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Naimaecosync as a Waste Management Aggregator in Supporting Extended Producer Responsibility for Industries in Indonesia

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A R T I C L E I N F O

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A B S T R A C T

Extended Producer Responsibility (EPR) is a program that holds industries accountable for their products' environmental impact throughout their lifecycle. To guide EPR implementation, Indonesia's Ministry of Environment and Forestry issued Regulation P.75/2019 on waste reduction by producers. One key government initiative is optimizing partnerships for post-consumer packaging waste collection through Waste Banks, TPST3R, Recycling Centers, and digital platforms. This research introduces NaimaEcoSync, a platform designed to streamline waste take-back by integrating waste management data and mapping reports for industries. Developed using the Scrum methodology, NaimaEcoSync achieved a usability score of 96.07%. The platform contributes to industry sustainability by reducing waste and supporting EPR implementation in Indonesia

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INTRODUCTION

Extended Producer Responsibility (EPR) is a program aimed at making industries responsible for the environmental impact of their products throughout the production chain, from design to disposal by consumers (Leal Filho et al., 2019). The concept of EPR was first introduced at the World Summit on Sustainable Development in 2002 in Johannesburg, although the term "EPR" was not explicitly mentioned at that time. The summit emphasized efforts to achieve sustainable production and consumption. During the G-8 meetings between 2003 and 2005, EPR was included as part of the 3R (reduce, reuse, recycle) components. Subsequently, more specific meetings on EPR were held in Tokyo in 2005 and 2006 (Cahill et al., 2011).

The adoption of the EPR concept in Indonesia is regulated by Law No. 18 of 2008 on Waste Management (Article 15), which states that industries are responsible for the disposal of packaging and products that are non-compostable or difficult to compost (Chaerul & Indrapta, 2024; Junianto & Sugandha, 2020; Made & Widyarsana, 2023; Sulami et al., 2018). Through Government Regulation No. 81 of 2012 (Article 1, point 5), industries acting as producers are defined as business entities that produce goods using packaging, distribute goods using packaging that is imported, or sell goods using containers that are non-degradable or difficult to degrade by natural processes. Producers are required to use recycled materials and manage the recycling of packaging. To provide guidelines on the implementation of EPR, especially the obligations of producers in reducing waste, the Ministry of Environment and Forestry issued Minister of Environment and Forestry Regulation No. 75 of 2019 concerning the Roadmap for Waste Reduction by Producers. This regulation mandates that industries limit waste generation, recycle waste, conduct take-back activities, and reuse waste. The roadmap is set for a 10-year period from 2020 to 2029, with a target of reducing waste and packaging of plastic, paper, glass, and aluminum by 30% of the total products and/or packaging produced and marketed by 2029.

Although EPR has been implemented in Indonesia, only 15 business entities are involved, with the amount of waste reduced being approximately 1,145.5 tons . Nevertheless, the Ministry of Environment and Forestry continues to conduct socialization and technical assistance regarding the waste reduction roadmap by producers (Regulation No. 75/2019). By the end of 2022, this assistance had been provided to 353 business entities. However, the implementation of Minister of Environment and Forestry Regulation No. 75 of 2019 has not yet been optimal. The lack of monitoring and evaluation instruments involving all relevant parties (pentahelix) such as the government, businesses, associations, academia, and the public is one of the contributing factors.

One of the government's steps in enhancing the effectiveness of EPR implementation is through optimizing partnership mechanisms in taking back post-consumer producer packaging waste with Waste Banks (Kraugusteeliana et al., 2024), TPST3R (Tiara Ningrum et al., 2023), Recycling Centers (Rosbach, 2022), digital platform start-ups, and others. The involvement of technology plays a crucial role in this optimization.

LITERATURE REVIEW

Research on the utilization of technology in the implementation of Extended Producer Responsibility (EPR) is still rare. A study conducted by Arisman and Yun Arifatul Fatimah discusses the potential for implementing sustainable economy and sustainable economic technology adopted in Indonesia to achieve the Sustainable Development Goals (SDGs) and its contribution to decarbonization efforts to mitigate the impacts of climate change. The sustainable economic technology adopted in Indonesia is usually driven by the situation in various cities. The adoption of such technology is carried out in cities that offer new systems to meet the requirements of those cities (Arisman & Fatimah, 2023).

This research proposes the development of a platform that will help industries optimize the waste take-back process in one stage. This system will be able to integrate waste management data, process it, and send waste mapping report data to industries. The system will be named NaimaEcoSync. It is hoped that NaimaEcoSync will contribute to producer sustainability through waste reduction and have a positive impact in supporting EPR in Indonesia.

METHODOLOGY

The development of platform implemented the Scrum methodology, which is currently popular in agile software development (Hron & Obwegeser, 2022). In the implementation of the Scrum method, the system development life cycle (SDLC), which includes requirements analysis, planning, implementation, testing, and maintenance, is carried out repeatedly within several sprints (Olorunshola & Ogwueleka, 2022). Figure 1 shows NaimaEcoSync development by using Scrum methodology.

A. Product Backlog

To begin this development, user requirements specifications are carried out. The results of the requirements specifications are then packaged into a series of user stories. User stories are concise, semi-structured descriptions of software needs or functions from the perspective of the users (Raharjana et al., 2020). This format facilitates the comprehension of software specifications and has become a standard method for documenting software requirements in agile development (Dewi et al., 2021).

Furthermore, user stories are grouped based on the users involved in this system, namely NaimaEcoSync Admin and Waste Management Facility User. The collection of user stories is arranged in the product backlog as the initial stage of Scrum software development (Sedano et al., 2019). The product backlog contains the tasks that need to be developed for the system. Table 1 and Table 2 respectively explain the product backlog for NaimaEcoSync Admin, and Waste Management Facility User.

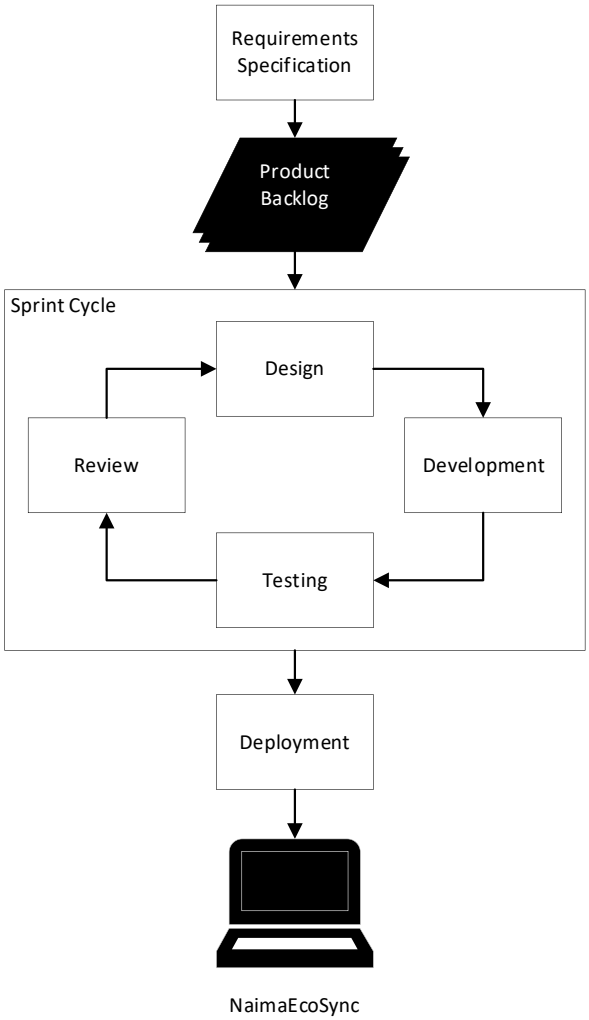

Figure 1. Naimaecosync Development with Scrum Methodology

Backlog ID	Backlog Task	Priority
US1001	As an Admin, I want to be able to register waste management facility so that the facility can use the services provided by NaimaEcoSync.	High
US1002	As an Admin, I want to be able to edit data related to waste management facility so that I can update facility's information.	High
US1003	As an Admin, I want to be able to add new waste calculation data so that I can update the waste management database at my facility.	High
US1004	As an Admin, I want to be able to view the list of waste calculations so that I can track the amount of waste managed at my facility.	High

US1006	As an Admin, I want to be able to edit waste calculation data so that I can adjust the waste management database at my facility.	High
US1007	As an Admin, I want to be able to delete waste calculation data so that I can adjust the waste management database at my facility.	High
US1008	As an Admin, I want to be able to import waste calculation data through an Excel file so that I can add waste calculation data in bulk.	Medium
US1009	As an Admin, I want to be able to add new waste category types so that I can categorize the types of waste I calculate.	High
US1010	As an Admin, I want to be able to view waste category types so that I can know the types of waste I calculate.	High
US1011	As an Admin, I want to be able to edit waste category types so that I can adjust the categorization of the types of waste I calculate.	High
US1012	As an Admin, I want to be able to delete waste category types so that I can adjust the categorization of the types of waste I calculate.	High
US1013	As an Admin, I want to be able to add new waste subcategories so that I can categorize the types of waste I calculate based on their subcategories.	Medium
US1014	As an Admin, I want to be able to view the waste subcategories so that I can know the types of waste I calculate based on their subcategories.	Medium
US1015	As an Admin, I want to be able to edit waste subcategories so that I can adjust the categorization of the types of waste I calculate based on their subcategories.	Medium
US1016	As an Admin, I want to be able to delete waste subcategories so that I can adjust the categorization of the	Medium

	types of waste I calculate based on their subcategories.

Table 2. Product Backlog for Waste Management User

Backlog ID	Backlog Task	Priority
US2001	As an Admin, I want to be able to add new waste calculation data so that I can update the waste management database at my facility.	High
US2002	As an Admin, I want to be able to view the list of waste calculations so that I can track the amount of waste managed at my facility.	High
US3003	As an Admin, I want to be able to edit waste calculation data so that I can adjust the waste management database at my facility.	High
US2004	As an Admin, I want to be able to delete waste calculation data so that I can adjust the waste management database at my facility.	High
US2005	As an Admin, I want to be able to import waste calculation data through an Excel file so that I can add waste calculation data in bulk.	Medium

B. Sprints Cycle

Sprint cycle is the phase that follows the Scrum methodology (Haugen et al., 2019). During the sprint cycle, a time limit or estimated duration of work is established, typically lasting one month or less, with a "Completed" increment process that results in a usable and potentially releasable product (Ashari et al., 2022). The duration of sprints remains consistent throughout the product development lifecycle. Each new sprint begins immediately after the previous one concludes (Anand et al., 2021; von Lieres und Wilkau et al., 2020). For each cycle involves four activities:

1. Design: At this stage, the list of user stories obtained from the requirements specification is mapped out in the form of a design. The design includes business process design, use case diagram design, activity diagram design, User Interface (UI) design, and database design.
2. Development: At this stage, the system is implemented according to the analysis and design results using the Laravel Framework. In the initial phase, the Minimum Viable Product (MVP), the system developed is web-based.
3. Testing: At this stage, system usability testing is conducted to ensure the system meets the stakeholder requirements, to measure how well the system

solves the problems, and to validate the accuracy of the amount of industrial waste production input against its waste roadmap.
4. Review: At the end of this activity, it can be decided whether improvements will be made to try to enhance the system's effectiveness or to proceed to the next sprint stage.
C. Deployment
After a series of sprints have been completed, the deployment process is carried out so that the system can be used directly by stakeholders.

RESULT

A. Development Results

1) Login Page: The Login Page is the user authentication page for accessing the available sections within the system. Only users with access rights can process data. The layout of the Login Page is shown in Figure 2.

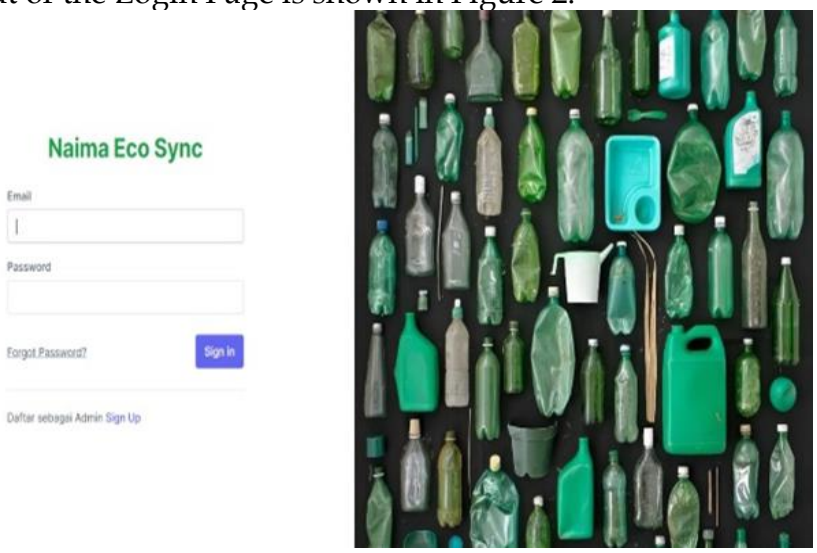

Figure 2. Login Page

2) Dashboard Page: This page displays a summary of waste calculation transactions, including the total amount of waste for each facility in kilograms, the percentage of reported waste categories, and the reported waste locations by province in a diagram format. Users can display dashboard diagrams based on date, province, facility, waste category, and sub-category. The layout of the Dashboard Page is shown in Figure 3.

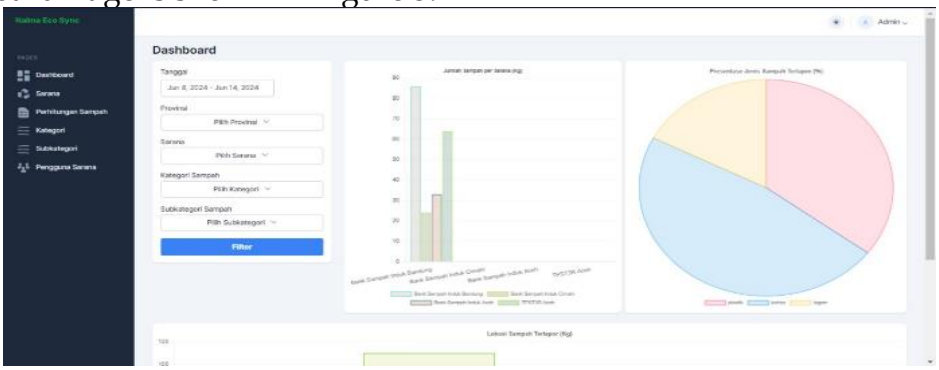

Figure 3. Dashboard Page

3) Waste Management Facility Page: This page is used to manage the Waste Management Facility data, handled by the NaimaEcoSync Admin. The layout of the Waste Management Facility Page is shown in Figure 4.

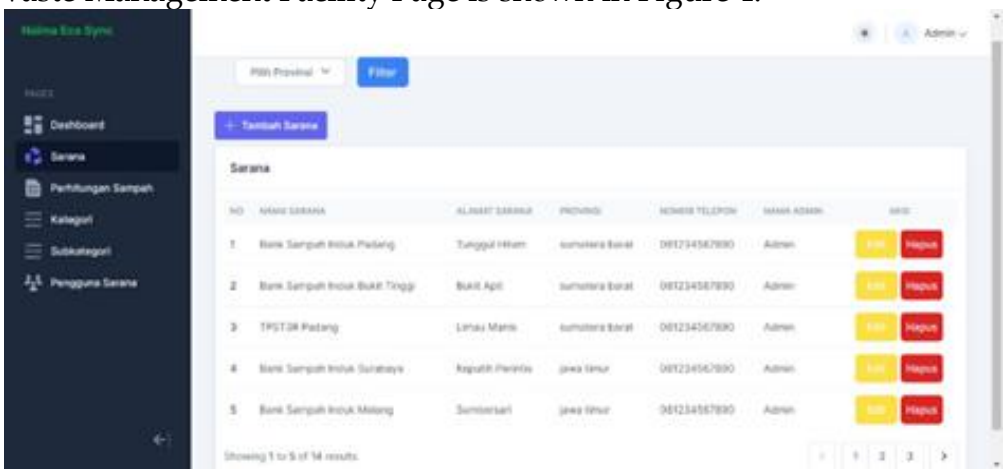

Figure 4. Waste Management Facility Page

4) Waste Calculation Page: This page is used to manage Waste Calculation data. The layout of the Waste Calculation Page is shown in Figure 5.

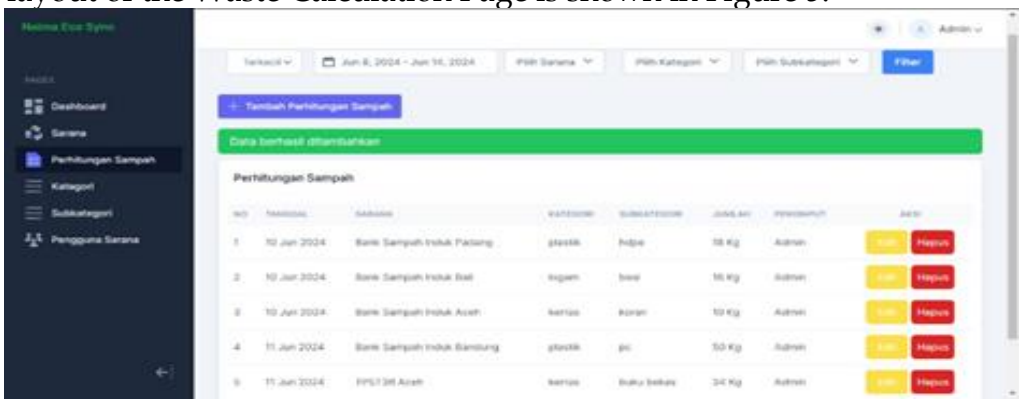

Figure 5. Waste Calculation Page

5) Waste Category Page: This page is used to manage Waste Category data, handled by the NaimaEcoSync Admin. The layout of the Waste Category Page is shown in Figure 6.

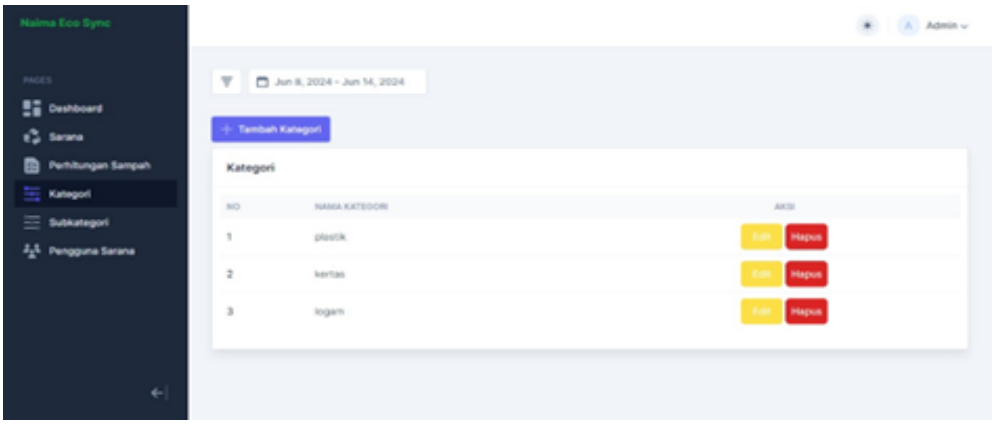

Figure 6. Waste Categori Page

6) Waste Sub Category Page: This page is used to manage Waste Sub-Category data, handled by the NaimaEcoSync Admin. The layout of the Waste Sub-Category Page is shown in Figure 7.

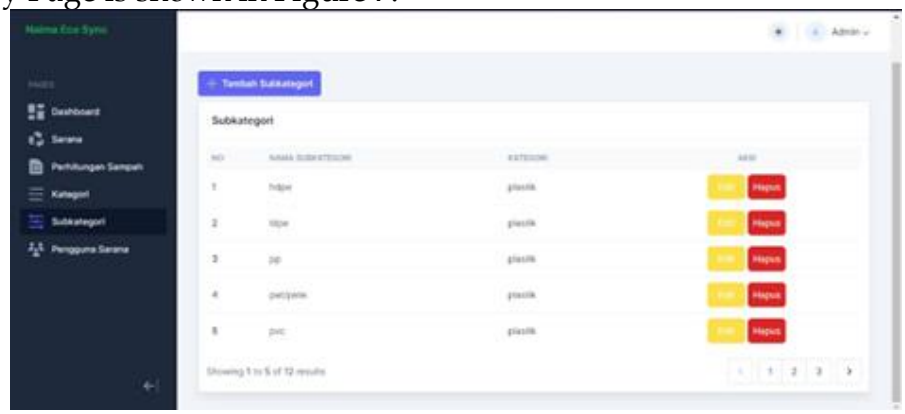

Figure 7. Waste Sub Category Page

7) Management User Page: This page is used to manage Facility User data, handled by the NaimaEcoSync Admin. The layout of the Facility User Page is shown in Figure 8.

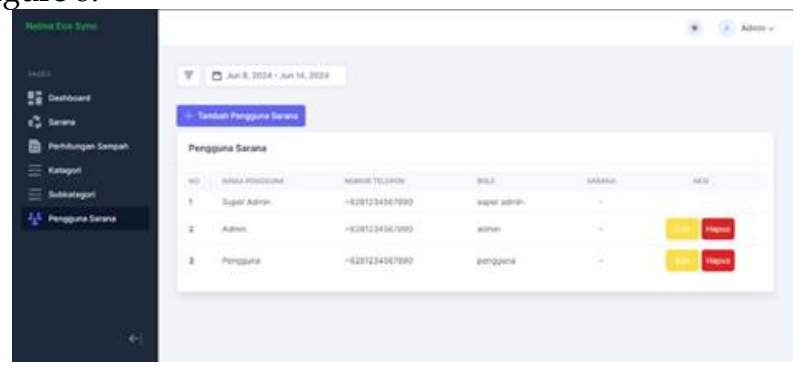

Figure 8. User Management Page

8) Page for Waste Management Facility User: This page is dedicated to Waste Management Facility Admins who have access to view the Dashboard Page and manage waste calculations. The layout of the Waste Management Facility User Page is shown in Figure 9.

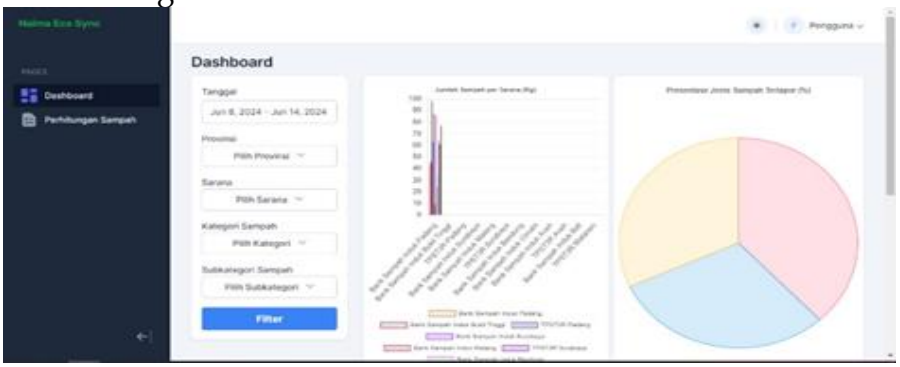

Figure 9. Page for Waste Management Facility User

B. Validation Results

1) Blackbox Testing: To verify that the software features function correctly, BlackBox testing is conducted on all system features, with the results summarized in Table 3. This testing confirms that all system features operate smoothly without any errors or bugs.

Table 3. Blackbox Testing Result

No	Functionality	Test Technique	Status
NaimaEcoSync Admin			
1	Login Page	Blackbox	Accepted
2	Dashboard	Blackbox	Accepted
3	Waste Management Facility	Blackbox	Accepted
4	Waste Calculation	Blackbox	Accepted
5	Waste Category	Blackbox	Accepted
6	Waste Sub Category	Blackbox	Accepted
7	User Management	Blackbox	Accepted
8	Logout	Blackbox	Accepted
Waste Management Facility User			
1	Login Page	Blackbox	Accepted
2	Dashboard	Blackbox	Accepted
3	Waste Calculation	Blackbox	Accepted
4	Logout	Blackbox	Accepted

2) Evaluation: An evaluation is conducted to determine the system's capability and ease of use for users, as well as to identify areas needing improvement. The evaluation results are used to enhance the effectiveness and efficiency of the NaimaEcoSync system. This evaluation involves four experienced users in the field of waste management.

The instrument used for the evaluation refers to ISO 25010:2011, which categorizes the evaluation based on quality characteristics such as Effectiveness, Efficiency, Satisfaction, Freedom From Risk, and Context Coverage.

Based on the evaluation of the NaimaEcoSync's usability presented in Table 4, the average values for various characteristics are as follows: effectiveness = 92.86%, efficiency = 100%, satisfaction = 94.64%, freedom from risk = 92.86%, and context coverage = 100%. The overall score, calculated by averaging these values, is 96.07%, placing it in the 'very good' category. This score demonstrates that NaimaEcoSync is highly effective and efficient, offers significant user satisfaction, and covers a broad range of contexts, although it still carries a notable level of risk.

Table 4. Evaluation Result Based on ISO 25010:2011

Characteristic	Statement	Average Percentation
Effectiveness	The NaimaEcoSync system is capable of processing data (displaying and storing it)	92.86%
	All menus and features of the NaimaEcoSync system function properly	
Efficiency	Each menu function in the application can store data	100%
Satisfaction	The NaimaEcoSync system is easy to operate	94.64%
	The menus and information displayed by the NaimaEcoSync system are easy to understand	
	Data security in the NaimaEcoSync system is reliable	
	The NaimaEcoSync system provides accurate and up-to-date data and information according to user requirements.	
	The output of the NaimaEcoSync system (data processing results) is presented accurately to facilitate user understanding	
	The information provided by the NaimaEcoSync system is easy to comprehend	
	The menus in the NaimaEcoSync system are easy to understand without difficulty	
	The font size on the NaimaEcoSync application's pages is clearly readable	
Freedom from Risk	Data in the NaimaEcoSync system can only be accessed by system users	92.86%
	The application system has a low failure rate when experiencing system failures	
	The NaimaEcoSync system can search all content within the system	
	The application system can track system usage errors	
	This program runs on commonly used operating systems or devices	
	New users can easily use this system	
Context coverage	Users can easily input the data required by the NaimaEcoSync system	100%
	The NaimaEcoSync system can display correct data according to keywords	

DISCUSSION

Digitalization has become crucial in the implementation of EPR. One essential aspect of EPR implementation is traceability. Currently, global companies are striving to adopt practices of sustainability, circular economy, and EPR. When discussing the implementation of EPR in the FMCG industry, companies face challenges in calculating the amount of packaging waste managed and identifying the sources of this waste. Currently, the process of recording packaging waste by FMCG companies in collaboration with waste management entities still employs manual methods. This poses challenges in terms of human resources, time, and susceptibility to errors. Companies also require more time to process and analyze collective data due to the large volume of information.

NaimaEcoSync is designed to address these waste management data recording issues. The ease of data recording and digital data processing offers advantages such as faster processing time, more efficient human resource utilization, and reduced error rates in data recording. The data results are displayed on a dashboard, providing comprehensive information and facilitating users in tracking waste flow. In other words, when collected waste is recorded, we can accurately determine the amount of managed waste in a specific area. Ultimately, this helps reduce the amount of unmanaged waste in the environment. It also simplifies the process for companies adopting the plastic credit scheme, thanks to robust plastic waste data recording. EPR has also become a regulation in Indonesia. As a result, by valid data recording, companies can ensure compliance with Indonesian regulations

CONCLUSION AND RECOMMENDATIONS

NaimaEcoSync was successfully developed using the Scrum methodology, which made the system development process effective and efficient. The system received an average evaluation score of 96.07%, indicating that it is easy to use and suitable for implementing EPR in industries in Indonesia.

Future Work

The system is a preliminary development and there are still opportunities for feature enhancements, including:

1. Each waste management facility having multiple users capable of conducting their own waste calculations.
2. Mapping waste based on sub-districts and villages, using data from waste management facilities in each area.
3. Improving error handling within the system.

FURTHER STUDY

This research still has limitations so further research is needed related to the topic Naimaecosync as a Waste Management Aggregator in Supporting Extended Producer Responsibility for Industries in order to Refine this research and increase insight for readers

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