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Barriers for Implementing Reverse Logistics in the Construction Sectors

Sherly Ayu Wardani[1], Naniek Utami Handayani[1], Mochamad Agung Wibowo[2]

[1]*Department of Industrial Engineering, Faculty of Engineering, Diponegoro University (Indonesia)*
[2]*Department of Civil Engineering, Faculty of Engineering, Diponegoro University (Indonesia)*

sherlyayuwardani@alumni.undip.ac.id, naniekh@ft.undip.ac.id, agung.wibowo@ft.undip.ac.id

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Abstract:

Purpose: This paper aims to identify the barriers to implementing Reverse Logistics in the construction sector and rank the barriers between the stakeholder, the phase in the project life cycle, and the strategic factors on the emergence of obstacles in implementing reverse logistics.

Design/methodology/approach: This research began by identifying barriers re- verse logistics through a systematic literature review. The method used in the systematic literature review was the PRISMA method. Next, the identification of barriers was assessed for their influence on successful reverse logistics implementation by the expert using a questionnaire instrument. The rating scale used was a Likert scale of 1 (greatly hinder the implementation of reverse logistics) to 5 (not significantly hinder the implementation of reverse logistics). Finally, the results of the expert assessment were used to rank barriers using TOPSIS.

Findings: There are 38 barriers in this study, classified as market and competitor factors, policy factors, supply chain factors, economic factors, knowledge-related factors, government support factors, and operational factors. The classification of barriers based on the project life cycle aims to increase stakeholder collaboration on reverse logistics performance issues. The results of this study indicate that the lack of government support for the implementation of RL (GS1) is the obstacle with the highest rank. These barriers are related to government support factors and arise in the green initiation phase of the project life cycle approach. The government's role as regulator and project owner will overcome GS1 barriers.

Research limitations/implications: The limitation in the scope of this research is specific to the construction sector in developing countries, particularly Indonesia. The object of construction in this study is the case of the Penjagaan-Losari highway project. Further research that examines barriers based on the project life cycle by entering the company scale or studying the relationship between barriers can also be done.

Practical implications: This study provides an analysis to stakeholders about the barriers in implementing reverse logistics. The ranking results become a reference for relevant stakeholders in developing a successful strategy for implementing reverse logistics and the PLC approach phases as a guideline for implementing the established strategy.

Social implications: The stakeholder of the construction project has to learn with reverse logistics barriers to improve reverse logistics performance.

Originality/value: This study analyzed reverse logistics implementation barriers in the construction sector in developing countries. The majority of research on reverse logistics implementation barriers examined the manufacturing sector in developed countries. This study also identifies barriers that show the relationship between barrier emergence in the project life cycle approach and stakeholders responsible for addressing barriers and associated problems. Previous research only identified obstacles based on stakeholder points of view and strategic factors in the implementation of reverse logistics. The drawback from the point of view of previous research is the difficulty of determining appropriate improvement efforts. Identifying barriers using a process-based approach such as the project life cycle will improve previous research weaknesses.

Keywords: reverse logistics, construction, project life cycle, stakeholders, TOPSIS

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1. Introduction

Based on data from the Ministry of Economic Affairs of the Republic of Indonesia, the construction sector contributed 10.2% of GDP in 2019. Another construction sector's role is absorbing 8.3 million workers (Direktorat Jenderal Bina Konstruksi Kementerian PUPR, 2019). The construction sector consumes 33% non-renewable resources, 40% energy (Densley Tingley & Davison, 2012), and 25% water resources. Besides, the construction sector produces 30-39% carbon CO2 (Shurrab et al., 2019) (Syamimi-Zulkefli, Mahmud & Mohd-Zainudin, 2019) and 30% material waste (Silva, Brito & Dhir, 2017). The construction sector plays an essential role in the country's economy, but the construction sector also impacts environmental damage (Balasubramanian & Shukla, 2017). Therefore, the critical part of the construction sector in contributing to the development of the country's economy also impacts environmental damage.

Reverse logistics (RL) is an approach that the construction sector can apply to solve waste and non-renewable resources (Chiou, Chen, Yu & Yeh, 2012). RL aims to generate added value in the waste generated along with the construction project phases and overcome the environmental impacts (Schamne & Nagalli, 2016). However, although RL can solve the construction sector's problem, RL implementation is still very minimal because factors hinder their performance (Chinda, 2017; Hosseini, Rameezdeen, Chileshe & Lehmann, 2015).

Chinda (2017) conducted another research on RL barriers in the construction sector. However, this study only ranks seventeen factors that influence RL implementation. Chinda's study provides information on stakeholders who influence these factors, but stakeholders do not know the appropriate phase to overcome these barriers (Chinda, 2017).

Obstacles in Govindan and Bouzon's (2018) research focus on RL barriers in the manufacturing sector so that this research will be conducted in Govindan and Bouzon's (2018) research. The analysis of Waqas, Dong, Ahmad, Zhu and Nadeem (2018) regarding barriers to implementing RL in the manufacturing industry, this study classifies barriers into eight criteria, such as barriers related to finance & economy (FEB), barriers related to knowledge and experience (KEB), obstacles related to law & regulations (RLB), barriers related to management (MNB), Barriers related to infrastructure and technology (ITB), Barriers related to the environment (ERB), Barriers related to market (MRB) and Barriers related to policy (DRR) (Waqas et al., 2018). Research by Ali, Arafin, Moktadir, Rahman and Zahan (2018) analyzed the relationship between barriers (dependent and independent) in the application of RL in the manufacturing sector (Ali et al., 2018). Research by Waqas et al. (2018) and Ali et al. (2018) analyzes the barriers in the manufacturing sector, so it is necessary to adjust to accommodate differences in characteristics between the manufacturing industry and the construction sector.

Hosseini et al. (2015) conducted a study to gather knowledge about Reverse logistics in the construction sector. This Hosseini study aims to provide knowledge about the importance of collaboration between stakeholders to implement RL successfully. The study of Hosseini et al. (2015) implicitly shows the stakeholders related to the obstacles that arise. However, the study of Hosseini et al. (2015) did not explain the relationship of barriers that arise with the design, construction, and operation phases. Therefore, the emergence of obstacles and the appropriate steps to overcome them are not known.

Previous research only identified obstacles based on stakeholder points of view and strategic factors in the implementation of reverse logistics. The drawback from the point of view of previous research is the difficulty of determining appropriate improvement efforts. Identifying barriers using a process-based approach such as the project life cycle will improve previous research weaknesses. Moktadir, Rahman, Ali, Nahar and Paul. (2019) state that identifies barriers based on project life cycle is essential (Moktadir et al., 2019). This paper aims to identify the obstacles to implementing Reverse Logistics in the construction sector and rank the barriers between the stakeholder, the phase in the project life cycle, and the strategic factors on the emergence of obstacles in implementing reverse logistics.

2. Theoretical Background

2.1. Life Cycle Concept

A *life cycle approach* is an approach used in various sectors. A *product life cycle* is an approach used by the manufacturing industry. Product life cycle plays an essential role in life cycle assessment (LCA), which is used to evaluate the environmental performances of products. The product life cycle in the manufacturing industry consists of five phases, namely (1) Pre-manufacturing, (2) Product Manufacturing, (3) Product Delivery, (4) Product Use and Refurbishment, and (5) Recycling and Disposal. This classification uses a supply chain perspective and excludes the design phase of a product. At the same time, the second starts the life cycle of a product with the need identification and considers supply chain activities as part of the production phase. Another approach in product life cycle classification uses a generic system perspective. This approach classifies the product life cycle into two phases, namely (1) the Acquisition phase and (2) the Utilization phase. The acquisition phase includes four sub-activities, namely (1) Conceptual design, (2) Preliminary design, (3) Detailed design and development, and (4) Production or construction. The utilization phase includes two sub-activities, namely (1) utilization and support and (2) retention and disposal (Labuschagne & Brent, 2005).

In contrast to the manufacturing sector, the life cycle approach in the construction sector is called the project life cycle. Based on European standard EN 15978:2011, phase in Life Cycle Assessment (LCA) of a building and considers four main life cycle stages: (1) product manufacture; (2) construction; (3) operations; and (4) end-of-life (Benachio, Freitas & Tavares, 2020). Other classifications in the project life cycle concept in measuring green supply chain management in the construction sector include (1) green initiation phase, (2) green design phase, (3) green material management, (4) green construction, and (5) green operation and maintenance. (Wibowo, Handayani & Mustikasari, 2018). The PLC concept in the GSCM perspective from Wibowo et al. (2018) aligns with the project life cycle concept in Pushpamali, Agdas and Rose. (2019) research. Pushpamali et al. (2019) classify activities in the supply chain into four stages, namely (1) Activities in the preconstruction stage, which include project initiation and design, (2) Construction stage, which includes material procurement and construction activities, (3) Post Construction stage which includes maintenance activities and (4) end of life phase which includes reverse logistics activities (Pushpamali et al., 2019). The difference between the life cycle concept in Wibowo et al. (2018) research and Pushpamali et al. (2019) lies at the End Use Phase. The End-Use Phase is related to the implementation of Reverse logistics (Pushpamali et al., 2019), while the reverse logistics in the research of Wibowo et al. (2018) is in the Green Construction Phase. Figure 1 illustrates the different life cycle concepts in the research of Wibowo et al. (2018) and Pushpamali et al. (2019).

The fundamental difference in the life cycle concept of the construction sector and the manufacturing sector is that the stakeholders involved in the product life cycle are in one organization (one company). In contrast, in the project life cycle of the construction sector, the stakeholders involved in each stage are different organizations, so that they have different perspectives and goals (Huang, Gao, Xu, Song, Geng, Sarkis et al., 2020).

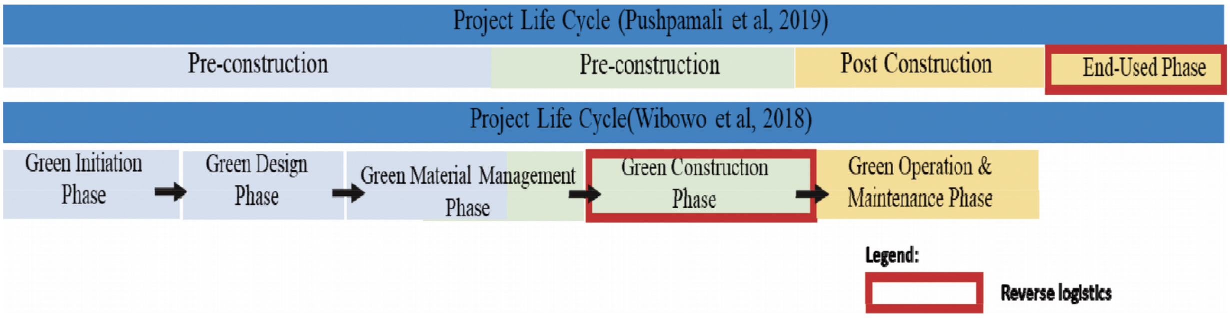

Figure 1. The difference between Life Cycle Concept In Green Project

2.2. Green Supply Chain Management

The traditional meaning of supply chain management is converting raw materials into a product and sending it to the final customer to obtain economic benefits. Supply chain management involves using limited resources, so the traditional supply chain concept must consider environmentally friendly aspects in its supply chain activities (Taghavi, Fallahpour, Wong & Amirali-Hoseini, 2021). This concept is known as the green supply chain management (GSCM) approach (Farida, Handayani & Wibowo, 2019). This approach became popular in the early 2000s and was applied by various automotive, electronics, agribusiness, and construction industries. (Badi & Murtagh, 2019).

Several researchers such as Da Rocha and Sattler (2009), Zhou, Chen and Wang. (2013), Ketikidis, Hayes, Lazuras, Gunasekaran and Koh (2013), Balasubramanian and Shukla (2017), and Wibowo et al. (2018) develop the green supply chain concept. Da Rocha and Sattler (2009) describe the idea of supply chain management in the construction sector in the end phase of building. This research tells the opportunities for using deconstructed materials to improve environmental performance in the construction sector supply chain (Da Rocha & Sattler, 2009). Zhou et al. (2013) describe the supply chain network of the construction sector. This network shows the stakeholders involved in managing material flow, physical flow, and reverse flow. However, the defined network (Zhou et al., 2013) forgets an essential aspect in supply chain management: information flow (Singh, 1996). Information flow has a vital role in increasing collaboration between stakeholders (Lotfi, Mukhtar, Sahran & Zadeh, 2013). Stakeholders' collaboration overcomes the problem of a fragmented construction sector supply chain (Balasubramanian & Shukla, 2017; Wibowo et al., 2018). Ketikidis et al. (2013) studied the relationship between green supply chain management (GSCM) practices, pressures, and environmental performance in Kosovo's construction industry. The study of Ketikidis et al. (2013) shows that the GSCM approach adopted by the construction sector significantly affects the achievement of environmental performance and measures the economic impact of the application of GSCM qualitatively (Ketikidis et al., 2013), so this study does not involve social aspects in measuring performance (Yu, Cheng, Ho & Chang, 2018). Balasubramanian and Shukla (2017) developed a GSCM concept model for the construction sector, which is more complex than previous research. This study explains the relationship between drivers, barriers, and green practice with the supply chain performance of the construction (Balasubramanian & Shukla, 2017); this study shows the relationship in the construction sector. Fragmented construction and various stakeholders involved in achieving good GSCM performance. Wibowo et al. (2018) developed a project life cycle (PLC) based GSCM concept.

PLC is an approach used by stakeholders to improve project performance. PLC-based GSCM divides activities in the supply chain into five phases, namely the green initiation phase, green design phase, green material management, green construction, and green operation and maintenance (Wibowo et al., 2018). The advantage of the GSCM concept by Wibowo et al. (2018) is that the performance achievements of each phase in the GSCM can be known so that the difficulties that hinder each phase can be mitigated. However, the concept of GSCM Wibowo et al. (2018) only develops GSCM to building maintenance activities. The life cycle stage in the PLC-based GSCM idea does not include building material issues at the end of the use phase. The whole life cycle phase concept in the supply chain process was developed by Huang et al. (2020). The entire life cycle concept in the supply chain process includes the extraction of raw materials, processing and manufacture of these raw materials, transportation, construction and retrofitting, use and maintenance, demolition and waste management, disposal, and circular processing through reuse, recycling, and recovery (Huang et al., 2020). Huang et al. (2020) whole life cycle stage concept (2020) focuses on developing a holistic perspective to mitigate environmental impacts using construction sector materials. Still, Huang et al. (2020) concept need to be developed into more detailed activities at the operational level, making it easier to implement the idea.

Previous research has shown that GSCM is an approach to improve environmental performance in the construction sector. The project lifecycle-based GSCM approach is an alternative to increase collaboration between stakeholders; the lifecycle-based GSCM approach can minimize fragmentation problems in the construction supply chain.

2.3. Reverse Logistics

2.3.1. Reverse Logistics Concept

Reverse logistics (RL) is an approach to activate material disposal activities to landfill in GSCM activities (Chen, Ignatius, Sun, Zhan, Zhou, Marra & Demirbag, 2019). The manufacturing sector implements this approach to address the waste problem, and the construction sector can also implement this approach (Hosseini, Chileshe, Rameezdeen & Lehmann, 2013a).

Murphy (1986) was the first author that introduced the reverse logistics concept; he used "reverse distribution" as an equivalent term and defined it as the "movement of goods from a consumer towards a producer in a channel of distribution." (Murphy, 1986). The concept of reverse logistics from Murphy (1986) only focuses on distribution activities, so this concept experienced rapid development starting in the 2000s. Dowlatshahi (2000) developed the idea of RL related to GSCM in managing information flow, money flow, goods flow, and waste flow (Dowlatshahi, 2000). Granlie, Hvolby, Cassel, De Paula and Soosay (2013) conducted a literature study on reverse logistics from 2000 to 2013 in the manufacturing sector. The literature study results from Granilie et al. (2013) showed that reverse logistics includes maintaining, servicing, reusing, and disposing of products, after-sales service, green supply chain management, and product life-cycle management. An important concept from the study of Granlie et al. is the overlap between RL, GSCM & Product life cycle (Granlie et al., 2013). Reverse logistics practice in the manufacturing sector is a strategic decision in a company. The success of reverse logistics implementation cannot be separated from the strategy set by the company (Ravi & Shankar, 2015). Previous studies on the reverse logistics concept in the manufacturing sector show that the implementation of RL in the manufacturing industry is integrated with the product life cycle concept so that the implementation of RL in the manufacturing industry is a strategic decision for companies to improve GSCM performance (Chen et al., 2019).

"The process of planning, implementing, and controlling the efficient and effective inflow and storage of secondary goods and related information against the direction of the traditional supply chain to restore value or proper disposal" is the definition of reverse logistics, according to Fleischmann (2001) and Chileshe, Rameezdeen, Hosseini, Martek, Li & Panjehbashi-Aghdam (2018). Reverse logistics is an approach that the construction sector can implement to overcome waste problems (Hosseini et al., 2013a) and the risk of environmental damage that arose during the construction process (Hammes, Souza, Rodriguez, Millan & Herazo, 2019). Understanding of RL construction sector lag behind manufacturing sectors (Hosseini et al., 2013a). The concept of reverse logistics sector construction in research by Hosseini et al. (2013a) is as shown in Figure 2.

Figure 2 shows the transfer of material in a reverse logistics project. The flow of material in Figure 2 can be illustrated in a highway construction project: raw materials such as sand, aggregate material, and cement are distributed from suppliers to off-site manufacturing (precast concrete manufacturing companies) for processing into sand; other materials such as asphalt are distributed from manufacture (supplier) to on-site assembly and installation. After the construction and installation process is complete, the road will be used; then, after reaching a specific lifetime, the road will be carried out a maintenance process. In the maintenance process, if the reverse logistics is not implemented, the material will be disposed of into the landfill or enter the end of use phase; on the other hand, if the project applies reverse logistics, the deconstruction process will be carried out so that the material and components are produced. Materials and components will be reconditioned so that they can be reused.

Reverse logistics (RL) in the construction industry is as a result of this defined as "how the area of business logistics plans, operates and controls the flow of logistics information corresponding to the return of post-sale and post-consumption goods to the productive cycle through reverse distribution channels, value-added of various types to them: economic, ecological, legal, logistical, corporate image" (Nunes, Mahler & Valle, 2009). The concept of RL supply and closed-loop represents the procedures dealing with materials back to the construction phase of a new project (Hosseini et al., 2015). Deconstruction in RL benefits extending the life of the building to gain profit and overcome the waste problem (Hosseini, Chileshe, Rameezdeen & Lehmann, 2013b, 2015). Hosseini et al (2013b) and Hosseini et al (2015) view RL as an independent practice. The main activity in RL practice in the construction sector is the deconstruction process (Chileshe, Rameezdeen, Hosseini, Lehmann & Udeaja, 2016). Pushpamali et al. (2019) research show that the construction industry ignores the impact of reverse logistics practices on upstream construction activities. Reverse logistics decisions must be made during the pre-construction activities where planning and designing take place, that reverse logistics is easy to implement (Pushpamali et al., 2019).

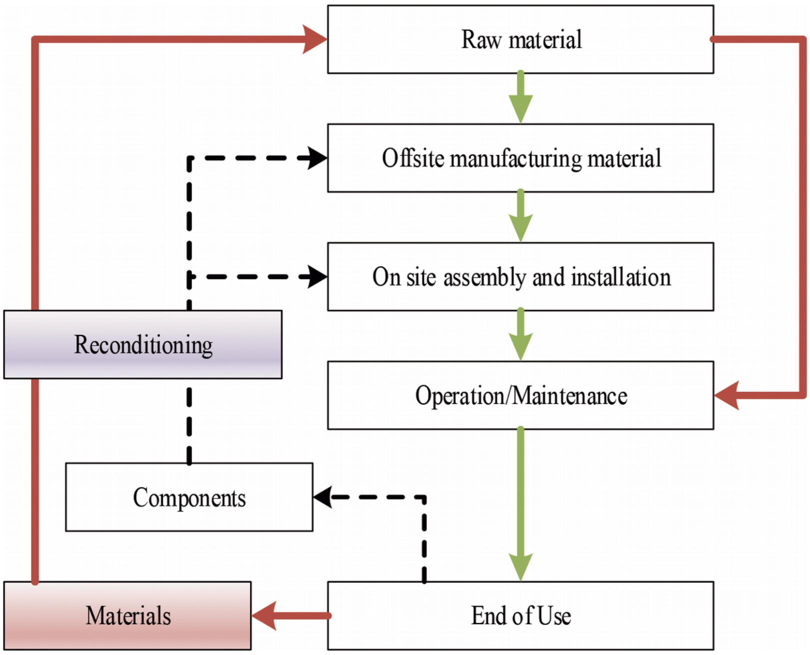

Figure 2. Reverse Logistics Flow Model (Hosseini, Chileshe, Rameezdeen & Lehmann, 2014)

Reverse logistics implementation cannot be separated from product return activities and product recovery activities. Product returns in reverse logistics include product returns for reuse in the manufacturing stage (known as manufacturing returns), distribution returns (related to the action of redistributing products or recovered material), and customer returns (product returns or the deconstruction process at the end of life cycle product) (Schultmann & Sunke, 2005). Several options for recovery activities:

- Reuse/resale reuses old buildings to be reused in new buildings without additional or further processing. In other words, the material can be directly used or sold (Hosseini et al., 2015; Schultmann & Sunke, 2005).
- Repair is an activity to repair damaged products to be reused, for example, repairing glass windows so that window frames do not need to be replaced (Maqbool, Rafique, Hussain, Ali, Javed, Amjad et al., 2019).
- Refurbishing is an activity similar to remanufacturing, where the collected products are reprocessed. Still, the condition cannot be returned to its original state or condition when the product is new (Van Weelden, Mugge & Bakker, 2016).
- Remanufacture refers to reprocessing used products or their restoration to their original state or like a new form (Hosseini et al., 2014; Maqbool et al., 2019).
- Recycling is the activity of reprocessing a material to obtain a material of the same quality. When a material that is reprocessed (recycled) has a different result from the initial quality of the material or the material that is recycled is of lower quality, it is known as down-cycling (Hosseini et al., 2015)

Previous studies' reverse logistics concept shows that the understanding and implementation of RL in the construction sector are different from the manufacturing industry. This difference can be seen from the manufacturer's perspective, which views RL as an integrated practice with the product life cycle, while the construction sector views RL as something independent (RL implementation is only during the construction process (Hammes et al., 2019; Wibowo et al., 2018)). Another difference relates to the service life of the product. In general, developments in the manufacturing sector have a shorter service life when compared to the construction sector (Krstić & Mareniak, 2012).

2.4. Reverse Logistics Barriers

Reverse logistics is an approach to minimize waste problems; the automotive and electronics industries first use this approach (Prajapati, Kant & Shankar, 2019a). However, reverse logistics is a new thing for the construction industry, especially in developing countries. Therefore, the construction industry needs to learn the techniques and concepts of applying reverse logistics from the manufacturing industry to implement reverse logistics successfully. Analyzing the obstacles in the implementation and adoption of reverse logistics is the first step to studying reverse logistics' performance in any industry (Prajapati et al., 2019a).

2.4.1. Previous Research Reverse Logistics Barriers

Factors that negatively affect the adoption of Reverse Logistics are called reverse logistics barriers (Prajapati, Kant & Shankar, 2019b). Identifying obstacles in RL implementation is the first step in developing strategies to improve RL performance (Schamne & Nagalli, 2016). Reverse logistics is one strategy to overcome limited resources that cannot be renewed and are not environmentally friendly (Chen et al., 2019). Therefore, identifying obstacles is an aspect that must be considered in formulating strategies (Radomska, 2014).

Govindan and Bouzon (2018) conducted a literature review of articles on RL barriers from 2004 to 2015. Several vital issues related to the identification of RL barriers are (1) the majority of countries in the study of RL barriers are developed countries while developing countries such as Indonesia rarely study this issue, (2) the manufacturing sector is the object of the study of the highest RL barriers compared to other sectors such as construction and (3) the majority of RL barriers studies use a single stakeholder perspective so that they do not represent differences in interests between stakeholders (Govindan & Bouzon, 2018). Further research from Govindan shows that RL plays an essential role in improving supply chain performance in the transition to a circular economy. Analyzing RL barriers is an alternative in accelerating the circular economy (Govindan & Hasanagic, 2018). Kaviani, Tavana, Kumar, Michnik, Niknam and Campos (2020) shows that RL systems are integral parts of sustainable operations and cleaner production. However, there are different barriers to implementing RL systems, particularly in developing countries, which inhibit companies from fulfilling their environmental responsibilities (Kaviani et al., 2020).

Involving all stakeholders and aligning stakeholder interests are essential in making strategic plans (Govindan & Bouzon, 2018). Considering these barriers from these multiple perspectives is critical for creating a comprehensive industrial strategy to implement RL successfully. Barriers analysis results of Govindan and Bouzon (2018) need adjustments to formulate a plan for implementing RL in the construction sector due to the different roles of stakeholders in the construction and manufacture sectors so that stakeholders' views on significant barriers will be different. Stakeholders in the analysis of multiple stakeholders in the manufacturing industry are Government, Customers, Organizations, and Society.

In contrast, the stakeholders in the construction sector are Government, project owner, Organization (contractors, supervisor consultant, and suppliers), and designers. Government policies and demands from customers influence the decisions and perspectives of organizations in the manufacturing sector. In contrast, in the construction sector, decisions are the authority of the project owner. When used in the construction sector, the adjustment of barriers analysis in Govindan and Bouzon's (2018) research cannot be separated from the differences in supply chain characteristics in the manufacturing and construction sectors. This is because reverse logistics is an alternative in accelerating the application of green supply chain management (Wibowo et al., 2018). The construction sector has a fragmented supply chain because stakeholders in each project life cycle phase are different organizations, and cooperation in a project is short-term. Research by Wibowo et al. (2018) uses a project lifecycle-based approach in analyzing the factors of GSCM implementation; a project lifecycle-based approach will make it easier for stakeholders to coordinate in improving supply chain performance.

Further research from Govindan shows that RL plays a vital role in improving supply chain performance in the transition to a circular economy. Analyzing RL barriers is an alternative in accelerating the circular economy (Govindan & Hasanagic, 2018). Kaviani (2020) shows that RL systems are an integral part of sustainable operations and clean production. However, there are distinct barriers to implementing RL systems, especially in developing countries, which prevent companies from fulfilling their environmental responsibilities (Kaviani et al., 2020). RL as a system to achieve sustainability and accelerate the circular economy transition so that the complexity of the end product of the life cycle increases. Improving stakeholder relationships throughout the product life cycle is an operational factor for increasing return flow (Ozkan-Ozen, Kazancoglu & Kumar-Mangla, 2020).

Another aspect that becomes a reference for the manufacturing sector in mapping obstacles is the functional aspect of RL. Practical aspects of RL are considered in determining strategies such as market and competitor strategic factors, government policies, economic conditions, organizational knowledge, government support, and operational aspects (Govindan & Hasanagic, 2018). The analysis of constraints in the manufacturing sector is the first step in the successful implementation of RL. Identification of RL in the manufacturing industry based on various stakeholder perspectives, product life cycle, and functional aspects of RL.

2.4.2. Reverse Logistics Barriers Construction Sectors

The construction sector needs to adopt aspects that are considered by the manufacturing industry in identifying barriers. In addition, the construction sector needs to adapt multiple stakeholder perspectives, barriers from each functional aspect of RL, and the project life cycle concept. Several previous studies on RL barriers in the construction sector:

Hosseini et al. (2015) conducted a study to gather knowledge about Reverse logistics in the construction sector. Hosseini's study aims to provide knowledge about the importance of collaboration between stakeholders to implement RL successfully. The output of Hosseini et al. (2015) study is the RL implementation scheme, drivers, and barriers in RL implementation. The classification of obstacles in Hossein et al. (2015) study includes barriers at the organizational level and barriers at the industry level. There are eight barriers at the corporate (contractor) level, namely (1) Excessive effort & time necessary, (2) higher initial cost, (3) low cost for disposal of materials, (4) lack of support from legislation and regulation, (5) necessity of suitable storage area on-site, (6) cultural perspectives against RL, (7) existence of hazardous substances in building and (8) consumer preferences and perceptions. Barriers at the industry level include (1) Buildings design not adopt easy dismantling concept, (2) lack of recovery facilities, infrastructure, technology, and market, (3) long life cycle of building, (4) immobility of buildings and massive size of building product, (5) lack of awareness in the construction industry, and (6) Uniqueness of each building for deconstruction (Hosseini et al., 2015). The study of Hosseini et al. (2015) implicitly shows stakeholders related to emerging barriers. However, Hosseini et al. (2015) study does not explain the relationship of emerging obstacles to the design, construction, and operations phases. Hence, the emergence of barriers and the appropriate stage for overcoming these barriers is unknown.

The study on the identification of barriers by Chileshe et al. (2016) adopts the concept of identifying barriers as in Hosseini et al. (2015) research, which identifies obstacles based on the organizational level. Chileshe et al. (2016) identified barriers to RL implementation at the industry, corporate, and project levels. She analyzed the correlation between barriers and successful RL implementation. The ease of the deconstruction process is the primary driver in the implementation of the RL construction sector. Chinda (2017) studied the factors that influence the success of reverse logistics in the Thai construction sector. The results of Chinda et al. research show that regulation is a determinant of reverse logistics implementation. In addition, this study shows stakeholders who implicitly influence RL implementation factors. Studies on the identification of barriers conducted by Chileshe et al. (2016) and Chinda (2017) only indicate that stakeholders are responsible for overcoming these obstacles but must be balanced with knowledge of the appropriate phase to implement improvement efforts. Analysis of the identification of barriers in terms of the project life cycle and related stakeholders will increase the ability of the construction sector to think in a more integrated manner. According to Lei, Huang and Huang (2019), the construction sector implements green supply chain management or reverse logistics to achieve sustainable construction. The construction sector must shift from partial sustainable performance improvement practices (focusing on the construction phase) to more integrated sustainable performance improvement practices through the concept of sustainable performance based on life cycle thinking (Lei et al., 2019). Life cycle thinking analyzes environmental performance throughout the product life cycle (Ingrao, Messineo, Beltramo, Yigitcanlar & Ioppolo, 2018).

Based on the description of the research regarding the identification of barriers to the implementation of reverse logistics in the manufacturing sector and the construction sector, this research classified barriers based on the project life cycle. Therefore, these stakeholders have responsibility for barriers and strategic factors related to these barriers. Figure 3 shows basic concepts from this research.

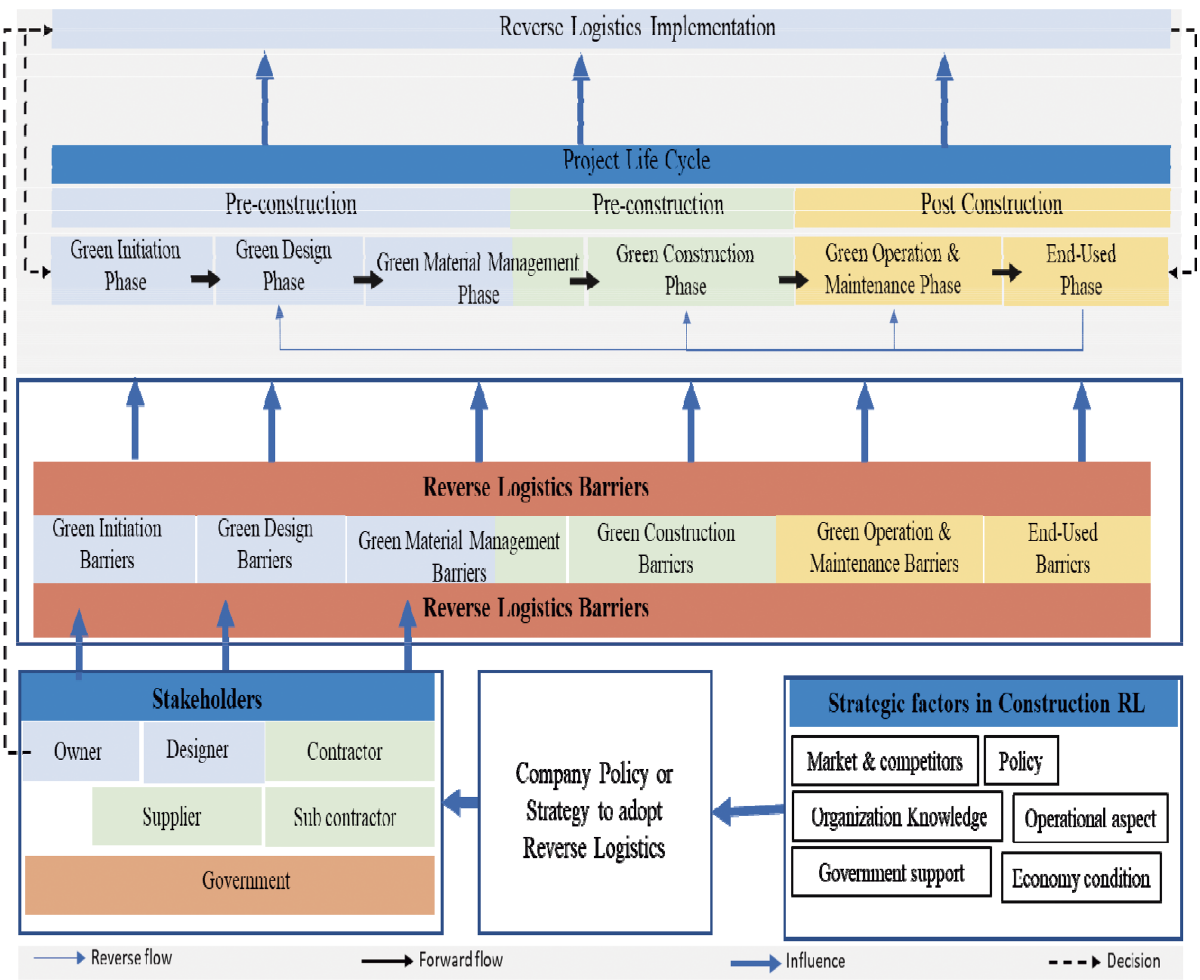

Figure 3. The Relationship between RL Implementation, PLC, Stakeholders &RL Functional Aspect

3. Research Methods

In this study, identification of RL barriers began with a literature review, then continued with data collection using a questionnaire instrument and data processing using TOPSIS. Figure 4 shows the sequence of steps in this study.

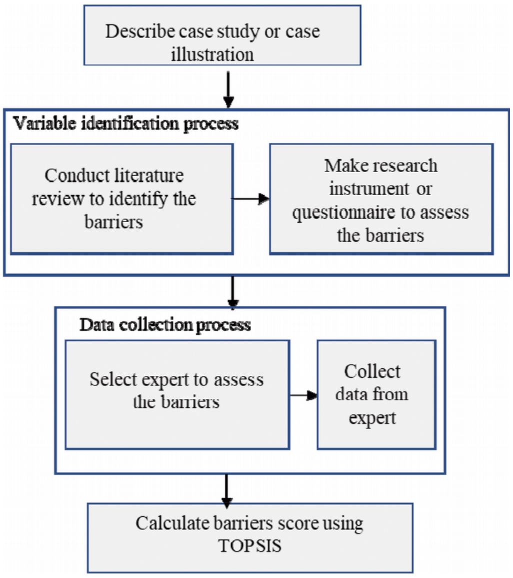

Figure 4. Research Methods

3.1. Case Illustration

Figure 5 shows an illustration of the case in this study is the Penjagaan-Losari highway project. In 2009 the Penjagaan highway maintenance project implemented reverse logistics. The application of reverse logistics in the project TOR requires a cold mix recycling base by foamed bitumen. In 2020 the Penjagaan-Losari highway maintenance project was carried out again, but maintenance in 2020 did not implement reverse logistics. As a result, the TOR maintenance project for the Penjagaan-Losari highway does not require a cold mix recycling base by foamed bitumen as in 2009. The case of reverse logistics that was not implemented again in the Penjagaan-Losari highway maintenance project in 2020 indicates the existence of barriers, so an in-depth analysis of barriers is needed, which has the most significant influence. Based on the illustration of the Penjagaan-Losari highway maintenance project case, the research questions in this research are:

1. What are the significant barriers to the implementation of RL practice?

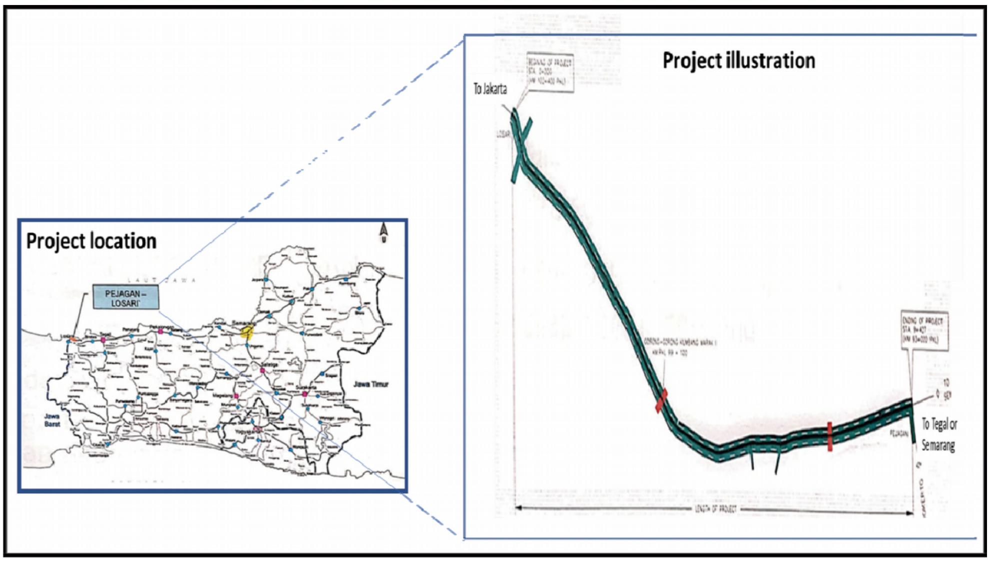

Figure 5. Losari-Penjagaan Highway Project

The practice of recycling materials on a road project was carried out in 2008. The “Losari-Penjagan” project has a length of 9km. “Losari Pejagan” Highway connects the province of Central Java with the area of West Java. “Losari Jagan” highway is located on the Trans Java route, so the “Losari Jagan” highway has a role in shortening the distance and delivery time; the existence of this road will reduce the cost and speed of road delivery. According to survey data from the Ministry of Transportation of the Republic of Indonesia in 2019, toll roads can reduce travel time by 38%; therefore, the role of toll roads is crucial.

3.2. Variable Identification Process & Data Collection

The research variables were obtained through literature review; In simple terms, the sequence of steps in the literature review process can be seen in Figure 6. (Ceulemans, Molderez & Van Liedekerke, 2015). At the literature review stage (see step 3 in Figure 6), the method used to analyze the barrier was the PRISMA method. PRISMA is a method for writing a systematic literature review. The advantage of this method is that it provides complete and detailed stages in a systematic literature review. There are four stages in the PRISMA method: identifying resources, screening articles, assessing eligibility, and selecting the included item. The systematic literature review process starts with choosing the database resource. Database resource used in Reverse Logistics barriers systematic literature review is Scopus. The total number of an article from Scopus was 154 article, whereas the keywords used in the identification process were: Reverse Logistics barriers, Reverse Logistics factors, and the construction industry. The second step is the screening process. The screening step aims to remove duplicate articles. The screening criteria are the type of article, the language (the only paper in English will continue to the next step), the publisher year, and the article field. After reading the abstract from the first step, the total number that will continue to the complete reading step is 30 articles. At the eligibility stage, on a more critical note, the titles, abstracts, and the main contents of all the articles were examined thoroughly to ensure that they fulfilled the inclusion criteria and fit to be employed in the present study to achieve the objectives of the current research. From the eligibility assessment, a total of 15 articles is ready to analyze. The total article that passes the previous three steps is 15 articles (Mohamed-Shaffril, Samah, Samsuddin & Ali, 2019).

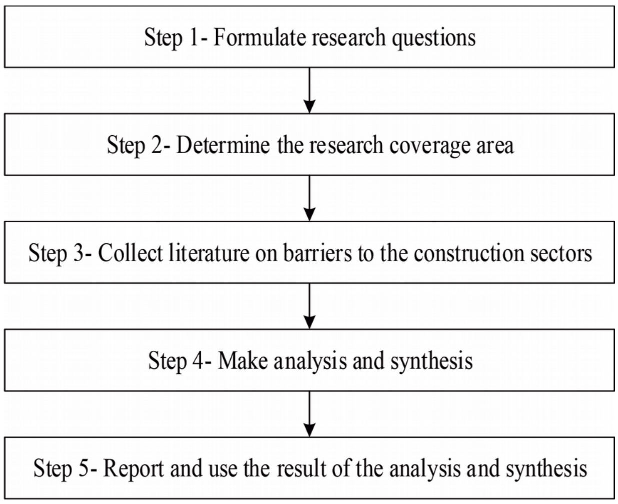

Figure 6. The steps of Literature Review

Data collection in this research using a questionnaire instrument. The questionnaire for the study was divided into seven sections: (1) Introduction about reverse logistics concept in construction sectors, (2) General information, (3) Barrier in green initiation phase, (4) Barrier in green design phase, (5) Barrier in green material management, (6) Barrier in green construction, (7) Barrier in green operation and maintenance phase and (8) Notes. General information expert includes expert functional title, expert role, and expert working experience. The notes section is a special section for experts to give their opinions regarding reverse logistics that are not included in the questionnaire or provide special comments for critical barriers. The rating scale used is a Likert scale of 1 to 5; a scale of 1 shows that the barrier does not significantly hinder RL implementation. In contrast, scale 5 means that it significantly hinders the performance of reverse logistics. Table 2 shows the characteristics of respondents. The selection of respondents in this study must meet the following criteria (Etikan, Musa & Alkassim, 2016):

a) Having knowledge related to research topics.
b) Having experience related to research topics.

c) Have the availability to participate.

d) Having the ability to communicate opinions, experiences, and knowledge.

In this study, Respondents consisted of construction project practitioners with at least five years of experience and academics who focused on sustainable construction and reverse logistics. The respondent's profile that participates in this study can be seen in Table 1.

Respondent	Role	Position	Experience
1	Practitioner	Owner	5years
2	Practitioner	Procurement & Logistics SPV	5 years
3	Practitioner	Head of civil engineer	>25 years
4	Researcher &Practitioner	Sustainable construction & GSCM	>25 tears
5	Practitioner	Designer	>5 years

Table 1. The characteristics of respondents

3.3. Data Calculation Methods

This study aims to rank the barriers in the implementation of reverse logistics; the purpose of the barrier ranking process is to assist stakeholders in developing improvement efforts based on significant barriers. Several multi-criteria decision-making methods that are often used in reverse logistics research, according to Prajapati et al. (2019b) are AHP, TOPSIS, ANP, Delphi, ISM, MIMAC analysis, DEMATEL, VIKOR, PROMENTHEE, and SAW (Prajapati et al., 2019b). The ten popular methods in reverse logistics are four methods that are often used to determine to rank; the four methods are AHP, TOPSIS, SAW & PROMENTHEE. Research by Widianta et al. (2018) compared the accuracy of the AHP, TOPSIS, SAW & PROMENTHEE methods in the ranking process. The comparison of the four methods shows that TOPSIS has the highest accuracy rate of 95%, PROMENTHEE of 93.34%, SAW of 81.67%, and AHP of 50% (Widianta, Rizaldi, Setyohadi, & Riskiawan, 2018).

The data processing technique used in the calculation process is TOPSIS. Using this method is because this method is suitable for the objectives of this research, such as ranking the barriers (Rezaei, 2015) of each PLC phase in implementing RL. Figure 7 shows the calculation step based on the TOPSIS algorithm.

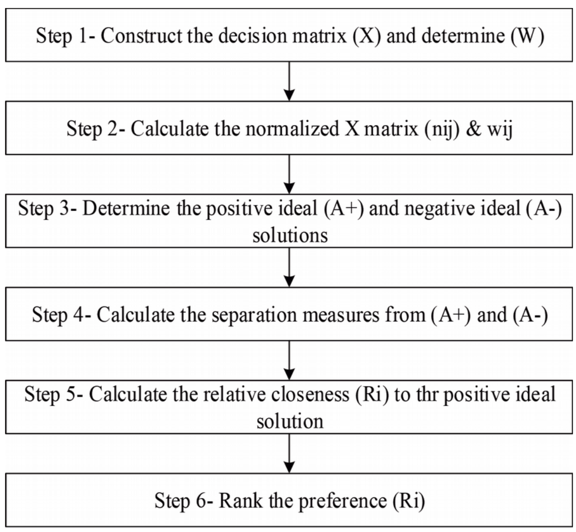

Figure 7. Step TOPSIS Methods (Rozkowska, 2011)

3.4. Mapping Reverse Logistics Barriers Methods

Mapping reverse logistics barriers is the last step in this research. This stage aims to present the results of obstacles in the form of an XYZ diagram (see fig.8). In the XYZ diagram, the x-axis represents the grouping of barriers based on the project life cycle. The y-axis shows the classification of obstacles from the stakeholder's side, and the z-axis shows the category of obstacles based on strategic factors in Construction RL. This diagram illustrates the classification of barriers based on:

1. Classification of obstacles based on the perspective of stakeholders and the project life cycle.
2. Classification of barriers based on strategic factors in Construction RL and stakeholder perspectives.
3. Classification of barriers based on the perspective of strategic factors in Construction RL and stakeholders.

The purpose of matching the XYZ diagram is to identify obstacles based on the three aspects on the XYZ axis; the depiction in the form of graphs aims to facilitate understanding of the results of the analysis of barriers.

4. Result and Analysis

4.1. Result

4.1.1. Barrier Identification Result

Based on the study literature, the barriers to implementing Reverse Logistics (RL) based on the phase in the PLC process approach can be seen in Table 3. These barrier identification results are used to compile a questionnaire to assess the barrier's effect on reverse logistics implementation.

No.	Barriers	Operational Definition	PLC*	Stkh**	Ref***
		Markets and competitors related image			
M1	Lack of commitment to Green image	The company does not realize that RL will have a beneficial effect on an environmentally friendly corporate image and increase competitiveness.	GI	O, C, CS	1, 5, 7, 8
M2	Lack of facility for the marketing of remanufactured product	There is no market (demand) for the results of the deconstruction process on reverse logistics.	GMM	C, CS	2
		Policy issue			
PI1	Penalties	There are no penalties for companies that do not implement RL	GI	O, G	1, 7, 8
PI2	Lack of law and regulation.	Lack of laws and regulations to prohibit illegal waste disposal and encourage the adoption of RL	GI	O, G	1, 5, 7, 8
PI3	Compliance to the laws and regulations/lack of motivation laws	Periodic audits by the authorities ensure companies' legal compliance that produces, handles, and trades back waste.	GMM	C, CS	1, 5, 6
PI4	Company policies related to green design	The commitment to implement green design is not included in the company policy.	GD	D	2, 7
PI5	Company policies related to green procurement	Commitments to implement green procurement are not included in company policy.	GMM	C, CS	2, 5, 7
PI6	Company policies related to green construction	The commitment to implementing green construction is not included in the company policy.	GC	C, CS	2, 8
PI7	Lack of waste management practices	The company does not implement waste management due to unclear regulations regarding best practice implementation.	GC	C, CS	5, 6
PI8	Lack of standards, codes, and guidelines	There are no best practices in implementing reverse logistics.	GC	C, CS	3, 8
PI9	Cultural perspectives against RL	The company culture does not support RL.	GC	C, CS	3
		Supply chain process			

No.	Barriers	Operational Definition	PLC*	Stkh**	Ref***
SC1	Innappropiate organization cooperation	Communication between stakeholders is less cooperative, which leads to a misunderstanding in the implementation of RL	All phase	O, D, C, CS, G	1, 5, 7, 13, 16
SC2	Agreement about recovery action with supplier or TPL	There is no specific contract with TPL regarding recovery actions (reduce, reuse, recycle, and disposal) and their costs.	GMM	C, CS	9
SC3	Information gap and lack of technological infrastructure, and market	Information regarding infrastructure, techniques, and markets from implementing reverse logistics are still minimal.	GMM	C, CS	2, 3, 5
SC4	Complexity for finding third party (TPL) to support Reverse logistics implementation	The procurement department's difficulty is to find a third party to collaborate in implementing RL, for example, an expert consultant to initiate a RL project.	GMM	C, CS	1, 5, 12
SC5	Inconsistent quality	Product quality is inconsistent when compared to products that are not produced from the RL process.	GMM GOM	C, CS	5, 6, 11
SC6	Limited demand forecasting & planning related with Recycled material.	The material planning and procurement department has difficulty on planning or forecasting the material demand generated during the RL process.	GMM	C, CS	5, 8, 12
SC7	Linear, sequential relationship between the design and construction phase.	The awareness of the relationship between the design phase and the construction phase regarding reverse logistics' successful implementation is still lacking.	GC	C, CS	3
Economic issue					
ER1	Cost reduction from the use of recycled materials	Cost savings obtained when using recycled materials.	GI GMM GOM	O, C, S	1, 5, 7
ER2	Lack of interest in investment/Higher initial cost	High investment when the company will implement reverse logistics.	GI,GC	O, C, S	2, 3, 5, 7, 8, 13
ER3	Financial constraints (high operational cost)	The operational costs in implementing reverse logistics are relatively high.	GMM GC	C, S	2, 8, 15, 17
ER4	Price of related equipment used in the RL process	The price of the equipment used to carry out the deconstruction process is relatively high.	GC	C, S	1
Knowledge issue					
KR1	Lack of awareness about the environmental issue (sustainability issue from non-renewable material)	Lack of knowledge about the benefits and examples of the reverse logistics application projects.	GI GD GC GMM	O, D, C, CS	3, 5, 8, 6, 7, 9
KR2	Lack of interest from top management	Top management support in the form of support and commitment.	GI	O	2, 7, 12, 15, 16, 17
KR3	Lack of understanding of different aspects of recycled materials.	Stakeholders understand the different aspects of material recycling. These differences include material composition, material damage, and material use patterns.	GI GD GMM	O, D, C, S	4
KR4	Unclear understanding of the benefits of deconstructing building	Stakeholders' understanding of the benefits of the deconstruction process in implementing reverse logistics is still lacking.	GI GD GMM GC GOM	O, D, C, CS, S	4

No.	Barriers	Operational Definition	PLC*	Stkh**	Ref***
KR5	Lack of Open-mindedness towards the use of recycled materials	Customers are not willing to use recycled material, which due to the RL process. Or The contractor is not willing to use recycled material, which is the result of the reverse logistics process.	GI GD GMM GC	O, D, C, CS, S	1, 3, 5, 6
KR6	Lack of environmental regulation awareness	Lack of knowledge about environmental laws and impacts that arise if you don't implement RL.	GI GMM	O, C, CS	5, 8
KR7	Consideration of the deconstruction process during the design phase	The ease of the deconstruction process is an essential consideration in designing buildings.	GD	D	1
KR8	Lack of understanding of challenges associated with deconstruction	Understanding the deconstruction process's difficulties at the end of the building phase is still lacking.	GD GC	D, C, CS	4, 10
KR9	Infrastructure readiness for RL implementation	The infrastructure owned by the company (tools, resources, skills) is not ready to carry out RL.	GC	C, CS	1, 11, 13
Government support					
GS1	Governmental support for the implementation of RL	Support from the government to encourage companies to implement RL	GI	G	1, 8, 14, 17
GS2	Lack of support from legislations and regulations	Policies and regulations that do not support reverse logistics.	GOM	C, CS, G	3, 14
Operational issue					
OR1	The uniqueness of each building for deconstruction	Each building has unique characteristics in the deconstruction process (e.g. the sequence of the process) to be challenging to do standard best practice.	GC	C	3
OR2	Low cost for disposal of material	Cost for disposal materials is cheap.	GC	C, S	3, 7
OR3	Buildings are not designed for easy dismantling	The building does not have a design that is easy to dismantle.	GC	C, CS	3
OR4	Lack of skilled worker in the RL process	Expert workers in the deconstruction process are rare.	GC GOM	C, SC	7, 12, 15

*GI: □ Green Initiation; GD:□ Green Design; G□ : Green Material Management; GC□ : Green Construction; GOM:□ Green Operation & Maintenance

**O: Project Owner; D: Designer/Architect; C: Contractor; G: Government; S: Supplier: CS □ Supervising consultans

***1: Chinda, 2017; 2: Ali et al., 2018; 3: Hosseini et al., 2015; 4: Chileshe et al., 2016; 5: Govindan & Bouzon, 2018; 6: Govindan & Hasanagic, 2018; 7: Waqas et al., 2018; 8: Moktadir et al., 2019; 9: Schultmann & Sunke, 2005; 10: Rezaei, 2015; 11: Nunes et al., 2009; 12: Kaviani et al., 2020; 13: Kumar & Dixit, 2018; 14: Caiado, Guarnieri, Xavier & Chaves, 2017; 15: Hosseini et al., 2014; 16: Huscroft, Hazen, Hall, Skipper & Hanna, 2013; 17: Wong, Chan & Wadu, 2016

Table 2. Compilation of barriers from study literature

4.1.2. Calculation Result

The literature study results will then be compiled into a barrier assessment questionnaire with a Likert scale of 1 to 5. The results of the five respondent's assessments were then be processed using the TOPSIS method. The calculation steps in this study are as in Figure 2. Table 3 shows that this calculation produced the order of the barrier's effect from each phase.

Code	Ri	Rank
Market & Competitor		
M1	0.107958	36
M2	0.218952	17
Policy issue		
PI1	0.257789	10
PI2	0.053023	38
PI3	0.184571	22
PI4	0.147474	27
PI5	0.116714	32
PI6	0.164318	24
PI7	0.076692	37
PI8	0.116714	33
PI9	0.115812	34
Supply chain process		
SC1	0.139481	28
SC2	0.115812	35
SC3	0.139481	29
SC4	0.228419	15
SC5	0.24413	13
SC6	0.156326	25
SC7	0.178929	23
SC8	0.414014	6

Code	Ri	Rank
Knowledge Issue		
KR1	0.19259	21
KR2	0.29392	9
KR3	0.31499	8
KR4	0.34515	7
KR5	0.23779	14
KR6	0.22459	16
KR7	0.25662	11
KR8	0.25662	12
KR9	0.12508	31
Government support		
GS1	0.77725	1
GS2	0.14877	26
Economic issue		
ER1	0.68356	2
ER2	0.41586	5
ER3	0.43992	4
ER4	0.21718	20
Operational issue		
OR1	0.21895	18
OR2	0.46924	3
OR3	0.21895	19
OR4	0.13948	30

Table 3. Barrier rank, the result from TOPSIS calculation

4.2. Analysis

Before implementing reverse logistics in a project, either in the manufacturing or construction sector, seeing the obstacles is very important. This knowledge will help companies build solutions to reverse logistics performance (Prajapati et al., 2019a). Based on the ranking results of the TOPSIS calculation, the seven barriers with the highest order will be the subject of discussion in this sector. Barriers have to do with the PLC phase with relevant stakeholders, stakeholders with relevant strategic factors, and the PLC phase with relevant topics. Identifying the relationship between the barrier of Reverse logistics performance with PLC, stakeholders, and the relevant issue can be seen in Figure 8.

Based on the ranking results using the TOPSIS method, it is found that the barriers are the most influential in inhibiting the implementation of RL. Table 4 shows the seven barriers that most influence the successful performance of reverse logistics.

Rank	Barrier/Code	Issue	PLC*	Stakeholder**
1	Governmental support for the implementation of RL/GS1	Government support	GI	G
2	Cost reduction from the use of recycled materials/ER1	Economic	GI, GMM & GOM	O, C & S
3	Buildings are not designed for easy dismantling/OR3	Operational	GC, EOL	C, SC
4	Lack of interest in investment/higher initial cost/ER2	Economic	GI & GC	O, C, & S
5	Financial constraints (high operational cost)/ER3	Operational	GMM & GC	C & S
6	Complexity in operation/SC8	Supply chain	GC & GOM	C & SC
7	Consideration of deconstruction process during the design phase/KR7	Knowledge	GD	D

*GI: Green Initiation; GD: Green Design; GMM: Green Material Management; GC: Green Construction; GOM: Green Operation & Maintenance; EOL: End of Life

**G: Government; O: Owner; C: Contractors; S: Supplier; D: Designer

Table 4. Top seven barriers in RL implementation

The project life cycle approach in the construction sector aims to handle all the details of the current project when the project is broken down into various phases, so mapping the barriers based on the phases in the project life cycle will make it easier for stakeholders to overcome these barriers and it gives understanding on RL barriers. Figure 8 shows that barriers can be identified by looking at the appearance of barriers based on three angles, such as (1) the project life cycle and the stakeholders involved in each phase in the project life cycle, (2) the emergence of barriers when viewed from the related problems and stakeholders who have the responsibility to resolve these barriers and (3) the appearance of barriers in the project life cycle associated with strategic factors. The reason for analyzing the barrier from three points of view is (1) Identifying barriers from the stakeholder's point of view aims to identify stakeholders responsible for overcoming these barriers, (2) Identifying barriers based on strategic factors in Construction RL aims to anticipate the barriers that arise when linked to developments in the construction sector and (3) Identifying barriers from the PLC's point of view aims to determine the right time to overcome the barriers Stakeholders involved in this study were owners, designers, contractors, surveillance consultants, suppliers, and the government. Wibowo et al. (2018) proposed a conceptual approach using a project life cycle approach to implement green supply chain management in the construction sector. The green supply chain concept from Wibowo et al. (2018) consists of five stages: (1) the green initiation stage, (2) the green design stage, (3) the green material management stage, (4) green construction, and (5) green operation & maintenance (Wibowo et al., 2018).

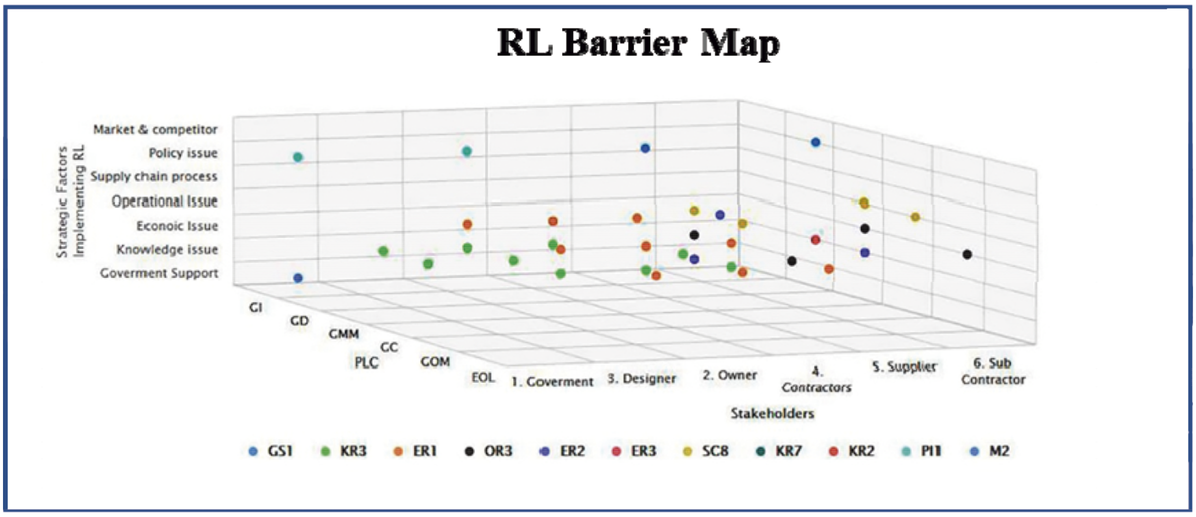

Figure 8. Illustration from RL barriers identification result

Each phase in the project life cycle involves different stakeholders, as shown in figure 9. Therefore, the project life cycle concept in green supply chain management is used to identify barriers. The reason is that reverse logistics implementation must be integrated with the implementation of green supply chain management. This reason is supported by Marsillac (2008), which examined the integration of reverse logistic practices with green supply chain management in the manufacturing sector (Marsillac, 2008). Marsillac (2008) argued that the application of reverse logistics and green supply chain management has the same goal in managing the product life cycle (in the manufacturing context) or the project life cycle (in the construction context). This assumption shows that when a company implements a reverse logistics design, its supply chain must also be adjusted to optimal performance. From this perspective, if there is a disturbance with the obstacle handling process, the barriers to implementing reverse logistics must also be mapped based on the project life cycle concept. Figure 9 shows project life cycle and stakeholders in each phase.

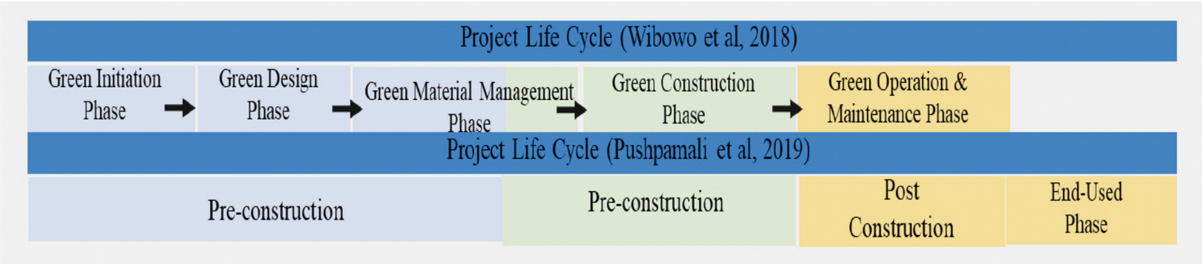

Figure 9. Project Life Cycle & Stakeholders

4.2.1. Project Life Cycle and Stakeholders Perspective

Projects in the construction industry are temporary and following a specific cycle called the project life cycle. This cycle starts from pre-project to post-project (Wibowo, Handayani, Nurdiana & Sholeh, 2017). Generally, the project life cycle consists of the initiation phase, the design phase, the material management phase, the construction phase, and the operation and maintenance phase (Wibowo et al., 2018). The project involves the various stakeholders in each phase of the Project Life Cycle (Wibowo, Handayani, Farida & Nurdiana., 2019). Therefore, the project's success depends on the stakeholder's active participation (Serrador & Rodney-Turner, 2014).

Stakeholders in every project life cycle have a role in the success of a green project. Planning and needs analysis are stages in project initiation (Dwivedi, 2021). This stage is a fundamental force to encourage the implementation of green projects. Stakeholder participation will increase efficiency (Dwivedi, 2021) in achieving project objectives, such as implementing green and sustainable concepts (Fu, Dong, Ge, Xiong & Gong, 2020). The application of reverse logistics in green projects is one approach to achieve sustainable construction. However, the successful implementation of reverse logistics faces several obstacles related to stakeholders' perspectives in the phases of the project life cycle.

4.2.1.1. Green initiation & Stakeholders (Government, Owner, Contractor and Suppliers) Perspective

The green initiation phase is the stage of determining the project concept, the dominant stakeholder in the green initiation phase is the owner. The owner has a role in determining the idea and specifications of the project. In addition, the owner plays a role in providing understanding to other stakeholders to collaborate in implementing reverse logistics in particular and green projects in general. Governmental support for the implementation of RL (GS1), Cost reduction from the use of recycled materials(ER1), and lack of interest in investment/higher initial cost (ER2) are barriers that hinder the implementation of the reverse logistics concept at the beginning of the project.

Figure 8 shows that Governmental support for the implementation of RL is a barrier related to regulations set by the government. Governmental support can be in the form of policies that encourage the implementation of reverse logistics. Government support can take tax cuts (property tax, building, and construction tax, income tax (buyers), and corporate tax) specifically for projects that apply the green concept. This unique policy is one of the media to promote green concept projects (Díaz-López, Navarro-Galera, Zamorano & Buendía-Carrillo, 2021). Overcoming the issue of governmental support barriers will affect the owner's decision at the green initiation phase. Government stakeholders are involved at earlier stages to ensure compliance related to the green principle at the project (Robichaud & Anantatmula, 2011).

Owners are stakeholders who have a dominant role in making decisions about RL implementation (Ho, Choy, Lam & Wong, 2012; Zhang, Li, Olanipekun & Bai, 2019) to realize sustainable construction (Zhang et al., 2019). The owners of a construction project are the government (for projects funded by the government) or private owners (for private parties' projects). The owner has set project goals and priorities at the initiation stage before green concepts and ideas enter the feasibility study stage. At the initiation stage, the owner considers the feasibility of implementing the project, especially from an economic perspective. In the feasibility study stage, obstacles in the form of investment costs for implementing reverse logistics are pretty high; this affects the owner's decision to adopt the reverse logistics concept in the project or not. Robichaud and Anantatmula (2011) revealed that governmental support in incentives, special taxes, and the determination of project permits that must apply green principles would reduce financial pressure from implementing green projects. Another effort to overcome the "high initial cost" problem is to plan green projects from the beginning of the project to minimize additional costs due to design changes at the construction stage. High initial cost arises the challenge of coordinating and communicating across a multidisciplinary team regarding project financial issues.

Figure 8 shows that the "lack of interest in investment/higher initial cost (ER2)" barriers involve the project owner, contractors, and suppliers. Contractors and suppliers are stakeholders who carry out the results of the project owner's decisions. Barriers "Higher initial costs" related to investment in equipment and technology to carry out the recycling process, for example, in the case of Jalan Penjagan -Losari. PT. TKL as a project contractor must pay to purchase a WIRTGEN machine to meet the criteria for using recycled materials that the owner has set. WIRTGEN Machine The WIRTGEN machine is needed to carry out the recycling process on the Losari-Penjagan Road project (see section 3.1 case illustration). Thus, lack of higher investment is related to high investment costs. If contractors and suppliers do not have the capital to purchase the necessary equipment, the implementation of reverse logistics will be hampered. Another impact of high investment costs is that the price of project work will be higher than ordinary materials, reducing profits and reducing interest in implementing reverse logistics.

Cost reduction from the use of recycled materials (ER1) are barriers that hinder the implementation of reverse logistics. Cost savings from recycled materials cannot offset the high amount of equipment and technology investment; this is a separate consideration for the owner to set a "reverse logistics application" clause in project contract documents (KAK and TOR). Contractors and suppliers will not carry out reverse logistics if there are no clauses in the KAK and TOR requiring suppliers and contractors to implement reverse logistics principles, such as using recycled materials.

Lack of governmental support for the implementation of RL (GS1), Cost reduction from the use of recycled materials (ER1), and lack of interest in investment/higher initial cost (ER2) affected in the absence of the owner's desire to implement RL (Govindan & Bouzon, 2018). The result of these three barriers is the lack of the owner's desire to make the supplier and contractor not implement the RL.

4.2.1.2. Green design & Stakeholders (Designer & Owner) Perspective

The green design phase is crucial in producing green buildings (Wibowo et al., 2019). The designer will realize the design according to the owner's goals and criteria, such as design for sustainability purposes or simplify the deconstruction process at the end of the project (Asharae, 2006). An essential role of a designer in a green project is to understand that green design offers long-term benefits. Designer goals can be achieved if the designer can realize an environmentally friendly plan and understand the concept of life cycle costs (Asharae, 2006; Kanters, 2018).

During the design phase (KR7), the deconstruction process is a barrier that appears at the green design stage. This obstacle is related to the unavailability of guidelines for making designs for deconstruction (Kanters, 2018). This guideline includes:

1. The effect of the overall building design.
2. The method of connectors and materials.
3. The need for preparation for the early design stage (deconstruction plan).

Other reasons why designers do not apply design concepts to deconstruction are the absence of regulations on used materials, increased cost of environmentally friendly designs, and long payback periods, which the owners do not tolerate (Kanters, 2018).

4.2.1.3. Green Material Management and Stakeholders (Contractors & Supplier)

Green material management is a phase related to the process of procuring goods and materials. Stakeholders who play a role in this phase are contractors and suppliers. The part of the supplier is to supply raw materials or provide services to launch projects. Contractors are stakeholders who can make a green project successful by providing preconstruction services. In addition, service preconstruction can be input to designers regarding the difficulties of implementing green projects in the construction phase (Ahn, Jung, Suh & Jeon, 2016). Therefore, suppliers and contractors are stakeholders who have a role in the successful implementation of green projects.

According to Fu et al. (2020), other stakeholders such as project owners have a significant influence on the behavior of suppliers and designers in implementing green behavior (such as the principle of reuse, recycle). In addition, government incentives also have a role in influencing project owner decisions (Fu et al., 2020). Based on the data collection results, there are two main barriers to the implementation of reverse logistics in the green material management phase. The two barriers are Cost reduction from the use of recycled materials (ER1) and Financial constraints (high operational cost) (ER3).

Cost reduction from the use of recycled materials (ER1) is related to the profit earned by the company. The process of recycling materials requires high costs; the price of recycled materials is high. This is related to the initial cost, which is relatively high. According to Govindan and Bozon (2018), to reduce the cost of recycling products, adopting the concept of design for remanufacturing, recycle or disassembly will facilitate the disassembly process at the end of the product's life so that that recycling costs can decrease. The construction sector can adopt the concept of design for remanufacturing from the start, as in Govindan and Bouzon's (2018) research; implementing design for deconstruction since the initiation phase will facilitate the deconstruction process that recycling costs can be reduced (Govindan & Bouzon, 2018).

The concept of design for disassembly since the project initiation phase is also a solution to increase the economic value of the material at the end of its useful life so that the profit obtained at the end of life becomes another effort to reduce the "high operational cost" barrier.

"High operational costs and financial constraints" barriers related to procurement activities in the construction sector. The main activity in procurement is supplier selection. Procurement practices in traditional projects are different from procurement practices in green projects. Procurement in traditional projects applies the concept of a win-lose relationship (choosing the lowest price supplier), while green projects offer the idea of partnering. Partnering is not a contract but an endeavor to establish non-adversarial working relationships through open communication and mutual commitment among project participants. Achieving good performance from financial and environmental aspects are the purpose of partnering in a green project (Mokhlesian, 2014).

Partnering relationships are a means of transferring knowledge between suppliers and contractors that awareness of the importance of the green concept is essential. Understanding will lead to trust and a commitment between contractors and suppliers to adopt the green concept (green supply chain, reverse logistics). Commitment will create a collaborative relationship, and cost savings will be made through collaboration to improve work operations' effectiveness that the partnership's impact will balance the high initial cost. The current procurement practice still applies the win-lose concept; there is no collaboration between suppliers and contractors to reduce costs.

4.2.1.4. Green Construction and Stakeholders (Contractors & supplier)

Green construction is the set of processes by which a profitable and competitive industry delivers built assets (buildings, structures, supporting infrastructure, and their immediate surroundings), allowing the following benefits: enhance the quality of life and offer customer satisfaction; offer flexibility and the potential to cater to user changes in the future; provide and support desirable natural and social environments; and maximize the efficient use of resources (Shurrab, Hussain & Khan, 2019). The green construction phase is a phase related to the process of realizing the design into a building. Green construction differs from conventional construction because of differences in its underlying principles and use of environmentally-friendly materials and technologies (Mokhlesian, 2014). The dominant stakeholders are contractors.

Based on the data processing results, the obstacle to the implementation of reverse logistics in the green construction phase is that Buildings are not designed for easy dismantling (OR3). Buildings that do not apply the DFD concept will not be able to extend the life of the building at the end of the use phase; the DFD concept must be implemented from the design stage (Akinade, Oyedele, Oyedele, Davila-Delgado, Bilal, Akanbi et al., 2020). Barrier OR3 is related to the designer's role in making environmentally friendly concept designs (Sang, Liu, Zhang, Zheng, Yao & Wang, 2018).

Barrier OR3 "Building are not designed for easy dismantling" is the impact of the lack of stringent legislation and policies on DFD (Akinade et al., 2020). Furthermore, the absence of a procedure for implementing DFD is seen in the absence of design criteria, which must apply the concept of DFD in green building assessments (Green building council, 2014). This results in the low awareness of designers, causing difficulties in the deconstruction process in the green construction phase.

Another barrier that hinders the implementation of reverse logistics at the green construction stage is complexity in operation (SC8). The complexity of the green construction phase can be viewed from both the demand and supply sides. On the demand side, the demand for recycled materials is minimal and increases demand uncertainty (Govindan & Hasanagic, 2018), thereby increasing the complexity in managing the recycled material supply chain. This is in line with the results of research by Akinade et al. (2020). The lack of a large enough market for recovered components is one of the barriers to using recycled materials in green projects. From the supply side, the lack of information about recoverable materials adds to the complexity of the procurement. Uncertainty in demand/supply adds to the complexity of recycled material management (Duque Ciceri, Sperandio & Garetti, 2009), affecting the contractor's desire to implement reverse logistics.

Supply and demand uncertainty is related to the source control activities, availability of distribution points for material sales, quality assurance, product standardization and specification, product certification, ease of material transportation, availability of storage facilities, access to market (Akinade et al., 2020). The expansion of the market will increase the demand for recycled materials, but the demand must be balanced with supply. In addition, the deconstructed material must meet market standards and not be damaged during the deconstruction process. This means that the building must think about ease of deconstruction (Akanbi, Oyedele, Omoteso, Bilal, Akinade, Ajayi et al., 2019; Akinade et al., 2020).

According to Akindae (2020), contractors prioritize relationships with owners compared to suppliers, and this attitude causes losses in reducing costs. Implementing RL from a financial perspective is an initial cost, but the opportunity to share the investment costs of equipment and technology to implement RL is an alternative to reduce costs.

4.2.1.5. Green Operation & Maintenance and Stakeholders (Contractors & Owner)

Green operation & maintenance is a phase after green construction. One of the focuses in operation and maintenance phase is understanding the need for the future generation to reuse and recycle components (Wibowo et al., 2018). In this phase, the contractors have handed over the building to the owner so that decisions regarding materials during the operations and maintenance phase are the owner's responsibility. If the owner decides to use recycled materials during maintenance, this decision will increase the demand for recycled materials.

Cost reduction from recycled materials (ER1) and Complexity in operation (SC8) are obstacles to the implementation of reverse logistics in the green operation and maintenance phase. Barrier ER1 is related to the cost savings obtained from recycled materials (Hosseini et al., 2013b). Complexity in operation is associated with the unavailability of information about green suppliers (Govindan & Hasanagic, 2018) (suppliers that provide recycled materials), making it difficult for owners to recycle materials in the maintenance process.

4.2.1.6. End of used phase (Owner)

Extending the life of the material at the end of the used phase is the goal of implementing reverse logistics. The ability to carry out the deconstruction process without damaging the material is important to ensure recycled material supply. Pushpamali et al. (2019) explained that the success of reverse logistics implementation depends on the owner's decision (Pushpamali et al., 2019).

The barrier that appears at the end-of-life phase is that buildings or highways are not designed for easy dismantling (OR3). The impact of designs that do not use the DFD concept is the high cost of deconstruction (Kanters, 2018) and sorting, reusing, and recycling materials (Chinda, 2017). Since the initiation phase, the reverse logistics implementation agreement will overcome the difficulties of the deconstruction process at the end of the life phase.

4.3. Strategic Factors in Construction RL Barriers and Stakeholders.

The successful implementation of reverse logistics cannot be separated from a company's goals, such as becoming a company with a green image. The company will develop a strategy to achieve the goals that have been set. Drivers and barriers affect the success of the company's strategy implementation, such as the reverse logistics implementation strategy. Considering these influential factors is essential to create a comprehensive industrial strategy in implementing RL (Govindan & Bouzon, 2018).

Strategic factors in Construction RL Barriers are factors that must be considered to achieve organizational goals. The strategy implemented of RL in one the company must have the ability to accommodate the strategic factors. Reverse logistics is an alternative strategy to overcome the waste problem (Wardani, Handayani & Wibowo, 2021). Figure 8 shows seven classifications of barriers based on the strategic factors in this study. The seven classifications are (1) Markets and competitors image, (2) Policy issue, (3) Supply Chain Process, (4) Economic issue, (5) Knowledge issue, (6) Government support, and (7) Operational factors. Barriers with the highest scores are mainly in the operational factors group. Owners, contractors, and suppliers are stakeholders who dominate the barrier of operational factors.

Operational factors are related to the difficulty of owners, contractors, and suppliers in implementing reverse logistics. The implementation of reverse logistics on a functional scale is in 6R activities (reduce, reuse, recycle, recover, redesign and remanufacture) (Maqbool et al., 2019). Reuse and recycle are the most preferred options in implementing RL at the operational level. The ease of implementation of reuse and recycle activities depends on the concept of design for deconstruction applied to buildings (Akinade et al., 2020).

Contractors and suppliers are stakeholders who carry out material reuse and recycle activities, but these two stakeholders are very dependent on the owner's decision. These two stakeholders are responsible for overcoming the barrier "Buildings are not designed with DFD (OR3)". Barrier OR3 is the barrier with the highest score on the operational criteria. Barrier OR3 makes it difficult for contractors to carry out the deconstruction process so that suppliers have difficulty finding suppliers of recycled materials. This obstacle will be overcome if the designer applies the DFD concept. It starts from the design phase. The OR3 barrier shows that the current implementation of RL is still partial (not yet integrated). Barriers related to operational factors show the importance of collaboration between stakeholders in overcoming various RL implementation issues and problems in RL implementation that are not integrated.

4.4. Strategic Factors in Construction RL Barriers and Project Life Cycle

Figure 8 shows the strategic factors that arose during each construction phase. In the green initiation phase, barriers that arise are related to government support, economic factors, and operational factors. Obstacles related to factors knowledge dominate the green design phase. Financial and operational barriers dominate the green material management phase and the green construction phase. Barriers in the green operation & maintenance phase are related to operational factors, while at the end of life phase, barriers are related to operational factors.

Barriers GS1 "Governmental support for RL implementation" is the highest-ranking barrier related to government support factors. At the green initiation stage, the government's role as the owner can be manifested in the regulations that encourage government-owned or private projects to implement RL. A clause regarding the implementation of RL on the KAK or TOR is the private owner's role. Supporting the government as a stakeholder who binds the private sector in implementing RL can be stated in regulations, incentives, or particular loans. Lack of government regulations, such as directives for implementing RL, resulted in the absence of the owner's desire to implement RL (Govindan & Bouzon, 2018). Another example of a lack of regulation is the absence of government support in policies such as government policies regarding special incentives for projects that adopt green projects such as construction projects that apply reverse logistics.

Barriers KR7" consideration of deconstruction process during the design phase" are barriers in the issue knowledge category in the green design phase. These barriers relate to the DFD (design for deconstruction) created by the architect. DFD is the practice to ease the deconstruction processes and procedures through planning and design. Deconstruction is the process of demolishing a building but restoring the use of waste materials. The DFD process is a vital strategy to conserve raw materials (Cruz, Chong & Grau, 2015). However, existing buildings were not built to be deconstructed, and the designer's knowledge of deconstruction was minimal. In this case, the designer finds it challenging to understand the quality of the material in the final phase of life because information about the difficulty of the process experienced by the contractor is not conveyed at the design stage (Akinade et al., 2020).

The operational factors is the factors that dominate the green material management, green construction, and green operation & maintenance phases. Barriers that dominate these three phases are that buildings are not designed for easy dismantling (OR3) and have high operational costs (ER3). Barrier OR3 relates to the designer's ability to apply the concept of DFD, while barrier ER3 relates to cost components arising from reverse logistics.

The implementation of reverse logistics will lead to additional activities at the end of the life phase, resulting in RL costs. According to Dantata, Touran and Wang (2005), the application of reverse logistics causes deconstruction costs, demolition costs, labor costs in the deconstruction process, and the salvage value obtained. If the salvage value obtained is greater than the total cost of labor, deconstruction, and demolition, the company will benefit from the implementation of RL (Dantata et al., 2005).

4.5. Classify Barriers Based on Project Life Cycle, Stakeholders Perspective and Strategic Factors in Construction RL.

It is necessary to investigate the barriers that hinder developing countries from implementing reverse logistics practices and explore related opportunities that facilitate its adoption (Ahmed, Thaheem & Maqsoom, 2019). Based on the classification of the project life cycle, stakeholder perspective, and strategic factors in construction RL, there are seven barriers to the adaptation of reverse logistics. The project life cycle approach in the construction sector aims to handle all the details of the current project when it is broken down into various phases; mapping the barriers based on the phases in the project life cycle will make it easier for stakeholders to overcome these barriers. Figure 8 shows that barriers can be identified by looking at the appearance of barriers based on three perspectives, such as (1) the project life cycle and the stakeholders involved in each phase in the project life cycle, (2) the emergence of strategic factors RL construction when viewed from the related problems and stakeholders who have the responsibility to resolve these barriers and (3) the barriers in the project life cycle associated with strategic factor in construction RL. The reason for analyzing the barrier from three points of view is (1) Identifying barriers from the stakeholder's point of view aims to identify stakeholders responsible for overcoming these barriers, (2) Identifying barriers based on Strategic factors in construction RL aims to anticipate the barriers that arise when linked to developments in the construction sector and (3) Identifying barriers from the PLC's point of view aims to determine the right time to overcome the barriers Stakeholders involved in this study were owners, designers, contractors, supervisor consultants, suppliers, and the government. Wibowo et al. (2018) proposed a conceptual approach using a project life cycle approach to implement green supply chain management in the construction sector. The green supply chain concept from Wibowo et al. (2018) consists of five stages: (1) the green initiation stage, (2) the green design stage, (3) the green material management stage, (4) green construction, and (5) green operation & maintenance (Wibowo et al., 2018).

Government support for the implementation of RL (GS1) is a barrier that appears in the green initiation phase. The stakeholder who has the authority to overcome this barrier is government. Government support in the form of policies will affect the owner's decision at the green initiation phase. Owners are stakeholders who have a dominant role in making decisions about RL implementation (Ho et al., 2012; Zhang et al., 2019) to realize sustainable construction (Zhang et al., 2019). The construction project owner is the government (for projects financed by the government) or private owners (for projects by private parties).

Owners of construction projects are classified into two, namely government and private owners. Government is the classification for government-funded projects, while the private owner is for private party projects. At the green initiation stage, the government's role as the owner can be manifested in the regulations that encourage government-owned or private projects to implement RL. For example, a clause regarding the implementation of RL on the KAK or TOR is the private owner's role. Supporting the government as a stakeholder who binds the private sector in implementing RL can be stated in regulations, incentives, or particular loans. Lack of government regulations, such as directives for implementing RL, resulted in the absence of the owner's desire to implement RL (Govindan & Bouzon, 2018). Another example of a lack of regulation is the absence of government support in policies such as government policies regarding special incentives for projects that adopt green projects such as construction projects that apply reverse logistics. This statement is also in line with the results of Olubunmi, Xia and Skitmore (2016) that special incentives are essential in increasing the application of green development (Olubunmi et al., 2016). Another effort to realize government support can be in the form of particular loans (Zhang et al., 2019).

Particular loans for green project financing involved the government as a regulator and involved banking or financial institutions in applying the green economy concept. The green economic concept stimulates green corporate actions, such as reverse logistics (Li, Zheng, Zhang, & Cui, 2020). In green finance, banks consider the company's ability to manage its business processes in an environmentally friendly and sustainable manner as the primary basis for obtaining loans and refusing loans for polluting companies (He, Zhang, Zhong, Wang & Wang, 2019) and do not manage the waste generated along the process. Special incentives can be in the form of tax deductions for green projects that implement reverse logistics, while particular loans can be in the form of special interest rates for green project financing capital loans. The government's GS1 barriers can be resolved through the right policies to foster the owner's desire and commitment to implement sustainable construction in general and reverse logistics in particular.

ER1 (cost reduction from recycled materials) is a barrier that appears in the phases of green initiation, green material management, and green operation & maintenance. Barrier ER1 involves the owner, contractor, and supplier. From the owner's point of view, in the green initiation phase, the cost savings from using recycled materials from reverse logistics do not provide significant cost savings compared to virgin material. This is supported by the opinion of respondent number four that there are no-cost savings obtained when using recycled material on a road construction project raises reluctance to reuse recycled material in the next project. From the contractor and supplier's side, the use of recycled materials does not provide cost savings. This is because the price of virgin material, especially in Indonesia, is lower. Based on respondents' numbers 2 and 3, the price of recycled materials is higher due to limited equipment and the unavailability of infrastructure in the reverse logistics process, resulting in expensive material recycling prices.

In the green construction phase, the contractor is a stakeholder responsible for overcoming the OR3 barrier. This difficulty is because the building does not apply DFD (design for deconstruction and dismantling) (Chinda, 2017). The existence of the DFD concept is because RL is not integrated since the beginning of the project. This is in line with research from Pushpamali et al. (2019). Therefore, overcoming this barrier requires collaboration between stakeholders since the green initiation phase.

Higher initial cost (ER2) is a barrier in the green initiation and green construction phases. The project owner, contractor, and consultant supervision are stakeholders associated with this barrier. High operational cost (ER3) is another barrier related to economic factors. These two barriers arise due to limited equipment and the unavailability of infrastructure. High operational costs in reverse logistics include: 1) labor cost, 2) inventory cost, 3) transportation cost: distances from site to site affect the transportation cost and the project budget, 4) processing cost, 5) specific sorting machine, 6) specific technology to implement RL, 7) matured market, 8) landfill charge and 9) availability of landfill (Chinda et al., 2013), the details about the nine cost components can be seen in Chinda, Kaewpitak, Supsinpaibool, Virivaroj and Tangbunjardvanich (2013).

The deconstruction process during the design phase (KR7) is a barrier that appears in the green design phase. The designer is a stakeholder who has an essential role in overcoming this phase. This barrier arises because of the absence of design criteria with the DFD concept at the green initiation stage. Thus, the designer does not create construction objects with the DFD concept. This barrier can be overcome with the DFD criteria proclaimed by the project owner at the project initiation stage. Ease in the deconstruction process depends on the design of the construction object itself. The ease of the deconstruction process will reduce the cost of RL, which is considered relatively high, and supported by the results of research from Chinda (2017), where the highest costs in the RL process are related to material deconstruction and sorting activities. The case of the deconstruction process will indirectly help overcome the OR3, ER2, ER3, and SC8 barriers. Therefore, it can be concluded that for RL to be easy to implement, integration and collaboration between stakeholders involved in every phase of the project life cycle in the construction sector are needed.

5. Theoretical Impaction

From a theoretical point of view, this study explores the barriers to implementing reverse logistics in the construction sector. This research has several main contributions related to reverse logistics. One of the contributions of this research is to develop the concept of barrier identification based on the project life cycle is process approach in the construction sector. The concept of identification of barriers in this study is expected to provide knowledge about significant barriers in the green initiation phase, green design, green material management, green construction, and green operation & maintenance, as well as stakeholders who have the responsibility to overcome these barriers. This study fills the gap where there is a lack of research on lifecycle-based RL barriers. This research analyzes barriers based on the PLC approach, stakeholder perspective, and strategic factors of RL Construction (see Figure 8)

Theoretically, this research offers a new concept in identifying barriers based on the stakeholders' point of view, project life cycle, and strategic factors for RL in construction. The results of the analysis of obstacles in this research are presented in the form of 3D diagrams. However, this concept rarely describes the results of the study of barriers in 3D.

6. Conclusion

This research states that there are factors of barriers to implementing reverse logistics in construction sectors. Stakeholders who have a role in overcoming the barriers are owners, government, contractors, supervisory consultants, suppliers, and designers, while strategic factors to reverse logistics include: 1. Markets and competitors-related factors, 2. Policy-related factors, 3. Supply chain processes, 4. Economic-related factors, 5. Knowledge-related factors, 6. Government support factors, and 7. Operational associated factors. The most significant factor is government support, while the most influential stakeholders in the successful implementation of reverse logistics are the government and the project owner.

Based on the study results, there were 38 barriers to the implementation of reverse logistics in the construction sector. Based on identifying the barrier at the green initiation phase, government support for RL's performance is the most significant barrier. The deconstruction process during the design phase is the most significant barrier to the green design phase. Lack of cost reduction from recycled material is a dominant barrier in the green material management phase. The green construction phase barrier is a building that is not designed for easy dismantling. Finally, complexity in operation is a barrier in the green operation and maintenance phase. Integration and coordination between stakeholders in each PLC phase are essential in overcoming the barriers.

Further research examines barriers based on the project life cycle by entering the company scale, or a study about the relationship between barriers can also be done. Incorporating the company scale element in leveling out the barriers aims to identify specific barriers at different company scales. An analysis can also be done with other SEM or ISM methods to understand the relationship between the barriers. Developing a suitable strategy to mitigate barriers in implementing reverse logistics can also be used as further research.

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