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Reverse logistics and electronic waste recycling: challenges and opportunities for the circular economy in Amazonas

Logística reversa e reciclagem de resíduos eletrônicos: desafios e oportunidades para a economia circular no Amazonas

Logística inversa y reciclaje de residuos electrónicos: desafíos y oportunidades para la economía circular en Amazonas

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Abstract

The growing consumption of electrical and electronic equipment increases waste generation and calls for environmentally sound collection and disposal alternatives. In Amazonas, long distances between municipalities and unequal access to infrastructure add complexity to reverse logistics. This study aimed to analyze the barriers and opportunities associated with reverse logistics and electronic waste recycling in the state and to relate those findings to the development of a web system prototype supporting responsible disposal. A qualitative, applied, exploratory, and descriptive approach was adopted, drawing on bibliographic and documentary research and an examination of prototype artifacts. The analysis identified barriers related to public access to information, the geographic coverage of collection points, reverse-chain costs, and coordination among stakeholders. Opportunities included refurbishment, material recovery, and productive inclusion. The technological outputs comprised functional requirements, use cases, data modeling, diagrams, and interface screens for a platform designed to provide disposal guidance, locate participating companies, and manage business profiles. Screens were compared with specified requirements through documentary inspection; functional tests and real-world use were not demonstrated. The study concludes that the prototype offers an organized information interface with potential to support existing initiatives, although its effectiveness still depends on technical validation, reliable data updates, and the engagement of local stakeholders.

Keywords: Reverse logistics. Electronic waste. Circular economy. Recycling. Amazonas.

Resumo

A expansão do consumo de equipamentos eletroeletrônicos intensifica a geração de resíduos e exige alternativas para sua coleta e destinação ambientalmente adequada. No Amazonas, as distâncias entre municípios e as diferenças de acesso à infraestrutura ampliam os desafios da logística reversa. Este estudo teve como objetivo analisar os obstáculos e as oportunidades da logística reversa e da reciclagem de resíduos eletroeletrônicos no estado, articulando essa análise ao desenvolvimento de um protótipo de sistema web de apoio ao descarte consciente. Adotou-se abordagem qualitativa, de caráter aplicado, exploratório e descritivo, mediante pesquisa bibliográfica e documental e descrição dos artefatos do protótipo. A análise identificou entraves ligados à informação disponível ao consumidor, à capilaridade dos pontos de recebimento, aos custos da cadeia reversa e à articulação entre seus agentes. Também foram reconhecidas oportunidades associadas ao recondicionamento, à recuperação de materiais e à inclusão produtiva. Como resultado tecnológico, foram apresentados requisitos funcionais, casos de uso, modelagem de dados, diagramas e telas de uma plataforma destinada à consulta de orientações, à localização de empresas e à gestão de perfis empresariais. A correspondência entre telas e requisitos foi examinada documentalmente, sem comprovação de testes funcionais ou de uso em ambiente real. Conclui-se que o protótipo organiza informações relevantes e pode

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apoiar iniciativas existentes, mas sua efetividade depende de validação técnica, atualização dos dados e participação dos atores locais.

Palavras-chave: Logística reversa. Resíduos eletroeletrônicos. Economia circular. Reciclagem. Amazonas.

Resumen
El aumento del consumo de equipos eléctricos y electrónicos intensifica la generación de residuos y exige alternativas para su recogida y gestión ambientalmente adecuada. En Amazonas, las distancias entre municipios y las desigualdades de acceso a la infraestructura agravan los desafíos de la logística inversa. Este estudio tuvo como objetivo analizar los obstáculos y las oportunidades de la logística inversa y del reciclaje de residuos electrónicos en el estado, vinculando este análisis con el desarrollo de un prototipo de sistema web de apoyo a la eliminación responsable. Se adoptó un enfoque cualitativo, aplicado, exploratorio y descriptivo, mediante investigación bibliográfica y documental y la descripción de los componentes del prototipo. Se identificaron obstáculos relacionados con la información disponible para el consumidor, la cobertura de los puntos de recepción, los costos de la cadena inversa y la coordinación entre sus agentes. También se reconocieron oportunidades de reacondicionamiento, recuperación de materiales e inclusión productiva. Como resultado tecnológico, se presentaron requisitos funcionales, casos de uso, modelado de datos, diagramas y pantallas de una plataforma destinada a consultar orientaciones, localizar empresas y gestionar perfiles empresariales. La correspondencia entre pantallas y requisitos se examinó documentalmente, sin acreditar pruebas funcionales ni uso en condiciones reales. Se concluye que el prototipo organiza información relevante y puede apoyar iniciativas existentes, aunque su eficacia depende de la validación técnica, la actualización de los datos y la participación de los actores locales.

Palabras clave: Logística inversa. Residuos eléctricos y electrónicos. Economía circular. Reciclaje. Amazonas.

1 Introduction

The presence of electrical equipment in everyday activities has been accompanied by increasingly frequent replacement and disposal cycles. When they cease to be used, cell phones, computers, monitors and other devices become waste of electrical equipment (REEE), whose composition can gather recoverable materials and substances that require specific handling. The Global E-waste Monitor 2024 report estimated the world generation of 62 million tons of these waste in 2022; only 22,3% of this volume was recorded as collected and recycled formally (BALDÉ et al., 2024).

In Brazil, the National Solid Waste Policy established the shared responsibility for the life cycle of the products and included the electronics among the categories subject to reverse logistics (BRASIL, 2010). Decree No. 10.240/2020 detailed the implementation of the system for household equipment (BRASIL, 2020). Despite this regulatory framework, Brazilian studies identify obstacles relating to the territorial coverage of the collection, to the joint between the

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reverse chain agents and to the consumer knowledge about appropriate forms of disposal (SANTOS; OGUNSEITAN, 2022; SCHNEIDER; AANESTAD; CARVALHO, 2026).

In the Amazonas, territorial features make the disclosure of reception and re-use alternatives especially relevant. There are concrete re-conditioning and digital inclusion experiences, for example, the Instituto Descarte Correto, identified by the Ministry of Communications among the Computer Re-conditioning Centers in Manaus (BRASIL, 2024). In August 2026, the Municipality of Manaus began the installation of a planned network of 62 Voluntary Delivery Points in partnership with the Circular Brain, indicating advances in the receipt structure but without representing, by itself, full coverage of the state territory (MANAUS, 2026).

Inadequate management of REEE involves economic losses and health risks. Metals and components can be recovered through urban recycling and mining processes, while informal dismantling and processing, carried out without adequate protection, can expos workers and communities to contaminants. The World Health Organization associates these inappropriate practices with health risks, especially among children (OMS, 2021). In addition to the collection and processing infrastructure, therefore, the quality of the information offered to the population integrates the research problem.

In front of this scenario, the following question was formulated: what challenges and opportunities of REEE reverse logistics can be identified in the Amazonas, in the light of literature and institutional documents, and how a web prototype can contribute to organizing appropriate disposal information?

The general goal was to analyze the challenges and opportunities of reverse logistics and recycling of REEE in the Amazonas and to present a prototype of web system aimed at access to guidelines, categories of materials and information about companies collecting. Specifically, it was aimed at: identifying documented obstacles and initiatives; linking these evidence to the information needs of the public; and describing the requirements, the modeling and the interfaces of the prototype, distinguishing expected functionalities from effectively demonstrated results.

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2 Theoretical framework

2.1 Electronic waste and environmental impacts

REEEs include equipment disposald after loss of utility, failure or technological replacement. Its components may include plastic, glass, iron and non- iron metals, as well as substances that require environmentally controlled treatment. WHO (2021) highlights the risks associated with burning, dismantling and informal recovery of materials, especially when such activities occur without protective measures.

The appropriate destination shall consider, in accordance with the conditions of the equipment, possibilities of extension of life, reuse of components and recycling.

Consumer behavior also interferes with the destination flows. In a systematic review, Dias et al. (2024) point out the importance of environmental awareness strategies; in a study conducted in João Pessoa, Brilhante and Nóbrega (2024) identified unknownness of the points of collection among the obstacles to the disposal. These evidence supports the need for accessible information, but do not allow to claim that such behavior occurs with the same intensity in all Amazon municipalities. According to Manaus, there is a punctual evidence: Vasconcelos, Simão and Souza (2024) interviewed 71 servants of a municipal secretariat and registered that about 90% of them did not know any law on the disposal of electronic waste, resulting limited to a single public body.

2.2 Reverse logistics, the National Solid Waste Policy and the circular economy

The reverse logistics organizes the return of products and materials after consumption, with a view to reuse or environmentally suitable destination. In the case of domestic electronics, Law No. 12.305/2010 and Decree No. 10.240/2020 define responsibilities and operating guidelines, including the involvement of manufacturers, importers, distributors, traders and consumers (BRASIL, 2010, 2020). The existence of rules, however, does not eliminate difficulties in implementation: Santos and Ogunseitan (2022) discuss barriers and possibilities of the Brazilian reverse logistics model.

The circular economy proposes to reduce the waste of resources through strategies such as maintenance, repair, reuse, remanufacturing and recycling. In the analysis of Brazilian challenges, Mancini et al. (2021) they emphasize that territorial and organizational diversity interferes with the adoption of circular practices. The Correia et al. (2024) they identified consumer participation, compliance with the standards and the joint between operators as

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relevant aspects of the reverse chain of REEE. Thus, the return of materials to production depends both on technical processes as well as on institutional and social conditions.

2.3 Urban mining and the economic potential of electronic waste

Urban mining consists in the exploitation of materials present in products and waste already incorporated into the built environment and into the flow of consumption. By studying the value of REEE in the Rio de Janeiro metropolitan region, Ottoni, Dias and Xavier (2020) highlighted the relevance of the location of collection points and the recycling structure for resource recovery. Giese, Lins and Xavier (2021) also discuss the role of urban mining cooperatives and the difficulties in organizing and operating this segment. The economic interest in recovering copper, aluminum and other materials does not mean that any operation is technically or financially viable. The composition of the equipment, the scale of receipt, the transport costs and the existence of appropriate facilities must be considered. Therefore, quantitative comparisons between gold contained in computers and natural minerals were avoided without indication of source and measurement conditions.

2.4 Reverse logistics and electronic waste recycling in Amazonas

In the Amazonas, the concentration of services and facilities in urban centers, associated with regional distances, requires attention to the concrete conditions of access to the disposal. The Instituto Descarte Correto, in Manaus, participates in the Computer Program for Inclusion through equipment refurbishment and digital training activities (BRASIL, 2024). This type of initiative includes waste management and reuse of devices for social purposes, without dismissing the environmentally appropriate destination of non-reusable components. In the municipality, the Law No. 2.501/2019 established the selective collection of electronic and technological waste in rural and urban areas of Manaus (MANAUS, 2019).

Another documented initiative is the cooperation between the Municipality of Manaus and the Circular Brain, formalized in August 2026 to expand the reception network of electrical and electronic equipment in the capital. The municipal administration reported the start of the installation of collectors and the forecast of 62 voluntary delivery points, with shipping of waste to the reverse logistics chain (MANAUS, 2026). The experience evidences the importance of integration between public power and companies, but the announcement and the start of the installation do not allow to conclude that all points were already operational or that municipalities in the interior had been addressed.

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3 Materials and methods

Applied, exploratory and descriptive research has been carried out with two complementary fronts: bibliographic and documentary analysis on REEE management and description of a web system prototype. The first allowed to recognize problems and opportunities reported in studies and public records; the second consisted of examining the objects provided by the team, including requirements, use cases, data models, diagrams and screenshots. There were no consumer interviews, measurements of waste generation in the Amazonas or experiments of environmental and economic impact. The results, therefore, express an analytical synthesis of the sources and the description of the technological solution, and not an assessment of effectiveness in real use.

3.1 Bibliographic and documentary research

The bibliographic search originally described by the authors used Google Scholar and the terms “reverse logistics”, “electronic waste”, “electronic waste recycling” and “circular economy”. The original document recorded 35 preliminary results; as no trial sheet was presented that allowed to reconstruct the deleted records, this number was not treated as a final sample.

For the composition of the article the bibliographic information was conferred on the pages of the newspapers and in institutional repositories, having been incorporated into the analysis 12 effectively identified scientific articles, published between 2020 and 2026. The selection considered relevance to the objective, verified indication of authority, year and vehicle of publication, as well as availability of summary or text for conference. References before 2020 were removed as a central scientific foundation, duplicated items and statements whose source could not be sustained.

The documentary survey included Law No. 12.305/2010 and Decree No. 10.240/2020, used by its regulatory validity, the international report The Global E-waste Monitor 2024, the publication of WHO on health risks and public records of the Ministry of Communications and the Municipality of Manaus. The 2010 and 2020 standards were retained by constituing legal frameworks, not scientific studies.

In the thematic summary, the evidence was grouped into four dimensions: consumer information and participation; infrastructure and costs; reverse chain governance; and material

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value and productive inclusion. Each dimension was related to the prototype requirements, without assuming that the tool, isolated, solves operational problems.

3.2 Prototype development

The team presented a prototype of the web system called EletroDescarte, intended to consult information about conscious disposal and to disclose companies receiving or purchasing certain REEE. The registered scope includes information guide, catalogue of categories, listing and filters by location, mode of service and type of waste, as well as recording and maintaining business profiles. The documented stages covered the definition of requirements, use cases, data modeling, diagrams and the elaboration of the interfaces displayed in the results section.

The proposal was delineated to the reality of access to disposal information in the Amazonas. Waste receipt services and initiatives already exist in the country and in the Amazonas capital itself; thus, the contribution presented is not the creation of an unpublished method of collection, but the organization, on a topic-oriented interface, of educational content and information that could be updated by the participating establishments. Effective integration with external bases, registration verification and automatic recording have not been demonstrated.

3.3 Tools and technologies

According to the documentation provided by the team, Java 21 was selected for application logic, Spring Boot for web services structure and MySQL for relative data storage. The brModelo was used in the representation of the data structure, and the PlantUML, in the elaboration of diagrams. These choices relate to the organization of the modules and the documentation of the links between companies and waste categories. The technology used in the front-end layer has not been verified, which is why a specific language or library has not been attributed to it.

4 Results and discussion

The results are presented in two sets: the specification artefacts and the prototype interface and the synthesis of the challenges and opportunities extracted from the literature and the documents consulted. The analysis distinguishes specific or visually represented features from technically verified functionalities, since no testing or operation records with users have been made available.

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4.1 Requirements elicitation

The Requirements Specification Document (SRS) delimited two interaction profiles: the citizen or visitor, who consults information and seeks disposal options, and the partner company, who has the available resources to register and update their institutional presentation. The following requirements represent the planned scope for the application, and not the confirmation that all functions are operational.

Functional requirements, organized in information and awareness modules, disclosure and management of companies, are in Framework 1.

Chapter 1 – Functional requirements of the system

The Code	Requirements	Description of
by RF-01	The Conscious Download Guide	To provide an informative guide on the environmental impact of electronic waste and the steps towards ecologically correct discharge.
by RF-02	Catalog of supported materials	List the types of accepted electrical waste (computers, cell phones, batteries, monitors, circuit plates and cables).
by RF-03	The window of companies	Show, on the home page, a list of cards with the active partners.
by RF-04	Data displayed on the card	Show on each card: photo or logo, name fantasy, mode of service (free collection and/or purchase of waste), short description of the services, location (city and state) and means of contact (telephone or WhatsApp).
by RF-05	Search and Filtering	Permit to filter companies by location (city/UF), accepted waste category and type of operation (only collect or purchase).
by RF-06	Registration of Company	Permit the registration of partners with CNPJ and social reason, name fantasy, email and password, phone/WhatsApp, full address, modalities, institutional summary and upload of the photo or logo.
by RF-07	Close to accepted categories	Allow the company to select, in the register or in the edition, the categories of materials that it accepts to receive.
by RF-08	Authorization and Panel of the Company	Enable login by email and password to access a limited panel in which the company updates registered data, image and accepted categories.

Source: Published by the authors (2026)

The non-functional requirements express the desired conditions of use, safety and compatibility, presented in Table 2. The simple definition of these conditions is not equivalent to verification of conformity or performance.

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Framework 2 – Non-functional system requirements

The Code	Requirements	Description of
by RNF-01	Usability and Responsibility	Responsive interface, with good navigation on computers, tablets and smartphones.
by RNF-02	Performance in the Images Upload	Send the photo or instantly, accepting files of up to 5 MB in PNG or JPG/JPEG formats.
by RNF-03	Security in the storage of credentials	Prove password storage by robust hash function, with algorithm and configuration subject to verification in technical testing.
by RNF-04	Privacy and Conformity	Providing privacy and data protection measures according to LGPD (BRASIL, 2018), with compliance verification in the subsequent stage.
by RNF-05	Availability and Compatibility	API and front-end compatible with the main browsers (Google Chrome, Mozilla Firefox, Microsoft Edge and Safari).

Source: Published by the authors (2026)

4.2 Use cases

The use cases describe the expected interactions between the defined profiles and the platform. For the visitor, access to educational content and search filters were provided without authentication. For companies, the scope includes registration, authentication and editing of the information itself.

Table 3 summarizes these specified flows, and Figure 1 shows their graphic representation.

Table 3 – Cases of use of the system

The Code	The case of use	The main actor	Description of
by UC01	The Conscious Download Guide	Citizen / Visitor	Reading content on the correct discharge and environmental impact of electronic waste, in addition to the catalogue of accepted materials. The public access.
by UC02	Viewing companies on the Home Page	Citizen / Visitor	Showing, on the home page, the cards of the active partners. The public access.
by UC03	Search and Filter Collective Points	Citizen / Visitor	Refining the list of companies by location, modality or waste category. When no company addresses the filters, the system informs that no collection point has been found.
by UC04	The company partner	The company partner	The company's autocadastro to appear on the window of the home page. Exceptions: CNPJ or already registered email; photo in invalid format or size.

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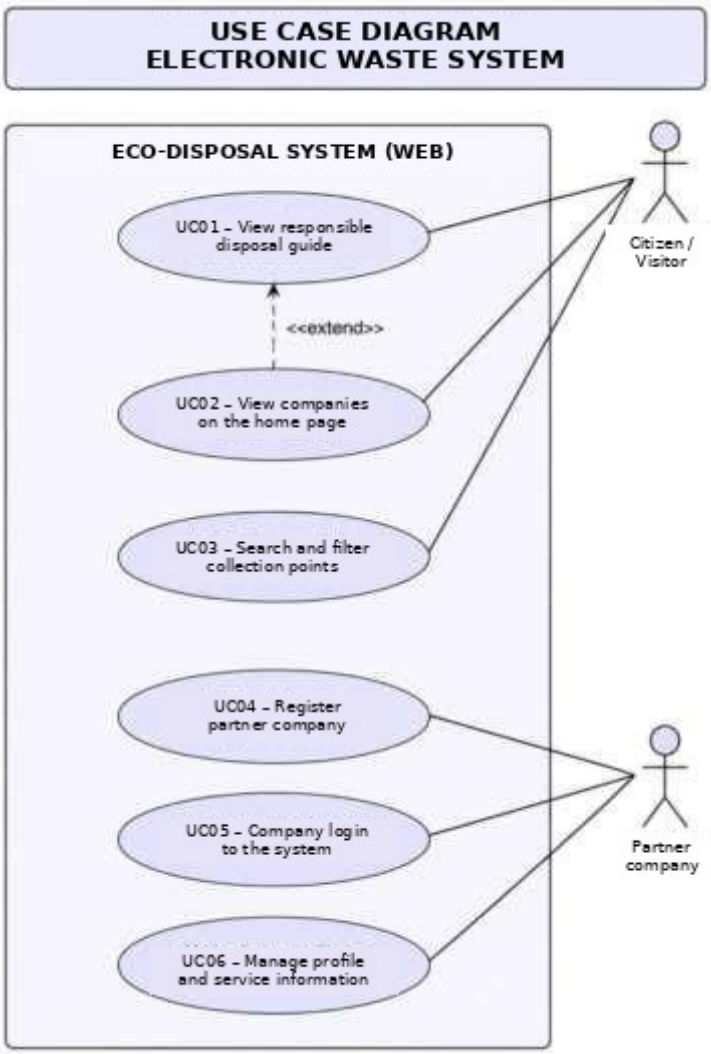
The Code	The case of use	The main actor	Description of
by UC05	Authentication of the system	The company partner	Email validation and password for access to the limited panel. Exception: Invalid credentials. Pre-condition: Preliminary registration (UC04)
by UC06	Management of Profile and Data	The company partner	Contact update, location, description, photo and accepted categories, with reflection on the home page cards. Pre-condition: the authenticated company (UC05).

Source: Published by the authors (2026)

Figure 1 – Main diagram of cases of use



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4.3 Database modeling

The relational modeling for MySQL articulates the entities Enterprise, Category_Lix and Enterprise_Category, described in Table 4. The structure was designed to link the participating organizations to the materials received by them.

Table 4 – Database Entities

The entity	Description of
The company	It stores the registration, location and contact data, the modalities of service (collection and/or purchase), the access credentials and the photo or logo of the partner companies displayed on the home page.
Category - Lixo	It represents the types of electrical waste accepted in the system, such as monitors, cell phones, batteries and circuit plates.
The Company - Category	Association entity that connects each company to the categories of waste that it is suitable to collect or buy.

Source: Published by the authors (2026)

The relationship between the Company and Category_Lixo is of the type many and was represented by the associative entity Enterprise_Category. In the modeling presented, each link records the correspondence between an organization and a particular category of waste. Figures 2 and 3 respectively represent the conceptual structure and the logical model; they do not constitute evidence of data integrity tests.

Figure 2 – Entity-relation diagram (DER)

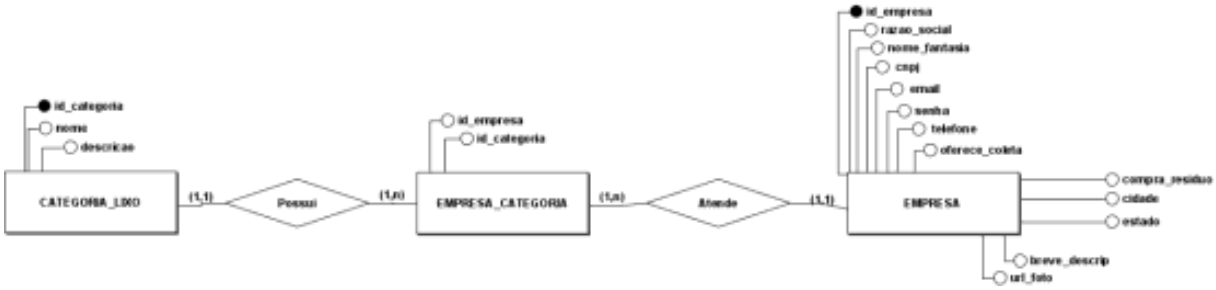

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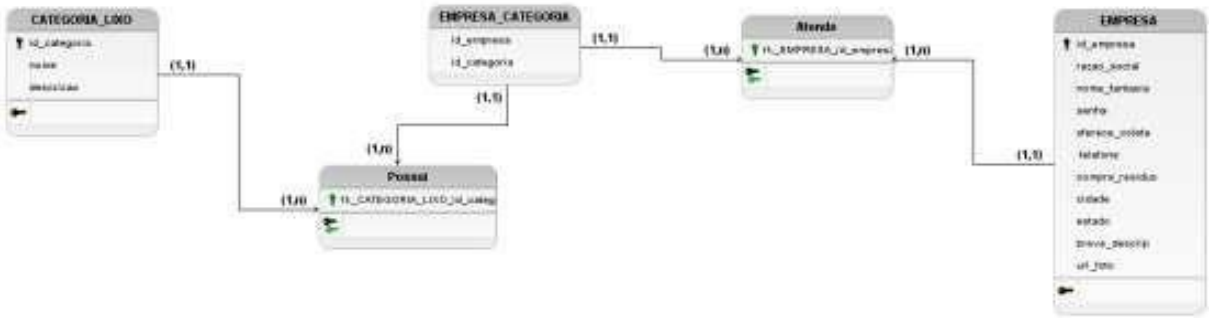
Figure 3 – Logical Data Diagram (DLD)



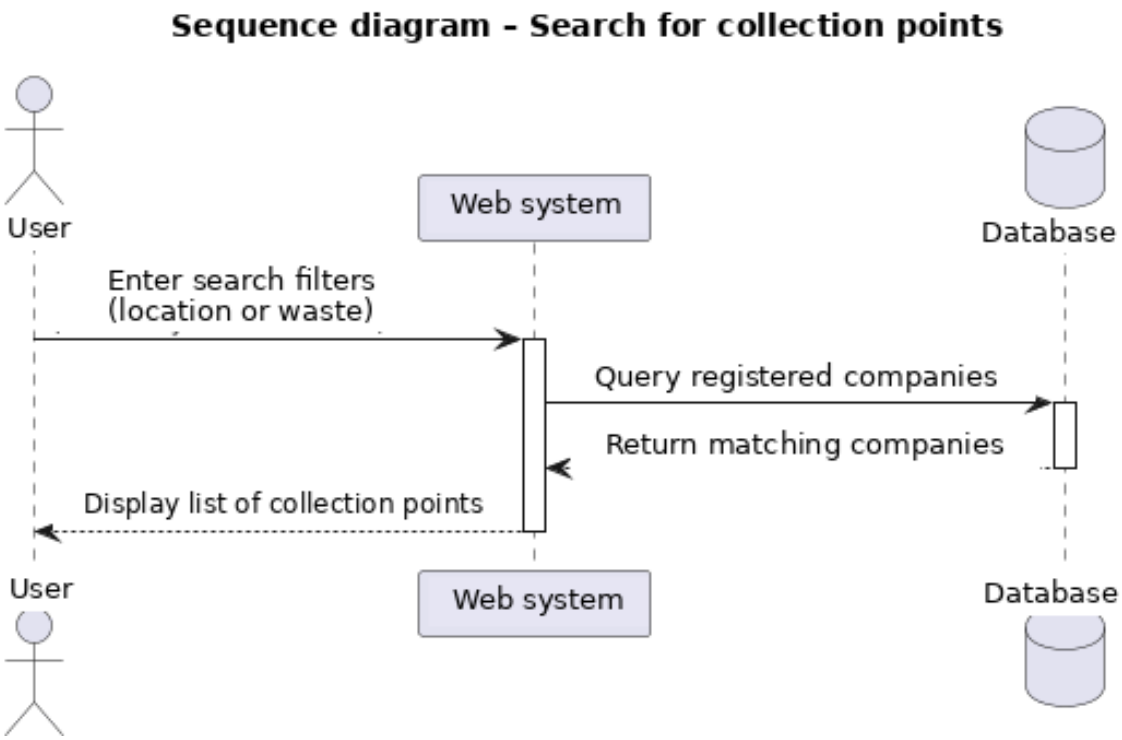
Source: Published by the authors (2026)

Figure 3 shows the logical model of the tables Enterprise, Category_Lix and Enterprise_Category. The distribution of the attributes includes identification and contact data of the organizations, types of material received and their respective links. This structure is compatible with the filters provided in RF-05 and with the category management associated with RF-07.

4.4 Diagrams

Figure 4 shows a sequence diagram relating to the search by collection points.

Figure 4 – Diagram of sequence



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In it, the user informs search criteria, the system consults the data of registered companies and the interface presents the corresponding records. This is the representation of the flow provided for in the case of use UC03.

The flow presented articulates the selection of filters, the base consultation and the presentation of the result to the visitor. The available documentation does not include execution records or response time measurements capable of proofing behavior in the production environment.

4.5 Implementation and presented interfaces

Figure 5 shows the page of the site, with awareness message and visual access to search points. This interface corresponds to the proposal for disclosure of guidelines and the public navigation provided for in RF-01 and RF-03.

Figure 5 – Start page and access to collection points



Source: Published by the authors (2026)

In Figure 6, the home page is presented in continuity, with content on environmental impacts and waste recovery. The registration exemplifies the educational component provided for in RF-01, without proof, by itself, the scope or update of the published information.

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Figure 6 – Educational content on environmental impact and circular economy



Source: Published by the authors (2026)

Figure 7 – Demonstrative list of companies and search filters

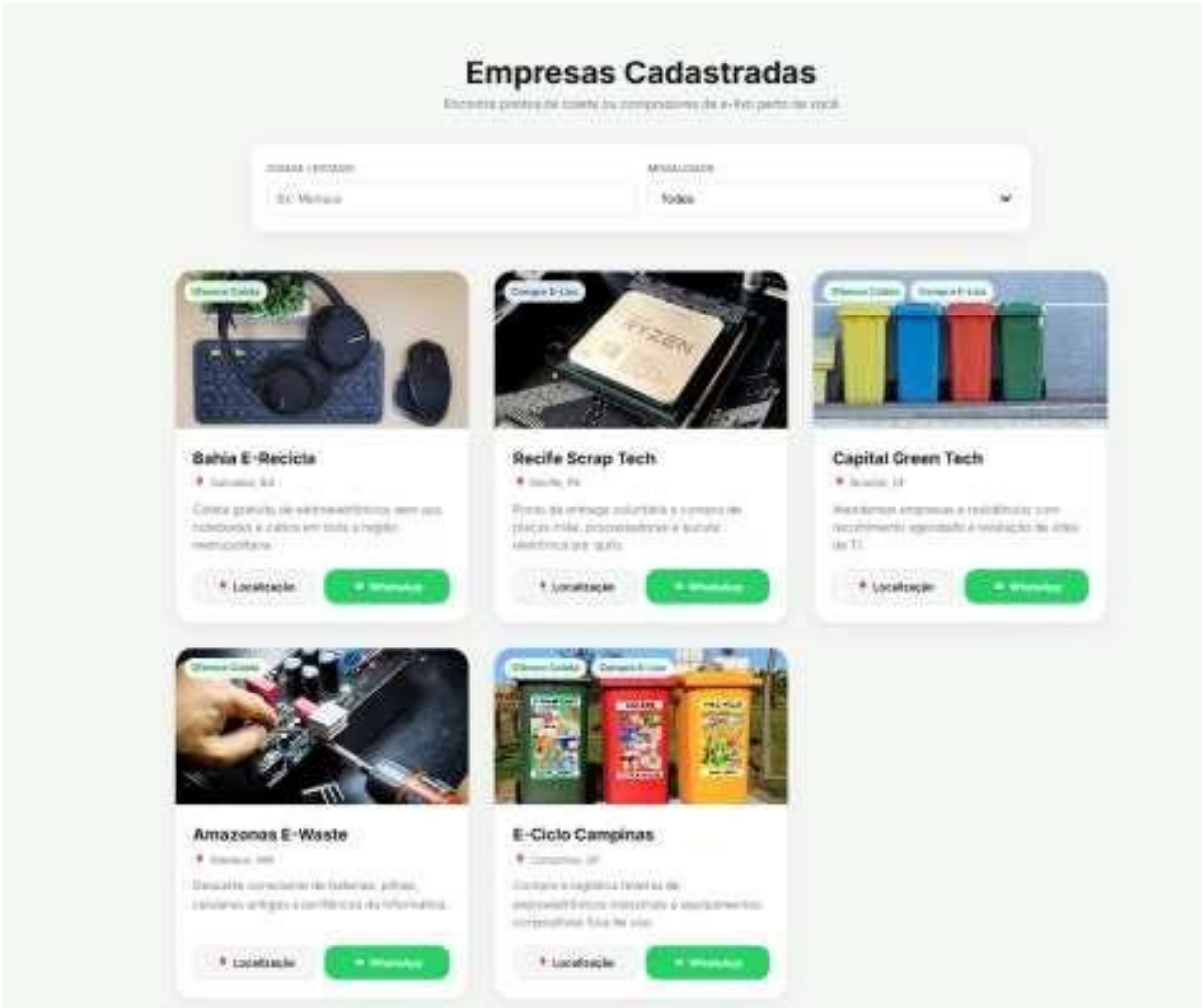

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Figure 7 collects demonstrative cards of establishments and filtering options. The image illustrates the RF-03, RF-04 and RF-05 requirements and the UC02 and UC03 use cases. The names displayed on the screen are consistent examples of the prototype; the image does not constitute proof of commercial partnership or validated record.

Figure 8 shows fields intended to edit a company's information. The screen relates to the profile management provided in RF-08 and UC06, and it is not possible to infer from the image that all recording, validation and recovery routines are completed.

Figure 8 – Enterprise profile editing interface



Source: Published by the authors (2026)

Figure 9 shows the interface intended for access by registered companies, linked to the case of use UC05. Your documentary existence does not replace authentication tests, errors and secure credentials storage.

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Figure 9 – Enterprise authentication interface



Source: Published by the authors (2026)

4.6 Challenges, opportunities and their relationship with the prototype

The articulated reading of scientific studies and institutional sources allowed to group the obstacles and possibilities of reverse logistics into four dimensions. The Framework 5 presents the evidence examined and the possible contribution of the platform, keeping the information needs separate from the material and institutional interventions necessary for the operation of the reverse chain.

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Framework 5 – Thematic synthesis of the challenges and the planned contributions

Dimensions	**Documented Challenge and Opportunity**	**Relationship with the prototype/limit**
Information to the consumer	Unknowledge of reception points and the need for environmental education (DIAS et al., 2024).	Discharge and filters (RF-01, RF-05); effectiveness depends on reliable content.
Territorial coverage	Costs of logistics and inequal distribution of services (SANTOS; OGUNSEITAN, 2022; SCHNEIDER; AANESTAD; CARVALHO, 2026).	Search by city and categories (RF-05); the system does not create physical points.
Coordinatio n of Actors	The importance of companies, operators and public initiatives in the reverse chain (VARGAS; CAMPOS; LUNA, 2024; MANAUS, 2026).	Business professionals and registration update (RF-06 to RF-08); it depends on accession and verification.
Value and Inclusion	Reconstruction, recycling and operation of cooperatives (OTTONI; DIAS; XAVIER, 2020; GIESE; LINS; XAVIER, 2021).	Disclosure of modalities and categories (RF-02 to RF-04); does not prove recovery of materials.

Source: Adapted by Dias et al. (2024), Santos and Ogunseitan (2022), Ottoni, Dias and Xavier (2020), Giese, Lins and Xavier (2021), Schneider, Aanestad and Carvalho (2026), Vargas, Campos and Luna (2024) and Manaus (2026).

The analysis indicates that the most directly linked contribution to the prototype scope is to reduce the dissemination of information about disposal possibilities, and not to replace the collection service. In Florianopolis experience described by Vargas, Campos and Luna (2024), the effectiveness of the reverse channels depended on the interaction between different agents. The same care applies to Amazonas: disclosing accepted companies and materials will only be useful if the data is kept up-to-date and if there is real receiving capacity.

The implementation of collectors in Manaus and the operation of reconstruction centers show that the region already has concrete actions (BRASIL, 2024; MANAUS, 2026). The prototype may function as a complementary interface, but performance comparison has not been made with the digital services of these organizations. Their contribution in this stage is the design of an information organization tool, not a technological innovation or an empirically demonstrated environmental impact.

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4.7 Documentary verification and evaluation limitations

Since no test performance reports were submitted, the assessment was limited to the correspondence between requirements, cases of use and visual evidence. Table 6 differentiates the elements effectively presented from those that still require technical verification.

Table 6 – Documentary verification of the presented resources

Recourse	Proof presented	Situation of validation
Guidelines and educational content (UC01)	Figure 5 and Figure 6.	Documented interface; utility with unevaluated users.
Listing and search (UC02–UC03)	Figure 7 and sequence diagram.	Flow and interface represented; untested filters.
Registration and business profile (UC04 and UC06)	Specification and Figure 8 (Profile edition).	Uncertain recording and persistence.
Authentication and Non-Functional Requirements (UC05)	Figure 9 and Figure 2.	Safety, performance and compliance of non-audited LGPDs.

Source: elaborated by the authors (2026), from the prototype artefacts.

The documentation of the functions and cases of use allowed to present the system structure and its application in the context of reverse electronic waste logistics. The developed interfaces demonstrate the organization of the information, the consultation resources and the possibilities of interaction between users and registered companies. As a possibility of improvement, it is recommended to extend the functional assessment of the system, taking into account aspects related to the usability, security, accessibility and performance of the tools available. It is also highlighted the importance of continuous updating of information about companies and collection points, contributing to the reliability of the data presented to users.

In the field of discussion, the results present a relationship with Brilhante and Nóbrega's study (2024), which identified the unknown location of the collection points as one of the difficulties faced by the population in the disposal of electrical waste. In this sense, the system

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developed contributes to facilitating access to information and bringing citizens closer to recycling initiatives.

However, Schneider, Aanestad and Carvalho (2026) point out that reverse logistics also faces challenges related to operating costs, available infrastructure, process transparency and data security. Thus, the platform developed represents a technological contribution to the disclosure of information and the incentive to the appropriate disclosure, although its action is inserted into a wider context of environmental, social and organizational responsibilities.

5 Final considerations

The study identified challenges recurring to the reverse logistics of electronic waste: difficulty in accessing destination information, inequal coverage of services, transportation and processing costs and the need for coordination among the chain participants. In the Amazon context, the documentary analysis found initiatives of receipt, reconstruction and digital inclusion, but did not find enough elements to measure their scope throughout the state.

The opportunities associated with the circular economy include extending the lifetime of the devices, recovery of materials and participation of cooperatives and social organizations. The consulted literature indicates that these possibilities depend on infrastructure, security, information and market conditions; therefore, no environmental or economic effects are attributed to the web system that have not been measured.

The prototype presented gathered specifications of requirements, data models, use cases, diagrams and screens aimed at disclosure of information and interaction with companies. Thus, the goal of analyzing the problem and presenting a technological proposal was met within the limits of a bibliographic, documentary and prototyping research. Available evidence shows the design of the interfaces and functional planning, but does not allow to ensure the full operation of the application.

As limitations, the absence of user assessment, documented functional tests, security audit and systematic verification of business information. Subsequent studies will be able to evaluate these aspects, compare the results with existing services and examine the availability of the solution in municipalities with different connectivity conditions.

The organization of information on a thematic platform may complement reverse logistics actions in the Amazonas, provided that it is accompanied by the participation of the operators, the responsible update of the data and the validation of its usefulness and security in real conditions of use.

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Declarations for submission

The ChatGPT tool (OpenAI, GPT-6, 2026) was used as an assistant resource in the ortographic and grammatical review, the tool also helped to identify three scientific studies relevant to the topic and the results discussed.

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