# A Rice Cultivation Management System: An Innovation for Supporting Rice Field Management and Rice Cultivation Process Monitoring

**Patravadee Vongsumedh**
Bangkok University, Pathumthani, Thailand
E-mail: patravadee.v@bu.ac.th

********

## Abstract

Although rice is the major agricultural crop of Thailand, it has been found that information and knowledge about Thai rice varieties, cultivation methods, and cultivation precautions were disseminated through scattered sources. Additionally, depending on the rice varieties and land properties, the rice cultivation process is complex. The inappropriate fieldwork may reduce both rice yield and quality. The objectives of this research and development were 1) to develop a rice cultivation management system, a web-based application used for providing useful rice information, and supporting rice field management and rice cultivation process monitoring, and 2) to evaluate the opinions and satisfaction of the target users toward the system prototype. The target users of the proposed system are Thai native farmers or Thai people who are interested in rice cultivation and starting to cultivate. The tools used for developing a system prototype are JSP, MySQL, and Bootstrap framework. The proposed system prototype consists of 8 main functions, which are 1) User Account Management 2) Rice Varieties Management 3) Rice Varieties Searching 4) Member Registration 5) Rice Field Registration 6) Rice Field Management 7) Rice Price Checking, and 8) Rice News and Declarations. During the system design and implementation phase, the contents and operation flows of the system prototype were validated and evaluated by experienced farmers, and rice researchers from Thailand Rice Science Institute (TRSI), Rice Department, Ministry of Agriculture and Cooperatives (MOAC). Moreover, at the final stage of system implementation, 10 farmers from Pathumthani province were invited to test and evaluate the system prototype through a focus group interview. The interview results indicated that the system prototype provided useful information on rice varieties and initial knowledge of Thai rice cultivation. Additionally, it facilitated the rice field monitoring and managing data related to the rice cultivation process.

**Keywords:** Rice Cultivation; Rice Cultivation Management System; Rice Information System; Rice Field Management

## Introduction

Rice is a major food source that has been with the Thai way of life for a long time. Throughout the past several years, Thailand has had one of the top three rice export rates in the world. This indicates the importance and acceptance of Thai rice for both domestic consumption and the world's rice market. In 2023, Thailand produced up to 30 million tons of rice and exported up to 8.76 million tons (Thai Rice Exporters Association, 2023). Although rice is the major agricultural crop of Thailand, it was found that information and knowledge about Thai rice varieties, cultivation methods, and precautions during cultivation were disseminated through scattered sources. The main method of disseminating information or

* Received: July 14 2024; Revised: July 30 2024; Accepted: August 1 2024

knowledge about rice cultivation among Thai farmers (and mostly for farmers in developing countries) is teaching from generation to generation (Tran & Nguyen, 2006). Consequently, new farmers who want to learn about Thai rice varieties or rice cultivation encountered difficulties in gathering and accessing information on rice cultivation. Based on the previous studies, various information systems and computing-related technologies were used for supporting and monitoring rice fields and rice cultivation process efficiently (Geo-Informatics and Space Technology Development Agency, 2016; Liu, Ismail, Wang, & Lin, 2021; Prasartkaew, Jongsawat, Prasartkaew, & Kanchanasatian, 2020; Tran & Nguyen, 2006). With the support of these technologies, rice productivity and quality were increased. Moreover, the management and fertilization of the rice fields were performed effectively and efficiently. However, these systems and related equipment come with a high price. Most of the farmers in developing countries cannot afford the systems and equipment setup (Natikar, Balikai, & Anusha, 2016; Porong et al., 2023; Singh & Varshney, 2010; Tran & Nguyen, 2006). For these reasons, to link the gap between traditional fieldwork and modern technology, a framework for developing a web-based application that supports the process of rice cultivation and provides useful information about Thai rice varieties and cultivation was proposed. In the pre-planting phase, farmers can search for information on interested rice varieties, initial knowledge of rice cultivation, and precautions against cultivation failure. After rice planting in the growth phase, the proposed system prototype enables farmers to record the rice field data and the rice cultivation data. Based on the recorded rice field data, a crop calendar is generated and used as operation guidance for monitoring the rice cultivation process in the growth phase. Moreover, in the post-production phase, the system prototype facilitates farmers to access rice-pricing data, rice news or declarations, and cultivation knowledge provided by other registered farmers.

## Research Objectives

The objectives of this research and development are as follows:

1) To develop a rice cultivation management system, a web-based application used for providing useful rice information (e.g. rice varieties, initial knowledge of rice cultivation, news and declarations, and rice pricing), and, additionally, for supporting rice field management and rice cultivation process monitoring.

2) To evaluate the opinions and satisfaction of target users toward the system prototype.

## Research Conceptual Framework

Based on the concept of Systems Development Life Cycle (SDLC), which divides the software development process into phases (Dennis, Wixom, & Roth, 2021; Tilley & Rosenblatt, 2017), and the support of information systems in the rice production cycle (Division of Rice Research and Development, n.d.; International Rice Research Institute, n.d.), the conceptual framework of this research and development was illustrated in Figure 1.

To support rice field management and rice cultivation process monitoring, the proposed system provides functions to facilitate operations in the pre-production phase, the growth phase, and the post-production phase of the rice production cycle. In the pre-production phase, information on rice varieties and the rice cultivation process is provided to farmers. During the growth phase, based on the selected rice variety and the recorded properties of the rice field, a crop calendar is generated and used for monitoring the rice field. System notifications are

generated and sent automatically to the field's owner to handle the situation timely. In the final stage of the rice production cycle, the post-production phase, rice pricing data is provided to farmers. Moreover, rice cultivation knowledge recorded by registered members can be shared with others.

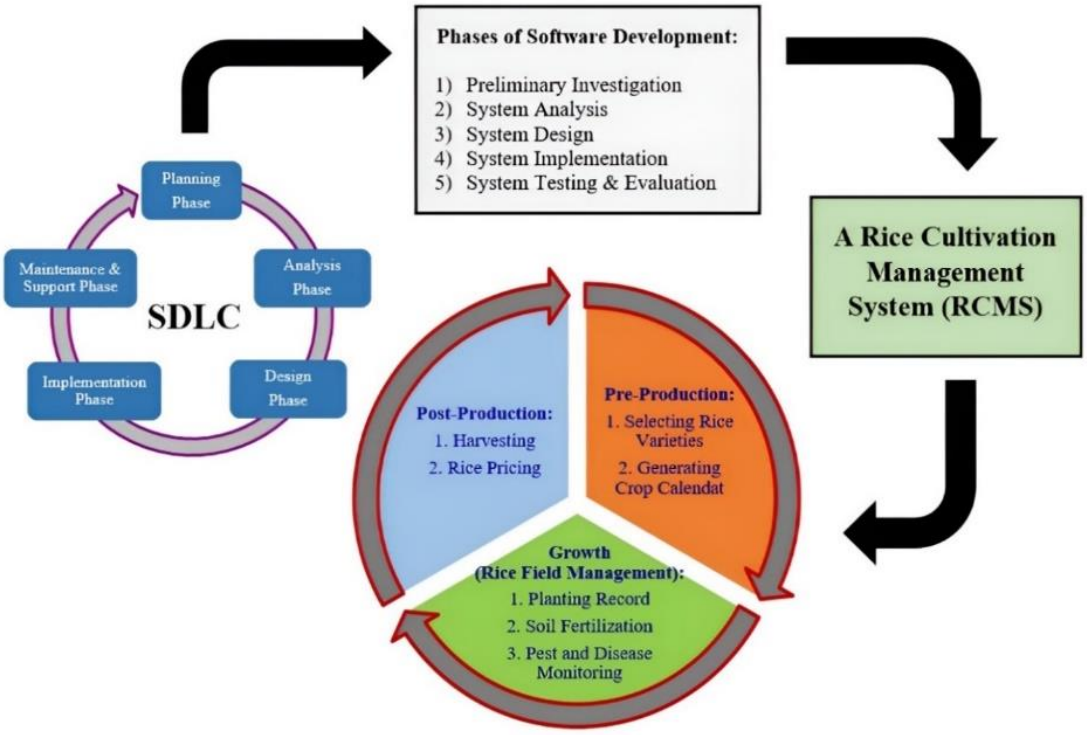


**Figure 1** Research Conceptual Framework

## Research Methodology

### 1. Research Population and Sampling

1) Population:

The research populations consist of Thai native farmers or Thai individuals interested in rice cultivation and those who are beginning to cultivate.

2) Sampling:

Based on the purposive sampling technique, in the preliminary investigation phase and the system design phase, 5 experienced Thai farmers from Pathumthani province and 3 rice researchers, as the domain experts, from the Thai Rice Science Institute (TRSI) were invited to join the focus group interview. Additionally, in the system testing and evaluation phase, 10 Thai farmers, who are the target users of the system, were purposively sampled to test and evaluate the system prototype.

### 2. Research Instruments:

1) Fact-Finding and System Evaluation Tools:

- In the preliminary investigation phase, the *"interview questions"* were used during a focus group interview to gather information on rice cultivation and users' requirements related to rice cultivation management from the target users and domain experts. Additionally,

the documents and websites that provide information on rice varieties, rice cultivation, and rice pricing were reviewed. The *"content analysis"* was used for identifying and collecting information on rice varieties, cultivation processes, and paddy/unmilled rice pricing in the rice market.

- In the system testing and evaluation phase, another set of *"interview questions"* was used to evaluate the system prototype. Following system testing, the target users were requested to evaluate the system prototype through a focus group interview.

All interview questions were validated by 3 domain experts in the area of software development and rice cultivation. The indices of Item-Objective Congruence (IOC) of all questions are rated from 0.67 to 1.00. These indicate that all questions clearly measured the identified objectives.

2) Software Developing Tools:

In the system implementation phase, the tools used for developing a system prototype are JSP, MySQL, and Bootstrap framework.

**3. Phases of Software Development:**

Based on the research conceptual framework represented in Figure 1, the software development process of the proposed system prototype was divided into 5 phases as follows:

*Phase 1: Preliminary Investigation*

The documents, books, and website which provide knowledge of rice varieties and cultivation were examined carefully. 5 experienced Thai farmers from Pathumthani province, one of the rice cultivation centres of Thailand, and 3 rice researchers from the TRSI were invited to join a focus group interview to summarize and verify the gathered rice varieties' information, cultivation knowledge, cultivation processes, and users' requirements related to rice cultivation management. These data were used as the primary contents of the system prototype.

*Phase 2: System Analysis*

Based on the information and knowledge gathered from phase 1, the capabilities of RCMS were scoped and detailed. As listed in Table 1, the proposed system prototype consists of 8 use cases. Then, the use case diagram, as shown in Figure 2, was created to represent system use cases and related actors.

**Table 1** System's Use Cases

| No. | Use Cases | Description | System's Target Users | | |
|---|---|---|---|---|---|
| | | | System Admin | Member (Registered Farmer) | General User |
| 1 | User Account Management | To manage (i.e., modify/edit, delete) the user accounts by system admin. The registered members, moreover, can modify/edit their accounts' details through this use case. | ✓ | ✓ | - |
| 2 | Rice Varieties Management | To manage (i.e., create, edit, and delete) details of Thai rice varieties published on the website. | ✓ | - | - |
| 3 | Rice Varieties Searching | To search for information on rice varieties by using the rice varieties' name or soil type as a search key. | ✓ | ✓ | ✓ |
| 4 | Member Registration | To register as a system member. A user account will be generated for the registered member. | - | ✓ | ✓ |

| No. | Use Cases | Description | System's Target Users | | |
|---|---|---|---|---|---|
| | | | System Admin | Member (Registered Farmer) | General User |
| 5 | Rice Field Registration | To register the rice field in a specific user account's name. The details of the rice field, such as field's size, start planting date, selected rice varieties, soil type, and location were recorded before planting. | - | ✓ | - |
| 6 | Rice Field Management | To manage (i.e., create, edit, and delete) the details of the registered rice field. After planting, RCMS checks the registered information of the rice field (i.e., start planting date and selected rice variety) to generate the crop calendar which is used for triggering farmers to fertilize and harvest. After fertilizing and harvesting, the fertilized date, harvested date, and amount of productivity were recorded by farmers. | - | ✓ | - |
| 7 | Rice Price Checking | To check the market price of paddy (or unmilled rice). | ✓ | ✓ | ✓ |
| 8 | Rice News & Declarations | To check news, declarations, or rice cultivation knowledge shared by the other registered farmers. | ✓ | ✓ | ✓ |

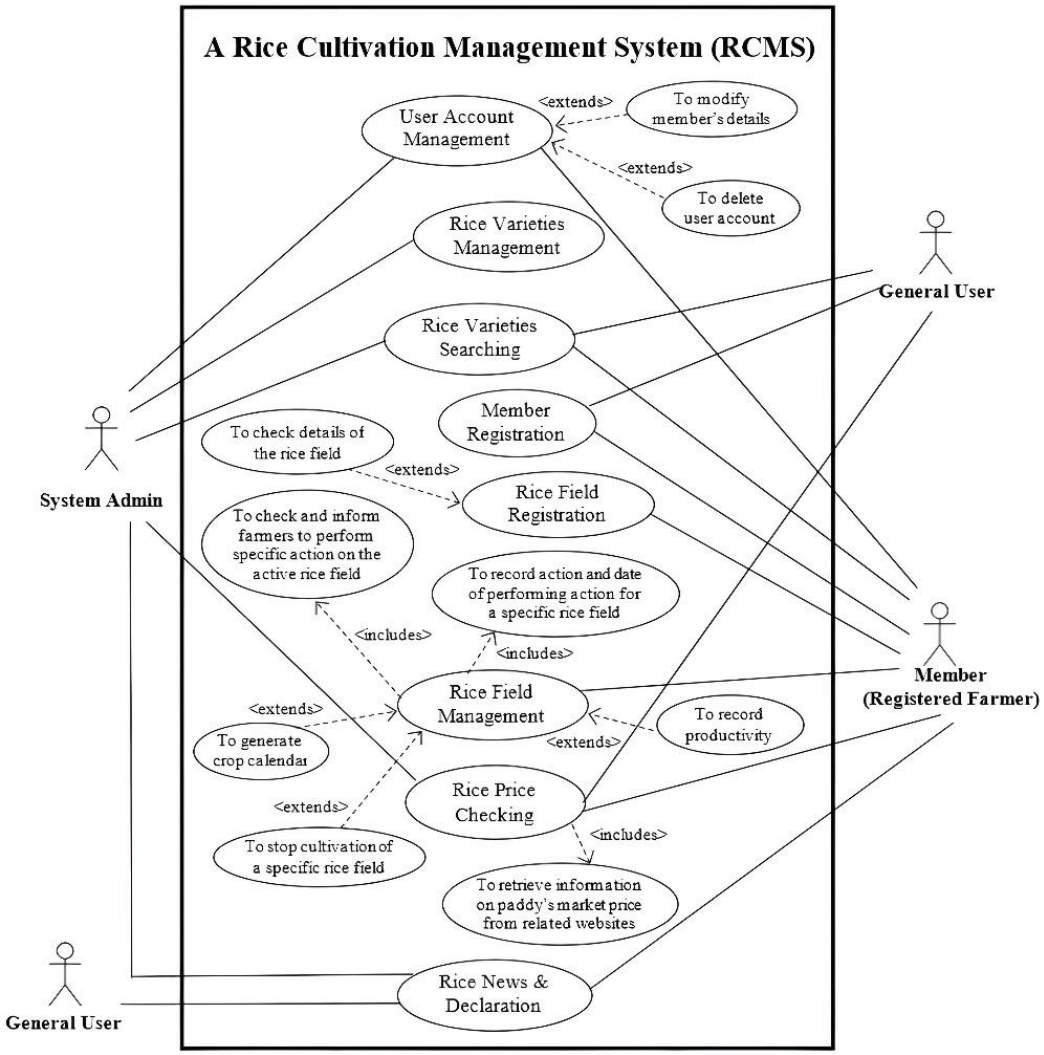


**Figure 2** A Use Case Diagram of RCMS

*Phase 3: System Design*

In the system design phase, system process design, database design, and Graphical User Interface (GUI) design were performed. The activity diagrams, Entity-Relationship Diagram (ERD), and mock-up screens of all use cases were created. Then, 3 rice researchers from the TRSI, and 5 experienced farmers from Pathumthani province were invited again to validate and evaluate the consistency of the system's workflow and the rice cultivation process through the represented mock-up screens. The mock-up screens were adjusted based on the stakeholders' comments. This process was performed repeatedly until the designed mock-up screens were accepted.

*Phase 4: System Implementation*

The design blueprints of all system components created from the system design phase were used as the guidelines in the implementation phase. JSP, MySQL, and Bootstrap framework are the main tools for coding. Some of the screenshots which represent system functions are shown in Figure 3 – 6.

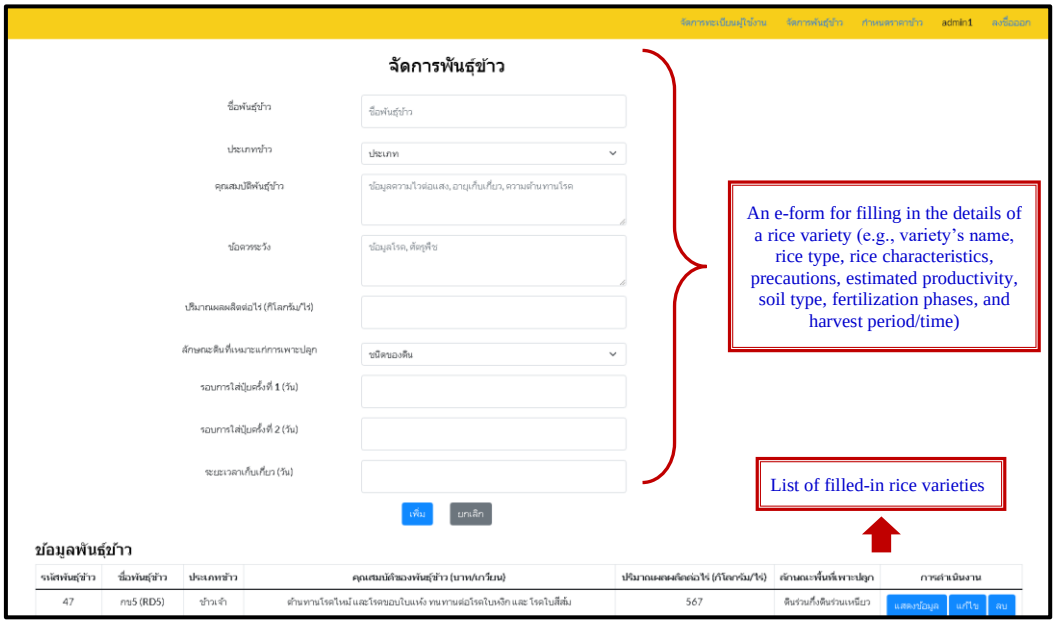


**Figure 3** Rice Varieties Management

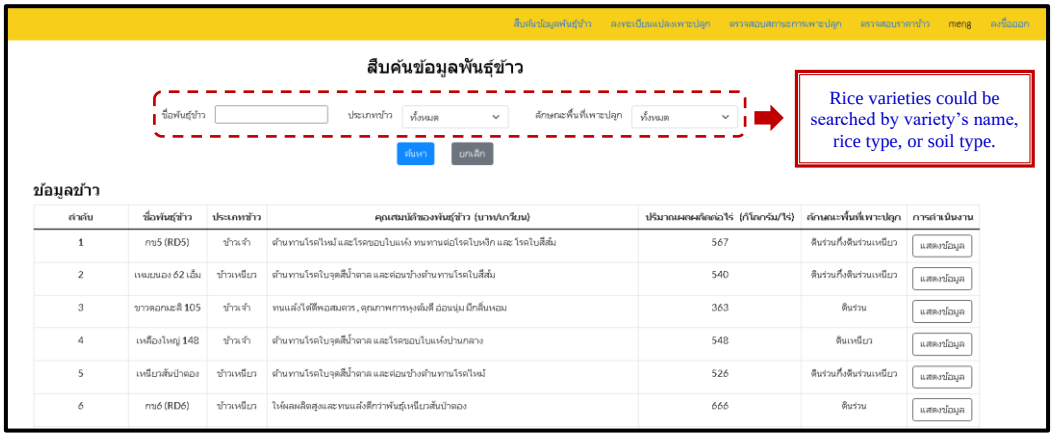


**Figure 4** Rice Varieties Searching

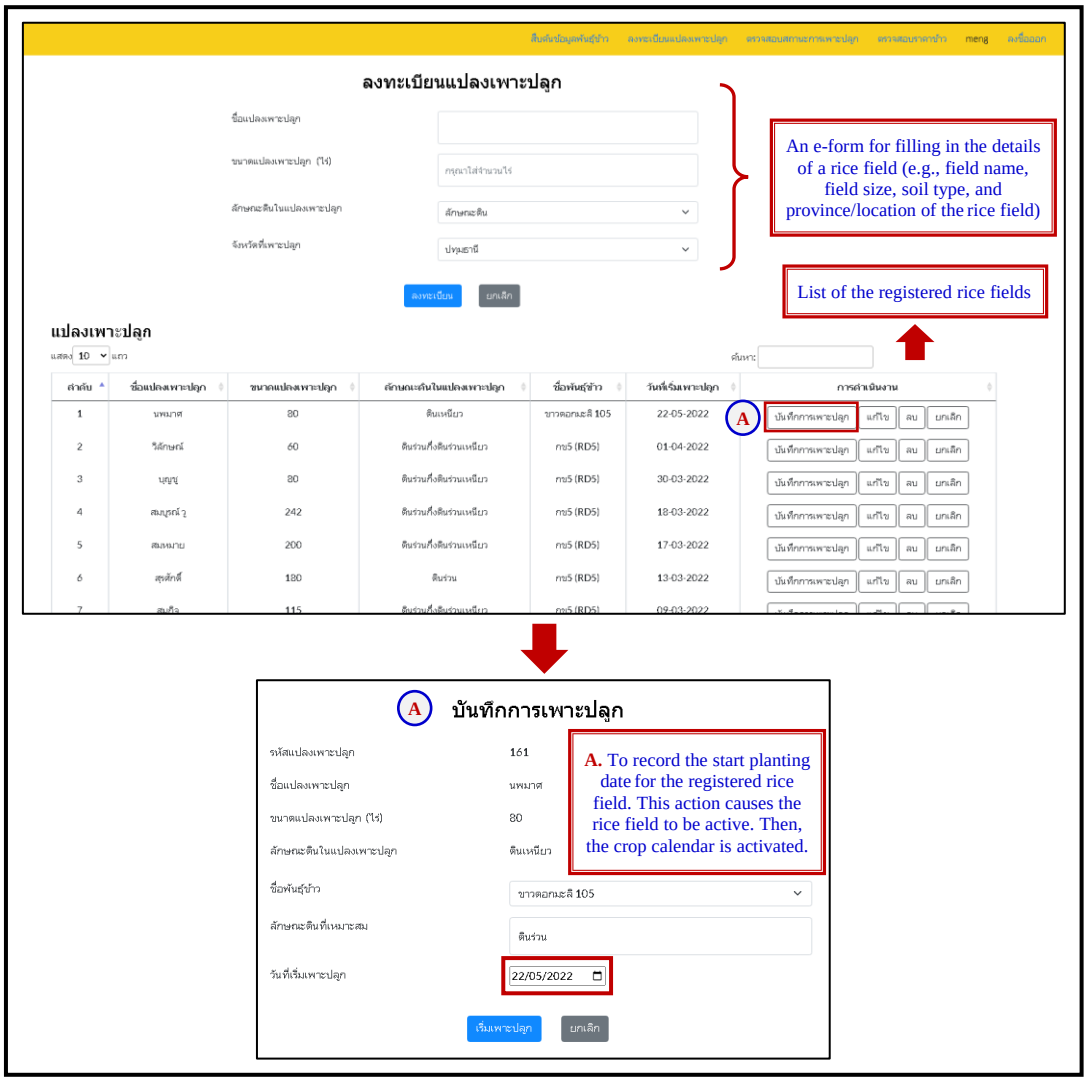


**Figure 5** Rice Field Registration

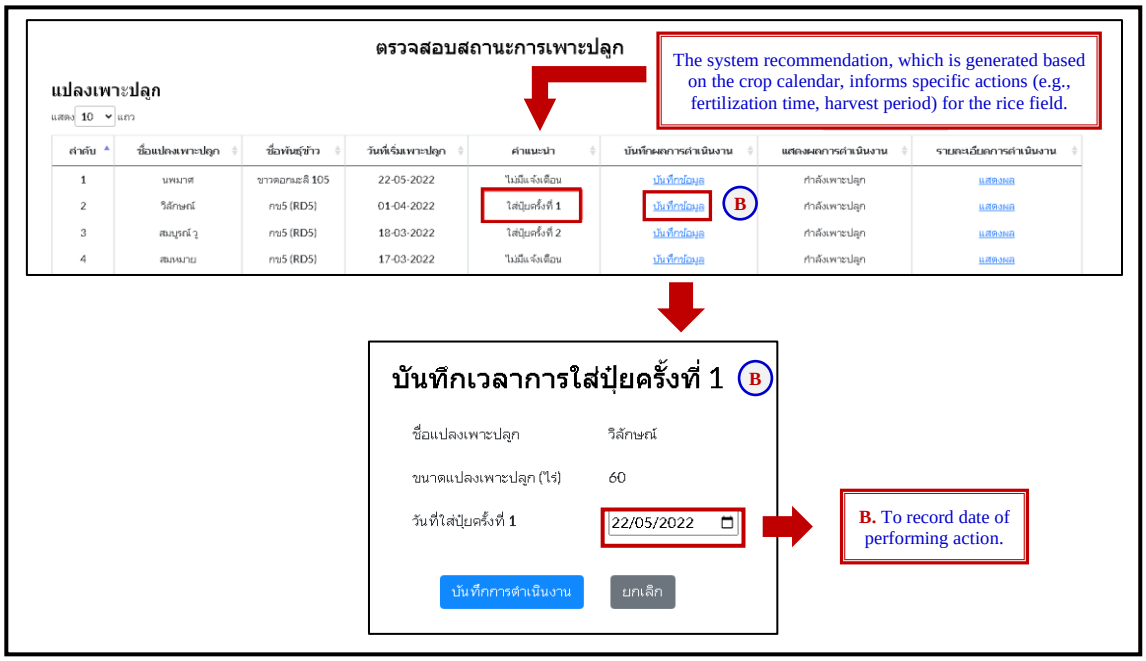


**Figure 6** Rice Field Management

*Phase 5: System Testing and Evaluation*

When the system implementation finished, 10 farmers from Pathumthani province were invited to test and evaluate the system prototype through a focus group interview. The validated interview questions were used as a research tool to determine users' opinions and satisfaction with the system prototype.

## Research Results

*1) System Development*

Based on the research methodology, the developed system prototype; a Rice Cultivation Management System (RCMS), consists of 8 main functions, which are 1) User Account Management 2) Rice Varieties Management 3) Rice Varieties Searching 4) Member Registration 5) Rice Field Registration 6) Rice Field Management 7) Rice Price Checking, and 8) Rice News and Declarations. The system prototype mainly serves Thai farmers in managing rice fields and rice cultivation process. After registering the rice field and identifying the start planting date, the status of the registered rice field is active and, then, the crop calendar of the active rice field is generated. This calendar triggers the system to send messages or useful information automatically to farmers at the right time in performing specific actions/activities on the active rice field (e.g., planting method, water management, soil fertilization, pests and diseases management, and harvesting). After harvesting, the productivity of the harvested rice fields is recorded by the farmers. These recorded data can be used not only for representing the effectiveness of the rice cultivation process on a specific rice field, but also for estimating the average productivity of each rice variety in a specific area. The rice field that gained the above-average productivity could be determined as a good practice. The rice cultivation knowledge and activities from the effective rice field can be shared with the other farmers in the community. The rice knowledge sharing primarily occurred.

*2) System Evaluation*

Following the system testing, 10 target users were invited to evaluate the system prototype through a focus group interview. The interview results indicated that the system prototype provided useful information on rice varieties and rice cultivation process along the rice production cycle (i.e., pre-production phase, growth phase, and post-production phase). The information on rice varieties and initial knowledge of rice cultivation which was previously scattered on several sources is now gathered and, then, shown on the proposed system prototype. The new farmers can access this useful information easily. The rice cultivation precautions and cultivation notifications provided by the system enable new farmers to avoid cultivation failure. Both experienced and new farmers expressed that the system facilitated efficient rice-field monitoring and rice cultivation management. Moreover, the system can be used as a primary source of rice knowledge sharing among farmers across various areas.

## Discussion

Based on the research methodology, a web-based system prototype used for supporting rice field management and rice cultivation process monitoring was developed. The system consists of 8 main functions, which are 1) User Account Management 2) Rice Varieties Management 3) Rice Varieties Searching 4) Member Registration 5) Rice Field Registration 6) Rice Field Management 7) Rice Price Checking, and 8) Rice News and Declarations. With the support of the proposed system, the farmers can effectively and timely manage their rice fields. The useful information on rice varieties, rice cultivation process, rice pricing, and news related to pest situations and climate change enables farmers to make effective decisions and take appropriate actions in their rice fields promptly. According to the previous research findings (Batte & Arnholt, 2003; Gyawali, Paudel, Jean, & Banerjee, 2023; Natikar, Balikai, & Anusha, 2016; Prasartkaew, Jongsawat, Prasartkaew, & Kanchanasatian, 2020), the combination of advanced information technology (or computer-based technology) and crop cultivation process (e.g., seed selection, land preparation, crop management, irrigation, pest control, and harvest) leads to better decision-making in agricultural management and improves efficiency. The tools and information provided help farmers increase the efficiency and effectiveness of labor, field monitoring, farming precision, and time spent in farming. The scattered information and knowledge on rice varieties and cultivation process are now integrated and represented through the proposed system. The integrated rice information and knowledge facilitate new farmers in seed selection and perform the right actions on the rice field. To avoid planting failure, the characteristics of rice varieties, precautions, and rice market price can be checked before making decision on selecting an appropriate rice variety for planting. The rice field's monitoring and system-triggered precautions, moreover, provided to the farmers led them to avoid cultivation failure. These features cause productivity to increase (Gyawali, Paudel, Jean, & Banerjee, 2023; Liu, Ismail, Wang, & Lin, 2021; Prasartkaew, Jongsawat, Prasartkaew, & Kanchanasatian, 2020).

Although, there are many technologies currently developed to support rice cultivation processes, such as irrigation control systems in rice fields (Liu, Ismail, Wang, & Lin, 2021; Malysheva, Khadzhidi, Kuznetsov, Sharaby, & Koltsov, 2020), remote sensing for soil and crop health analyzing systems, or remote sensing for pest detecting and management systems (Natikar, Balikai, & Anusha, 2016), one of the big obstacles for applying advanced technologies (or precision farming technology) for supporting rice cultivation in developing countries is finance. Most farmers in developing countries cannot afford advanced and

expensive technology for the rice fields due to financial issues (Natikar, Balikai, & Anusha, 2016; Porong et al., 2023; Singh & Varshney, 2010; Tran & Nguyen, 2006). Therefore, efforts to use technology to support rice cultivation processes, which can assist farmers in managing, monitoring rice fields, and supervising the cultivation process efficiently and effectively, must adapt technology to fit the financial circumstances of farmers. The technology should not incur high expenses that ultimately become costs to be borne in rice cultivation. These issues are crucial considerations for researchers and stakeholders involved. Moreover, the rice cultivation process is complicated. Inappropriate fieldwork may lead to low productivity and quality. Cultivation experience is very important. Therefore, to bridge the gap between conservative fieldwork and modern cultivation technology, effective and efficient sharing of rice cultivation knowledge is another issue that needs to be carefully considered.

## Research Suggestions

**Suggestions for further study and development:**

*1) To develop the AI module for supporting rice cultivation management and knowledge sharing:*

Although the details of all performed actions/activities and the rice productivity of the registered rice fields were recorded by the system, the farmer, who is not the fields' owner, is not allowed to access the rice field data directly. The registered members/farmers can only share their rice cultivation knowledge with others through the prepared knowledge-sharing web board. The rice cultivation questions or problems could be raised by novice farmers. The experienced farmers, then, give feedback on these questions or problems. So, to provide effective and efficient rice cultivation management and knowledge sharing, the AI modules used for supporting rice cultivation management and knowledge sharing could be developed. With the support of this module, in the pre-production phase, the system can recommend the appropriate rice varieties for the registered rice field. This recommendation can be made by determining the field's properties combined with rice prices in the rice market. In the growth phase, the AI modules detect news and declarations shown on the "News & Declarations" web board to find out pest and disease situations that occurred in the same area of registered rice fields. The system warning messages (or notifications) would be sent automatically to the field's owner to handle the situation timely. Moreover, in the post-production phase, the productivity of all rice varieties in each area (or each province) will be analyzed and ranked. The rice fields which provide good and above-average productivity are selected as the "good practices". And, with the permission of the rice field's owner, the actions/activities performed on the good-practice rice field could be shared automatically with the others.

*2) To re-design the user interface of RCMS:*

The responsive web design could be taken into account. The features of responsive web enable farmers to access the RCMS anywhere and anytime through various mobile devices.

**Suggestion for application use:**

Before the system launch, users need to be appropriately trained in how to use the RCMS. Understanding the role of each function in the program bridges the gap between fieldwork and modern cultivation technology effectively and efficiently. Moreover, system accessibility is another issue that requires more attention. Since finance is a major obstacle to implementing rice cultivation technology in developing countries, the proposed system (or RCMS) must be easily accessible. Without needing new devices, farmers should be able to download and use this application on both desktop computers and mobile devices.

## Reference

Batte, M. T. & Arnholt, M. W. (2003) Precision farming adoption and use in Ohio: case studies of six leading-edge adopters. *Computers and Electronics in Agriculture***.** 38 (2), 125-139.

Dennis, A., Wixom, B. H., & Roth, R. M. (2021). *Systems analysis and design*. (11th ed.). MA: Wiley.

Division of Rice Research and Development. (n.d.). Rice Knowledge Bank: Pre and Post Production. *Online.* Retrieved January 8, 2024, from https://ricecloud.ricethailand.go.th/RKB/posthavest.html.

Geo-Informatics and Space Technology Development Agency. (2016). Geographic information system for community-based rice management and GISagro. *Online.* Retrieved April 16, 2024, from https://www.gistda.or.th/news_view.php?n_id=4539&lang=TH.

Gyawali, B. R., Paudel, K. P., Jean, R, & Banerjee, S. B. (2023) Adoption of computer-based technology (CBT) in agriculture in Kentucky, USA: Opportunities and barriers. *Technology in Society.* 72 (C).

International Rice Research Institute. (n.d.). Step-by-Step Production. *Online.* Retrieved January 10, 2024, from http://www.knowledgebank.irri.org/step-by-step-production.

Liu, L., Ismail, M. H., Wang, Y., & Lin, W. (2021). Internet of Things based Smart Irrigation Control System for Paddy Field. *AGRIVITA Journal of Agricultural Science*. 43 (2), 378-389.

Malysheva, N., Khadzhidi, A., Kuznetsov, E., Sharaby, N., & Koltsov, A. (2020). Justification of elements of rice cultivation technology. *XIII International Scientific and Practical Conference "State and Prospects for the Development of Agribusiness – INTERAGROMASH 2020"*. 26-28 February 2020. Rostovon-Don, Russia, 1-7.

Natikar, P. K., Balikai, R. A., & Anusha, C. (2016). Pest management strategies in precision farming. *Journal of Experimental Zoology India.* 19 (1), 1-8.

Porong, J. V., Walingkas, S. A. F., Tulungen, A. G., Tumewu, P., Doodoh, B., Managanta, A. A., Mamalimbong, R., & Liwu, S. L. (2023). Rice cultivation technology at the farmers' level in North Bolaang Mongondow District, Indonesia. *International Journal of Multicultural and Multireligious Understanding.* 10 (12), 216-220.

Prasartkaew, C., Jongsawat, N., Prasartkaew, B., & Kanchanasatian, K. (2020). The use of the Internet of Things for a more effective and efficient way of growing rice. *2020 18th International Conference on ICT and Knowledge Engineering (ICT&KE)*. 18-20 November. Bangkok, Thailand. 1-4.

Singh, P. K. & Varshney, J. G. (2010). Adoption level and contraints in rice production technology. *Indian Research Journal* of *Extension Education*. 10 (1), 91-94.

Thai Rice Exporters Association. (2023 ). *Rice exports quantity and value: 2023* . Retrieved May 31, 2024, from http://www.thairiceexporters.or.th/statistic_2023.html.

Tilley, S., & Rosenblatt, H. J. (2017). *Systems analysis and design*. (11th ed.). Bostom: Cengage Learning.

Tran, D. V. & Nguyen, N. V. (2006). International rice commission newsletter (Vol.55): The concept and implementation of precision farming and rice integrated crop management systems for sustainable production in the twenty-first century. *Online.* Retrieved May 31, 2024, from https://openknowledge.fao.org/server/api/core/bitstreams/4e12b284-8ebd-4324-b667-38c7f5250602/content#page=97.