eLife Cycle Assessment (LCA) of Plastic Products to Support the Sustainable Develepment Goals/SDGS in Indonesia: Literature Review

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Abstract. The low-carbon and circular economy are part of the green economy development in the redesign strategy of Indonesia's economic transformation towards an advanced Indonesia. The concept of life cycle thinking in creating sustainable products is needed to prevent pollution that impacts the environment. Life Cycle Assessment (LCA) can be applied to measure the environmental impact of using raw materials and energy, production processes, and product transportation. Several studies use LCA to analyze the environmental impact of plastic products and plastic recycling in Indonesia. This study uses a descriptive-analytical approach with the Systematic Literature Review (SLR) method. It aims to describe the potential role of LCA studies on plastic products and recycling, to support the achievement of the SDGs in Indonesia. The results of the LCA references review are grouped based on aspects of minimizing the resulting carbon emissions and the use of energy used in producing plastic products, reducing plastic use, replacing plastic use, redesigning or recycling plastic, increasing plastic waste collection, increasing plastic waste recycling capacity, and expanding controlled landfill facilities. The roles of LCA discussed include achieving a low-carbon economy, a circular economy, and reducing plastic waste in the ocean.

Keywords: Life Cycle Assessment (LCA) · Plastic Products in Indonesia · SDGs in Indonesia · Low Carbon Economy · Circular Economy · Reduction of Plastic Waste in the sea

1 Introduction

Indonesia's economic recovery efforts in achieving the target of Indonesia Vision 2045 were delayed due to the Covid-19 pandemic. This effort was carried out by redesigning Indonesia's economic transformation strategy, consisting of (1) human resource development (HR); (2) increasing the productivity of the economic sector; (3) green economy development; (4) accelerating digital transformation; (5) strengthening domestic economic integration; and (6) the relocation of the State Capital (IKN) as a source of new growth and economic balance between regions. The green economy includes a

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low-carbon economy, a circular economy, a blue economy, and energy transition. The sustainable development agenda for the achievement of the SDGs in Indonesia in 2045 includes low-carbon development and climate-resilient development [1].

In Indonesia, the waste management process on land is still ineffective, causing garbage to leak into the sea. To reduce Plastic Waste in the sea, The Indonesian government initiated the National Plastic Action Partnership (NPAP) with the Global Plastic Action Partnership to tackle plastic pollution. NPAP supports national marine plastic waste reduction, which is expected to accelerate progress toward achieving the SDGs (World Economic Forum, 2020). The product of the life cycle consists of raw materials, production processes, machinery/equipment, and product use to waste management causes environmental impacts. Efforts to reduce environmental impact can be carried out by applying the principle of Life Cycle Thinking. Life Cycle Thinking (LCT) and Life Cycle Assessment (LCA) are needed to support sustainable transition decisions in the policy domain [2].

[3] Reviewed the implementation of LCA by examining the objectives and scope of LCA, functional units, impact assessment categories, system boundaries, geographic context and sensitivity and uncertainty analysis. The purpose of this review is to find out the prospect of using LCA in waste management in the future. According to [4], research and publications related to the implementing of LCA in Indonesia are still relatively small. In other hand, several studies related to LCA in Indonesia from 2010 to 2016 have been reviewed by [5] with a research focus on bioenergy, plantations, animal husbandry, aquaculture, waste management, water treatment, and various manufacturing products. Besides that, [6] have also reviewed publications on LCA implementation from 2018 to 2021. The areas reviewed include waste management products, water management, the manufacturing industry, mining, fisheries, and plantations.

LCA also has the potential to support the implementation of EU (European Union) policies and SDGs through a more holistic approach to production and consumption along the value chain [7]. In line with this, the potential for LCA support for plastic products in Indonesia can also support the achievement of the SDGs in Indonesia through the implementation of a low-carbon economy, a circular economy, and the reduction of plastic waste in the sea. This study intend to describe the potential role of LCA studies in achieving Indonesia's SDGs, especially in developing sustainable plastic products, based on examples of exploration results in the literature reviewed.

2 Methods

This research uses a descriptive analysis approach and applies the Systematic Literature Review (SLR) method, through a review and analysis of literature from published research, in the form of journals, proceedings, and graduation thesis related to the Life Cycle Assessment (LCA) of plastic products in Indonesia. The literature used comes from searches on the Scopus database, Google Scholar, Semantic Scholar, Google Search, and the document-sharing platform https://123dok.com. Therefore, this study did not explore the Company Performance Rating Program (PROPER) results. The period of the literature used is from 2012 to 2022. The search was carried out from the beginning of June to the second week of August 2022.

Literature screening was carried out using the following keywords: “Plastic Life Cycle Assessment”, “LCA Plastik”, “Life Cycle Assessment Plastik”, “Penilaian Daur Hidup”, “Life Cycle Assessment di Indonesia”, “Life Cycle Assessment Polystyrene”, “Life Cycle Assessment Polyethylene”, “Life Cycle Assessment Polyester”, “Life Cycle Assessment Polypropylene”, “Life Cycle Assessment Bahan Plastik”, and “Plastic Life Cycle Assessment and Sustainability Development Goals in Indonesia”. The number of literature in the Scopus database is 12, Google Scholar is 284, Semantic Scholar is 130, Google Search is 272, and searches on the 123dok.com platform are 132.

Furthermore, the identified literature is filtered by removing documents that do not research the Life Cycle Assessment (LCA) of plastic products in Indonesia. So that the number of literature filtered into the Scopus database is 4, Google Scholar is 32, Semantic Scholar is 7, Google searches (Google Search) is 16, and searches on the 123dok.com platform are 2. Filtering with the keywords “Plastic Life Cycle Assessment and Sustainability Development Goals in Indonesia” did not get results. The results of filtering the database obtained the same literature, so the total literature that will review is 27 kinds of literature. The literature that is used as a reference is as follows.

NPAP has established 5 (five) System Change Scenarios (SCS) to reduce the leakage of plastic flows into the sea, which are: (1) reducing or replacing the use of plastic; (2) redesigning plastic products and plastic packaging so that they can be reused or recycled with high value; (3) double the collection of plastic waste; (4) double the current recycling capacity; and (5) construct or expand controlled landfill facilities [8].

3 Results and Discussion

3.1 Results

The Relationship between the Results Review and the Aspects of the Review

The results of the LCA references review are grouped into 7 (seven) aspects, that are: (1) minimizing the resulting carbon emissions and the use of energy used in producing plastic products; (2) reducing plastic use; (3) replacing plastic use; (4) redesigning or recycling plastic; (5) increasing plastic waste collection; (6) increasing plastic waste recycling capacity; and (7) expanding controlled landfill facilities. An overview of the relationship between the results of the review and the aspects being reviewed is shows in Table 2.

Table 2. The Relationship between the Results Review and the Aspects of the Review.

Description:

1	:	Minimizing the resulting carbon emissions and the use of energy used in producing plastic products	5	:	Increasing plastic waste collection
2	:	Reducing plastic use	6	:	Increasing plastic waste recycling capacity
3	:	Replacing plastic use	7	:	Expanding controlled landfill facilities
4	:	Redesigning or recycling plastic			

Table 1. Literature Review

No	Year	Example	Font size and style
1	2022	Amiruddin, Inoue & Grause	The Analytical Hierarchy Process (AHP) is used to complement the results of the technology evaluation with the Life Cycle Assessment approach in the management of PET bottle waste
2	2022	Sutanto & Rumende	Life Cycle Assessment of Plastic Components in the Production of Automotive Filter
3	2021	Neo, Soo, Tan, Cady, Tong, & Low	Life Cycle Assessment of Plastic Waste End-of-Life for India and Indonesia
4	2021	Christy	Life Cycle Assessment of raw plastic grain products
5	2020	Irzalinda & Ardi	Life Cycle Assessment on flexible plastic packaging
6	2020	Rosmiati & Hadiyanto	Life Cycle Assessment and energy efficiency from an industry of plastic waste recycling
7	2020	Ningrum, Afiuddin & Ramadani	Life Cycle Assessment on extruder process
8	2020	Tirto	Life Cycle Assessment on plastic waste processing in the manufacture of eco-bricks
9	2020	Tiogana	Plastic Waste Life Cycle Assessment in Jakarta
10	2019	Haryanto & Cahyani	Life Cycle Assessment on household plastic biogas digester
11	2019	Khairona	Life Cycle Assessment in the polystyrene cup manufacturing process
12	2019	Evangelista	Life Cycle Assessment of bottled water production process
13	2019	Ibnu	Life Cycle Assessment and eco-efficiency for Polyethylene Terephthalate (PET) drinking bottle production process
14	2019	Intan & Santosa	Life Cycle Assessment of bricks made from the waste of building material and plastics (LDPE and PET)
15	2018	Abidin, Nathania & Trirahayu	Life Cycle Assessment on shopping bags made from recycled plastic, goodie bags, and bioplastics

(*continued*)

Table 1. (*continued*)

No	Year	Example	Font size and style
16	2018	Guntur Noya	Life Cycle Assessment on packaging products made from polystyrene foam
17	2018	Mutiara	Lean thinking and Life Cycle Assessment in backsheet diapers products
18	2018	Laurance & Kasena	Life Cycle Assessment on the battery container
19	2017	llhamdika	Life Cycle Assessment on plastic recycling
20	2017	Sirait	Life Cycle Assessment for evaluation of energy use and CO_2 gas emissions in the plastic waste recycling supply chain
21	2017	Saputra & Hanafi	The importance of data quality in using Life Cycle Assessment: comparative case study between injection molding machines in processing poly propylene
22	2015	Hidayat, Tama & Kusuma	Life Cycle Assessment in the plastic bag production process
23	2015	Utami	Life Cycle Assessment on polyester yarn production
24	2013	Pujadi & Yola	Life Cycle Assessment for sustainability packaging analysis
25	2013	Yani, Warsiki & Wulandari	Life Cycle Assessment on PET (Polyethylene Terephthalate) bottle products
26	2013	Hartini &Oktafiano	Life Cycle Assessment to reduce the environmental impact of toothbrush products
27	2013	Sari	Life Cycle Assessment for selection of materials and processes in plastic container products

Source: Literature Search by the Author

Discussion of 7 (seven) Aspects to Review to Support the Redesign Strategy for the Achievemnet of SDGs in Indonesia

Aspects of Minimizing the Resulting Carbon Emissions and The Use of Energy Used in Producing Plastic Products. The entire literatures reviewed have the objective of LCA analysis related to CO2 emission calculations, analysis and interpretation of the environmental impact of the life cycle of plastic products in Indonesia. The results of the LCA analysis recommend the need for minimizing carbon emissions and efficient use of energy. Recommendations from the results of the review are divided into 4 (four) categories, that are minimizing carbon emissions [9]; efficiency of energy use [10–14],

Table 2. The Relationship between the Results Review and the Aspects of the Review.

Literature	Aspect						
	1	2	3	4	5	6	7
(Amirudin, Inoue & Grause, 2022)				v			
(Sutanto & Rumede, 2022)	v			v			
Neo, Soo, Tan, Cady, Tong & Low, 2021)	v					v	v
(Christy, 2021)	v						
(Irzalinda & Ardi, 2020)	v		v				
(Rosmiati & Hadiyanto, 2020)	v					v	
(Ningrum, Afiuddin & Ramadani, 2020)	v		v	v			
(Tirto, 2020)	v				v		
(Tiogana, 2020)	v						v
(Haryanto & Cahyani, 2019)	v						
(Khairona, 2019)	v		v				
(Evangelista, 2019)	v						
(Ibnu, 2019)	v			v			
(Intan & Santosa, 2019)	v						
(Abidin, Nathania & Trirahayu, 2018)	v			v			
(Guntur & Noya, 2018)	v				v	v	v
(Mutiara, 2018)	v						
(Laurance & Kasena, 2018)	v						
(Ilhamdika, 2017)	v						
(Sirait, 2017)	v						
(Saputra & Hanafi, 2017)	v						
(Hidayat, Tama & Kusuma, 2015)	v			v			
(Utamim, 2020)	v						
(Pujadi & Yola, 2013)	v	v					
(Yani, Warsiki & Wulandari, 2013)	v					v	
(Hartini & Oktafiano, 2013)	v	v					
(Sari, 2013)	v			v			

Source: processed by the author

minimizing carbon emissions and energy efficiency [15–21], and minimizing GHG by implementing plastic products from other activities. [22].

The impact of open burning of plastic waste on GHG and health is shown in the case of the condition of plastic waste in final disposal [23] and the illegal burning of plastic waste [24]. The environmental impact of the production process of various types of plastics such as: Low-Density Polyethylene (LDPE) [9, 15, 22, 25]; Linear Low-Density Polyethylene (LLDPE) [17, 26]; Polyvinyl Chloride (PVC) [22]; High-Density Polyethylene (HDPE) [16, 18–20, 27, 28]; Polypropylene (PP) [29, 30]; [21]; Polyethylene (PE) [11, 12]; Polystyrene (PS) [30–32]; plastic waste [24, 33]; PET [9, 26, 27, 34]; pellet material [10]; bioplastic [19]; Polypropylene (original resin) and Polypropylene (recycle) [13]; and Polyester. [14].

The impact of energy use and transportation is shown in: pellet production [10, 15, 18]; raw materials and seeds [11, 12]; sheet plastic bag products [20]; PET bottle products [34]; and the use of electrical energy, diesel oil, and gasoline [14].

The environmental impact and magnitude of carbon emissions from the use of tools are shown in the case of thermoforming and injection [16, 31]; extruder [17, 25]; heating cooling cutting [11, 12]; packaging [11]; pressing and cutting [31]; ring spinning yarn [14]; and HVAC systems [27].

Comparison of the environmental impact of the production process of several types of plastic is shown in the case of PET, LLDPE, and Al [26]; Polypropylene (PP), Low-Density Polyethylene (LDPE), and High-Density Polyethylene (HDPE) [16](Sari, 2013); PET with glass [34]; polystyrene with wood waste [28]; HDPE (recycled), polypropylene spunbond (goodie bag) and bioplastics [19].

The role of using plastic for a certain period can reduce the impact of GHG emissions is shown in the case of household biogas digesters [22], as well as the need for life cycle thinking in policy making [17].In the application of LCA, the importance of data quality as a decision support tool [29].

Aspects of Reducing Plastic Use. There are 2 (two) studies describe efforts to reduce the use of plastics by replacing them with non-plastic materials, as described in the paragraph below. LCA analysis comparing toothbrush handle products from polystyrene and wood waste. The result is conclusion that it can reduce eco-costs per year is quite significant [28]. LCA analysis of packaging products made from polystyrene, polypropylene, and paper resulted in the conclusion that paper is more environmentally friendly than other products [30].

Aspects of Replacing Plastic Use. There are 3 (three) studies that describe efforts to replace the use of plastic with other plastic materials, as described below. The environmental impact of the extruder process for making plastic sacks has a significant impact on ozone. Recommendations for reducing impact by replacing polypropylene with polylactic acid and recycling the resulting plastic waste [25]. The use of polystyrene in the extraction of raw materials and the cup-making process has a significant environmental impact. Impact reduction recommendations are made by replacing polystyrene with PVC [31]. Comparison of the environmental impact of 2 flexible plastic packaging materials shows that plastic packaging made of OPP/CPP/Al has a lower impact value than PET/LLDPE/Al [26].

Aspects of Redesigning or Recycling Plastics. There are 5 (five) studies that propose redesign, consisting of 2 (two) studies redesigning the production process made from plastic. In addition, there are 3 (three) studies that propose the recycling of plastic products.

Redesign of the production of mineral water bottles made from Polyethylene Terephthalate (PET) to reduce energy consumption and costs, carried out with a centralized chiller. Eco-efficiency approach gives a ratio of 50.3%, and experimental results showed there was a decrease of 38% [27] Environmental impact reduction is carried out by using more environmentally friendly raw materials, adding fans and air conditioners, using masks, implementing environmental management, and replacing transportation equipment with larger capacities [20]. The research proposes recycling by selecting materials (making containers) that can be recycled based on Eco Indicator 99 data [16]. The LCA analysis of the extruder process for making plastic bags made of polypropylene recommends replacing polypropylene with polylactic acid and recycling the resulting plastic waste [25]. AHP analysis was used to complete the LCA results for PET production. The best option to reduce the impact of PET production is recycling [35].

In addition, there are 2 (two) studies that propose the redesign and recycling of plastics, as described in the following paragraph. The results of LCA's research on automotive filter products made from Low-Density Polyethylene (LDPE) propose to change the capacity of transport trucks, raw materials, production machines, and recycling of raw materials [15]. The results of the LCA analysis of shopping bag products show that recycled plastic (HDPE) is more environmentally friendly than polypropylene spunbond (goodie bags) and bioplastics. Recommendations from the results of this study, it is necessary to redesign shopping bag products with recycled plastic materials [19].

Aspects of Increasing Plastic Waste Collection. There are 2 (two) studies describe efforts to increase plastic waste collection, as described below. The LCA analysis of the production process for packaging made from polystyrene foam found potential environmental impacts at the production, extraction, and disposal stages. A recommendation for improvement is the procurement of polystyrene foam waste collection [32]. On the other hand, [33]stated that plastic waste needs to be collected and used as an eco-brick.

Aspects of Increasing Plastic Waste Recycling Capacity. There are 5 (five) studies illustrate the need to increase plastic waste recycling capacity. From the results of research on packaging products made from polystyrene foam, for the disposal stage, it is recommended to apply open-loop recycling and increase the recycling capacity [32]. In the LCA sensitivity analysis of plastic waste in Indonesia, it is found that a large number of plastic rejects from recycling activities increases the amount of unmanaged plastic waste. So, increasing the recycling capacity is the right step to reduce the amount of unmanaged plastic waste [23].

Efforts to reduce the amount of plastic waste can be supported by increasing the recycling capacity of plastic waste [18]. Enlarging plastic recycling capacity is also demonstrated by utilizing PET and LDPE plastic waste mixed with construction waste to manufacture low-carbon bricks [9]. The economic value of recycling encourages expanding plastic waste recycling activities [34].

Aspects of Expanding Controlled Landfill Facilities. There are 3 (three) studies describe efforts to expand controlled final disposal facilities, as described in the paragraph below.

Currently, the amount of plastic waste that Jakarta does not manage correctly is 72%. If plastic waste in the landfill and not transported can be reduced by 30%, the impact on the environment of each category will be reduced by ± 56% [24]. An analysis of the EOL Hotspot Treatment in Indonesia shows that the open burning of plastic waste has a significant impact on GHG. That landfill is a major contributor to the toxic effects of marine ecosystems. Investment in mechanical recycling will help reduce unmanaged plastic waste and carbon emissions [23]. One of the recommendations from the impact analysis of packaging products made from polystyrene foam which is challenging to decompose naturally is combustion with a special incinerator. [32].

3.2 Discussion

The Role Life Cycle Assessment (LCA) in the Achievement of the SDGs Strategy

The findings of these 7 (seven) aspects become the basis for interpretation and justification of the role of LCA in achieving the SDGs, especially in the implementation: (1) a low-carbon economy, (2) a circular economy, and (3) a strategy to reduce the leakage of plastic waste into the sea. The relationship between Life Cycle Assessment of Plastic Products to Support SDGs can be seen in Fig. 1

The Role of LCA in Achieving a Low-Carbon Economy. (Sala, Amadel, Beyloet, & Ardente, 2021) Have explored the evolution and implementation of life cycle concepts and approaches to policy in the European Union. The conclusion is that the European Union has pioneered implementing Life Cycle Thinking/Life Cycle Assessment in the policy. However, its implementation still requires further study to support decisions holistically in support of a sustainable transition. The implementation of low-carbon and climate-resilient development in the sustainable development agenda is expected to reduce emissions, emission intensity, and potential loss of GDP (Gross Domestic Product).[1].

Various studies on low-emission products have been carried out, such as Polylactic Acid (PLA), which can absorb CO2 in the production process, so it is expected to become a low-carbon material [36]. Then [37] reviewed LCA studies for bioplastics, with several recommendations, namely implementing biogenic carbon storage credits. Research on consumer behaviour using kitchen utensils made of plastic produces recommendations

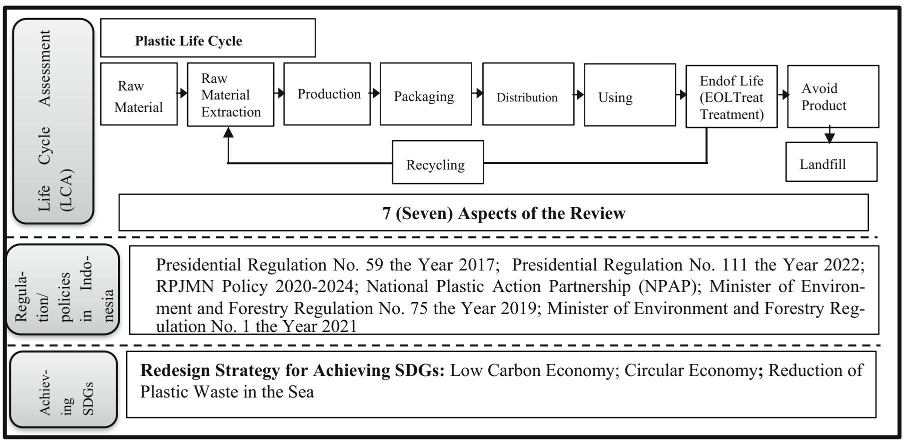

Fig. 1. Relationship between Life Cycle Assessment of Plastic Products to Support SDGs. Source: processed by the author

on the need to reduce the consumption of plastic types to reduce the impact of GHG emissions [38].

Measurement of carbon emissions is needed to determine the environmental impact on low-carbon economic development. One way to measure carbon emissions can be done using Life Cycle Assessment (LCA). From the measurement results, products with lower carbon emissions can be selected. The role of Life Cycle Assessment (LCA) in the aspect of the emission reduction and energy efficiency discussed in the literature includes 4 (four) categories, that is minimizing carbon emissions, energy efficiency, minimizing carbon emissions and energy efficiency, and using plastic products in reducing emissions in other activities.

Data on the number of carbon emissions from the results of the LCA analysis are useful for showing the magnitude of the impact of various activities: (1) landfilling plastic waste, (2) burning open plastic waste, (3) conditions of the production process, (4) energy use, (5) transportation, and (6) use of tools. In addition, it can show a comparison of the environmental impact of the production process between types of plastic, and the role of plastic use in other activities at a particular time.

LCA assessment on the resulting product is a must for companies holding PROPER by the Minister of Environment and Forestry Regulation No. 1 of 2021 article 16 paragraph 2. With this PROPER, companies can encourage their entire supply chain to be sustainable and encourage the achievement of SDGs 12 and 13.

The Role of LCA in Achieving a Circular Economy and Reducing Plastic Waste in the Sea. A circular economy is an economical approach that takes the benefits of recycling waste into resources through technological feedback mechanisms, natural ecosystems, and resource stocks that increase over time. LCA can show environmental, social, and economic impacts of circular economy activities. In addition, LCA can provide insight into trade-offs such as water use, energy, carbon, material use, and recycled content, and can be a verifier in realizing a sustainable economy [39, 40].

Primary recycling is closed-loop recycling, where a plastic waste product is recycled back into the same product. Secondary recycling is open-loop recycling, where plastic waste is downcycled into other products. This primary and secondary recycling occurs through mechanical recycling [23]. [41] Suggested that LCA results in mechanical recycling will produce lower emissions than virgin plastic. The choice of using recycled plastic materials is preferred if the use of recycled materials can replace virgin plastic by at least 70–80%. The research [42] concludes that the optimal environmental performance of recycling is obtained by pre-treatment (sorting, cleaning), which is also adapted to the recycling technology used.

To support the goal of the 12 SDGs, responsible consumption and production, the Ministry of Environment and Forestry has issued a regulation on producer obligations in waste reduction through Minister of Environment and Forestry Regulation No. 75 of 2019. The regulation explains that reducing product packaging waste can be made through the restriction, recycling and reuse of waste. This regulation can support the System Change Scenario (SCS) set by NPAP.

The role of LCA in supporting the development of a circular economy is discussed in the following paragraph. Efforts to replace plastic with other plastic materials are carried out by choosing raw materials with a lower carbon emission impact value. In addition, efforts to recycle plastic products can be made by redesigning the production process and the product itself. The redesign of the production process is carried out on production machines, recycling machines, and modes of transportation. Meanwhile, product redesign is done by replacing raw materials. By recycling products, there is an opportunity to extend the product life cycle and become the object of a circular economy.

Furthermore, efforts are needed to increase the collection of plastic waste by increasing the collection of waste and utilization of plastic waste in other products. To increase the recycling capacity of plastic waste, it can be made by implementing open-loop recycling for packaging products made from polystyrene. In addition, it can do by making products from plastic waste mixed with other types of waste. The economic value of recycling encourages the expansion of plastic waste recycling activities and contributes to developing a circular economy.

The role of LCA in supporting the strategy to reduce the leakage of plastic waste into the sea is discussed in the following paragraph. In the long term, reducing the release of micro plastics into the environment during production, consumption, and disposal can be done through improved product design. In addition, integrated waste management is needed based on international cooperation in handling marine plastic waste [43]. [44] Has researched the application of eco-design and LCA in systemic decision-making, for redesigning frozen food packaging from small and medium business products. The atudy's results concluded that integrated decision-making at the design stage would benefit a sustainable supply chain, better recycling, and lower energy consumption. It will further reduce the use of plastic and prevent marine pollution.

Efforts to replace the use of plastic materials with non-plastic materials are carried out by applying the principles of eco-cost and environmentally friendly. Reducing the use of plastic materials allows plastic circulating in the terrestrial to reduce, which will impact reducing plastic waste in the sea. Reducing plastic waste on and preventing plastic waste leakage of plastic waste into the sea is carried out by recycling and redesigning plastic products. Increasing plastic waste collection and recycling capacity waste is beneficial in reducing unmanaged plastic waste so that it does not leak into the sea.

The final disposal of controlled plastic waste needs to be expanded, so that plastic waste in landfills and not transported plastic waste can be reduced. One of the steps taken is an investment in mechanical recycling. Handling the final disposal of certain plastic waste materials (e.g., polystyrene foam) can be done by burning them in special incinerators.

From the paragraphs above, it can be concluded that the LCA study plays a role in justifying the sustainability of the circular economy and supporting the reduction of plastic waste in the sea. So that goals 12 and 13 of the SDGs in Indonesia can be achieved.

4 Conclusion

The role of LCA in achieving SDGs related to the management of plastic products includes the role of identification and analysis: (1) low-carbon plastic products, (2) sustainable plastic products, and (3) implementation of strategies to reduce plastic waste in the ocean. Identification and analysis of low-carbon plastic products include measuring the impact of carbon emissions on the plastic life cycle so that the product with the lowest emission impact can be selected.

The discussion of circular economy objects in the literature review includes: (1) replacing the use of plastic with other plastic materials, (2) redesigning and recycling plastic products, (3) increasing the collection of plastic waste, (4) utilizing plastic waste into other products, and (5) increase the recycling capacity of plastic waste. In this study, the discussion on the role of LCA in the circular economy is limited to the trade-offs of resource use related to (1) the environmental impact of the application of recycled plastic product percentage content, (2) reducing the use of single-use plastic products with alternative materials in their life cycle and (3) load efficiency and transport distance.

Meanwhile, the role of LCA in formulating a strategy for reducing plastic waste at sea is carried out by identifying weaknesses and good practices in managing plastic waste on land. Examples of leakage prevention in the literature reviewed include: (1) measures to reduce plastic use, (2) efforts to recycle and redesign plastic products, (3) multiply collections, (4) increase recycling capacity, and (5) expansion of premises controlled final disposal of plastic waste. These results show that the LCA study of plastic products is sufficient to provide a detailed description of the role of the LCA in supporting the achievement of the SDGs in Indonesia.

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