Jurnal Presipitasi
Media Komunikasi dan Pengembangan Teknik Lingkungan
e-ISSN: 2550-0023

Vol 21, No 1, 2024, 1-11
Article available at homepage presipitasi

Review Article

The Effectiveness of Using Eco-Friendly Bag to Support Sustainable Development Goals: A Review

Annisa Indah Pratiwi[1]*, Nadia Rizki Ariyani[1], Chintya Komala Sari[1], Abdul Rahman[1]
[1]Research Centre for Sustainable Production System and Life Cycle Assessment - National Research and Innovation Agency (BRIN)
* Corresponding Author, email: annisa.indah.pratiwi@brin.go.id

Abstract
Nowadays, most people use eco-friendly bags as alternatives to plastic grocery bags. This comes from the government's strategy of prohibiting plastic bag use and requiring the use of eco-friendly supermarket bags instead. Eco-friendly bags are the most recent developments in supermarket bags made from environmentally friendly raw materials. However, using eco-friendly bags is not the ideal option because it generates new trash clusters as a result of their use and contributes to the impact of climate change. This article examines the effectiveness of using eco-friendly bags in reducing plastic waste and how it relates to SDG 13. This research uses qualitative methods related to analysing the environmental impact of environmentally friendly bags. It was found that bio-based plastics had the lowest GWP values. Several solutions to the problem of plastic bag pollution have been offered, including the development of new biodegradable bag technology, making policies or other incentives encouraging people to reuse shopping bags, and researching eco-friendly bag innovation in Indonesia using LCA.

Keywords: Eco-friendly bags; environment; sustainable development goals; climate change

1. Introduction

Plastic is described as a substance made up of macromolecules known as polymers (Wijayanti et al., 2016). Generally, plastic materials are often found in various sectors. According to Balwada et al. (2021), the packaging industry consumes the most plastic, contributing for 35-40% of total consumption and producing 59% of waste landfill. The plastic grocery bag is one of the packaging sectors analysed in this research. Based on data compiled from the Ministry of Environment's National Waste Management Information System on the composition of national waste in 2021, plastic waste is the second largest type of waste after food waste, where the waste amount produced is 30,881,803.15 tons per year, with plastic waste representing for 17.7% of total waste output in Indonesia (Ministry of Environment, 2021). Despite the numerous advantages that customers and producers recognize, plastic grocery bags have an environmental impact from raw material extraction to manufacturing and trash disposal (during their life cycle) (Li et al., 2022). In addition, Indonesia is ranked second as a contributor to plastic waste in the ocean, reaching 187.2 million tons after China in 2015 (Jambeck et al., 2015).

In early 2019, the Indonesian government launched the National Plastic Action Partnership (NPAP) in collaboration with the Global Plastic Action Partnership to take action on plastic pollution. NPAP supports Indonesia's National Action Plan on marine waste management, Indonesia's National Waste Management Policy and Strategy and efforts towards achieving national marine plastic waste reduction. There are several combinations of system scenarios created by System Change Scenario (SCS) to achieve the target of reducing plastic leakage by 70%, namely: 1) reduce or replace plastic use, 2) redesign plastic products and packaging, 3) double plastic waste collection, 4) double capacity existing recycling, and 5) create or expand controlled waste disposal facilities to handle an additional 3.3 million tonnes of plastic trash per year by 2025 (World Economic Forum, 2020).

One of the system scenarios created by SCS that has already started to be implemented is by reducing or replacing plastic waste usage. This is evidenced by the issuance of regulations in some regions regarding the ban on the use of single-use plastic bags in many traditional markets, supermarkets, and shopping centres. People are obliged to replace plastic grocery bags with eco-friendly shopping bags. Eco-friendly shopping bags are reusable shopping bags made of any material, including dry leaves, paper, cloth, polyester and its derivatives, as well as recycled materials, that have suitable thickness, can be recycled, and are intended to be used repeatedly (Governor of DKI Jakarta Province, 2019).

One crucial aspect of the numerous eco-friendly bag innovations that have started to appear is constantly overlooked, namely the environmental impact brought on by the manufacturing of these products. Research regarding the impact of environmentally friendly shopping bags on the environment in Indonesia is still limited. Abidin et al. (2018) have carried out a life cycle assessment on recycled plastic, goodie bags (cloth bags), and bioplastic and found that the selection of environmentally friendly shopping bags needs to be seen from various aspects, including material, production process, product distribution and storage, length of use of the product, and recycling or disposal. Therefore, it is necessary to review articles related to research on the impact of shopping bags on the environment that has been carried out in several countries, readjusting them to the most frequently used bags and the right materials to support the accelerated implementation of SDG number 13 in Indonesia. The eco-friendly bags that will be compared include bioplastic, paper, polypropylene, polyester, jute, biopolymer, nylon, cotton, etc. The examples of eco-friendly bags are shown in Figure 2. The examples of eco-friendly bags are shown in Figure 2. Using the right eco-friendly bag will help support the achievement of SDGs target number 13 regarding climate change. SDG 13.2 aims to integrate climate change mitigation activities into national policies, strategies, and planning (Ministry of National Development Planning/Bappenas, 2017).

2. Methods

This study was conducted with a qualitative research method based on document studies that are mostly carried out in the Web of Science (WoS) and Scopus database. The authors opt for the keywords about "life cycle assessment", "eco-friendly bag", "sustainability", "environment impact", and the combination of the two words which were written in the recent ten years (2012-2022). Aside from that, a comparison of the Life Cycle Assessment (LCA) for all sorts of eco-friendly bags in the globe, in terms of environmental impact, materials, and frequency of using eco-friendly bags, is the focus in selecting articles.

3. Result and Discussion

The initial results from scientific research search based on specified keywords, obtained 27 articles explaining about eco-friendly bags from around the world. However, not all eco-friendly bags are acceptable for use in Indonesia, due to a lack of production resources. So, the search had to be narrowed down again, and the final results were 20 articles.

3.1 Material and Environmental Impact Comparison of Eco-Friendly Bag

After searching for articles with keywords about "life cycle assessment", "eco-friendly bag", "sustainability", "environment impact", and the combination of the two words used, several materials were found that had been discussed in previous studies. Figure 1, as seen below, is a summary of the frequency of grocery bag materials, including eco-friendly bags. The types of materials that are most often studied are HDPE, bioplastic (BBP), and paper. Meanwhile, research on jute, oxo-biodegradable, biopolymer, nylon, cardboard boxes, and rucksack materials is still limited considering their infrequent use.

After recording the frequency of eco-friendly bag materials that have been studied, the analysis is adjusted to the eco-friendly bags that are commonly used in Indonesia. The eco-friendly bags discussed consisted of five materials, including cotton, paper, bioplastic (BBP), polypropylene (PP), and polyester as shown in Figure 2. An explanation of the material, manufacturing process, and environmental impact of each eco-friendly bag is as follows.

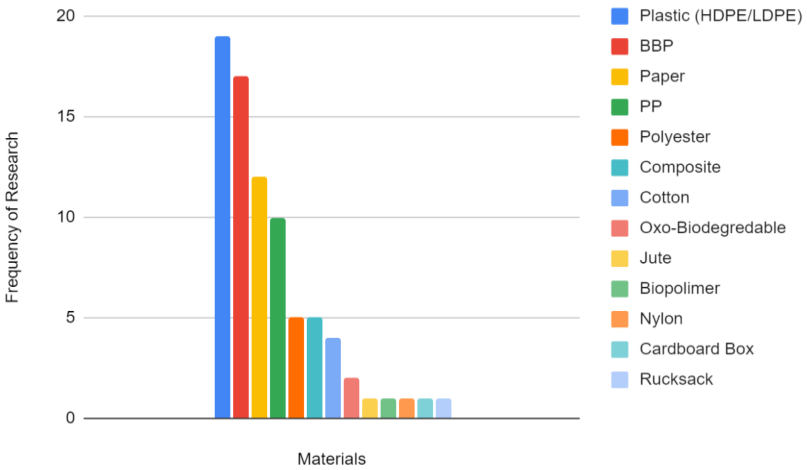

Figure 1. Frequency of research related to grocery bag materials

Figure 2. The eco-friendly bags that are commonly used in Indonesia, (a) Cotton bag, (b) paper bag, (c) bioplastic bag, (d) polypropylene bag, (e) polyester bag

3.1.1 Paper

Paper bags consist of unbleached and bleached paper bags (The Danish Environmental Protection Agency, 2018). Paper bags are created from pulpwood, a sustainable resource from trees. They may be recycled to create corrugated cardboard and are biodegradable (Pitawala et al., 2022). However, obtaining pulpwood necessitates the removal of trees, which affects animal homes and ecosystems.

Making pulpwood requires a lot of energy because the machinery needs to be powered by coal, natural gas, or electricity. When the energy and water from the cradle to the gate are considered, it is discovered that the water of paper requires 300 L per kilogram of fibre. In contrast, the energy consumption consumes 21.6 MJ per kilogram of fiber (Muthu and Li, 2014).

Li et al. (2022) comparing alternatives to plastic bags, stated that paper bags have key advantages, including being compostable and reducing the environmental damage brought on by burning crops. However, paper bags also have limitations, including increasing energy usage and bleaching-related chlorine effluent. Muthu and Li (2014) described the manufacturing scheme in Figure 3.

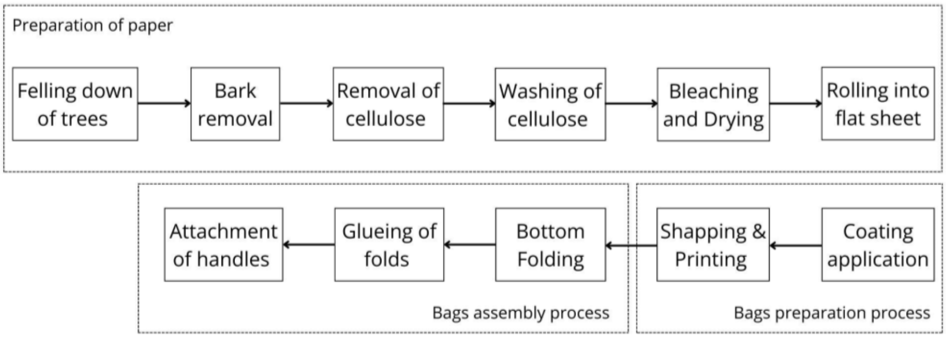

Figure 3. The paper manufacturing process
Source: (Muthu and Li, 2014)

Most of the LCA research on paper bags refers to 1-time use, given its lightweight, not waterproof, and easy to tear. Based on the LCA study by Civancik-Uslu et al. (2019) with the research object of supermarket bags in Spain, paper bags have the highest abiotic resource depletion, global warming potential, and eutrophication potential values compared to HDPE bags, LDPE bags, PP bags, and biodegradable bags. Civancik-Uslu et al. (2019) use GaBi software in LCA calculations assuming the paper bag material used is 100% recycled, and the limit system is cradle-to-grave. In addition, Kimmel et al. (2014) in his paper also states that although the composition of 100% recycled, easy to recycle, and comes from renewable sources, paper bags have a significant impact on the environment compared to reusable bags.

Other studies were also conducted by Ahamed et al. (2021) using the 'CML 2001eJan 2016' method version with GaBi software and a cradle-to-grave limit system related to single-use kraft paper bags in Singapore. In his research, single-use kraft paper bags have dominant values on global warming potential (including and excluding biogenic carbon. Following a survey, the existing supply of paper bags comes from cutting down trees, which harms both plants and animals and requires energy from coal or natural gas during production, as mentioned by Pitawala et al. (2022).

This is in contrast to the findings of Stafford et al. (2022), who analyzed brown kraft paper bags in South Africa using SimaPro LCA Software v 9.0 and The ReCiPe 2016 (H) as an impact assessment method. The study's discovery that the imported biodegradable plastic and the paper bag among single-use bags both had less impact on the environment than HDPE and LDPE bags is remarkable. This is largely explicable by the negative environmental effects of South African plastic production using the coal-to-liquids method (Fischer–Tropsch Synthesis). According to the findings of Anwar et al. (2020), plastic shopping bags have a higher potential to cause global warming than unbleached paper grocery bags. The primary factor causing this effect is the amount of electricity used during the manufacture and the production phase.

3.1.2 Cotton

Cotton bags (tote bags or canvas bags) are an alternative to plastic which are generally used by many people. Cotton, a significant commercial crop, is a major source of natural fiber (Zhang et al., 2021). Generally, cotton has higher tensile strength than HDPE and is biodegradable (Ahamed et al., 2021).

According to The Danish Environmental Protection Agency (2018), there are two types of cotton, conventional and organic. Grocery bags are often made from conventional cotton fibers.

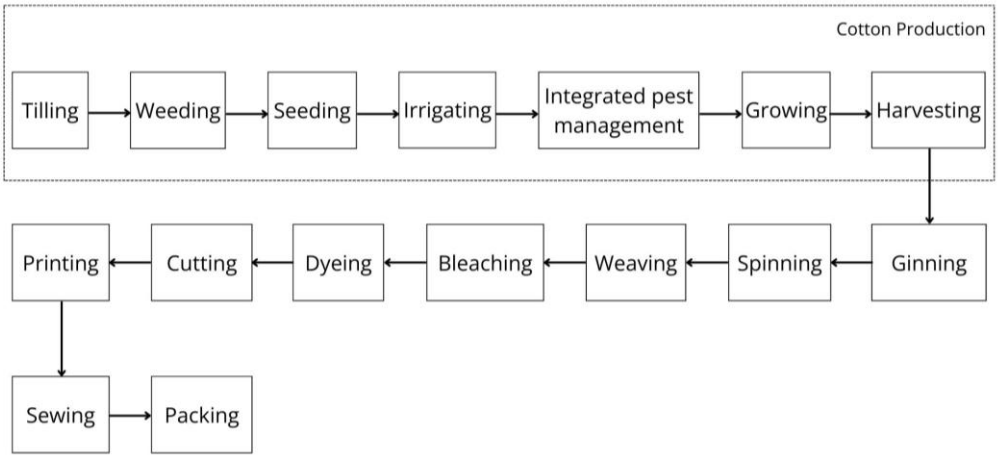

Figure 4. Cotton bag manufacturing process
Source: The Danish Environmental Protection Agency (2018) and Zhang et al. (2021)

Cotton cultivation has a huge environmental effect due to the effective use of water, fertilizer, and chemicals (Zhang et al., 2021). When the energy and water, from the cradle to the gate are considered, it is discovered that the water demand from cotton bags exceeds 680 times per kilogram of fiber production (Ahamed et al., 2021). Conventional cotton fiber requires 22,000 kg of water per kilogram of fiber production, whereas organic cotton requires 24,000 kg of water per kilogram of fiber production (Muthu and Li, 2014). This is because water is the main requirement of agriculturally sourced products. For energy consumption, organic cotton consumes 54 MJ per kilogram of fiber and conventional cotton consumes 60 MJ per kg of fiber (Muthu and Li, 2014).

The type of textile bag material is reused lots of times in order to reduce their environmental impact, organic cotton is reused as a waste bin bag 149 times to minimize less impact on climate change. Similar to conventional to minimize less impact on climate change, conventional cotton bags were reused as waste bin bags 52 times (The Danish Environmental Protection Agency, 2018). Based on The Danish Environmental Protection Agency (2018), the limit used in analyzing LCA cotton bags is from the cradle to the grave, where all steps from production material, manufacturing, distribution to end of life, and all environmental impacts are calculated. Mostly the data needed use the ecoinvent database version 3.4, EASETECH, and literature review. In this paper, two end-of-life (EOL) scenarios were made for cotton bags, namely EOL 1 (incineration) and EOL 3 (reuse as a waste bin bag before being incinerated). The results of climate change from EOL 1 are cotton organic 1.1E+01 kg CO_2 eq and conventional 3.9E+00 kg CO_2 eq. For EOL 3, the values of climate change are cotton organic 1.1E+01 kg CO_2 eq and conventional 3.8E+00 kg CO_2 eq.

Cotton bags have a high potential environmental impact if compared with plastic bag HDPE, especially at the cotton production stage. So, it is necessary to reconsider using cotton bags as an alternative to plastic bags (Muthu et al., 2012). Compared to HDPE, the GWP value from the cotton bag production process is higher.

3.1.3 Bioplastic (BBP)

Bioplastic or Bio-based plastics can significantly reduce dependence on fossil fuels and the environmental impact resulting from the production process (Kaewphan and Gheewala, 2013). BBP are produced from agricultural feedstock (natural resources), such as vegetable oil, starch, corn, potatoes, cellulose, sugarcane, and others (Abidin et al., 2018; Rattana and Gheewala, 2019). Starch-based bioplastics are the most widely used in Indonesia because of their low CO_2 emission and ease of decomposition by microorganisms (Wahyuningtiyas and Suryanto, 2018). Apart from that, the biomass is easy to get. One of the most starchy biomasses is cassava, which allows starch from cassava to be used as raw material for making plastics (Wahyuningtyas and Suryanto, 2017), apart according to Wahyuningtiyas & Suryanto (2018), Indonesia is the third largest cassava producing country in the world with an average production of 23.90 million tons.

While in Thailand, Sugarcane is the primary raw material that promises to be used in BBP production, because Thailand is the second largest sugar exporter after Brazil. As a result, PLA is presently the most common form of BBP produced on the market. It is created from lactic acid produced by sugar fermentation (Rattana and Gheewala, 2019). Figure 5 shows a diagram of the process of making bioplastics.

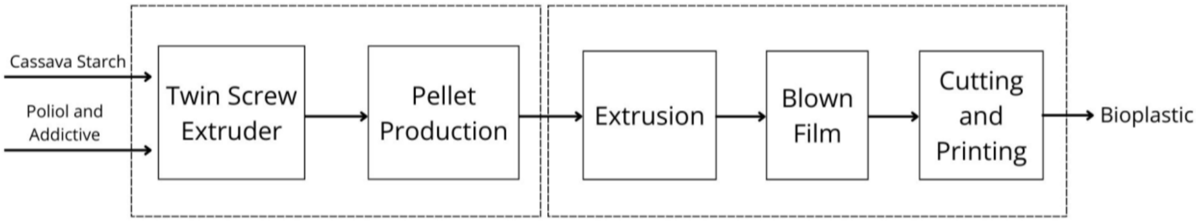

Figure 5. Bioplastic manufacturing process
Source: Abidin et al. (2018)

The result LCA of PLA's BBP (length is 30.48 cm, width is 50.8 cm, and thickness is 0.06 mm), shown in the paper by Rattana & Gheewala (2019), for making 1 kg BBP the consumption of energy is 1.045 kWh/kg bioplastic bag. Using the impact assessment ReCiPe midpoint method (version 1.13, 2016), the GWP result can be shown in Table 1. PLA resin manufacture (67%) (utilization of energy and chemicals) was the primary contributor to the GWP, while the second contributor was sugarcane cultivation and harvesting (14%) (Nitrogen fertilizers). For fossil depletion 70% the primary contributor is PLA resin manufacture because of electricity consumption. The degradation of BBP bags in landfills has a bigger impact.

Meanwhile, the value of GHG emission and energy consumption of cassava bags carried out in Indonesia is described in the paper by Abidin et al. (2018), GWP is 1.04E+06 kgCO_2/kg of product, the total energy requirement required is 12.0428 kWh/kg where the highest energy requirement is when converting raw material into pellets in the first part (can be seen in the process flow image) of 10.9983 kWh/ kg. The water requirement of 0.0119 kL/kg is quite large because the water requirement starts from planting cassava to become bioplastic, and the land requirement is 0.82835 m^2/kg. The contributors who create the largest GHG emissions are not included in the paper of Abidin et al. (2018). However, in the paper of Kaewphan and Gheewala (2013) indicated that the stages of PHA and glucose synthesis during the fabrication of cassava bioplastics produce approximately 85% of total GHG emissions across the life cycle of bioplastic bags.

Table 1. The result of global warming potential and fossil depletion bioplastic PLA
Source: (Rattana and Gheewala, 2019)

Environmental impact	Cradle to gate	Cradle to grave with landfill treatment	Cradle to grave with recycling
GWP (kg CO_2 eq./FU)	9.01E+08	8.37E+08	2.75E+08
Fossil depletion (kg oil eq./FU)	2.49E+08	2.26E+08	8.73E+07

According to Wahyuningtiyas & Suryanto (2018), the duration of the decomposition of each type of bioplastic varies from 5 days to a maximum of 50 days. If concluded based on previous papers

(Abidin et al., 2018; Kaewphan and Gheewala, 2013; Rattana and Gheewala, 2019), changing plastic bags with bioplastic offers various advantages, including 1) capable of reducing the consumption of fossil fuels, 2) ability of the decomposition, 3) using biomass agriculture to promote the utilization of local agricultural resources, 4) increase the value of agricultural resources, and 5) minimize dependency on fossil fuel imports. However, the GHG emissions produced from the manufacture of bioplastics are higher than the HDPE process. As a result, to decrease GHG emissions from bioplastics need to improve efficiency such as using non-multiplying raw materials like in processing PLA bioplastic and using methane emissions as an energy source throughout its life cycle (Rattana and Gheewala, 2019).

In contrast, most of research concludes that bioplastic bag has less environmental impact compare to other materials, especially biodegradable copolyesters and cornstarch-based thermoplastic materials (Civancik-Uslu et al., 2019; Mori et al., 2013), biodegradable bags starch based PE bags (Durak, 2016), and bio-based polyester mixed with a mineral substance and vegetable oils (GAIA, 2019).

3.1.4 Polypropylene (PP)

Eco-friendly bags that are often found in supermarkets and convenience stores in Indonesia are spunbond bags or commonly known as goodie bags. The raw material used to make the cloth bag is derived from petroleum which is processed into polypropylene powder and undergoes a spunbonding process so that it becomes a non-woven cloth bag (Abidin et al., 2018). The following is an example of a diagram of the process of making a spunbond bag, as shown in Figure 6.

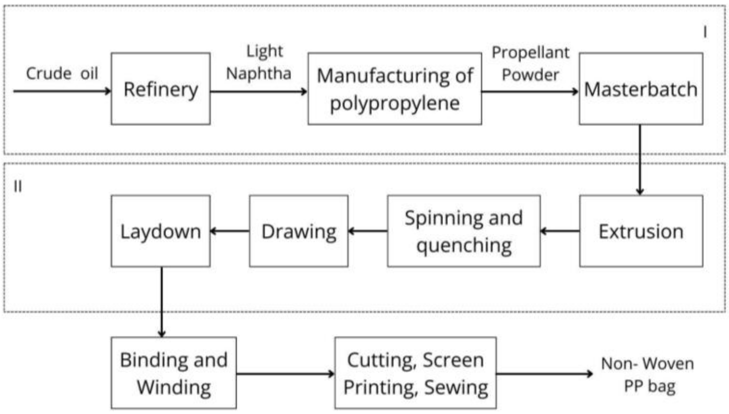

Figure 6. The spunbond bag manufacturing process diagram
Source: Abidin et al. (2018)

The use of spunbond bags or PP non-woven bags has been widely used in several countries to help reduce the use of plastic waste. Making spunbond bags requires energy and produces emissions and pollution from the production process. This results in exhaust emissions which are one of the contributors to the global warming potential. With the life cycle assessment (LCA) method, it can be seen the impact of the spunbond bag production process resulting in exhaust emissions.

Research conducted by Abidin et al. (2018) in Indonesia can be seen that the value of GWP is 4.791 kg CO_2/FU, where this value is still greater than recycled plastic of 0.7994 kg CO_2/FU. The total energy required is 6.1597 kWh/kg, where the highest energy requirement is when converting raw material into pellets in the first part (can be seen in Figure 6) of 5.4014 kWh/kg. The water consumption is 0.00372 kL/kg and the land requirement is 0.0277781 m2/kg greater than the land requirement for 100% virgin HDPE plastic production because the spunbond bag manufacturing process requires spunbonding process tools.

In another study conducted in China based on the paper by Muthu et al. (2012), the PP non-woven bag production process was carried out with different technology. At the end of the production process, it was carried out by conventional sewing and thermal. By using SIMAPRO and IPCC 2007 GWP V 1.1 software, method for 100 and 20 years, GWP results were obtained with a cradle-to-gate scope which can be seen in Table 2.

From the results of the GWP, the major contributors are transportation by diesel trucks, the use of electricity, and energy in the bag and energy manufacturing process (Muthu et al., 2012). Based on previous papers from Abidin et al. (2018) and Muthu et al. (2012), it is concluded that the use of spunbond shopping bags has advantages, namely 1) it is a multiple-use shopping bags (used many times), so spunbond is not required to be purchased each time a person goes shopping., just bring a spunbond bag from home, and 2) recyclable because it is made of polypropylene and can be processed into other products. However, the GWP value of spunbond bags is greater than that of plastic bags. Moreover, the management of spunbond bags waste is by burning. It was mentioned above regarding the major contributors that occurred in the manufacture of PP non-woven bags. According to Muthu et al. (2012), transport is one of the major contributors that can be controlled, it is preferable to seek for the nearest firm or using renewable energy sources for transportation. Furthermore, in the EOL production process, it is recommended to use conventional sewing instead of using thermal.

Table 2. Impact GWP using IPCC 2007 results - 100 Years and 20 Years
Source: (Muthu et al., 2012)

Impact category (unit)	Sewn Bag	Thermal Bag
IPCC GWP 100 a (kg CO_2 eq)	60.7	86.3
IPCC GWP 200 a (kg CO_2 eq)	62.5	88.6

3.1.5 Polyester

According to The Danish Environmental Protection Agency (2018), polyester fibers are woven to create plastic bags. These polyester fibers, which are often thinner and lighter than the original polymers (such as PP or PET) and are generated by the processing of other polymer types, produce an extremely light and foldable multiple-reuse bag. Based on the type of polyester consists of woven and non-woven. LCA research on polyester bags is rarely done, so there was a lack of information on the carrier bag production process. Stafford et al. (2022) have performed LCA calculations on polyester consisting of woven and non-woven using SimaPro LCA Software v 9.0 and The ReCiPe 2016 (H) as an impact assessment method. The results show in Table 3 that polyester bags had the lowest environmental impacts for all indicators, except the persistence of leaked material.

Table 3. The result of GWP polyester bag
Source: Stafford et al. (2022)

Type of woven	GWP (kg CO_2 eq)	Water consumption (m^3)	Land use
Polyester woven	0.7971	0.0029	0.0089
Polyester non-woven	0.2746	0.0022	0.0053

3.2. The Appropriate Eco-Friendly Bag Innovation in Indonesia and Its Relation to SDGs: Climate Action

Regarding the reduction of greenhouse gas emissions, it is part of the action against global climate change (SDGs point 13). This goal is very important, as the global temperature has increased over the years, causing various environmental problems such as melting glaciers and increasing ocean levels, among many others. In this sense, plastic has a great contribution. As a result of the ban on the use of plastic bags, every business actor and the consumer has begun to look for alternatives to environmentally friendly plastic bags following government recommendations.

The results of several eco-friendly bag materials on grocery bag products in several foreign countries can be one of the recommendations for choosing an eco-friendly bag in Indonesia. Figure 7 shows the five material grocery bags were analyzed based on previous studies. BBP material has the lowest GWP's value compared to other materials. The utilization of BBP material can be considered as a strategy to overcome environmental issues in achieving GHG emission reductions, in order to achieve the target point of SDGs 13.2 to integrate climate change anticipation action. Aside from that, the utilization of BBP material could be used against agricultural and plantation waste, which is subsequently processed to produce feedstock for the production of BBP. Whereby the SCS scenario for reducing the impact of plastic is appropriately implemented.

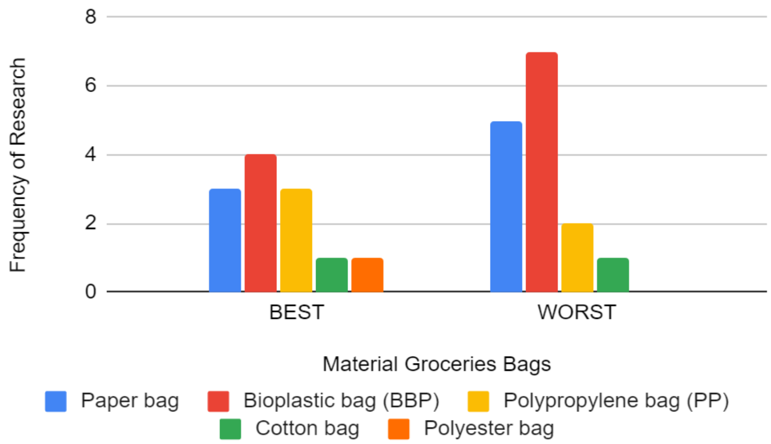

Figure 7. The GWP's result from the material groceries bags by previous researchers

The link between the selection of the right eco-friendly bag material and the achievement of SDGs point 13 can be through the life cycle assessment method with the global warming potential environmental impact indicator, which can be an indicator in helping to reduce greenhouse gas emissions. The Indonesian government has made policies regarding low-carbon development and climate resilience as the backbone of the green economy, where efforts have been made to integrate low-carbon development policies and climate resilience into the 2020-2024 RPJMN. Low carbon development and climate resilience have become a national priority agenda in the 2020-2024 RPJMN. There are five main strategies for low carbon development in Indonesia to increase economic growth while reducing GHG emissions by 27.3% in 2024. One of the strategies is waste management and the circular economy (Yananto, 2021).

The waste management sector is one of the sectors that becomes a national priority in the 2020-2024 RPJMN. In the 2020-2024 RPJMN emission reduction target in the waste management sector, the Ministry of National Development Planning (Bappenas) has committed to reducing waste emissions by 9.4% (in 2024) from waste management baseline emissions in 2030. The potential achievement of GHG emission reductions up to 2019 for the waste management sector will reach 31,550.85 Gg CO_2eq until 2019. Eco-friendly bags with appropriate and effective materials from waste and emission aspects will help achieve SDGs point 13, where these points relate to greenhouse gas produced by industry, as well as reducing new waste clusters from the use of inappropriate materials.

4. Conclusions

Each country has its strategy and policy for dealing with the use of shopping bags made from plastic bags. The various eco-friendly bags that are emerging today, especially those that are widely used, include five types of materials, cotton bags, paper bags, BBP bags, PP bags, and polyester bags. The five types of materials used in Indonesia are reviewed from various journals and linked to SDGs point 13 (climate change). Through this study, alternative grocery bags had been compared systematically and provide insights on optimizing the use and reduction of grocery bags in the future. The comparison of various alternative grocery bags is based on the value of global warming potential. The five material grocery bags were analyzed based on previous studies, BBP material has the lowest GWP's value compared to other materials.

Finally, this study propose several suggestions, including developing new bio-degradable bag technology and research on LCA of eco-friendly bag innovation in Indonesia is also expected to be carried out, considering that such studies are rarely found. The challenge of eco-friendly bags is pricey than conventional plastic. The production process and the right technology development will help reduce the cost of the production process for making eco-friendly bags, as well as selecting the right materials will help reduce the price of eco-friendly bags. The policy of eco-friendly bags is also needed to increase the amount of eco-friendly bags usage which will have an impact on reducing eco-friendly bags prices.

Acknowledgement

Parts of this paper have been presented at the 1st Sustainability International Conference: Equitable Environment and Resource Management for Poverty Alleviation on 15-17th November 2022. The authors thank to colleagues from the Research Center for Sustainable Production System and Life Cycle Assessment, the National Research and Innovation Agency, who provided insight and supported this research.

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