African Journal of Social and Behavioural Sciences (AJSBS)
Volume 16, Number 7 (2026) ISSN: 2141-209X
https://doi.org/10.68442/ajsbs/2026/v16i7.128

USER-CENTRED DESIGN FACTORS IN THE ADOPTION OF A SIMPLIFIED AI AGRICULTURAL ADAPTATION TOOLKIT AMONG SMALLHOLDER FARMERS IN NIGERIA

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ABSTRACT: The increasing application of artificial intelligence (AI) in agriculture presents opportunities for improving access to agricultural information, farm decision-making and productivity, but adoption among smallholder farmers depends substantially on whether technologies are understandable, acceptable and compatible with users' circumstances. This study examined user-design factors associated with behavioural intention to adopt a Simplified AI Agricultural Adaptation Toolkit (SAAAT) among smallholder farmers in Nigeria. Guided principally by the Unified Theory of Acceptance and Use of Technology (UTAUT), the study examined effort expectancy, attitude towards technology, social influence, facilitating conditions, self-efficacy and anxiety as predictors of behavioural intention and performance expectancy. Data were obtained from 300 smallholder farmers selected from Ebonyi, Benue and Taraba States through a multistage sampling procedure. Descriptive statistics, reliability analysis, Pearson correlation and multiple regression were used. The findings indicate that the predictors jointly accounted for substantial variance in behavioural intention ($R^2 = .58$) and performance expectancy ($R^2 = .53$). Effort expectancy, attitude towards technology, social influence, facilitating conditions and self-efficacy were positively associated with adoption-related outcomes, whereas anxiety showed a negative association. The findings underscore the importance of designing agricultural AI tools around farmers' practical capabilities, confidence, social environment and access to enabling infrastructure. The study concludes that user-centred design is essential for translating AI opportunities into usable and context-sensitive agricultural innovation for smallholder farmers.

Keywords: Artificial Intelligence, Smallholder Farmers, Technology Adoption, Behavioural Intention, Performance Expectancy, UTAUT, SAAAT

INTRODUCTION

Agriculture remains central to livelihoods, food systems and economic development in Nigeria, particularly through the activities of smallholder farmers. Across developing agricultural systems, smallholders are increasingly expected to respond to pressures involving productivity, climate variability, market access and food security. At the same time, digital technologies and artificial intelligence are creating new possibilities for weather information, disease and pest identification,

https://doi.org/10.68442/ajsbs/2026/v16i7.128

soil monitoring, irrigation decisions, farm management and extension support (Food and Agriculture Organization [FAO], 2022; Ahmad & Nabi, 2021).

The value of an agricultural technology, however, does not depend only on its technical capability. Adoption also depends on whether prospective users perceive it as useful, understandable, manageable and compatible with their everyday activities. Technology adoption research has consistently shown that perceived usefulness, ease of use, social influence, facilitating conditions and related beliefs shape users' intentions and subsequent behaviour (Davis, 1989; Venkatesh et al., 2003). In agricultural settings, these considerations become especially important where digital literacy, affordability, connectivity and institutional support vary considerably across communities (Dissanayake et al., 2022; El Bilali et al., 2021).

Recent literature also indicates that digital literacy is an important condition for meaningful agricultural technology adoption. Arangurí et al. (2025) noted that technology adoption in agriculture is influenced by users' skills and the availability of strategies that reduce barriers to digital engagement. In Nigeria, agricultural extension systems have also been challenged by infrastructural and institutional limitations that can reduce the reach of emerging technologies (Agoh et al., 2024; Federal Ministry of Agriculture and Rural Development [FMARD], 2020). The National Bureau of Statistics (NBS, 2023) further documented persistent differences in access to information and communication technologies, reinforcing the need for solutions that are simple and context-sensitive.

The proposed Simplified AI Agricultural Adaptation Toolkit (SAAAT) responds to this context by emphasising user design rather than technology deployment alone. The central premise is that the needs, concerns and capabilities of intended users should inform the design of an agricultural AI toolkit. Such an approach is consistent with user-centred technology development and with the argument that adoption models should be applied in ways that recognise the social and contextual realities of users (Palau-Saumell et al., 2019).

The increasing availability of AI-based agricultural applications has not automatically translated into widespread use among smallholder farmers. A technology may offer potentially useful functions while remaining difficult to understand, inaccessible or poorly aligned with the realities of its intended users. This challenge is particularly relevant in rural communities where farmers may face limited digital literacy, unreliable electricity and connectivity, financial constraints and inadequate access to technical support (Agoh et al., 2024; NBS, 2023).

A further concern is that technology development may sometimes be driven primarily by technical possibilities rather than by systematic examination of users' perceptions and practical concerns. The result can be a mismatch between the design of an application and the capacities or expectations of its intended users. Davis (1989) and Venkatesh et al. (2003) demonstrated the importance of user perceptions in technology acceptance, while Dissanayake et al. (2022) highlighted the relevance of technology-adoption theories in agricultural contexts.

https://doi.org/10.68442/ajsbs/2026/v16i7.128

For SAAAT to become a practical agricultural support tool, it is therefore necessary to identify the psychological and contextual factors that may encourage or inhibit farmers' intention to use it and their expectations about its performance. The present study addresses this gap by examining six user-design factors—effort expectancy, attitude towards technology, social influence, facilitating conditions, self-efficacy and anxiety—in relation to behavioural intention and performance expectancy regarding SAAAT among smallholder farmers in selected Nigerian states.

THEORETICAL FRAMEWORK

Unified Theory of Acceptance and Use of Technology (UTAUT)

The study was principally anchored on the Unified Theory of Acceptance and Use of Technology (UTAUT) developed by Venkatesh et al. (2003). UTAUT integrated propositions from several established technology-acceptance and behaviour theories to explain users' acceptance and use of information technology. Its core constructs include performance expectancy, effort expectancy, social influence and facilitating conditions. Later applications and extensions have demonstrated the usefulness of the framework across different technological and organisational settings (Palau-Saumell et al., 2019).

The present study adapts the UTAUT perspective to the agricultural context. Effort expectancy reflects the degree to which farmers perceive SAAAT as easy to understand and use. Social influence concerns the extent to which relevant people and community members may encourage its use. Facilitating conditions represent the perceived availability of resources and infrastructure required for use. Attitude towards technology and self-efficacy were incorporated because users' evaluations and confidence in their ability to engage with technology are relevant to adoption. Anxiety was included as a potential inhibitor because apprehension about technology can discourage intended use.

The UTAUT framework is also compatible with the Technology Acceptance Model (TAM), which emphasises perceived usefulness and perceived ease of use as important determinants of technology acceptance (Davis, 1989). Agricultural technology research has shown that no single model necessarily captures every contextual feature of adoption, making contextual adaptation important (Dissanayake et al., 2022; El Bilali et al., 2021). Accordingly, the present model emphasizes the specific user-design variables considered most relevant to SAAAT.

The study conceptualised effort expectancy, attitude towards technology, social influence, facilitating conditions, self-efficacy and anxiety as predictors of behavioural intention and performance expectancy. Behavioural intention was additionally examined as a predictor of performance expectancy. Positive perceptions of ease of use, attitude, social support, enabling conditions and self-efficacy were expected to enhance adoption-related outcomes, while anxiety was expected to operate in the opposite direction.

https://doi.org/10.68442/ajsbs/2026/v16i7.128

HYPOTHESES

The following hypotheses were posited to guide the study:

1. Effort expectancy will significantly predict behavioural intention to use SAAAT.
2. Attitude towards technology will significantly predict behavioural intention to use SAAAT.
3. Social influence will significantly predict behavioural intention to use SAAAT.
4. Facilitating conditions will significantly predict behavioural intention and performance expectancy.
5. Self-efficacy will significantly predict adoption-related outcomes associated with SAAAT.
6. Anxiety will significantly predict behavioural intention to use SAAAT.
7. Behavioural intention will significantly predict performance expectancy regarding SAAAT.

METHOD

Participants

The participants comprised 300 smallholder farmers selected from Ebonyi, Benue and Taraba States, Nigeria, representing South-East, North-Central and North-East geopolitical zones, respectively. The states were selected because of the presence of substantial smallholder agricultural activity and their relevance to the study's geographical coverage. One hundred farmers were selected from each state. The participants were farmers who owned or actively managed small farmsteads and had engaged in agricultural production within the previous five years. Farmers operating highly mechanised agricultural enterprises were excluded because the study focused specifically on smallholder farming contexts. Of the 300 participants, 171 (57.0%) were males and 129 (43.0%) were females. Their ages ranged from 18 to 68 years, with a mean age of 43.24 years (SD = 10.87). In terms of age distribution, 54 (18.0%) were aged 18–30 years, 92 (30.7%) were aged 31–40 years, 88 (29.3%) were aged 41–50 years, while 66 (22.0%) were aged 51 years and above. Regarding farming experience, 64 (21.3%) had 1–5 years of farming experience, 83 (27.7%) had 6–10 years, 94 (31.3%) had 11–20 years, while 59 (19.7%) had 21 years or more. The participants were selected through a multistage sampling procedure involving the purposive selection of the study states, identification of farming communities, and simple random selection of eligible farmers within the identified communities/clusters.

Instruments

Data were collected using a structured questionnaire comprising measures of the major study variables. The instruments were presented on a 5-point Likert-type response format, ranging from 1 = Strongly Disagree to 5 = Strongly Agree. The measures were as follows:

Effort Expectancy Scale: Effort expectancy was measured using a 4-item scale adapted from Venkatesh et al. (2003). The scale assessed the extent to which participants perceived the SAAAT

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as easy to understand, learn and use. The scale demonstrated good internal consistency in the present study, with a Cronbach's alpha of .82.

Attitude towards Technology Scale: Attitude towards technology was assessed using a 5-item measure adapted from Davis (1989) and subsequently applied in technology-acceptance research. The items assessed participants' favourable or unfavourable evaluations of using the proposed agricultural technology. The scale recorded a Cronbach's alpha of .84, indicating good reliability.

Social Influence Scale: Social influence was measured using a 4-item scale adapted from Venkatesh et al. (2003). The measure assessed the extent to which farmers perceived that important people, fellow farmers, community members and relevant agricultural personnel would encourage or support their use of SAAAT. The scale yielded a Cronbach's alpha of .79.

Facilitating Conditions Scale: Facilitating conditions were assessed using a 4-item scale adapted from Venkatesh et al. (2003). The items assessed the availability of resources, devices, connectivity, electricity, technical assistance and other conditions necessary for using SAAAT. The scale produced a Cronbach's alpha of .81.

Self-Efficacy Scale: Self-efficacy was measured using a 5-item scale adapted from computer self-efficacy measures developed by Compeau & Higgins (1995). The scale assessed participants' confidence in their ability to learn and successfully use SAAAT for agricultural activities. The scale demonstrated good internal consistency, with a Cronbach's alpha of .86.

Technology Anxiety Scale: Technology anxiety was assessed using a 4-item scale adapted from Meuter et al. (2003). The items assessed apprehension, nervousness and uncertainty associated with using a new digital agricultural technology. The scale recorded a Cronbach's alpha of .78, indicating acceptable internal consistency.

Behavioural Intention Scale: Behavioural intention to use SAAAT was assessed using a 3-item scale adapted from Venkatesh et al. (2003). The items measured participants' intention, willingness and plans to use the toolkit when available. The scale demonstrated strong internal consistency, with a Cronbach's alpha of .88.

Performance Expectancy Scale: Performance expectancy was measured using a 4-item scale adapted from Venkatesh et al. (2003). The items assessed the extent to which participants believed that using SAAAT would improve farm-related decision-making, productivity, access to useful agricultural information and overall farming performance. The scale yielded a Cronbach's alpha of .86.

All the instruments demonstrated acceptable to good internal consistency, with Cronbach's alpha coefficients ranging from .78 to .88. The questionnaire was reviewed for clarity, relevance and contextual appropriateness before administration to the participants.

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Procedure

Following the identification and selection of the study locations, the researchers contacted the relevant community and farming groups within the selected clusters to facilitate access to eligible smallholder farmers. The purpose of the study was explained to the prospective participants, and participation was voluntary. Participants were informed that the information provided would be used strictly for research purposes and that their responses would be treated confidentially. Only farmers who met the study's inclusion criteria and agreed to participate were included in the study. The researchers and trained research assistants administered the structured questionnaires directly to the selected farmers. Where necessary, the items were explained to participants in simple and understandable terms without influencing their responses. Participants were given sufficient time to complete the questionnaire based on their individual understanding and experience with agricultural activities and technology use. For participants who required assistance because of reading or comprehension difficulties, the research assistants read the items to them and recorded their responses as stated by the participants.

The questionnaire administration was conducted across the selected farming communities in Ebonyi, Benue and Taraba States. The research team maintained consistency in the administration procedure across the three states to minimise variations in data collection. Completed questionnaires were checked for completeness at the point of collection, and improperly completed or substantially incomplete copies were excluded from the analysis. A total of 300 properly completed questionnaires were retained for data analysis, comprising 100 participants from each of the three states.

Design and Statistics

A cross-sectional correlational survey design was adopted. The design was considered appropriate because the study sought to determine the relationships and predictive contributions of selected user-design variables without manipulating the study variables. Descriptive statistics were used to summarise participant characteristics and study variables. Internal consistency was examined using Cronbach's alpha, while Pearson product-moment correlation was used to assess bivariate associations. Multiple regression was employed to determine the predictive contributions of the user-design variables to behavioural intention and performance expectancy. Statistical significance was evaluated at the .05 level.

RESULTS

The findings indicate that the measures demonstrated acceptable internal consistency and that the principal study variables were meaningfully related. The regression analyses showed that the selected user-design factors accounted for substantial proportions of variance in behavioural intention and performance expectancy.

https://doi.org/10.68442/ajsbs/2026/v16i7.128

Table 1. Demographic Characteristics of Participants (N = 300)

Characteristic	Category	n	%
Sex	Male	171	57.0
	Female	129	43.0
Age	18–30 years	54	18.0
	31–40 years	92	30.7
	41–50 years	88	29.3
	51 years and above	66	22.0
State	Ebonyi	100	33.3
	Benue	100	33.3
	Taraba	100	33.3
Years farming	1–5 years	64	21.3
	6–10 years	83	27.7
	11–20 years	94	31.3
	21 years and above	59	19.7

Table 2. Descriptive Statistics, Reliability and Intercorrelations of Study Variables

Variable	M	SD	α	1	2	3	4	5	6	7	8
1. Effort Expectancy	3.62	.71	.82	1.00							
2. Attitude to Technology	3.71	.68	.84	.54**	1.00						
3. Social Influence	3.48	.76	.79	.43**	.49**	1.00					
4. Facilitating Conditions	3.39	.80	.81	.46**	.44**	.41**	1.00				
5. Self-efficacy	3.57	.73	.86	.50**	.52**	.39**	.48**	1.00			
6. Anxiety	2.41	.84	.78	-.31**	-.35**	-.22**	-.28**	-.34**	1.00		
7. Behavioural Intention	3.66	.70	.88	.59**	.63**	.46**	.55**	.58**	-.42**	1.00	
8. Performance Expectancy	3.73	.66	.86	.52**	.58**	.42**	.57**	.54**	-.36**	.68**	1.00

Note. α = Cronbach's alpha. **p < .01.

Table 3. Multiple Regression Predicting Behavioural Intention

Predictor	B	SE B	β	t	p
Effort Expectancy	.21	.05	.21	4.20	<.001
Attitude towards Technology	.26	.05	.25	5.10	<.001
Social Influence	.13	.04	.14	3.18	.002
Facilitating Conditions	.16	.05	.18	3.42	.001
Self-efficacy	.18	.05	.19	3.63	<.001
Anxiety	-.13	.04	-.16	-3.19	.002
Constant	1.07	.20	—	5.35	<.001
Model	R^2 = .58; Adjusted R^2 = .57; F(6, 293) = 67.51; p < .001				

https://doi.org/10.68442/ajsbs/2026/v16i7.128

The regression model was significant, $F(6, 293) = 67.51$, $p < .001$, explaining 58% of the variance in behavioural intention. Effort expectancy, attitude towards technology, social influence, facilitating conditions and self-efficacy made positive significant contributions, while anxiety made a significant negative contribution.

Table 4. Multiple Regression Predicting Performance Expectancy

Predictor	β	t	p	Decision
Effort Expectancy	.17	3.41	.001	Supported
Attitude towards Technology	.21	4.29	<.001	Supported
Social Influence	.12	2.58	.010	Supported
Facilitating Conditions	.20	3.96	<.001	Supported
Self-efficacy	.15	3.07	.002	Supported
Anxiety	-.11	-2.31	.022	Supported
Overall PE model	$R^2 = .53$; Adjusted $R^2 = .52$; $F(6,293) = 54.92$; $p < .001$			

Table 5. Summary of Hypothesis Decisions

Hypothesis	β	t	p	Decision
H1: Effort Expectancy → BI			$p < .001$	Supported
H2: Attitude → BI			$p < .001$	Supported
H3: Social Influence → BI			$p = .002$	Supported
H4: Facilitating Conditions → BI/PE			$p \leq .001$	Supported
H5: Self-efficacy → outcomes			$p \leq .002$	Supported
H6: Anxiety → BI			$p = .002$	Supported
H7: BI → PE	.68	15.96	<.001	Supported

The performance-expectancy model was significant and explained 53% of the variance. Behavioural intention was also strongly associated with performance expectancy ($\beta = .68$, $p < .001$), supporting H7. All seven hypotheses were therefore supported by the findings.

DISCUSSION

The findings indicate that effort expectancy was a significant positive predictor of behavioural intention. This suggests that farmers who perceive SAAAT as easier to understand and use are more likely to express an intention to adopt it. This pattern is consistent with the logic of TAM and UTAUT, in which perceived ease and effort requirements influence acceptance of technology (Davis, 1989; Venkatesh et al., 2003). In a smallholder setting, simplicity is especially relevant because a technically sophisticated tool may have limited practical value if users cannot readily navigate it.

Attitude towards technology also contributed significantly to behavioural intention and performance expectancy. This finding is consistent with broader technology-adoption literature,

https://doi.org/10.68442/ajsbs/2026/v16i7.128

which emphasises that users' evaluations of technology can influence their willingness to engage with it (Dissanayake et al., 2022). A favourable attitude may arise where farmers perceive the technology as relevant to actual farm problems rather than as an abstract digital innovation.

Social influence significantly predicted behavioural intention. This finding suggests that adoption cannot be understood entirely as an individual decision. Farmers operate within social networks involving family members, fellow farmers, extension personnel, community leaders and other trusted actors. The result accords with UTAUT's treatment of social influence as a determinant of technology acceptance (Venkatesh et al., 2003) and supports the broader agricultural technology literature emphasising the role of social and institutional contexts (El Bilali et al., 2021).

Facilitating conditions were positively associated with the adoption-related outcomes. This is important because willingness to use an application may not translate into actual engagement when farmers lack connectivity, suitable devices, electricity, technical assistance or other resources. The finding is consistent with the practical challenges identified in Nigerian agricultural technology adoption, including infrastructural and extension-system constraints (Agoh et al., 2024; FMARD, 2020; NBS, 2023).

Self-efficacy also showed a positive contribution. Farmers who believe they can successfully use technology are more likely to approach a new system with confidence and persistence. This result is compatible with the broader behavioural literature and with the technology-adoption perspective that users' perceived capability can influence engagement. In the context of SAAAT, this implies that design should not merely simplify the interface but should also provide opportunities for guided learning and successful early experiences.

Anxiety showed a negative association with behavioural intention and performance expectancy. The finding indicates that apprehension about technology may constitute a barrier to adoption. This is particularly relevant where prospective users have limited prior exposure to digital tools. Rather than treating anxiety as an isolated individual problem, the result supports the need for user education, supportive demonstrations and designs that minimise uncertainty.

Taken together, the results show that adoption of SAAAT is multidimensional. The findings align with Venkatesh et al. (2003) while also demonstrating why agricultural applications require contextual consideration of digital literacy, infrastructure, social environment and users' confidence. This is consistent with recent reviews that emphasise the importance of digital competencies and context-specific strategies in agricultural technology adoption (Arangurí et al., 2025; Dissanayake et al., 2022).

The findings have implications for the design and implementation of SAAAT. First, user interfaces should prioritise simplicity and clear navigation. Second, implementation should include demonstrations and basic digital-literacy support to strengthen farmers' confidence. Third, community-level opinion leaders, extension personnel and peer farmers can be incorporated into sensitisation and onboarding. Fourth, facilitating conditions such as device compatibility, low-data

operation, offline functionality where feasible and access to technical support should be considered during development. Finally, anxiety-reducing features such as simple instructions, error recovery and supportive feedback may improve users' willingness to engage with the toolkit.

The study was cross-sectional, so the findings describe relationships at the time of data collection and do not establish temporal causality. The study also covered selected states and therefore should not automatically be generalised to every category of Nigerian farmer. Finally, the use of self-report measures may introduce response bias. These limitations should be considered when interpreting the findings and when designing subsequent validation studies.

RECOMMENDATIONS

1. Design SAAAT around simplicity, clear navigation and locally understandable language so that farmers with varying levels of digital literacy can use the toolkit with minimal difficulty.
2. Integrate practical demonstrations, onboarding sessions and peer or extension-worker support to strengthen farmers' technology self-efficacy and reduce anxiety.
3. Engage farmers and relevant agricultural stakeholders throughout the user-design and testing stages so that the toolkit reflects actual farming needs and social contexts.
4. Prioritise facilitating conditions by considering affordability, device compatibility, connectivity constraints, technical support and low-resource operating environments during development.
5. Conduct further longitudinal and multi-state validation studies to examine sustained use of SAAAT and to test whether the identified predictors translate into actual adoption and agricultural outcomes.

CONCLUSION

The study examined user-design factors associated with behavioural intention and performance expectancy concerning a Simplified AI Agricultural Adaptation Toolkit for smallholder farmers in Nigeria. The findings indicate that effort expectancy, attitude towards technology, social influence, facilitating conditions and self-efficacy positively contribute to adoption-related outcomes, whereas anxiety constitutes a negative factor. The substantial variance explained by the models suggests that successful agricultural AI adoption requires attention to both technological usability and the psychological and contextual conditions surrounding users. SAAAT should therefore be developed as a farmer-centred intervention in which simplicity, confidence-building, social support and enabling conditions are treated as integral components of the technology rather than as issues to be addressed after deployment.

FUNDING

This research was funded by the Tertiary Education Trust Fund (TETFund) through the Institutional-Based Research (IBR) Grant.

ACKNOWLEDGEMENT

The authors appreciate the Tertiary Education Trust Fund (TETFund) for funding this research through the Institutional-Based Research Grant and acknowledges the support of Nnamdi Azikiwe University, Awka.

AUTHORS' CONTRIBUTION

All four authors contributed to the conception of the study and the development of the research design. They jointly supervised data collection and analysis, interpreted the findings and prepared the manuscript. All authors read and approved the final version.

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