy smallholder farmers and identified which external factors most strongly influence the core TAM constructs.

Theoretical framework

The research was grounded in the extended Technology Acceptance Model (TAM2), which adds social influence processes and cognitive instrumental processes to the original TAM framework [7]. In the agricultural context, social influence captures the role of peer farmers, extension agents, and community leaders in shaping technology perceptions. The model hypothesized that perceived usefulness and ease of use would directly predict behavioral intention, while external variables (digital literacy, age, education, social influence) would operate indirectly through the two core TAM constructs. The knowledge-attitude-practice sequence from extension theory was integrated with TAM, positioning knowledge of app features as a precursor to attitude formation (usefulness/ease perceptions) and subsequent practice (actual usage behavior) [8].

Materials and Methods

Materials

A cross-sectional survey design was adopted. The target population comprised smallholder farmers in Analamanga, Vakinankaratra, and Itasy regions who had been exposed to at least one mobile extension application through government or NGO programs. Purposive sampling through regional extension offices and farmer cooperatives identified 213 eligible respondents. The survey instrument

contained 46 items adapted from validated TAM scales by Davis and Venkatesh, with modifications for the agricultural context [4, 9]. Items were translated into Malagasy and back-translated for accuracy. Data collection occurred between January and September 2022 through the Faculty of Agriculture, University of Antananarivo, Madagascar. Pilot testing with 18 farmers in Ambohidratrimo district confirmed instrument clarity and cultural appropriateness.

Methods

Structural Equation Modeling (SEM) was performed using

AMOS version 26 to test the hypothesized TAM framework. Model fit was assessed through chi-square/df ratio (<3.0), CFI (>0.90), and RMSEA (<0.08). Path coefficients (β) and significance levels were estimated using maximum likelihood estimation. Mediation effects of digital literacy were tested using the bootstrapping method with 5,000 resamples. Group comparisons by age category used multi-group SEM with measurement invariance testing. Descriptive statistics and bivariate correlations were computed in SPSS version 26 [10].

Results

Table 1: TAM construct scores by farmer age category and path coefficients

Variable	<35 yrs (n=68)	35-50 yrs (n=91)	>50 yrs (n=54)	Overall mean	Path β	p-value
Perceived Usefulness	3.91	3.42	2.63	3.38	0.47	<0.001
Perceived Ease of Use	4.12	3.08	2.21	3.18	0.38	<0.001
Digital Literacy	3.74	2.89	1.87	2.89	0.31*	<0.01
Social Influence	3.46	3.21	2.93	3.21	0.22	<0.05
Behavioral Intention	4.03	3.37	2.48	3.34		
Actual Sustained Use (%)	52.9	36.3	18.5	38.1		

Digital literacy path coefficient refers to its indirect effect on behavioral intention through perceived ease of use. Perceived usefulness was the strongest predictor of behavioral intention ($\beta = 0.47$), followed by ease of use ($\beta =$

0.38). Young farmers consistently scored highest across all constructs. The intention-to-sustained-use conversion rate was only 38.1% overall, dropping to 18.5% among farmers over 50.

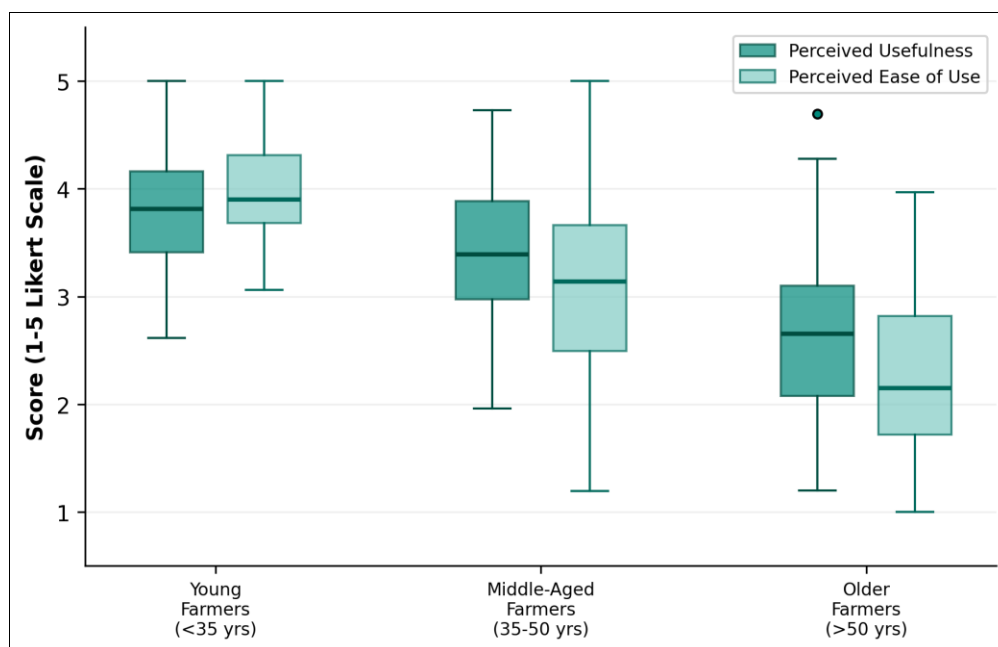


Fig 1: Distribution of perceived usefulness and ease of use scores by farmer age category

Both perceived usefulness and ease of use showed clear age gradients. Young farmers displayed the tightest score distributions (lowest variance) on both constructs, while older farmers showed wider spread and lower medians. The

ease of use gap between young and older farmers (median difference = 1.9 points) was larger than the usefulness gap (1.3 points).

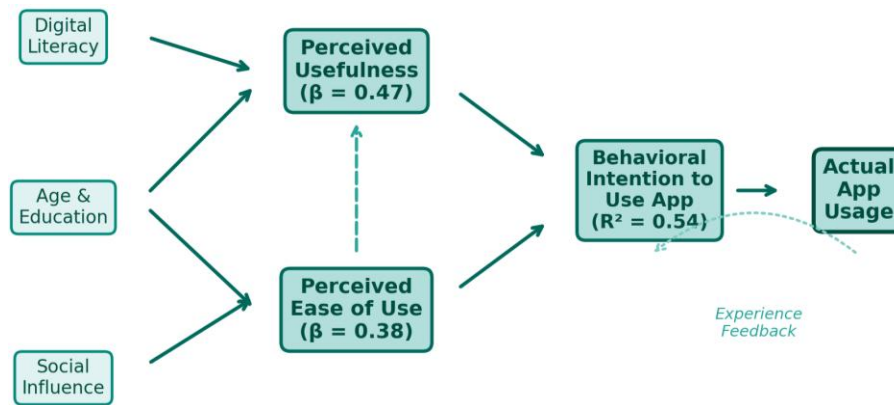


Fig 2: Technology acceptance model framework applied to mobile extension application engagement

The model shows external variables (digital literacy, age/education, social influence) feeding into the two core TAM constructs, which predict behavioral intention ($R^2 = 0.54$) and subsequently actual app usage. The experience feedback loop from actual usage back to behavioral intention represents the cyclical nature of technology acceptance over time.

Discussion

The TAM framework demonstrated reasonable explanatory power in this agricultural context, with perceived usefulness and ease of use together accounting for 54.3% of variance in behavioral intention. This is comparable to TAM performance in other developing-country agricultural technology studies, where R^2 values typically range from 0.40 to 0.60 [5, 11]. Perceived usefulness emerged as the stronger predictor ($\beta = 0.47$ vs 0.38), consistent with Davis's original finding that usefulness is weighted more heavily than ease when users evaluate whether to adopt a technology [4]. For extension app developers, this means that content relevance and practical value matter more than interface simplicity, though both are needed.

The most concerning finding is the 38.1% conversion rate from high behavioral intention to sustained use. This intention-behavior gap appears wider than what TAM typically predicts in non-agricultural settings and may reflect constraints specific to rural Madagascar: intermittent network connectivity, smartphone sharing among household members, and competing demands on farmers' time during growing seasons [12]. The sharp age gradient in both TAM constructs and actual usage rates suggests that mobile extension strategies assuming uniform farmer populations will underperform. Extension agencies might consider age-differentiated approaches app-based delivery for younger farmers combined with voice-based or SMS alternatives for older cohorts [13, 14].

Conclusion

This research tested the Technology Acceptance Model in the context of mobile extension application engagement among Malagasy smallholder farmers. Perceived usefulness and ease of use significantly predicted behavioral intention, confirming TAM's applicability in this agricultural context. However, the weak translation of intention into sustained usage particularly among older farmers signals that acceptance alone is insufficient for engagement. Mobile

extension programs should address post-adoption barriers including connectivity, digital literacy, and content currency alongside initial acceptance factors. Age-specific deployment strategies appear necessary given the pronounced generational differences in both technology perceptions and actual usage patterns observed across the three regions [15].

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