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Contribution of Technology Adoption to the Environmental and Socio-Economic Conditions of Vegetable Producers in Svay Rieng Province

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Abstract. *Extension workers have been instrumental in encouraging farmers to adopt new technologies, aiming to improve productivity, income, social status, and climate resilience. This study investigates challenges in technology adoption and its impact on vegetable production, economic and social enhancement, and climate resilience in Svay Rieng province. Data from 302 agricultural cooperative members were analyzed using Pearson's correlation to examine relationships and linear regression to predict factors influencing farmers' achievements. Results show that internal challenges (labor, capital, technical know-how) significantly influence success, followed by external challenges. Investments in hard technologies (e.g., net houses, drip irrigation) strongly correlated with achievements, while soft technologies (technical knowledge) had a lesser impact. Regression analysis identified internal challenges and adoption of hard technologies as key predictors, explaining 25% of overall performance, including 36%, 29%, and 25% of economic, social, and climate resilience improvements, respectively. For production, only internal challenges and hard technologies were determinants, predicting 30%. Addressing internal challenges and enhancing technology applications are critical to improving vegetable producers' success in the province.*

Keywords: *Agricultural Technology, Benefits of Technological Adoption, Rural Development*

1. INTRODUCTION

The adoption of agricultural technology has increasingly become a pivotal factor in enhancing the productivity and resilience of smallholder farmers, particularly in developing countries. In Cambodia, the agricultural sector remains a significant driver of the economy, with vegetable production contributing substantially to rural livelihoods and national food security. Despite this importance, farmers in provinces like Svay Rieng face numerous challenges in adopting modern technologies, which often limit their capacity to increase productivity and improve socio-economic conditions (Thort, 2019). Moreover, the low rate of technology adoption in vegetable farming highlights the need for targeted interventions to address barriers such as limited access to capital, technical knowledge, and market opportunities (Keo & Roth, 2023). Addressing these challenges is essential to support farmers in achieving sustainable agricultural practices and adapting to climate change. The effectiveness of these services can be constrained by both internal challenges, such as limited labor and financial resources, and external challenges, such as infrastructure gaps and market uncertainties (Ke & Babu, 2018). Understanding these constraints and their interplay with technology adoption is key to designing strategies that can maximize the socio-economic and environmental benefits for smallholder vegetable producers. In

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addition, there is limited research examining how these challenges interact to influence key outcomes such as economic improvement, social enhancement, and climate resilience. Moreover, the environmental implications of adopting these technologies in resource-scarce settings like Svay Rieng Province remain poorly understood. This gap in knowledge limits the ability of policymakers and stakeholders to design targeted interventions that effectively address these barriers and promote sustainable agricultural practices.

Objectives

This study examines the challenges in technology adoption and its impacts on vegetable production performance contributing to economic and social enhancement, and climate resilience of vegetable producers in Svay Rieng province.

2. METHODOLOGY

Site And Sample

Svay Rieng province is situated in the southeast part of Cambodia. According to Provincial Department of Agriculture, Forestry and Fisheries (PDAFFF) (2020), 87% of the province's population (667,260 individuals) live in rural areas and 68.5% of them are involved in agricultural production. In 2018, the province reported the land area for vegetable production of 1,760 hectares, generating vegetables of 18,480 tons per year equivalent to 33% of the total demand in the province (SAAMBAT Project, 2020). The province is home to 86 agricultural cooperatives (ACs) in which 9 ACs are involved in vegetable production with a total number of 933 households. These ACs are actively producing vegetables, supplying them to provincial and national markets, in a more collective way. Since the study focuses on vegetable producers, 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%, confidence level of 95%, response rate of 50%, resulting in a total sample of 273 samples. During the survey a total sample of 302 was interviewed in which 92% of them are male and the majority of them are above 45 years old with more than half completed only primary school (Table 1).

Construction Of Survey Questionnaire

The construction of the items in the questionnaire followed the identified objectives of the study. Likert Scale is targeted for the intended questions. After completion of the questionnaire, validity and reliability checking were conducted. Firstly, it was sent to three agricultural extension experts in the rural development field to confirm the validity of the tool for making the revision. 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 farmers in the province. Then, questionnaire testing was conducted with 36 households to determine the reliability of the questionnaire. The result of the reliability calculation using Cronbach's Alpha is 0.795 which is acceptable to deploy for actual data collection.

3. DATA ANALYSIS

Analysis of the processed data include descriptive statistics such as frequency, percentage, means, mode, and standard deviation to measure 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 independent and dependent variables, finding out the relationship between the determinants of influencing factors and technological adoption behaviours of farmers through the calculation of multiple correlations. Lastly, Multiple Regression Analysis was conducted to demonising a number of unnecessary factors through Stepwise Multiple Regression Analysis.

4. RESULTS

Access To Technology

Awareness of technology among farmers is high for most technologies, such as net houses (96%), plastic houses (93%), and seed selection (95%), indicating widespread familiarity with these practices. The highest adopted technology among farmers seen in plastic houses (92%), net houses (88%), soil erosion management (85%), and smart irrigation (82%), reflecting a strong focus on infrastructure and environmental management. Moderate adoption is observed for practices like IMPM (77%), fertility management (75%), and good agricultural practices (62%), indicating progress in sustainable farming but with room for improvement. However, lower adoption rates for key practices like seed selection (30%), crop rotation (32%), and organic agriculture (31%) suggest barriers in technical limitations. Additionally, only around half of the farmers have adopted critical business practices like financial management (53%), marketing (51%), and production planning (49%), while post-harvest and packaging is adopted by just 44%, revealing missed opportunities for value addition.

Challenges In Production And Technological Adoption

Vegetable producers in Svay Rieng province have faced various challenges in their production mainly on environmental challenges being emerged as the most critical ones, followed by technical and input-related issues, emphasizing the need for targeted interventions in these areas to improve productivity and resilience among vegetable producers. At the same time, major barriers to their adoption of technologies are the high investment cost, affecting 83% of respondents, indicating financial constraints as the primary challenge. Too complicated technologies (20%), lack of technical support (19%), and lack of labour force (16%) are the moderate barriers, suggesting that complexity, insufficient guidance, and workforce shortages also hinder adoption.

Benefits Of Adopting Technologies

The findings suggested that vegetable producers have benefited in a number of aspects including improved production, economic, social status, and resilient to environmental condition. Firstly, the production benefits highlighted significant improvements in efficiency and quality. With respondents rating the highest for increased production times (67.11), reflecting improvements in operational efficiency. Savings in time and labor (65.94), cost reductions (65.91), and improved quality and values (64.29) further emphasize the effectiveness of the interventions in streamlining processes and delivering higher-quality outputs. These ratings highlight the perceived value of production improvements in achieving sustainable productivity gains.

Secondly, economic benefits received high ratings, with increased yields (65.17) and income (63.76) standing out as important indicators of financial growth. Increased production size (62.88) and the ability to meet market demand (63.43) demonstrate the alignment of agricultural outputs with market needs. Ratings for solving capital shortage issues (64.01) and increased profits (63.80) suggest enhanced financial capacity, ensuring better economic security and sustainability for stakeholders.

Thirdly, social impacts are well-rated, reflecting tangible improvements in community-level benefits. Increased child education opportunities (64.92) and better social recognition (63.80) demonstrate the positive effects of agricultural development on family and community well-being. Knowledge sharing (61.77), collaboration among producers (62.56), and increased participation in agricultural events (61.95) highlight the empowerment of individuals through networking and capacity-building initiatives. Opportunities for leadership (60.48) also indicate progress toward greater social inclusion and influence.

Lastly, environmental outcomes received positive ratings, indicating the effectiveness of sustainable practices. Resilience to pests (64.03) and reduced environmental pollution (63.95) reflect advancements in ecological health and resource management. Improved production resilience (62.70) and adaptability to water shortages (61.62) and saturated soil (60.70) underscore the significance of climate-resilient farming techniques. These ratings emphasize the growing emphasis on balancing agricultural productivity with environmental sustainability.

Overall, the ratings across production, economic, social, and environmental aspects reflect a cohesive system of agricultural improvement. Enhanced efficiency and quality in production contribute to economic growth by increasing yields, profits, and market responsiveness. Economic stability enables investments in social initiatives, such as education, collaboration, and leadership, while sustainable environmental practices ensure the longevity of these benefits. Together, these aspects form an interconnected framework that drives agricultural development, social progress, and environmental resilience, fostering sustainable and inclusive growth.

Correlation Analysis

To understand the relationship between the technological adoptions and its benefits, correlation analysis was conducted, shown in Table 2. Hard technologies refer to physical infrastructure such as net house, plastic house and irrigation whereas soft technologies refer to the technological awareness of the producers. In addition, management refers to knowledge regarding the marketing, planning, and post-harvest technologies which producers know.

Table 1. Correlation between technology adoption and benefits (n=302)

Factors	Hard technology	Soft technologies	Management	Internal challenges	External challenges	Production benefits	Economic benefits	Social benefits	Environmental benefits	Overall benefits
Hard technology	1									
Soft technologies	0.420**	1								
Management	0.308**	0.482**	1							
Internal challenges	-0.152**	0.109	0.253**	1						

Factors	Hard technology	Soft technologies	Management	Internal challenges	External challenges	Production benefits	Economic benefits	Social benefits	Environmental benefits	Overall benefits
External challenges	-0.296**	-0.108	-0.025	0.401**	1					
Production benefits	0.318**	0.040	-0.044	-0.495**	-0.268**	1				
Economic benefits	0.324**	0.018	-0.095	-0.547**	-0.274**	0.876**	1			
Social benefits	0.185**	-0.099	-0.173**	-0.529**	-0.210**	0.766**	0.849**	1		
Environmental benefit	0.210**	-0.122*	-0.136*	-0.464**	-0.223**	0.702**	0.739**	0.764**	1	
Overall benefits	0.283**	-0.044	-0.120*	-0.551**	-0.263**	0.912**	0.945**	0.924**	0.877**	1

The relationship test shows that hard technologies have been perceived in a more positive way by vegetable producers, indicating less value being given to soft technologies. Hard technologies are significantly associated with all aspects including internal and external challenges (negative association) whereas benefits in production and economics are the highest followed by environmental and social benefits at the last benefits. This indicates that hard technologies can convince respondents to value its benefits as they are more visualized to producers. On the contrary, soft technologies are not statistically associated with any challenges and benefits, except the management. The association tests imply two interpretation distinctions of awareness either producers have inadequate knowledge and limitedly valued soft technologies or they have truly had the soft knowledge but lack capital in investing in improving hard technologies. However, it is more evident that the earlier interpretation stands more valid as the internal challenges are found to be very significantly related with all the benefits in a negative way. The external challenges found to be at the same direction with a lesser extent. Apart from this, management knowledge has a slight relationship with the overall benefits of the production.

Analysis of the variances for the multiple regression analysis

To determine the effects of the technology adoptions on the overall benefits in production, economic, social, and environmental, Linear Multiple Regression analysis was conducted. Eighteen technologies or sub-variables to the identified independent variables analysed earlier were included in the equation. The result showed that the 18-technology adoption rate was able to 41% estimate the benefits, from the adoption, as the correlation coefficient of model was 0.668 (Table 2). This indicates a significant prediction of the factors in determining producers' benefits.

Table 2. One-Way ANOVA of the multiple regression analysis of the 13 variables predicting the level of beneficial performance

Source of Variation	df	SS	MS	F
Regression	18	37.570	2.087	12.391*
Residual	277	46.661	0.168	
Total	295	84.231		

(* = Significance, α = 0.05)

Analysis Of Variance For The Stepwise Multiple Analysis

Since the 18 technologies contain variables with limited influences on the level of benefits from the production, further analysis using stepwise multiple regression is conducted to determine the most influential technologies that can generate a significant estimate of the overall production benefits. The results of the analysis were shown in Table 3.

Table 4. One-Way ANOVA of the multiple regression stepwise analysis of the 18 technologies predicting the level of benefits from the adoption

Source of Variation	df	SS	MS	F
Regression	9	36.815	4.091	24.673*
Residual	286	47.416	0.166	
Total	295	84.231		

(* = Significance, α = 0.05)

The above result indicated that 9 technologies can generate significant impacts on the result of the vegetable producers. The equation can still estimate the benefits of the production at 41% as the r value of the equation was 0.661.

Repeating the linear multiple regression analysis for each type of the four benefit groups; production, economic, social and environment; the result indicated that the adoption of technology can highly predict the result of each type at 38%, 36%, 40%, and 30% respectively. The result indicates the significant contribution of technologies to production at different aspects which are very crucial for the livelihood development of vegetable producers within the province.

5. DISCUSSION AND CONCLUSION

Various technologies have been promoted within the province. The most influential technologies include net house, fertilizer application, good agriculture practices, organic farming, soil erosion management, financial management, IPM, crop rotation and greenhouse. The study results confirmed that the accomplishment of vegetable producers in terms of production, economic, social and environment are highly attributable to the adoption of technologies including hard and soft technologies and management. Vegetable farmers in Svay Rieng province perceived hard technologies as the most influential contributors to their achievement while limited acknowledgement was given to soft technologies. The management was more associated with social and environmental than the production and economic benefits. As per these findings, it is recommendable that the promotion of technologies should be given to these technologies while the focus should be providing more value to soft technologies since there is limited recognition. In addition, a higher promotion of physical infrastructure is very important to cope with various challenges, especially external ones.

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