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Barriers and enablers of digital extension services' adoption among smallholder farmers: the case of Cambodia, the Philippines and Vietnam

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ABSTRACT

Digital Extension Services (DES) could help smallholder farmers access science-based information to boost agricultural output and resource efficiency. Gaining insight into the factors influencing farmers' use of digital extension services was essential for executing behaviour change. A total of 937 farmers from Cambodia, the Philippines, and Vietnam were chosen as the sample for the study. This study employed the Theory of Planned Behaviour (TPB) framework by utilising a structural equation model. The findings showed a range of concerns pertaining to farmers' attitudes and actions regarding the use of digital extension services. Subjective norms, perceived behaviour control, and farmers' perceived usefulness had a favourable and significant impact on the uptake of digital extension services. Research has shown that both perceived risks and household wealth have a favourable impact on adoption rates. However, it is important to note that barriers and enablers differ throughout the three nations in Southeast Asia due to variations in culture, customs, norms, and socioeconomic factors. The paper presents a strategy to enhance farmers' engagement in DES technology by enhancing digital infrastructure, facilitating farmer access to hardware devices through government subsidies or private sector assistance, ensuring equitable access for women and youth, and organising additional training for key stakeholders.

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Adoption; challenges; opportunities; digital extension

1. Introduction

Smallholder farmers in developing countries, such as those in the Southeast Asia region, are often trapped in a vicious cycle of low productivity and agricultural market issues, such as the lack of timely information, inaccessible technologies, and unavailable financial services (Meemken & Bellemare, 2020). Agricultural extension services play a critical role in accessing these services and bridging the gap between information transfer and farming practices to help smallholder farmers increase farm productivity and reduce operational costs (Mapiye et al., 2021). However, access to agricultural extension services remain a critical issue in many rural areas. Conventional agricultural extension services have been criticized for their inability to provide satisfactory services that meet farmers' needs due to their different characteristics. Additionally, conventional extension services have not equally benefited female and male farmers due to differences in the control of production resources and participation in training programmes (Kansiime et al., 2021). Smallholder farmers are often reported to be left behind and unable to manage increasing risks in the face of market liberalization, climate and environmental changes, and the economic and social impacts of accelerated and advancing technologies (Fan & Rue, 2020). Moreover, during the COVID-19 pandemic, several economic activities

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were disrupted in farming communities and families in many developing countries. This hastened the shift to digital communication and engagement platforms, which are seen to be more cost-effective (Kansiime et al., 2021; Naika et al., 2021).

The digital extension services (DES) offered new pathways for farmers, as they were directly accessed with information that provides substantial knowledge on current updates about farming activities and related agricultural issues (Kansiime et al., 2021). Several studies indicated that digital extension services offer many opportunities in the agriculture sector, making extension services delivery more cost-effective (Naika et al., 2021). Through social media and smartphone devices, farmers had numerous opportunities to improve their price negotiation capacities, find alternative markets, and were able to sell or buy produce at better prices. Farmers could also access timely information and engaged stakeholders, including extension workers, officers of farmers' associations, agricultural policymakers, suppliers, logistics providers, and traders (Naika et al., 2021; Tumbo et al., 2018).

While there have been major advancements in digital extension services (DES) in the global arena, Southeast Asia, though still in a learning phase, has moved to a catch-up phase. Access to digital extension services remain limited, with fragmented and unreliable services that are incapable of reaching last-mile end users (Kansiime et al., 2021; SEARCA, 2021). Many studies have discussed opportunities and barriers to the adoption of digital extension services in the agriculture sector in general (Sidibe et al., 2021; Sonam & Khare, 2015). However, little attention has been given to factors affecting the adoption behaviour of smallholder farmers towards digital extension services, especially in developing countries in Southeast Asia. Additionally, very few studies have attempted to observe the farmers' behaviour towards a digital extension service (Rabbi et al., 2020). Without a thorough understanding of the adoption behaviours of smallholder farmers, service providers may take advantage of setting opportunistic high-risk investments at the expense of smallholder farmers. This study aimed to explore the factors influencing the behaviour of smallholder farmers towards the adoption of Digital Extension Services (DES) as a mechanism to improve agricultural productivity in Southeast Asia, focusing on Cambodia, the Philippines, and Vietnam. A comparative analysis of the three-country context offered insights into the significant factors influencing the adoption behaviour of smallholder farmers. This would provide an understanding to help policymakers and DES providers develop policies and programmes that can positively affect smallholders' adoption of DES.

2. Theoretical background and hypothesis development

2.1. Digital extension services

Digital extension services (DES) have been defined in various ways. Rajkhowa and Qaim (2021b) defined DES as services that provide farmers with general market and weather information through mobile phones, text messages, or internet applications, agricultural techniques via video training or call centres, and interactive voice response services for farmers. According to the Food and Agriculture Organization (FAO, 2023), DES utilizes interactive messaging or voice responses, smartphone applications that connect farmers to multimedia advisory content, farm inputs, and buyers. Meanwhile, Kermah and Birindwa (2021) utilized four pillars to explain DES, which included the enabling environment (e.g. mobile networks, internet connectivity, and mobile phone penetration), digital agricultural innovations, big data analytics, and business development services. The common factor in these definitions was the provision of internet-based extension services in the agricultural sector, facilitating interaction between service providers and farmers. These shared characteristics serve as the definition of DES in this study.

2.2. Farmers' adoption behaviours and role of Agricultural extension services

Agricultural extension services have been recognized as the most important information channel to farmers worldwide, particularly the poor farmers (Mtega, 2021). Through agricultural extension services, farmers' problems can be identified for research and for the modification of agricultural policies to the benefit of rural communities (Ngugi et al., 2014). Baig and Aldosari (2013) and Sennuga et al. (2021) stated that agricultural extension had a momentous role in facilitating farmers' learning; encouraging the adoption of improved technologies and innovations; addressing their challenges; promoting agricultural production and providing critical access to knowledge and information. Technical advice was key to

agricultural extension services and effective extension services were those widely accepted and adopted by farmers. In other words, to promote farmers' adoption of new technologies, extension services needed to be enhanced/ improved (Danso-Abbeam, 2022). Digital extension services have been considered as an approach to deploy effective remote farming technologies (USDA., 2021). In addition, extension providers needed to comprehensively understand the contextual factors that influence adoption and decision-making of smallholder farmers (Sennuga et al., 2021) to identify compatible extension strategies for different communities. Various theories and methods have been employed to investigate factors affecting farmers' adoption of innovations with different specific context using various theories, such as cognitive dissonance theory; diffusion of innovation theory; task technology fit model; expectation disconfirmation theory or expectation confirmation theory, theory of planned behaviour; technology acceptance model (TAM), the unified theory of acceptance and use technology. The theory of planned behaviour was one of the most appropriate frameworks used recently for identifying factors affecting adoption behaviours of farmers (Narine et al., 2019; Sennuga et al., 2021).

2.3. Research framework

This study used the theory of planned behaviour (TPB) as a basis for investigating barriers and enablers of smallholder farmers' adoption of DES. The original TPB developed by Ajzen and Driver (1991) had three main constructs, including attitude (ATT), subjective norm (SN) and perceived behavioural control (PBC). Like any other theory, the TPB had its own limitations, particularly, it ignored external factors that may influence behaviour and did not take into account reverse-causal relations that can influence its base constructs. The TPB has been flexibly and widely applied in various fields of study to investigate the behavioural intentions of surveyed individuals. Its original framework allows researchers to add more latent variables or constructs to accommodate research needs (Lyu et al., 2024; Taherdoost, 2018). It does not matter if the additional constructs have been used in previous studies or not, but they were hypothesized to be important for research objectives and for researchers to explore more diverse research fields (Greaves et al., 2013). Based on the shared characteristics of DES, this study tried to add more constructs to make the research results more reliable. The Theory Adoption Model (TAM), one of the adoption theories which suggests that farmers' decision-making to apply a technology is significantly influenced by their perceived ease of use and perceived usefulness or usefulness comparison (UC) to conventional practice (Pandey et al., 2018; Parab et al., 2010). Recently, the integration of TAM and TPB has been widely used to predict and understand users' adoption of various technologies and information systems (Dong et al., 2022; Voss et al., 2021). In addition, user perceived trust (PT) was found to be one of the most important factors affecting farmers' adoption of extension services (Dung, 2020). Both UC and PT influenced farmers' attitude towards using extension services (Wu et al., 2011). Thus, it was significant/ to include UC and PT in the model. Perceived risk was also a new construct that not many studies have integrated into the analyses. Due to the risky nature of high-tech services in the agricultural sector, perceived risk was assumed to influence farmers' adoption of DES. Therefore, aside from the three latent variables of the original TPB introduced by Ajzen and Driver (1991), the extended TPB (ETPB) employed in this study included additional constructs of usefulness comparison (UC) and perceived trust (PT); perceived risks (PR); and individual social variables (age, farm size, and income). The indicators under each latent variable were derived from previous studies and from in-depth interviews of key informants and local officers in the studied areas. The research hypotheses for this study were, therefore, formulated related to the ETPB and individual social variables.

2.4. Research hypothesis

According to Ajzen and Driver (1991), subjective norm refers to social norm that compels a person to perform a particular behaviour. In this study, the social norm can be the pressure from family members, neighbours, the community, extension agencies/staff, local leaders, or private sectors towards the adoption of DES for farming or community norm regarding digitalization and modernization of farming. Social pressure tends to positively influence the adoption of innovations (Shang et al., 2021). Therefore, this study proposed the following hypothesis:

H1: Subjective norms influencing individual farmers positively affect their intention to adopt DES.

Perceived behaviour control (PBC) was the second core construct that indicates an individual's perception of the ease or difficulty in performing a particular service. Farmers' intention to adopt DES would be high when they perceive themselves as knowledgeable, capable, and skillful in effectively using and managing the services. Therefore, this study proposed the following hypothesis:

H2: Perceived behavior control positively influence the adoption of DES

Attitude (ATT) was defined by Ajzen and Driver (1991) as the degree to which an individual favourably or unfavourably assesses the behaviour being examined. Thus, farmers' attitude affects their psychology regarding the adoption of DES for their farming. When farmers perceived the positive roles of a newly introduced technique or service and showed interest in using it, they became more willing to pay for and adopt it for their livelihood activities (Chiou et al., 2021; Taherdoost, 2018). Therefore, it was assumed that:

H3: Individual farmer's attitude is positively associated with adoption behavior (AB)

Usefulness comparison (UC) comprised farmers' perceived usefulness of DES compared to conventional extension services (Tien et al., 2022; Ulhaq et al., 2022). Usefulness comparison was one of the key steps in farmers' adoption decision process (Sen et al., 2021). Recent studies have indicated that the more advantages of the innovation are perceived by individual farmers, the better their attitude towards the behavioural adoption of the innovation (Eze et al., 2021; Ulhaq et al., 2022). Therefore, the following hypothesis was proposed:

H3a: Usefulness comparison is positively associated with individual farmer's attitude toward adoption behavior.

Perceived Trust (PT) was essential for increasing farmers' adoption of agricultural extension services and ensuring agricultural output. According to Zhou et al. (2023), farmers' trust in agricultural extension referred to their belief and expectation of maintaining social interaction with service providers. Through continuous information exchange with service providers, farmers with a strong sense of trust would actively learn new technologies, had a more comprehensive understanding of new technologies, and gradually promoted the adoption of these technologies themselves (Wang et al., 2020; Zhou et al., 2023). In digital services, there may be increased uncertainty due to the lack of direct face-to-face interaction. Particularly, with the lack of information about legal status and institutionalization, users may not trust the information provided by DES. Therefore, this paper proposed:

H3b: Farmers' trust on digital extension services positively influence their adoption of DES.

Risk perception was an important variable in the analysis of adoption behaviour. They were defined as a subjective loss experienced by individuals when they strive to achieve a desired outcome (Featherman & Pavlou, 2003). Given that the agricultural production system heavily relied on natural conditions, farmers encountered numerous risks and uncertainties. Recently, there have been numerous studies investigating risk perception in adoption of digital services, concentrated on e-banking services. Several degrees of perceived risk existed depending on individuals' relationships with providers, understanding of e-technologies and willingness to take risks (Khan & Abideen, 2023; Ramtiyal et al., 2022). Users who perceived greater risks of adoption of the services were likely to have reduced intentions to adopt them (Wei et al., 2018), and the perception of risk significantly influenced the perceived cost-effectiveness and convenience (Li & Huang, 2009). Therefore, this research proposed:

H4: Perceived risk is negatively associated with farmers' decision to adopt DES.

Socio-economic and demographic factors: Previous adoption studies have shown that individuals' socio-economic characteristics were important for making adoption decisions. Factors such as age, education level, sex of the household's head, and household income significantly influenced farmers' adoption of ICTs (Burke & Sewake, 2008; Narine et al., 2019). However, results of in-depth interviews showed that education level and sex of the household head were not important for DES but age of household head was. Besides, farm and household economic characteristics, including household income and farm size, were assumed to be significantly associated with DES adoption decision (Arhin et al., 2024; Duran et al., 2020). Based on these findings, this study proposed the following hypotheses:

H5: Age of household head is negatively associated with decision to adopt DES.

H6: Farm size of individual household is positively associated with decision to adopt DES

H7: Household annual income positively influences adoption of DES.

Moderating factors: Adoption behaviour has been found to be directly shaped by attitude, subjective norm, PBC, and perceived risks (Ali et al., 2020; Dong et al., 2022; Ulhaq et al., 2022). These relationships were indirectly influenced by various local-specific factors such as culture, customs, norms, tribes, and political issues (Chiou et al., 2021). Thus, the country of residence (COR), covering Cambodia, the Philippines, and Vietnam, was considered a moderating variable for the relationship between ATT, PBC, SN, PR, and adoption behaviour. Therefore, the following hypotheses were formulated:

H8: the COR moderates the effects of PBC on farmers' adoption of DES

H9: the COR moderates the effects of ATT on farmers' adoption of DES

H10: the COR moderates the effects of SN on farmers' adoption of DES

H11: the COR moderates the effects of RP on farmers' adoption of DES

3. Methodology

3.1. Site selection

South-East Asia (SEA) comprises a diverse range of countries at varying levels of development and endowments. The region has made remarkable progress in improving food security, with the agriculture sector rapidly changing towards digitization, especially during the COVID-19 pandemic. Comparing different countries on adoption behaviour of DES can provide valuable insights that highlight the common barriers and informing strategies in a coordinate manner to increase the DES adoption among farmers. This study selected Cambodia, the Philippines, and Vietnam based on the following premises: First, Vietnam was regarded as a high ICT adopter for agriculture, while Cambodia and the Philippines were classified as starters. The different characteristics toward adoption in digital extension services provide varying critical insights. Secondly, the three countries have different cultures, farming systems, and political climates. Therefore, the determinants of DES could be captured comparatively. Location of three countries is presented in Figure 1.

Each country selected two provinces from which to take representative samples of smallholder farmers who recently received DES that capture the variability in agricultural activities and experiences in agriculture digital extension services. Two districts per province, and at least one commune per district, were selected based on ecological zones, locations, and the availability of DES. The total sampling for the survey was 937 households across Cambodia, the Philippines, and Vietnam. Each country had a minimum of 300 samples selecting 150 from each province. The systematic random sampling was employed where enumerators were asked to interview respondents from each 3rd or 5th house based on population density in the selected village. Only adult respondents who aged from 18 years old and with consent forms were interviewed. The sampling distribution is presented in Table 1.

3.2. Data collection

Secondary data for this study were collected from scientific publications and reports from related departments. The mapping of available types of digital extension services in Cambodia, the Philippines, and Vietnam was sourced from scientific publications and reports received from departments of extension and rural development at provincial and national levels. Secondary data were used to develop the assumption of explanatory and independent variables in the TPB. Secondary data used for background setting included types of services, service providers, clients, related stakeholders, operational services, costs of services, and related policies.

Primary data were collected through household surveys and key-informants' interviews. Policymakers at the national, regional, provincial levels, as well as extension workers at local government units at the district and commune levels, were interviewed. Development partners, scholars, private service providers, representatives of farmers' organizations, and cooperatives were also included and actively engaged throughout the research process, particularly during consultative workshops following a carefully designed impact pathway blueprint. In total, 34 meetings and 11 interviews were conducted, involving 72 participants. The main themes of questions asked to key-informants were related to existing interventions of DES in the country, farmers' need for DES', challenges of DES adoption, DES operators, and relevant action plan about DES. Through meetings, local officers were consulted to finalize the list of

Figure 1. Map of study sites in South East Asia Countries.

variables of ETPB. These questions were asked again during the national consultative workshop in each country. The information gathered from these meetings was qualitatively explained in the discussion section to complement the statistical results.

For the household survey, the requirement for factor analysis guided the generation of the sample size, which should be at least five times the number of observed variables in the study. In this case, the number of observed variables were 31; therefore, the minimum number of households interviewed were 155 (5 * 31) (see Appendix 1). The use of structural equation modeling suggested a sample size larger than 200. Since the study covered three countries, a larger sample size led to more accurate results. The total sample of 937 households (referred to Table 1) satisfied the sampling requirement to control the observed variables and their degrees of freedom.

Table 1. Total sampling for households' survey in Cambodia, Philippines, and Vietnam.

Country	City/ Province	District /Barangay	Total Sampling
Cambodia	Kampong Chhnang	Samaki Meanchey	85
		Rolear P'Ear	79
	Preah Vihear	Rovieng	81
		Sangkum Thmei	70
Sub-Total for Cambodia			315
Philippines	Leyte	Local Government Units (LGUs) of Barugo, Baybay City, Inopacan, Leyte-Leyte, Palo and Merida	168
	Biliran	LGU of Almeria, Biliran, Caibiran Kawayan and Naval	144
Sub-Total for Philippines			312
Vietnam	Quang Tri	Trieu Phong	81
		Cam Lo	80
	Thua Thien Hue	Phu Vang	75
		Quang Dien	74
Sub-Total for Vietnam			310
Total Sample Households = 937			

The study methods and protocol were approved by the Research Ethics Committee for Social Sciences and Humanities of Hue University (No. 2000/QĐ-ĐHH, dated 16/12/2021). All methods were carried out in accordance with the relevant guidelines and regulations. An informed consent form was obtained from all participants for data collection.

3.3. Data analysis

The analysis involved four steps. First, exploratory factor analysis (EFA) was applied since some parts of the questionnaire were suggested by local officers. Second, confirmatory factor analysis (CFA) in AMOS software was employed to check the reliability and validity of the constructs. Third, structural equation

modeling (SEM) was used to test the impact of enablers and barriers on farmers' adoption of DES. In this case, the variable on adoption of DES is measured on a Likert scale from 1 to 5, where 1 represented 'never' and 5 represented 'always'. Lastly, a multiple-group analysis was conducted to test the moderating effect of the country of origin on the relationship between SN, PBC, ATT, PR, and adoption. All variables in each behavioural component were measured on a Likert scale from 1 to 5, where 1 represented 'strongly disagree', 2 represented 'disagree', 3 represented 'neither agree nor disagree', 4 represented 'agree', and 5 represented 'strongly agree'. Additionally, descriptive analysis using SPSS 22 was performed to assess the profile of the research sample. The Theory of Planned Behaviour guided the development of the theoretical analysis framework of the study (Figure 2). Adoption behaviour (AB) was the dependent variable in the adoption model, indicating the level of adoption, continuation of adoption, and expansion. The independent variables of the model included the constructs of the latent variables of the ETPB.

4. Results

4.1. Respondents' socio-economic and demographic characteristics

Table 2 presents the descriptive results of the demographic characteristics of the respondents. Female farmers accounted for 49% of the respondents. Additionally, more than 27% of the respondents in Vietnam had a high school education. This indicates that most farmers in Vietnam are educated but have not attained higher education, as is the case in the Philippines, where the percentage is high at 43%. The average age of the respondents was 51 years, with an average farming experience of over 29 years. Farmers aged 50 and above accounted for 29% and 25% respectively, indicating that the majority were relatively old but possessed extensive farming experience. The average farm size was approximately 1.3 hectares but varied significantly between countries. The average annual household income was $5,127 USD. Table 2 illustrates the variation in household income among the three countries.

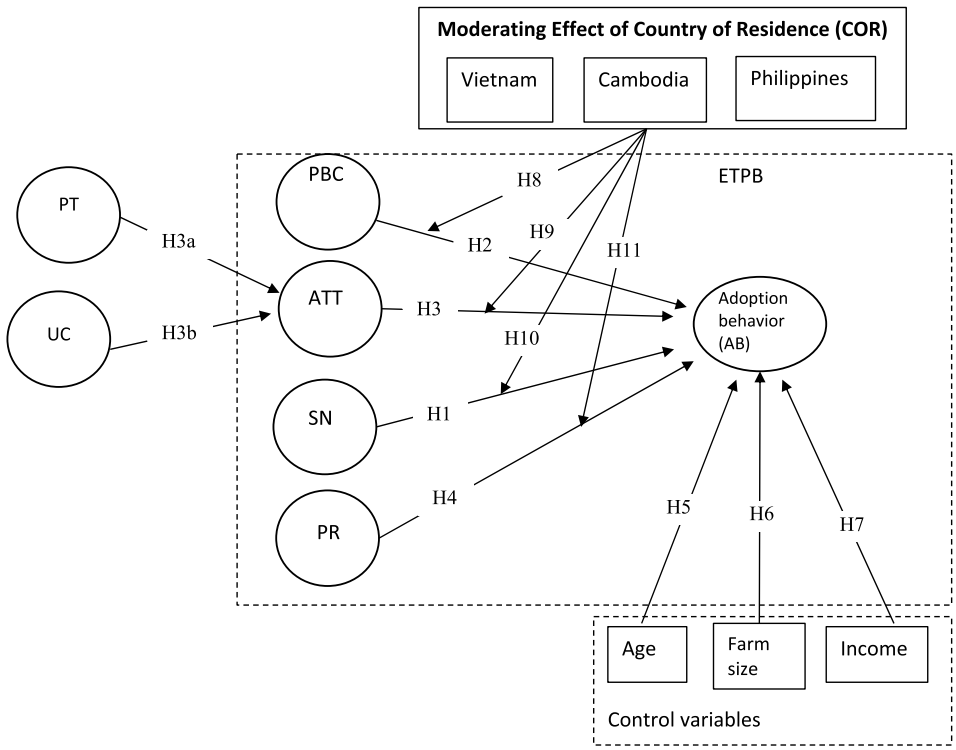

Figure 2. Research model and hypotheses.

Table 2. Respondent demographic profile (n = 937).

Variables	unit	Countries			Sig.	All countries
		Cambodia (n = 315)	Philippines (n = 312)	Vietnam (n = 310)		
Average age of household head	year	43.31 (12.59)[a]	55.49 (12.11)	54.21 (10.76)	0.001	50.97 (1.98)
	<30	17.5	1.9	1.9	-	7.2
	>30-40	25.7	10.9	11.0	-	15.9
	>40-50	26.0	22.1	22.3	-	23.5
	>50-60	21.3	28.5	36.5	-	28.7
	>60	9.5	36.5	28.4	-	24.8
Gender female hh/ female respondents	%	36.2	51.6	64.5	0.001	49.2
Average education level of household head	Year	5.52 (3.42)	8.15 (3.08)	7.29 (3.12)	0.001	6.98 (3.42)
	Illiteracy	11.4	0.3	1.0	-	2,6
	Primary	49.2	17.2	35.2	-	32,9
	Secondary	25.1	39.1	46.1	-	37,2
	Highschool and higher	14.3	43.4	17.7	-	27,3
Average farming years	year	22 (11.69)	29.78 (14.58)	31.23(9.18)	0.001	27.59 (12.71)
Average farm size	ha	2.19(1.62)	1.02 (0.87)	0.65 (0.97)	0.001	1.29 (1.63)
Average annual income	$USD	5,229.83 (6,097.61)	2,269.77 (4,593.43)	7,897.63 (5,156.34)	0.001	5,126.82 (5,790.36)
Awareness about DES	%	95.9	69.9	34.5	0.001	66.9
Have been using DES	%	69.2	69.9	83.2	0.001	74.1

[a]Number in parentheses is standard deviation.

About 67% of respondents had heard or knew about digital extension services (DES). This figure was highest in Cambodia (96%) and relatively low in Vietnam (34.5%). However, the ratio of households using DES among the respondents was higher than the ratio of respondents' awareness of DES. This may be due to many farmers using the information on digital devices without regard for quality or the service providers. Farmers tended to imitate others who use it. Among the 937 interviewed households, 74% (694) had been using DES.

4.2. Variable reliability analysis

Among the 31 indicators of the latent variables, 26 were adapted from previous studies where relationships with other indicators within the latent variables had been confirmed. Six (6) indicators were proposed by local officers and experts, and they need to be tested for reliability and validity. The reliability analysis was conducted using Cronbach's alpha and EFA techniques, resulting in Cronbach's alpha coefficients higher than 0.6. This indicated that the results of different statements/items used for attitude, subjective norm, behaviour control, risk perception, as well as perceived trust and usefulness comparison can be summed, allowing the mean to be used to present these constructs (Bruijnis et al., 2013). The results of the EFA test show that the Kaiser-Meyer-Olkin for all constructs (KMO = 0.913) exceeded the recommended value of 0.6. Bartlett's test of sphericity reached statistical significance ($P < 0.001$), achieving an adequate level to proceed. The results of the EFA identified a seven-dimensional construct that explained 75% of the variance (see Appendix 2).

4.3. Construct validity analysis

To assess the measurement model and establish convergent as well as discriminant validity of the construct, the confirmatory factor analysis tool was employed. The following criteria were used for assessing model fit indices: $\chi 2/df \leq 5$; comparative fit index (CFI) ≥ 0.9; Tucker-Lewis index (TLI) ≥ 0.9; root mean square error of approximation (RMSEA) ≤ 0.08; and standardized root mean residual (SRMR) ≤ 1. Results show that the indices for the measurement model indicate a good fit with X2/df = 3.4 < 5; CFI = 0.94 > 0.9; TLI = 0.93 > 0.9; RMSEA = 0.06 < 0.08; and SRMR = 0.05 < 1. Two items (UC3 and PT3) were dropped due to their factor loadings being lower than 0.5. The results of reliability as well as convergent and discriminant validities for this model are presented in Appendix 3. The factor loading for all variables ranges from 0.65–0.89 and

Table 3. Correlations among constructs.

Constructs	Perceived Risks	Subjective Norm	Attitude	Usefulness Comparison	Perceived Behavioural Control	Trust Perceived	Adoption behaviour
Perceived Risks							
Subjective Norm	−0.001						
Attitude	−0.030	0.492					
Usefulness Comparison	−0.106	0.542	0.573				
Perceived Behavioural Control	−0.191	0.349	0.427	0.444			
Perceived Trust	−0.250	0.445	0.532	0.662	0.382		
Adoption Behaviour	−0.479	0.285	0.325	0.532	0.399	0.530	

is significant at the 0.001 level. Construct reliability of the latent variables ranges from 0.86–0.91, and AVE ranges from 0.57–0.71. Table 3 shows the bivariate correlations among constructs. All correlation coefficients in this study were below 0.70, suggesting that all measures were appropriate for further analysis. Furthermore, all constructs achieved discriminant validity, as all AVE values shown in Appendix 3 were greater than the square correlation estimate (Fornell & Larcker, 1981). Thus, this measurement model indicates a high degree of reliability as well as convergent and discriminant validity.

4.4. Analysis of the structural model

The model fit indices of the structural model were at an acceptable level: $X^2/df = 3.5 < 5$, $CFI = 0.93 > 0.9$, $TLI = 0.91 > 0.9$, $RMSEA = 0.06 < 0.08$, and $SRMR = 0.06 < 1$. The R^2 values for the entire structural model and the attitude model were 0.46 and 0.40, respectively. The standardized path coefficients were all significant at the 0.001 level, except for the two observed variables (Farm size and age) (Table 4). Thus, the model fits the data well.

As shown in Table 4, ATT, SN, PBC, and the level of household income had significant and positive impacts on farmers' adoption of DES, with standardized coefficients of 0.179, 0.139, 0.212, and 0.231, respectively. Risk perceived (RP) was found to have a significant negative influence on farmers' adoption decision of DES, with a standardized coefficient of −0.433. Farm size and age of household heads were found to have a non-significant impact on farmers' adoption of DES. In addition, UC and trust had a significant positive impact on farmers' attitude towards the adoption of DES. Thus, the model results confirmed hypothesis H1, H2, H3, H3a, H3b, H4, H7, H8, H9, H10, and H11, and rejected the other two hypotheses: H5 and H6.

4.5. Testing the moderating effect of country of residence (COR)

To examine the moderating effect of COR on the relationship between subjective norm, PBC, attitude, perceived risk, and adoption, a multi-group analysis was conducted. Prior to performing the multiple-group analysis to determine whether COR serves as a moderator, an examination was

Table 4. SEM Model results, combined for 3 countries.

			Standardized coefficient	Sig
Latent variables				
Attitude	< –	Usefulness comparison	0.423	***
Attitude	< –	Trust	0.261	***
Adoption	< –	Subjective Norm	0.139	***
Adoption	< –	Perceived behavioural Control	0.212	***
Adoption	< –	Attitude	0.179	***
Adoption	< –	Risk	−0.433	***
Socio-economic and demographic factors				
Adoption	< –	Farm size	−0.012	Ns
Adoption	< –	Age	0.042	Ns
Adoption	< –	Income	0.231	***

Note: ***: $p < 0.001$; Ns: non-significant

Table 5. Standardized coefficients of the direct impacts of subjective norm, PBC, attitude and perceived risk on adoption between COR groups.

	Philippines		Vietnam		Cambodia		
Influencing factor	Standardized coefficient	t value	Standardized coefficient	t value	Standardized coefficient	t value	Significant difference
Subjective norm	0.51	4.76***	0.10	−1.00ns	0.31	3.74***	Yes
Perceived BC	0.31	3.71***	.0.20	2.93**	0.35	4.62***	Yes
Attitude	0.06	1.05ns	0.28	4.1***	0.15	2.14*	Yes
Perceived risk	−0.13	-1.86^{+}	−0.46	−4.29***	0.04	0.64^{ns}	Yes

$^{+}p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$, ns: non-significant.

conducted to assess the equivalence or variability of the factor loadings in the measurement models across the three countries. Following Cheung and Rensvold (2002), a comparison was made between the unconstrained measurement model and the constrained measurement model, utilizing the difference in chi-square. The goodness-of-fit measures obtained from this test of invariant factor loadings were satisfactory ($\chi 2/df = 2.045$, CFI = 0.91, RMSEA = 0.04, SRMR = 0.04), and the difference in model fit between the unconstrained and constrained models for the groups differing in COR was significant at the 0.001 level ($\chi 2$ difference = 336.2, $p = 0.000$). Consequently, the unconstrained model was used to test the moderating effect of COR.

Table 5 shows that most structural paths from the influencing factors to adoption were significant. The path coefficients of the influencing factors on adoption vary among the three countries. After conducting a multiple-group analysis, the Chi-square test for the differences was significant for subjective norm ($\Delta\chi 2 = 631.2$, $\Delta df = 2$, $p < 0.001$), PBC ($\Delta\chi 2 = 820.2$, $\Delta df = 2$, $p < 0.0001$), attitude ($\Delta\chi 2 = 676.4$, $\Delta df = 2$, $p < 0.0001$), and perceived risk ($\Delta\chi 2 = 12.6$, $\Delta df = 2$, $p < 0.001$). Therefore, the findings support the hypothesis regarding the difference in the impact of subjective norm, PBC, attitude, and perceived risk on adoption behaviour among the three countries. In other words, barriers and enablers for the adoption of DES by farmers are significantly different among the three countries. PBC significantly influenced the adoption decision of DES among respondents in all three countries. SN significantly influenced individual farmers' adoption behaviour of DES in the Philippines and Cambodia, but not in Vietnam. Attitude significantly influenced respondents' adoption of DES at the $P < 0.001$ level in Vietnam and at the $P < 0.05$ level in Cambodia, while it did not significantly influence the adoption decision of respondents in the Philippines. Perceived risk is an important factor for the adoption decision toward DES among respondents in Vietnam, but not in Cambodia and the Philippines (Table 5).

5. Discussion

This research uncovered numerous issues pertaining to farmers' behaviour regarding the adoption of DES in Cambodia, the Philippines, and Vietnam. The adoption of DES by farmers in these countries is influenced by various factors. These factors encompass not only the latent variables within the TPB but also other latent variables from the expanded TBP and TAM, such as PR and household income.

5.1. Result of SEM and multigroup analysis

The results of SEM analysis provided evidence that ATT, SN, and PBC were positively related to farmers' behaviour towards the adoption of DES. This finding supports the results of previous studies by Bruijnis et al. (2013), Giampietri et al. (2018), Ulhaq et al. (2022), and Ali et al. (2020), which indicated that attitude toward a new technology had a strong influence on farmers' decision to adopt it. The positive and significant correlation between ATT and AB of farmers in this study indicated that farmers' assessment of the advantages and benefits of DES to their farming significantly influenced their adoption decision. The more favourable the assessment of the ease of use, comfortability, compatibility, updating, and diversification of DES, the higher the likelihood of adopting it for farming. Farmers who were not aware of DES and lack information on its availability may not accurately assess its usefulness and advantages, leading to a negative perception towards its adoption. Additionally, the significant positive influence of Perceived Trust (PT) and UC on ATT indicated that farmers' attitude towards the adoption of DES depended on their

trust in DES and their perception of its usefulness compared to conventional extension services. These findings align with previous studies suggesting that potential adopters were more likely to consider a technology or service that they perceived as compatible with their farming conditions and capacity, enhancing farming production and benefits (Coggins et al., 2022; Li et al., 2020). The significant dependence of ATT on PT implied that farmers' trust in DES plays a crucial role in forming their attitude towards adoption. Since DES is new to farmers and provides online communication, without physical interaction, it may increase uncertainty and risk (Corbitt et al., 2003). Users are more likely to use digital services if they have a higher degree of trust in e-service providers and are more experienced in using such services. In fact, DES providers and extension systems are unknown to the majority of respondent farmers in the studied countries (Dung, 2020; Sen et al., 2021). Furthermore, field surveys revealed that the current DES used by farmers, such as information services on public websites, online or offline mobile applications, and social media platforms like Facebook, Zalo, Telegram, and Messenger, as well as technical services like YouTube, come from unknown sources and providers, lacking legal status and institutionalization. As a result, farmers' trust in DES providers, service quality, and the usefulness of DES for their farming are compromised and continue to be constraints to their attitude and adoption decision.

However, this research found that the relationship between ATT and adoption behaviour was largely dependent on context. The results of multiple groups (Table 4) show that ATT had a significant positive impact on farmers' adoption decisions of DES in Vietnam and Cambodia at $P < 0.001$ and $P < 0.05$, respectively, but were insignificant in the context of the Philippines. The non-significant impact of ATT on DES adoption behaviour in the Philippines context may be due to other factors, such as the lack of financial resources, the willingness to spend on technology, and weak internet connectivity. There is also a prevailing expectation that farmers will receive government subsidies associated with the delivery of DES. With these factors, a positive attitude of farmers may not necessarily translate into adoption behaviours.

For the subjective norm (SN), the significantly positive impact of SN on AB indicates that farmers' adoption behaviour is significantly influenced by reference groups or external forces, such as governmental extension workers, agricultural officers, private DES providers, neighbours, and cooperative director boards. This finding confirms the results of studies by Beedell and Rehman (2000), Geng et al. (2010) and Tambo et al. (2024), suggesting that social pressure is an important factor in influencing farmers' willingness to adopt new technologies, particularly cleaner or sustainable practices. Through various approaches, such as the dissemination of information, direct communication, and demonstrations, farmers are convinced by extension workers or service providers about the usefulness and benefits of the recommended technology or services, which increases their willingness to adopt. In contrast, Borges et al. (2014) and Arhin et al. (2024) found that farmers often seek advice from important individuals, mainly key informants in their community, when making adoption decisions. They also frequently learn informally from their neighbours through demonstration models or successful practices of pioneers in the region, rather than being influenced by external forces. This is confirmed by two recent studies on the adoption of ITCs in shrimp farming in the Southern region of Vietnam (Ulhaq et al., 2022) and the adoption of climate adaptation in the upland area of Thua Thien Hue province, the central region of Vietnam (Sen et al., 2021). Importantly, these studies found that adoption is a voluntary decision that depends on the socio-economic context and the characteristics of the technology itself, particularly digital services/e-banking and online tax services (Ali et al., 2020; Chiou et al., 2021; Xie et al., 2017). This finding is consistent with the multigroup analysis, which shows that SN had a significant positive influence on farmers' adoption behaviour of DES in Cambodia and the Philippines but had a non-significant influence in Vietnam. Thus, the lack of convincing messages from external forces, including extension agencies and DES providers from both the government and private sectors, as well as the lack of an enabling environment within immediate farming communities, may partly explain why DES adoption is lower in Cambodia and the Philippines. One of the most common issues is that extension workers are unclear about the applications of DES, which hampers their ability to effectively convey the fundamental concepts of DES that would convince farmers. In the Philippines, in particular, many farmers in various communities have not adopted DES due to a lack of collaborative partnerships between farmer cooperative presidents and

members, who could encourage farmers to use DES. The social norm regarding the adoption of DES in farming has varied perspectives across the three countries, since farmers' adoption of new techniques depended mainly on neighbours and extension service providers (Barwani et al., 2023).

With regards to perceived behavioural control (PBC), the positive and significant influence of PBC on AB indicates that farmers' perceptions of their own capability to successfully use DES to enhance their farming production are important enablers for their decision to adopt DES. The stronger and better the capability perceived by farmers in using DES for farming, the greater the likelihood of adopting that service. This finding aligns with the majority of previous adoption studies (Shang et al., 2021; Van Slyke et al., 2004). The standardized coefficient of PBC resulting from multigroup analysis exhibited a very high value and significance level of 0.001 and 0.01, respectively, for all three countries, indicating that PBC is the most influential factor affecting farmers' adoption of DES. Conversely, those who have not adopted DES or have low AB scores may be constrained by a lack of confidence in their capacity and uncertainty regarding the usefulness of available DES. Therefore, it is necessary to make compatible DES available to farmers, engage in more capacity-building activities, and implement better communication strategies.

The significant negative impact of perceived risk (PR) on AB indicates that PR is an important factor inhibiting farmers' adoption of DES for their farming. The more farmers perceive the loss and uncertainty of using DES for their farming, the less likely they are to adopt the services. In other words, farmers who perceived no risk at all or less risk would be more willingly adopt DES. However, the multigroup analysis confirmed this finding only for the Vietnamese context but not for Cambodia and the Philippines. It indicates that Vietnamese farmers' adoption of DES for their farming is likely related to their perception of the risk associated with using DES. In fact, Vietnamese farmers who were involved in in-depth interviews for the AgriFoSe project have experienced losses when purchasing inputs (such as vegetable seedlings and water pumping) online. The quality of the products was not as advertised online, and farmers faced difficulties in proper communication with the sellers after making payments. Those who have experienced such losses were not willing to purchase the services. From the interviews, respondent farmers expressed concerns about the quality of DES and are unwilling to adopt them unless DES are nationalized and provided by well-known providers. This finding is consistent with previous studies on customer adoption of e-banking (Sanayei & Bahmani, 2012; Yao et al., 2013) and ICTs in shrimp farming (Ulhaq et al., 2022).

The non-significant impact of PR on AB in the context of Cambodia and the Philippines may be related to the still unreliable nature of DES with regard to scientifically based information, as it is new and still in the initial stage of development and dissemination to farmers. In Cambodia, farmers have not yet explored the different types of DES and are still unaware of the available options, although some have already used them. Farmers lack experience in using and accessing DES for their farming and have not observed pilot farms utilizing DES. As a result, farmers are concerned about the quality, assurance, and security of using DES for their farming, as well as the cost-effectiveness of implementing DES. In the Philippines, varied DES have been developed by the government; however, farmers have minimal access due to lack of information about its availability, particularly the application-based DES needing internet connectivity.

The non-significant impact of farm size and age on the adoption of DES indicates that the decision to use DES for farming is not related to the farmer's age or farm size. Our research assumed that old age and small-scale farm size might serve as barriers to using DES. We believe that older farmers may find it difficult to use digital devices and therefore hesitate to change their conventional practices, especially during the early stages of agricultural digitalization. Additionally, it was presumed that using DES on small farms might not be cost-effective, leading us to believe that small-scale farmers would not prioritize innovation on their farms. However, the results contradicted our assumptions. The field survey demonstrated that farmers of all ages and scales collaborate in groups such as cooperatives, disregarding age differences. Moreover, all the farms in the study area were small-scale farms, which was our focus. Consequently, farmers of any age and farm size are willing to adopt DES if they find it useful and perceive the potential benefits. This finding aligns with a study on farmers' adoption of ICT in shrimp farming in Vietnam (Ulhaq et al., 2022).

There is a significant positive impact of household income on AB, indicating that the higher income level

of a household leads to a greater willingness for the household to adopt DES for their farming. In other words, low income is likely to act as a barrier for poor households in adopting DES for their farming. This finding confirms the results of studies on the effects of household income on the behavioural adoption of ICTs in agricultural production in many countries around the world (Ali, 2011; Anbarasan & Neelam, 2015; Andegebe et al., 2021).

5.2. Country specific

The results of the multigroup analysis showed significant differences in the impact of subjective norm, PBC, attitude, and perceived risk on adoption behaviour among the three countries, indicating that adoption behaviour is a country-specific and contextual issue. These findings confirm the results of previous studies (Shang et al., 2021; Ulhaq et al., 2022). Since attitude, PBC, SN, and PR cannot be independent of the social-ecological and economic context, and largely depend on the culture, customs, and socio-economic conditions of their community and country (Au & Enderwick, 2000); however, the barriers and enablers to the adoption decision of DES are different in the three studied countries.

According to Li et al. (2020), the standardized coefficients of a variable in the multi-group analysis and its level of significance indicate the level of contribution of that variable in forming the adoption decision. This means that a higher value of the standardized coefficient, combined with a stronger level of significance, indicates a greater contribution of that variable in shaping one's adoption behaviour. The results of the multigroup analysis (Table 4) revealed significant variations in the absolute values of the standardized coefficients, as well as the levels of significance, among the three countries. In the Philippines, SN emerged as the most important variable for the adoption decision of DES, followed by PBC and then PR. In Vietnam, PR played the most crucial role, followed by ATT and PBC. In Cambodia, PBC contributed the most to the formation of farmers' adoption behaviour, followed by SN and then ATT. These results suggest that barriers to adoption behaviour in the Philippines and Cambodia primarily revolve around variables related to SN and PBC, whereas barriers to the adoption of DES among farmers in Vietnam are mainly associated with PR, ATT, and PBC. Across three countries, PBC is the most common barrier.

6. Conclusions and recommendations

The adoption of digital extension services (DES) among smallholder farmers in South-East Asia has been suggested as a possible solution to break the vicious cycle of low productivity and agricultural product market issues. However, stimulating the adoption of a new agricultural extension platform requires a critical understanding of the various behavioural and attitudinal underpinnings that characterize farmers who have been strongly influenced by the traditional agricultural extension services approach.

There are several factors influencing smallholder farmers' adoption, and the strength of influence varies depending on the context and situation of the farmers. The combined Theory of Adoption Model (TAM) and Theory of Planned Behaviour framework offer insights that farmers are likely to be strongly influenced when they perceive ease of use and usefulness of the technology compared to conventional practices (UC). Social norm (SN) is also a strong enough influence to drive individuals to perform the desired action, and perceived risk can be overcome by translating it into favourable long-term benefits.

The results of the study indicate that barriers and enablers for adoption significantly differ among the three covered countries, reflecting the diversity of cultures, customs, farming practices, experiences, and socio-economic conditions of the farmers. Significant factors with positive impacts include subjective norm, perceived behaviour control, farmers' attitudes towards perceived usefulness and trust, perceived risk, and household income.

Interesting differences in the results are observed in terms of the variability of influence of these factors. For instance, the subjective norm significantly influences farmers' adoption behaviour in the Philippines and Cambodia but not in Vietnam, while attitude significantly influences farmers' adoption behaviour in Vietnam and Cambodia but not in the Philippines. Risk perception is an important factor for adoption in Vietnam, but not in Cambodia and the Philippines. Indeed, one of the critical commonalities across countries is trust concerns. Farmers felt skeptical about the accuracy and credibility of information provided through DES, especially if farmers used to have negative experiences with technology or advisory services from extension worker.

To stimulate the adoption of digital extension services (DES) in the agriculture sector, policymakers can take several actions: (1) Improve digital infrastructure,

such as internet connectivity and electricity; (2) Facilitate farmers' access to hardware gadgets, like smartphones and televisions, through government subsidies or support from private service providers, ensuring equal access for women and youth; (3) Conduct more training workshops for extension service providers, including government extension workers, agricultural officers, and private DES providers. To mitigate risks resulting from marketing malpractices, stronger cybersecurity measures should be implemented between and among market players to ensure the protection of both parties. Additionally, the establishment of a foolproof market application and registry of legitimate and bona fide players is recommended.

The study was successful in applying the Expanded Theory of Planned Behaviour that combined the original TPB, TAM and perceived risks, a new variable previously ignored in adoption studies but found important in the adoption of Digital Extension Services (DES) making it capable of investigating internal and external factors affecting intention to adopt DES. However, it has limited discussions on the details of what factors will likely encourage farmers whether to adopt or not in general beyond the three countries covered. It is therefore suggested that future studies investigate the magnitude of impact of each factor correlated to farmers' behaviour adoption to DES.

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Appendices

Appendix 1: Indicators of farmers' behaviour of adoption of DES (Likert scale: 1-5).

Latent variables	Indicators	Source
Perceived risk (PR)	PR1: I think using DES is risky because of a lack of quality assurance	Local officers
	PR2: I think paying for DES is risky because of a lack of legal support/ lack of institutionalization	(Weerakkody et al., 2016)
	PR3: I think paying for DES is risky because of the poor internet connection	(Weerakkody et al., 2016)
	PR4: I think using DES is risky because it is costly	Local officers
	PR5: I think using DES is risky because of a lack of technical expertise or support, and lack of responsibility (i.e. inability to respond/reply on the inquiries of the farmers)	Local officers
Attitude (ATT)	ATT1: Using DES is a good idea	Ulhaq et al., 2022; Chang et al., 2016
	ATT2: Using DES is suitable and necessary for my farm and my household conditions	Ulhaq et al., 2022; Chang et al., 2016
	ATT3: It helps me easily access needed farming information	Local officers
	ATT4: DES quickly provides updated information	Chang et al., 2016
	ATT5: DES provides diversified farming information	Local officers
	ATT6: I will encourage fellow farmers to use DES for their farming needs	Ali et al., 2020)
Subject norm (SN)	SN1: Government officials promote and support the adoption of DES	(Ali et al., 2020)
	SN2: Service providers often contact and want me to adopt DES	Ulhaq et al., 2022
	SN3: The farmer cooperative president and members encourage me to use DES	Tien et al., 2022, Local officers
	SN4: The Municipal or City Agriculturist encourages me to use DES	Tien et al., 2022
Usefulness Comparison (UC)	UC1: DES helps me communicate with qualified and responsible extension workers	Narine et al., 2019
	UC2: Using DES reduces production costs and labour requirements	Pandey et al., 2018; Parab et al., 2010
	UC3: Using DES protects my health and the environment	Eze et al. (2021)
	UC4: I feel more capable and proactive when I use DES for my farming needs	(Shang et al., 2021)
	UC5: Using DES is cost-effective in the context of market integration	Rajkhowa & Qaim, 2021b
Perceived behaviour Control (PBC)	PBC1: DES is easily accessible	Ulhaq et al., 2022
	PBC2: It is easy to navigate DES for my farming needs	Taherdoost, 2018
	PBC3: I am confident in my ability to use DES effectively	(Ali et al., 2020)
	PBC4: I understand well the available DESs and can support and guide other famers	Rajkhowa & Qaim, 2021b
Perceived Trust (PT)	PT1: I believe that quality of DES will be well controlled by the related agencies/ departments	Duran et al., 2020
	PT2: I believe that DES providers are trustworthy	Duran et al., 2020
	PT3: I believe that DES providers are farmer or user oriented	Van Slyke et al., 2004; Yao et al., 2013
	PT4. I believe that DESs are effectively provided by well-known and trustworthy organizations.	Van Slyke et al., 2004; Yao et al., 2013
Adoption behaviour (AB)	AB1. I have been using DES and will continue using it	Sidibe et al., 2021; Ulhaq et al., 2022; Tien et al., 2022
	AB2. I intend to invest more on DES for my farming need	
	AB3. I have benefited from DES and I will share and encourage other farmers to use DES for their farming needs	

Appendix 2. Exploratory factor analysis results.

	Factor loading	Eigenvalue	Cronbach's alpha	Variance explained (%)	Cumulative variance explained (%)
Perceived Risk		**9.860**	**0.930**	**31.8**	**31.8**
PR1: I think using DES is risky because of a lack of quality assurance	0.88				
PR2: I think paying for DES is risky because of a lack of legal support/ lack of institutionalization	0.90				
PR3: I think paying for DES is risky because of the poor internet connection	0.85				
PR4: I think using DES is risky because it is costly	0.87				
PR5: I think using DES is risky because of a lack of technical expertise or support, and lack of responsibility (i.e. inability to respond/reply on the inquiries of the farmers)	0.85				
Attitude		**4.462**	**0.894**	**14.34**	**46.2**
ATT1: Using DES is a good idea	0.75				
ATT2: Using DES is suitable and necessary for my farm and my household conditions	0.73				
ATT3: It helps me easily access needed farming information	0.78				
ATT4: DES quickly provides updated information	0.80				
ATT5: DES provides diversified farming information	0.78				
ATT6: I will encourage fellow farmers to use DES for their farming needs	0.69				
Subjective Norm		**2.384**	**0.862**	**7.7**	**53.9**
SN1: Government officials promote and support the adoption of DES	0.81				
SN2: Service providers often contact and want me to adopt DES	0.83				
SN3: The farmer cooperative president and members encourage me to use DES	0.81				
SN4: The Municipal or City Agriculturist encourages me to use DES	0.87				
Usefulness Comparison		**2.172**	**0.902**	**7.0**	**60.9**
UC1: DES helps me communicate with qualified and responsible extension workers	0.54				
UC2: Using DES reduces production costs and labour requirements	0.82				
UC3: Using DES protects my health and the environment	0.83				
UC4: I feel more capable and proactive when I use DES for my farming needs	0.65				
UC5: Using DES is cost-effective in the context of market integration	0.76				
Perceived Behavioural Control		**1.869**	**0.826**	**6.0**	**66.9**
PBC1: DES is easily accessible	0.85				
PBC2: It is easy to navigate DES for my farming needs	0.77				
PBC3: I am confident in my ability to use DES effectively	0.83				
PBC4: I understand that DES can support and guide other famers	0.71				
Perceived Trust (PT)		**1.288**	**0.861**	**4.2**	**71.1**
PT1: I believe that private and public agencies can assure the quality of DES	0.71				
PT2: I believe that DES service providers are trustworthy	0.79				
PT3: I believe that the farmers are in the best interest of DES providers	0.73				
PT4: I believe that DESs are effectively provided by well – known and trustworthy organizations.	0.77				
Adoption Behaviour (AB)		**1.208**	**0.856**	**3.9**	**75.0**
AB1: I have been using DES and will continue using it.	0.85				
AB2: I intend to invest more on DES for my farming needs.	0.74				
AB3: I have benefited from DES and I will share and encourage other farmers to use DES for their farming needs	0.68				

Appendix 3. Confirmatory factor analysis (CFA) results.

	Factor loading (|)	CR	AVE	Cronbach's alpha
Attitude (ATT)		**0.887**	**0.571**	**0.894**
ATT1: Using DES is a good idea	0.65			
ATT2: Using DES is suitable and necessary for my farm and my household conditions	0.69			
ATT3: It helps me easily access needed farming information	0.82			
ATT4: DES quickly provides updated information	0.86			
ATT5: DES provides diversified farming information	0.84			
ATT6: I will encourage fellow farmers to use DES for their farming needs	0.64			
Subjective Norm (SN)		**0.893**	**0.677**	**0.862**
SN1: Government officials promote and support the adoption of DES	0.82			
SN2: Service providers often contact and want me to adopt DES	0.88			
SN3: The farmer cooperative president and members encourage me to use DES	0.75			
SN4: The Municipal or City Agriculturist encourages me to use DES	0.83			
Perceived Behaviour Control (PBC)		**0.874**	**0.635**	**0.826**
PBC1: DES is easily accessible	0.74			
PBC2: It is easy to navigate DES for my farming needs	0.87			
PBC3: I am confident in my ability to use DES effectively	0.84			
PBC4: I understand that DES can support and guide other famers	0.72			
Usefulness Comparison (UC)		**0.884**	**0.656**	**0.902**
UC1: DES helps me communicate with qualified and responsible extension workers	0.74			
UC2: Using DES reduces production costs and labour requirements	0.78			
UC3: Using DES protects my health and the environment	Dropped			
UC4: I feel more capable and proactive when I use DES for my farming needs	0.84			
UC5: Using DES is cost-effective in the context of market integration	0.87			
Perceived Risk (PR)		**0.908**	**0.711**	**0.930**
PR1: I think using DES is risky because of a lack of quality assurance	0.83			
PR2: I think paying for DES is risky because of a lack of legal support	0.87			
PR3: I think paying for DES is risky because of the poor internet connection	0.81			
PR4: I think using DES is risky because it is costly	0.88			
PR5: I think using DES is risky because of a lack of technical expertise or support, and lack of responsibility (i.e. inability to respond/reply on the inquiries of the farmers)	0.84			
Perceived Trust (PT)		**0.875**	**0.700**	**0.861**
PT1: I believe that private and public agencies can assure the quality of DES	0.79			
PT2: I believe that DES service providers are trustworthy	0.89			
PT3: I believe that the farmers are in the best interest of DES providers	Dropped			
PT4: I believe that DESs are effectively provided by well – known and trustworthy organizations.	0.84			
Adoption Behaviour		**0.860**	**0.673**	**0.856**
AB1: I have been using DES and will continue using it.	0.78			
AB2: I intend to invest more on DES for my farming needs.	0.89			
AB3: I have benefited from DES and I will share and encourage other farmers to use DES for their farming needs	0.78			

Note: All factor loadings are significant at 0.001 level.