

AidTrack: An Intelligent Relief Distribution and Tracking System for Disaster Response Management

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Abstract

This study presents the design, development, and evaluation of AidTrack, a web-based system designed to enhance disaster relief operations in Santo Tomas, Pampanga, where challenges such as inefficient manual processes, fragmented records, and duplication of aid distribution are commonly experienced. A mixed-methods approach was employed, where qualitative data were gathered through interviews and focus group discussions with barangay officials and MSWD personnel, while quantitative data were collected through post-test surveys using the System Usability Scale (SUS) and Technology Acceptance Model (TAM). The system was developed using the Agile Scrum methodology, allowing iterative refinement based on continuous stakeholder feedback and evolving operational requirements. AidTrack integrates key functionalities such as beneficiary verification through QR codes, real-time inventory monitoring with automated alerts, relief distribution scheduling, eligibility checking, and AI-assisted support features for decision-making and user interaction. Evaluation results indicate that AidTrack is highly usable and well-accepted by users, with consistent positive feedback across usability and technology acceptance measures. The system demonstrates improvements in coordination, transparency, and operational efficiency in disaster relief processes. The integration of security mechanisms and AI-based tools further enhances data reliability, reduces redundancy in beneficiary identification, and supports timely decision-making during relief operations. Overall, AidTrack transforms traditional manual relief operations into a streamlined and data-driven system, offering local government units an efficient and scalable tool for managing disaster response activities in selected barangays of Santo Tomas, Pampanga.

Keywords: Agile Scrum, AI-Assisted Prioritization, Barangay Operations, Disaster Management, Inventory Monitoring, QR Code Verification, System Usability

Introduction

Background of the Study

Disasters in the Philippines often disrupt communities by limiting access to resources and slowing aid

delivery, with local government units (LGUs) facing challenges such as poor coordination, duplicate aid distribution, and weak recordkeeping [6, 12]. Past events such as Typhoon Reming, Typhoon Yolanda, and Tropical Storm Sendong exposed how these issues become more severe in remote areas where reliable data is limited, while reports also indicate that relief goods may go unused or spoil because of poor tracking and monitoring systems [9]. New technologies such as artificial intelligence (AI), QR codes, and cloud-based systems can improve disaster response through real-time inventory monitoring, beneficiary verification, and faster communication [1, 11]. However, many LGUs still rely on manual and error-prone processes that reduce operational efficiency during disaster response activities.

This study introduces AidTrack, a relief distribution and tracking system designed to make operations faster, fairer, and more transparent by combining real-time tracking, QR-based verification, AI prioritization, and a chatbot to support barangays and MSWD staff. The system is also aligned with the United Nations Sustainable Development Goals (SDGs). Specifically, AidTrack contributes to SDG 1 (No Poverty) by ensuring timely and equitable relief distribution, SDG 13 (Climate Action) by strengthening preparedness and response to climate-related disasters, SDG 11 (Sustainable Cities and Communities) by supporting resilient local systems, and SDG 16 (Peace, Justice, and Strong Institutions) by promoting accountability, transparency, and efficiency in aid operations. Guided by these goals, AidTrack serves as a smart, scalable solution to improve disaster relief management and ensure that resources reach the people who need them most.

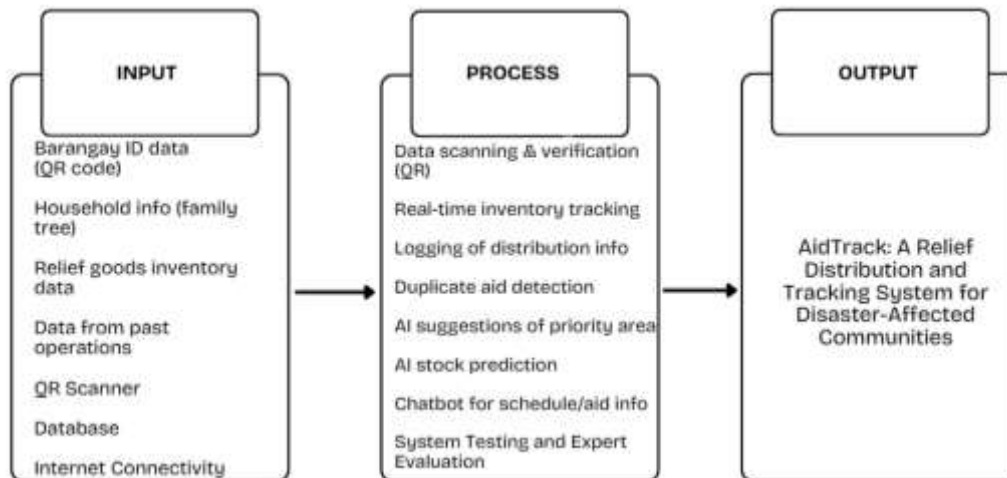
Statement of the Objectives

To design and develop a digital relief distribution and tracking system that integrates real-time inventory monitoring, QR code-based beneficiary verification, household data tracking, and AI-driven features such as intelligent assistance and decision-support tools to improve the efficiency, fairness, transparency, and accountability of aid delivery for disaster-affected barangays under the Municipal Social Welfare and Development (MSWD). The proposed system is intended to reduce manual errors and support more accurate and organized relief distribution operations during disaster response activities.

Conceptual Framework or Theoretical Framework

The conceptual framework illustrates how AidTrack enhances disaster response operations through the integration of digital monitoring, verification, and intelligent support mechanisms. Inputs include resident data such as barangay IDs in QR format, household profiles, inventory records, and historical relief operation data. These inputs are processed through QR-based beneficiary verification, real-time inventory monitoring, duplicate claim prevention, and AI-driven features including barangay prioritization, stock forecasting, and chatbot-assisted community support. The system also promotes centralized coordination and data consistency among barangays and MSWD personnel during relief operations. The outputs include faster and fairer aid distribution, improved inventory management, reduced duplication, and enhanced communication, transforming manual processes into an efficient digital workflow that helps ensure no family is left behind.

Figure 1. Conceptual Framework



Methods

Research Design and Model Used

This study used a mixed-methods design to capture both measurable outcomes and contextual insights. Qualitative data were gathered through interviews and FGDs with barangay officials and MSWD personnel to identify operational challenges and needs in existing relief distribution processes. Quantitative data were collected through post-test surveys using the System Usability Scale (SUS) [3] and Technology Acceptance Model (TAM) [4] to assess AidTrack’s usability, ease of use, perceived usefulness, and intention to use. The integration of both qualitative and quantitative approaches allowed the study to examine not only system performance metrics but also user experiences and operational perspectives. Combining both methods ensured survey results were supported by real-world insights from disaster relief stakeholders, providing a more comprehensive evaluation of the system’s effectiveness in practical deployment scenarios.

System Development Methodology

The development of AidTrack was guided by the Agile Scrum methodology, chosen for its iterative and flexible approach to software development. The process was organized into short, time-boxed sprints, with each sprint delivering a functional increment of the system, allowing for incremental progress and early validation of features. At the end of each sprint, feedback was gathered from end-users and experts, informing subsequent iterations and enabling continuous refinement of the system. Key roles—including the Product Owner, Scrum Master, and Development Team—facilitated the workflow through backlog management, sprint planning, daily stand-ups, and sprint reviews, ensuring coordination and accountability throughout the development process. Agile Scrum was selected for its adaptability to evolving requirements and its emphasis on stakeholder collaboration, making it particularly suitable for building AidTrack, which requires a balance of usability, reliability, and responsiveness to real-world disaster relief operations. This iterative approach ensured that system improvements were continuously aligned with user needs and operational requirements in barangay and MSWD settings.

Figure 2. Agile Development Model



Participants and Setting

Participants were selected through purposive sampling from all seven barangays of Santo Tomas, Pampanga, based on their direct involvement in planning, coordinating, and implementing relief operations. The sample included barangay officials and MSWD personnel to ensure that the evaluation reflected actual operational contexts and requirements. Their experience in inventory management, beneficiary validation, and relief distribution provided relevant insights for assessing the system's practicality during real disaster response scenarios. Inclusion of participants from all barangays ensured representation of varying operational practices and challenges across the municipality.

Research Instrument

AidTrack was evaluated using a mixed-methods approach. Qualitative data from interviews and FGDs with barangay officials and MSWD personnel were used to explore challenges in aid tracking, duplication, and coordination within existing relief operations. Quantitative data from system trial runs and post-test surveys using the System Usability Scale (SUS) [3] and Technology Acceptance Model (TAM) [4] assessed usability, ease of use, perceived usefulness, and intention to use. In addition, official documents such as distribution records and inventory reports were reviewed to validate and support the findings from both qualitative and quantitative data. Data were analyzed through descriptive statistics and content analysis to provide both measurable and contextual insights into the system's effectiveness.

Data Collection Procedure and Analysis

A formal request for approval was secured from the LGU before data collection to ensure compliance with local protocols and ethical considerations. Interviews and FGDs with barangay officials and MSWD staff were then conducted, followed by AidTrack trial runs and post-test surveys to assess usability and system performance in actual operational scenarios. Official records were also reviewed to validate reported improvements and ensure consistency between system outputs and existing documentation. Survey data were analyzed using mean and standard deviation on a 4-point Likert scale to determine levels of usability, ease of use, and acceptance, while qualitative data were examined through content analysis to generate themes related to usability, distribution challenges, and community relevance. This mixed-method

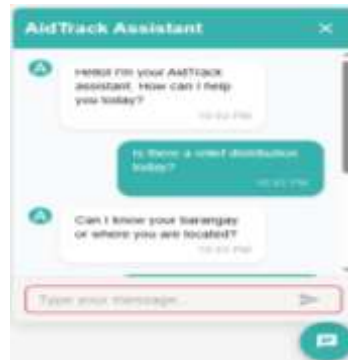
approach provided both statistical evidence and narrative insights into AidTrack’s overall effectiveness in disaster relief operations.

Results and Discussions

The AidTrack system is designed with a robust architecture and a suite of integrated features that collectively support efficient, transparent, and data-driven disaster relief operations. Its architecture combines modular components that work together seamlessly, ensuring scalability, security, and ease of use for both administrators and end-users across different operational levels. Each feature—from household profile management and inventory monitoring to QR code generation, eligibility verification, and AI-powered assistance—addresses specific challenges commonly encountered in relief distribution, particularly those related to accuracy, coordination, and timeliness. By presenting both the overall system framework and its key functionalities, this section highlights how AidTrack enhances coordination, minimizes errors, and strengthens accountability in delivering aid to disaster-affected communities. The integration of these components enables a more organized workflow that supports real-time decision-making and improves overall efficiency in disaster response operations. These findings provide a foundation for understanding the system’s practical impact and its potential role in improving disaster relief operations at the local government level.

System Architecture and Features

Figure 3. AidTrack Chatbot Page



AidTrack Assistant Chatbot. Provides real-time support by answering common inquiries such as relief schedules. Users enter questions through a text input box, and the chatbot prompts for location details to deliver accurate, barangay-specific responses. This feature improves accessibility, reduces uncertainty, and supports timely decision-making during relief operations.

Figure 4. AidTrack Household Management Page



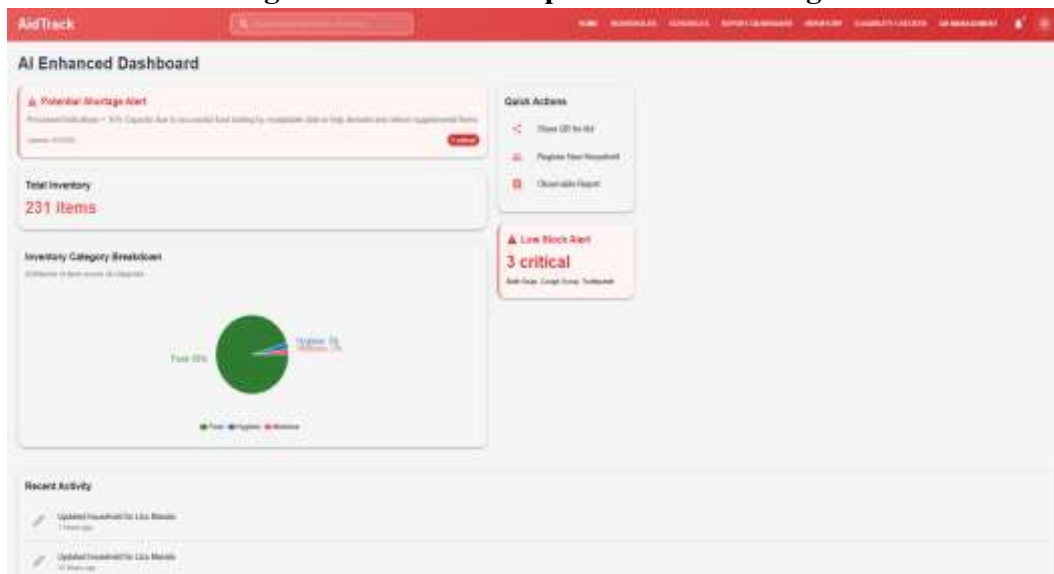
Household Management Page. Offers a centralized dashboard for managing household profiles. Summary cards display key metrics, while a searchable and filterable table lists household details. Users can add, edit, or delete records through interactive forms, supporting accurate household tracking and efficient data management.

Figure 5. AidTrack Schedule Page



Relief Distribution Schedule Page. Serves as the main interface for planning and monitoring relief events. Users can create, refresh, and filter schedules by location, date, or item type. Event details are presented in a table, with a modal view providing a read-only overview of selected schedules to ensure transparent and organized operations.

Figure 6. AidTrack Report Dashboard Page



AI-Enhanced Dashboard. The AI-Enhanced Dashboard serves as the central hub of AidTrack, providing an overview of relief operations and real-time alerts. Key features include the Potential Shortage Alert and Low Stock Alert for critical items like bath soap, cough syrup, and toothpaste, enabling administrators to prioritize restocking. The dashboard also displays Total Inventory Count, an Inventory Category Breakdown pie chart, Quick Actions, and a Recent Activity Log, supporting proactive decision-making, efficient resource management, and transparency in relief distribution.

Figure 7. AidTrack Inventory Management Page



Inventory Management Page. Enables administrators to monitor and update relief goods with real-time alerts, inventory summaries, and category breakdowns. Filtering options and confirmation modals support quick retrieval of information while maintaining data accuracy and integrity.

Figure 8. AidTrack QR Code Generator and Management



QR Code Generation and Management. Provides tools for creating, distributing, and tracking household QR codes. Key statistics and a searchable table display household details and QR code previews, with quick actions for viewing, downloading, or printing, ensuring smooth verification during distribution.

Figure 9. AidTrack Eligibility Checker



Eligibility Checker. The Eligibility Checker module provides a streamlined interface for verifying relief distribution status via QR code scanning or manual search (name, ID, or contact number). By validating real-time data against the database, the system ensures a transparent and efficient verification process while preventing duplication and errors.

System Usability Scale

Table 1. Summary of Results: System Usability Scale (SUS)

Respondents	Mean	SD	Interpretation
Officials	2.84	0.52	High Usability
IT Professionals	2.74	0.53	High Usability
Households	2.69	0.51	High Usability
Grand Mean/SD	2.76	0.52	High Usability

Table 1 presents the comparative evaluation of the AidTrack system’s usability across three respondent groups. Officials recorded the highest mean score of 2.84 (SD = 0.52), indicating that the system’s scheduling and administrative features are intuitive and well aligned with operational needs. This was followed by IT Professionals, who obtained a mean score of 2.74 (SD = 0.53), validating the system’s technical soundness and functional logic. Households yielded a slightly lower but comparable mean score of 2.69 (SD = 0.51), suggesting that while the system remains highly accessible to the general public, non-technical users may experience minor differences in usability compared to professional users. Despite these variations, the close range of scores confirms that AidTrack maintains a high usability standard across all groups. Consistent standard deviation values also show agreement among respondents, demonstrating a balance between technical functionality and user-friendly design.

Technology Acceptance Model

Table 2. Officials Factors Influencing the Use of AidTrack

Factors	Mean	SD	Interpretation
Perceived Usefulness (PU)	3.77	0.42	Very High Acceptability
Perceived Ease of Use (PEU)	3.75	0.43	Very High Acceptability
Behavioral Intention to Use (BIU)	3.82	0.39	Very High Acceptability
Grand Mean /SD	3.78	0.41	Very High Acceptability

Table 2 details the factors influencing the acceptance of AidTrack among officials, evaluated through the Technology Acceptance Model (TAM). The system received an overall rating of "Very High Acceptability" (Grand Mean = 3.78, SD = 0.41), indicating exceptional reception by target users. This suggests that the system meets user expectations in terms of both functionality and usability, indicating a high likelihood of adoption with minimal resistance from end users. Specifically, Behavioral Intention to Use (BIU) garnered the highest score (M = 3.82, SD = 0.39), demonstrating a strong willingness among respondents to adopt and integrate the system into daily tasks. This positive intent is driven by high ratings for Perceived Usefulness (M = 3.77) and Perceived Ease of Use (M = 3.75), confirming that the system is viewed as performance-enhancing and intuitive. The consistently low standard deviations across all constructs (≤ 0.43) signify a strong consensus regarding the system's design and functionality.

Conclusion and Recommendations

Conclusion

The AidTrack system demonstrates a comprehensive, integrated approach to enhancing disaster relief operations through digital solutions. Its conceptual framework illustrates how resident data, inventory records, and historical operations are processed via QR-based verification, real-time inventory monitoring, duplicate claim prevention, and AI-powered assistance to produce faster, fairer, and more transparent aid distribution. The mixed-methods evaluation confirmed that AidTrack is both usable and contextually relevant, addressing the operational challenges faced by barangay officials and MSWD personnel.

The Agile Scrum methodology facilitated iterative development, ensuring that each system component—from household management and relief scheduling to inventory tracking, QR code generation, eligibility checking, and AI-driven prioritization—was refined based on continuous user feedback. Security measures, including JWT-based access control and HMAC SHA-256 token signing, protect sensitive beneficiary information while maintaining efficient QR code management. AI integration via Dialogflow enhances both user interaction through the chatbot and operational decision-making by prioritizing high-need areas and generating proactive alerts [1, 11].

Overall, AidTrack transforms manual and error-prone disaster relief processes into a streamlined, data-driven workflow. By combining usability, security, and intelligence, the system improves coordination, accountability, and responsiveness, ensuring that relief reaches those who need it most while empowering local government units with a practical tool for efficient disaster management. This supports the system's potential for implementation in real-world disaster response operations.

Recommendations

To address the gaps identified in this study and maximize the impact of AidTrack, the following recommendations are proposed:

1. **Enhance Training and Capacity Building.** Conduct regular orientation sessions, hands-on workshops, and refresher training for barangay officials and local agency personnel. Emphasize practical exercises on QR code generation, eligibility verification, inventory management, and AI-assisted features to ensure smooth adoption and confident system use.
2. **Continuously Improve System Features.** Regularly update and refine key functionalities, including QR verification, AI-driven prioritization, and the chatbot assistant, based on user feedback. Incorporate usability testing and feature enhancements to maintain reliability, responsiveness, and user satisfaction.
3. **Promote Inter-Agency Collaboration and Data Integration.** Facilitate real-time sharing of data across barangays and MSWD personnel. Strengthen communication channels and establish protocols for coordinated operations, reducing duplication and improving resource allocation.
4. **Ensure Data Accuracy and Integrity.** Maintain up-to-date household profiles, inventory records, and distribution logs. Implement routine audits and validation procedures to support informed decision-making, transparency, and accountability in relief operations.
5. **Monitor, Evaluate, and Adapt.** Conduct periodic assessments of system performance, user engagement, and operational outcomes. Use these insights to identify areas for improvement, guide future development, and ensure AidTrack continues to align with evolving disaster management needs.
6. **Plan for Sustainability and Scalability.** Develop strategies for long-term system maintenance, including technical support, software updates, and resource allocation. Explore the potential to scale

AidTrack to neighboring municipalities or additional disaster response programs, ensuring broader community benefit.

Implementing these recommendations will enhance the Municipality of Santo Tomas' capacity for efficient, equitable, and transparent disaster relief operations, ultimately strengthening resilience and community trust in local disaster management systems.

Acknowledgement

The authors would like to acknowledge the Municipal Government of Santo Tomas, Pampanga and the seven barangays involved in this study for their support and cooperation. Special thanks to Sir Gabriel Intal of the MSWD Office for his assistance and guidance throughout the conduct of this research. The authors also acknowledge the University Research Ethics Board (REB) for granting ethical clearance for this study.

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