



PLANNING MALAYSIA:

Journal of the Malaysian Institute of Planners

VOLUME 23 ISSUE 6 (2025), Page 361 – 377

QUEENAPP: A DECISION-SUPPORT PRODUCTION SCHEDULING SYSTEMS TOWARDS IMPROVED PINEAPPLE FARMING

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Abstract

Pineapple (*Ananas comosus*) is one tropical fruit that is most traded worldwide. Currently, around 90 countries and areas around the world grow pineapples. In the Philippines, Queen Pineapple (QP), which is a variety of pineapple, occupies 2,525 hectares of agricultural land, and is the prime agricultural commodity in Camarines Norte, where 92% of the pineapple in the Bicol Region comes from. For many years, the production of QP in the province, as well as in the country, has relied mainly on no particular schedule and thus has no access to data-driven insights that help with decision-making. In this study, the main objective is to develop an application that will improve pineapple farming and enhance production scheduling using a rule-based algorithm. A Rational Unified Process was used to develop the system, where the Projected Planting Schedule using Timetable, Automatic Production Cost, and ROI Computation, and Data Visualizations are the main features that helped the farmer maximize the resources in planting and harvesting pineapple. The respondents agreed (4.17) with the overall perceived performance and strongly agreed (4.34) on the acceptance of the system; these results strongly suggest that the system is well-designed, promotes positive user experiences, and meets its intended objectives in optimizing pineapple farming processes. The system was well accepted by end users, thus it is usable and effective.

Keywords: Decision Support System, Pineapple Farming, Queen Pineapple

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INTRODUCTION

Pineapple (*Ananas comosus*) is the second most important tropical fruit worldwide after mango and remains a major revenue source for many agricultural economies. In 2017, global production reached approximately 25.8 million tons (Altendorf, 2019), with China, Brazil, the Philippines, and India as leading producers. The Philippines is among the top exporters, and Camarines Norte serves as a major production area of the Queen Pineapple (QP), cultivating about 2,525 hectares. As the flagship agro-commodity of the province, QP accounts for 92% of the Bicol Region's pineapple output and has been a primary livelihood source since the 1950s (PCAARRD ISPWEB, 2022). Despite its importance, QP production has long relied on non-standardized schedules, posing challenges to sustainability amid growing concerns about climate change and land productivity.

Pineapple yields are influenced by factors such as labor availability, farm size, fertilizer application, and pest management. Studies by Ria et al. (2021) and Oniah and Okon (2022) emphasize that variables including labor, fertilizer costs, and sucker prices significantly affect productivity. Persistent labor constraints remain a concern, as many farmers still depend on manual methods and lack access to advanced agricultural equipment (Ghazi et al., 2023). Insufficient knowledge of efficient farming practices further hinders productivity (KanjanaMongkolniphath et al., 2022).

The absence of an organized production scheduling system exacerbates these issues. In Camarines Norte, farmers typically plant without a coordinated schedule, resulting in irregular harvests and periods of oversupply. Logistics challenges—such as poor road access and high transport costs—intensify the problem (Enibe & Raphael, 2020). Price volatility and the perishability of pineapple complicate market forecasting, making profitability difficult to sustain. Research by Nahar et al. (2020) and Campita et al. (2022) highlights the crucial role of marketing channels and price stability in ensuring viable pineapple farming. These challenges underscore the need for a system that delivers timely, accurate, and actionable information to farmers.

Technology interventions have shown potential in addressing similar agricultural concerns. Previous studies have explored mobile applications and artificial intelligence (AI) for disease detection, recommendation systems, and fruit classification (Rekha et al., 2022; Bandara et al., 2022; Cuong et al., 2022; Arboleda et al., 2021). While these innovations provide useful insights, none directly address the critical problem of production scheduling—a gap that the present research seeks to fill.

This study proposes the development of QueenApp, a decision-support system designed to improve pineapple production in Camarines Norte through a rule-based scheduling algorithm. This applies predefined rules to input variables—such as farm size and soil quality—to generate optimal planting and

harvesting recommendations. Rule-based approaches are well-suited to agriculture due to their transparency, interpretability, and grounding in established farming practices.

Rule-based algorithms in decision support systems have been successfully applied in pest control, pesticide scheduling (Sumaryanti, Istanto, & Pare, 2020), irrigation management based on soil moisture and crop requirements (Yousif et al., 2018), and precision agriculture (Mehedi et al., 2024). For pineapple production, such systems can guide farmers in determining appropriate planting cycles, fertilizer timing, and harvest periods aligned with market demand.

A major limitation in current pineapple farming is inefficient data management and the absence of predictive tools to support decision-making. This leads to suboptimal scheduling, resource misallocation, and market mismatches. QueenApp aims to address these constraints by integrating real-time data, predictive analytics, and rule-based recommendations into an accessible platform for farmers. By providing accurate and timely guidance, the system supports better scheduling, enhances resource management, and reduces waste.

Effective production scheduling is essential for improving both profitability and sustainability. It enables precise application of inputs, reduces production costs, minimizes environmental impacts, and helps synchronize supply with market demand—preventing oversupply and stabilizing prices. Through these capabilities, QueenApp represents an important step toward modernizing pineapple production in Camarines Norte and strengthening its economic viability.

Overall, the challenges facing pineapple cultivation in Camarines Norte—from uncoordinated scheduling to high input costs and limited technological adoption—highlight the need for a comprehensive decision-support tool. This research introduces QueenApp, a rule-based production scheduling system designed to optimize farm operations, improve productivity, and enhance the long-term sustainability of pineapple farming. By combining real-time data, predictive modeling, and geospatial insights, QueenApp has the potential to empower farmers with informed, data-driven decision-making and contribute to the continued advancement of the pineapple industry in the region.

RESEARCH METHODOLOGY

Research Design

This study employed a developmental and quantitative research design to evaluate the usability of QueenApp. The research approach focused on system development and collecting measurable data regarding farm production, scheduling optimization, and resource management. Through statistical and computational analysis, the system's impact on farm productivity was assessed.

Data Collection

Data collection was conducted through both primary and secondary sources to ensure a comprehensive and accurate analysis of QueenApp's impact on pineapple farming.

Primary data were gathered through surveys and structured interviews with agricultural extensionists from the Office of the Provincial Agriculturist (OPAG) in Camarines Norte. These engagements provided valuable insights into the common challenges faced by pineapple farmers, including inefficient scheduling, resource management issues, and unpredictable yields.

Secondary data comprised historical records, soil quality assessments, and climate pattern reports collected from 2020 to 2023. Additionally, relevant literature from agricultural research journals, government reports, and scientific studies was reviewed to contextualize the findings and support the development of QueenApp. These sources provided a broader understanding of existing agricultural practices, market trends, and technological advancements in precision farming.

System Development

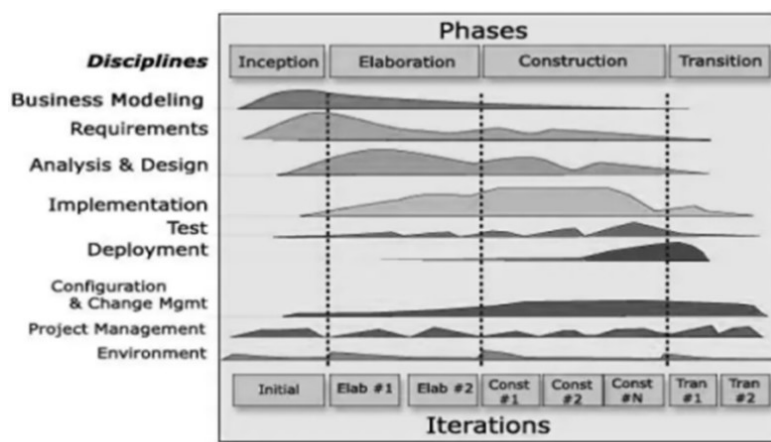


Figure 1: Rational Unified Process (RUP)

The development of QueenApp followed the Rational Unified Process (RUP) model as shown in Figure 1, ensuring a systematic and iterative approach. The Inception Phase involved understanding business needs, defining project scope, and identifying key system requirements. During the Elaboration Phase, the system architecture was designed, incorporating rule-based algorithms, machine learning components, and geo-spatial data models. In the Construction Phase, core functionalities such as geotagging pineapple farms, automated

fertilizer computation, and predictive yield analysis were implemented. The final stage, the Transition Phase, involved rigorous testing with farmers and agricultural experts. This phase included refining system performance based on feedback, ensuring usability, and finalizing deployment procedures.

System Architecture

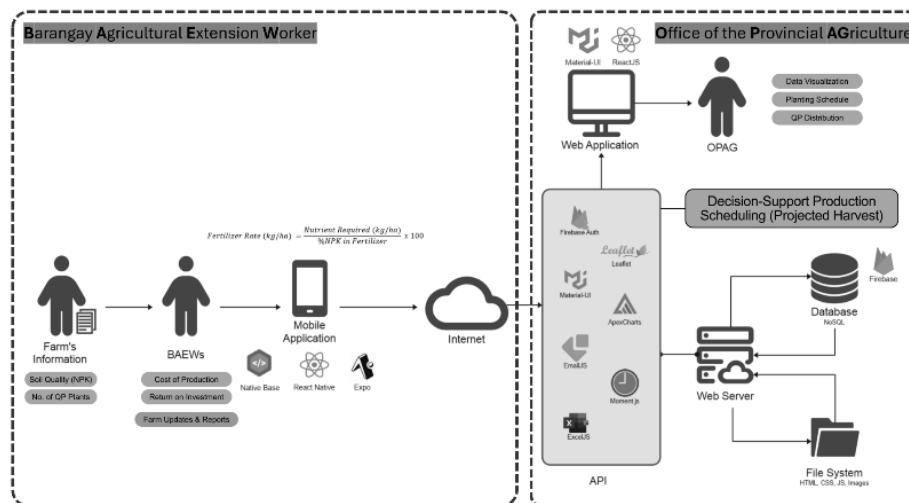


Figure 2: System Architecture

The system architecture of QueenApp in Figure 2 provides a structured framework that integrates multiple components to enhance pineapple farming operations and production scheduling. It consists of three main layers: Users, Applications, and Backend Infrastructure, ensuring real-time data processing, efficient communication, and intelligent decision support. The system serves two primary users: OPAG Admins, who manage data visualization, planting schedules, and Queen Pineapple (QP) distribution through a web application, and Barangay Agricultural Extension Workers (BAEWs), who collect and update farm-related data such as soil quality (NPK levels), costs of production, return on investment, and farm reports via a mobile application. This data is used to compute the required fertilizer rates and optimize crop management.

The application layer facilitates seamless interaction between users and the system. The web application, built with ReactJS and Material-UI, provides OPAG Admins with interactive dashboards, planting schedules, and farm distribution insights. Meanwhile, the mobile application, developed using React Native, NativeBase, and Expo, allows BAEWs to gather farm data, update reports, and monitor production costs in real-time. These applications

communicate with the backend infrastructure over the internet, ensuring continuous synchronization and accessibility.

At the core of the backend infrastructure is the developed system, which connects the applications with the database through an API layer. The system integrates multiple technologies such as Firebase Auth for secure authentication, Leaflet for farm mapping, ApexCharts for data visualization, EmailJS for automated notifications, Moment.js for scheduling, and ExcelJS for data export and analysis. The web server processes user requests, while a NoSQL Firebase database efficiently stores farm-related data. Additionally, a file system manages resources such as HTML, CSS, JavaScript files, and images to support application functionality.

The Decision Support Production Scheduling (Projected Harvest) module is the core intelligence of the system managed by the OPAG, analyzing farm data to generate optimized planting schedules, fertilizer recommendations, and soil health insights. This module supports efficient resource allocation, prevents oversupply, and minimizes production losses by providing real-time farm updates and strategic recommendations. Through this architecture, QueenApp enhances farm management, improves scheduling, and enables data-driven decision-making, making it a scalable and efficient solution for Queen Pineapple farming in Camarines Norte.

Evaluation Matrix

Table 5: Five-Point Likert Scale and Interval

Likert-Scale Description	Scale	Interval
Strongly Agree (SA)	5	4.21 to 5.00
Agree (A)	4	3.41 to 4.20
Neutral (N)	3	2.61 to 3.40
Disagree (D)	2	1.81 to 2.60
Strongly Disagree (SD)	1	1.00 to 1.80

Source: Nyutu et al. (2021)

The study applied the ISO/IEC 25010:2011 software quality standard to assess the system's overall performance using a five-point Likert scale, following the approach of Afriani, Wahyuddin, and Perdana (2022) and Mt Akhir et al. (2021) in Table 1 and the app development evaluation method used by Nicart et al. (2024). The assessment focused on three key metrics: Functional Suitability, Performance Efficiency, and Reliability. Functional Suitability was measured by the system's ability to optimize farming operations, such as scheduling and fertilizer management. Performance Efficiency was assessed through system response time, data processing speed, and overall computational effectiveness (Mohamed et al., 2021). Reliability metrics included uptime stability, fault tolerance, and error handling in real-time operations

(Karunathilake et al., 2023). Additionally, a user acceptance test was conducted using the Technology Acceptance Model (TAM) framework. This evaluation measured users' perceived ease of use, attitudes toward technology adoption, and intention to use the system in real-world farming scenarios (Cai et al., 2023). The researchers used Cronbach's Alpha to measure the internal consistency reliability of a set of questions on a scale.

RESULTS AND DISCUSSION

Key Features

QueenApp, like in the study of Chen et al. (2024), was developed to enhance efficiency in pineapple farming by integrating decision-support tools tailored for resource management and production scheduling using a mobile application as an interface for agriculture extensionists shown in Figure 3.

← Pagkalkula

KALKULAHIN

Nitrogen (N), Phosphorus (P), and Potassium (K)

LLS (Low, Low, Sufficient) ▼

Klase ng Lupa

Loam ▼

Bilang ng Tanim

30000 Kalkulahin

COST AND RETURN ANALYSIS 1.00 HA PINEAPPLE PRODUCTION

Particulars	Quantity	Unit	Price/Unit (₱)	Total Price (₱)
Fertilizers				
Apply during the 1st month				
Ammophos (16-20-0)	0.5	bag	1,463.58	731.8
Urea (Granular) (46-0-0)	1	bag	3,000	3,000
Muriate of Potash (0-0-60)	0	bag	1,820	0
Complete (14-14-14)	1.5	bag	1,582.07	2,373.1
Apply during the 4th month				
Urea (Granular) (46-0-0)	1.5	bag	3,000	4,500
Muriate of Potash (0-0-60)	0	bag	1,820	0
Water Soluble Calcium Nitrate (17-0-17)	0.5	bag	1,500	750
Apply during the 7th month				
Ammophos (16-20-0)	0.5	bag	1,463.58	731.8
Urea (Granular) (46-0-0)	1	bag	3,000	3,000
Muriate of Potash (0-0-60)	0	bag	1,820	0
Complete (14-14-14)	1.5	bag	1,582.07	2,373.1

← Pagkalkula

Apply during the 10th month

Urea (Granular) (46-0-0)	1.5	bag	3,000	4,500
Muriate of Potash (0-0-60)	0	bag	1,820	0
Water Soluble Calcium Nitrate (17-0-17)	0.5	bag	1,500	750

Total Fertilizer Input: ₱22,708

Materials:

Flower Inducer (ethrel)	0.5	liter	800	400
Land Rental	1	Hectare	5,000	5,000
Urea	21	kilo	60	1,260
Diuron	2	kilo	747	1,494
Sticker	1	liter	450	450
Planting Materials	30,000	pcs	1	30,000

Total Material Input: ₱38,604

Labor:

Cleaning/Sorting	10	MD	350	3,500
Fertilizer Application	4	MD	350	1,400
Flower Induction	4	MD	400	1,600
Spraying	8	MD	400	3,200
Hauling	15	MD	350	5,250
Plowing	10	MAD	350	3,500
Land Clearing	15	MD	350	5,250
Harvesting	15	MD	350	5,250
Planting	15	MD	350	5,250
Harrowing	4	MAD	350	1,400

Total Labor Input: ₱35,600

Total Cost of Production ₱96,912

Good Size	27,000	pcs	10	270,000
Butterball	3,000	pcs	6	18,000

Net Return ₱191,088

ROI 66.35 %

Figure 3: Production Cost and ROI Computation

In the previous study, Esteban and Santos (2021) used data science to develop an online platform for crop production with a decision support system to help the younger generation of Filipino farmers. The purpose of the system is to monitor farming activities, costs, and meteorological data to increase crop productivity. All farmers will benefit significantly from the Decision Support System's agricultural chronology and weather data, which is also anticipated to improve the country's economic status by boosting smallholder productivity. Moreover, Bucci et al. (2020) presented that the economic advantages of a higher crop yield and lower input costs (such as seed, fertilizer, and agrochemicals), as

well as lower fuel consumption, must be considered, as must the environmental advantages of more accurate fertilizer and agricultural chemical targeting. Additional elements considered in production planning procedures include fertilization to guarantee the quantity of nutrients in the soil (Albornoz, Véliz, Ortega, & Ortíz Araya, 2020) and economical seed planting (Ahsan & Dankowicz, 2019).

$$(1) \text{ Fertilizer Rate } \left(\frac{kg}{ha} \right) = \frac{\text{Nutrient Requirement } \left(\frac{kg}{ha} \right)}{\% \text{ NPK in Fertilizer}} * 100$$

The system's Automated Fertilizer Calculation feature, using (1), helps farmers apply precise amounts of fertilizer based on real-time soil data, reducing costs and promoting sustainable practices. For the Return On Investment (ROI), the system calculates the total net return divided by the gross return and then multiplied by 100 based on the (2) used by the OPAG.

$$(2) \text{ ROI} = \left(\frac{\text{Net Return}}{\text{Gross Return}} \right) * 100$$

```
function getFertValue(N, P, K, fertilizerOptions) {
  let options = [];
  const { lowest, field, fertilizers } = getFunction(N, P, K, fertilizerOptions);
  for (const f1 of fertilizers) {
    let n1 = N; let p1 = P; let k1 = K;
    const percent1 = f1[field] / 100;
    const amount1 = (lowest / percent1);
    n1 = n1 - (amount1 * (f1.N / 100));
    p1 = p1 - (amount1 * (f1.P / 100));
    k1 = k1 - (amount1 * (f1.K / 100));
    ...
    if (fertObj1 === null) { continue }
    const price1 = fertObj1.price
    const totalPrice1 = price1 * amnt1;
    if (n1 <= 0 && p1 <= 0 && k1 <= 0) {
      const len = options.length;
      options.push(
        [{
          ...fertObj1,
          qntyPrice: amnt1,
          price: formatNum(price1),
          totalPrice: formatNum(totalPrice1),
        }]);
      continue;
    }
    ...
    const sortedOptions = options.sort((a, b) => {
      const sumA = a.reduce((sum, fert) => sum + fert.totalPrice, 0);
      const sumB = b.reduce((sum, fert) => sum + fert.totalPrice, 0);
      return sumA - sumB;
    }).slice(0, 5);
    return sortedOptions;
  }
}
```

Figure 4: Code Implementation

Figure 4 presents the actual code that implements the mathematical formulas labeled as (1) and (2). These formulas are used in a mobile application designed specifically for agricultural extensionists. The implementation uses a rule-based algorithm, which means the system follows a set of predefined rules or conditions like "if-then" logic. These rules are derived from domain knowledge, likely based on farming practices or agricultural research. The purpose of the code is to automate the calculations or decisions derived from formulas (1) and (2), helping the users analyze farm data more efficiently, make consistent, data-driven recommendations, and support decision-making for improved farming operations.

The Projected Planting Schedule using the Timetable in Figure 5 (a) incorporates crop maturity to recommend optimal harvesting times, ensuring higher profitability and improved product quality (Badmus & Aderinto, 2019).

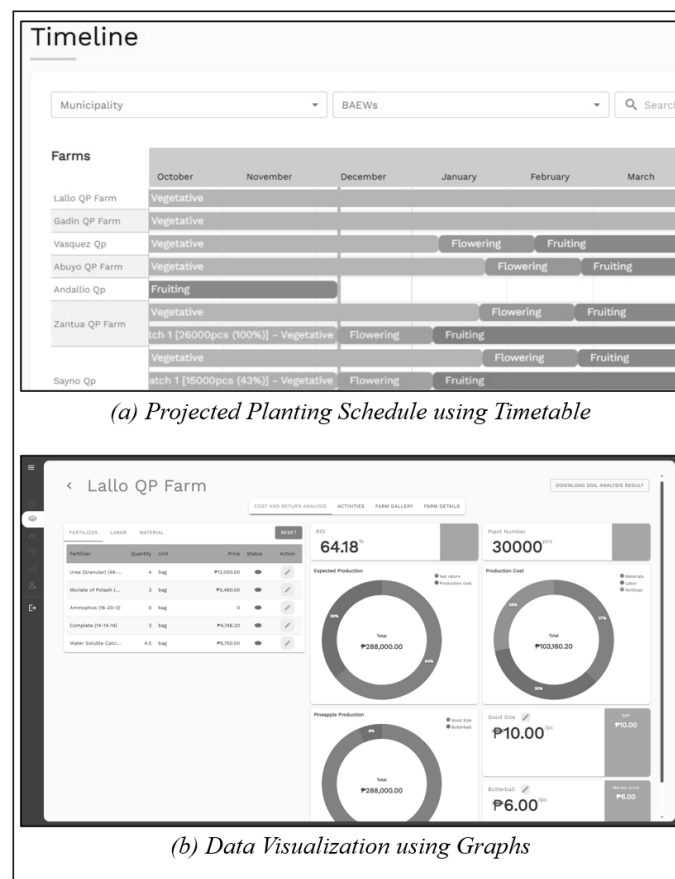


Figure 5: Other Key Features

This feature collectively supports a more systematic and data-driven approach to pineapple farming, ultimately enhancing productivity and sustainability. In previous work, Sajid and Hu (2022) proposed a two-stage crop planting model that suggests planting dates based on logistical and capacity constraints and plant growth. The best planting dates are then chosen using a rule-based algorithm to ensure that weekly harvesting amounts don't surpass the storage capacity. Additionally, Huang et al. (2020) created a model that schedules crops in a commercial plant factory to optimize revenue by figuring out which crops are grown, how many are grown, and when. Crop characteristics, including cultivation duration, volume change, numerous harvest dates, and yield rates under various environmental conditions, are all taken into account by the model in addition to crop market pricing.

Data Visualization using Graphs in Figure 5 (b) allows farmers to forecast harvest volumes accurately, preventing market oversupply and financial losses (Coulibaly, Du, & Diakité, 2021). Geotagging Pineapple Farms provides real-time tracking of farm locations and soil conditions, enabling better land management and optimizing land use (Mwangi, Odhiambo, & Naminde, 2021). Charts, graphs, maps, and other visualization techniques demonstrate how well agricultural data can be represented in a form that is both meaningful and actionable (Kumari et al., 2024). Crop monitoring, weather forecasting, soil analysis, and yield prediction are just a few agricultural processes where data visualization techniques can be applied. They talked about how farmers may find patterns, trends, and anomalies by using visualizations to comprehend and analyze vast amounts of data from sensors, drones, and satellite photography. The authors also examine how cutting-edge technology like artificial intelligence and machine learning can be integrated with data visualization techniques. Similarly, Athesan and Ghazi (2024) proposed dashboard design components with multiple-view concepts from various angles, emphasizing improving smart farming's ecological sustainability, productivity, and resource management. It is anticipated that the suggested dashboard visualization will produce an efficient display that operates in accordance with its purported usage capability. By offering thorough and understandable visualizations of important environmental factors, these dashboard design components empower farmers to make well-informed decisions that maximize crop yields.

Perceived Performance

Table 2: Overall Perceived Performance Evaluation

Indicators	Weighted Mean	Interpretation
1. Functional Suitability	4.20	Agree (A)
2. Performance Efficiency	4.20	Agree (A)
3. Reliability	4.10	Agree (A)
Overall Weighted Mean	4.17	Agree (A)

Table 2 presents the evaluation results of QueenApp using the rule-based algorithm, yielding an overall weighted mean of 4.17, which reflects strong user satisfaction with the system's functionality and performance. The highest scores were recorded in Functional Suitability and Performance Efficiency (both 4.20), indicating that the system effectively delivers its intended capabilities while operating with notable efficiency. These findings reinforce earlier definitions stating that functional appropriateness enables a system to perform as intended and reduce user difficulties (Boneza, 2023), while functional suitability ensures that explicit and implicit user needs are met through complete, correct, and reliable outputs (Vacca et al., 2024). As Wacas (2023) emphasizes, performance efficiency ensures essential processes are executed swiftly, with optimal resource utilization and responsiveness—even under heavy user demands.

Although Reliability received a slightly lower rating of 4.10, the score still signifies dependable system behavior, with minor opportunities for improvement in fault tolerance, error handling, and system recovery. Importantly, the reliability of the instrument used in the evaluation is supported by a Cronbach's alpha of 0.90, indicating excellent internal consistency among the assessment items.

Overall, the strong mean rating of 4.17 confirms that QueenApp is perceived as a functional, efficient, and reliable decision support system. These results validate its capability to enhance pineapple farming and production scheduling in Camarines Norte, while also highlighting areas for future refinement to further strengthen system stability and user confidence.

Degree of Acceptance

Table 3: Overall Degree of Acceptance Evaluation

Indicators	Weighted Mean	Interpretation
1. Perceived Ease of Use	4.42	Strongly Agree (SA)
2. Attitude Towards Using	4.27	Strongly Agree (SA)
3. Intention of Use	4.32	Strongly Agree (SA)
Overall Weighted Mean	4.34	Strongly Agree (SA)

Table 3 summarizes the overall assessment of the system's usability and acceptance based on three key indicators. The results reveal a high level of agreement among users, with an overall weighted mean of 4.34. This indicates that respondents perceive the system as highly usable, beneficial, and worth adopting. Reliability analysis further supports the robustness of these findings, with a Cronbach's alpha of 0.87, demonstrating good internal consistency among the survey items.

Among the individual indicators, Perceived Ease of Use scored the highest with a weighted mean of 4.42, reflecting that users find the system straightforward, user-friendly, and efficient in optimizing pineapple farming. This result emphasizes the system's intuitive design and practical application. Attitude Towards Using garnered a weighted mean of 4.27, showing that respondents view the system positively and appreciate its potential to enhance farming practices. While slightly lower than the other indicators, this score still demonstrates strong acceptance and satisfaction. Finally, Intention of Use received a weighted mean of 4.32, reflecting the users' willingness to adopt and recommend the system for pineapple farming. This suggests a high level of trust and belief in the system's potential to improve farming outcomes.

The evaluation is limited to important features such as the production cost and ROI computation using the mobile application, projected planting schedule using the timetable, and data visualizations using graphs available in the web application. These features were evaluated based on the degree of acceptance by end users, using inputs derived from the self-reported data provided by OPAG.

Overall, the results demonstrate that the system is well-developed, with respondents strongly agreeing on its usability, effectiveness, and value in pineapple farming. These findings underline the system's readiness for broader adoption and implementation in the agricultural sector.

CONCLUSION

The development of QueenApp as a Decision Support Production Scheduling System has demonstrated significant potential in enhancing pineapple farming efficiency in Camarines Norte. The system integrates IT-driven solutions, predictive analytics, and geospatial insights to improve fertilizer application, planting schedules, and harvest planning.

To further enhance its impact, several recommendations are proposed. Integration with IoT-enabled soil sensors and climate monitoring devices can improve real-time data accuracy, enabling more precise fertilizer application and yield forecasting. Expanding QueenApp's functionality to support other crops would allow broader agricultural adoption beyond pineapple farming. Furthermore, enhancing user training and providing continuous support through workshops and technical assistance will maximize farmer adoption and

utilization. Collaborations with government agencies and agricultural institutions can facilitate widespread implementation and policy support for smart farming practices. Finally, integrating AI-driven analytics and machine learning models can refine QueenApp's decision-support capabilities, making it a more adaptive and intelligent agricultural management tool.

Overall, QueenApp represents a significant advancement in digital agriculture, helping farmers improve efficiency, maximize profitability, and contribute to sustainable farming practices. Its continued development and adoption have the potential to drive agricultural innovation, making farming more precise, data-driven, and economically viable.

ACKNOWLEDGEMENT

The researchers extend their sincere gratitude to the agricultural stakeholders of Camarines Norte for generously sharing their time, insights, and experiences. Appreciation is also given to the Office of the Provincial Agriculture for their support in providing valuable data and technical guidance. Lastly, the authors thank their academic mentors and colleagues whose expertise and encouragement greatly contributed to the completion of this study.

DISCLOSURE STATEMENT

The authors declare that there are no known financial, professional, or personal conflicts of interest that could have influenced the conduct or outcomes of this study.

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Received: 2nd September 2025. Accepted: 14th September 2025