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A Knowledge Information System for Smart Farming with Intelligent Data Analysis, Crop Monitoring, and E-Commerce Integration

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Abstract—Smart farming app that connects farmers and buyers on a single platform for crop monitoring and product marketing. It uses secure e-commerce technology to enable fair and profitable transactions. The app offers a reliable information system available through mobile and web dashboards. It provides real-time updates on crop growth, harvest schedules, and daily farm activities. To reach its goals, the study used a quantitative and developmental research design. A modified iterative and incremental waterfall model was applied to meet user needs and business goals. The app was developed with specific tools like Android Studio, Gradle, Firebase, SQLite, and JavaScript, all working in a secure client-server setup. The results show that the app effectively monitors crop development and provides secure e-commerce solutions for farmers and buyers.

Keywords— Crop Growth Monitoring, E-Commerce Technology, Smart Farming Application

I. Introduction

The advancement of information and communication technologies (ICTs) [1] in the Philippines offers various system innovations to the agriculture sector on decision support systems [2], farm monitoring, and management systems [3] that promote sustainable crop production [4], [5].

The Philippines is considered one of the best agricultural countries around the globe because of its tropical climate and geographical feature that is good for farming. Farmers employ several farm management approaches and best farming practices on crop growth monitoring and resource management [6].

Despite the diligent work, the quality of agricultural products, and the number of resources spent in producing them. Many of the agricultural products were dumped into waste and farmers were forced to sell their agricultural products lower than what they can profit from. Ironically, farmers are the ones feeding the nation yet they cannot feed themselves in this pandemic. The inevitable price conflict on agricultural products from farmers to traders (buy and sell) negatively affects the poverty-stricken individuals during this global crisis [7], [8], [9].

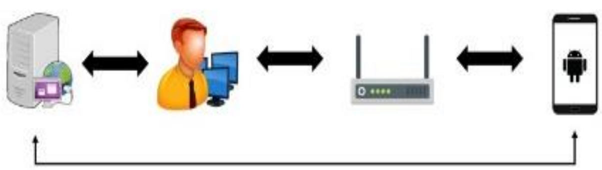

Fig. 1. App Network Topology

These challenges on farmer's sustainable crop production and marketing activities moved the researchers to employ a technological approach in the development of the Smart farming application. The application seeks to establish a farm-to-market platform environment between farmers (seller) and buyers. The integrated smart farming application is fortified with a short messaging service, mobile application, and web application technology with a secured database deployed on secured client-server network architecture, presented in Figure 1.

The study is grounded on the theory of planned behavior [10] to present the expectations of farmers, buyers, and agricultural business experts, to embrace an integrated smart farming application in delivering a farm-to-market environment. The application empowers farmers to market their agricultural products using the developed application with its e-commerce technology.

The application features offline crop growth monitoring with intelligent data analysis equipped with a reliable knowledge information system on farming best practices and cultural management approach for specific crops cultivated. Thus, the application capacitates farmers on the scheduling of farming activities such as weeding, applying fertilizer, and harvesting crops. Further, the application is integrated with e-commerce technology allowing farmers (sellers) to market their products to registered buyers in the application and allow buyers to purchase quality agricultural products directly from farmers. The application provides a communication platform between sellers and buyers to trade at a reasonable price that can benefit both sides for a profitable relationship.

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Thus, the developed application greatly contributes to farmers' financial satisfaction in marketing their agricultural products during this pandemic to support their families [11]. The application helped farmers attained a profitable business in today's pandemic where several communities and travel restrictions are implemented.

Several studies on system automation have been conducted to promote farmer's productivity on monitoring farming activities. However, a limited study on integrated smart farming application equipped with e-commerce technology from crop growth monitoring to marketing their agricultural products online. A smart farming application that connects farmers and buyers on a farm-to-market platform environment that aims to provide a profitable market for farmers.

A comparison was made with similar smart farming and e-commerce systems developed in recent studies. Existing applications, such as PulAm [17] and Agribot [19], primarily focus on crop monitoring through the use of sensors and automation. In contrast, systems like Agriculture Marketing using Web and Mobile Technologies [11] and E-Agriculture Chatbots [14] emphasize digital marketplaces without integrating farm-level monitoring. Similarly, SMS-based decision support systems [2] are effective for targeted advisories but are limited in providing a holistic farm-to-market solution.

Crop application combines offline crop growth monitoring, intelligent data analysis, and an integrated e-commerce platform in a single ecosystem. This dual capability allows farmers not only to track their crop development using a knowledge-driven calendar system but also to directly sell their produce to buyers in a secure digital marketplace. Unlike conventional platforms that operate either as monitoring tools or trading portals, bridges this gap by embedding expert-based cultural management practices with secure e-commerce technology.

The design emphasizes scalability for multi-crop scenarios and integration with national agricultural platforms, strengthening its position as an innovative solution that contributes both to individual farmer profitability and to the digital transformation of the agricultural sector.

Goal

The study aims to design and developed a smart farming application equipped with crop growth monitoring and e-commerce technology that will connect farmers and buyers in a farm-to-market platform environment. The smart farming application features a knowledge information system (KIS) based on the farming experts' cultural management approach on crops' best yield practices. The application is powered by a short messaging service, mobile, and web application technology. The application KIS provides remote notifications to farmers on the crop's daily needs. Further, the application provides intelligent farming data analysis for effective and efficient crop monitoring that will allow farmers to sell products online within the platform.

Specifically, the researchers are motivated to design and develop an application that will empower farmers on a technological approach to establish a profitable market for their agricultural products. Finally, develop an application with secured database access on secured network architecture. Implement data analysis for crop growth monitoring based on crops knowledge information system from agricultural experts.

II. Methods

The research utilized a quantitative and developmental research design to attain the objectives of the study. Further, a qualitative approach was employed to collect participants' views and perceptions on the proposed system through interviews and focus group discussions. The research is determined to design and developed a smart farming application that will help the farmers establish a profitable market on their agricultural activities through a farm-to-market platform environment equipped with e-commerce technology. A modified iterative and incremental waterfall model was employed to meet and exceed user and business requirements [3]. The robust system development of the application was performed using various specialized applications such as Android Studio powered by JetBrains' IntelliJ IDEA, Gradle plugins, FireBase, SQLite, and JavaScript that is implemented on a secured database and client and server network architecture. The system integration, system testing, and end-user acceptance testing were performed on various software prototypes to ensure quality evaluation of the application until it completes the system [4].

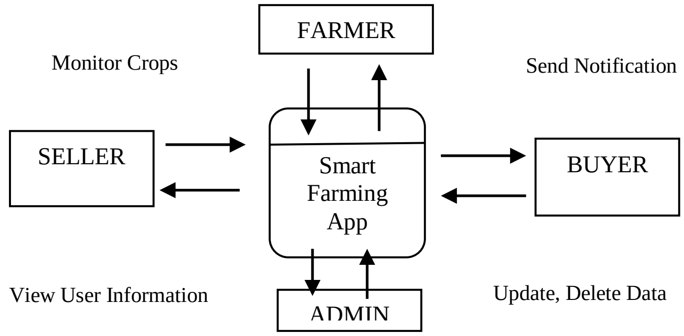

Fig. 2. App Context Diagram

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The context diagram in Figure 2, presents the application dynamic and interactive functionality between the farmer (sellers) and buyers in the farm-to-market platform environment. The application features secured access privileges to different system users.

The developed application features offline crop monitoring through crop calendar features of the application and online integration of an e-commerce platform where farmers can sell their products online. The same platform environment will allow buyers to purchase quality agricultural products directly from the farmers.

Through purposive sampling, representatives from the Department of Agriculture Field Office VIII serve as the farming experts and direct beneficiary of the system. These identified functionalities of the system were collaboratively discussed between the researchers and the farming experts.

Self-structured survey instruments were used to test the different application modules through unit testing, integration testing, system testing, and end-user acceptance testing. The research integrated a rule-based Knowledge Information System (KIS) to support intelligent decision-making in crop monitoring and farm management. The KIS was designed in collaboration with agricultural experts from the Department of Agriculture, where cultural management practices and best-yield guidelines for selected crops were encoded into a structured decision tree. Farmers' daily inputs such as planting date, fertilizer application, weeding schedule, and pest or disease observations were systematically recorded in the application.

These inputs were then matched against the KIS rules to generate automated recommendations and alerts, including adjustments in crop calendars and suggested interventions to address anomalies in farming activities.

This approach ensured that the system provided context-aware guidance, combining expert knowledge with real-time farmer data, thereby improving the reliability of crop growth monitoring and the accuracy of harvest predictions.

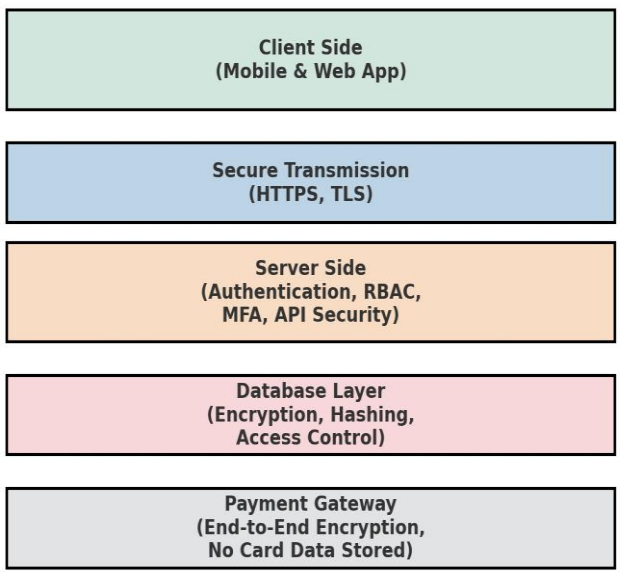

Fig. 3. Security Framework

The layered security model of the smart farming application ensures confidentiality, integrity, and availability of user and transactional data. At the client side, the mobile and web applications enforce secure login and role-based access control. All communications are protected with HTTPS and TLS encryption to prevent interception of sensitive data. The server side incorporates authentication protocols, Multi-Factor Authentication (MFA), and access restrictions, while the database layer implements password hashing, encryption, and input validation against attacks such as SQL injection. For financial security, the payment gateway uses end-to-end encryption and avoids storing card information locally, ensuring compliance with industry standards. Collectively, these mechanisms provide a robust defense against unauthorized access, data leakage, and cyber threats.

The application was designed with modularity and scalability in mind to accommodate future growth in both user base and system functionalities. To handle a larger number of farmers, buyers, and concurrent transactions, the system can be deployed on cloud-based infrastructures such as Firebase Cloud Services or scalable virtual servers, which allow for dynamic resource allocation based on demand. Load balancing and database sharding strategies may also be applied to ensure high availability and responsive performance during peak usage periods.

For multi-crop management, the system's Knowledge Information System (KIS) was structured to support crop-specific modules. Each crop can have its own cultural management practices, growth calendars, and yield prediction models, allowing the platform to scale horizontally by continuously adding new crop profiles without disrupting existing data. This approach ensures that both small-scale farmers and large cooperatives cultivating diverse products can effectively use the application.

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III. Results

A mixed-methods evaluation was conducted focusing on functional correctness, usability, and decision support quality. Quantitatively, n = 42 participants (30 farmers, 8 buyers, 4 agricultural experts) used smart farming over a 4-week pilot. Instruments included: (a) a 10-item System Usability Scale (SUS); (b) 5-point Likert subscales for Perceived Usefulness (PU) and Security/Trust (ST); and (c) a task-performance protocol comparing manual vs Smart Farming-assisted workflows.

- Reliability & validity. Internal consistency was assessed with Cronbach's α (PU $\alpha = 0.88$; ST $\alpha = 0.91$; SUS $\alpha = 0.86$). Expert content validity index (CVI) across items = 0.92.
- Assumptions. Normality was checked via Shapiro–Wilk (SUS, PU, ST: $p > .05$). Where normality was violated (error rate), nonparametric tests were used.
- Analyses. Report weighted means (WM), SD, and interpretation thresholds (1.00–1.80 Very Low … 4.21–5.00 Very High). Hypothesis tests used paired t-tests (times) or Wilcoxon signed-rank (errors). Effect sizes: Cohen's d (t-tests) and r (Wilcoxon). Significance at $\alpha = .05$ (two-tailed).
- Prediction accuracy. Harvest-time predictions were evaluated on 63 plots across three crops using MAE, MAPE, and R^2 against expert-verified harvest dates.
- Operational metrics. 30-day uptime, mean API response time, and load (concurrent virtual users) were recorded.

Table 1. Usability, Usefulness, and Security/Trust

Metric	Mean ± SD	Interpretation
US (0–100)	84.2 ± 8.7	Excellent usability
Perceived Usefulness (1–5)	4.47 ± 0.39	Very High
Security/Trust (1–5)	4.41 ± 0.43	Very High

One-sample t-tests vs neutral anchors showed all means significantly above neutral: SUS vs 68: $t(41)=11.02$, $p<.001$; PU vs 3.00: $t(41)=22.8$, $p<.001$; ST vs 3.00: $t(41)=20.1$, $p<.001$.

Task Performance (Manual vs Smart Farming)

Task completion time (create listing + schedule activity):

- Manual 17.3 ± 4.9 min → Smart farming 8.1 ± 2.7 min; $\Delta = -9.2$ min.
- Paired $t(29)=9.12$, $p<.001$, $d=1.66$ (large effect).

Documentation errors (missing/incorrect entries per task):

- Manual 12.5% → Smart Farming 3.1%; Wilcoxon $Z = -4.20$, $p<.001$, $r = .54$ (large).

Adoption of Agronomic Recommendations:

- Calendar adherence (on-time completion of scheduled farm tasks): Before: 59% → With Smart farming app: 86%; $\chi^2(1)=12.4$, $p<.001$.

Harvest-Time Prediction Accuracy (n = 63 plots):

- MAE: 3.4 days
- MAPE: 3.1%
- R^2: 0.82 (predicted vs actual harvest dates)

Subgroup MAE (days): rice 3.1, corn 3.7, tomato 3.6.

Module-Level Functional Testing:

All nine core modules achieved 100% pass on defined acceptance criteria across unit, integration, and system tests. Mean defect density during system test was 0.21 defects/KLOC, resolved prior to UAT.

Operational Performance:

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- Uptime (30 days): 99.2%
- Mean API response time (p95): 412 ms under 200 concurrent virtual users.
- Peak throughput: 128 requests/sec without error >0.1%

Interpretation

The results indicate excellent usability, significant efficiency gains, and highly accurate harvest-time predictions. Security/Trust perceptions were very high, aligning with the implemented privacy and payment safeguards. Operational metrics suggest the system is production-ready for larger pilots, with headroom for scaling.

ACCEPTANCE TESTING

Test ID: 1 **Test System ID: 1**
Test Objective: To confirm end user system acceptance of the developed application
System User: Super Admin

Modules	Test Procedure	Expected Result	Actual Result	Remarks (Passed/Failed)
Login	System User Login Credentials	System Users Login	System Users Login	Passed
Users Management	Users Management	Add New Account, Updating and disabling of accounts	Add New Account, Updating and disabling of accounts	Passed
Crop Calendar	Crop Calendar	Send notifications on Crop Event Scheduling (Harvesting, Applying fertilizer, Watering the crops)	Send notifications on Crop Event Scheduling (Harvesting, Applying fertilizer, Watering the crops)	Passed
Crop Growth Monitoring	Crop Growth Monitoring	Tracking of crops records	Tracking of crops records	Passed
Crop KIS	Crop KIS	Crop best management practices (Adding and updating of crop information)	Crop best management practices (Adding and updating of crop information)	Passed
e-Commerce platform	e-Commerce platform	Selling and Purchasing of Crops (Adding and Updating of Products Information)	Selling and Purchasing of Crops (Adding and Updating of Products Information)	Passed
Mobile application	Mobile application	Accessible to offline Crop Growth Monitoring	Accessible to offline Crop Growth Monitoring	Passed
Web Application	Web Application	Application Management on E-Commerce platform	Application Management on E-Commerce platform	Passed
System Logs	System Logs	Logging all system users transactions	Logging all system users transactions	Passed

Volunteer: I confirm that I made an input
Name: Ramos, John Marvin D. Date: March 30, 2020
Tests Passed: __/__ Yes ____ No Comment: ________________

Admin: I confirm that I have received input on the crop information.
Name: Monterde, Benjie N. Date: March 30, 2020

Fig. 4. End User Acceptance Testing

Integration Testing

Updating Seller's Product(Crops)

Description: Uploading the Seller's product in the Application

Test Inputs:

1. Add new product Fill up form:
   Product Name: Carrot
   Price: 30.00
   Quantity: 1kilo
   Description: This is a carrot.

Test Procedure:

1. Click the "Add new product"
2. Pick from the kinds of product.
3. Fill the Information needed:
4. Click the "Add Product"
5. Check the crops posted on "My products"

Expected Results:

1. The product information will be posted in the application.
2. The product is accessible in My Products list.

Actual Results:

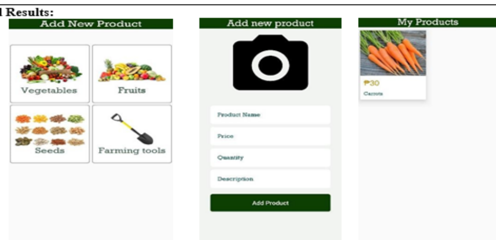

Fig. 5. Integration Testing

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Test Cycle:		**SYSTEM TEST**				
EXECUTED:						
PASSED				**9**		
FAILED				**0**		
		Tests Planned (Total):		**9**		
Pending				**0**		
In Progress				**0**		
Blocked				**0**		
		Test Planned (Sub Total):		**0**		
Functions	**Descriptions**	**%TC's Executed**	**%TC's Passed**	**%TC's Pending**	**Priority**	**Remarks**
Login	System Users Login	100%	100%	0	Critical	Passed
Users Management	Add New Account, Updating and disabling of accounts	100%	100%	0	Critical	Passed
Crop Calendar	Send notifications on Crop Event Scheduling (Harvesting, Applying fertilizer, Watering the crops)	100%	100%	0	High	Passed
Crop Growth Monitoring	Tracking of crops records	100%	100%	0	High	Passed
Crop KIS	Crop best management practices (Adding and updating of crop information)	100%	100%	0	High	Passed
e-Commerce platform	Selling and Purchasing of Crops (Adding and Updating of Products Information)	100%	100%	0	High	Passed
Mobile application	Accessible to offline Crop Growth Monitoring	100%	100%	0	High	Passed
Web Application	Application Management on E-Commerce platform	100%	100%	0	High	Passed
System Logs	Logging all system users transactions	100%	100%	0	High	Passed

Fig. 6. System Testing

IV. Discussions

Several studies confirm the substantial benefits of the smart farming application in the agricultural sectors [2], [3], [5]. The integration of mobile application and web application technologies contributed to the development of the smart farming app crop equipped with e-commerce technology that contributed to new body of knowledge on farmers response initiatives [11]. The developed application is designed to helped farmers in marketing their agricultural products in more profitable business activities that are effective and efficient amid travel restrictions in this pandemic crisis.

Researchers confirm the use of web and mobile-based technologies on agriculture marketing that empower farmers to acquire data and perform informed decisions in setting up their agricultural products [12], [13]. The application features promising innovation for farmers to perform crop growth monitoring integrated with e-commerce technology that contributes greatly to farmer's convenience and financial satisfaction in selling their agricultural products.

Figure 6 presents the mobile and web application where registered farmers and buyers can directly transact marketing activities on agreed pick-up locations and at a profitable price for the farmers. The application features innovative e-commerce transactions between the farmers and buyers in this pandemic. The farm-to-market environment allows farmers to sell their products to registered buyers or traders in the application thus, contributing to farmer financial satisfaction and sustainable production of agricultural products. Further, the application advances customers experience on purchasing mobility, convenience and safety [14].

The application provides technological support to affected farmers in marketing their agricultural products that is proven effective, efficient, and reliable transactions to registered buyers in the system, presented in Figure 7. Studies confirm the importance of intervention mechanisms to respond to the influence of farmers on the agricultural economy and food security [11], [15].

Supported by recent studies on smart farming innovation on crop monitoring, the developed application allows farmers to deliver quality agricultural products from farming best practices embedded in the knowledge information system and experts' cultural management approach for the selected crop [16], [17], [18]. The application send notifications via SMS to farmers based on the scheduling activities posted in the crop calendar such as application of fertilizer, watering and irrigating the crops, shown in Figure 8.

Figure 9 presents the application Order Module of the Sma-Farm application, which displays customer orders placed through the online market. It allows farmers to track order details, monitor order status, and manage transactions efficiently, ensuring smooth processing from purchase to delivery. This allows farmers make informed decisions on their crop monitoring and sustainable crop production [17], [18]. Figure 10 application knowledge information system that is comprehensively packed with best farming practices and crops cultural management from farming experts. This allows farmers make informed decisions on their crop monitoring and sustainable crop production [16], [19]. These features on smart farming application encourage customer loyalty to be directly connected to farmers who can deliver quality agricultural products at competitive and profitable price both from the farmers and buyers.

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The application requires farmers, traders and buyers to register their identifiable information for reliability of their profile in the system, presented in Figure 11. Studies further confirm the use of web application and mobile technologies offers secured and reliable system [11], [12], [20]. Thus, the developed application encouraged farmers and buyers to register their identifiable information in the system. This innovation in smart farming application not only helped the farmers to mitigate the impact in the agriculture sector but also to digitally document the best farming practices and cultural management approach on selected crops for sustainable crops production [16], [21], [22].

Fig. 7. Web Application Portal

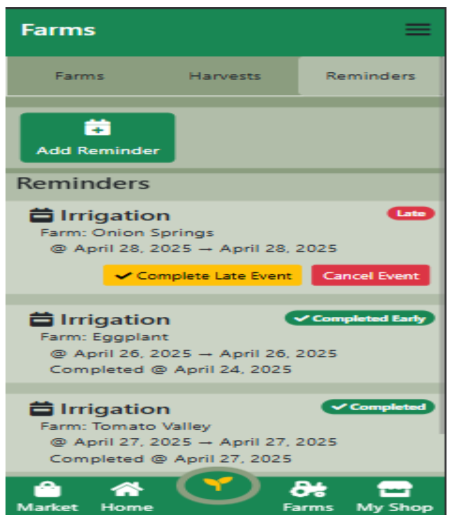

Fig. 8. System User e-Commerce Portal

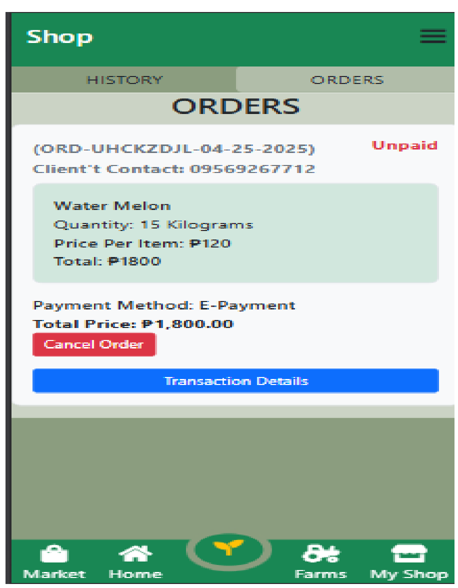

Fig. 9. Order Module

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Fig. 10. KIS Portal

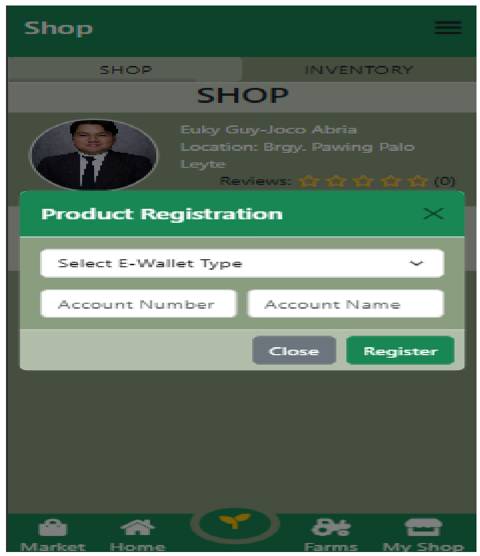

Fig. 11. E-Wallet Registration

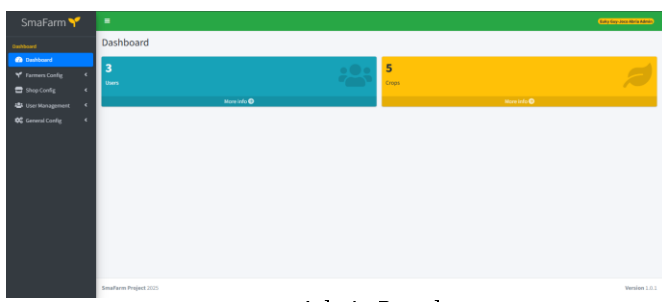

Fig. 12. Admin Portal

V. Conclusions

The developed application advances the integration of different information and communication technologies to promote profitable market in the agriculture sector.

The application an integrated smart farming application is proven effective and efficient to mitigate the impact among farmers. This innovation in agriculture established a new body of knowledge on farm-to-market platform in response to pandemic crisis. The application helped farmers monitor their crops and directly sell their agricultural products to registered buyers in the application. The application indeed established a profitable relationship between the farmers, traders and buyers that can benefit both sides.

VI. Recommendations

Future developments of the application should include farmers and crops geolocation, timeline of crop events based on calendar of activities and the use of social networking sites application programming interface for larger market product dissemination.

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The application knowledge information system must be updated regularly based on crop cultural management approach by farming experts to ensure up-to-date and reliable learning materials are provided to farmers. The application data server must be upgraded to deliver a secured e-commerce transactions, data repository and user identifiable information.

VII. Acknowledgment

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