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MORALITY BEFORE KNOWLEDGE

Post-consumer plastic waste management strategy: A study of producer responsibility implementation

Siti Kardian Pramiati[1,*]
[1] *Department of Environmental Science, School of Environmental Science, Universitas Indonesia, Central Jakarta, Jakarta 10430, Indonesia.*
*Correspondence: dhiankui@gmail.com

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ABSTRACT

Background: The dynamic urban lifestyle changes human behaviour in selecting consumer goods products. Urban communities prefer goods in suitable and economical packaging when carrying out their activities. This study was conducted in Jakarta and aimed to analyze the perceptions of consumers, producers, and the role of the informal sector in waste management so that alternative producers' responsibility schemes can be formulated in the management of post-consumption plastic waste. **Methods:** In this study, quantitative and qualitative methods were used with data analysis using descriptive statistics. In the next step, an Analytical Hierarchy Process (AHP) has been prepared for identifying the best alternative scheme of EPR for post-consumer plastic waste management. **Findings:** They showed that the highest criteria value (0.27) that was considered in the EPR implementation was the environmental impacts potential criteria. At the stage of selecting alternative EPR schemes, the highest to lowest scores respectively are partnership schemes with waste management organizations (2.83), product design optimization (2.78), post-consumption waste recall (2.11), and development of recycling facility (1.28). There are some fundamental issues that are considered in the waste management system in Indonesia, including limited capacity for waste management in the regions, inadequate infrastructure, application of regulations, and lack of public awareness, including in the consumer goods manufacturing industry. **Conclusion:** This is high time for the implementation of a circular economy, especially among plastics waste. **Novelty/Originality of this article:** Through the Extended Producer Responsibility (EPR) concept approach, this research sheds light that the manufacturing industry is more encouraged to contribute to their post- consumer waste management.

KEYWORDS: analytical hierarchy process (AHP); circular economy; extended producer responsibility (EPR); plastic waste management.

1. Introduction

High population growth in urban areas due to migration from rural areas has led to changes in urban lifestyles, including increased economic growth and social improvements within urban communities (Suthar & Singh, 2015). The dynamic activities of urban communities cause changes in lifestyle and consumption patterns. Smaller packaged consumer goods are created to meet the demands of highly mobile urban populations, targeting lower-to-middle-income markets. Various types of single-use packaging products trigger an increase in waste generation, which, if not well managed, can lead to public health issues and environmental pollution. The high population in Indonesia in 2020, which reached 270.2 million, contributed to an increase in the volume of waste generated (Badan Pusat Statistik, 2021). According to data from the National Waste Management Information

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System, the national waste generation in 2020 reached 32,168,135.19 tons. However, only 15,167,553.06 tons, or about 45.81% of the waste, were managed.

The National Plastic Action Partnership (NPAP) report reveals that approximately 4.8 million tons, or 70% of all plastic waste in Indonesia, is not well managed. Waste that is not properly managed may end up in the ocean, leading to various problems, both directly and indirectly, such as water, air, and soil pollution; increased greenhouse gas emissions; the spread of diseases; flooding disasters; and other issues. In its research, the World Economic Forum estimates that there are currently 150 million tons of plastic waste in the oceans, with 8 million tons of plastic waste leaking into the oceans each year. If no strategic efforts are made, by 2050, the volume of plastic waste in the oceans will exceed the volume of fish (World Economic Forum, 2020). Plastic is widely recognized as an increasing priority in waste management (Barnes et al., 2009; Gregory, 2009; Teuten et al., 2009; Jambeck et al., 2015; Borrelle et al., 2020). A similar study conducted by the Oceanographic Research Center of the Indonesian Institute of Sciences found that around 0.27-0.60 million tons of plastic waste enter Indonesian waters every year (Cordova et al., 2019). Plastic waste in the ocean has caused serious negative impacts on marine life, livelihoods, and public health (Jing & Sutikno, 2020; Maskun et al., 2022).

In Indonesian cities, only around 60% of the waste is transported to Final Disposal Sites, where it is disposed of through landfilling (Damanhuri, 2012). Landfilling has become the primary method used by cities to address waste issues. Jakarta, as a large city with a high population density and rapid industrial growth, also faces waste management problems. The waste generation in the Jakarta Capital Region (DKI Jakarta) in 2020 was 3,654,812.22 tons. The amount of waste deposited at the TPA in Jakarta reached 11,000 tons per day, with 273 tons still not managed (KLHK, 2021). The waste mound at the Bantargebang TPA reaches a maximum height of 50 meters above the existing 104-hectare land. It is estimated that by 2035, the volume of waste in Jakarta will exceed 9,000 tons per day (BPS, 2021).

According to KLHK (2021), the largest source of waste in DKI Jakarta comes from households, generating 854.94 tons, followed by the office sector, which contributes 430.73 tons. This data indicates that household waste management has not been optimized, making it the primary source of waste in DKI Jakarta. The public's behavior in waste management was studied by the Central Statistics Agency through the Environmental Indifference Survey in 2018. The survey produced an Environmental Indifference Index, indicating that the highest environmental indifference in Indonesia occurs in the dimension of waste management, compared to indifference toward energy management, water conservation, or the use of public transportation (BPS, 2018).

At the national level, Presidential Regulation No. 97 of 2017 on the National Policy and Strategy (Jakstranas) for Household Waste and Similar Waste mandates a target for 100% waste management by 2025. This regulation is strengthened by the issuance of Regional Policy and Strategy (Jakstrada). This step significantly encourages behavior changes among the public and producers. The plastic waste collection system can involve consumers, retailers as distributors of plastic-packaged products, and informal sector recyclers (Dahlbo et al., 2018; Septiani et al., 2019). Following the mandate of Article 15 of Law No. 18 of 2008 on Waste Management, the Ministry of Environment and Forestry has issued Ministerial Regulation No. 75 of 2019 on the Roadmap for Waste Reduction by Producers. This regulation serves as the legal foundation for regulating waste reduction by producers, especially for non-degradable and non-reusable waste, such as plastic packaging. It outlines the producers' responsibility from planning waste reduction, implementation, evaluation, and reporting (KLHK, 2021; Wang & Karasik, 2022).

However, the regulation does not specifically mention the obligation to manage plastic packaging waste. The concept of extended producer responsibility is still being implemented voluntarily. Producers worry that the implementation of this extended responsibility may lead to increased production costs. The growing volume of plastic waste has yet to be matched by improvements in waste management infrastructure and service quality, due to issues such as cost, human resources, and limited facilities (Ayu et al., 2011).

Another challenge in plastic waste management is the behavior and involvement of urban communities in managing plastic waste, as well as the suboptimal participation of businesses in fulfilling their responsibilities as producers of plastic-packaged products. Therefore, studies on community participation, the role of the informal sector, and producers' involvement in plastic waste management are also needed. This research aims to address four issues: (1) public perceptions and participation levels in the extended producer responsibility scheme, (2) the role of the informal sector in plastic waste reduction by producers, (3) business perceptions on expanding producer responsibility, and (4) strategies for implementing expanded producer responsibility in waste management.

2. Methods

The method used in this research is a combination method (mixed method) with the aim of obtaining better results. The quantitative method was applied in the collection of questionnaire data to analyze public perceptions and the perceptions of business actors. The qualitative method was used to analyze the social and economic aspects of the community and government policies, through interviews with relevant parties. The research was conducted over a period of six months, starting from July to October 2020, and continued from August to September 2021. The research timeline included the stages of literature study, distribution of questionnaires and interviews, secondary data collection, data processing and analysis, as well as the preparation of the research report. The data collection techniques are shown in the data collection matrix in the following Table 1.

Table 1. Data collection matrix

Num.	Data	Type of data	Instrument of data collection
1	Community perception	Primary	Questionnaire
2	Community participation level	Primary	Questionnaire
3	Role of the informal sector	Secondary	Data from relevant agencies/institutions
4	Business actors' perception	Primary	Questionnaire and interview
5	Plastic waste management strategies	Primary Secondary	Questionnaire and interview Literature review

The research timeline included the stages of literature study, distribution of questionnaires and interviews, secondary data collection, data processing and analysis, as well as the preparation of the research report. The data collection techniques are shown in the data collection matrix in the following Table 1. The data processing technique is presented in the data processing matrix in Table 2.

Table 2. Data processing matrix

Num.	Data	Data processing
1.	Community perception	Summing the most frequent responses and processing data using descriptive statistical analysis.
2.	Community participation level	Summing the most frequent responses and processing data using descriptive statistical analysis.
3	Role of the informal sector	Analyzing data from the informal sector waste managers.
4	Business actors' perception	Summing the most frequent responses and analyzing the results of the questionnaire and interviews descriptively.
5.	Plastic waste management strategies	Selecting criteria using the Analytic Hierarchy Process (AHP) method and performing calculations using Microsoft Excel software.

3. Results and Discussion

3.1 Community participation level in plastic waste management

The term participation is used by Cohen & Uphoff (1977) to refer to the involvement of a significant number of people in various situations or actions that can improve their quality of life (Thoha, 2011). Participation is active and voluntary involvement driven by either intrinsic or extrinsic reasons, throughout all stages of activities, including planning, implementation, monitoring, evaluation, and the utilization of results. These definitions suggest that participation is understood as a sociological process of community involvement in activities within their environment aimed at improving their quality of life.

In waste management activities, individuals have different roles. The level of community participation in waste management can be divided into four categories: individual level, community level, participation in program and policy formulation, and the highest level is participation in community management, which involves being a member of a group responsible for overseeing the program's execution and decision-making, while involving other group members (Mazengo, 2016). According to van de Klundert & Anschutz (2001), community participation in waste management systems consists of several levels. Community participation in waste sorting at the source is one form of community-based waste management. The level of participation in this study refers to the community's involvement in sorting waste, especially plastic waste, and submitting it through available plastic waste collection facilities.

Regarding the question on how waste is managed in residential areas, 44% of respondents stated that they rely solely on waste collection services without sorting the waste beforehand, while 23.2% of respondents sort their waste before it is collected. Additionally, 19.8% of respondents do not use collective waste collection services, opting instead to dispose of their waste directly at the nearest disposal site. The remaining 12.3% of respondents indicated that they burn their household waste. The survey results regarding waste management methods are shown in Figure 1.

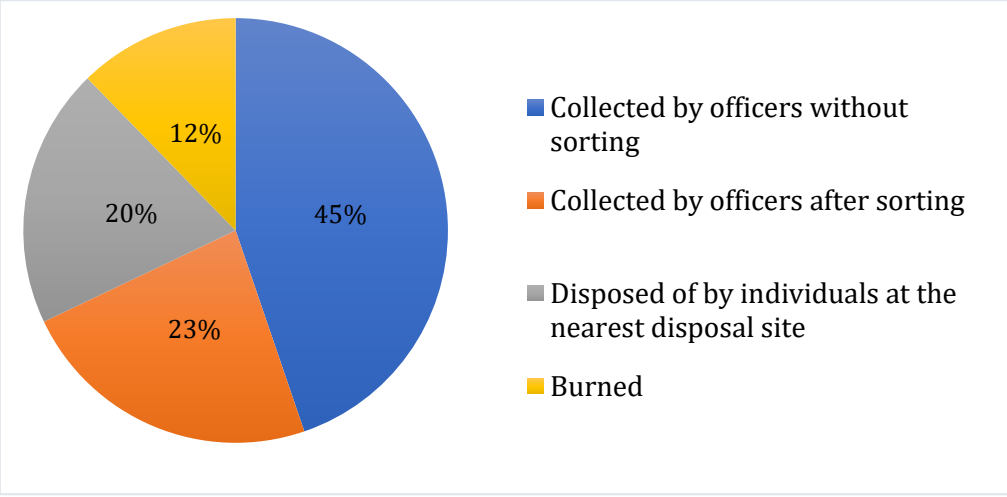
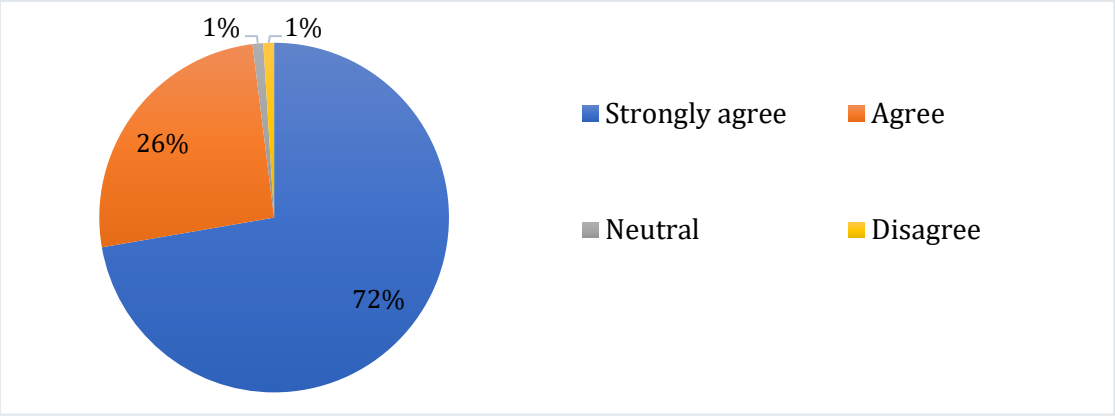


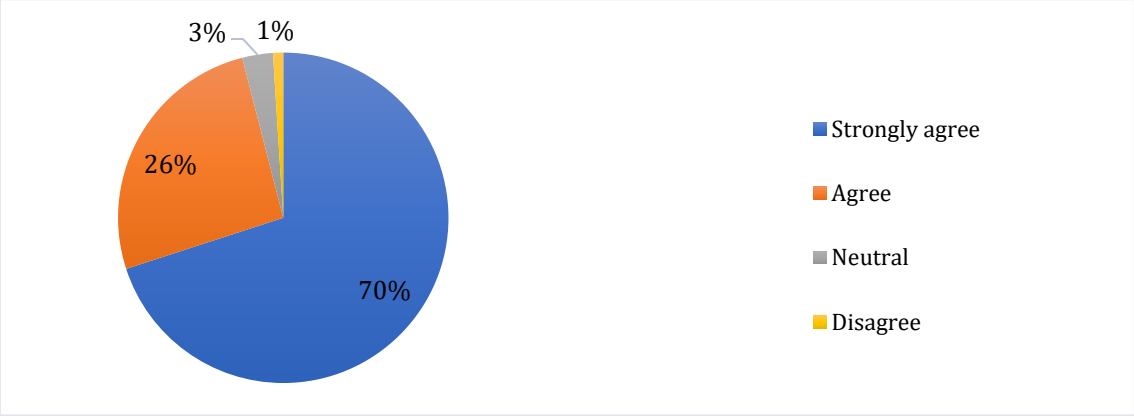
Fig. 1 Percentage of household waste management

In the following question, respondents provided their opinions regarding government regulations and the urgency of implementing producer responsibility in plastic waste management. The results of the community perception analysis are presented in the figure 2. Next, regarding public perception of waste reduction policies through producer responsibility, 73% of respondents expressed agreement and support for government regulations related to packaging waste management, including the issuance of the Ministry of Environment and Forestry Regulation No. 75 of 2019 on the Roadmap for Waste Reduction by Producers. 70% of respondents believed that the responsibility for post-

consumption waste management should lie with producers, as they have expressed concerns about the rising costs of consumer goods, while waste management systems in residential areas remain suboptimal. The expansion of producer responsibility is hoped to serve as a solution to the growing issue of plastic packaging waste, which almost everyone consumes daily.



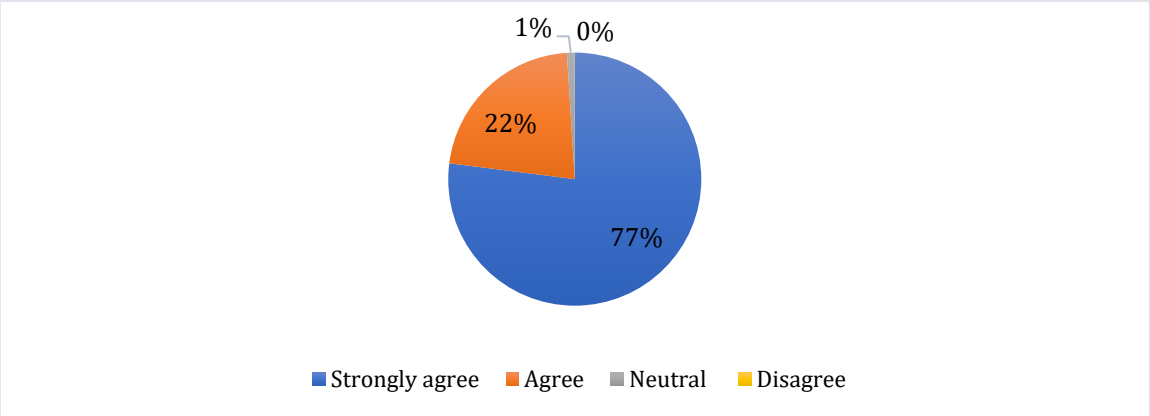
(a)



(b)

Fig. 2 analysis results: (a) Public support for government regulations on producer responsibility implementation; (b) Public opinion on the implementation of producer responsibility

In the next phase, respondents' feedback on waste reduction schemes by producers, such as plastic packaging take-back programs, was analyzed. The majority of respondents gave positive feedback, as evidenced by the survey results showing that 77% of respondents strongly agreed that producers should take the initiative to expand their responsibility by implementing post-consumption plastic packaging take-back programs. Regarding the community's willingness to collect post-consumption plastic waste, 65% of respondents expressed readiness to participate in plastic packaging waste collection, while only 1% stated that they did not want to be involved in post-consumption plastic waste collection activities.



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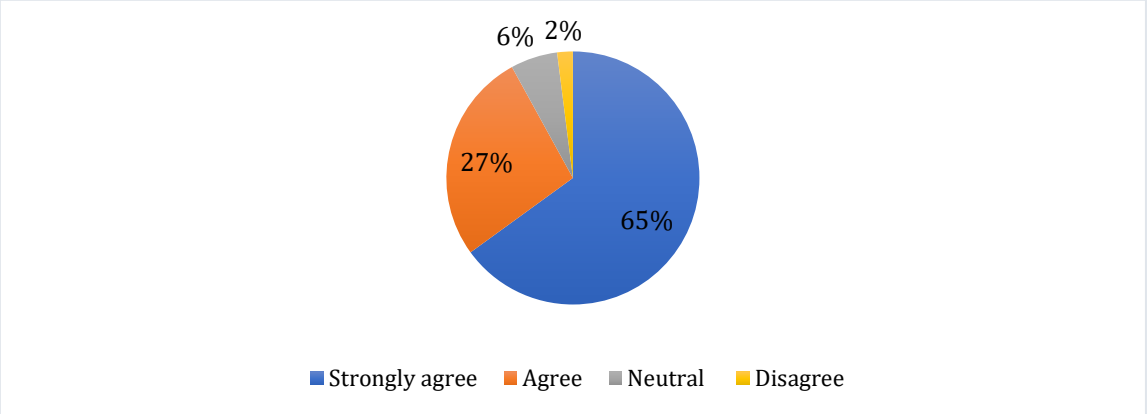

(b)

Fig. 3. Analysis results ; (a) public opinion on the plastic waste take-back program; (b) public willingness to participate in plastic waste collection

Consumers also responded to questions about the producer responsibility schemes that should be implemented in their community. The results of these responses are presented in Figure 4.

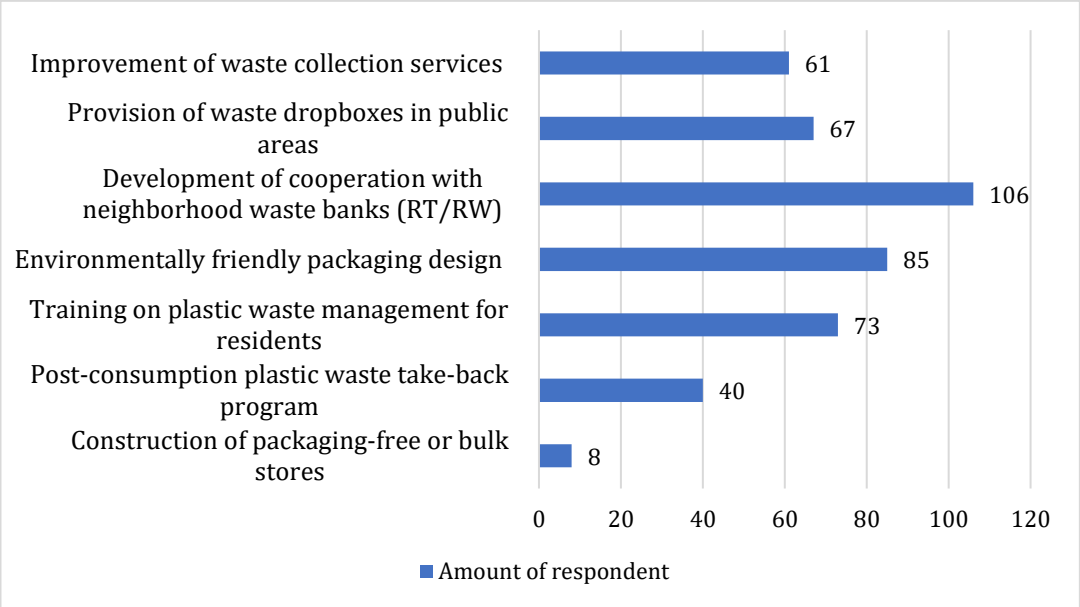

Fig. 4. Producer responsibility schemes needed by the community

In supporting efforts to reduce waste by producers, the public has identified several schemes that are acceptable and feasible for implementation in their communities, including: (a) construction of packaging-free or bulk stores; (b) post-consumption plastic waste take-back programs; (c) training on plastic waste management for residents; (d) environmentally friendly packaging design; (e) development of cooperation with neighborhood waste banks; (f) provision of dropboxes in public areas; (g) improvement of waste collection services. The most frequently chosen scheme was the development of neighborhood-scale waste banks, selected by 106 respondents, followed by the environmentally friendly packaging design scheme (85 respondents), and plastic waste management training for residents (73 respondents).

Efforts to build the sustainability of urban waste management systems require effective social interventions, one of which is by providing incentives to the public (Narayana, 2009; O'Connell, 2011; Adi, 2013; Zastrow, 2017). Respondents who agreed with and supported the implementation of waste reduction by producers were then asked about their motivations and suggestions for incentives offered by producers for participating in the plastic waste take-back program. A total of 147 respondents (33%) suggested direct discounts for the return of post-consumption plastic waste, and 139 respondents (32%) proposed offering shopping vouchers as incentives for consumers who return post-consumption plastic waste. 99 respondents (23%) suggested a program that exchanges post-consumption plastic waste for reward points or savings, and 4 respondents proposed cash back as an incentive for the plastic waste take-back program. 36 respondents (8%) stated that no incentives were required for returning post-consumption plastic waste.

3.2 The role of the informal sector

The informal sector referred to in this research includes community institutions/organizations involved in the collection, distribution, and processing of plastic packaging waste, such as waste collectors (*lapak/bandar*) and waste banks. Data on the informal sector includes information on plastic waste management activities at waste banks and waste collectors in the DKI Jakarta area, obtained from the National Waste Management Information System/*Sistem Informasi Pengelolaan Sampah Nasional* (SIPSN) and the Waste Bank Management Information System (Simba.id), Ministry of Environment and Forestry, 2022.

3.2.1 The role of waste collectors (lapak)

Waste management activities carried out by waste collectors (*lapak*) focus solely on collecting waste from individual scavengers. The collected waste consists only of materials with economic value, such as inorganic waste like plastic packaging (bottles, cups), cardboard, paper, or glass. Nearly all of this waste is channeled to be processed into raw materials for recycling, with the remaining 7.65 tons having the potential to become raw materials for upcycling.

Table 3. Amount of waste managed through waste collectors

Area	Collected (tons)	Managed (tons)	Recycled raw materials (tons)	Up cycle raw materials (tons)
West Jakarta	48,923.57	48,923.57	48,923.57	0
East Jakarta	190,042.30	189,796.87	189,796.87	0
Central Jakarta	44,638.36	44,411.94	44,638.36	0
North Jakarta	33,438.70	33,401.04	33,393.39	7.65
South Jakarta	117,851.99	117,851.99	117,851.99	0
Total	434,894.92	434,385.41	434,604.18	7.65

From Table 3, it is evident that the amount of inorganic waste collected at waste collectors (*lapak*) in the five regions totaled 434,894.92 tons. Meanwhile, the waste that was

processed amounted to 434,385.41 tons, with the remainder becoming residual waste. The waste reduction carried out by the waste collectors and scavengers is calculated to be 14.12%.

3.2.2 The role of waste banks

Another informal sector examined in this research is the waste bank. Nationwide, the number of waste banks has been increasing year by year. The latest data shows that, in 2021, there were 11,552 waste banks spread across Indonesia, with 1,942 of these located in the DKI Jakarta area (KLHK, 2022). This growth in the number of waste banks has been accompanied by an increase in the number of people becoming customers. Nationwide, in 2020, there were 419,204 active customers, but the number decreased in 2021 to 377,881 active customers. In the DKI Jakarta area, there were 51,833 active customers. The following table presents data on the amount of waste managed by the waste bank units in the five regions of DKI Jakarta in 2021.

Table 4. Amount of waste managed through waste banks

Area	Waste input (kg/year)	Raw material for animal feed (kg/year)	Raw material for compost (kg/year)	Raw material for recycling (kg/year)	Raw material for up-cycle (kg/year)
West Jakarta	4,662,312.00	0.00	0.00	368,346.00	923,970.00
East Jakarta	11,467,480.92	0.00	0.00	11,319.440.28	39,010.80
Central Jakarta	5,243,774.87	0.00	0.00	3,122,402.21	33,023.14
North Jakarta	137,741.13	0.00	0.00	66,432.01	0.00
South Jakarta	2,484,039.51	0.00	0.00	2,484,039.39	0.00
Total	23,995,348.43	0.00	0.00	17,360,659.89	99,003.94

Data from the waste banks in the five regions of DKI Jakarta show that most of the inorganic waste collected in the waste banks (95%) can be utilized as raw materials for the recycling industry, with only 5% being suitable for upcycling. The total plastic waste collected in the waste banks amounts to 23,995,348.43 kg per year, or 23,995.35 tons per year. From this, the waste reduction achieved by the waste banks is calculated to be 0.78%.

The waste reduction figure is quite low, indicating that the collection rate through waste banks is still very small, as it only reduces 0.78% of the waste generated in Jakarta. However, when considering the waste reduction figures from both the waste collectors (lapak) and the waste banks, it is clear that the informal sector plays an important role in collecting and taking back inorganic waste, especially plastic packaging waste. If collaboration between producers and the informal sector is optimized, the Extended Producer Responsibility (EPR) scheme for plastic packaging take-back could function more effectively. This research supports the findings of Kustanti et al. (2020), which stated that informal recycling actors in the Purwodadi Subdistrict managed to reduce plastic waste by 10.08%.

3.2 Perceptions of business actors

The business actors sampled in this research were producers from the manufacturing sector of consumer goods, including five companies: (1) PT. A (packaged milk producer), (2) PT. B (household cleaning products producer), (3) PT. C (snack food and bottled beverage producer), (4) PT. D (disposable diaper producer), and (5) PT. E (cosmetics and health supplement producer). According to the sample criteria, the respondents providing data were employees with a minimum of three years of experience working in units such as Corporate Affairs, Health Safety and Environment, Production/Distribution/Packaging, or Human Resources and Development. Regarding the types of packaging used for consumer goods products, the research findings show that 37.5% of products use PET/PETE plastic

packaging, 25% use cardboard packaging, and the remainder consists of PP, HDPE, and PVC packaging.

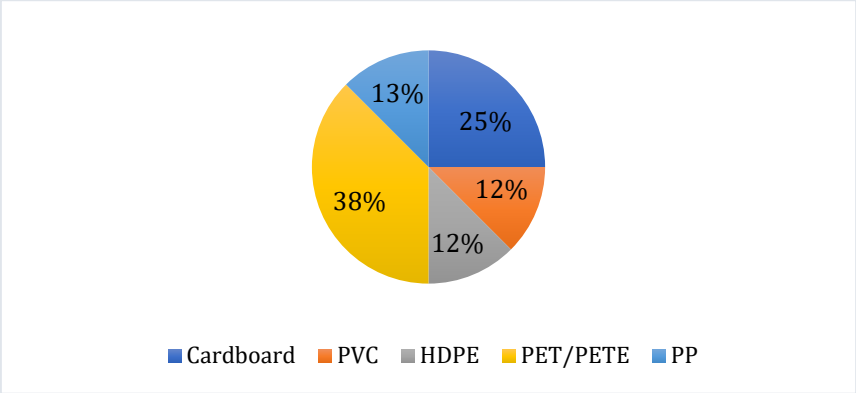

Fig. 4. Type of packaging used by the producen

Regarding knowledge of waste management regulations and expanded producer responsibility, all respondents indicated that they are aware of the latest regulation, which is the Ministry of Environment and Forestry Regulation No. 75 of 2019 concerning the Roadmap for Waste Reduction by Producers. All respondents agreed that producers should be responsible for managing the packaging waste generated by their products, with the most common reason being to improve the product quality and make it more environmentally friendly.

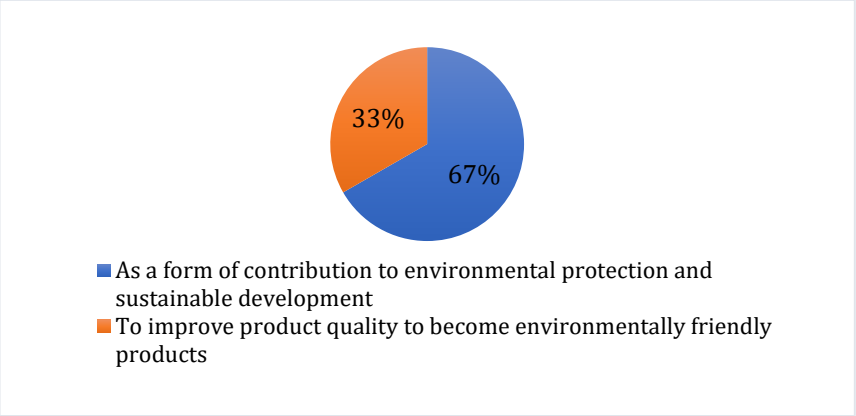

Fig. 5. Reasons producers agree with regulations related to producer responsibility

To determine whether respondents have implemented responsibility in terms of waste reduction, the question regarding the actions taken by producers in managing plastic waste was answered by the five producers. The data reveals that all five producers have implemented material/raw material efficiency in their production processes, conducted environmental education/campaigns for the public, and collaborated with the community in waste management activities. Through cooperation with the government, all five producers chose to use government-owned infrastructure and facilities for waste management. In response to follow-up questions regarding the form of producer responsibility, the majority of respondents indicated that they prioritize financial responsibility, particularly by allocating post-consumption waste management funds into the company's environmental cost plan.

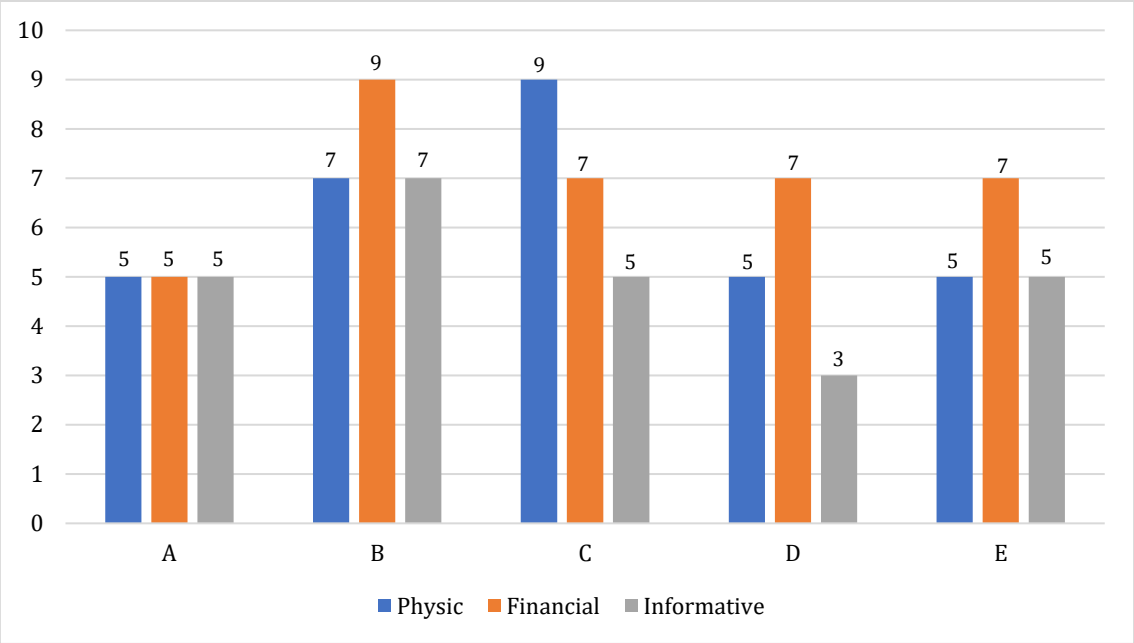

Fig. 6. Producer responsibility forms

The research findings in Figure 6 illustrate that producers tend to opt for financial responsibility. In comparison to physical or informational responsibility, producers place greater emphasis on internalizing the costs for waste reduction within the company. According to Lindhqvist's theory (2000), the financial responsibility undertaken by producers includes all costs associated with collection, recycling, and final processing of the products they produce.

3.3 Selection of alternative plastic waste management models through producer responsibility

There are several factors that producers consider when implementing an extended responsibility scheme. From the questionnaire submitted to the producers, it was found that the criteria for producers to implement their extended responsibility are shown in Figure 7. All five producers stated that they need to consider the company's image, potential environmental impacts, and the ability to adapt to the local community when applying the extended corporate responsibility scheme.

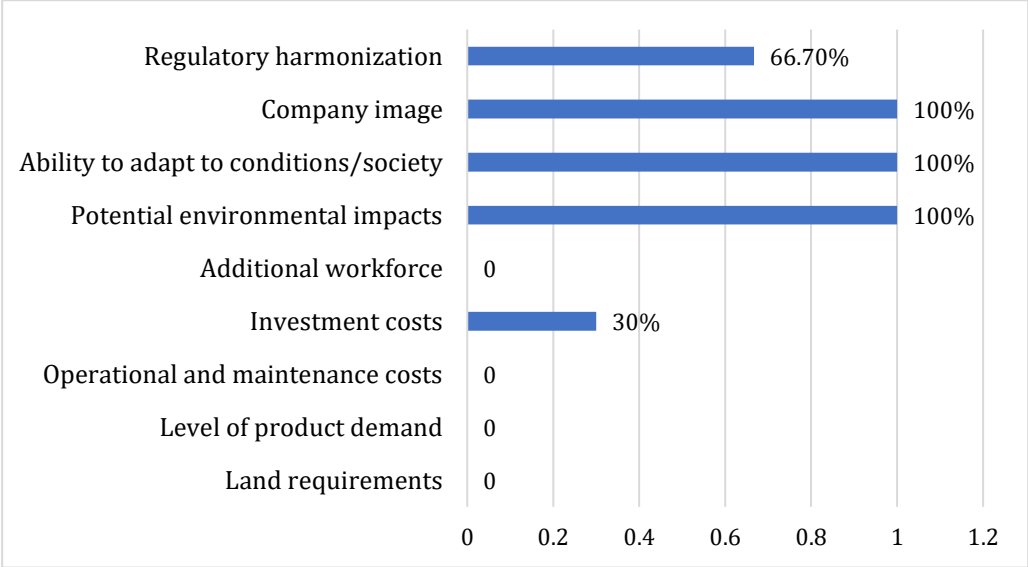

Fig. 7. Criteria considered by producers

Meanwhile, 66.70% of the companies consider regulatory harmonization, and 30% believe that the investment costs required for implementing extended responsibility should also be taken into account. Based on a literature review and the results of the questionnaire, several criteria were formulated for selecting a packaging waste management model through the concept of producer responsibility implementation. These criteria are explained to facilitate the selection of priorities. The descriptions are as follows.

First is company image (C1). Company image refers to the public or consumer's perception, impression, or image of the organization or company. A good company image is essential for the sustainability of the business process, as it influences all elements within the company. The second is regulatory harmonization (C2). This criterion indicates the level of alignment between the proposed model and the policies or regulations in place. Third is potential increase in workforce (C3). The likelihood of needing additional workforce for implementing the proposed model. Fourth is product demand level (C4). The likelihood of increased product demand as a result of implementing the proposed model. Fifth is operational and maintenance costs (C5). Operational and maintenance costs refer to the routine costs incurred by the company for each stage of implementing the proposed model. Sixth is investment costs (C6). This refers to the total transaction costs the company must pay to implement the proposed responsibility model. Seventh is land requirements (C7). The land usage needed, which should be considered when implementing the proposed model. Eight is environmental impact potential (C8). The potential level of environmental impact from implementing the proposed model. Ninth is adaptation to local conditions (C9). The ability of the proposed model to adapt to local conditions such as community activities, culture, and the roles of formal/informal sectors.

For the alternatives for waste reduction responsibility implementation, producers mentioned several options, namely (1) efficiency in production processes and redesigning product packaging (A1); (2) creating drop boxes or collection points for packaging waste in public areas (A2); (3) developing a recycling system within their company (A3); (4) partnering with organizations or service providers for packaging waste management (A4). The weighting of criteria in this study was performed using an Excel spreadsheet to simplify calculations. The combined weighting results from the informants are arranged into a pairwise comparison matrix as shown in the Table 5.

Table 5. Pairwise comparison matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9
C1	1.00	0.25	16.00	3,00	0.25	16,00	16,00	0.06	24,00
C2	4.00	1.00	8.00	16,00	4,00	6,00	16,00	0.50	3,00
C3	0.13	0.04	1.00	0.06	0.03	1.00	2,00	0.06	0.06
C4	0.33	0.06	16.00	1.00	1.00	1,50	16,00	0.06	1.00
C5	4.00	0.25	16.00	1.00	1.00	1.00	8,00	2,00	16,00
C6	0.06	0.17	1.00	0.67	1.00	1.00	8,00	0.13	1.00
C7	0.06	0.06	0.50	0.06	0.13	0.13	1.00	0.06	0.13
C8	16.00	1.00	16,00	16,00	0.50	8,00	16,00	1.00	8,00
C9	0.04	0.17	16,00	1.00	0.13	1.00	8,00	0.13	1.00
Total	25.63	3.00	90.50	38,79	8,03	35,63	91.00	4,00	54,19

The next step is to normalize the combined pairwise comparison data obtained. The results of the data normalization can be seen in the table below:

Table 6. Normalized pairwise comparison matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9
C 1	0.05	0.12	0.37	0.23	0.12	0.35	0.13	0.01	0.33
C2	0.01	0.03	0.12	0.28	0.12	0.00	0.27	0.01	0.08

C 3	0.00	0.00	0.01	0.00	0.01	0.00	0.02	0.01	0.00
C 4	0.00	0.00	0.08	0.02	0.06	0.02	0.13	0.01	0.01
C 5	0.19	0.12	0.08	0.16	0.50	0.35	0.13	0.74	0.33
C 6	0.00	0.26	0.03	0.01	0.02	0.01	0.13	0.01	0.01
C 7	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.01	0.00
C 8	0.75	0.47	0.18	0.28	0.12	0.24	0.09	0.19	0.22
C 9	0.00	0.00	0.12	0.03	0.02	0.01	0.09	0.01	0.01

After the pairwise comparison matrix has been compiled, the analysis process is carried out by calculating the weight of each criterion. The weighting results for each criterion are as follows.

Table 7. Criterion weights

Criterion	Weight
Corporate image	0.17
Regulatory harmonization	0.22
Potential for additional workforce	0.01
Product demand level	0.07
Operational and maintenance costs	0.16
Investment costs	0.04
Land requirements	0.01
Potential environmental impacts	0.27
Adaptation to local conditions	0.05

From the table above, it can be observed that the highest weight is on the eighth criterion, which is the potential environmental impact, with a weight of 0.27, and the second highest is the regulatory harmonization criterion, with a weight of 0.22. However, to ensure that these criterion values are consistent, it is necessary to proceed with calculating the Consistency Ratio (CR).

The ratio index used for the weighting of criteria is 1.45 because this study involves nine criteria. The calculation results show that the Consistency Ratio (CR) value is -0.62. If the CR value is ≤ 0.1, then the data is considered consistent, and the process can proceed to the next stage. After evaluating each criterion, several criteria with the highest weights were identified. The next step is selecting alternatives while considering the existing criteria. The selection of alternatives was carried out through a literature review and interviews with experts representing government, private sectors, and environmental advocates, namely: (1) informant 1 from a government agency; (2) informant 2 from a practitioner and CSR advocate from a Non-Governmental Organization (NGO); (3) informant 3 from a senior staff in Corporate Affairs in a beverage packaging manufacturing company; (4) informant 4 from a senior staff in the Production and Packaging Division of a household product manufacturing company. These expert informants assisted in the weighting of criteria and validation using a ratio scale guide based on Saaty & Vargas (2012). The pairwise comparison calculations from each informant are presented on separate sheets in Appendix 4. For selecting an alternative producer responsibility model, the researcher referred to the results from the questionnaire as mentioned in the previous section, which include as follow.

First is optimization of product packaging design (A1). This effort involves optimizing product packaging by reducing plastic raw materials, replacing packaging with more easily biodegradable materials, using recycled materials, and adding labels with information on the packaging. Second is packaging waste collection (A2). Post-consumption packaging can be collected by designing a Deposit Refund System, creating Drop Boxes at public locations, or collecting it through informal sectors such as Waste Banks. Third is development of recycling facilities (A3). Recycling activities can be carried out by businesses building an ecosystem for packaging waste recycling at their operational locations or other locations, allowing the company to manage and collect waste independently. Fourth is partnership with packaging waste management organizations (A4). Businesses manage packaging

waste by partnering with packaging waste management organizations or Packaging Recovery Organizations (PRO). In this case, businesses do not directly carry out collection, processing, or provide collection or processing facilities but instead form contracts with waste management service providers. From these four packaging waste management alternatives, a comparison matrix was created between each alternative for each criterion, leading to the values presented in the Table 8.

Table 8. Weighting of alternatives for criterion 1

	A1	A2	A3	A4	Priority/Average value
A1	0.6207	0.8340	0.3616	0.1488	0.4913
A2	0.0172	0.0232	0.5424	0.0083	0.1478
A3	0.1552	0.0039	0.0904	0.7934	0.2607
A4	0.2069	0.1390	0.0056	0.0496	0.1003
Amount	1.0000	1.0000	1.0000	1.0000	1.0000

By calculating using Formula 3.3, the Consistency Ratio value for the data in Table 8 is -0.36. This value is ≤ 0.1, indicating that the data is consistent. The highest weight value among the alternatives is found in row A1, which is the alternative for optimizing packaging design. Based on the Company Image criterion, the optimized packaging design becomes the proposed packaging waste management model because the new design, which is more recyclable and informative, will enhance both the product's and the company's image in the eyes of consumers.

Table 9. Weighting of alternatives for criterion 2

	A1	A2	A3	A4	Priority/Average value
A1	0.5333	0.7701	0.1333	0.6923	0.5323
A2	0.0222	0.0321	0.4000	0.0385	0.1232
A3	0.2667	0.0053	0.0667	0.0385	0.0943
A4	0.1778	0.1925	0.4000	0.2308	0.2503
Amount	1.0000	1.0000	1.0000	1.0000	1.0000

The same calculation is performed for all criteria. In Table 9, the Consistency Ratio is -0.80, indicating that the data is consistent. For Criterion 2, which is regulatory harmonization, the highest average value is found in alternative 1, which is optimizing product design. This is because the process of changing product and packaging designs highly depends on the harmonization of existing regulations, both at the national and local levels.

Table 10. Weighting of alternatives for criterion 3

	A1	A2	A3	A4	Priority/Average value
A1	0.0391	0.0286	0.3616	0.1250	0.1386
A2	0.9381	0.6857	0.5424	0.1667	0.5832
A3	0.0098	0.1143	0.0904	0.6667	0.2203
A4	0.0130	0.1714	0.0056	0.0417	0.0579
Amount	1.0000	1.0000	1.0000	1.0000	1.0000

The Consistency Ratio for Table 10 is -0.72, meaning the data is consistent. For the criterion of potential increase in workforce, the highest value is found in alternative A2, which is the post-consumption packaging collection scheme. This is because the post-consumption packaging collection program carried out by producers will require a collection and handling mechanism for packaging waste. This mechanism will also need additional labor, aside from the company's own employees, thus increasing the demand for new labor.

Table 11. Weighting of alternatives for criterion 4

	A1	A2	A3	A4	Priority/Average value
A1	0.5714	0.4417	0.1775	0.2759	0.3666
A2	0.2857	0.2209	0.7989	0.1379	0.3608
A3	0.0714	0.0061	0.0222	0.5517	0.1629
A4	0.0714	0.3313	0.0014	0.0345	0.1096
Amount	1.0000	1.0000	1.0000	1.0000	1.0000

The Consistency Ratio value in Table 11 is -0.29, indicating that the data is consistent. The highest weight for Criterion 4 is in A1, the packaging design optimization alternative. Criterion 4 considers the level of product demand. Modifying or updating packaging design can influence consumer attitudes toward the product. Changes in packaging for a brand can be an attraction for consumers, which may increase demand for the product. Therefore, to boost product demand, the optimal packaging design alternative is the best choice.

Table 12. Weighting of alternatives for criterion 5

	A1	A2	A3	A4	Priority/Average value
A1	0.0976	0.1622	0.0851	0.0891	0.1085
A2	0.0976	0.1622	0.1277	0.1782	0.1414
A3	0.0244	0.0270	0.0213	0.0198	0.0231
A4	0.7805	0.6486	0.7660	0.7129	0.7270
Amount	1.0000	1.0000	1.0000	1.0000	1.0000

The Consistency Ratio value for Table 12 is 0.003, indicating that the data is consistent. The highest weight value is found in alternative 4, with a value of 0.7270. Alternative 4 is the development of cooperation with packaging waste management organizations. From the business perspective, operational and maintenance costs are more efficient and effective if packaging waste management is handled through a partnership with a waste management organization.

Table 13. Weighting of alternatives for criterion 6

	A1	A2	A3	A4	Priority/ Average value
A1	0.1078	0.8340	0.0851	0.0947	0.2804
A2	0.0030	0.0232	0.1277	0.1263	0.0700
A3	0.0269	0.0039	0.0213	0.0211	0.0183
A4	0.8623	0.1390	0.7660	0.7579	0.6313
Amount	1.0000	1.0000	1.0000	1.0000	1.0000

The Consistency Ratio value for Table 13 is -0.80, indicating consistency. In the weighting for Criterion 6 (investment costs), the highest value is found in alternative 4, which is developing a partnership with a packaging waste management organization. Similar to the operational and maintenance cost criterion, the investment cost criterion is also crucial in choosing a packaging waste management scheme. Through a partnership with a waste management organization, the company does not need to purchase machinery or build additional supporting facilities, thus reducing the investment costs.

Table 14. Weighting of alternatives for criterion 7

	A1	A2	A3	A4	Priority/Average value
A1	0.3158	0.7701	0.3810	0.2727	0.4349
A2	0.0132	0.0321	0.2857	0.0909	0.1055
A3	0.0395	0.0053	0.0476	0.0909	0.0458
A4	0.6316	0.1925	0.2857	0.5455	0.4138
Amount	1.0000	1.0000	1.0000	1.0000	1.0000

The Consistency Ratio value in Table 14 is -0.89, indicating that the data is consistent. In the weighting for Criterion 7, which considers the increased land requirements, the

highest average value is found in alternative 1, which is optimizing packaging design. Considering the criterion of increased land requirements, only alternative 1 requires little to no land expansion, as packaging design optimization can be done within the existing operational area by adjusting the product and packaging design, raw materials, and/or production technology used.

Table 15. Weighting of alternatives for criterion 8

	A1	A2	A3	A4	Priority/ Average value
A1	0.1967	0.5854	0.2308	0.1364	0.2873
A2	0.0164	0.0488	0.0769	0.0455	0.0469
A3	0.3934	0.0732	0.4615	0.5455	0.3684
A4	0.3934	0.2927	0.2308	0.2727	0.2974
Amount	1.0000	1.0000	1.0000	1.0000	1.0000

The Consistency Ratio value for Table 15 is 0.01, indicating consistency. The highest weight value is found in alternative 3, which is developing recycling facilities. This alternative is considered to have the most significant environmental impact. Choosing to build a recycling system allows packaging waste from a product to have a longer lifespan due to the recycling process developed by the company.

Table 16. Weighting of alternatives for criterion 9

	A1	A2	A3	A4	Priority/Average value
A1	0.0952	0.0667	0.1818	0.2353	0.1448
A2	0.7619	0.5333	0.3636	0.4706	0.5324
A3	0.0476	0.1333	0.0909	0.0588	0.0827
A4	0.0952	0.2667	0.3636	0.2353	0.2402
Amount	1.0000	1.0000	1.0000	1.0000	1.0000

The Consistency Ratio value for the data in Table 16 is -1.06, indicating consistency. For Criterion 9, which is adaptation to local conditions, the highest weight value is found in the alternative of the packaging waste collection scheme. According to the informants' perspectives, the packaging waste collection scheme is the easiest to adapt to local conditions and the social and economic circumstances of the community. The post-consumption packaging collection will involve the community and informal sectors in sorting and collecting packaging waste, making this scheme the most adaptive to local conditions. The next step is to calculate the combined weight values for all four proposed EPR scheme alternatives, resulting in the following:

Table 17. Combined weight values for all criteria

Alternative	Weight	Rank
Product design optimization	2.7845	2
Packaging recall	2.1112	3
Development of recycling facilities	1.2765	4
Cooperation with packaging waste management organizations	2.8278	1

From the table above, it is evident that the weighting order for the proposed alternatives for the producer responsibility extension scheme are as follows: Cooperation with packaging waste management organizations, Product design optimization, Packaging take-back, and Recycling facility development. The development of cooperation with the chosen packaging waste management organization does not align with the findings of Mariano (2019), which suggest that the Extended Producer Responsibility (EPR) concept in Indonesia would be more appropriate if it adopted EPR models from developed countries, given that producers would need to incur costs for post-consumer waste management. However, the results of this study are consistent with Ayu et al. (2011) findings, which state that the presence of packaging waste management organizations would facilitate producers in managing their packaging waste. This organization is formed by several producers and

informal sectors that design management strategies, formulate waste collection targets, and develop facilities needed to meet these targets.

Partnerships with waste management organizations not only aid in enhancing post-consumer plastic packaging take-back and recycling efforts, but also ensure the use of more environmentally friendly packaging, while ensuring the sustainability of the raw material supply chain. Within the framework of the Ministry of Environment and Forestry Regulation Number 75 of 2019 on the Roadmap for Waste Reduction by Producers, three elements are involved in the implementation of EPR: producers, the community, and local governments. However, this study only analyzes the producer and community variables, without involving the local government variable. Based on the results of the AHP weighting of alternatives, several post-consumer plastic waste management strategies can be proposed as follows.

In efforts to reduce waste, producers can implement limitations, recycling, and the reuse of post-consumer packaging waste. The implementation stages are not directly carried out by producers, but producers designate waste management service agencies through a cooperation agreement. The forms of partnership include activities such as waste collection, sorting, processing, and reusing post-consumer waste as raw material for production, among others. Through these partnerships, producers can also enhance their communication, information, and education strategies with consumers. Producers need to convey information about the product's raw materials, packaging materials, and EPR-related programs. Campaigns for product packaging take-back programs and the selection of environmentally friendly products can indirectly build a positive image for both the product and its producer. Community participation and the informal sector play a crucial role in the EPR scheme. As consumers, the public needs to increase their understanding of selecting environmentally friendly products, sorting and managing waste properly for recyclability, and choosing accessible waste management services that do not burden consumers.

4. Conclusions

Based on the results obtained in this research, the following conclusions can be drawn: The public supports regulations related to the implementation of producer responsibility and is willing to participate in the execution of the EPR scheme for post-consumer plastic waste management. The informal waste management sector contributes to the implementation of EPR, particularly in the post-consumer plastic waste take-back scheme. Business actors support the expanded producer responsibility policy for post-consumer plastic waste management by establishing partnerships with the informal sector and involving community participation. The recommended producer responsibility extension scheme for post-consumer plastic waste management is a partnership with plastic packaging waste management organizations, involving other informal sectors, and strengthening community participation.

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Biographies of Author

Siti Kardian Pramiati, Environmental Science, School of Environmental Science, Universitas Indonesia, Central Jakarta, Jakarta 10430, Indonesia.

- Email: dhiankui@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A