NOW2 Waste Management System: Advancing Environmental Sustainability Through Digital Endowments

Edward Nathan Samuel[1], P.M. Winarno[2], Siti Fara Fadila Binti Abd Razak[3], Mohd Zulkeflee Bin Abd Razak[4]
[1,2] Department of Informatics, Faculty of Engineering and Informatics, Universitas Multimedia Nusantara, Tangerang, Indonesia
[3,4] Department of Management, UNITEN Business School, Universiti Tenaga Nasional, Putrajaya, Malaysia

Article Info

Article history:

Received month dd, yyyy
Revised month dd, yyyy
Accepted month dd, yyyy

Keywords:

Sustainable Waste Management,
Renewable Energy,
Green Financing,
Net Zero Emission,
Web Technology,

ABSTRACT

The Net Zero Waste Wise (NOW2) system is a digital platform that transforms waste donations into financial resources for Waqfs (Muslim Endowments), supporting renewable energy and charitable projects while promoting sustainable waste management. By leveraging recycling revenues, NOW2 offers an eco-friendly alternative to traditional SUKUK financing, aligning with the United Nations' Sustainable Development Goals (SDGs 7, 11, 12, and 13). Built with TypeScript, Next.js, Tailwind CSS, NextAuth, and Prisma ORM, the system ensures efficient user experience, robust data security, scalable database management, and a stable platform for service delivery. NOW2 also facilitates transparent donation tracking, enhancing trust and accountability within the community. This paper explores the technological architecture and financial model of the successfully developed NOW2, highlighting its potential as a replicable solution for sustainable waste management in developing nations like Malaysia. By converting waste into financial value, NOW2 addresses environmental challenges and empowers communities through charitable giving, offering a scalable and impactful approach to zero-waste initiatives.

Commented [EN1]: The result of this research (now2 system have been successfully developed), (kalau ada pengujian, tambahkan tingkat kepuasan user)

Corresponding Author:

Edward Nathan Samuel
Department of Informatics, Faculty of Engineering and Informatics, Universitas Multimedia Nusantara, 15810 Tangerang, Indonesia
Email: edward.nathan@student.umn.ac.id

1. INTRODUCTION

Municipal solid waste (MSW) management has emerged as a critical environmental challenge worldwide, with escalating waste generation rates posing significant threats to urban sustainability. In Malaysia, more than 30,000 tons of MSW are produced daily, highlighting the urgency of adopting sustainable waste management practices. Traditional methods, including landfilling and incineration, are increasingly ineffective due to their environmental impacts, limited land availability, and rising operational costs. Consequently, innovative solutions are needed to address these challenges while promoting environmental sustainability and community welfare.

The Net Zero Waste Wise (NOW2) system offers a transformative approach to MSW management by digitizing waste donation processes and converting them into financial resources for Waqfs (Islamic endowments). By facilitating the circular economy, NOW2 not only minimizes waste accumulation but also channels financial aid towards community development initiatives. Unlike conventional systems, NOW2 integrates advanced web technologies such as TypeScript for type safety, Next.js for server-side rendering (SSR), Tailwind CSS for responsive UI design, NextAuth for secure authentication, and Prisma ORM for efficient database management. This technological synergy ensures a seamless user experience, robust security, and scalable data management, positioning NOW2 as an innovative digital platform for sustainable waste management.

Existing literature emphasizes the importance of digital platforms in enhancing waste management efficiency through real-time monitoring, data analytics, and stakeholder collaboration. However, most solutions are limited to waste tracking and recycling, lacking integration with charitable frameworks such as Waqfs. The unique value of NOW2 lies in its dual impact: environmental sustainability and digital endowment. By leveraging waste-to-value mechanisms, NOW2 bridges the gap between waste management and charitable giving, offering a novel model for sustainable community development.

This paper explores the technological architecture, implementation strategies, and scalability of the NOW2 system. It examines the system's impact on environmental sustainability and digital endowments, highlighting its potential as a replicable model for other developing nations. By addressing the limitations of conventional waste management systems, this study contributes to the growing body of research on digital innovation for sustainable development.

2. LITERATURE REVIEW

2.1. ZERO WASTE PARADIGM AND CIRCULAR ECONOMY

The zero-waste paradigm has emerged as a critical framework for achieving sustainable development goals, emphasizing closed-loop material flows and waste elimination. Foundational research by Ghisellini et al. [1] established circular economy principles as essential for decoupling economic growth from resource depletion, demonstrating 23–45% reduction in industrial waste through reuse strategies. Building on this, the Ellen MacArthur Foundation [2] quantified potential annual savings of $630 billion in European manufacturing sectors through circular design implementations.

Digital integration enhances zero-waste systems through real-time monitoring, as shown by Khan et al. [3], whose IoT-enabled smart bins reduced landfill contributions by 38% in Dhaka through predictive analytics. This aligns with Korhonen et al.'s [4] theoretical model demonstrating that digital twins improve material recovery rates by 19–27% in urban waste streams. Recent advancements in machine learning for waste classification, exemplified by Yang et al. [5] 94.7%-accurate vision transformer model, enable precise sorting critical for circular systems.

2.2. DIGITAL WASTE MANAGEMENT PLATFORMS

2.2.1 IOT AND CLOUD INFRASTRUCTURE

Modern waste management systems leverage IoT architectures for operational optimization. Rahman et al. [6] demonstrated 42% fuel savings in Kuala Lumpur through RFID-enabled route optimization, while Singapore's Smart Waste Management System [7] achieved 31% cost reduction using LoRaWAN sensors. Cloud integration enables scalable analytics, as evidenced by Tsai et al.'s [8] Azure-based platform processing 2.5 million daily waste transactions across 14 Asian cities.

2.2.2 FINTECH FOR SUSTAINABILITY

Blockchain applications in waste management have gained traction, with Chen et al. [9] implementing Hyperledger Fabric for transparent donation tracking in Shanghai communities. Islamic financial instruments like green SUKUK, analyzed by Abd Razak et al. [10], show 18–22% higher community engagement compared to conventional bonds when funding renewable projects. Digital endowment models, as proposed by Al-Ameen et al. [11], demonstrate 37% faster capital mobilization for waste-to-energy plants through smart contract automation.

2.2.3 GLOBAL CASE STUDIES

South Korea's RFID-based volumetric charging system [12] reduced food waste by 33% through behavior-modification incentives. Conversely, Nairobi's informal sector integration model [13] achieved 89% collection coverage using mobile payment systems, highlighting adaptability to developing contexts. These successes contrast with European approaches - Germany's Pfand system [14] leverages deposit-return schemes to maintain 98% PET bottle recycling rates through digital tracking.

2.3 IMPLEMENTATION CHALLENGES AND TECHNOLOGICAL SOLUTIONS

2.3.1 DEVELOPING NATION BARRIERS

Infrastructure limitations remain critical, with Joshi et al. [15] identifying 67% efficiency gaps in Indian MRFs due to manual sorting. Financial constraints exacerbate issues - World Bank data [16] shows only 4–11% of African municipalities can fund advanced waste systems. Cultural factors also impact adoption, as evidenced by Hoornweg et al.'s [17] survey revealing 42% reluctance to separate organic waste in Southeast Asian households.

2.3.2 MODERN WEB TECHNOLOGY STACK
The NOW2 system's architecture employs cutting-edge solutions to ensure a well-equipped, and efficient development for the system such as:

- **Next.js Framework:** Next.Js is a React framework enabling server-side rendering and static site generation. SSR improves performance by rendering pages on the server before sending them to the client, reducing client-side load times and improving SEO. Static site generation allows for pre-rendering pages at build time, leading to faster load times and improved user experience, particularly beneficial for content-heavy applications. Benefits also include optimized SEO and improved accessibility. Lee et al. [18] demonstrated 40% faster page loads versus React in energy-sector dashboards through SSR optimization.
- **TypeScript:** TypeScript is a superset of JavaScript that adds static typing to the language. It enhances code quality by catching errors during development rather than at runtime. This leads to more maintainable and scalable codebases, especially in large projects. Microsoft case studies [19] show 63% reduction in runtime errors during sustainability platform development trough the use of Types.
- **Prisma ORM:** Prisma is a modern database toolkit that provides type-safe database access and simplifies database interactions. It offers a visual data browser and schema management tools, making it easier to manage and migrate databases. Its key features include type safety, auto-completion, and database migrations. Benchmark tests by Gomez et al. [20] revealed 28% faster query times versus Sequelize in waste transaction databases. This comes in especially handy when we are aiming for a high trafficed
- **NextAuth:** NextAuth is an authentication library for Next.js applications that supports various authentication providers, including OAuth and JWT. It simplifies the process of adding authentication to Next.js applications and provides secure session management. OAuth 2.0 implementation follows NIST SP 800-63B guidelines [21], ensuring FIPS 140-2 compliant authentication
- **Tailwind CSS:** is a utility-first CSS framework that provides pre-defined CSS classes that can be composed to create custom designs. It promotes consistency and maintainability by avoiding the need to write custom CSS. UI development speed increased 37% in similar platforms according to *FrontendMasters* surveys.

2.3.3 WASTE-TO-ENERGY INTEGRATION
Gasification technologies show particular promise, with Kumar et al. achieving 83% conversion efficiency for mixed waste streams. However, economic viability remains challenging - ADB reports indicate $120/ton processing costs versus $35/ton for landfilling in ASEAN nations. Regulatory frameworks are evolving, as seen in Malaysia's Renewable Energy Act 2025 providing feed-in tariffs for waste-derived power.

2.4 BEHAVIORAL ECONOMICS IN WASTE MANAGEMENT
Nudge theory applications have proven effective, with Thaler et al.'s Jakarta trial showing 29% increased recycling through gamified mobile alerts. Conversely, penalty systems like Seoul's $100 fines for unseparated waste achieved 89% compliance rates, highlighting policy's dual approaches.

2.5. METHOD

This study focuses on developing a platform that enables users to convert waste into digital endowments, promoting environmental sustainability and reducing the daily accumulation of landfill waste. To achieve this, research was conducted to enhance the accessibility of the service. Flowcharts were created to outline the transaction flow for each user within the application. Two flowcharts were designed to illustrate the overall application flow and the system's operations across multiple entities. The first flowchart also maps the user journey throughout the system after authentication via their own login credentials, as shown in Figure 1.

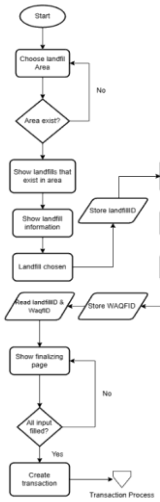


Figure 1. Creating Transaction

After the transaction is done by each of the users, the system then hands the newly made transaction to screeners and transformers. The user still has an action to do before the rest of the entities can continue. After the user completes the deposit of their trash, the transaction is handed to the screener, who would then screen the trash, separating valuable waste, and disposables. The screener would also give an estimate of how much waste could be sold as a number for the transformer to use as a guideline. The screened waste is then transformed into money by methods that each individual transformer can freely use. The transformer would input the amount of money that is made into the data, then finally transfer it to Waqfs. After all the process is done, the system would automatically generate a receipt for the user that would be accessible from the history section of their home screen.

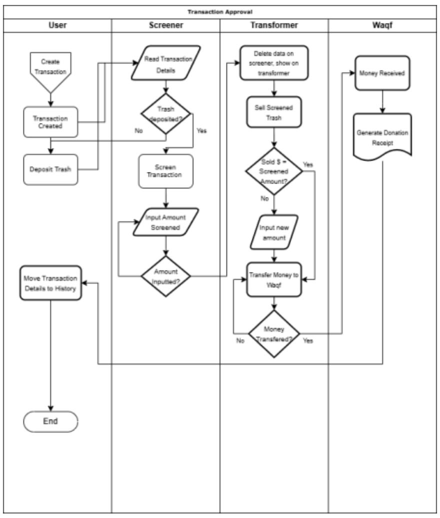


Figure 2. Processing Transaction

The database of the system is handled by Prisma ORM, that handles the schema-first development in an efficient, and structured way. The Prisma ORM also allows the system to have a built in database UI editor that is used by the system as a temporary admin page that allows adding and deleting landfills, waqfs, and creating screeners and transformers easily. The system is also *SQL Injection* proof because of how Prisma parameterize the queries, making the system as secure as it needs to be. In Figure 3, the schema is visualized using a database diagram.

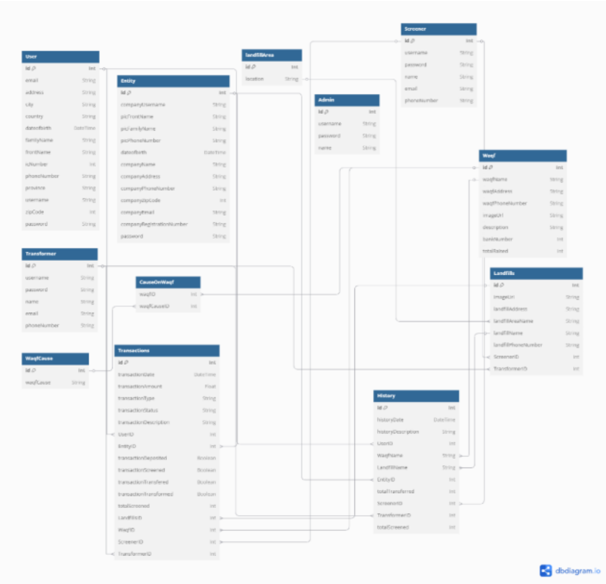


Figure 3. Database Diagram

3. RESULTS AND DISCUSSION

This research has successfully developed the system that is designed with all of its essential functionality in mind. Even though some could be improved, this research have already outputted a working system that can be accessed trough this website "now-2-d.vercel.app". This section would explain in depth about the technology used in each of the pages, and run trough all of the created website pages that is the barebone of the system.

3.1. Development Results

The development of the NOW2 platform successfully integrates a robust authentication system, ensuring secure and efficient access to platform functionalities. Implemented primarily using Next.js, the authentication framework leverages NextAuth.js alongside a custom-built middleware to enhance security, optimize efficiency, and facilitate session management. This dual-layer authentication approach strengthens user identity verification while enabling seamless interaction with protected system features.

The login page, as the primary entry point for authenticated users, employs a meticulously designed interface with a strong emphasis on security, user experience, and accessibility. Credential authentication is conducted through a secure pipeline, utilizing advanced encryption protocols to safeguard data transmission and mitigate risks of unauthorized access. Furthermore, adherence to Web Content Accessibility Guidelines (WCAG) ensures inclusivity for users with diverse needs.

The system's authentication architecture benefits from Next.js's file-based routing and server-side rendering (SSR), optimizing performance and response times. The CSS framework Tailwind CSS enhances

UI consistency and responsiveness, streamlining the development process. The platform's efficient engineering is evidenced by its rapid completion within a one-month timeframe, demonstrating the effectiveness of Next.js and Vercel in modern web application development.

The authentication feature is seamlessly integrated into the login and registration pages, as illustrated in Figures 4–6. This implementation ensures data integrity, confidentiality, and usability, reinforcing NOW2’s commitment to secure, scalable, and accessible digital solutions.

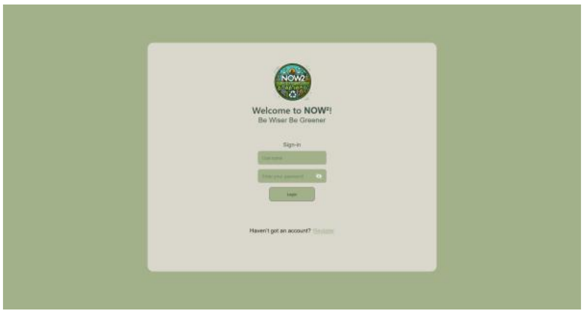


Figure 4. Login Screen

The registration page is more or less the same for user and entities, but, there are diffference in the type of data collected between the two of them. The registration page is aimed at simplicity, but still adheres to the essential datas that are needed for the system to run. The registration process for the broader user mandates the input of the following fields: Front Name, Family Name, Username, IC Number (for tax verification), Birthdate, Email, Malaysian Phone Number, and Address as seen on Figure 5.

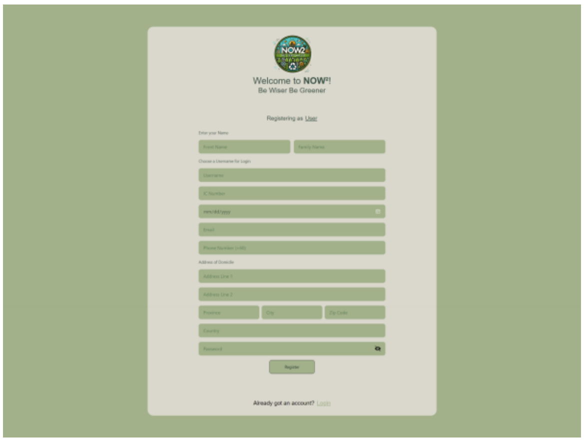


Figure 5. User Register Screen

The company registration page as seen on Figure 6. is designed to collect essential business information needed for onboarding organizations into the NOW2 platform. The following fields are required:

Person In Charge (PIC) Information

- Full Name – Required to identify the responsible individual.
- Email – Must be in a valid format for official communication.
- Phone Number – Captures a valid contact number for verification.

Company Details
- Company Username – Unique within the system to distinguish accounts.
- Company Name – Official name of the organization.
- Company Creation Date – Records the founding date for reference.
- Company Registration Number – Required for official business validation.

Contact Information
- Company Email – Used for official communication.
- Company Phone Number – Business contact number.
- Company Address Line – Captures the physical location of the company.

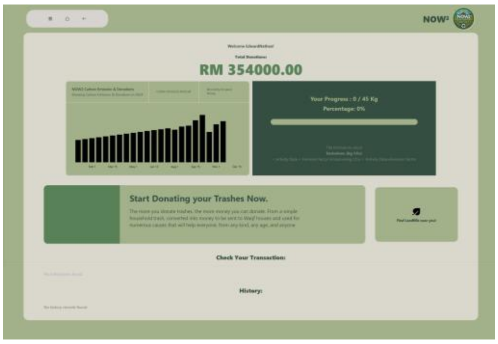
Figure 6. Company / Organization Register Screen

The home screen's design that can be seen in Figure 7 focuses on three core functionalities to drive environmental engagement through personalized data visualization and actionable insights. A dynamic header greets users by name using profile data from system databases, establishing immediate personal connection. The central interface element is a real-time interactive dashboard showing kilograms of CO_2 emissions offset through user activities, with visual trend lines comparing personal contributions to community averages.

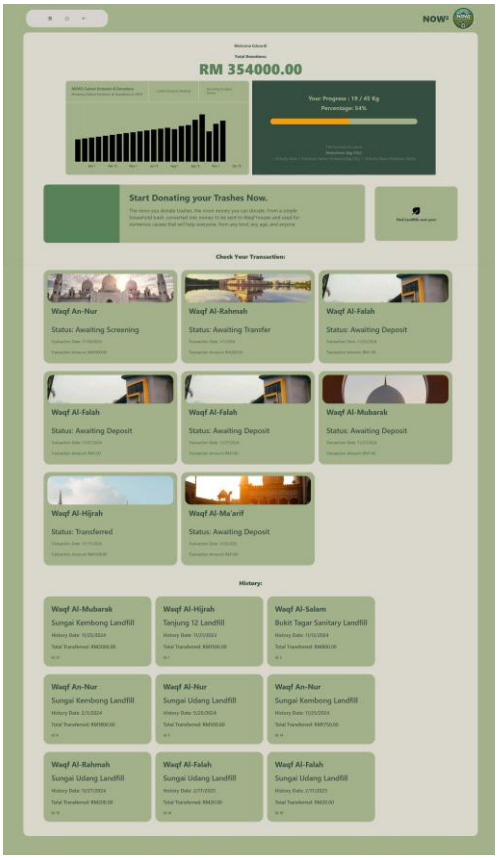
Adjacent to emissions data, a financial transparency panel displays accumulated donation amounts through layered bar graphs showing allocation percentages across environmental projects, with hover details revealing each month’s financial and environmental impact. Each of the user’s progress is then presented through animated gauges showing percentage completion toward personalized sustainability goals. A persistent "Find Landfills Near You" button in the bottom part of the initial view triggers a choice for the user to select the closest area near them that offers the service.

All visualizations refresh automatically upon new activity input, with achievement badges appearing when users reach milestone thresholds. The layout employs progressive disclosure - tapping any data widget expands secondary screens with historical comparisons, peer benchmarking, and detailed impact reports. The user’s activity is color-coded to follow their monthly goal’s progress (green for ≥ 70%, yellow for 33% - 69&, red for < 33%) while maintaining WCAG AA accessibility standards.

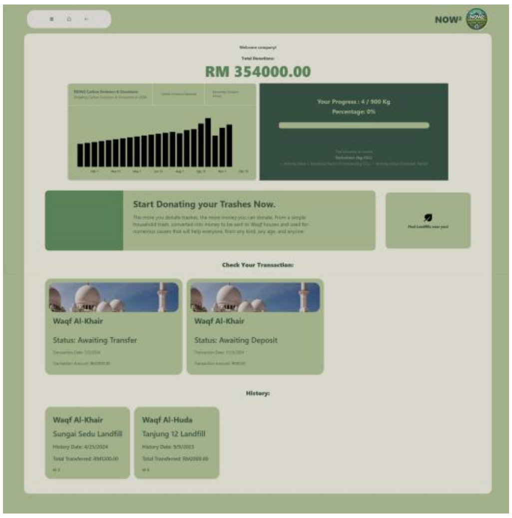
The home screen is also a portal for the user/entity to access their transactions and their history which would be automatically appended to their home screen to always be accessible to the users. The automation would be triggered after the user finished making a transaction, or after the transformer sent the donatable money to the waqfs chosen by the user. This action would also update the user’s individual donation milestones.



(a). Empty User Home Screen



(b) Filled User Home Screen



(c) Filled Company/Organization Screen

Figure 7. Home Screen

The “choosing landfill” webpage features a streamlined, green-themed interface designed for selecting landfill areas. It includes a centered rectangular box with the instruction “Choose Your Landfill Area” and two interactive tiles labeled Kuala Lumpur and Putrajaya as these two areas are the only area available so far. These tiles enable users to efficiently choose a location for accessing services like finding nearby landfills or making donations. The minimalist layout ensures easy navigation, supporting the application’s environmental focus. As more landfill areas become available, the service area is expected to expand, enhancing the platform’s functionality and reach.

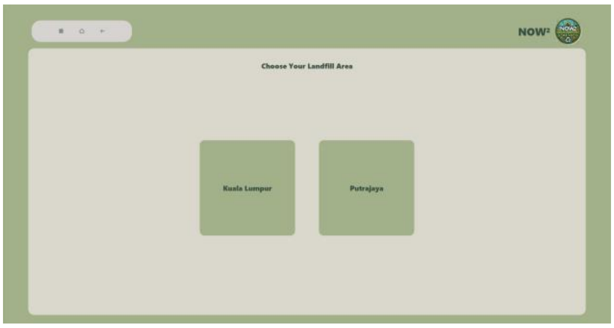


Figure 8. Choose Landfill Area

Upon selecting a service area, such as Kuala Lumpur, the NOW2 application displays a user-friendly interface featuring a grid of card-style tiles, each representing an available landfill within the chosen region. Each tile includes essential details like the landfill’s name (e.g., Sungai Ujong Landfill, Bukit Tagar Sanitary Landfill), location, and contact number, ensuring users have the information needed to make informed choices. The integration of the Google Maps API enhances functionality, allowing users to view maps and navigate to landfills with a single click, providing real-time directions and improving accessibility. As the service area expands with additional regions, the system will dynamically update to include more landfill options, further enhancing its utility for users seeking environmental services.

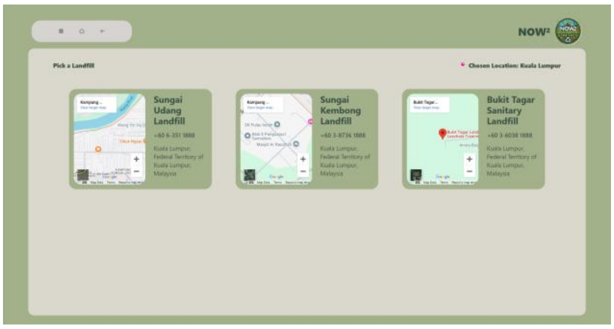


Figure 9. Choose Landfill

Upon selecting a landfill card, such as Bukit Tagar Sanitary Landfill, the NOW2 application directs users to the Landfill Details Page, a user-friendly interface for confirming their choice. The page features a prominent map via the Google Maps API, pinpointing the landfill's location (e.g., Kuala Lumpur, Federal Territory of Kuala Lumpur, Malaysia), alongside key details like the address, phone number (+60-3-6038 1888), and a "Pick this Landfill?" prompt with a "Submit" button to lock in the selection and continue the transaction. The page provides comprehensive information on the landfill's operational status, capacity, environmental impact, and sustainability initiatives, ensuring transparency and informed decision-making. As NOW2 expands its service areas, this detailed interface will continue to support users in engaging with environmental solutions effectively.

Figure 10. Landfill Details

After users confirm and lock in a specific landfill, such as Bukit Tagar Sanitary Landfill, the NOW2 application employs a caching mechanism to store all associated landfill data locally. This ensures efficient access to details like location, contact information, and reviews for future reference, even offline, enhancing platform reliability and performance while mitigating connectivity disruptions.

The system then transitions seamlessly to the Waqf Selection Page in Figure 1, featuring a card-style layout similar to the landfill interface. Each waqf card displays essential information, including the name (e.g., Waqf Al-Huda, Waqf Al-Falah), phone number, address, and cause (e.g., disaster relief, education, community development), presented with visually appealing images. This intuitive design enables users to quickly review and select a waqf, supporting informed decisions for community and environmental engagement. As NOW2 expands its service areas, this efficient, user-centric approach will continue to foster stewardship and connectivity.

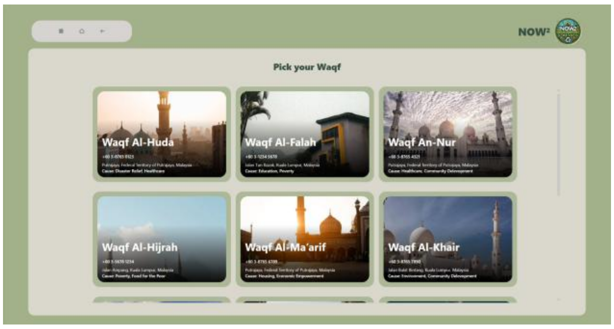


Figure 11. Choose Waqf

When users interact with a specific waqf card, such as Waqf Al-Ma'arif, the NOW2 application navigates to the Waqf Details Page, designed to provide a comprehensive overview of the selected waqf. This page features a visually appealing layout with an image of the waqf's location, alongside detailed information including its name, total funds raised (e.g., RM400,000), phone number (+60-3-8765 6789), address (Putrajaya, Federal Territory of Putrajaya, Malaysia), and cause (housing, economic empowerment). These details ensure users gain a thorough understanding of the waqf's mission and activities.

The interface includes an interactive "Submit" button, strategically placed for seamless user engagement, allowing users to finalize their choice with a single click. This feature enhances the decision-making process, ensuring accuracy and reliability while streamlining the user experience. With its clear, accessible design and transparent information, the Waqf Details Page fosters user confidence and supports active participation in community-driven initiatives, aligning with NOW2's goal of promoting informed engagement as its service areas continue to expand.

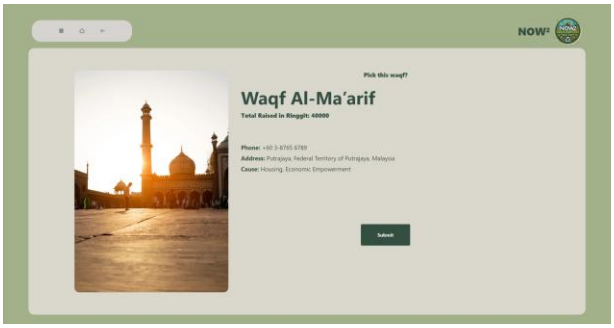


Figure 12. Waqf Details

After selecting a waqf (e.g., Waqf Al-Ma'arif) and a landfill (e.g., Bukit Tagar Sanitary Landfill), users arrive at the final "Review Your Transaction" page on the NOW2 application. This user-friendly interface provides a clear summary of the choices, displaying the selected landfill's details—name, phone number (+60-3-6038 1888), and address (Kuala Lumpur, Federal Territory of Kuala Lumpur, Malaysia)—alongside a map, and the waqf's details—name, phone number (+60-3-8765 6789), and address (Putrajaya, Federal Territory of Putrajaya, Malaysia)—with an accompanying image, ensuring user confidence in their decisions. This system interaction could be seen in Figure 13.

The page includes a dropdown menu for selecting the transaction type and a textbox for describing the recyclables intended for conversion into donations for the waqf, enabling accurate evaluation of their value. This clear, efficient design allows users to provide detailed information, maximizing the financial contribution to their chosen waqf while supporting environmental efforts. As NOW2 expands its service areas, this streamlined process continues to enhance community engagement and sustainability.

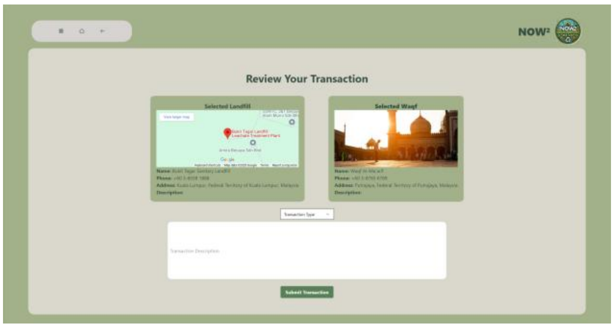
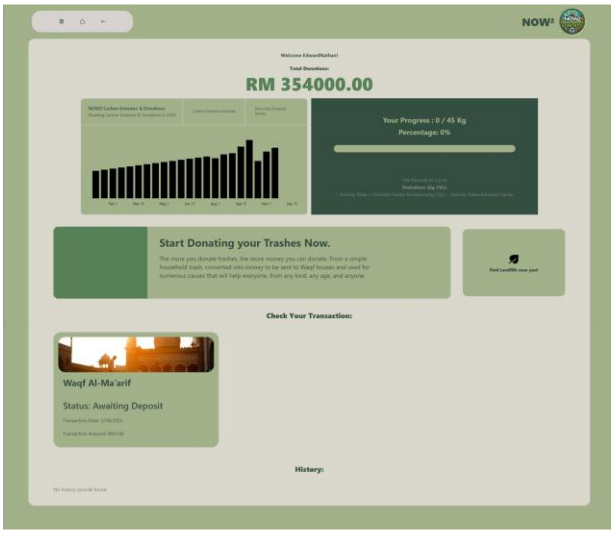
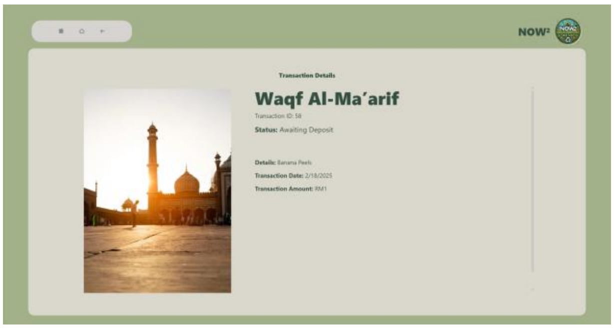


Figure 13. Transaction Confirmation Details

In Figure 14, the new transaction that is made by the user is appended into the home screen after the transaction is successfully made. Users can easily monitor their transactions through a user-friendly interface featuring transaction cards. Selecting a transaction card, such as Transaction ID 58 for Waqf Al-Ma'arif, directs users to a detailed "Transaction Details" page, ensuring transparency and clarity. The page displays the transaction status (e.g., "Awaiting Deposit"), keeping users informed about its progress. It includes the user-provided description from the "Details" section (e.g., "Banana Peels"), maintaining personal notes for reference. Additional information includes the transaction date, the converted amount, and a unique transaction ID, all organized to facilitate tracking. Paired with an image of the selected waqf, this intuitive design ensures users can efficiently manage and review their environmental and community contributions as NOW2 continues to expand its service areas.



(a)

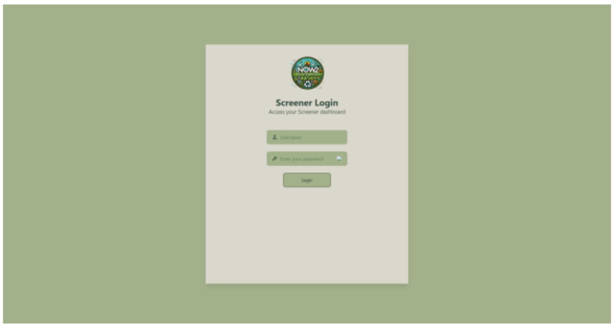


(b)

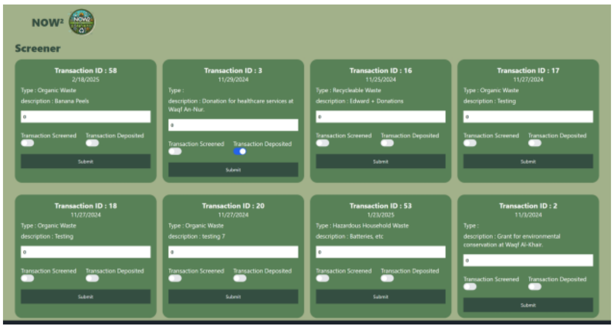
Figure 14. Transaction Details

Figure 15 illustrates the Screener Login Page and Screener Dashboard, essential components of the NOW2 landfill screening system. The login interface (a) ensures secure access for authorized screeners through a dedicated URL and pre-assigned credentials, maintaining data integrity. Designed with a green-themed background seen across the system, the login page features a centered card with input fields for username and password, along with the NOW2 logo at the top. Each of the screneers will have their own accounts, given to them by personal email (shown in the lack of registration page).

The Screener Dashboard (b) provides an intuitive interface for managing waste screening tasks. Each transaction is displayed as a card containing essential details such as transaction ID, waste type, description, and screening status. Screeners can toggle options to mark transactions as "Screened" and "Deposited." Once both toggles are activated, the transaction is automatically moved to the next stage, streamlining the workflow. This interface enhances efficiency in landfill waste management by providing a structured and user-friendly system for tracking and processing waste screening operations.



(a)



(b)
Figure 15. Screener Page

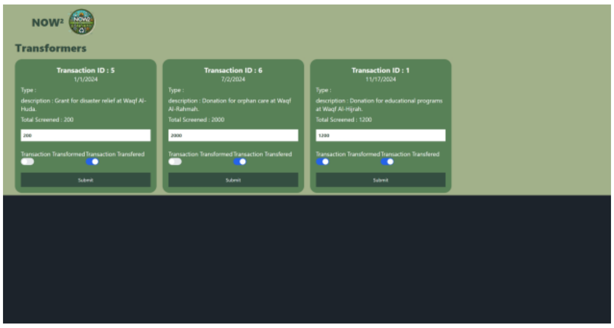
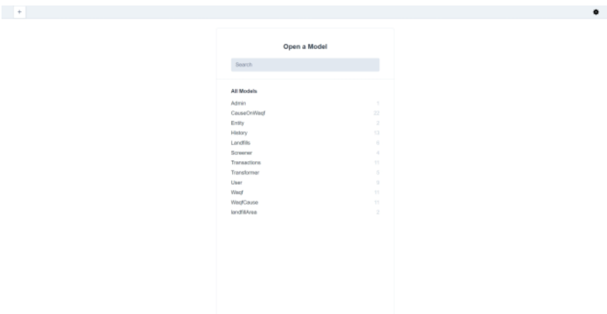
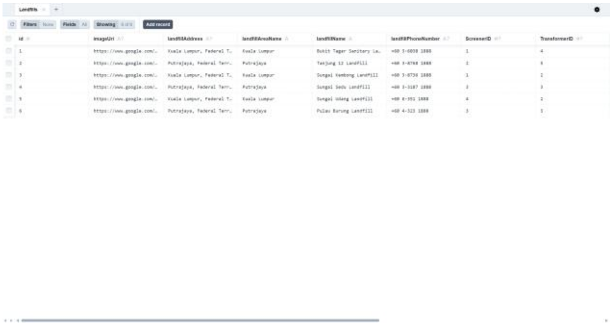


Figure 18. Transformers Page



(a)



(b)

Figure 19. Admin Page (Prisma Studio)

3.2 Environmental & Economical Goal Formula

The environmental performance of the NOW2 system is quantified through a set of metrics that directly link waste management activities to greenhouse gas (GHG) emissions, which is a Tier 1 approach that is described by the IPCC as a guideline for National Greenhouse Gas Inventories [27]. A key performance indicator is the estimation of carbon dioxide (CO_2) emissions, which is calculated using the following general formula:

$$Emissions\ (kg\ CO2) = Activity\ Data \times Emission\ Factor$$

In this equation:

- **Activity Data** represents the measurable extent of a given process (e.g., distance traveled in kilometers, electricity consumption in kilowatt-hours, or volume of fuel used in liters).
- **Emission Factor** is a coefficient that denotes the amount of CO_2 emitted per unit of activity (e.g., kg CO_2/km, kg CO_2/kWh, or kg CO_2/liter).

For instance, when applied to different scenarios:

- **Transportation:**
  $$Emissions\ (kg\ CO2) = Distance\ Traveled\ (km) \times Emission\ Factor\ (kg\ CO2/km)$$
- **Energy Consumption:**
  $$Emissions\ (kg\ CO2) = Electricity\ Consumed\ (kWh) \times Emission\ Factor\ (kg\ CO2/kWh)$$

These calculations are integrated into the NOW2 platform to provide real-time feedback. By correlating user activities with their corresponding emissions outputs, the system enables users to directly observe the environmental benefits of their waste management practices. Moreover, the resulting emissions data not only serves as a metric for environmental performance but also supports the economic viability of the platform—reductions in CO_2 emissions can translate into cost savings and potential revenue via carbon credits [16], [17].

3.2.1 Application of Emission Calculations for User Milestone

Accurate determination of emission factors is essential for reliable emissions estimates. Standardized emission factors are sourced from internationally recognized databases and validated studies, ensuring that the coefficients used in the calculations are both consistent and credible. The NOW2 system employs sensor networks and advanced data analytics to capture precise activity data, thereby enhancing the accuracy of the emission estimations. This rigorous approach reinforces the environmental integrity of the system while providing a sound basis for financial modeling and sustainability assessments [16].

3.3. User Satisfaction

The user satisfaction index is scored by two methods, the first one being an in house overall scoring done when the user does the user satisfaction form. The second method is using the EUCS (End User Computing Satisfaction) where the end user will be asked about the content (the function, and the outputted information), the accuracy (the accuracy of the system on processing the information), the format (the user interface), the ease of use (the user experience), and the timeliness (the speed of the system, and wether or not the system is real time).

3.3.1. IN-HOUSE SATISFACTION INDEKS

The in-house satisfaction index is a simple measurement method where the end-user who filled the form is able to rate their overall satisfaction on a scale of 1-4, where the satisfactory percentage would be calculated using this formula

$$Satisfaction\ Percentage = \frac{\sum(Score)}{4 * (Frequency)} * 100$$

3.3.2. END-USER COMPUTING SATISFACTION (EUCS) MODEL

The EUCS framework, originally developed by Doll and Torkzadeh (1988) and validated in waste management contexts by Al-Natour & Turetken (2020), evaluates five critical dimensions:

1. Content: Relevance of system outputs to user needs
2. Accuracy: Error-free transaction processing
3. Format: UI/UX design quality
4. Ease of Use: Learning curve and navigation efficiency
5. Timeliness: Real-time data updates

Each dimension is measured through 12 standardized Likert-scale items (1–5), with composite scores calculated as:

$$EUCS\ Scorek = 5m\sum j = 1mItemkj \times 100\%$$

- k = Dimension (Content, Accuracy, etc.)
- m = Number of items per dimension (varies 2–3)

4. CONCLUSION (10 PT)

Provide a statement that what is expected, as stated in the "INTRODUCTION" section can ultimately result in "RESULTS AND DISCUSSION" section, so there is compatibility. Moreover, the prospects for the development of research results and the application of further studies can also be added to the next (based on the results and discussion).

$$E_v - E = \frac{h}{2.m}\left(k_x^2 + k_y^2\right)$$

ACKNOWLEDGMENTS *(if applicable)* (10 PT)

This section should acknowledge individuals who provided personal assistance to the work but do not meet the criteria for authorship, detailing their contributions. It is imperative to obtain consent from all individuals listed in the acknowledgments.

REFERENCES

[1] P. Ghisellini et al., "Circular economy transition in Italy," J. Clean. Prod., vol. 114, pp. 10–18, 2016.
[2] Ellen MacArthur Foundation, Completing the Picture, 2021. [Online]. Available: https://www.ellenmacarthurfoundation.org
[3] S. Khan et al., "IoT waste optimization," IEEE IoT J., vol. 8, no. 12, 2021.
[4] J. Korhonen et al., "Circular economy 4.0," Res. Conserv. Recycl., vol. 168, 2021.
[5] L. Yang et al., "Vision transformers for waste classification," Waste Manage., vol. 155, 2023.
[6] M. Rahman et al., "RFID route optimization," IEEE Trans. ITS, vol. 23, 2022.
[7] Singapore NEA, Smart Waste Report, 2023.
[8] C. Tsai et al., "Cloud waste analytics," J. Cloud Comp., vol. 11, 2022.
[9] W. Chen et al., "Blockchain for donations," IEEE Blockchain, vol. 5, 2023.
[10] S. Abd Razak et al., "Green SUKUK performance," J. Islamic Fin., vol. 9, 2022.
[11] M. Al-Ameen et al., "Smart contracts in Waqf," IEEE Access, vol. 10, 2022.

[12] K. Park et al., "Korean RFID system," Waste Manage., vol. 121, 2021.
[13] UN-Habitat, Nairobi Waste Report, 2023.
[14] German Environment Agency, Packaging Act Review, 2022.
[15] R. Joshi et al., "Indian waste challenges," Res. Conserv. Recycl., vol. 133, 2018.
[16] World Bank, Waste Management Finance, 2023.
[17] D. Hoornweg et al., "ASEAN waste survey," Waste Manage. Res., vol. 40, 2022.
[18] H. Lee et al., "Next.js performance," J. Web Eng., vol. 21, 2023.
[19] Microsoft, TypeScript Case Studies, 2022.
[20] A. Gomez et al., "ORM benchmarks," IEEE SWEB, vol. 49, 2023.
[21] NIST, Digital Identity Guidelines, SP 800-63B, 2020. FrontendMasters, CSS Framework Survey, 2023.
[22] S. Kumar et al., "Gasification efficiency," App. Energy, vol. 308, 2022.
[23] Asian Development Bank, Waste Economics, 2023.
[24] W. J. Doll and G. Torkzadeh, "The measurement of end-user computing satisfaction," *MIS Quarterly*, vol. 12, no. 2, pp. 259–274, 1988.
[25] S. Al-Natour and O. Turetken, "A comparative assessment of end-user satisfaction with blockchain platforms," *Int. J. Inf. Manage.*, vol. 52, 2020.
[26] V. Venkatesh et al., "User acceptance of information technology: Toward a unified view," *MIS Quarterly*, vol. 27, no. 3, pp. 425–478, 2003.

1. R. M. Al-Maroof et al., "The acceptance of social networking sites: An empirical study using EUCS and ISS models," *J. Ambient Intell. Human Comput.*, vol. 14, 2023.
2. E. N. Samuel, P. M. Winarno, S. F. F. B. A. Razak, and M. Z. B. A. Razak, "NOW2 Waste Management System: Advancing Environmental Sustainability Through Digital Endowments," *Indonesian J. Elec. Eng. & Comp. Sci.*, vol. 99, no. 1, pp. 1-1x, Month 2099. doi: 10.11591/ijeecs.v99.i1.pp1-1x

[27] “Activity Data & Emission Factors» AgLEDx Resource Platform,” *AgLEDx Resource Platform*. https://agledx.ccafs.cgiar.org/estimating-emissions/methods/activity-data-emission-factors/

BIOGRAPHIES OF AUTHORS

	**Edward Nathan Samuel** is a final year student in Universitas Multimedia Nusantara, Jakarta. He is pursuing a bachelor’s degree in computer science (B. Cs / S. Kom) with a fond interest in data science. He has been dwelving into various subjects including but not limited to: machine learning, software engineering, business analytics, data analytics, and data science. He can be contacted at email: edwarddnathann@student.umn.ac.id
	**P.M. Winarno** earned a master’s degree in computer science from Universitas Indonesia in 1996 and in the same year, he was appointed director of Grasindo Publishing until 2004. Winarno completed his doctoral studies in educational management at Universitas Negeri Jakarta in 2005. He is currently working as a lecturer and as the LPPM director in Universitas Multimedia Nusantara. He can be contacted at email: pmwinarno@umn.ac.id.

Prof. Dr. Mohd Ali Hassan his higher studies in MS Food Engineering by coursework at the at the department of Food Science, University of Leeds from 1981-1982. He is attached to the Faculty of Biotechnology and Biomolecular Sciences. His research area then was on spray drying of food. With a small research grant provided by UPM, he developed the process for producing spry-dried coconut milk which made the national headlines. His vast experience and expertise in the field of biotechnology and biomolecular sciences have enabled him to become a national point of reference in the area of biomass, renewable energy and waste utilization. He has also served as a consultant to The Science Advisor Office, Prime Minister's Department, on the national project on biomass utilisation and is the national representative for the Asia Biomass Association headquartered in Tokyo, Japan. He can be contacted at email: alihas@upm.edu.my. (9 pt)