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THE INFLUENCE OF CULTURAL FACTORS ON THE ACCEPTANCE OF ALTERNATE WETTING AND DRYING TECHNOLOGY AMONG RICE FARMERS IN THE VIETNAMESE MEKONG DELTA

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Abstract: The purpose of this study is to explore the determinants in the adoption of Alternate Wetting and Drying (AWD) technology. For this purpose, we propose an AWD technology acceptance model based mainly on the technology acceptance model (TAM) and other relevant theories. Eight factors are included to assess the model: awareness (AW), social influence (SI), facilitation conditions (FC), agro-engineering setting (AS), perceived usefulness (PU), perceived ease of use (PEOU), attitude towards the use (AT), and behavioral intention (BI). The study draws on semi-structured interviews with 150 rice farmers in three locations in the VMD, including Vinh Thanh district in Can Tho city, Tieu Can district in Tra Vinh province, and Thoai Son district in An Giang province. This study employs the structural equation modeling (SEM) method to test and confirm the hypothesized model. Results indicate that eight out of 12 hypotheses were supported, while four were not supported. Data on actual adoption also reveal that social factors were considerable drivers for farmers to adopt AWD technology. The study is novel and valuable since it employs the TAM to study the factors influencing the acceptance of AWD technology in the VMD context.

Keywords: Sustainability, alternate wetting and drying technology, technology acceptance model, sustainable rice production, Vietnamese Mekong delta.

Introduction

With an area of about 65,000 km^2 and 4 million ha of cultivatable land, the Mekong Delta is the largest in Viet Nam (Le *et al.,* 2007). The Delta has an extensive network of 7,000 km of main canals, 4,000 km of secondary canals on-farm systems, and over 20,000 km of sea dikes (DARD, 2003, as cited in Le *et al.*, 2007). As of April 2019, the Delta has a population of 17.3 million people (accounting for 18% of the country's population) (VCCI, 2020). Annually, the Delta provides up to 50% of Vietnam's rice production, of which 90% is exported (IIUCN & VAWR, 2016; Tong, 2017).

In recent years, because of climate change, water shortages have threatened the livelihoods of rural people (Nhan & Trung, 2011) and rice production has been adversely affected. Thuy and Anh (2015) found that water stress reduced paddy yields in the VMD. Water shortages during the dry season is feared to continue as an alarming issue in the next ten to twenty years. Under such a scenario, rural people would struggle to sustain their livelihoods (World Bank, 2019).

To mitigate the impacts of climatic changes and sustain rice production, there is a need to promote new practices that can enhance water use efficiency in production (ADB, 2019). The alternate wetting and drying (AWD) technology has been identified as a proven method for optimizing irrigation water use in rice production (Siopongco *et al.*, 2013). Unlike traditional farming practices, in AWD the rice fields get alternately flooded and non-flooded resulting in reduced use of irrigated water. With results of several studies in Asian countries, including the Philippines, Vietnam and Bangladesh, Lampayan *et al.* (2015) argued that applying AWD would save up to 38% of water, reduce irrigation costs and increase profit from 17%

to 38%. Furthermore, the application of AWD contributes to reducing emissions by up to 90% compared to conventional flooded cultivation (Adhya *et al*., 2014). Wang *et al.* (2020) also found that the AWD technology significantly saves irrigated water, reduces emissions and enhances yields.

Despite these well-documented benefits, the actual adoption of AWD technology is pretty limited due to technical and social barriers. These include inadequate assistance from the local extension staff (Alauddin *et al*., 2020), irregular training programs to transfer the AWD technology to farmers (Kürschner *et al.*, 2010), and the possibility of reduced yield if this technology is applied in sandy soil or clay with shallow water tables (Howell *et al*., 2015).

As can be seen from the above discussion, AWD technology has great potential to enhance the adaptability of rice farmers to water shortage conditions. However, to promote the widespread adoption of AWD technology, it is necessary to better understand the factors influencing the acceptance of this technology. Therefore, this study was guided by the question: "What are the factors influencing the adoption of AWD technology among rice farmers in the VMD?" For this research question, we employ the technology acceptance model (TAM) as it is one of the most widely used models in behavior studies. This study aims to apply the TAM model with complements from relevant theories such as TRA, UTAUT to determine the factors influencing the adoption of the AWD technology among rice farmers in the VMD, with particular focus on social factors and community connectedness, and propose measures to promote the application of AWD in rice cultivation.

Materials and Methods

The process of transforming from a conventional production model into a more advanced one is dynamic and affected by economic, social and regulatory factors (Bush, 2006; Leucht *et al.,* 2010). Andersson and D'Souza (2014) also concluded that factors influencing the degree of technological acceptance fall into technical, social and environmental categories. Alam *et al.* (2014) argued that the process is driven by the awareness of individuals.

Relevant Theories

The literature has several theories that explain technology acceptance intention in association with various determinants. These include the Technology acceptance model (TAM) by Davis (1989), the Theory of planned behavior (TPB) by Ajzen (1991), the Theory of reasoned action (TRA) by Ajzen (1975), TAM 2 by Venkatesh *et al.* (2000), TAM 3 by Venkatesh (2008), and Unified theory of acceptance and use of technology (UTAUT) by Venkatesh *et al.* (2003). Zhou and Abdullah (2017) presented an integrated and revised TAM as shown in Figure 1.

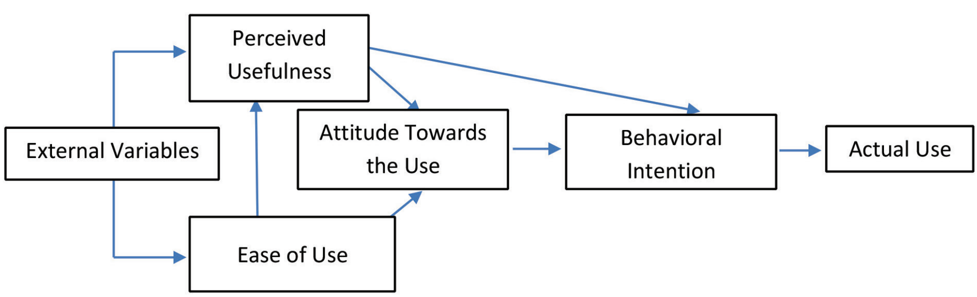

Figure 1: Technology Acceptance Model (TAM)
Source: Zhou and Abdullah (2017)

Research Model

On the basis of the Technology acceptance model (TAM) and the aforementioned literature, the proposed research model for this study is shown in Figure 2. Each factor corresponds to one latent variable and is measured by several observed variables. Table 1 provides detailed description of the latent variables in the model and the respective theories.

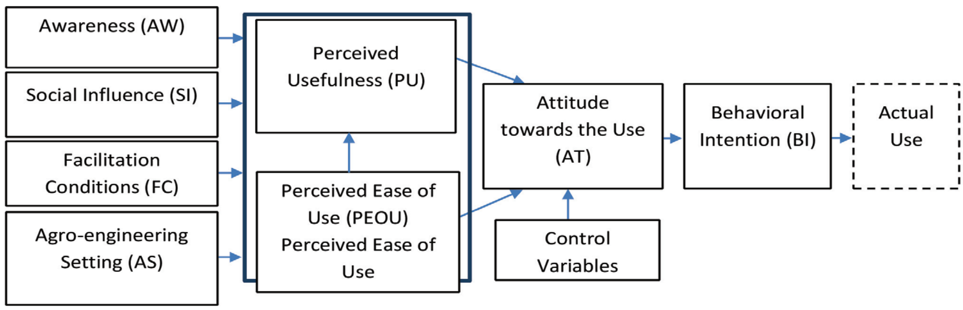

Figure 2: The proposed research model
Source: Proposed by authors

Table 1: Description of the factors in the model

Factor	Definition	Theory	References
Awareness (AW)	The degree to which users/farmers perceive the benefits and limitations of the technology. In this study, this factor refers to farmers' awareness of climate change, AWD technology, etc.	TRA	Ajzen (1975)
Facilitation Conditions (FC)	The degree to which an individual believes that the existing technical and organizational infrastructures assist him/her in applying the technology. Those conditions might be government incentives, knowledge about the technology, support from farmer groups or extension services, etc.	UTAUT	
Social Influence (SI)	The degree to which an individual perceives that other people think he/she should use the technology. SI refers to subjective perception, social elements, and the image or status of an individual.	UTAUT	Ajzen (1991); Thompson *et al.* (1991); Moore and Benbasat (1991)
Agro-engineering Setting (AS)	The agro-engineering setting refers to the density and quality of water supply canals, autonomous irrigation, leveled fields, etc.		Yamaguchi *et al.* (2017)
Perceived Usefulness (PU)	The degree to which an individual believes that applying a particular technology will enhance his/her job performance.	TAM	Davis (1989)
Perceived Ease of Use (PEOU)	The degree to which an individual believes that the application of the technology does not require much effort.	TAM	Venkatesh *et al.* (2003); Küschner *et al.* (2010)
Attitude towards the Use (AT)	AT means the positive or negative perception of the user about the AWD.	TRA	Venkatesh (2003)
Behavioral Intention (BI)	BI refers to the conscious actions of an individual, e.g. accepting the AWD technology.	TAM	Davis (1989); Yamaguchi *et al.* (2017)

Hypotheses

Following are the hypothesized relationships among the factors in the proposed research model.

– Hypothesis 1: AW will positively influence PU
– Hypothesis 2: SI will positively influence PU
– Hypothesis 3: FC will positively influence PU
– Hypothesis 4: AS will positively influence PU
– Hypothesis 5: PEOU will positively influence PU
– Hypothesis 6: AW will positively influence PEOU
– Hypothesis 7: SI will positively influence PEOU
– Hypothesis 8: FC will positively influence PEOU
– Hypothesis 9: AS will positively influence PEOU
– Hypothesis 10: PEOU will positively influence AT
– Hypothesis 11: PU will positively influence AT
– Hypothesis 12: AT will positively influence BI

Alternate Wetting and Drying Technology **(AWD)**

The International Rice Research Institute developed and introduced the AWD technology when water scarcity became a burning issue in Asia (Yamaguchi *et al.*, 2016). According to IRRI's guidance, the process of AWD application is pretty simple. Farmers can use plastic tubes 30 cm long with a diameter of 10 - 15 cm so as to easily check the water levels inside the tubes. When applying this technology, farmers flood their fields up to 5 cm and reflood once the field water level has dropped to 15 cm below the soil surface.

Research Areas

This study was conducted in three areas, including Vinh Thanh district in Can Tho city, Tieu Can district in Tra Vinh province and Thoai Son district in An Giang province. The common feature of these three regions is that rice is the main crop in their agricultural structure. The cropping calendar for rice cultivation is also quite similar in all three study areas. The Summer-Autumn (*He - Thu*) season usually starts at the end of the dry season (May) and ends by the middle of the rainy season (August). The Autumn-Winter (*Thu - Dong*) season, from August to November, is also known as the rainy season. Meanwhile, Winter-Spring (*Dong - Xuan*) is the dry season: farmers start sowing at the end of the year and harvest in March next year. Winter-Spring crop is apparently the main crop of the year because it has higher yields than the other two.

Measurements

We collected two main groups of information about farmers in this study: (1) farmer demographics; (2) exploration of the factors developed in the research model, including AW, SI, FC, AS, PU, PEOU, AT and BI. While the nominal scale is utilized for the demographic information, the 5-point Likert scale is used to measure observed variables, in which "1" means strongly disagree, "2" disagree, "3" neither agree nor disagree, "4" agree and "5" strongly agree.

Sample

A quantitative survey was conducted in December 2020, in the form of face-to-face interviews using semi-structured questionnaires previously designed and tested. Respondents were rice farmers in the three study areas. 150 households (or 50 households per province) were selected by the convenient sampling method. This sample size is large enough for the measurement model in this study because it comprises 26 observed variables. According to Hair *et al.* (1998), the necessary sample size is n = 130 (26 x 5). Several other studies have also suggested that a sample size of 100 to 150 is suitable for SEM analyses (Anderson & Gerbing, 1988).

Data Analysis Method

This study applies the structural equation modeling (SEM) method using AMOS 23 software. SEM is employed since it allows us to combine factors (latent factors) with observed variables (measurement indicators) (Clogg & Bollen, 1991). According to Hair *et al.* (2010), SEM is a very suitable analytical method to test hypothesized relationships and explain multivariate relationships. Literature review shows that SEM is a popular method in many research areas, such as psychology (Anderson & Gerbing, 1988; Hansell & White, 1991), sociology (Lorence & Mortimer, 1985; Lavee, 1988), management (Tharenou *et al.,* 1994) etc.

For data analysis in this study, we conducted the following steps: (1) Evaluating the scale with Cronbach's Alpha; (2) Exploratory factor analysis (EFA); (3) Confirmatory factor analysis (CFA) and (4) Structural equation modeling (SEM) analysis. We used descriptive analysis for the demographic information using SPSS 20 software.

Results and Discussion

Demographic Characteristics of the Survey Respondents

Table 2 presents some demographic characteristics of the survey sample. First, of 150 farmers interviewed three out of four respondents were men. This reflects the fact that, in rice cultivation, men still play the main role. Second, nearly one-third of the sample were from the Khmer ethnic group. Third, most of the surveyed farmers had low levels of education. Nearly 87% had no professional qualification, and very few farmers had a diploma or Bachelor's degree (2.7% and 3.3%, respectively).

Table 2: Characteristics of the sample (N=150)

		Sample *N*	**Sample** *%*
Gender	Male	112	74.7
	Female	38	25.3
Age (years)	[30-39]	30	20.0
	[40-49]	51	34.0
	[50-59]	49	32.7
	[60 or more]	20	13.3
Marital status	Single	12	8.0
	Married	133	88.7
	Widowed	5	3.3
Ethnicity	Kinh	103	68.7
	Khmer minority	47	31.3
Religion	Christian	52	35%
	Buddhistic	98	65%
Economic status	Rich	48	32.0
	Average	101	67.3
	Near poor	0	0.0
	Poor	1	0.7

		Sample *N*	Sample %
Level of education	Not finished primary school	24	16.0
	Primary school	42	28.0
	Secondary school	56	37.0
	High school	28	18.0
	Vocational degree	11	7.3
	Diploma (2-year degree)	4	2.7
	Bachelor's degree	5	3.3
Income			*VND mil*
	Mean	150	10.2
	Min		1.0
	Max		30.0
	Std. Dev.		6.3
Of which, income from off-farm activities	None	28	18.7
	[Less than 20%]	48	32.0
	[21% - 40%]	24	16.0
	[41% - 60%]	39	26.0
	[60% or more]	11	7.3
Plot size owned	[Less than 1 ha]	28	18.7
	[1 - 1.9 ha]	51	34.0
	[2 - 2.9 ha]	28	18.7
	[3 ha or more]	43	28.7
Farming experience	[Less than 10 years]	18	12.0
	[10 - 19 years]	38	25.3
	[20 years or more]	94	62.7

Most of the respondents were better-off farmers (67.3%), nearly one third were rich (32%) and only one farmer was near-poor. The percentage of income from non-agricultural activities shows that of most farmers in the study area did not rely on agriculture. For example, up to 33.3% of farmers said that over 40% of their income came from off-farm activities.

The Evaluation Results of the Scale in the Research Model

It is necessary to verify the reliability of the scales of factors in the research model. For this purpose, we used Cronbach's Alpha as the first step in our analysis. Factors with Cronbach's Alpha equal to or greater than 0.6 will be retained, and any observed variables with the Corrected Item-Total Correlation smaller than 0.3 will be dropped out from the model (Trong & Ngoc, 2008). Results in Table 3 show that the scales of all factors were reliable with Cronbach's Alpha greater than 0.6 and the Corrected Item-Total Correlation greater than 0.3.

Exploratory Factor Analysis (EFA)

Following the scale reliability testing with Cronbach's Alpha, we conducted the Exploratory Factor Analysis (EFA) separately for independent and dependent variables. According to Trong and Ngoc (2008), accepted valuables must satisfy the following conditions: the KMO (Kaiser-Meyer-Olkin) $\geq$ 0.6, the

Total Variance Explained ≥ 50% and the Factor Loading ≥ 0.5. Variables that do not meet these conditions will be removed.

Table 4 shows the EFA results. The variable AS1 was dropped because it had the Factor Loading smaller than 0.5 while variable SI1 was extracted as it joined the AS factor. All KMO values were greater than 0.6, meaning that the factor analysis was consistent with the real data. The Barletl's Test value of 0.000 confirms that the measurement variables were internally correlated within groups of factors.

Confirmatory Factor Analysis (CFA)

We continued the process with the Confirmatory Factor Analysis (CFA) to check the existence of the observed valuables and the relationships of factors. As shown in Table 5, we applied the criteria suggested by Hu and Bentler (1999), Baumgartner and Homburg (1996), Doll *et al.* (1994) to assess the model appropriateness. The results indicate that the model met all conditions. The convergence and the unidimensionality of variables were also ensured.

Table 3: The results of verifying the scale reliability

Factors	**Observed Variables**	**Cronbach's Alpha**	**Total Correlation *Lowest Value***
Awareness (AW)	3	0.817	0.594
Social Influence (SI)	4	0.692	0.316
Facilitation Conditions (FC)	3	0.801	0.533
Agro-engineering Setting (AS)	3	0.644	0.353
Perceived Usefulness (PU)	4	0.853	0.500
Perceived Ease of Use (PEOU)	3	0.855	0.692
Attitude towards the Use (AT)	3	0.755	0.498
Behavioral Intention (BI)	3	0.917	0.797

Table 4: The results of Exploratory Factor Analysis (EFA)

Factors	**Items**	**Factors**			
		1	**2**	**3**	**4**
Awareness (AW)	AW2	0.906			
	AW3	0.832			
	AW1	0.745			
Social Influence (SI)	SI2		0.890		
	SI3		0.714		
	SI4		0.710		
Agro-engineering Settings (AS)	AS2			0.834	
	AS3			0.730	
	AS1			0.584	
Facilitation Conditions (FC)	FC1				0.926
	FC2				0.867

KMO (Kaiser-Meyer-Olkin): 0.792
Bartletl's Test Sig: 0.000
Total Variance Explained *(Extraction Sums of Squared Loadings)*: 67.86%

Assessment of the Structural Model

The next step in the process was the analysis of the structural model to determine and quantify the relationships between the factors and the farmers' intention to adopt the AWD. Table 6 and Figure 3 show the hypotheses testing results.

In our proposed theoretical model, there are four exogenous factors (AW, SI, AS and FC) and four endogenous factors (PEOU, PU, AT and BI). Results from SEM analysis indicate that eight hypotheses were supported and four were not supported. In particular, AW and AS had positive relationships with PU, of which AW (β = 0.508, p <0.001) had a stronger influence compared to AS (β = 0.314, p <0.005). Likewise, AW (β = 0.363, p <0.001) had the strongest positive relationship on PEOU, followed by SI (β = 0.344, p <0.001) and AS (β = 0.321, p <0.005). While both PEOU and PU had a positive and significant influence on AT, PU (β = 0.530, p <0.001) was a stronger factor in comparison with PEOU (β = 0.447, p <0.001). AT (β = 0.605, p <0.001) had a positive and significant influence on BI.

The Correlations between Social Factors and Farmer's Acceptance of AWD Technology

The survey results show that social factors, such as social connectedness, were considerable drivers for farmers to adopt AWD technology. This was particularly true when up to 68% of farmers reported that they *"applied AWD technology because of the encouragement from*

Table 5: The CFA results with relevant reference sources

Assessment Criteria	**CFA Results**	**Required Values**	**References**
χ2/df (cmin/df)	1.891	≤ 3	Hu and Bentler (1999)
CFI	0.894	≥ 0,8 (accepted)	Hu and Bentler (1999)
GFI	0.815	> 0,8 (accepted)	Baumgartner and Homburg (1996) Doll *et al.* (1994)
RMSEA	0.077	≤ 0,08	Hu and Bentler (1999)
PCLOSE	0.000	> 0,05	Hu and Bentler (1999)

Table 6: Hypotheses testing of the SEM

Hypothesis				**Co-efficient β**	***p*-value**	**Results**
H1	AW	→	PU	0.508	0.000	Supported
H2	SI	→	PU	0.032	0.760	Not supported
H3	FC	→	PU	-0.141	0.114	Not supported
H4	AS	→	PU	0.314	0.011	Supported
H5	PEOU	→	PU	0.016	0.914	Not supported
H6	AW	→	PEOU	0.363	0.000	Supported
H7	SI	→	PEOU	0.344	0.000	Supported
H8	FC	→	PEOU	-0.077	0.350	Not supported
H9	AS	→	PEOU	0.321	0.005	Supported
H10	PEOU	→	AT	0.447	0.000	Supported
H11	PU	→	AT	0.530	0.000	Supported
H12	AT	→	BI	0.605	0.000	Supported

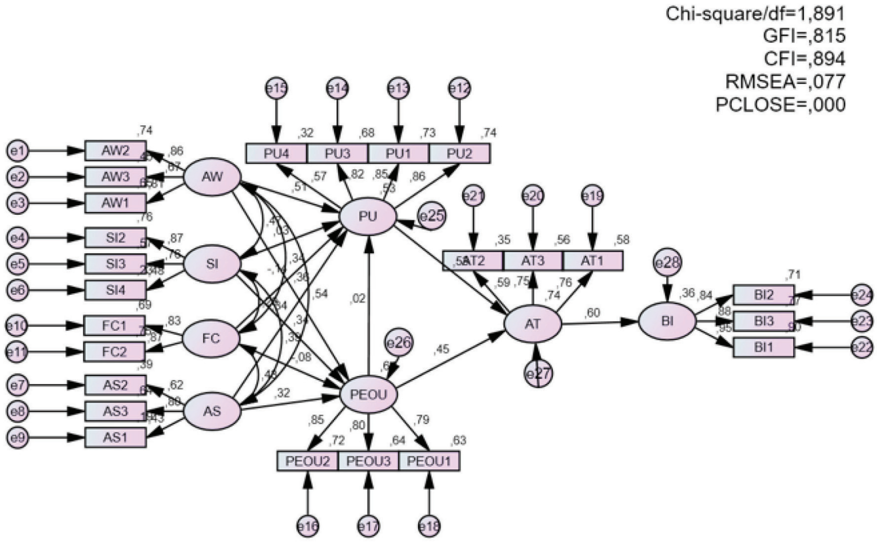

Figure 3: Structural equation modeling
Source: Authors' estimation, 2020

other cooperative members". Other reasons were "*I want to mimic and replicate good practices from my peers around (59%)", "I feel it was wrong not to apply AWD technology while the others around do (25%)"*. This characteristic shows that the social connectedness had a certain influence on an individual's AWD adoption.

We also tested the correlation between the religious belief factor on the intention to adopt AWD technology using the Independent-Sample T-Test. In this study, 52 farmers were Christian and 98 were Buddhistic (35% and 65%, respectively). The results show that there was a significant difference in the intention to apply AWD technology between groups of farmers having various religious beliefs, with the significance level sig <0.05.

The SEM results confirm that the "Awareness - AW" factor had a positive influence on the adoption of AWD technology among rice farmers in the Mekong Delta. This was in conformity with several previous studies in which AW was found to be an important driver for the adoption of new technologies (Garcia *et al.*, 2008; Rodrigues *et al.*, 2010; Komendantova *et al.*, 2012). In other words, the full awareness of AWD technology together with suitable farming conditions will motivate farmers to adopt this water-saving technology. Therefore, it is necessary to enhance the capacities of the extension staff so that they can provide rice producers with adequate technical training and guidance on the AWD application (Alauddin *et al.*, 2020; Kürschner *et al.*, 2010). In addition, mechanisms to encourage farmers to save water should also be introduced (Adhya *et al.*, 2014).

The "Social Influence - SI" factor positively influenced the "Perceived ease of use - PEOU", which indicates that the community connectedness and social factors are driving elements in the AWD technology adoption among farmers. Members of the cooperative management boards or good practitioners should take the pioneering role in applying new technologies. As a consequence, this would encourage the adoption of other members of the community.

The "Agro-engineering Setting - AS" factor had a positive influence on the "Perceived ease of use - PEOU" and thus had a role in promoting farmers' adoption of AWD technology. This result is an important suggestion for policymakers and the agricultural sector during their implementation of programs and projects to introduce and replicate AWD technology in rice cultivation. For example, it is necessary to choose suitable farming areas to introduce AWD technology. According to Yamaguchi Takayoshi *et al.* (2017), some prerequisites to ensure when applying AWD technology include quality of water supply sources, irrigation autonomy, leveled fields, etc. Farmers should also consider the soil types prior to applying AWD technology. For instance, clay or sandy soils are not suitable for the AWD application because of their poor water retention (Howell *et al.*, 2015).

Both the "Perceived ease of use - PEOU" and the "Perceive Usefulness - PU" had a positive and significant impact on the AWD adoption among farmers. This result conforms with studies by Venkatesh *et al.* (2003), Han (2003) and Liang and Yeh (2008).

Conclusion

This study proposes a theoretical model based on the Technology Acceptance Model (TAM) to evaluate the factors affecting the AWD adoption among rice farmers in three regions in the VMD. For this research purpose, we applied the Structural Equation Modeling (SEM) method to analyze and test hypotheses based on data collected from direct interviews with 150 rice farmers.

The SEM results indicate that the "Awareness" and the "Ago-engineering Setting" factors had positive relationships with the "Perceived Usefulness"; whereas the "Awareness" and the "Social Influence" factors had a positive impact on the "Perceived Ease of Use". While both the "Perceived Ease of Use" and the "Perceived Usefulness" had a positive and significant influence on the "Attitude towards the Use", the "Perceived Usefulness" was a stronger factor. The "Attitude towards the Use" had a positive and significant influence on "Behavioral Intention".

From these findings, several measures are proposed to promote the adoption of AWD technology:

(1) Regular activities, such as farmer group meetings and knowledge-sharing events, should be carried out to raise rice farmers' awareness about the benefits of AWD technology

(2) The agricultural sector needs to enhance the capacities of their extension staff so that they can provide rice producers with adequate technical training and guidance on AWD application

(3) Members of cooperative management boards or good practitioners should take the lead in applying new technologies

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