Research article

Factors Influencing Agricultural Technology Adoptions by Vegetable Producers in Svay Rieng Province, Cambodia

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Abstract Efforts by extension workers to facilitate the adoption of climate-smart agriculture technologies are crucial. Document analysis reveals that vegetable producers adjust their production techniques based on the availability of technologies, influenced by two key determinants: Contextual Driving Factors (CDF) and Perceptual Force Factors (PFF) towards these technologies. Eight parameters were identified within CDF and eleven within PFF. This study aimed to assess the impact of these factors on technology adoption levels among 302 vegetable producers who are members of agricultural cooperatives in Svay Rieng Province. Utilizing Linear Multiple Regression analysis, this research identifies four CDFs – water shortage, resource scarcity, market competition, and water management challenges, and three PFF – result demonstration, anxiety, and perceived image, are significantly influencing the adoption of the technologies. These seven factors collectively contribute to the predictive model with an R-value of 0.612, explaining 36% of the variance in adoption levels. The findings suggest that successful technological adoption is influenced by the four CDFs, actually observed to be the external challenges, producers, and producers' positive perceptions towards these technologies. Effective extension strategies should be tailored to contextual realities, defined as CDFs, and aim to present technologies in a compelling and favorable light.

Keywords agricultural extension, farmer technology adoption, rural development

INTRODUCTION

Agricultural extension plays a vital role in improving agricultural productivity and cost-benefits for producers. Scientists, government agencies, commercial vendors, and extension workers aim to address technical shortcomings among producers by introducing various beneficial techniques and technologies (Cook et al., 2021). The primary goal is to influence behavioral changes in producers in response to production, economic, societal, and environmental challenges including sustainable development or climate changes (Cook, 2024). As reported by the Cambodian Ministry of Agriculture, Forestry, and Fisheries (MAFF) in 2019, the Ministry deployed 841 extension workers at the national, provincial, and district levels, serving 2.1 million agricultural households nationwide (MAFF, 2019). Given this widespread reach, the effectiveness and efficiency of designing extension strategies and techniques are crucial. The level of technological adoption is influenced by factors such as relative advantage, compatibility, complexity, trialability and observability, and socioeconomic factors of the households (Farquharson et al, 2013). As a result, we identified the internal and external factors relevant to technological adoption and we categorized them into two groups which we name as the contextual driving factors (CDF) and perceptual force factors (PFF). The former refers to the actual situation and challenges that vegetable producers are facing in their current situation while the latter refers to the perception-based factors which are the belief of the producers. As these factors are the drivers of technological adoption, understanding the most important factors that determine adoption by producers will be beneficial in formulating appropriate agricultural extension strategies contributing to the enhancement and maximization of adoption while minimizing efforts and ineffective strategies. This study aims to identify the relevant factors influencing producers' decisions to adopt agricultural technologies, serving as a foundational formula for the development of a more effective extension strategy for Cambodia.

OBJECTIVES

This study aims to establish the relationship between independent factors influencing the decision-making process of vegetable producers in Svay Rieng Province regarding the adoption of agricultural technologies within their region.

STUDY FRAMEWORK

The Farmer Technology Adoption Model (FTAM) emphasizes external variables as initiating factors that influence producers' perceptions, ultimately shaping their decisions to accept technologies, and leading to their actual application (Amin and Li, 2014). There are challenges in adopting available technologies that producers have been facing. The first group of factors were categorized as Contextual Driving Factors (CDF), directly attributable to their actual resources and challenges being faced. The description of the factors is provided in Table 1.

METHODOLOGY

Site and Sample

Svay Rieng province is located in the southeast part of Cambodia. According to the Provincial Department of Agriculture, Forestry, and Fisheries (PDAFF), 87% of the province's population of 667,260 individuals live in rural settings with 68.5% of the population involved in agricultural production (PDAFF, 2020). In 2018, the province reported a land area for vegetable production of 1,760 hectares, generating 18,480 tons of vegetables per year, equivalent to 33% of the total demand in the province (SAAMBAT Project, 2020). The province is home to 86 agricultural cooperatives (ACs) of which 9 ACs are involved in vegetable production with a total membership of 933 households. These ACs actively produce and supply vegetables, to provincial and national markets, leveraging the benefits gained through the cooperative. Since the study focuses on vegetable producers who are members of the AC only, the members of the 9 ACs were selected for the study. To determine the sample of vegetable producers in the province, Cochran's formula was used to calculate the sample size with a margin error of 5%, a confidence level of 95%, and a response rate of 50%, resulting in a total sample of 273 individuals. The final population sample was 302 in which

92% were male gender, the majority were older than 45 years of age, and more than half completed primary school (Table 2).

Table 1 The study's variables

Independent variables	Definition / Description
AFF: Actual force factors	
AFF1: Lack of resources	Lack of resources includes a lack of capital for investment and labor forces that hinder producers' ability to expand production and invest in new technologies (Chuong, 2019)
AFF2: Water management challenges	The factor refers to the challenges that producers have excess water during the wet season while insufficient water during the dry season (Chhun et.al., 2021).
AFF3: Water shortage	This factor is critical to preventing producers from expanding production, either due to high expenses or unavailable water in certain areas (Chuong, 2019)
AFF4: Market prices	The low selling price of their products, resulting in minimal or no benefits due to market fluctuations discourages producers from continuing or expanding their production (Chuong, 2019; Muhammad, 2020).
AFF5: Pest and diseases	This is another significant concern, causing producers to hesitate in maximizing their production (Chuong, 2019).
AFF6: Competition	This factor refrains producers from expanding their production as the market is being competed by neighboring countries (Chhun et.al., 2021).
AFF7: High input cost	High input costs are an emerging barrier, preventing producers from experimenting with new technologies (Bhushan and Reddy, 2020).
AFF8: Poor quality inputs	This factor makes farmers concerned about low-quality inputs which can lead to poor results (Bhushan and Reddy, 2020).
PPF: Perceptual force factors	
PFF1: Job relevance	When producers have learned about new technologies, they assess the level of their relevance to their actual situation, called perceived relevance (Venkatesh and Davis, 2000).
PFF2: Output quality	Then, the quality of the product resulting from technology application is another factor driving their acceptance (Venkatesh and Davis, 2000).
PFF3: Result demonstration	The importance of tangible high-quality products (PFF3) (Venkatesh and Davis, 2000).
PFF4: Image	The potential positive image that producers expect from the result of the adoption is essential (Venkatesh and Davis, 2000).
PFF5: Perception of external control	This factor refers to the relationship that producers have with individuals who have technical expertise they are able to seek support, creating an expectation of successful technology application (Amin and Li, 2014).
PFF6: Self-efficacy	Another factor is the producers' personal level of knowledge adequacy regarding the technical knowledge of technology (Amin and Li, 2014).
PFF7: Innovation	This factor refers to producers' level of capability in innovating while adopting technologies to their specific situations (PFF7) (Amin and Li, 2014).
PFF8: Perceived enjoyment	Ease of use, in which producers feel that they can use the technologies joyfully is another driver of adoption (Venkatesh and Bala, 2008).
PFF9: Objective usability	The actual results from the adoption which can be transformed to be a benefit is another factor as well (Venkatesh and Bala, 2008).
PFF10: Anxiety	At the time of adoption, producers feel nervous regarding the technologies which can hinder producers from advancing to the next stage of application (Venkatesh and Bala, 2008).
PFF11: Subjective norm	This factor refers to the result from adoption that can be negatively influenced by social effects, impacting technology adoption positively (Venkatesh and Bala, 2008)
DVALL: Dependent variables	
DV1: Agricultural technology adoption	Referring to the level of adopting agricultural technologies including smart climate agricultural technologies and general technologies which are promoted for enhancing agricultural production of producers
DV2: Managerial and marketing knowledge adoption	Another type of technology is the managerial and marketing knowledge that producers are expecting to adopt to improve their production.

Construction of Survey Questionnaire

The construction of the items in the questionnaire followed the identified parameters in Table 1. The Likert Scale is revised for the intended questions. After completion of the questionnaire, validity, and reliability checking were conducted. First, it was sent to three agricultural extension experts in the rural development field to confirm the validity of the tool for revising. The revision was conducted until the questionnaire reached the level of satisfaction from the experts that they are valid as per the study objectives and contextual situation of vegetable producers in the province. Then, questionnaire testing was conducted with 36 households who are vegetable producers and members of the ACs to determine the reliability of the questionnaire. The result of the reliability calculation using Cronbach's Alpha was 0.795 which is acceptable to deploy for actual data collection.

Table 2 Profiles of respondents (*n=302*)

No	Variables		Frequency	%
1	Sex of household head			
		Male	279	92%
		Female	23	8%
2	Age of household head			
		< 31	6	2%
		31 - <45	44	15%
		45 - 60	162	54%
		> 60	90	30%
3	Education of household head (the % total = 93%)			
		Primary school or below	171	57%
		Secondary school	89	29%
		High school	18	6%
		Beyond high school	3	1%

Data Collection

The collection of data was conducted between May and August 2023, using a paper-based questionnaire by a group of four trained fourth-year students, who used the data as their study requirement. Each vegetable producer was requested to agree and sign before participating in the survey. The rejecting producers were recorded in the list to seek a replacement. Then, the questionnaires collected were entered into Excel and kept confidential by the research team.

Data Analysis

Analysis of the processed data includes descriptive statistics such as frequency, percentage, means, mode, and standard deviation to measure the tendency and variability of the observations in the data set. Pearson Product Moment Correlation was used to determine the correlation between independent and independent variables, and between independent and dependent variables, measuring the relationship between the influencing factors and technological adoption of producers through the calculation of multiple correlations. Lastly, Multiple Regression Analysis was conducted to remove a number of unnecessary factors through Stepwise Multiple Regression Analysis. The adoption level was interpreted into three key categories either in positive or negative adoption as per the absolute value: low (0.00-0.33), medium (0.34-0.66), and high (0.67-1.00).

RESULTS

Variable Reduction and Profile

Each variable can be covered by more than one question. In this regard, compiling those questions into the specific factors was conducted to obtain the final response to the questions. The result from the survey indicated that independent variables generally fell at medium and higher levels, except competition and poor-quality output which fell below the average. The result contrasts with dependent variables which fell into a below-average level indicating the level of adoption is quite low (Table 4).

Table 4 Profile of the study's variables (*n=302*)

Independent variable					
AFF	Means	SD	PFF	Means	SD
AFF1	3.06	0.68	PFF1	3.70	0.53
AFF2	3.53	0.81	PFF2	3.61	0.62
AFF3	3.09	0.99	PFF3	3.71	0.60
AFF4	3.19	0.80	PFF4	3.42	0.60
AFF5	3.42	0.84	PFF5	3.26	0.62
AFF6	2.91	0.68	PFF6	3.21	0.59
AFF7	3.11	0.78	PFF7	3.18	0.66
AFF8	2.71	0.66	PFF8	3.42	0.53
Dependent variables			PFF9	3.42	0.70
DV1	2.26	0.65	PFF10	3.27	0.69
DV2	2.32	0.68	PFF11	3.40	0.58
DVALL	2.32	0.68			

Correlation Analysis

To understand the relationship between the independent variable and dependent variable, Pearson Products' Moment Correlation r was used. The tests of the bivariate correlations indicated the relationship of testing of predictors themselves, predictors, and dependent variables.

Table 5 Correlation among all parameters within the study framework

Variables	AFF1	AFF2	AFF3	AFF4	AFF5	AFF6	AFF7	AFF8	DV1	DV2	DVAll
AFF1	1	.282**	.236**	.220**	.359**	.127*	.315**	.101	.051	.253**	.139*
AFF2		1	.332**	.177**	.413**	.175**	.200**	.162**	.108	.068	.107
AFF3			1	.407**	.337**	.394**	.048	.193**	-.299**	-.222**	-.310**
AFF4				1	.321**	.344**	.230**	.298**	-.179**	-.004	-.135*
AFF5					1	.253**	.380**	.174**	-.090	.004	-.065
AFF6						1	.131*	.292**	-.251**	-.193**	-.263**
AFF7							1	.234**	.016	.221**	.100
AFF8								1	-.158**	-.084	-.151**
DV1									1	.496**	.939**
DV2										1	.765**
DVAll											1

Variables	PFF1	PFF2	PFF3	PFF4	PFF5	PFF6	PFF7	PFF8	PFF9	PFF10	PFF11	DV1	DV2	DVAll
AFF1	-.116*	.014	.041	-.048	-.181**	-.129*	-.154**	-.121*	.063	.039	-.208**	.051	.253**	.139*
AFF2	.054	.132*	.088	-.012	.030	.023	-.007	.057	-.004	-.002	.058	.108	.068	.107
AFF3	.027	-.132*	-.152**	-.085	.097	-.090	.010	-.010	-.195**	.153**	-.004	-.299**	-.222**	-.310**
AFF4	.015	-.080	-.132*	-.115*	.062	-.045	-.026	.015	-.163**	.127*	-.042	-.179**	-.004	-.135*
AFF5	-.010	-.028	-.099	-.088	-.015	-.046	-.077	-.072	-.043	-.002	-.085	-.090	.004	-.065
AFF6	-.006	-.058	-.119*	-.047	.047	-.008	.022	.035	-.156**	-.017	-.016	-.251**	-.193**	-.263**
AFF7	-.174**	.052	-.004	.014	-.036	-.017	-.031	.006	.041	.022	-.047	.016	.221**	.100
AFF8	-.057	-.009	-.092	.052	.141*	.042	.054	.052	-.056	.055	.100	-.158**	-.084	-.151**
PFF1	1	.500**	.464**	.404**	.448**	.338**	.340**	.441**	.194**	.181**	.427**	.270**	.020	.208**
PFF2		1	.640**	.480**	.381**	.434**	.347**	.481**	.406**	.216**	.389**	.325**	.273**	.349**
PFF3			1	.539**	.291**	.426**	.237**	.446**	.421**	.178**	.345**	.394**	.385**	.445**
PFF4				1	.337**	.528**	.391**	.436**	.449**	.235**	.437**	.248**	.223**	.272**
PFF5					1	.409**	.353**	.441**	.171**	.350**	.487**	.030	-.137*	-.032
PFF6						1	.499**	.542**	.425**	.302**	.532**	.129*	.104	.137*
PFF7							1	.516**	.343**	.241**	.487**	.041	-.047	.012
PFF8								1	.462**	.335**	.593**	.117*	.096	.125*
PFF9									1	.319**	.473**	.137*	.256**	.203**
PFF10										1	.462**	-.148**	-.099	-.149**
PFF11											1	.058	-.027	.032
DV1												1	.496**	.939**
DV2													1	.765**
DVAll														1

*Notes: *p-value is below 0.05 and **p-value are below 0.01*

The statistics show that all of the factors except, six variables: AFF2, AFF7, AFF8, PFF5, PFF7, and PFF11, are significantly associated with the dependent variable. In addition, the correlation testing within the independent variables shows that cross-component (the AFF and PFF) variables are generally not statistically associated.

Analysis of the Variances for the Multiple Regression Analysis

The analytical results of the 19 predictors whether they can influence the agricultural technology adoption of vegetable producers indicated that the predictors could estimate the level of technological adoption of vegetable producers in Svay Reing Province.

Table 6 One-way ANOVA of the multiple regression analysis of the 19 variables predicting the level of technological adoption (*n =302*)

Source of Variation	df	SS	MS	F
Regression	19	56.434	2.970	10.119*
Residual	282	82.778	0.294	
Total	301	139.213		

*Notes: * = Significance, α = 0.05*

Analysis of Variance for the Stepwise Multiple Analysis

As the 19 variables contain the variables with limited association with the level of technology adoption, further analysis using stepwise multiple regression is conducted to determine the most appropriate predictors for technology extension. The results of the analysis are shown in Table 7.

Table 7 One-Way ANOVA of the multiple regression stepwise analysis of the 19 variables predicting the level of technological adoption (*n =302*)

Source of Variation	df	SS	MS	F
Regression	7	52.114	7.445	25.130*
Residual	294	87.098	0.296	
Total	301	139.213		

*Notes: * = Significance, α = 0.05*

Table 8 The parameters of the estimate equation of the level of technological adoption of vegetable producers in Svay Rieng province (*n = 302*)

Estimators	b	$SE._b$	β	t	β's Order
Constant	1.163	.316		3.677*	1
PFF3	.387	.064	.343	6.065*	2
AFF3	-.160	.038	-.234	-4.255*	3
PFF10	-.208	.048	-.212	-4.362*	4
AFF1	.179	.049	.178	3.635*	5
AFF6	-.175	.051	-.174	-3.450*	6
AFF2	.114	.043	.136	2.664*	7
PFF4	.135	.063	.119	2.138*	8
R =	0.612	F =	4.571*		
R^2 =	0.374	a =	0.156		
$SE._{est}$ =		$\pm$0.544			

*Notes: * = Significance, p-value = 0.05*

Estimators of the Estimation Equation

From Table 8, the analytical results show that seven predictors significantly influence the level of technology adoption by producers in Svay Reing province at a 0.05 significant level. The prediction order of the predictors is PFF3, AFF3, PFF10, AFF1, AFF6, AFF2, and PFF4 at 0.05 significant level. The multiple regression strength as a whole is 0.612, and it can be stated that the level of technological adoption of vegetable producers in Svay Rieng province can be described by the seven predictors of 37.4 percent with the standard error of estimate of ±0.544. The Y intercepts of the unstandardized estimation equation which is 1.163.

DISCUSSION AND CONCLUSION

The study results indicate that vegetable producers are more likely to adopt technologies when they observe tangible results from specific demonstrations. However, the successful adoption of these technologies is contingent upon the availability of water for vegetable production. It is crucial to manage anxiety levels among producers by addressing concerns associated with technology adoption. This is reflected in the accessibility of resources for financial and labor investment, emphasizing the pivotal role of resource availability. Introducing technology effectively requires providing support and confirming that producers have sufficient manpower for trial implementation. Acknowledging that competition poses a barrier leading to hesitancy among producers to adopt technologies is important. Additionally, water management becomes a significant factor due to the highly fluctuating availability of water, necessitating effective management. The social image derived from technology adoption is crucial for producers who aim to showcase that they are knowledgeable and progressive regarding their adoption of technology.

RECOMMENDATIONS

In this context, it is recommended that extension workers tailor demonstrations to align with producers' available resources and ensure adequate water for production to facilitate technology adoption. Moreover, extension agencies can only promote technology in locations with sufficient water and water management capacity. At this juncture, agricultural extension strategies should prioritize providing adequate infrastructure to producers before investing in operations that may be inoperable. Addressing producers' anxiety requires constant monitoring and support to reassure them of the benefits at the trial's conclusion. This is essential for a smooth and warm application, ensuring the product's marketability and profitability. Therefore, introducing an appealing technology that enables producers to demonstrate and share their achievements with neighbors is vital.

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