ปัจจัยที่ส่งผลต่อการพัฒนาระบบฟาร์มอัจฉริยะในยุคดิจิทัล: แนวทางแอปพลิเคชันบนมือถือ

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บทคัดย่อ

การศึกษาในครั้งนี้มีวัตถุประสงค์เพื่อศึกษาปัจจัยของระบบการเกษตรอัจฉริยะสำหรับการเกษตรในยุคดิจิตอล ซึ่งมีการพัฒนาระบบที่มีความรู้เกี่ยวกับเทคโนโลยี IoT ซึ่งสามารถใช้ในการส่งข้อมูลระหว่างอุปกรณ์และสามารถวิเคราะห์ข้อมูลโดยอัตโนมัติด้วยการแสดงข้อมูลในเวลาจริงของเซ็นเซอร์ที่สามารถวัดได้และอุปกรณ์ควบคุมเพื่อควบคุมองค์ประกอบของสิ่งแวดล้อมเพื่อให้เหมาะกับการเจริญเติบโตของพืชด้วยสมาร์ทโฟนมือถือ การวิจัยนี้สามารถลดค่าใช้จ่ายและเวลาของพนักงาน ข้อมูลที่ได้รับจากการวัดจะถูกเก็บไว้ในฐานข้อมูลของผู้ใช้ข้อมูลที่ถูกเก็บรวบรวมจากตัวอย่างทั้งหมด 400 ตัวอย่างของเกษตรกรในท้องถิ่นโดยการตรวจสอบอย่างละเอียดและตามความสะดวกของผู้ตอบสนอง การวิเคราะห์สถิติที่ใช้ในการศึกษานี้คือค่าเฉลี่ยทางคณิตศาสตร์ ความถี่ อัตราเปอร์เซ็นต์ ปกติกับสถิตการวิเคราะห์ที่เปรียบเทียบ

ผลการวิเคราะห์แสดงให้เห็นว่า โมเดลสถาปัตยกรรมของปัจจัยที่ส่งผลกระทบต่อการพัฒนาระบบการเกษตรอัจฉริยะสำหรับเกษตรกรในยุคดิจิตอลที่มีแอพพลิเคชั่นมือถือ เข้ากันได้ดีกับข้อมูลทางประสบการณ์ โมเดลนี้สอดคล้องกับข้อมูลทางประสบการณ์ด้วย Chi – Square = 59.966, df = 45, Sig. = 0.067 > 0.05 และ CMIN/df. = 1.333 < 3.0 ผลการวิเคราะห์จากการปรับตัวของรุ่นแสดงให้เห็นว่ามีความสม่ำเสมอและมีเกณฑ์ค่าสถิติที่สมบูรณ์

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FACTORS AFFECTING SMART FARMING SYSTEM DEVELOPMENT IN THE DIGITAL ERA: A MOBILE APPLICATION APPROACH

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ABSTRACT

This study aims to investigate the factors of smart farming systems for agriculture in the digital age that have developed systems with knowledge of IoT technology that can be used to transfer data between devices and can automatically analyze data with real-time display from measurable sensors and control devices to control environmental factors to suit the growth of crops. By using mobile smartphones, this research can reduce labor costs and time. The data obtained from the measurements is stored in the user database. Data was collected from a total of 400 samples of local farmers, with thorough screening and respondents selected according to their preferences. The statistical analyzes used in this study were mathematical averages, frequencies, percentages, standard deviations and comparative analysis statistics.

The analysis results showed that the structural equation model of the factors influencing the development of smart farming systems for farmers in the digital era with mobile applications was in good fit with the empirical data. The model was consistent with the empirical data, with Chi-square – = 59.966, df = 45, Sig. = 0.067 > 0.05 and CMIN/df. = 1.333 < 3.0. The analysis results of model fitting show that the criteria for consistency and statistical value are met.

Keywords: Smart Farming, Internet of Things (IoT), Arduino

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Introduction

Agriculture in Thailand still faces many problems especially in terms of productivity due to farmers lacking in-depth information and current climate is very volatile so checking the condition of environment in which the crop is grown is essential. At present, electronic technology, telecommunication technology and computer networks have made great progress, using wireless sensor network application to check the condition of the environment can make environmental monitoring more efficient (Jebri et al., 2015). Internet of Thing (IoT) technology has been applied in many important areas, resulting in many new innovations, The concept of 'Smart Farming' involves using electronic and computer technology including information technology, technology development to facilitate Management of agricultural farms in the form known as Smart farming system, the application of knowledge of science and technology in order to be consistent with Thailand 4.0 Thailand 4.0 refers to the government's initiative to transform the country into a technologically advanced and innovation-driven economy. It can lower staffing and time expenses, as users are unable to manually configure operational controls, which is bringing technology to help promote agriculture. This research aimed to design a control unit for measuring environmental conditions such as temperature and humidity as well as soil moisture and to examine factors affecting the development of smart farming systems for farmers in the digital era with mobile applications. So that people can use it easily, conveniently, save time via 4G Internet or Wi-Fi technology and control various devices via a smartphone. The information sent from the wireless sensor network is the current environment information and information is constantly changing. Farmers can use the information for planting planning, streamline the production process to increase productivity and can predict future productivity.

Research Objectives

This research aims to develop smart farming systems for farmers in the digital era with mobile applications and has the following objectives:

1. To analyses the underlying factors contributing to issues and utilize scientific and technological expertise to facilitate the advancement of agriculture.

2. The objective is to create an affordable sensor system that can continuously monitor the environment and send alerts using IoT technology.

3. To investigate the level of customer satisfaction with the utilization of the mobile application system for managing the smart farming system.

Conceptual Framework

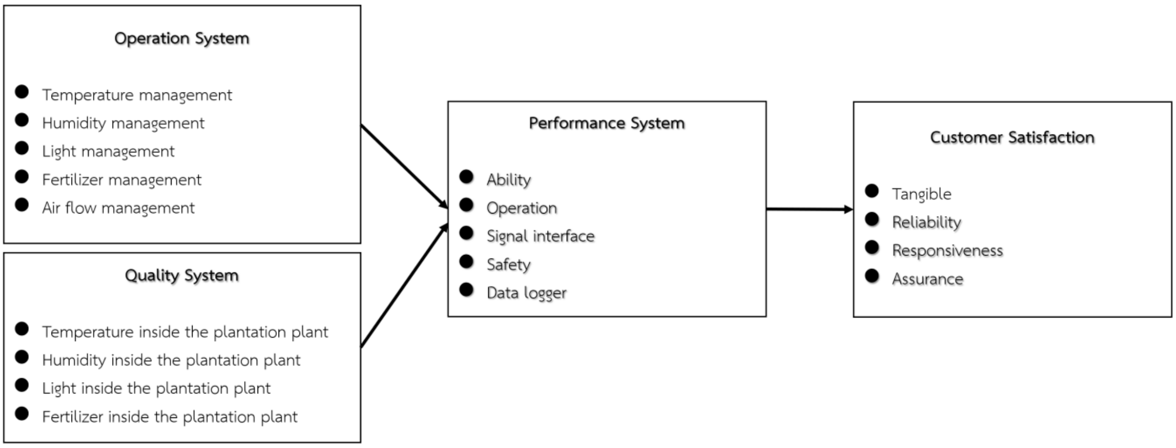

Figure 1 Conceptual Framework

Research Hypotheses

The hypotheses of this research are as follows.

Hypothesis 1 Operational management influences the efficiency of smart farming systems for farmers in digital era.

Hypothesis 2 Quality control influences the efficiency of smart farming systems for farmers in digital era.

Hypothesis 3 The efficiency of smart farming systems influences customer satisfaction using mobile applications.

Literature Review

Computer Embedded System

The literature review encompasses current research documentation on the subject of smart farming. This section will analyses a study that comprehensively covers all aspects of a smart agricultural system based on the Internet of Things (IoT), (Farooq et al, 2019).

Embedded System is a tiny computer system that is embedded in electrical appliances and various electronic players, to add intelligence to those devices through software, which is different from the general computer processing system. Cheap embedded system is widely used in vehicles, home and office electrical appliances, electronic device software, technology hardware, technology network, network technology, communication technology, mechanical technology and various toys. The term embedded system comes from the system that is a processing system just like a computer system. But this system is embedded in other devices that are not computers. At present, embedded systems have developed more. In an embedded system, it consists of microcontroller or microprocessor devices that use embedded systems are evident such as mobile phone. In embedded systems, different operating systems are also put into operation. Therefore, embedded systems may work from controlling light bulbs to being used in spacecraft. Agriculture holds the highest share in Thailand's economy, accounting for 18% of the gross domestic product and engaging around 57% of the population residing in rural regions. Currently, the use of IoT technology is helping agriculturalists and technologists address challenges faced by farmers, such as water management shortages and productivity concerns, by using innovative solutions. State-of-the-art IoT innovations have successfully recognized and addressed all of these difficulties, offering effective solutions to enhance productivity and save costs (Kunstadter et al., 2019).

Internet of Things: IoT

The Internet of Things (IoT) is an emerging technology that enables objects to establish remote connections in order to facilitate intelligent farming (Jaishetty & Patil, 2016). The Internet of Things (IoT) technology enables the monitoring of plants and the remote retrieval of information via mobile phones and devices. Farmers utilize sensors and devices to evaluate weather conditions and forecast production quantities. The Internet of Things (IoT) significantly contributes to water harvesting, as well as the monitoring and control of water flow rates. It also aids in the assessment of crops' water needs, timing of water supply, and water conservation efforts, more extensively than ever before (Yong et al., 2018). In the farming sector, the communication infrastructure of IoT technologies has had a significant impact on development. This has encompassed the integration of smart items, remote data collection, utilization of microcontrollers and sensors via mobile devices and the internet, cloud-based intelligent analysis, interfacing, decision-making, and the automation of agricultural activities. These proficiencies have significantly transformed the agriculture industry by enhancing resource utilizations, mitigating climate impacts, and enhancing crop productivity (Elijah et al., 2018). The farming sector has been significantly influenced by the adoption of IoT technology, especially in terms of its communication infrastructure. This encompasses the integration of smart items, remote data collection, utilizations of vehicles and sensors via mobile devices and the internet, cloud-based intelligent analysis, interfacing, decision-making, and the automation of agricultural activities. These skills have completely transformed the agriculture sector by enhancing resource utilizations, mitigating climate impacts, and enhancing crop productivity (Varga et al., 2017).

The yield monitoring mechanism adheres to the yield, moisture content, and quality of the produce. The quality is contingent upon effective pollination with high-quality pollen, particularly in the face of fluctuating environmental conditions (Wietzke et al., 2018).

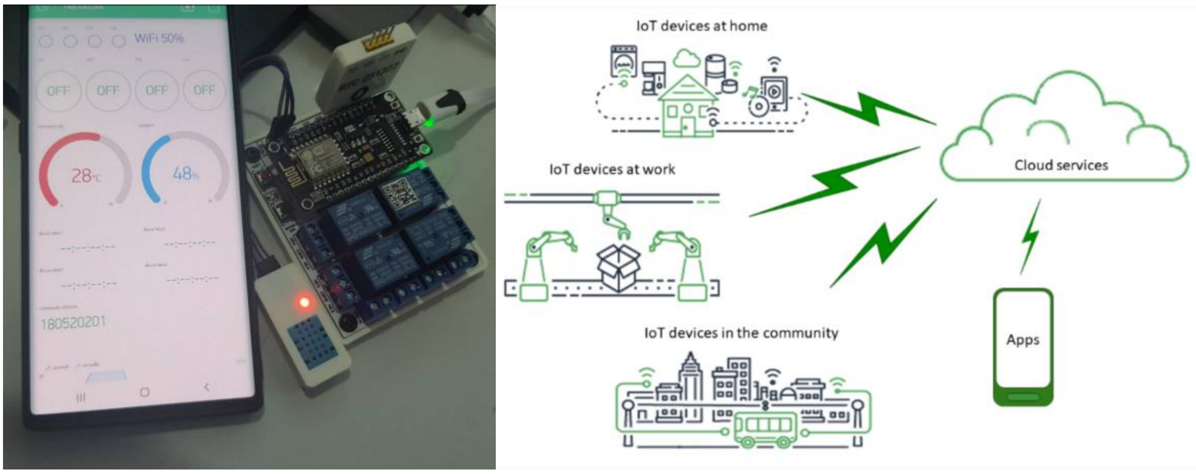

Figure 2 General structure of the smart farming system development system for digital age farmers with a mobile application by the researcher.

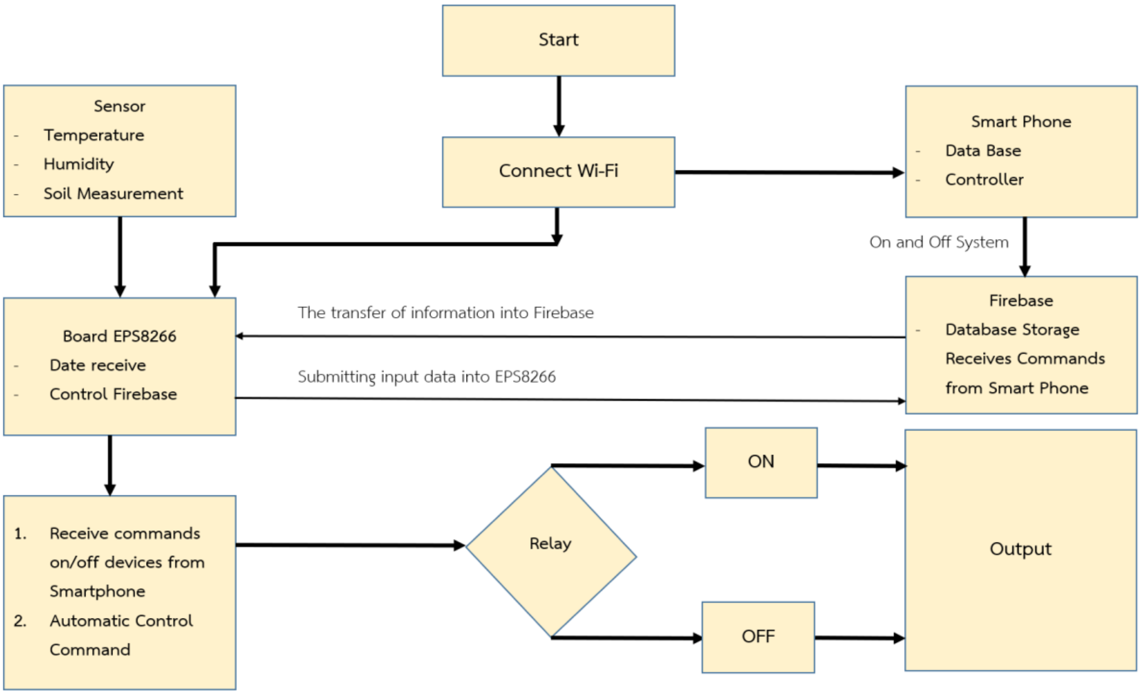

Figure 3 Working process of the smart farming system for farmers in digital era with a mobile application by the researcher.

Smart Farm

An overview of the current research being conducted in key technological industries related to IoT-based farming has been presented, highlighting the industrial developments in this field. The discourse has revolved around the policies implemented by many nations to establish a uniform framework for the integration of Internet of Things (IoT) technology in the field of smart agriculture. Finally, the obstacles and issues in agricultural technologies based on the Internet of Things (IoT) that can be enhanced have been addressed.

Figure 2 illustrates the current patterns and developments in smart farming, as referenced by source.

Figure 3 depicts the primary elements of smart farming based on the Internet of Things (IoT).

Smart Farm, Precision Farm or farms that bring Information technology science used as a tool for convenience and ease of management, which can be processed quickly and accurately, efficient use of available resources increases quantity and quality of output, reduce production costs, safe for consumers and the environment leading to be able to compete internationally. Smart farming is farming with innovation which is very popular in foreign countries such as the United States and Australia and at present begins to spread to countries in Europe, Japan, Malaysia and India, which are countries known for their technology systems. Technology has been implemented in agriculture to enhance production efficiency. (O'Grady & O'Hare, 2017). Technology has been used in many ways to enhance management practices and minimize the need for agricultural labor. Presently, there is a consistent decline in the workforce employed in the agriculture sector, particularly in developed nations. There will be a decline in agricultural workforce, but these countries have shifted their focus towards the agricultural sector. Consequently, they have implemented various technologies to aid in management, leading to the production of high-quality agricultural products in sufficient quantities to meet market demand. Thailand has had a longstanding association with agriculture dating back to ancient times. The majority of the population in the country consists of farmers. Hence, it is imperative for the government to priorities the implementation of smart farming techniques and increase the integration of information technology in the agricultural sector. This would result in the development of sustainable and eco-friendly agricultural practices (Liakos et al., 2018). In the future, the data will then be stored in a database linked to the processing stage and forwarded to the fertilizer spreader on the tractor equipped with a GPS (Global Positioning System) system, making fertilizer application can determine what type of fertilizer to be applied, quantity and location on the farm in order to meet the needs of plants and help reduce the rate of loss of fertilizer or reduce the toxicity of fertilizers that are valuable to those plants (Jangaard et al., 2019).

Research Methodology

A study on factors affecting the development of smart farming systems for farmers in the digital era with mobile applications. It is survey research by collecting data obtained from questionnaire. The researchers gathered data from a combined total of 400 samples of farmers residing in the provinces of Bangkok, Shandong, Shinjuku, Yama, Pattaya, and Nantes. The study employed a comprehensive statistical analysis, which involved calculating mathematical averages, frequency values, percentages, and standard deviations, along with other relevant statistical measures. This approach was chosen based on careful examination and the convenience of the participants. The research tools were verified for content accuracy by the experts and data reliability analysis. All items have an IOC value from the assessment of 3 experts more than 0.50, which means that question is valid to be used, and the value of variables in each dimension were greater than 0.70, which was the acceptable for reliability of the data (Hajiar, 2014).

Data were analyzed by descriptive statistics: frequency, percent, mean, standard deviation. Inferential Statistics analysis was used for analysis consisting of Confirmatory Factor Analysis or CFA and Structural Equation Model: SEM analysis to verify the harmonization of the research model with empirical data (Model Fit), consistency of the model with empirical data (Assessment of Model Fit). The indexes used to verify the consistency of the model with empirical data include Chi-Square Index, CMIN/df., CFI, GFI, IFI, NFI, AGFI, RMSEA and RMR as criteria to verify the model's consistency. Data were analyzed from statistical ready-made computer programs. The results of data analysis and interpretation are presented in an annotated table format. The results of the research can be summarized as follows:

Part 4.1: The results of the analysis of general information about farmers consisted of gender, age, status, education level, position, net income per month, duration for agricultural operations, size of establishment and the location of the establishment. The questions are Nominal scale, Ordinal scale and Ration scale.

Part 4.2: Factors Affecting the Development of Smart Farming Systems for Farmers in digital era with Mobile Applications. The question is in the form of a Rating Scale with 5 levels, with level 5 meaning "the most" and level 1 meaning "the least". This section provides a comprehensive review of customer satisfaction with services and operations conducted using mobile operating systems. These include crop services, temperature control, crop factor equipment, and personnel services.

Part 4.3: Satisfaction with using the service Smart farming system for farmers in digital era with mobile applications. The question is in the form of a rating scale with 5 levels, where level 5 means "the most" and level 1 means "the least". This section provides an examination of service satisfaction that impacts performance across various mobile operating systems, covering factors such as functionality, signal interface, security, and data logging.

Part 4.4: Confirmatory Component Analysis of Factors Affecting the Development of Smart Farming Systems for Farmers in digital era with Mobile Applications.

Part 4.5: An analysis of correlation problems between model variables of factors affecting the development of smart farming systems for farmers in digital era with mobile applications.

Part 4.6: Structural Equation Analysis of Factors Affecting the Development of Smart Farming Systems for Farmers in digital era with Mobile Applications.

Part 4.7: Results of the hypothesis testing of factors affecting the development of smart farming systems for farmers in digital era with mobile applications.

Research Findings

Data Analysis on General Information

The results of general data analysis about the sample of 400 people can be summarized as follows: Entrepreneurship nature, The management structure in the workplace and the type of agricultural products. The results of the analysis are as follows.

Table 1. Frequency and percent of general information of sample group

General Information on Organization		Frequency	%
Entrepreneurship	Monoculture Farmers in Cultivation	35	8.75
Nature	Mixed-culture Farmers in Cultivation	175	43.75
	Import	156	39.00
	Export	22	5.50
	Others	12	3.00
	Total	**400**	**100.00**

Table 1. Frequency and percent of general information of sample group (Cont.)

General Information on Organization		Frequency	%
Management Structure in the workplace	Thai entrepreneurs hold 100.00%	141	35.25
	Thai entrepreneurs hold more shares than foreign entrepreneurs.	179	44.75
	Foreign entrepreneurs hold more shares than Thai entrepreneurs.	60	15.00
	Foreign entrepreneurs hold 100.00%	20	5.00
	Total	**400**	**100.00**
Products Type	Hydroponics farmers	118	29.50
	Perennial fruit farmers	27	6.75
	Vegetables farmers	181	45.25
	General Mushroom farmers	61	15.25
	-1 to +18C mushroom farmers	13	3.25
	Total	**400**	**100.00**

Analysis of factors affecting the development of smart farming system for farmers in digital era with mobile application.

In this section, the results of the analysis of factors affecting the development of smart farming systems for farmers in the digital era can be presented with a mobile application for managing the operation system. The quality of management and efficiency of the smart farming system and the satisfaction of customers using mobile applications. The results of the analysis are as follows.

Table 2. Mean, Standard Deviation and Operation system factors analysis (n = 400)

Operation System Factors	$\bar{X}$	SD.	Agreed Level
Temperature management	4.02	0.72	Strongly agree
Humidity management	3.90	0.80	Strongly agree
Light management	4.07	0.75	Strongly agree
Fertilizer management	4.11	0.76	Strongly agree
Air flow management	4.02	0.79	Strongly agree
Total Average	**4.02**	**0.69**	**Strongly agree**

Table 3. Mean, Standard Deviation and Quality system factors analysis (n = 400)

Quality System Factors	$\overline{X}$	SD.	Agreed Level
Temperature inside the plantation plant	4.07	0.75	Strongly agree
Humidity inside the plantation plant	4.14	0.79	Strongly agree
Light inside the plantation plant	4.35	0.69	Mostly agree
Fertilizer inside the plantation plant	4.39	0.72	Mostly agree
Total Average	**4.24**	**0.68**	**Mostly agree**

Table 4. Mean, Standard Deviation and Performance system factors analysis (n = 400)

Performance System Factors	$\overline{X}$	SD.	Agreed Level
Ability	4.38	0.69	Mostly agree
Operation	4.33	0.61	Mostly agree
Signal Interface	4.25	0.66	Strongly agree
Safety	4.19	0.69	Strongly agree
Data Logger	4.31	0.65	Mostly agree
Total Average			Mostly Agree

Effects of satisfaction in using smart farming system services for farmers in digital era with mobile applications.

In this section, the results of the analysis of satisfaction in the use of smart farming system services, Tangibility, Reliability, Responsiveness, and Assurance of Smart farm, are analyzed as follows.

Table 5. Average, standard deviation of Customer Satisfaction Factors Using Mobile Application Systems (n = 400)

Customer Satisfaction Factors Using Mobile Application Systems	$\overline{X}$	SD.	Agree Level
Tangibility	4.22	0.75	Mostly agree
Reliability	3.99	0.67	Strongly agree
Responsiveness	4.10	0.63	Strongly agree
Assurance	4.12	0.66	Strongly agree
Total Average	**4.13**	**0.48**	**Strongly agree**

Confirmatory component analysis (CFA) of factor models affecting preferences towards smart farming systems for farmers in digital era with mobile applications.

1. Operation System Factors

The results of the analysis of the management system variables in the model of factors affecting the satisfaction of smart farming system for farmers in digital era with mobile applications. Therefore, the coherence of the model was examined using confirmatory component analysis by performing Multi Factor CFA Model with the results of the confirmatory component model analysis found that it was consistent with the empirical data at a good level with Chi - Square = 76.113 df = 58 Sig. = 0.056 > 0.05 and CMIN/df. = 1.312 < 3.0 and CFI 0.998 > 0.90, GFI 0.980 > 0.90, AGFI 0.928 > 0.80, RMSEA 0.028 < 0.05, RMR 0.027 < 0.05, NFI 0.991. > 0.90 and harmonious index in comparison with the base model (IFI), it was 0.998 > 0.90, which these indices passed the criteria set for both. It can be said that the model is consistent with the empirical data shown in Figure 4 and the analytical results in Table 6.

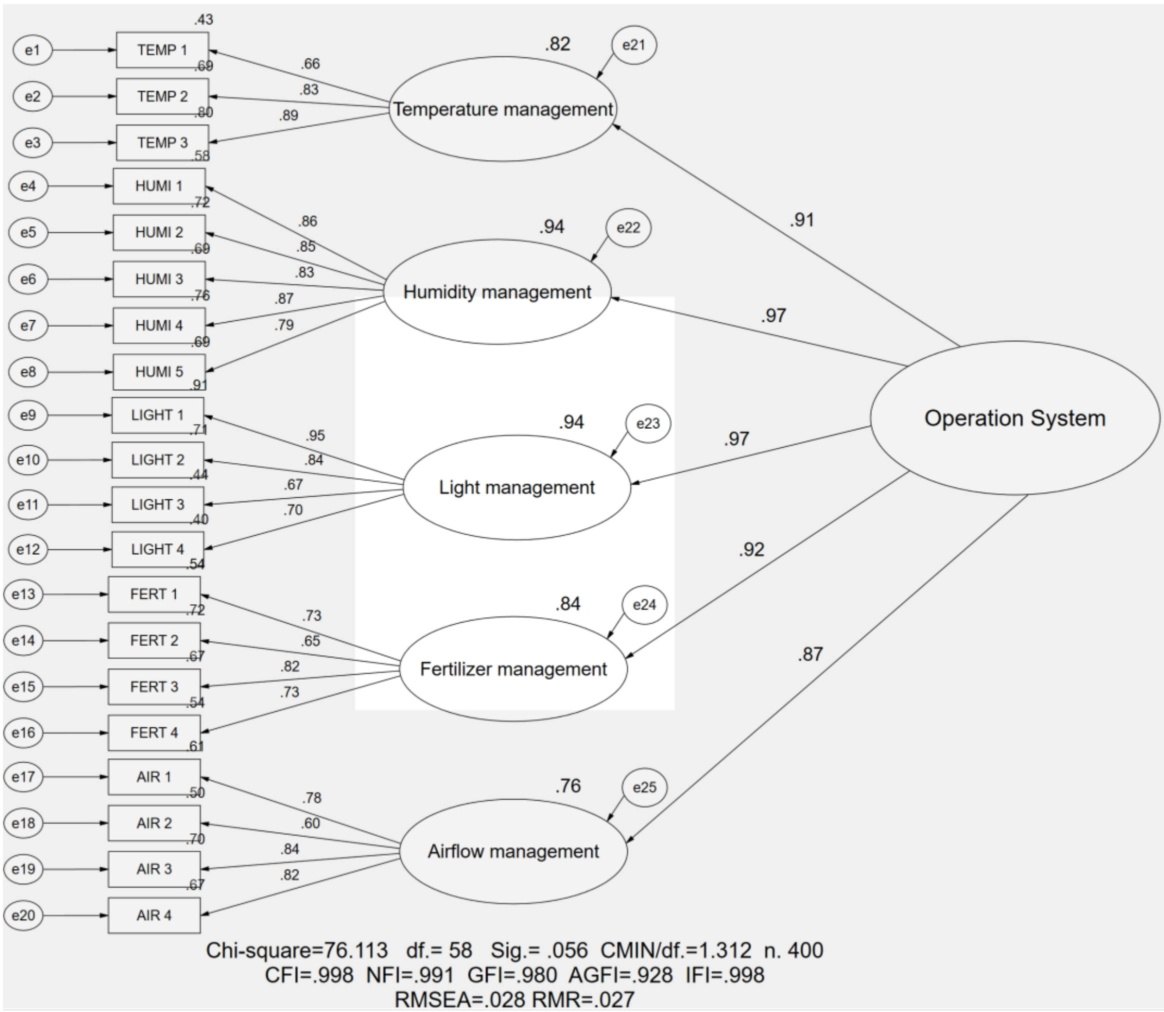

Figure 4 Multi-factors confirmatory component analysis: Operation Systems Factor

Table 6. Latent variables of confirmatory component analysis: Operation Systems Factor

Operation Systems Factor	λ	SE.	t-value	R^2	AVE	CR.
Temperature management	0.91			82.00%	0.534	0.685
Humidity management	0.97	0.063	17.625**	94.00%	0.581	0.821
Light management	0.97	0.05	15.703**	94.00%	0.518	0.721
Fertilizer management	0.92	0.059	14.621**	84.00%	0.587	0.713
Air flow management	0.87	0.059	15.681**	76.00%	0.592	0.718

2. Quality System Factors

The results of the analysis of variables in the Quality System Factors model of factors affecting the development of smart farming system for farmers in digital era with mobile applications. Therefore, the coherence of the model was examined using confirmatory component analysis. The Multi Factor CFA Model was analyzed and found that it is good fit with empirical data with Chi – Square = 51.212 df = 45, Sig. = 0.243 > 0.05 and CMIN/df. = 1.138 < 3.0 and CFI was 0.999 > 0.90, GFI was 0.984 > 0.90. , AGFI was 0.953 > 0.80, RMSEA was 0.019 < 0.05, RMR was 0.010 < 0.05, NFI was 0.994 > 0.90 and IFI was 0.999 > 0.90. This passed the specified criteria. In other words, the model is consistent with the empirical data shown in Figure 5 and the analytical results in Table 7.

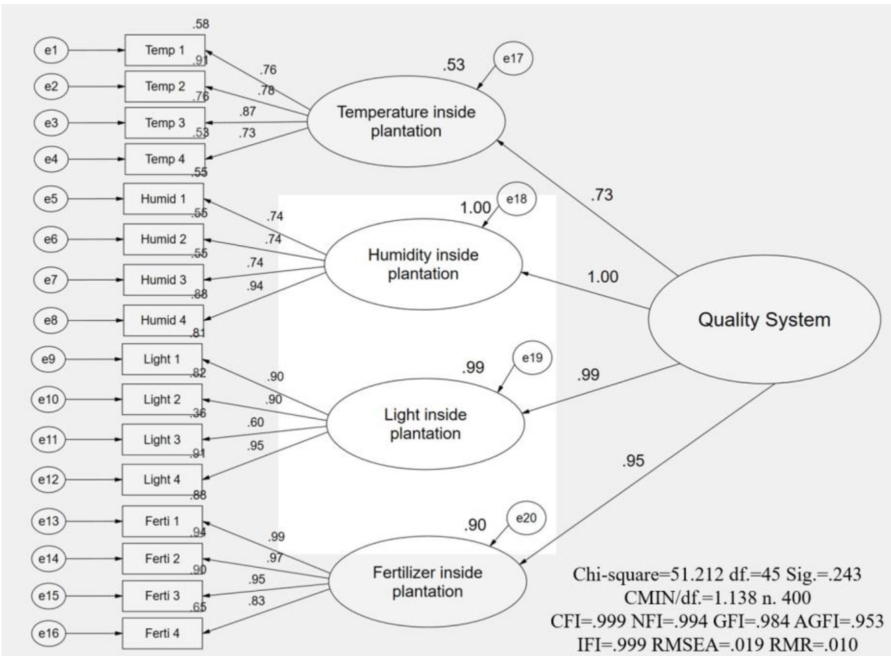

Figure 5 Multi-factors confirmatory component analysis: Quality System Factors

Table 7. Multi-factors confirmatory component analysis: Quality Systems Factors

Quality System Factors	λ	SE.	t-value	R^2	AVE	CR.
Temp inside plantation	0.73			53.00%	0.617	0.865
Humidity inside plantation	1.00	0.17	12.913**	100.00%	0.633	0.872
Light inside plantation	0.99	0.17	12.954**	99.00%	0.724	0.911
Fertilizer inside plantation	0.95	0.14	13.013**	90.00%	0.873	0.965

3. Performance System Factors

The results of the analysis of variables in the performance system factors model on the use of the factors affecting the development of smart farming systems for farmers in the digital era with mobile applications. Therefore, the coherence of the model was examined using confirmatory component analysis. The Multi Factor CFA Model was analyzed. There was good fit with the empirical data with Chi – Square = 132.071 df = 112 Sig. = 0.95 > 0.05 and CMIN/df. = 1.179 < 3.0 and CFI was 0.998 > 0.90, GFI was 0.972 > 0.90. , AGFI equals 0.931 > 0.80, RMSEA equals 0.021 < 0.05, RMR equals 0.017 < 0.05, NFI equals 0.987 > 0.90 IFI equals 0.998 > 0.90 which these indices pass the specified criteria. In other words, the model is consistent with the empirical data shown in Figure 6 and the analysis results in Table 8.

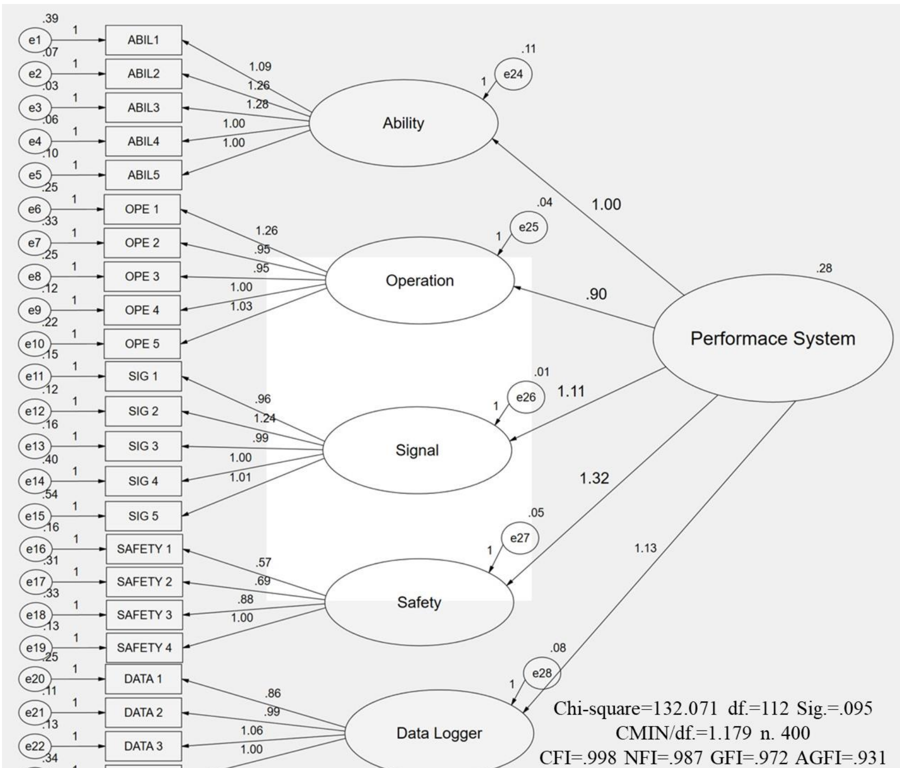

Figure 6. Multi-factors confirmatory component analysis: Performance Systems Factors

Table 8. Multi-factors confirmatory component analysis: Performance Systems Factors

Performance Systems Factors	λ	SE.	t-value	R^2	AVE	CR.
Ability	0.85			72.00%	0.837	0.953
Operation	0.92	0.06	14.884	84.00%	0.545	0.856
Signal interface	0.99	0.07	15.133	98.00%	0.615	0.887
Safety	0.95	0.07	18.409	91.00%	0.606	0.881
Data logger	0.90	0.07	17.324	81.00%	0.736	0.918

4. Satisfaction with factors affecting the development of smart farming systems for farmers in the digital era with mobile applications.

Analysis of dependent variables in the factor model affecting the development of smart farming system for farmers in digital era with mobile application. Satisfaction of using smart farming system services and was used to check the coherence of the model using confirmatory factor analysis. By analyzing the Multi Factor CFA Model, the results of the analysis were found to be in good fit with the empirical data, with Chi - Square = 514.553 df = 323 Sig. = 0.055 > 0.50 and CMIN/df. = 1.593 < 3.0 and CFI 0.987 > 0.90, GFI 0.932 > 0.90, AGFI 0.875 > 0.80, RMSEA 0.039 < 0.05, RMR 0.048 < 0.05, NFI 0.965 > 0.90 and IFI 0.987 > 0.90 Index These passed the criteria set for both it can be said that the smart farming system service satisfaction model for farmers in digital era with mobile applications. is consistent with empirical data The analytical results are shown in Table 9.

Table 9. Multi-factors confirmatory component analysis on the use of smart farming system services for farmers in the digital era with mobile applications.

Satisfaction in using smart farming system for farmers in digital era with mobile application	λ	SE.	t-value	R^2	AVE	CR.
Tangible	0.98	0.74	4.215**	96.00%	0.760	0.957
Reliability	0.39			15.00%	0.678	0.988
Responsiveness	0.43	0.17	6.496**	19.00%	0.757	0.956
Assurance	0.22	0.14	4.435**	5.00%	0.532	0.896

Research Findings

The researcher analyzed the Structural Equation Model: SEM of the factors affecting the development of smart farming systems for farmers in the digital era using mobile applications to check the suitability and accuracy of SEM and adjust the model to be complete to make the statistical values acceptable by connecting variables Modification Indices and checking the suitability and accuracy of SEM by considering variable weights and R^2 values to check the covariance of the indicators. The results are summarized in Figure 7. The multi-factors confirmatory factor model for the satisfaction of using smart farming system services for farmers in digital era with mobile applications found that SEM that affects the development of smart farming systems for farmers in the digital era with mobile applications were in good fit with empirical data corresponds to the concept of Hair et al. (2006), Bollen (1989) and Jöreskog and Sörbom (1996), indicating that the model is consistent with the empirical data with Chi - Square = 59.966 df = 45 Sig. = 0.067 > 0.05 and CMIN/df. = 1.333 < 3.0. The analysis results from the model adjustment were found to be consistent and these statistics passed the criteria set out in Table 10.

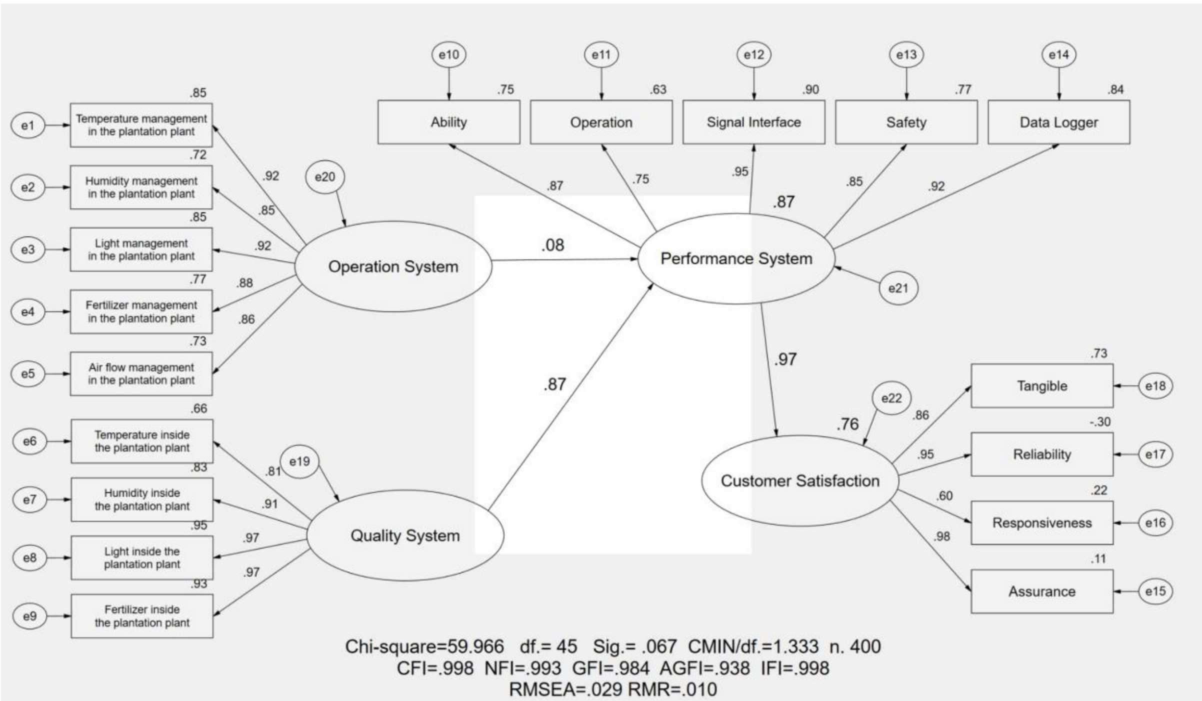

Figure 7. Multi-factors confirmatory component analysis on the use of smart farming system services for farmers in the digital era with mobile applications.

Table 10. Statistical evaluation of the harmony of structural equations modeling factors affecting the development of smart farming system for farmers in digital era with mobile application after adjustment

Index	Criteria	Result	Evaluation	References
Chi -Square	p. > 0.03	59.966	PASSED	Hair et al. (2006); Bollen (1989); Jöreskog and Sörbom (1996)
CMIN/df.	< 5.0	1.333	PASSED	Bollen (1989); Diamantopoulos & Siguaw (2000)
GFI	≥ 0.90	0.984	PASSED	Hair et al. (2006); Browne and Cudeck (1993)
AGFI	≥ 0.90	0.938	PASSED	Durande-Moreau an Usunier (1999); Harrison- walker (2001)
NFI	≥ 0.90	0.993	PASSED	Hair et al. (2006), Mueller (1996)
IFI	≥ 0.90	0.998	PASSED	Hair et al. (2006), Mueller (1996)
CFI	≥ 0.90	0.998	PASSED	Hair et al. (2006), Mueller (1996)
RMR	< 0.05	0.029	PASSED	Diamantopoulos & Siguaw (2000)
RMSEA	< 0.05	0.010	PASSED	Hair et al. (2006); Browne and Cudeck (1993)

Conclusion and Discussion

Analysis of smart farming system development study for farmers in digital era with mobile application were quantitative research methods conducting surveys and gathering information obtained from Questionnaire. The sample group was 400 agricultural entrepreneurs in in Bangkok, Phra Nakhon Si Ayutthaya Province, Pathum Thani Province and Nonthaburi Province with instrument reliability testing according to the concept of the Cronbach Alpha Formula, 40 samples tested the reliability of the tool with a high level of reliability with a test value of 0.976 from the causal relationship test, congruence with empirical data. It was pointed out that the Structural Equation Model of factors affecting service satisfaction is consistent with the empirical data conditionally at the statistical acceptance level. It can be summarized in Table 11: results of the Structural Equation Model and the causal factor model affecting the development of smart farming system for farmers in digital era with mobile applications are as follows:

Table 11. The results of the Structural Equation Model analysis are causal factors affecting the development of smart farming system for farmers in the digital era with mobile applications

Variables (Relationship)			λ	SE.	t-value	Sig.	R^2
Performance Systems Factors	<--	Quality Systems Factors	0.87	0.03	26.886	0.000**	87.00%
Performance Systems Factors	<--	Operation Systems Factors	0.08	0.02	3.232	0.001*	87.00%
Satisfaction in using systems	<--	Performance Systems Factors	0.97	0.06	12.049	0.000**	76.00%

** Significant level 0.001 * Significant level 0.05

The analytical results demonstrated the causal relationship between the parameters that impact satisfaction in the service delivery of frozen and processed seafood. The regression coefficient of the independent variable determines the standard score, which serves as the decision coefficient indicating the variable's influence. The test results are reported as statistically significant at a significant level of 0.001 and 0.05.

1. Comparative Fit Index: CFI, which the analytical result is 0.998 > 0.90. The index result is according to the concept of Hair et al. (2006), where a good CFI should be 0.90 or higher, indicating that the model has relative consistency.

2. Goodness of Fit Index: GFI represents the amount of variance and covariance that can be explained by the model. The result of the analysis is 0.984 > 0.90. The result of the index is according to the concept of Hair et al. (2006) and Mueller (1996), where a good GFI should be 0.90 or more, indicating that the model has relative consistency.

3. Adjusted Goodness of Fit Index: AGFI represents the amount of variance and covariance explained by the adjusted model with degrees of freedom. The AGFI is generally between 0 and 1, where the acceptable AGFI should be greater. 0.90, which the analysis result is 0.938 > 0.90. The index result is in accordance with the concept of Durande-Moreau an Usunier (1999), where a good AGFI should be 0.90 or higher, indicating that the model has relative consistency.

4. Root Mean Square Error of Approximation: RMSEA is a statistical value used to test the hypothesis. A very good RMSEA value should be less than 0.05 or between 0.05 and 0.08, meaning the model is quite consistent with the empirical data. The analysis result is

0.010 < 0.08, which is a very good RMSEA value. The index result is conceptual, meeting the criteria of Hair et al. (2006), Browne and Cudeck (1993), indicating that the model is consistent. relative

5. Normed fit index; NFI is a statistical value used to test the hypothesis. The acceptable NFI should be greater than 0.90, which the analysis result is 0.993 > 0.90. The index value is in line with the concept of Hair et al. (2006). indicates that the model has relative consistency.

6. Incremental fit index; IFI is an index value that compares the test pattern with the base model where every variable is not correlated with a value greater than 0.90, which indicates that the theoretical model can be used to explain the correlation of the variables well. Acceptable IFIs should be greater than 0.90, where the analytical results were 0.998 > 0.90. The index effect was in accordance with the concept of Hair et al. (2006), showing that the model was relatively consistent.

7. Root Mean Square Residual: RMR is a statistical value used to test the hypothesis. The RMR value should be less than 0.05, which is a good value should be equal to 0 or closest to 0. The analysis results have an RMR value of 0.029 < 0.05. which is a very good RMR value. The effect of the index is conceptually consistent with the criterion Diamantopoulos and Siguaw (2000) shows that the model has relative consistency.

Table 12. Structural Causal Impact Summary Modeling Activity Factors, Development of smart farming system for farmers in the digital era with mobile applications

Variable Data	Influence.	Performance	Customer Satisfaction
Operation System Factor	Direct Impact	0.08	-
	Indirect Impact	-	0.08
	Overall Impact	0.08	0.08
Quality System Factor	Direct Impact	0.87	-
	Indirect Impact	-	0.84
	Overall Impact	0.87	0.84
Performance System Factor	Direct Impact	-	0.97
	Indirect Impact	-	-
	Overall Impact	-	0.97
R^2		87.00%	76.00%

Modeled structural causal analysis of factors Affecting Smart Farming System Development in the Digital Era: A Mobile Application Approach that performance system factors had the highest influence with a backwardness factor of 0.97, quality control system factors and status factors with a Backwardness coefficient of 0.84, and operation management system factors with an back wardity factor of 0.08, and the research found that quality and status control factors had a direct positive influence on performance factors with the backward value of 0.77, supported by the management system factor with a downwardness rate of 0.08.

Recommendation

From research findings on factors affecting the development of smart farming systems for farmers in the digital era with mobile applications presented as a recommendation for this research and the suggestions for the next research are as follows.

1. According to research results, entrepreneurs are satisfied with smart farming system services for digital agriculture. Responsiveness has the lowest value. Therefore, farmers should pay attention to promoting convenience and speed in contacting the service of the system as well as attaching importance to safety inspections when importing emergency systems and there should be contingency plans for emergency situations that may occur during the use of smart farm systems.

2. According to research results on the efficiency of smart farm systems for digital agriculture. The signal interface has the greatest influence on the satisfaction. Therefore, the company should focus on setting the signal range of the application and have a systematic workflow. There is an operational process to increase the efficiency of communication between the device and the smartphone operating system in order to be competitive and to increase the efficiency of the management of smart farming system services for digital agriculture to be more effective.

Recommendation for future research

1. The future research should examine the elements that influence the advancement of a smart farming system for farmers in the digital age, utilizing mobile applications. This should be done by categorizing farmers based on their characteristics and the sort of business they engage in. The goal is to enhance operational management for optimal efficiency and effectiveness.

2. The future research should investigate the factors that influence the advancement of a smart farming system for farmers in the digital era, utilizing mobile applications. This can be achieved by incorporating additional variables and theories, such as service quality factors and trust in the utilization of the service. These factors should serve as a framework for the development of a research model, aiming to maximize the benefits derived from the study.

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