

EcoKonek : A Web-Based Solution for Responsible E-waste Disposal and Bridging the Digital Gap in Local Communities in Mexico Pampanga

EcoKonek: Cleaner Communities, Connected Futures

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The main findings (novelty) and why they are important and useful:

EcoKonek introduces a unified community-based electronic waste management and digital inclusion system that integrates an AI-powered support chatbot, barangay-level drop-off mapping, and a real-time environmental impact dashboard within a single platform. Unlike traditional manual waste tracking that relies on fragmented local records and uncoordinated household disposal, EcoKonek ensures faster, more accurate, and transparent collection and device redistribution workflows. Its novelty lies in combining real-time classification guidance, localized drop-off point visualization, and automated sustainability metrics to support decision-making at the household, volunteer, and local government unit (LGU) level. This makes the system not only a tracking tool but also a socio-environmental decision-support platform that improves accessibility, community engagement, and ecological accountability in localized recycling operations.

Keywords: Circular economy, Digital inclusion, E-waste management, Sustainability, Web-based system

Abstract

Electronic waste (e-waste) and the digital divide remain pressing issues in the Philippines, particularly in local communities where access to proper disposal systems and digital resources is limited.

This study utilized a descriptive quantitative research design involving 50 respondents from Mexico, Pampanga. Data were collected through structured surveys and analyzed using descriptive statistics. The system was developed using Agile and Scrum methodologies to ensure iterative improvements.

Findings revealed high user satisfaction in terms of usability, accessibility, and system effectiveness. Respondents showed strong willingness to participate in responsible e-waste disposal and device donation.

The platform successfully integrates features such as an AI-powered chatbot, barangay-level mapping, and an environmental impact dashboard.

The study demonstrates that EcoKonek is a feasible and scalable solution for addressing e-waste management and digital inequality. It highlights the potential of integrating technology, community engagement, and sustainability practices into a unified platform for local implementation.

Background

Electronic waste (e-waste) has become a growing environmental concern worldwide, driven by the increasing consumption of electronic devices and rapid technological advancement. In the Philippines, improper disposal of e-waste contributes to environmental pollution and health risks due to hazardous materials such as lead and mercury. At the same time, many functional electronic devices are discarded despite the presence of underserved communities that lack access to digital tools, contributing to the persistence of the digital divide.

Existing policies, such as the Ecological Solid Waste Management Act (RA 9003), provide a regulatory framework for waste management. However, there remains a lack of accessible, centralized, and technology-driven solutions specifically addressing e-waste at the community level. Local government units (LGUs) and organizations often rely on manual processes, which limit efficiency, transparency, and scalability.

To address these challenges, this study introduces EcoKonek, a web-based platform designed to facilitate responsible e-waste disposal and promote digital inclusion. The system integrates features such as an AI-powered chatbot for user guidance, barangay-level mapping for drop-off points, a donation redistribution module, and an environmental impact dashboard.

This paper presents the development and evaluation of EcoKonek as a community-based solution for sustainable e-waste management and digital equity in Pampanga.

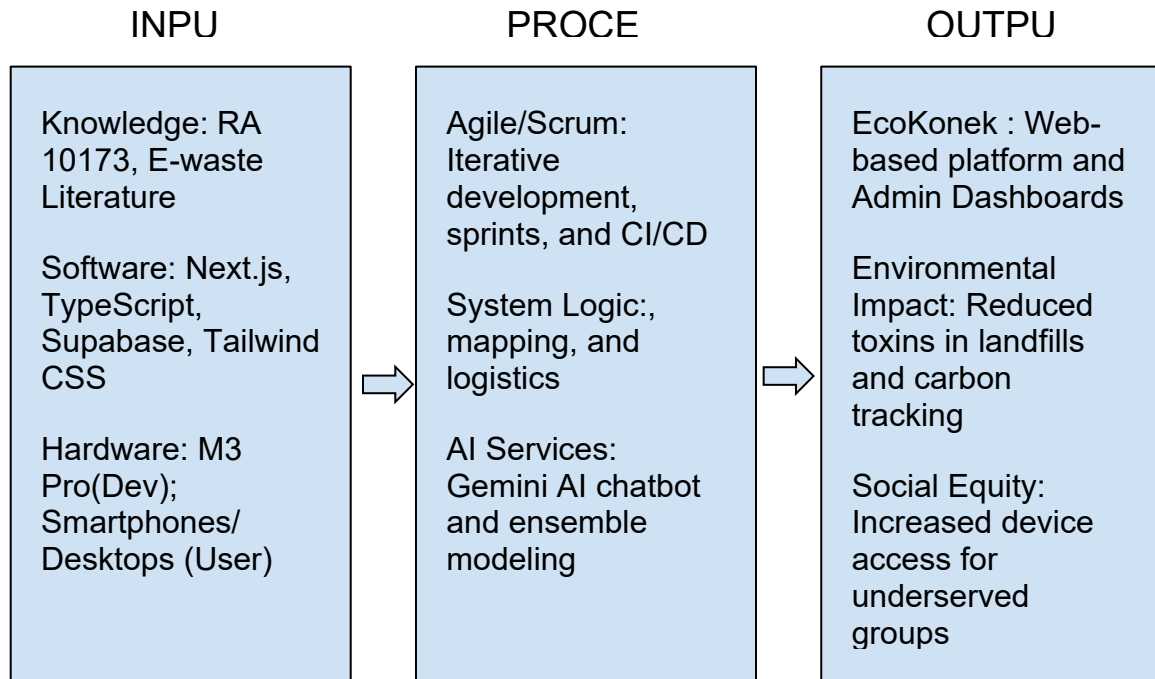
Methods

Research Design and Model Used

This study employed a descriptive quantitative research design to assess user awareness, behavior, and perceptions related to e-waste management and digital inclusion. The approach focused on collecting measurable data to identify trends and evaluate the potential usability and acceptance of the proposed system.

Parallel to the research design, the development of EcoKonek followed the Agile Development Framework with Scrum methodology, enabling iterative system design, continuous testing, and refinement based on user feedback and collected data.

Figure 1. IPO Framework of the System



System Development Approach

The development of the EcoKonek platform followed an Agile-based iterative process, divided into six targeted sprint cycles. This methodology ensured developmental flexibility, allowing the system to incrementally integrate core functionalities such as the AI Chatbot, geospatial mapping, and impact dashboards while adapting to user feedback.

Table 1: Sprint Cycles for the Development of EcoKonek

Sprint Phase	Sprint Goal	Key Deliverables
Sprint 1	Establish a secure system foundation and user authentication infrastructure.	Configured PostgreSQL database and Row-Level Security (RLS); developed user login/registration interface.
Sprint 2	Develop the core e-waste submission engine and automated classification logic.	Built device submission forms with image upload; implemented logic to differentiate between recycling and donation items.
Sprint 3	Integrate geospatial mapping for localized drop-off point accessibility.	Integrated Google Maps API; developed interactive markers and dashboards for barangay-level drop-off centers.

Sprint 4	Implement AI-driven assistance and a centralized sustainability resource hub.	Integrated Google Gemini AI for the interactive chatbot; developed the educational hub for e-waste hazard awareness.
Sprint 5	Quantify environmental impact and gamify user engagement through rewards.	Implemented CO ₂ footprint reduction algorithms; designed the environmental impact dashboard and eco-points system.
Sprint 6	Deploy administrative oversight tools and a social stewardship community platform.	Built the LGU administrative dashboard for collection tracking; developed the community feed to foster social engagement.

Participants and Setting

The study was conducted in Mexico, Pampanga, involving a total of 50 respondents from local households aged 15 to 60 years old. Participants were selected to represent a range of users with varying levels of awareness and access to e-waste management practices.

Research Instrument

Data were collected using a structured survey questionnaire designed to measure:

- i. Awareness of e-waste disposal practices
- ii. Perceived usefulness of the system
- iii. Ease of use and accessibility
- iv. Willingness to adopt the platform

The survey instrument was pilot-tested to ensure clarity, reliability, and relevance to the study objectives.

Data Collection Procedure and Analysis

Data collection was conducted through a digitally distributed survey, allowing respondents to provide input efficiently. The collected data were analyzed using descriptive statistical methods, including mean scores and frequency distribution, to identify patterns in user perception and behavior.

The findings were then used to inform system improvements within the Agile development cycle, ensuring that the platform design aligns with user needs and expectations.

Results and Discussion

The EcoKonek PH web application achieved a highly successful evaluation from the IT expert panel, generating a cumulative Grand Mean of 3.91 with an overall standard deviation (SD) of 0.38, which corresponds to a "High" verbal interpretation. This positive statistical outcome demonstrates that the platform is technically sound, well-designed, and fully capable of operating as a dependable e-waste management solution. The small overall standard deviation of 0.38 indicates a strong consensus among the software engineers and system consultants, proving that the evaluators were in unified agreement regarding the system's structural quality and operational readiness.

Table 2. Overall Summary of ISO 25010 Quality Characteristics

Statement	Mean	SD
Functional Suitability	3.53	0.33
Performance Efficiency	4.50	0.00
Compatibility	4.60	0.23
Usability	4.00	0.45
Reliability	3.80	0.45
Security	3.80	0.45
Maintainability	3.80	0.45

System Architecture and Features

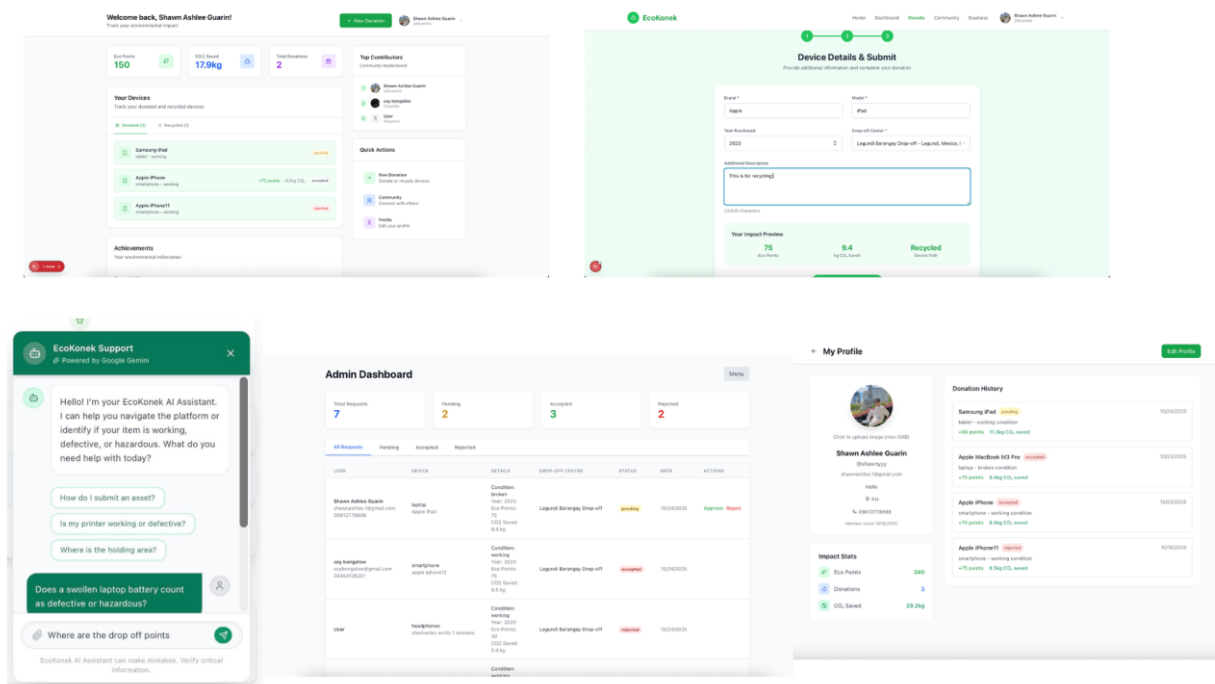


Figure 2. Core User Features of the EcoKonek Platform

The User Dashboard serves as a personalized central hub, offering users a real-time overview of their environmental contributions, including earned eco-points, CO₂ saved, and a tracker for donated or recycled devices.

The Device Submission Form functions as the core data collection interface, enabling users to input device details, upload verification photos, and select verified drop-off centers to ensure accurate and accountable processing for recycling or redistribution.

The EcoKonek AI Chatbot provides 24/7 real-time assistance by leveraging Google Gemini to respond to user inquiries, guide them on proper e-waste classification, and clarify safety protocols for hazardous items.

The Admin Dashboard provides a centralized administrative oversight tool, allowing platform managers and Local Government Units (LGUs) to monitor pending collection requests, approve or reject device submissions, and track overall system analytics in real time.

The Profile Page acts as a dedicated space for users to manage their personal information, aggregating their donation history and environmental impact statistics to foster transparency and sustained motivation for environmental action.

Perceived Usefulness and Usability

To assess user perception, the platform's usability and effectiveness were evaluated using a 10-statement System Usability Scale (SUS) administered to community respondents. The results demonstrated exceptional user satisfaction, particularly highlighting the platform's multi-device accessibility, intuitive interface, and success in motivating responsible environmental actions.

Table 3: *System Usability Scale (SUS) - User Perception*

Statement	Mean	SD	Verbal Interpretation
The EcoKonek PH app is intuitive, easy to navigate, and simple to use even for first-time users.	3.54	0.54	Very High
I was able to access and use EcoKonek PH without technical issues using my available device and internet connection.	3.56	0.50	Very High
The educational content in EcoKonek PH is clear, accurate, and helped me better understand e-waste and its environmental impact.	3.52	0.50	Very High
EcoKonek PH's donation system effectively supports digital inclusion for students, seniors, and persons with disabilities (PWDs).	3.42	0.54	Very High
EcoKonek PH motivates and encourages me to responsibly dispose of my electronic waste.	3.48	0.50	Very High
The barangay-level tracking feature increases environmental awareness and participation within my community.	3.44	0.50	Very High
After using or learning about EcoKonek PH, I feel more empowered to take positive action for the environment.	3.36	0.56	Very High
I would recommend EcoKonek PH to others in my school, workplace, or community.	3.5	0.58	Very High
The donation and redistribution system is transparent, trustworthy, and provides a secure way to donate functional devices.	3.4	0.57	Very High
EcoKonek PH effectively connects me with my local barangay's e-waste management programs and activities.	3.52	0.50	Very High
The scheduling process for e-waste pickups through EcoKonek PH is convenient, reliable, and timely.	3.42	0.54	Very High

Behavioral Intention to Use

The results demonstrate a strong willingness among respondents to adopt and recommend the platform. Participants expressed interest in using EcoKonek for future e-waste disposal and indicated that the system encourages responsible environmental behavior.

Furthermore, respondents showed openness to participating in community-based collection initiatives, suggesting that the platform can support increased engagement at the barangay level.

Results and Discussion:

Technical Quality Evaluation To validate the technical robustness and software quality of the platform, IT experts evaluated the system based on the ISO/IEC 25010 standards. The high overall scores confirm that EcoKonek is highly secure, exceptionally fast, and ready for scalable enterprise deployment.

Table 4: Overall Summary of ISO 25010 Quality Characteristics

Characteristic	Mean	SD	Verbal Interpretation
Functional Suitability	3.53	0.33	High
Performance Efficiency	4.50	0.00	Very High
Compatibility	4.60	0.23	Very High
Usability	4.00	0.45	High
Reliability	3.80	0.45	High
Security	3.80	0.45	High
Maintainability	3.80	0.45	High
Overall Grand Mean:	3.91	0.55	High

Bridging the Digital Gap through Hardware Accessibility

A core objective of EcoKonek is to bridge the digital divide by ensuring the platform remains fully functional on legacy and low-end devices. The platform's lightweight, serverless architecture enables seamless access for underserved residents using standard, mid-range smartphones without significant technical latency.

Table 5: *Smartphone End User Specifications*

Component	Specification Requirement
Processor	1.5 GHz Quad-Core (e.g., Snapdragon 400 series) or A11 Bionic Chip or equivalent
Memory (RAM)	2 GB (Minimum) / 4 GB (Recommended)
Camera	8 MP with Autofocus (for device verification)
Storage	100 MB available for web-cache
Display	5.0-inch LCD (720 x 1280)
Operating System	Android 7.0 (Nougat) or newer; iOS 12.0 or newer
Connectivity	Stable 3G / 4G LTE / Wi-Fi

Data Collection Procedure and Analysis

The interpretation of the evaluation data utilized standardized adjectival rating scales to ensure objective analysis. A 4-point Likert scale was used to assess community end-user perception (SUS), while a 5-point Likert scale was applied to the IT experts' technical evaluation (ISO/IEC 25010) to capture precise functionality metrics.

Table 6: *Descriptive Rating Scales for System Evaluation*

Scale (4-Point User SUS)	Adjectival Rating	Interpretation	Scale (5-Point IT Expert ISO)
4	Strongly Agree	Very High Acceptability	4.21 – 5.00
3	Agree	High Acceptability	3.41 – 4.20
2	Disagree	Moderate / Low Acceptability	2.61 – 3.40
1	Strongly Disagree	Very Low Acceptability	1.00 – 2.60

Conclusion

EcoKonek presents a practical and technology-driven approach to addressing the challenges of e-waste management and digital inclusion at the community level. The findings of the study indicate that users are receptive to a web-based platform that simplifies disposal processes, improves awareness, and enables the redistribution of functional electronic devices.

The integration of features such as an AI-powered chatbot, barangay-level mapping, and an environmental impact dashboard demonstrates the potential of combining digital tools with community-based initiatives. These features contribute to enhancing user engagement and supporting informed decision-making in responsible e-waste handling.

While the system has shown promising results in terms of usability and user acceptance, it remains in the development and evaluation stage. Further implementation through pilot testing in collaboration with local government units and partner organizations is recommended to validate its effectiveness in real-world settings.

Overall, EcoKonek highlights the potential of leveraging web-based technologies to promote sustainable practices and bridge the digital divide. With continued development and stakeholder collaboration, the platform can serve as a scalable model for community-driven environmental and social innovation.

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