Vol. 7, No. 4, December 2025

ISI Journal of Information Systems and Informatics

Published By Asosiasi Doktor Sistem Informasi Indonesia

Utilization of the AgriTrack Information System to Strengthen Smart Farming Practices in Small-Scale Hydroponic Enterprises

Eka Wahyu Sholeha[1], Arif Supriyanto[2], Hendrik Setyo Utomo[3], Eka Ridhoni August Firmansyah[4], Aisyah[5], Ardhi Hidayat[6], Liny Mardhiyatirrahmah[7]

[1234567]Politeknik Negeri Tanah Laut, Jl. Ahmad Yani No. KM.06 Pemuda, Pelaihari and 70815, Indonesia

Email: [1]ekawahyus@politala.ac.id, [2]arif@politala.ac.id, [3]hendrik.tomo@politala.ac.id, [4]ekaridhoniaugustfirmansyah23@mhs.politala.ac.id, [5]aisyah23@mhs.politala.ac.id, [6]ardhi.hidayat@mhs.politala.ac.id, [7]linymardhiyatirrahmah@politala.ac.id

Received: Nov 5, 2025

Revised: Nov 24, 2025

Accepted: Dec 5, 2025

Published: Dec 23, 2025

Corresponding Author:

Author Name*:

Eka Wahyu Sholeha

Email*:

ekawahyus@politala.ac.id

DOI:

10.63158/journalisi.v7i4.1385

Abstract. The implementation of smart farming in small-scale hydroponic enterprises is often constrained by high automation costs and technological complexity. This study examines the utilization of the AgriTrack information system as a practical approach to strengthening smart farming practices through structured digital data management. AgriTrack was utilized in a small-scale hydroponic farm using a Software Development Life Cycle (SDLC) Waterfall approach, encompassing system configuration, operational deployment, and evaluation through functional testing and user acceptance testing. The system applies a cycle-based relational data model to manage cultivation records from sowing to harvesting and integrates automated scheduling with Telegram Bot notifications. Testing results indicate a 100% success rate across core operational functions, while user evaluation shows that routine cultivation data recording time was reduced from several minutes to under one minute per entry. Notification delivery was consistently observed within approximately one minute after scheduled triggers, supporting timely operational decisions. These findings demonstrate that AgriTrack effectively strengthens smart farming practices in MSME-scale hydroponic enterprises by improving efficiency and accountability, while providing a scalable foundation for gradual adoption of advanced technologies such as IoT and data analytics.

Keywords: AgriTrack, Agricultural Information System, Smart Farming, Small-Scale Hydroponic Enterprises

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

1. INTRODUCTION

Hydroponic farming has become an attractive solution for sustainable food production, especially in urban areas with limited land availability. By eliminating the need for soil, hydroponics enables efficient use of water, nutrients, and space while maintaining consistent crop quality, making it ideal for small-scale farming enterprises [1], [2]. Recent studies highlight that hydroponic systems support high productivity and resource efficiency, thus contributing significantly to modern smart-farming practices [3], [4]. With increasing climate variability and growing urban populations, hydroponics continues to gain strategic importance as an accessible and scalable method of cultivation.

Despite its potential, many small-scale hydroponic farmers, like Harvest House Garden in Pelaihari, still struggle with inconsistent and unstructured record-keeping, which remains largely manual. Such paper-based logs often lead to data loss, inaccurate scheduling of sowing and harvesting, inefficient nutrient administration, and difficulty monitoring plant development stages [5], [6]. These challenges contribute to operational inefficiencies, production delays, and resource wastage, especially among Micro, Small, Medium Enterprises (MSME) farmers who lack access to advanced automation technologies [7], [8]. This condition is evident in real hydroponic practices, where poor record-keeping disrupts crop cycles and leads to shortages or oversupply of seedlings, ultimately affecting financial stability and production outcomes.

Existing research on smart farming for hydroponics primarily focuses on automation and IoT-based environmental monitoring. Prior studies have developed systems that monitor nutrient levels, pH, temperature, and humidity through sensor integration and wireless data transmission [5], [9]. Other works explore fully automated hydroponic greenhouses equipped with IoT-based irrigation control and nutrient dosing mechanisms [6]. Not only that, most focus on advanced automation or IoT-based solutions that demand significant financial and technical resources [10], [11], [12], [13], [14]. Although these systems demonstrate promising improvements in precision agriculture, they often require costly hardware components, reliable internet infrastructure, and advanced user competence, making them less suitable for micro and small-scale hydroponic operations.

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

A review of the literature indicates that most existing studies in hydroponic smart farming focus on automation and environmental monitoring rather than on simple data management or documentation of cultivation cycles. For instance, several works explore IoT-based hydroponic systems with automated water or nutrient control [15], [16], [17], but such systems often involve hardware, sensors, and infrastructure less feasible for small-scale or resource-limited farmers. Although there are some efforts to build web-based systems for hydroponic cultivation management, these prior systems do not emphasize structured cycle-based record-keeping, growth-stage tracking, and scheduling utilities tailored to small-scale hydroponic farm operational workflows [18]. This shows a clear gap that there is a notable scarcity of lightweight, user-friendly, web-based information systems designed specifically to support systematic documentation of planting cycles, nutrient schedules, maintenance reminders, and harvest planning for MSME hydroponic farmers.

To address this gap, this study proposes AgriTrack, a lightweight and accessible web-based information system specifically designed for MSME hydroponic farmers. The novelty of AgriTrack lies in its focus on cycle-based recording, structured documentation of plant growth stages, automatic maintenance reminders, and nutrient-tracking features, all delivered through a low-cost and user-friendly platform. Rather than emphasizing automation, AgriTrack establishes the foundational digital layer necessary for future smart-farming integration such as IoT sensors and data analytics.

This research aims to: (1) implement AgriTrack as a web-based information system to support structured hydroponic cultivation record-keeping; (2) evaluate system functionality using black-box testing and user acceptance testing; and (3) analyze how AgriTrack improves operational efficiency and accountability in small-scale hydroponic farming.

2. METHODS

This study employs a development research approach to create AgriTrack, a functional information system designed for structured hydroponic cultivation management. The development process followed the Software Development Life Cycle (SDLC) with a Waterfall model, chosen for its suitability in environments where requirements are well-

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

defined from the start and remain stable throughout the process. This model is particularly effective for small-scale hydroponic enterprises, where the target users may have limited digital literacy. The sequential, clear-cut stages of the Waterfall model provide a structured framework, ensuring that users can easily follow the process and adopt the system. In contrast to iterative models, which involve frequent changes and continuous user involvement, the Waterfall model minimizes cognitive load, offering better clarity and coherence in system functionalities [19].

User feedback was systematically collected at the end of each stage to validate outputs and ensure that the system met the user's needs. This controlled feedback mechanism was designed to prevent disruptions to completed stages while maintaining the methodological rigor of the development process. As such, the development process allowed for structured refinement without undermining the integrity of earlier work.

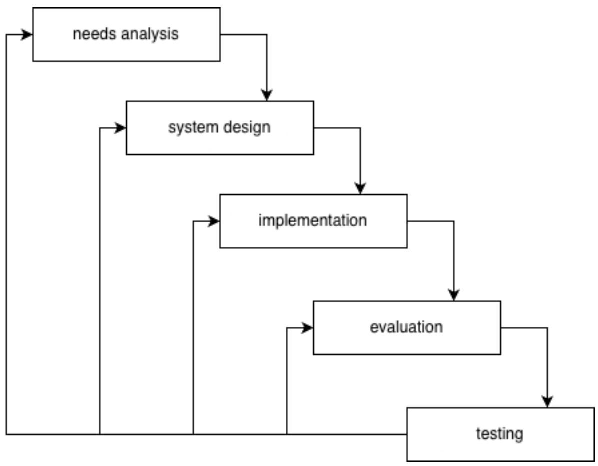

Figure 1. Waterfall Model

2.1. Needs Analysis

A comprehensive needs analysis was conducted through observations and structured interviews with the owner of Harvest House Garden, a small-scale hydroponic business. The goal was to identify key workflow inefficiencies and data management challenges arising from manual record-keeping practices. These insights informed the formulation of both functional and non-functional system requirements. The requirements were then validated through a follow-up confirmation process with the user, ensuring that the system would address the specific operational needs of the enterprise. This stage culminated in a clear, validated list of system functionalities to guide the subsequent development phases.

2.2. System Design

The system design phase included the creation of a detailed database schema and architectural blueprint. An Entity Relationship Diagram (ERD) was developed to model the core entities required for hydroponic management, such as CropCycle, MaintenanceLog, NutrientSchedule, and HarvestRecord. One-to-many relationships were established within the database schema to ensure that multiple activities could be associated with a single crop cycle while ensuring data normalization.

Security measures were integrated into the system design to protect sensitive data. Basic security protocols included user authentication, input validation, and SQL query sanitization. Prepared statements were employed within the CodeIgniter framework to prevent SQL injection attacks and safeguard against malicious user inputs. A clear separation of concerns was maintained in the design, creating distinct modules for the presentation, application logic, and data management layers of the system.

2.3. Implementation

During the implementation phase, AgriTrack was developed using a combination of web technologies: HTML, CSS, and JavaScript (with Bootstrap for responsive design), PHP (using the CodeIgniter framework for its MVC architecture), and MySQL for database management. The system was structured into modular components to ensure scalability and maintainability. Core modules included crop cycle management, scheduling, notifications, and reporting functionalities.

1) Frontend Development: HTML and CSS were used for page layout and design, with Bootstrap integrated to ensure a mobile-responsive user interface.
2) Backend Development: PHP and the CodeIgniter framework were utilized to manage the application logic, implement user authentication, and handle the communication between the user interface and the database.
3) Database Development: MySQL was used to store and manage the system's data. The database schema was designed to ensure efficient data retrieval and storage, optimized for the needs of hydroponic farm management.

The modular architecture supports future extensibility and the integration of additional features, such as IoT sensor data collection and advanced analytics.

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

2.4. System Testing

System testing was conducted to verify that the functionalities worked as expected. Black-box testing was employed, where the system's outputs were tested based on various inputs, without knowledge of the internal workings of the system. The primary objective was to ensure that the system met the functional requirements as specified during the needs analysis. A summary of key test cases is provided in Table 1.

Table 1. Black-Box Test Case Summary

Module	Expected Outcome	Status
Login	Successful authentication	Pass
Crop Cycle Input	Data stored correctly	Pass
Scheduling	Accurate schedule display	Pass
Notification	Timely reminder	Pass
Reporting	Report generated	Pass

User Acceptance Testing (UAT) involved three users from Harvest House Garden. The system was tested under normal operational conditions and was not evaluated under high-load or concurrent access scenarios.

2.5. System Evaluation

The evaluation phase assessed the system's usability, functional correctness, and perceived benefits to the end users. Data collected during user interactions with AgriTrack was documented, and user feedback was systematically analyzed to identify areas for improvement. In particular, feedback focused on the system's ease of use, effectiveness in addressing the needs of the hydroponic farm, and overall user satisfaction.

Future enhancements were also considered during the evaluation phase. These include potential integration with Internet of Things (IoT) sensors to monitor environmental conditions (such as temperature, humidity, and light) and the incorporation of advanced data analytics to optimize crop growth and resource use.

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

3. RESULTS AND DISCUSSION

3.1. System Design and Implementation

AgriTrack was successfully implemented as a lightweight web-based information system to support structured recording of hydroponic crop life cycles in small-scale farming environments. The system adopts a modular architecture consisting of planting table management, crop data, seedling records, cultivation cycle tracking, harvest documentation, and an automated notification module integrated with a Telegram Bot. This modular and relational structure ensures that cultivation data are consistently recorded and traceable across all growth stages.

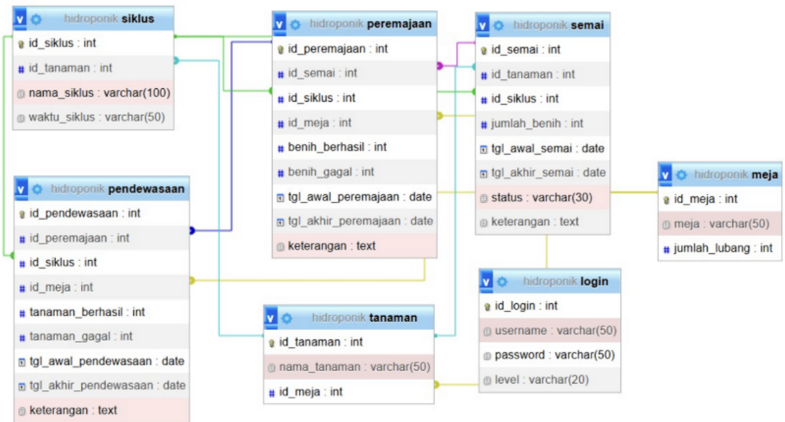

Figure 2. Database Structure

The system was developed using CodeIgniter 4 as the PHP framework, MySQL as the database management system, and HTML, CSS, and JavaScript for the frontend, with Bootstrap applied to support responsive design. These technologies were selected for their stability, ease of maintenance, and suitability for developing structured information systems in resource-constrained agricultural settings.

AgriTrack implements a cycle-based data model in which planting, transplanting, growth, and harvesting activities are stored in interconnected relational tables. This structured and time-stamped data organization provides a foundational layer for future smart-farming analytics, enabling the potential for historical trend analysis, yield monitoring, and gradual integration of sensor-based data without immediate reliance on complex IoT infrastructure.

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

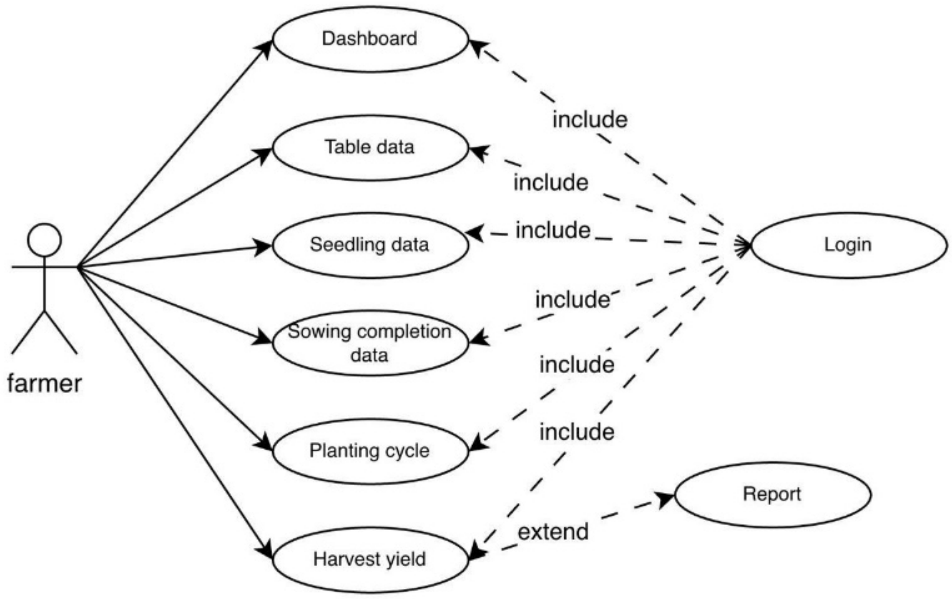

Figure 3. Use Case AgriTrack

Figure 3 presents the use case diagram that is illustrating system interactions with the primary user, such as farm owners or staff. Users perform essential operations such as managing planting tables, inputting seedling data, monitoring cultivation cycles, receiving automated notifications, and recording harvest outcomes. The interaction design emphasizes simplicity and clarity to accommodate users with limited technological literacy. From a security perspective, the current implementation applies basic protection mechanisms appropriate for small-scale and prototype-level deployment. Input validation is enforced across all data entry forms to ensure data integrity and reduce the risk of invalid submissions or simple injection attacks. More advanced security features—such as strong password hashing, role-based access control, and enhanced authentication—are not yet implemented and are identified as priorities for future system development. Overall, the system design and implementation results indicate that AgriTrack successfully delivers a stable, low-cost, and structured digital platform that supports systematic hydroponic cultivation management in small-scale farming contexts.

3.2. Developed Modules and Features

The Table Module (Figure 4) manages information on planting tables, including table identifiers and the number of available planting holes. These data serve as the spatial foundation for crop placement during the transplanting process. Edit and delete

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

functions allow farmers to update records according to physical changes in the field. Structuring table data in relational form enables accurate mapping between crops, locations, and production capacity, which is essential for future analytics such as space utilization efficiency and yield-per-table evaluation.

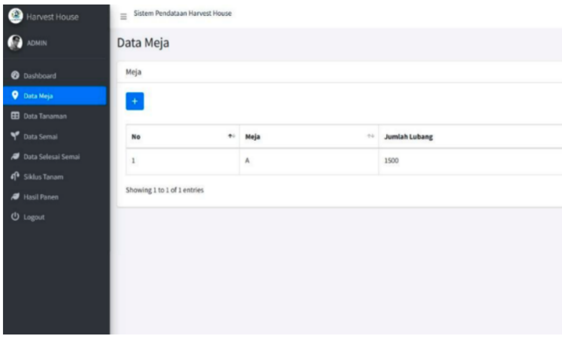

Figure 4. Table Module

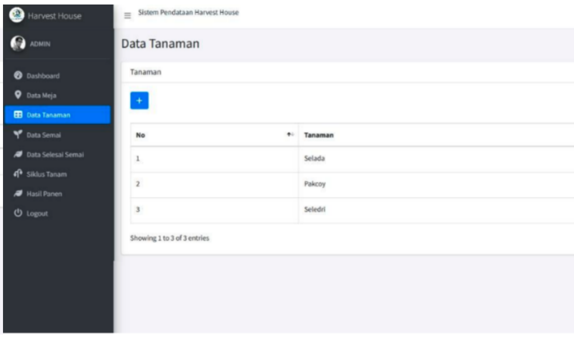

Figure 5. Plant Module

The Plant Module (Figure 5) stores crop type information (e.g., lettuce) and links each plant to its associated seeding, cultivation, and harvest records. This relational linkage allows the system to track plant performance across multiple growth cycles. By maintaining consistent plant identifiers, the system supports longitudinal analysis, such as growth duration comparison, crop-specific yield trends, and cycle success rates.

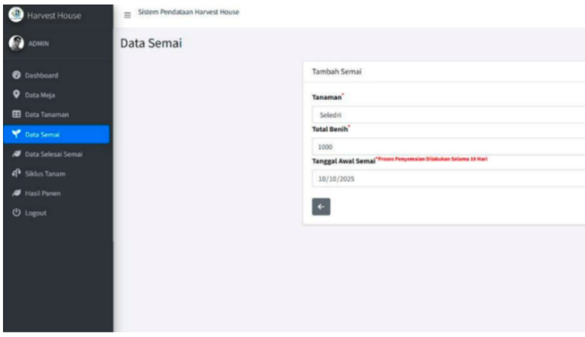

Figure 6. Seedling Module

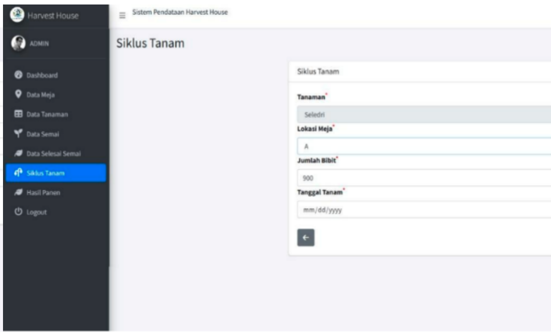

Figure 7. Cycle Management Module

The Seedling Module (Figure 6) records sowing activities, including plant type and sowing start date. Based on predefined cultivation parameters, the system automatically calculates the seeding duration (e.g., 10 days) and triggers a Telegram Bot notification when seedlings are ready for transplanting. The "Finish Sowing" action ensures seamless data transition to the cultivation cycle stage, preserving historical continuity. This time-

ISI Journal of Information Systems and Informatics

Published By Asosiasi Doktor Sistem Informasi Indonesia

stamped seedling data forms a critical dataset for analyzing transplant timing accuracy and early-stage growth performance.

The Crop Cycle Management Module (Figures 7) monitors plant growth from post-transplanting to harvest. The system tracks cultivation duration (e.g., 35 days) and automatically notifies users when crops approach harvest readiness. Action options include data updates, deletion, harvest initiation, and report generation. By structuring growth-stage data into defined cycles, the system enables future analytics such as cycle duration optimization, harvest prediction, and identification of recurring delays or failures.

Figure 8. Telegram bot notification

The Telegram Bot Module (Figure 8) delivers automated notifications at critical cultivation milestones, specifically “Ready to Transplant” and “Ready to Harvest.” This event-driven notification mechanism ensures timely intervention without continuous manual monitoring. From a data perspective, notification logs provide temporal markers that can be correlated with user actions, enabling future analysis of response times, workflow compliance, and scheduling effectiveness.

Table 2. Summary of Developed Modules and Their Analytical Potential

Module	Core Function	Key Data Recorded	Analytical Potential
Table Management	Register and manage planting tables	Table ID, capacity (holes)	Capacity utilization analysis; spatial production planning

Module	Core Function	Key Data Recorded	Analytical Potential
Plant Management	Manage crop types	Crop name, category	Crop performance comparison; yield trend by crop
Seedling Module	Record sowing stage	Crop type, sowing date	Transplant timing accuracy; seedling success rate
Cultivation Cycle	Track plant growth stages	Growth duration, status	Cycle efficiency analysis; harvest timing prediction
Harvest Module	Record harvest outcomes	Yield quantity, failures	Yield evaluation; loss analysis; productivity metrics
Notification System	Deliver time-based alerts	Event timestamp, alert type	Compliance monitoring; schedule adherence analysis

3.3. End-to-End Workflow Scenario

The workflow begins with the registration of planting tables, where the farmer defines available tables and the number of planting holes for each. This step establishes the physical capacity constraints of the cultivation area and serves as the spatial reference for subsequent processes. Next, the farmer records plant types to be cultivated, such as lettuce, which are later linked to sowing, growth, and harvest data. Once plant data are defined, the sowing process is recorded in the seedling module by specifying the crop type and sowing date. Based on the predefined seeding duration, the system automatically calculates the transplanting schedule and sends a notification via the Telegram Bot when seedlings are ready to be moved to the planting table.

After transplanting, the crop enters the cultivation cycle management stage. The system tracks the growth duration and continuously updates the crop status based on time-stamped records. When the predefined harvest time is reached, an automatic notification is sent to remind the user that the crop is ready for harvest. Finally, the farmer records harvest outcomes, including yield quantity and optional failure notes, completing the production cycle.

This end-to-end scenario demonstrates how AgriTrack integrates all cultivation stages into a single, continuous digital workflow. Each stage produces structured and relational data that are preserved throughout the lifecycle, ensuring data continuity from sowing to harvest. Such a workflow not only reduces manual coordination but also establishes a

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

complete historical dataset that can support future analytics, performance evaluation, and gradual smart-farming enhancement.

3.4. Security and Notification Performance

AgriTrack applies basic security controls suitable for small-scale farming environments, primarily through consistent input validation and user authentication. Input validation prevents invalid numeric entries and malformed data, ensuring database integrity across cultivation stages. Authentication testing confirmed that only authorized users can access the system, with incorrect credentials properly rejected. While advanced mechanisms such as role-based access control and password recovery are not yet implemented, the current security level is adequate for prototype and MSME-scale deployment.

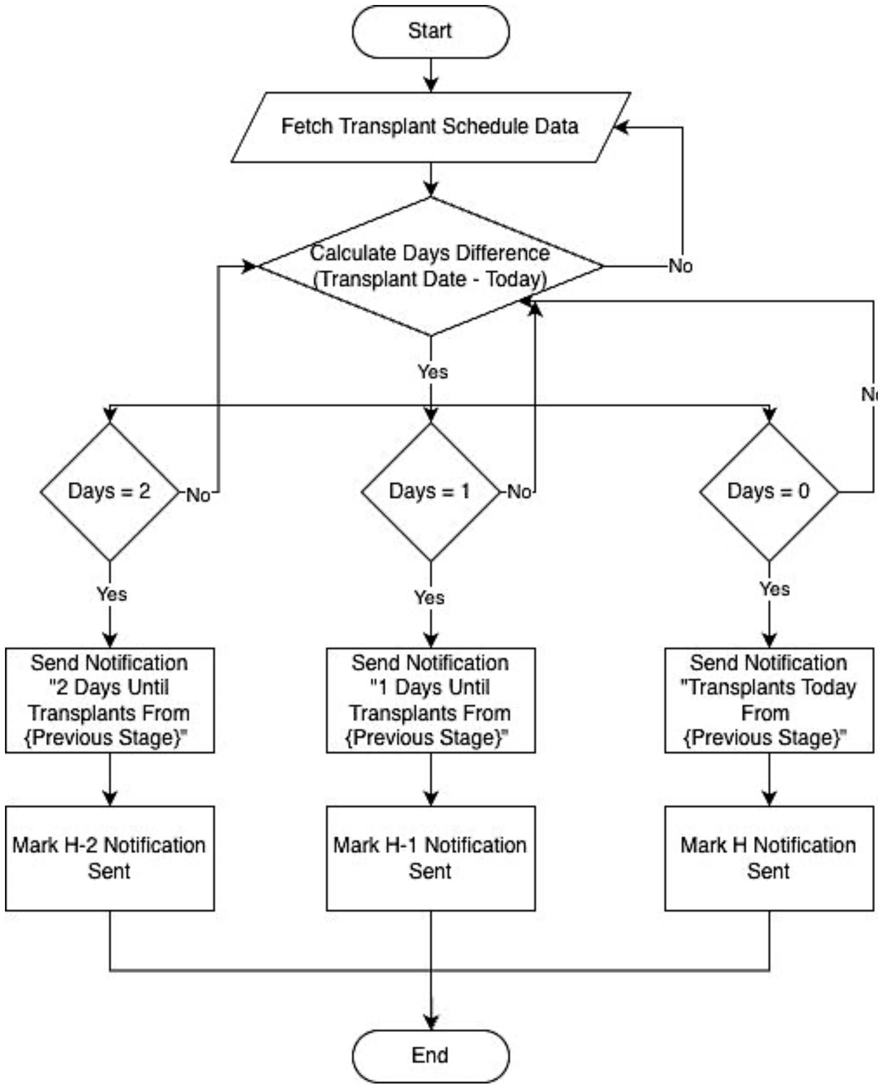

Figure 9. The Process of Sending Notifications

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

Figure 9 illustrates the process of sending transplanting notifications via the Telegram Bot, which begins with the system running on a scheduled basis to retrieve transplanting schedule data from each cultivation stage module, namely seeding, rejuvenation, and maturation. The system then calculates the day difference between the scheduled transplanting date and the current date for each retrieved record. Based on this calculation, the system evaluates the conditions for H−2, H−1, and H0 (transplanting day). If any of these conditions are met and the notification for the corresponding stage has not yet been sent, the system sends a reminder message according to the plant's current cultivation stage and updates the notification status to prevent duplicate deliveries. This process ensures that transplanting notifications are delivered in a timely, controlled, and well-managed manner across all cultivation phases.

Notification performance evaluation shows that Telegram Bot alerts for critical events ("Ready to Transplant" and "Ready to Harvest") were delivered reliably with delays within one minute in both local and hosted environments. Early notification duplication issues were resolved by improving trigger logic, resulting in stable real-time delivery. Overall, the system demonstrates reliable operational security and timely notifications, supporting daily farming activities while maintaining low system complexity and clear scalability for future enhancement.

Table 3. Security and Notification Performance Evaluation

Deployment Stage	Test Focus	Objective	Key Result	Improvement Action
Prototype	Input validation	Prevent invalid numeric data	Invalid inputs successfully rejected	Numeric validation implemented
Local	Authentication	Verify login security	Secure login with error notification	Password recovery planned
Local	Data integrity	Ensure safe data transition between cycles	No data loss during transplant and cycle updates	History tracking added
Local	Telegram notification	Measure notification delay and reliability	Delay ≥ 1 minute, no missed alerts	Duplicate trigger logic fixed
Hosting	System security stability	Ensure secure access across devices	Stable access on mobile and desktop	–

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

Deployment Stage	Test Focus	Objective	Key Result	Improvement Action
Hosting	Real-time notification	Evaluate server-side notification latency	Delay ≤ 1 minute	–

3.5. System Testing

System testing was performed to validate that all AgriTrack modules operated correctly within real operational workflows. The evaluation covered five core functional areas: basic data management, cultivation processes (seedling and planting cycles), harvest management, reporting, and Telegram Bot integration. Functional testing confirmed that all modules met their specified requirements, including consistent relational data handling, correct stage transitions, and accurate scheduling logic. Automated notifications for transplanting (10 days) and harvesting (35 days) were triggered as expected, and data transfers between cultivation stages occurred without loss or duplication. The harvest module successfully supported yield recording, failure documentation, and PDF report generation.

Integration testing verified stable and timely communication with the Telegram Bot, enabling event-based notifications without requiring continuous system access. User acceptance testing (UAT), conducted with the farm owner and staff during actual production activities, indicated that the system was usable and aligned with daily operational needs. Minor usability improvements were applied based on user feedback. A summary of the testing outcomes is provided in Table 4.

Table 4. Summary of System Testing Results

Module	Test Scenario	Success Criteria	Result	Remarks
Basic Data Management	Add, edit, and delete planting tables and plant types	Data saved correctly; no dependency conflicts	Passed	Relational integrity maintained across modules
Seed Data Module	Record seedling data and trigger transplant reminder	Data stored accurately; notification sent after 10 days	Passed	Telegram Bot notification delivered on schedule

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

Module	Test Scenario	Success Criteria	Result	Remarks
Seed-to-Planting Transition	Execute "Finish Sowing" action	Data moved to planting cycle without loss or duplication	Passed	Seamless data transition verified
Planting Cycle Module	Monitor growth stages and trigger harvest notification	Data displayed correctly; notification sent after 35 days	Passed	Cycle-based scheduling functioned as designed
Planting-to-Harvest Transition	Proceed plants to harvest stage	No duplicated or missing records	Passed	Data continuity preserved
Harvest Module	Input yield data, failure counts, and notes	Data saved; optional fields handled without error	Passed	Flexible data entry supported
Reporting Feature	Generate harvest report in PDF format	Report generated correctly and downloadable	Passed	Output suitable for documentation
Telegram Bot Integration	Send automated notifications based on system events	Messages delivered accurately and on time	Passed	System–bot synchronization stable
User Acceptance Testing (UAT)	Real-use operation by farm owner and staff	System usable and aligned with daily workflow	Passed	Minor UI refinements applied

3.6. Discussion

Based on the overall testing process involving three participants and covering 12 scenarios across the prototype, local, and hosting stages, the system demonstrated stable performance with an overall success rate of approximately 91.6% across all main functions. Most core features—including navigation, data input, automated scheduling, cultivation cycle transitions, and real-time notifications—operated as expected under both local and hosted testing environments. The identified issues were minor in nature, primarily related to interface layout, validation clarity, and requests for additional features such as a "quick add" button and a password recovery option. No critical issues were found that could hinder field operations; therefore, the system is considered to

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

have met user acceptance testing (UAT) standards and is deemed ready for use while remaining open to further feature enhancements.

Improving operational time efficiency is one of the most significant impacts observed from the implementation of the AgriTrack system in a small-scale hydroponic production environment. Prior to system adoption, critical operational data, such as planting schedules, table availability, and harvest timelines that were recorded manually using a whiteboard, as illustrated (Figure 9). This manual approach reflects common practices among small and micro-scale hydroponic farmers, where digital infrastructure is often minimal or absent [20], [21].

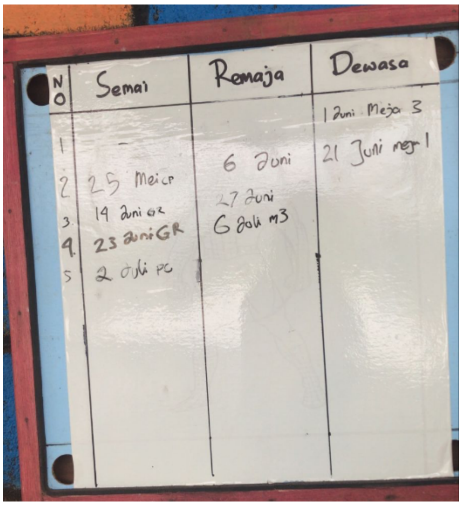

Figure 10. Schedules Whiteboard

Manual record-keeping introduced several operational challenges, including data loss risks, inconsistent updates, delayed information access, and frequent human error. Similar issues have been widely reported in controlled-environment agriculture, where reliance on handwritten logs and fragmented documentation negatively affects decision-making accuracy and workflow coordination [5], [17]. In the observed case, farmers frequently forgot critical cycle dates, leading to delayed harvesting and suboptimal resource utilization. Such inefficiencies are consistent with findings in recent smart farming studies that identify manual scheduling as a key bottleneck in small-scale agricultural operations [22].

The implementation of AgriTrack transformed these processes by digitizing and integrating all recording and monitoring activities into a unified web-based system. Data are entered once and automatically synchronized across modules, enabling real-time access to planting cycles, growth stages, and harvest forecasts. The system further enhances operational reliability through automated cycle-based scheduling and notification delivery via a Telegram Bot, significantly reducing dependency on memory-based or manual reminders. Prior research has demonstrated that automated reminders and digital scheduling improve task compliance and timeliness in agricultural workflows, particularly in resource-constrained settings [9], [23].

The observed impacts of AgriTrack can be summarized as follows. First, data recording and updating processes became more efficient, as entries are validated and reused across reporting and monitoring functions without duplication. Second, automated scheduling and notifications ensured timely execution of planting and harvesting activities, aligning operational actions with predefined growth cycles. Third, rapid access to accurate information enabled faster decision-making and improved coordination among workers. Fourth, redundant tasks were eliminated, as a single data entry supports multiple operational needs. These outcomes align with broader findings in smart hydroponic and aquaponic system research, where structured digital data management is shown to improve operational consistency and productivity [20], [22], [24].

Despite these benefits, the current implementation of AgriTrack has several limitations. From a security perspective, protection mechanisms are presently limited to basic input validation. While this approach is generally sufficient for controlled, small-scale farming environments, it may not be adequate for larger deployments or scenarios involving sensitive production data. Recent studies emphasize the importance of stronger security layers—including encryption, role-based authentication, and secure database access—in web-based agricultural information systems [25], [26]. Therefore, future development should incorporate enhanced authentication mechanisms, encrypted data transmission, and more comprehensive access control to improve system robustness and trustworthiness.

In addition to security enhancements, future development of AgriTrack is directed toward gradual integration with Internet of Things (IoT) technologies. IoT integration would

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

enable the system to automatically receive real-time cultivation data—such as nutrient solution quality, temperature, humidity, and other environmental indicators—through connected sensors. This approach has been shown to significantly improve monitoring accuracy and reduce manual workload in hydroponic systems [9], [21], [27]. Importantly, a phased integration strategy allows small-scale farmers to adopt smart farming technologies incrementally, in accordance with their technical readiness and financial capacity, rather than forcing a transition to complex and costly industrial-scale solutions [23], [28].

The findings demonstrate that AgriTrack effectively functions as a low-cost digitalization layer for small-scale hydroponic operations. By prioritizing simplicity, cycle-based recording, and user-friendly notification mechanisms, the system addresses foundational operational challenges before introducing advanced automation. This positioning distinguishes AgriTrack from many existing smart farming solutions that emphasize sensor-driven automation but overlook the basic data management needs of micro and small enterprises. As such, AgriTrack contributes a practical and scalable pathway toward smarter farming practices tailored to MSME hydroponic farmers, reinforcing the importance of contextualized technology adoption in agricultural digital transformation [1], [5], [8], [12].

4. CONCLUSION

This study confirms that AgriTrack, developed as a web-based information system successfully fulfills its objectives by (1) implementing a structured, cycle-based digital recording system for hydroponic cultivation, (2) validating system functionality and usability through black-box testing and user acceptance testing, and (3) demonstrating measurable improvements in operational efficiency, scheduling accuracy, and data accountability in a small-scale production environment. The system reliably digitizes core cultivation workflows while maintaining usability for users with limited technological literacy. From an engineering standpoint, AgriTrack establishes a low-cost digitalization layer that prioritizes structured data management as a foundation for smart farming without immediate reliance on complex automation or IoT infrastructure. Although the current implementation is limited by basic security mechanisms, single-site deployment, and non-predictive analysis, its modular and data-centric architecture provides a scalable

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

framework for future enhancements, including stronger security controls, predictive analytics, and incremental sensor integration.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to Politeknik Negeri Tanah Laut for the financial support provided through the 2025 Research Grant Program. This support has been instrumental in the successful completion of this study.

REFERENCES

[1] P. A. C. Setiawan, N. I. Er, and G. Sukadarmika, "Pertanian Vertikal Pintar: Peran IoT dalam Mewujudkan Keberlanjutan dan Efisiensi Sumber Daya," *Majalah Ilmiah Teknologi Elektro*, vol. 24, no. 1, pp. 23–34, Aug. 2025, doi: 10.24843/MITE.205.v24i01.P03.

[2] D. Lim, K. Keerthi, S. Perumbilavil, C. S. Suchand Sandeep, M. M. Antony, and M. V. Matham, "A real-time on-site precision nutrient monitoring system for hydroponic cultivation utilizing LIBS," *Chem. Biol. Technol. Agric.*, vol. 11, no. 1, p. 111, Aug. 2024, doi: 10.1186/s40538-024-00641-6.

[3] Md. R. Al Mamun, A. K. Ahmed, S. M. Upoma, M. Haque, and M. Ashik-E-Rabbani, "IoT-enabled solar-powered smart irrigation for precision agriculture," *Smart Agricultural Technology*, vol. 10, p. 100773, Mar. 2025, doi: 10.1016/j.atech.2025.100773.

[4] D. Suleman *et al.*, *Pengantar Agribisnis Dan Ketahanan Pangan*. CV Widina Media Utama, 2025. Accessed: Dec. 11, 2025. [Online]. Available: https://repository.penerbitwidina.com/publications/610545/

[5] H. Hasanah, R. Susanto, and W. Lestari, "Internet of Things-Based Hidroponic Plant Monitoring System," *Jurnal Sisfokom (Sistem Informasi dan Komputer)*, vol. 14, no. 4, pp. 484–488, Oct. 2025, doi: 10.32736/sisfokom.v14i4.2443.

[6] F. Hermawan *et al.*, "Strategi Keberlanjutan Usaha Hidroponik Green House Jawa Timur Dengan Analytical Hierarchy Process (AHP): East Java Green House Hydroponic Business Sustainability Strategy Using The Analytical Hierarchy Process (AHP)," *Jurnal Ilmiah Inovasi*, vol. 24, no. 3, pp. 216–221, Dec. 2024, doi: 10.25047/jii.v24i3.5140.

[7] R. Baharta, E. Sobari, and M. A. Aris, "Smart Microcontroller-Controlled Hydroponic System for Optimized Environmental Monitoring in Small-Scale Farming," *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, vol. 16, no. 4, pp. 11–16, Dec. 2024, doi: 10.54554/jtec.2024.16.04.002.

[8] A. Yunan and S. Kurniadi, "Implementation of Fuzzy Inference Mamdani System Based on Graphic User Interface for the timing of planting rice on rice plants in traditional farming systems in South Aceh district," *Jurnal Inotera*, vol. 6, no. 2, pp. 119–127, Nov. 2021, doi: 10.31572/inotera.Vol6.Iss2.2021.ID151.

[9] S. A. Wibowo, K. A. Widodo, and D. Rudhistiar, "Smart Farming System untuk Tanaman Hidroponik Berbasis Internet of Things," *Jurnal Bumigora Information Technology (BITe)*, vol. 5, no. 1, pp. 17–30, June 2023, doi: 10.30812/bite.v5i1.2691.

[10] F. P. E. Putra, M. A. Mahmud, and I. S. Maqom, "Pengembangan Sistem Pemantauan Lingkungan Berbasis Internet of Things (IoT) di Kampus," *Digital Transformation Technology*, vol. 3, no. 2, pp. 996–1001, 2023, doi: 10.47709/digitech.v3i2.3457.

[11] J. Arshad *et al.*, "Implementation of a LoRaWAN Based Smart Agriculture Decision Support System for Optimum Crop Yield," *Sustainability*, vol. 14, no. 2, p. 827, Jan. 2022, doi: 10.3390/su14020827.

[12] R. B. Lukito and C. Lukito, "Development of Water Quality Control and Monitoring Systems for Hydroponic Plants Based on the Embedded Web," *International Journal of Emerging Technology and Advanced Engineering*, vol. 11, no. 08, pp. 80–88, Aug. 2025, doi: 10.46338/ijetae0821_10.

[13] A. Wijaya, M. van den Heuvel-Panhuizen, and M. Doorman, "Opportunity-to-learn context-based tasks provided by mathematics textbooks," *Educ Stud Math*, vol. 89, no. 1, pp. 41–65, May 2015, doi: 10.1007/s10649-015-9595-1.

[14] B. A. Rafi, M. Sarosa, and A. D. W. Sumari, "Implementation of an IoT-Based High Efficiency and Low Maintenance Lettuce Hydroponic System," in *2024 International Conference on Electrical and Information Technology (IEIT)*, Sept. 2024, pp. 14–18. doi: 10.1109/IEIT64341.2024.10763247.

[15] Y. Ananda, Y. A. Putra, L. A. Siregar, and I. Roza, "Perancangan Sistem Hidroponik Pada Kontrol Ph, Nutrisi, Kelembaban Menggunakan Logika Fuzzy Berbasis Internet of Thing," *Journal of Telecommunication and Electrical Scientific*, vol. 2, no. 01, pp. 41–48, Jan. 2025, doi: 10.24010/jtels.v2i01.1062.

ISI Journal of Information Systems and Informatics
Published By Asosiasi Doktor Sistem Informasi Indonesia

[16] R. Fahlefie and D. Damayanti, "Sistem Kendali Kualitas Air pada Tanaman Hidroponik berbasis Internet of Things: Internet of Things-Based Water Quality Control System for Hydroponic Plants," *MALCOM: Indonesian Journal of Machine Learning and Computer Science*, vol. 5, no. 4, pp. 1266–1273, Oct. 2025, doi: 10.57152/malcom.v5i4.2062.

[17] S. Rifka, R. Ramiati, R. Dewi, U. Khair, and H. Setiawan, "Embedded Smart Farming System for Soil and Hydroponic Planting Media Based on The Internet of Things," *Sinkron : jurnal dan penelitian teknik informatika*, vol. 9, no. 1, pp. 188–196, Jan. 2025, doi: 10.33395/sinkron.v9i1.14255.

[18] D. Primasari, "Sistem Informasi Hidroponik Berbasis Website (Hydroponic Awakening Revolution [HAR])," *INFOTECH journal*, vol. 7, no. 1, pp. 69–75, May 2021, doi: 10.31949/infotech.v7i1.1093.

[19] R. S. Pressman, *Software Engineering: A Practitioner's Approach*. Palgrave Macmillan, 2005.

[20] U. Shareef, A. U. Rehman, and R. Ahmad, "A Systematic Literature Review on Parameters Optimization for Smart Hydroponic Systems," *AI*, vol. 5, no. 3, pp. 1517–1533, Sept. 2024, doi: 10.3390/ai5030073.

[21] M. Farhan, S. Meena, and G. Sinha, "Smart Farming with IoT: A Paradigm Shift in Hydroponic Cultivation of Leafy Greens," *NG Agriculture Insights*, vol. 1, no. 2, pp. 34–37, July 2025, doi: 10.5281/zenodo.16032445.

[22] M. Anila and O. Daramola, "Applications, technologies, and evaluation methods in smart aquaponics: a systematic literature review," *Artif Intell Rev*, vol. 58, no. 1, p. 25, Nov. 2024, doi: 10.1007/s10462-024-11003-x.

[23] A. Ahmed, R. Alnawasrah, B. Almadani, F. Aliyu, and M. Ghaleb, "Contemporary smart hydroponics systems: Taxonomy, enabling technologies, and challenges," *Internet of Things*, vol. 34, p. 101794, Nov. 2025, doi: 10.1016/j.iot.2025.101794.

[24] A. Aurasopon, T. Thongleam, and S. Kuankid, "Integration of IoT Technology in Hydroponic Systems for Enhanced Efficiency and Productivity in Small-Scale Farming," *ATA*, vol. 27, no. 4, pp. 203–211, Nov. 2024, doi: 10.2478/ata-2024-0027.

[25] K. K. Y. Shin, T. P. Ping, M. G. B. Ling, C. Chee Jiun, and N. A. B. Bolhassan, "*SMART GROW* – Low-cost automated hydroponic system for urban farming," *HardwareX*, vol. 17, p. e00498, Mar. 2024, doi: 10.1016/j.ohx.2023.e00498.

[26] T. Akter, T. Mahmud, R. Chakma, N. Datta, M. S. Hossain, and K. Andersson, "Smart Monitoring and Control of Hydroponic Systems Using IoT Solutions," in *2024 Second International Conference on Inventive Computing and Informatics (ICICI)*, June 2024, pp. 761–767. doi: 10.1109/ICICI62254.2024.00128.

[27] S. Khan, "Digital Agriculture: Transforming Modern Farming With Next-Gen Technologies: A Review," *International Journal of Creative Research Thoughts*, vol. 13, no. 4, pp. 119–125, Aug. 2025, doi: 10.1729/Journal.44821.

[28] V. Kumar, K. V. Sharma, N. Kedam, A. Patel, T. R. Kate, and U. Rathnayake, "A comprehensive review on smart and sustainable agriculture using IoT technologies," *Smart Agricultural Technology*, vol. 8, p. 100487, Aug. 2024, doi: 10.1016/j.atech.2024.100487.