

FARMSTAT: A Comprehensive Analytics System for Managing Agricultural Yields, Farmers Profiles, and Benefit Distribution in Tayabas City

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Abstract. The local agricultural sector still relied on traditional methods of managing agricultural data such as crop yields, crop distribution, and fertilizer usage. These traditional methods, including manual record keeping and monitoring, are prone to errors and time-consuming. This study aimed to develop a comprehensive analytics system for Tayabas City that enables the real-time monitoring of agricultural yields, such as crop yield monitoring, farmer profiles, and benefit distribution, like crop and fertilizer management. The Agile Software Development Lifecycle Model was the method used for system development in small parts and manageable tasks. Through the design, development, and continuous improvements of the system, the feedback of the users was utilized for the enhancement of the system. The system included features such as user registration and authentication for the secure account, particularly the City Agriculturist, farmer management for adding, updating, and organizing farmers; fertilizer and crop distribution management to track availability and distribution data; and crop yield monitoring to record and analyze crop data per barangay. Features like notification that alert users, a data analytics dashboard that visualizes insights through graphs, charts, and report generation in PDF or in Excel format. Additionally, the system has a mobile application, allowing farmers to view and submit harvested crops, and promotes digital literacy in the local agricultural sector by providing a user-friendly interface and multilingual support. The system evaluation was conducted based on heuristic evaluation and ISO/IEC 25010 standards with criteria focused on usability, reliability, and functionality. The results of end-user evaluations demonstrated both strong user satisfaction and system effectiveness. Thus, the Farmstat served as a digital tool that transformed traditional monitoring into a smart and comprehensive analytics-driven operation in Tayabas City.

Keywords: Comprehensive analytics system; agricultural yields; farmers profiles; benefit distribution

Introduction

Agriculture is one of the primary sources of livelihood in Tayabas City. However, the local agricultural sector still relies heavily on traditional methods to manage agricultural data, including crop yields and the distribution of seeds and fertilizers. These conventional practices, which depend on manual record-keeping and paper-based monitoring, are not only time-consuming but also highly prone to human error. Furthermore, local agricultural offices lack analytical tools to track crop production effectively, hindering their ability to engage in informed planning and efficient resource management.

Over the past few years, rapid digitalization has transformed socioeconomic activities worldwide, driven by expanding internet connectivity and the widespread affordability of digital devices that have created a global digital ecosystem (Jorge-Vázquez et al., 2021). In the agricultural domain, integrating data analytics offers a powerful alternative to traditional methods. According to Shvets et al. (2024), data analytics plays a crucial role in modern agriculture by turning raw field data into valuable, real-time insights that allow stakeholders to monitor crop productivity accurately and optimize resource utilization.

Accurate tracking of agricultural outputs, seeds, and fertilizers is essential for providing precise data, planning effectively, reducing costs, managing cash flow, and forecasting future requirements. Digital management systems equipped with features such as crop yield monitoring, data analysis, and automated reporting significantly contribute to improved management techniques across the sector (Tracextech, 2024).

To address these local challenges, Farmstat was developed as a comprehensive digital analytics tool for Tayabas City. By providing interactive dashboards, mobile capabilities, and real-time monitoring of crop yields and benefit distribution, Farmstat enhances agricultural decision-making. Ultimately, the platform empowers both city agriculturists and local farmers, fostering sustainable agricultural development throughout the region.

Research Questions

This study aimed to address the problem faced by the City Agriculturist of Tayabas City in managing agricultural yields, farmer profiles and distribution of agricultural benefits. Agriculture plays a big role in the city's economy but currently there's no centralized system for tracking real-time agricultural data, organized farmers records and benefit distribution.

Specifically, this study sought to find the answer to the following questions:

1. How can a comprehensive analytics-based system improve the monitoring and reporting of agricultural yields in Tayabas City?
2. How can the system effectively manage and organize farmer information across different barangays?
3. What features can be implemented to ensure ease of use and data accuracy for the city agriculturist managing agricultural data?
4. What is the impact of using a farmstat on the efficiency of monitoring, accuracy of reporting and decision-making of the city agriculturist in managing agricultural data?

Scope and Delimitation of the Study

This study focuses on the design, development, and evaluation of FARMSTAT, a system for managing agricultural data in Tayabas City that supports the Office of the City Agriculturist in organizing farmer information, monitoring crop yields, and tracking farming inputs such as seeds and fertilizers through a centralized digital platform. The study involves selected respondents, including office personnel and registered farmers, and evaluates the system using questionnaires based on a 5-point Likert scale to assess functionality, usability, reliability, and overall performance, following the Agile Software Development Lifecycle Model. The system is specifically designed for Tayabas City to support local data management and decision-making through real-time monitoring and reporting. However, the study is limited to this location and may not be applicable to other areas, does not include advanced features such as predictive analytics or integration with national databases, and focuses only on short-term system performance and user satisfaction rather than long-term impacts. Additionally, it relies on self-reported data that may be biased and does not deeply examine factors such as internet connectivity, user skills, and device availability, but still provides a foundational framework for improving agricultural data management through digital solutions.

Literature Review

E-Governance in Agriculture

E-Governance in agriculture refers to the application of information and communication technologies (ICT) by government agencies to enhance the delivery of agricultural services, improve transparency, and facilitate efficient communication with stakeholders. The Department of Agriculture has implemented e-government initiatives to promote agricultural development and improve farmers' livelihoods. Artificial intelligence (AI) applications have been explored to leverage agriculture through e-government public services and big data. According to Gkikas et al. (2023), AI is emphasized as an innovative game-changer that seeks to enhance the effectiveness of government and radically change the delivery of public services. The National e-Governance Plan in Agriculture (NeGP-A) is proposed to provide relevant information and services to the agricultural community, business, and all enhancing stakeholders. Its mission is to provide relevant information and services to farmers, private organizations, and the imperative stakeholders. From 2010-11, as seven pilot states, the program grew to include all states from 2014-15. The primary objective of the program is to enhance the access of farmers to the crucial agricultural data at various stages of crop production so that farmers can make informed decisions towards increased productivity. In the Philippines, the Department of Agriculture (DA) has implemented several ICT projects such as the formation of the Digital Agriculture Team, the modernization of the Registry System for Basic Sectors in Agriculture (RSBSA), and the building of the agriculture-based central data ecosystem (Abcde). These initiatives are aimed at modernizing agricultural practices as well as data management.

Crop Yield Monitoring

Crop yield monitoring refers to the process of gathering and making analyses based on the quantity and quality of crops harvested. Crop monitoring is likely to expand in the future due to increasing demand for high yield, profitability for farmers and food safety and traceability. According to MarketsandMarkets (2023), the global crop monitoring market will increase from USD 2.2 billion in 2020 to USD 4.4 billion by 2025, at a CAGR of 15.2%. This growth has been driven by increasing demand for agricultural productivity, profitability, food traceability, and sustainability. It is further predicted that growth will proceed beyond 2025. According to Verified Market Research (2024), the crop monitoring market may reach a value of USD 9.37 billion by the year 2031, with a growth rate of 14.69% from 2024 to 2031. This expansion is driven by the adoption of precision farming techniques and the integration of advanced technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) in agriculture. This expansion is because of the implementation of precision farming techniques and the implementation of advanced technologies in agriculture, such as artificial intelligence (AI) and the Internet of Things (IoT). In addressing the questions of how data mining and machine learning could be used in crop management, Chergui et al. examined the use of historical and real-time data to increase productivity and crop decision-making. Bassine et al. (2023) gave an overview of the contribution of machine learning, the Internet of Things (IoT), and remote sensing techniques to yield predictions that are more accurate and scalable. Based on the research of Lagrazon & Tan (2023), advanced machine learning techniques, such as Gaussian Process Regression, have the potential to estimate how much rice and corn will be produced using climate data. This approach maintains that this method helps farmers keep the MAPE below 3.4 percent, enabling them to plan and harvest crops more effectively. The study shows that using data in agriculture models can be used to increase production and support eco-friendly farming methods, especially against the challenges of climate change. These studies demonstrate how incorporating data-based analytics into crop yield monitoring can be used to enhance productivity and promote sustainable farming practices, which are the primary goals of the research and development system.

Data Analytics in Agriculture

The usage of data analytics can change the way farmers control their operations. This can be achieved by allocating resources, forecasting yields, and improving productivity. According to the study, one can use historical data analysis with the help of big data analytics (Rajesh et al., 2022). To examine the analysis of past historical data by using big data analytics, it is useful to solve agricultural problems through improvement of positive agricultural trends and resource management. This research offers alternatives for upgrading existing farmer practices and converting them to big data analytics, which has also resulted in income growth and reduced farm wastage. It also offers techniques to enable farmers to minimize losses, improve their predictions of yields, and make better decisions in all situations. The research provided viable solutions along with minor improvements to the existing farming practices, which is why big data Analytics must be adopted by agriculture to remain viable and competitive in development. It also provides insights that help farmers make informed decisions regarding crop management and resource allocation. Marjudi et al. (2023) explain that data analytics in agriculture is the process of using computers to detect trends and analyze large datasets. The system operates four types of analysis, including descriptive, diagnostic, predictive, and prescriptive analysis, to contribute to decision-making and increase agricultural productivity and efficiency. As stated by Birudararaju et al. (2021), agricultural development can be transformed by using a smart tool, which is an analytics-based tool that integrates both hardware and software technologies. The development using analytic methods will transform farming by reducing poverty, which develops solutions to human crises and conflicts.

Benefit Distribution

The distribution of crops and fertilizers plays a major role in the productivity of agriculture, ensuring that all farmers receive the required inputs on time, making sure that all farmers get the required inputs in time. However, the consumer of the traditional model of agricultural products increases demand of high-quality products, high yield and high fertilizer usage are gaining more priority and unsustainable (Yu et al., 2023). Combining biomass data with geographic and meteorological data can support a complete study of processes. can also be guided by improving the quality of crops and soil control (Liang et al., 2023). the allocation of fertilizers and crop inputs and how to be apply them various locations to enhance the productivity. The use of digital monitoring and documentation systems has also been identified as effective in enhancing agricultural distribution. The Rice Competitiveness Enhancement Fund (RCEF) program was one such program that was developed in September 2020; it was necessary at the time of the COVID-19 pandemic to track and allocate certified seeds in real time to farmers. It contains multiple applications of the seed allocation, delivery, and inspection, helping to analyze the data efficiently to make a policy and be transparent. The project supplies about 3.4 million seed bags to one million farmers in a year. The RCEF is also included in the Rice

Tariffication Law, which aims to allocate P3 billion every year for high-quality rice seeds, facilitated by the local government units and legislators. (Berto, 2024)

Related Systems

Different existing systems and platforms possess features that contribute to the development of agri-based data management and decision-support systems. These systems demonstrate how technology integration in agriculture can support effective crop monitoring, distribution management, and data-driven decision-making by local government units. A similar system to the proposed research development system is the DA-AMIA Information System, designed by the Department of Agriculture for its climate change adaptation program. The purpose of this information system is to gather and interpret information regarding crop performance and potential risks arising from climate change. The system allows the city agriculturist to monitor and assess the performance of farming and crop production with the help of data visualizations. Similar to the proposed research development system, it assists in the collection and analysis of local agricultural data to inform and guide farming decisions. Both systems also depend on core functions that enable the communities to adapt to climate change in a better way, including collecting information, monitoring risks, and providing quick reporting. The Rice Crop Manager (RCM) is a digital tool developed by PhilRice and the International Rice Research Institute for managing rice crops. RCM helps the farmers to manage their rice crops by suggesting details on when, how, and how much fertilizer should be applied in each place. The system gathers information from farmers on their phones and provides instant feedback. The primary objective is to enhance the amount of crops that would be manufactured using fewer resources. As with the research development system, RCM is dependent on data submitted by farmers to assist in making informed choices. At the same time, FARMSTAT includes data for numerous crops, tracks the usage of fertilizers, and helps LGUs analyze data. Both systems work to improve crop management using technology, but FARMSTAT is designed to include more types of crops and how they are stored.

Methodology

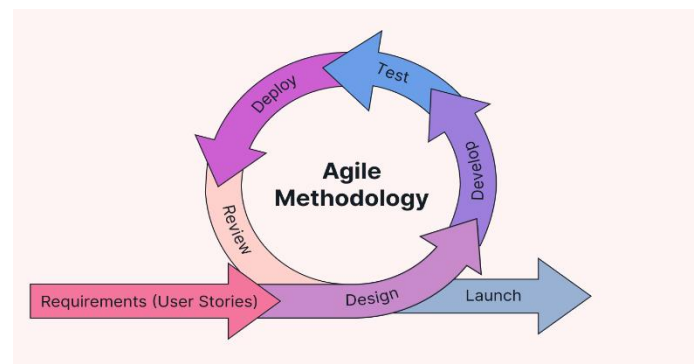


Figure 1: Agile Software Development Lifecycle Model

Figure 1 shows the Agile Software Development Lifecycle Model, which served as an iterative approach that mainly focused on flexibility, alongside collaboration and speed in delivery. Agile methodology was composed of multiple short development cycles called sprints, where features are designed, developed, tested, and improved based on continuous feedback from farmers and city agriculturists. This model provided an effective system for responding to changing demands, with stakeholders remaining actively involved throughout the development process. Agile transformed software development into smaller sequential units with sequential delivery. The methodology required teams to follow a sequence of activities that began with gathering, followed by planning, and continued through design and coding and continued through testing and review phases. For this study, the agile model proved to be the most suitable approach for the agriculture field requirements and characteristics of the developed system. This study used the Agile Software Development Lifecycle Model to design and implement FARMSTAT: A Comprehensive Analytics System for Managing Agricultural Yields, Farmers Profiles, and Benefit Distribution in Tayabas City. This methodology allowed continuous iteration and close collaboration with end-users, ensuring that the evolving system met actual field requirements. A continuous iterative process that combined close end-user collaboration with farmers and agricultural officers allowed the system to achieve matching field requirements throughout its design and implementation phase.

Research Participants

This study included the Office of City Agriculturist - LGU Tayabas City and the selected registered farmers in Tayabas City are the respondents of this research development system.

Data Gathering Procedure

A structured questionnaire was given to the City Agriculturist of the LGU of Tayabas City and chosen registered farmers who acted as respondents for the research development system, also to evaluate the research study. The questionnaire evaluated the key attributes of the system in terms of its functionality, usability, reliability, and overall performance. The respondent's feedback was quantified using a 5-point Likert scale, allowing the level of satisfaction with various features and usability of the system to be measured. The collected data will be analyzed using a 5-point Likert scale, allowing for the interpretation of respondents' perceptions and attitudes toward the system. The Likert scale ranges from 1 (Strongly Disagree) to 5 (Strongly Agree), which allows the researcher to measure all the factors of the system's performance and the user satisfaction in a quantitative way. Moreover, the thematic analysis of qualitative data collected through open-ended questions was used to determine common themes and insights. Through this data analysis plan, the researchers hoped to gain a clear picture of how the stakeholders view the centralized inventory system so that they can make informed decisions and improve the system based on the responses provided by the users.

Results and Discussions

The evaluation was conducted using heuristic evaluation and ISO/IEC 25010 software quality standards that focus on the functionality, usability, reliability, and overall system performance. The evaluation also considers key factors like content quality, system appropriateness, visual design, navigation, and cost-benefit value. The evaluation was answered by the city agriculturist and selected registered farmers in Tayabas City.

Table 1. End-User Evaluation Results

Indicator	Description	Mean	Verbal Interpretation
A. Content			
Content Quality	The system covers all the specified functional requirements.	4.53	Strongly Agree
Appropriateness	The system is appropriate for their needs.	4.46	Strongly Agree
Authenticity	The system is authentic and realistic.	4.53	Strongly Agree
Adaptability	The system accommodates a variety of transactions/features related to the needs of the target users in improving their tasks/transactions.	4.30	Strongly Agree
B. Design			
Graphics and Design	The system is attractive and interesting in terms of its:		
	a. Layout	4.40	Strongly Agree
	b. Color combination	4.30	Strongly Agree
	c. Graphs (if available)	4.40	Strongly Agree
Navigation	The system presents functions and information in an inviting and motivating manner encouraging continued interaction	4.60	Strongly Agree
C. Other Consideration			
Cost/Benefit	The benefit of the system clearly justifies the cost when compared with existing similar system	4.70	Strongly Agree
Over-all Rating		4.46	Strongly Agree

Table 1 presents the evaluation results of the end users in terms of content, design, navigation, and other considerations, based on the responses of 15 respondents, they all strongly agreed that the system covers all specific functional requirements and is suitable for farmers and city agriculturists.

Table 2. System Evaluation Result of IT Expert

Indicator	Mean	Verbal Interpretation
1. Functional Suitability.	5.00	Strongly Agree
2. Interaction Capability	4.60	Strongly Agree
3. Reliability	4.30	Strongly Agree
4. Security	5.00	Strongly Agree
5. Maintainability	4.60	Strongly Agree
Over-all Rating	4.70	Strongly Agree

Table 2 shows the results of the system evaluation conducted by IT experts. The results show strongly agreement to all criteria in terms of functional suitability, interaction capability, reliability, security, and maintainability of the system.

Use Case Diagram of the FARMSTAT System

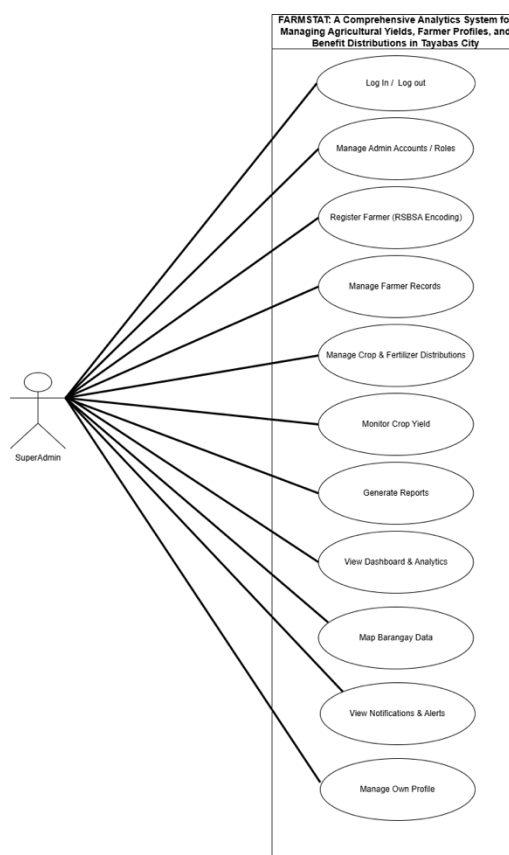


Figure 2: Use Case Diagram of the Super Admin

Figure 2 displays the system function in the SuperAdmin, who can access all the system. Aside from regular admin tasks, the SuperAdmin can also manage admin accounts and roles, ensuring proper access control.

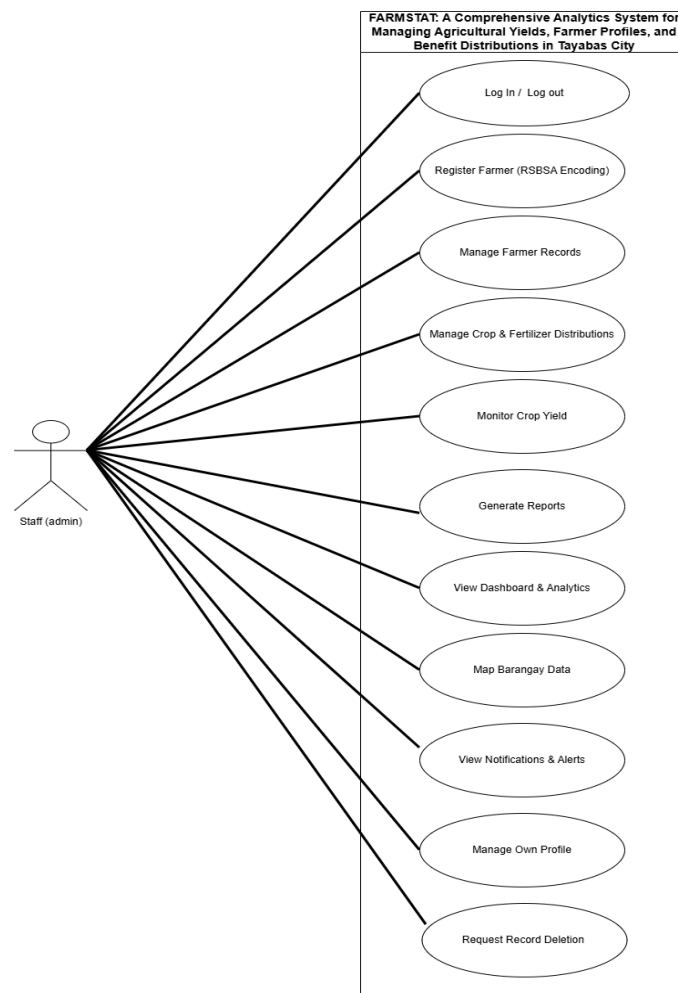


Figure 3: Admin Use Case

Figure 3 shows the system features accessible to the Staff/Admin users. The staff can perform tasks, such as RSBSA farmer registration, managing farmer records, monitoring crop yields, managing crop and fertilizer distributions, generating reports, and viewing analytics dashboards. However, the staff/admin users does not have permission to delete records, and their access is limited, it can create, read and update only.

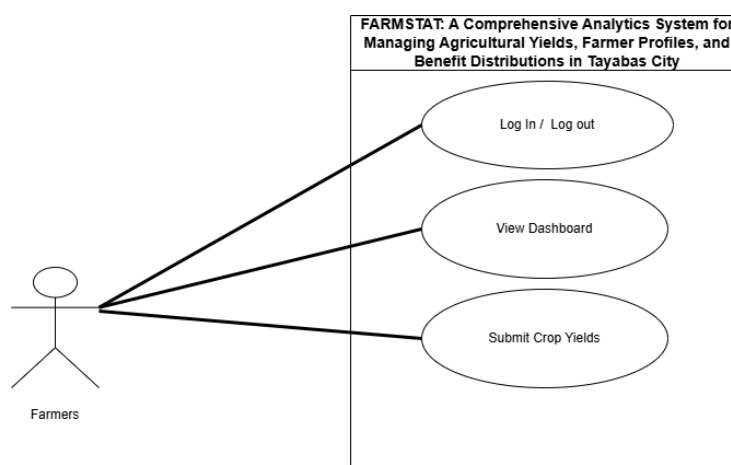


Figure 4: Farmers Use Case

Figure 4 focuses on the farmer-side functionalities in the FARMSTAT mobile application. Farmers are allowed to log in/log out, view their dashboard, and submit crop yields for monitoring.

Activity Diagram of the System

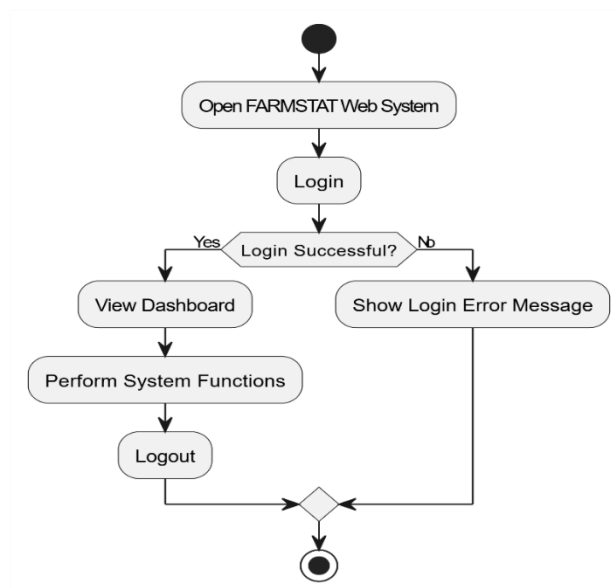


Figure 5: Admin Activity Diagram (Full Web Workflow)

Figure 5 illustrates the entire staff/admin workflow of the FARMSTAT web system. It starts with login validation, followed by module selection by the admin, which includes registering farmers, record management, distribution monitoring, report generation, mapping, and alerts. The end of the process is the logout, which indicates the complete operation cycle. The end of the process is the logout, which indicates the complete operation cycle.

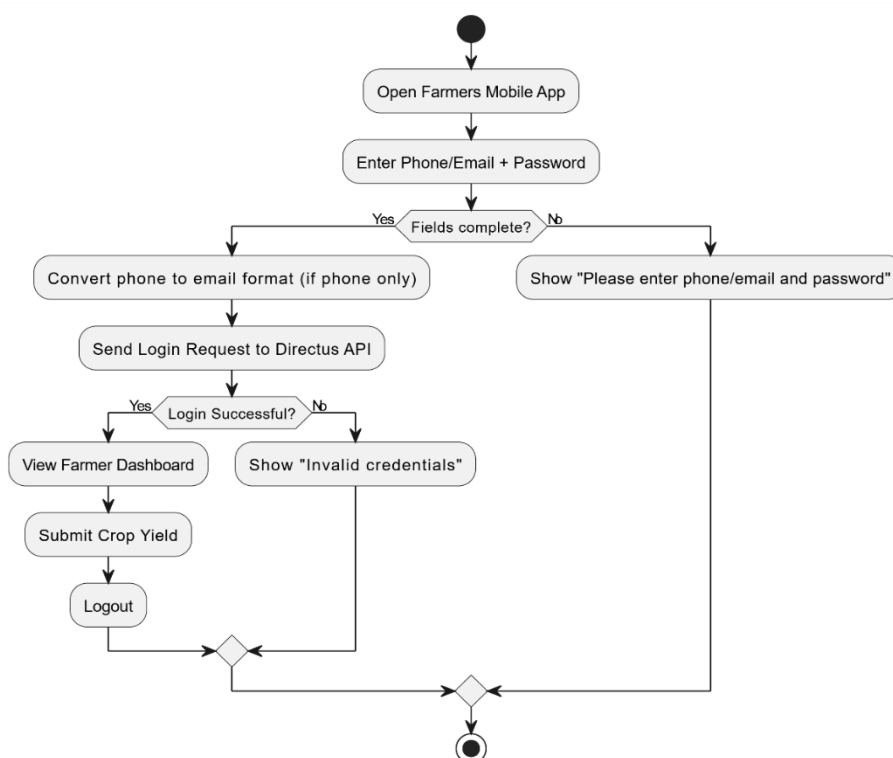


Figure 6: Farmers Activity Diagram (Mobile Login Flow)

Figure 6 illustrates the step-by-step workflow of the farmer's login in the mobile app. It includes decisions such as field completeness, credential validation, and the role authorization before allowing access to the dashboard. It also has error handling, such as showing the invalid input or access denied messages.

Sequence Diagram of the System

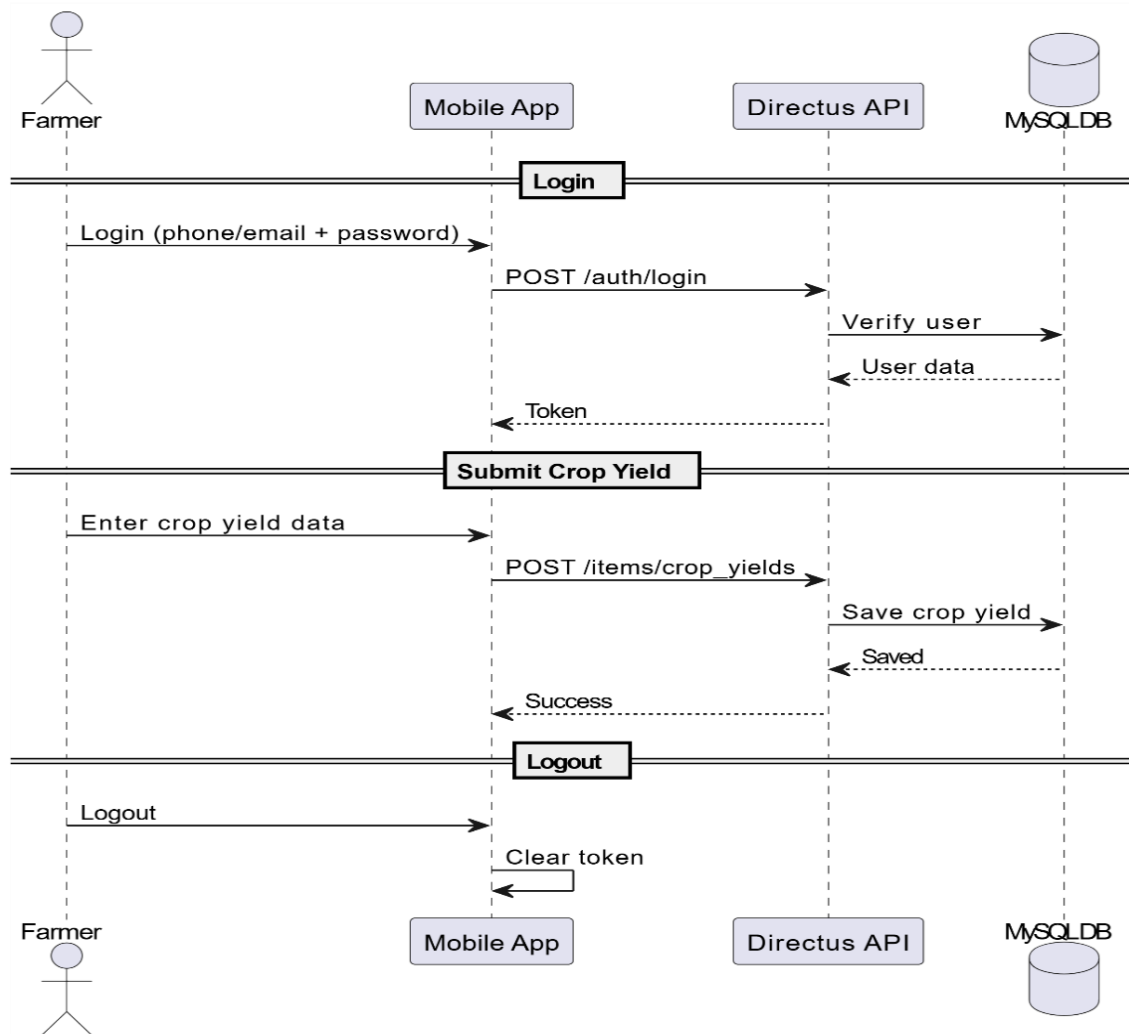


Figure 7: Sequence Diagram (Farmer Login + Submit Crop Yield + Logout)

Figure 7 describes the communication flow between the Farmer Mobile App, Directus API, and MySQL Database. It shows how login credentials are validated, tokens are generated, and crop yield records are submitted through API requests before being stored in the database. It also includes the logout process where stored tokens are cleared.

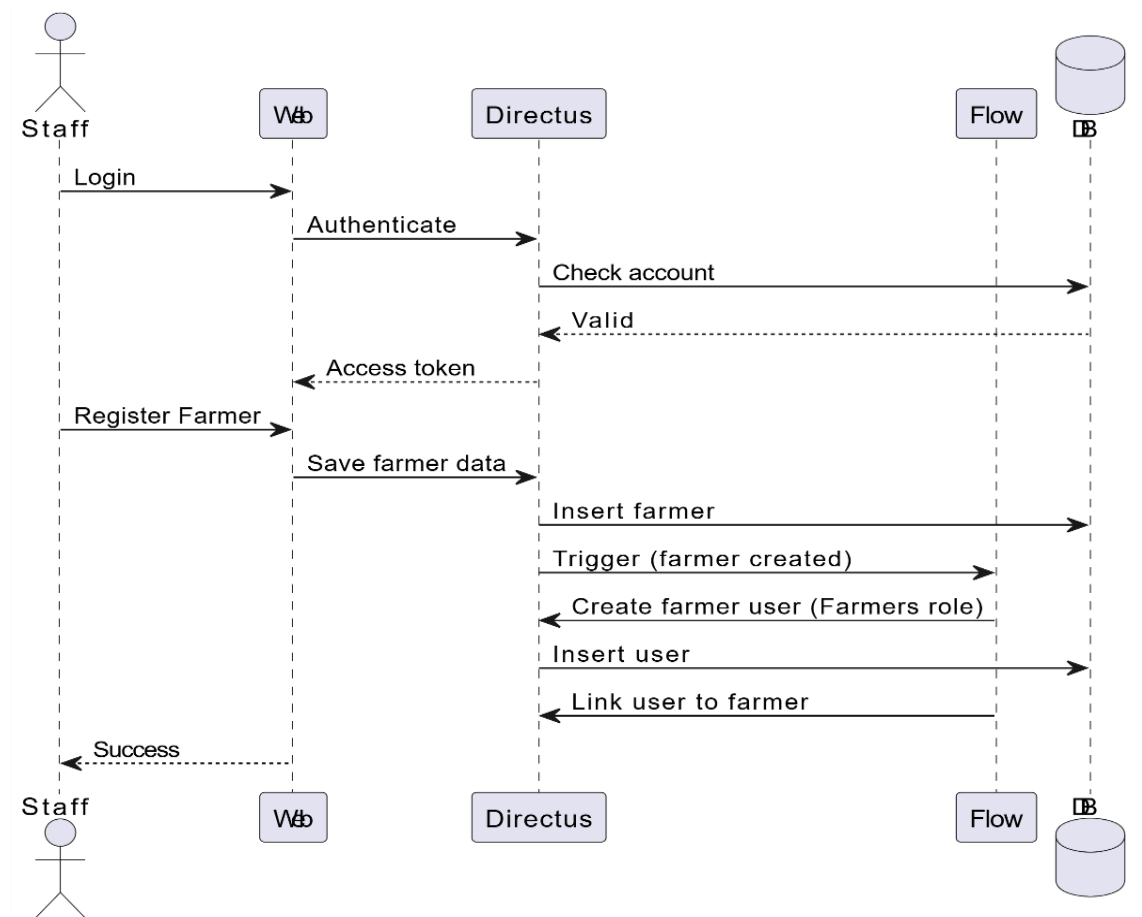


Figure 8: Sequence Diagram (Web Login)

The diagram shows the interaction between the Web Dashboard (React + Nginx) and Directus API and Directus Flow to receive farmers. Once a staff has encoded the data of farmers, the system automatically initiates a flow that will generate a farmer user account and connect it with the farmer record. This automation is to make sure that farmers need not create accounts manually in order to access the mobile app.

ER Diagram of the System

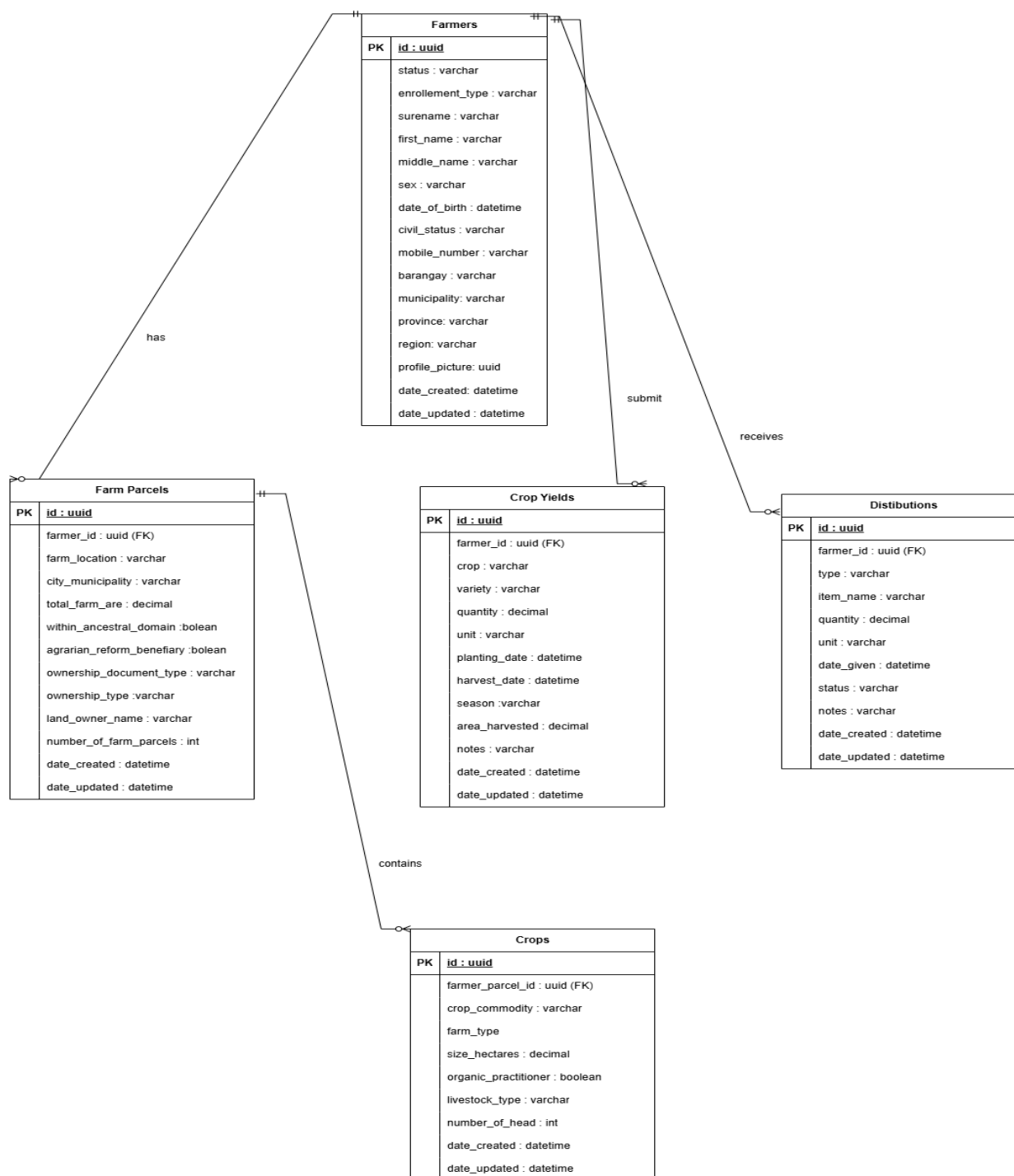


Figure 9: ER Diagram (Database Relationship)

This figure shows the database design and the relationships of the system. It shows that farmers can have multiple farm parcels, can submit crop yields, and can receive distributions, while parcels contain crop related information.

Screenshots of the Developed System

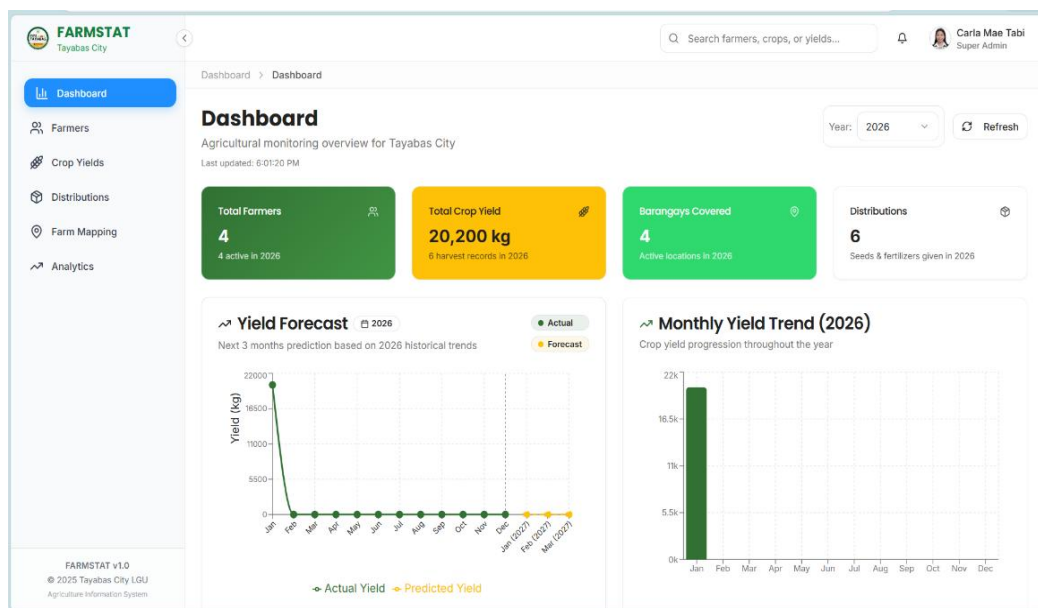


Figure 10: Dashboard Page

Figure 10 is the Dashboard page provides an overview of agricultural activities such as total farmers, crop yields, distribution per year the graphs that show monthly yield and yield forecasts baes on the past data. It also supports decision making in summarized data.

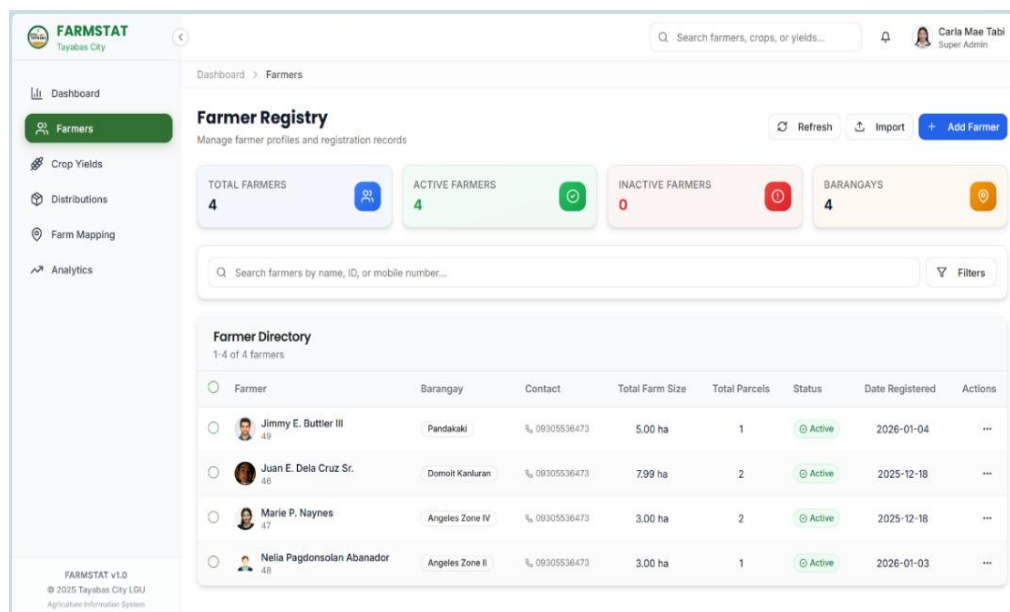


Figure 11: Farmer Management

Figure 11 is the farmer management that city agriculturists manage the profile and registration records of the registered farmers it also needs for the other modules such as monitor crop yield and benefit distribution.

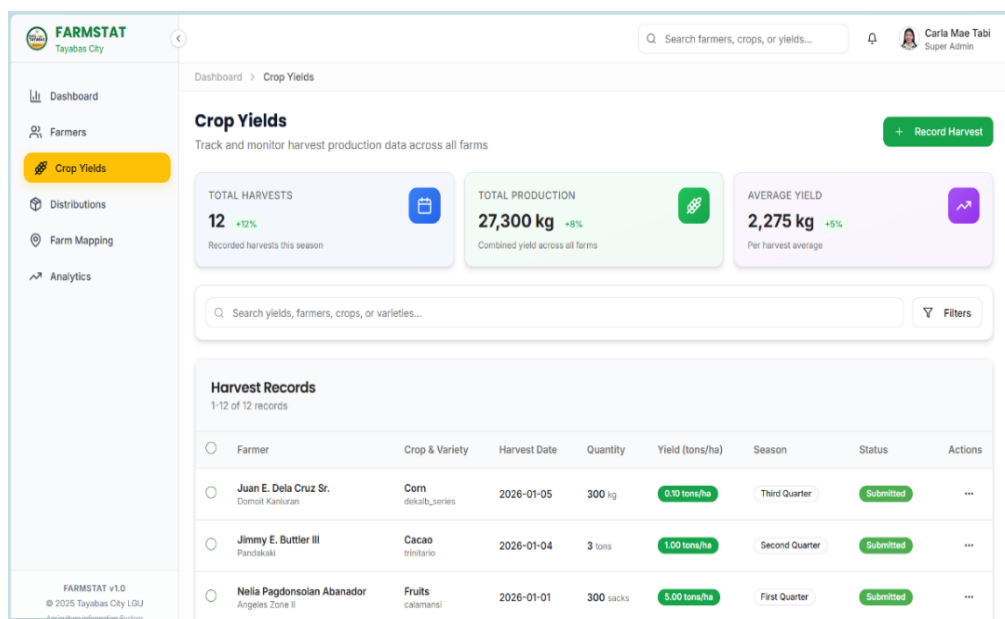


Figure 12: Crop yield monitoring

Figure 12 shows the crop yield page tracks harvest output and yield performance, it provides summary metrics such as total harvests, total production, and average yield for a selected period. It supports tracking of agricultural outputs for the monitoring and assessment of the productivity of agricultural products.

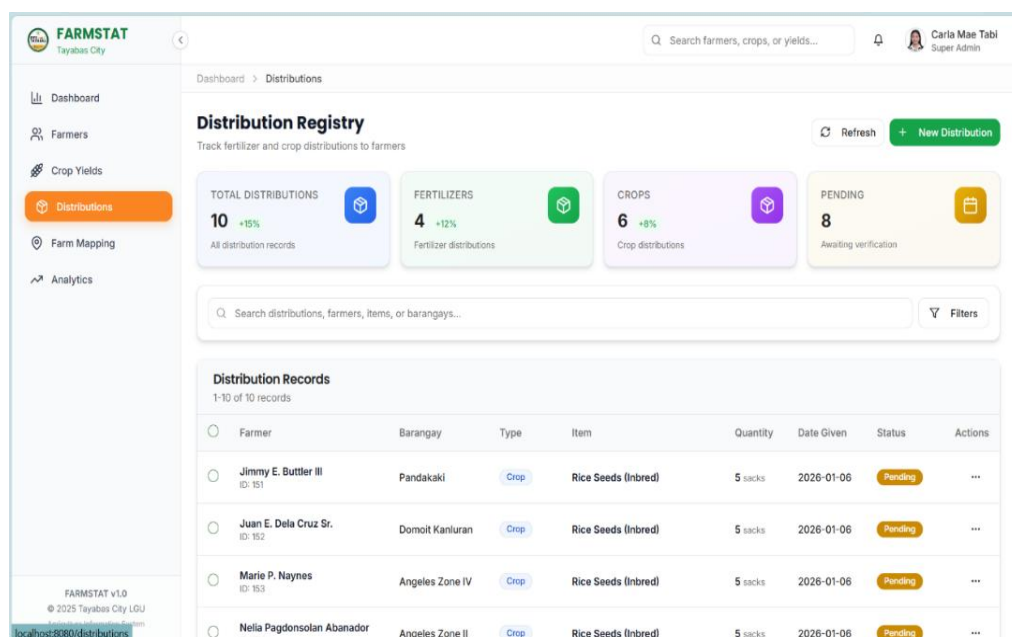


Figure 13: Distribution Management

Figure 13 shows the distribution management registry can track the distribution benefits like crops and fertilizers to the registered farmers it also helps the city agriculturist to monitor status and ensures that the transparency and accountability was distributed properly.

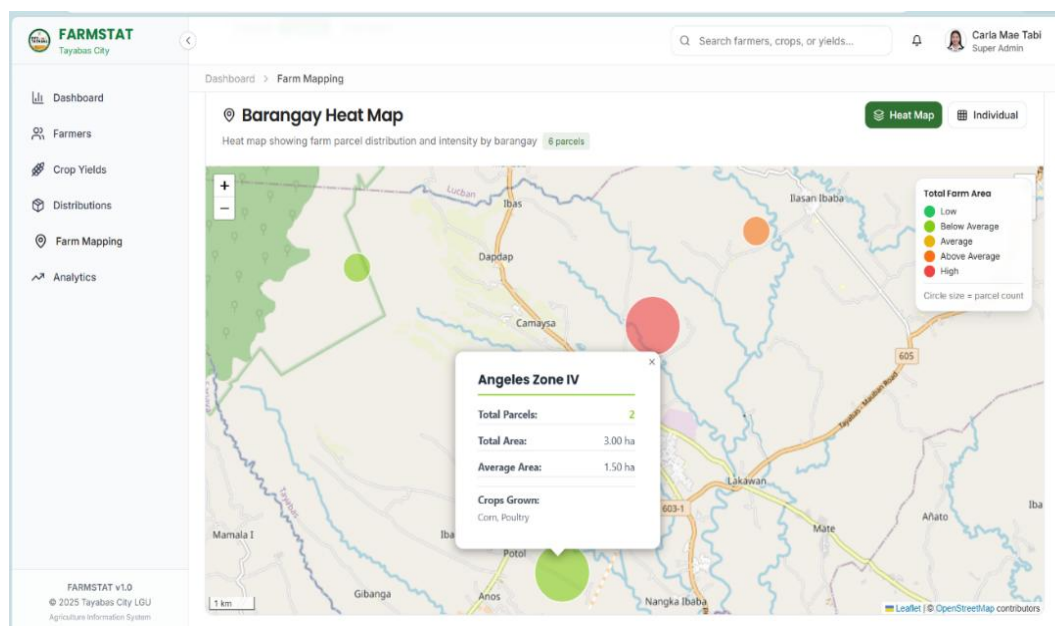


Figure 14: Barangay Mapping

Figure 14 illustrates the barangay heat map represents farm parcels in Tayabas City each circle corresponds to a barangay with size and color of a total farm area clicking the circles reveals the total farm parcels, land area, average area and crop grown.

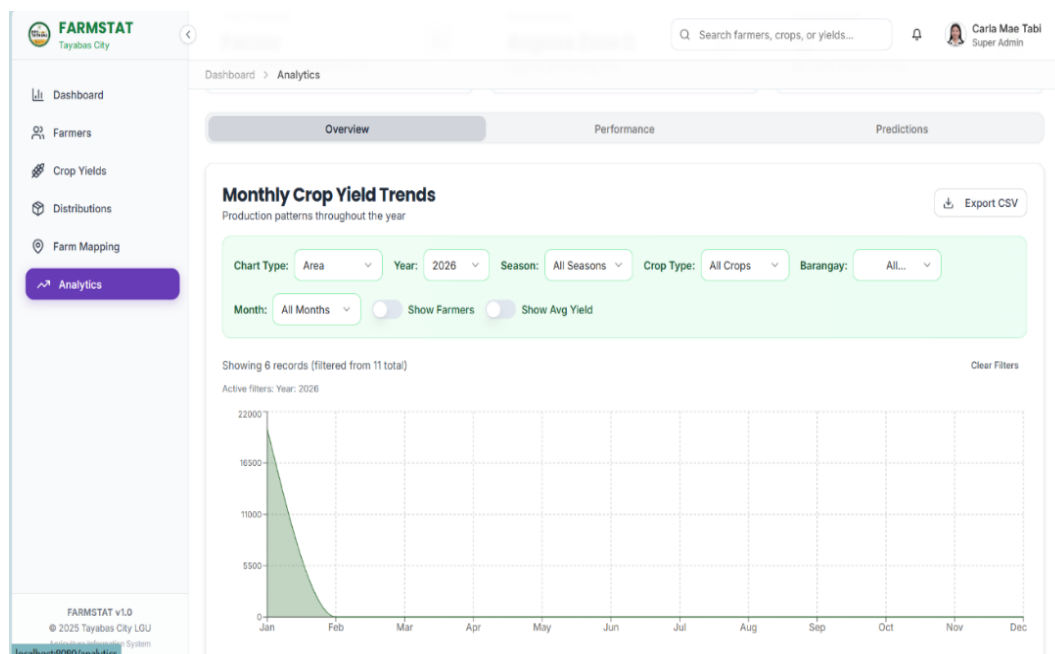


Figure 15: Analytics

Figure 15 presents the analytics module showing monthly crop yield trends it also serves the graphic visualization that can identify peak and low productions periods using charts and graphs. This can help with data driven plans and performance in the future agricultural analysis.

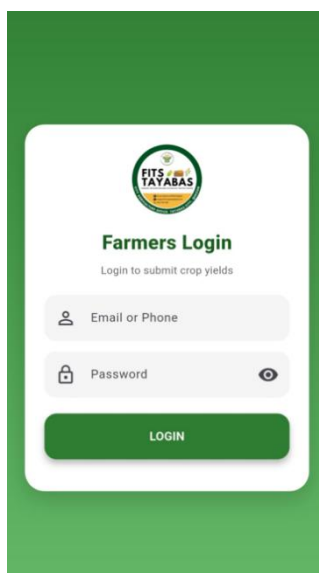


Figure 16: Farmers Login (Mobile Application)

Figure 16 is the Farmers Login Screen, the authentication interface of the FARMSTAT mobile application where farmers enter their registered email/phone number and password to access the system. This function ensures that only authorized farmer users can log in and use the mobile features of the application. After successful login, the user is redirected to the farmer dashboard where they can submit crop yield records.

Figure 17: Crop Yield Form (Mobile Application)

Figure 17 is the Crop Yield Form Screen where farmers encode and submit their crop yield information into the FARMSTAT mobile application. It allows the user to select the crop type and variety, then enter important yield details such as quantity harvested, unit of measurement, and harvested area (hectares). This form also includes the growing period inputs (planting and harvest dates) to ensure accurate yield monitoring and analytics for reporting purposes.

Ethical Considerations

To ensure the responsible development and implementation of Farmstat, key ethical principles were strictly observed throughout the study, starting with obtaining informed consent from all participating

farmers, local officials, and the City Agriculturist after fully explaining the project's purpose and assuring them that participation was entirely voluntary. In strict compliance with the Data Privacy Act of 2012 (Republic Act No. 10173), all personal information, contact details, and barangay-level records were encrypted, secured behind user authentication protocols, and reported in anonymized, aggregated formats to protect individual identities. Additionally, the system promoted digital equity by incorporating a user-friendly interface and multilingual support, ensuring that farmers with varying levels of digital literacy could access benefits and submit reports without facing technological barriers. Finally, data integrity was maintained through automated verification processes within the platform, ensuring fair, transparent, and unbiased tracking of crop yields and fertilizer distribution across all local communities.

Conclusion

In conclusions, the farmstat effectively addressed the limitations of traditional manual agricultural record-keeping practices by providing a centralized and analytics-based system, by improving the organization of farmers' profiles, and monitoring agricultural yields and managing benefit distribution. The Farmstat system addressed the challenges faced by city agriculturists in Tayabas by transitioning manual record keeping into a centralized and analytics-based system, resulting in improved data accuracy, faster report generation, and support decision making. The evaluation results conclude that the farmstat is user-friendly to its intended users. The system is also reliable in its functionality and supports efficient monitoring and reporting of agricultural data. Based on the ISO/IEC 25010 evaluation, the study concludes that the Farmstat meets the international software quality requirements, resulting in the fact that the Farmstat is reliable, secure, and maintainable and that it is suitable for implementation.

Recommendations

Based on the results of the study, several recommendations were suggested. The local government unit of Tayabas, especially the City Agriculture Office, encouraged to adopt the Farmstat system to improve their management of agricultural yields, farmer profiles, and benefit distribution by ensuring the effectiveness of the system we recommend to promote proper training and orientation for the city agriculturist and registered farmers. For the use of Farmstat, it helps to improve data organization, real-time monitoring, and transparency in the agricultural sector. For future System improvements, advanced analytics features such as yield forecasting using machine learning and weather-based decision support system is recommended. However, expanding mobile functionalities for farmers, such as notifications in distribution schedules and farm analytics based on their crop yield submissions, may improve. In terms of security and data privacy, it is recommended to strengthen data protection mechanisms and the integration of security in different agricultural databases and information systems. Having regular maintenance and updates should also be conducted for reliability and adaptability for future requirements. The system is enhanced by extending its coverage to other cities or municipalities to assess the scalability and adaptability in agricultural contexts. To provide user training for non-technical users during system deployment.

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