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Development of a Smart Agriculture Platform for Modern Management of Longan Orchards

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Abstract

Smart agriculture has emerged as a critical approach in modern agricultural systems. This study aimed to develop a smart agriculture platform for longan orchards by integrating Internet of Things (IoT) technologies and digital systems for precision farming. The study population comprised 100 large-scale agricultural producers located in the provinces of Chiang Mai and Lamphun, Thailand. The developed platform incorporated six core technologies: IoT-based smart irrigation, weather monitoring, insect trapping, cultivation recording with NFC tags, drone-based spraying, and farm accounting, along with additional modules for fruit cluster pruning and online marketing. All components were integrated through a cloud-based mobile application. The evaluation results showed that the platform increased the average yield to 6,575 kilograms per hectare, representing a 27.6% increase, while significantly reduced water and electricity consumption, lowered farmers' workloads, and improving overall farm management efficiency. Farmers demonstrated a high level of understanding in using the platform and expressed a need for further training. The platform is cost-effective, practical, and suitable for adoption in longan orchards, particularly those larger than 0.16 hectares.

Keywords: Keywords: Longan, Smart Agriculture, Precision Farming, IoT, Platform

INTRODUCTION

Longan (Dimocarpus longan Lour.) is an important economic crop in Thailand, contributing substantial income for farmers and representing significant export value in both fresh longans and dried whole longan fruit (Tansuchat et al., 2023). Longan cultivation is mainly practiced in northern provinces, including Chiang Mai, Lamphun, and Chiang Rai, due to favorable climate conditions that promote flowering and fruit development. However, longan production is strongly affected by various factors, including climate variability, soil fertility, irrigation management, fertilization practices, and pest control strategies.

Currently, climate change is affecting plant growth and productivity (Janni et al., 2024), which in turn poses new challenges for longan farmers, making it necessary to enhance yield and fruit quality while reducing production costs (Sritontip et al., 2014). As conventional cultivation methods are becoming less effective in limiting the impacts of climate change on longan production. Thus, there is an increasing need to adopt advanced, data-driven farming systems that can support more sustainable cultivation.

To address these challenges, precision and smart farming technologies provide effective solutions by integrating IoT-based sensors, drones, digital crop monitoring, and cloud-based farm management platforms (Alahmad et al. 2023). By enabling precise input management, early detection of pests and diseases, yield prediction, and traceability, these innovations enhance both productivity and sustainability of longan cultivation under variable environmental conditions. This research aims to develop an integrated smart farming platform for longan cultivation by building upon technologies and knowledge generated through ongoing studies at Maejo University, Chiang Mai, Thailand. The proposed platform is expected to improve production efficiency, reduce costs, and serve as a model for sustainable longan farming, contributing to Thailand's competitiveness and leadership in agricultural innovation within the ASEAN region.

MATERIALS AND METHODS

Study Site and Experimental Design

The field experiment was conducted in four commercial longan orchards in northern Thailand, each comprising 0.32 hectares and divided into two 0.16-hectare plots. Treatment plots were managed using an intelligent agricultural platform, whereas the control plots were maintained under conventional production practices.

Design of the Intelligent Agricultural Platform

The intelligent agricultural platform was structured into four functional components: (1) Data Input, which integrated seven agricultural applications for longan orchard management; (2) Server, a central computing unit responsible for real-time data processing and analysis; (3) Data Output, which delivered processed information and management recommendations to a farmer-oriented dashboard accessible via mobile devices; and (4) Database, a storage and server system that maintained production and environmental data to support decision-making and long-term.

Hardware devices, including soil moisture sensors, environmental sensors (temperature, humidity, and solar radiation), and automated irrigation controllers, were deployed in the experimental plots to generate real-time input data for the platform.

Evaluation of Orchard Management Systems

The effects of the intelligent agricultural platform were evaluated in longan orchards by comparing treatment plots with control plots managed under conventional practices. Measurements included the number of inflorescences, fruit clusters per tree, and yield.

Statistical analysis

All measurements were averaged per orchard, and differences between treatment and control plots were assessed using a two-sample t-test ($\alpha = 0.05$). When normality assumptions were not met, the non-parametric Mann–Whitney U test was applied. Analyses were conducted using IBM SPSS Statistics 28.0.

RESULTS & DISCUSSION

Development and Performance of the Database System

A database system was designed to store and process data collected from the seven applications. The design and development process focused on establishing a systematic data storage framework, emphasizing data structuring to ensure efficient and rapid retrieval. The stored data were formatted to be readily available for analysis and reporting, thereby supporting decision-making and enabling accurate and timely information delivery. The system was developed with the objective of facilitating reporting and data accessibility in a manner that enhances overall efficiency and effectiveness, as shown in **Figure 1.**

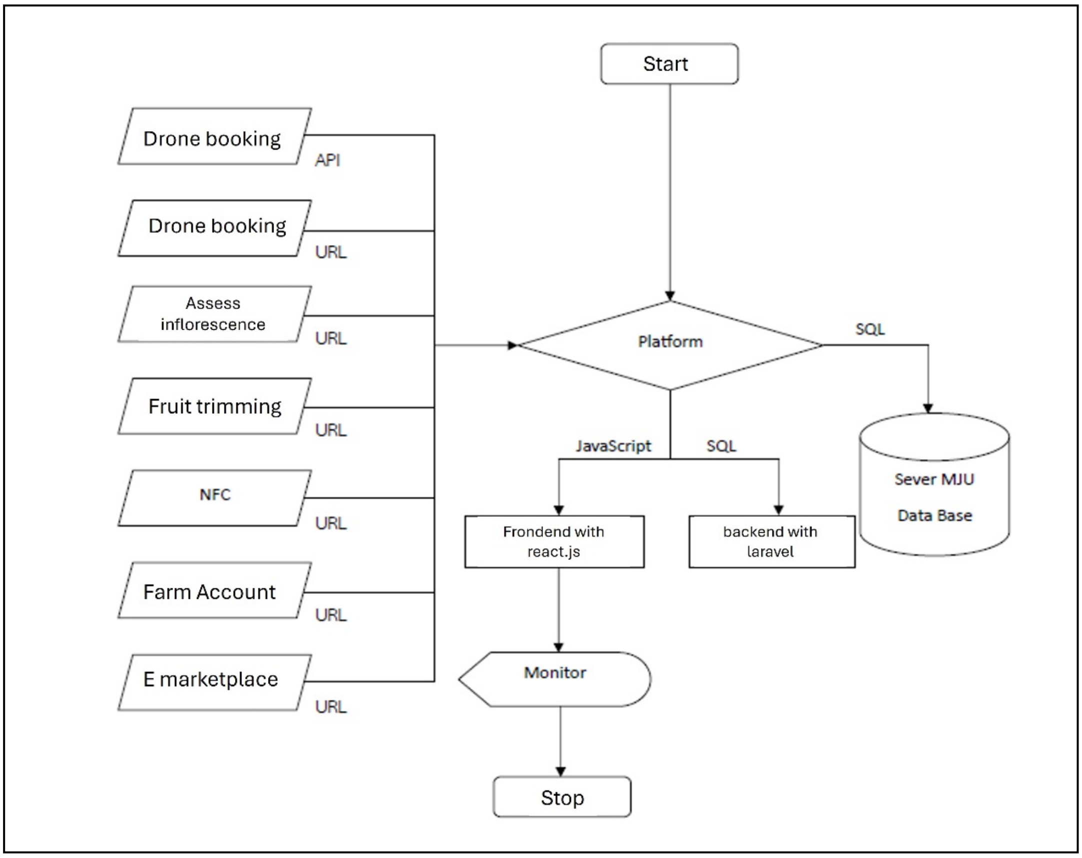

Figure 1. Data Storage Infrastructure of the Intelligent Agricultural Platform

UX/UI Development for Longan Orchard Management Platform

The UX/UI design was focused on creating an interface that is user-friendly and straightforward. The web application was customized to meet the needs of farmers, considering the wide range of user ages. The system layout and design emphasized the management of production factors at each stage of longan development. The development process of longan was divided into six stages: pruning, mature leaf stage, flowering induction, flowering, fruit setting, and harvesting. The system was built to provide the right controls and guidance for each developmental stage, as shown in **Figure 2.**

Effects of the Intelligent Agricultural Platform on Flowering, Fruit Set, and Yield in Longan Orchards

The effects of the intelligent agricultural platform on longan production parameters are presented in **Table 1.** Longan trees managed using the intelligent agricultural platform exhibited a higher number of inflorescences (77.45 ± 6.12) compared with those under conventional practices (72.23 ± 6.21). Similarly, the number of fruit clusters per tree was greater in platform-managed trees (68.23 ± 4.14) than in the control group (63.08 ± 4.22). Yield was also higher in plots managed with the intelligent platform (4,491 ± 197.62 kg/ha) compared with conventional plots (3,517.5 ± 283.94 kg/ha). Statistical analysis using an independent-samples T-test at a 95% confidence level revealed that the number of inflorescences, fruit clusters per tree, and yield were all significantly higher in orchards managed with the intelligent agricultural platform than in those under conventional management ($p < 0.05$). These results indicate that the platform enhances flowering, fruit set, and overall productivity in longan orchards.

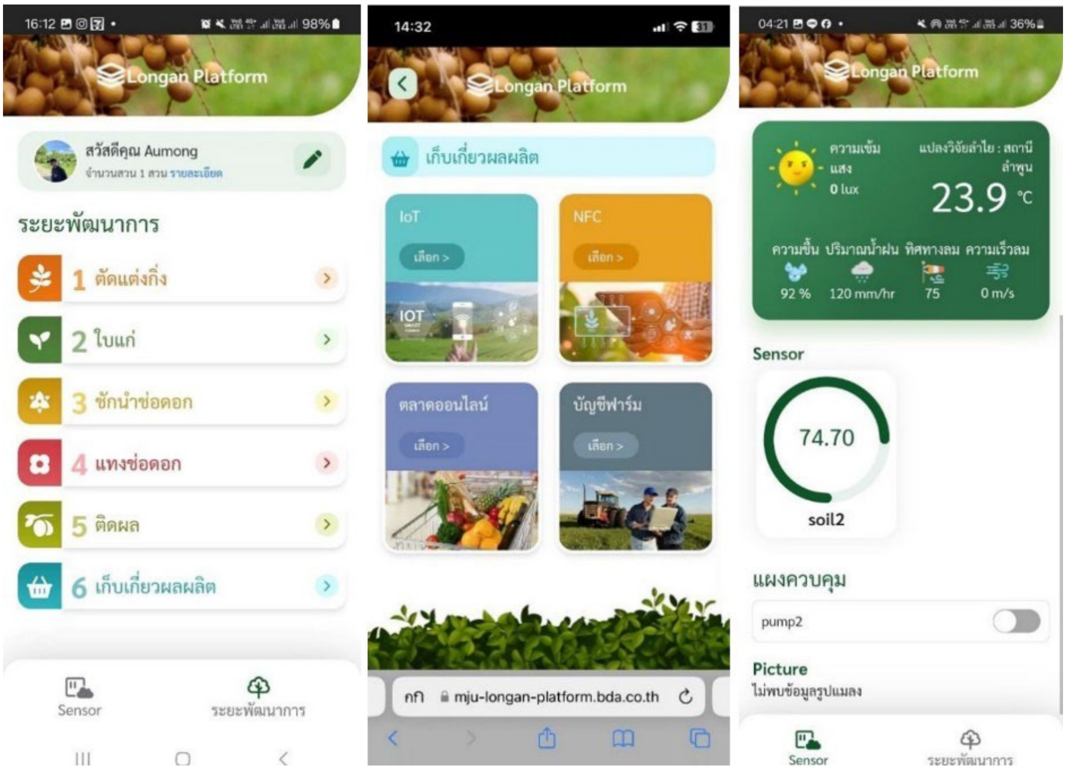

Figure 2. Illustrative examples of the UX/UI design for the intelligent agricultural platform

Table 1. Comparison of inflorescences, fruit clusters, and yield between intelligent agricultural platform and conventional orchard management

Parameter	Intelligent agricultural platform	Conventional practices
Number of inflorescences	77.450 ± 6.122	72.232 ± 6.209
Fruit clusters per tree	68.225 ± 4.135	63.075 ± 4.221
Yield (kg/ha)	4,491.00 ±197.62	3,517.50 ± 283.94

Values are presented as mean ± SD. Sample size: Number of inflorescences and fruit clusters per tree, n = 40 of longan tree; Yield, n = 10 of longan tree.

Smart agriculture plays a pivotal role in modern farming systems. Our findings are consistent with Harika et al. (2024), who demonstrated that the adoption of smart agriculture practices and predictive tools enhances agricultural productivity. This alignment suggests that integrating intelligent management systems can effectively improve crop yield and optimize farm operations. Furthermore, Roy and Medhekar (2025) reported that farmers' implementation of precision agriculture technologies not only enhanced resource-use efficiency and overall farm performance but also mitigated environmental impacts in large-scale farms in Australia. Taken together, these studies underscore the potential of advanced agricultural technologies to support sustainable and efficient farming practices.

CONCLUSIONS

The intelligent agricultural platform significantly improves productivity and management efficiency in longan orchards. Longan orchards using the platform showed higher numbers of inflorescences and fruit clusters per tree, as well as increased yield, compared with conventional practices. The platform integrates IoT-based monitoring, automated irrigation systems, and digital management tools, which collectively reduce resource use and labor requirements. These findings confirm that the intelligent agricultural platform is a practical and effective solution for enhancing longan production, particularly in medium- to large-scale orchards. Its adoption can support sustainable agricultural practices, strengthen farmers' competitiveness, and serve as a model for precision agriculture implementation both in Thailand and internationally.

Future Directions and Recommendations

Future research should expand the platform to additional crop types and orchard scales to increase its applicability across diverse agricultural settings. Enhancing predictive analytics, such as yield forecasting and pest–disease outbreak prediction, could further strengthen decision-support capabilities. Providing training and continuous technical support will help improve farmers' digital literacy and ensure effective platform adoption. Integration with national agricultural databases and market intelligence systems may also enhance market access, reinforce value chain linkages, and support long-term sustainability in smart agriculture.

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