Chapter 1

Introduction

1.1 Research Background

Waste has been an issue in recent years, according to Filipenco (2025), 3.825 tons of waste are created every minute and huge volumes end up in landfills or open dump sites. In addition to that, there is an expectation of an increase in solid waste by nearly 2 billion tons, and by 2025, will reach 3.8 billion tons. The rapid growth of waste creates a serious challenge for urban waste management systems, particularly in rapidly growing cities and metropolitan areas (Zohoori & Ghani, 2017).

In Indonesia, nationally, waste generation has exceeded 65 million tons per year (BPS-Statistic, 2018). And according to Suwarno (2025), only 10% of Indonesia's garbage is sorted for recovery and recycling; the majority of this work is done by the unorganized sector. High-value items are mostly the focus when collecting recycled materials, but nevertheless it will become less attractive if the materials are contaminated. It's also important to note that in emerging cities like Jakarta, there are still major obstacles related to the system sustainability and municipal waste management service capacities (Chaerul et al., 2024; Aksoy & San, 2019). And because of that, Indonesia is currently facing a significant pressure in waste management, this is due to the increase in production and consumption activities (Saraswati et al., 2025).

In addition to the waste collection issue, there is a critical obstacle that lies in the management of the recycled materials supply chain in Indonesia. According to Noor et al., (2020), waste production has increased drastically as a result of urbanization. And typically the parties that

are in charge of urban areas are often informal and poorly documented. According to de Jong et al. (2026), in most developing nations, informal waste pickers are quite common in bigger cities and contribute significantly to the reuse and recycling of materials. It is also known that the informal sector's operations are "invisible," nothing is known about how much contribution is given (Ravisandiran et al., 2023).

The current system for waste management is facing challenges such as transparency and accountability, creating mistrust and inefficiencies (Kumar et al., 2024). Within this system, there is no traceability regarding the materials collected; the origin of the materials remains unknown, and there is no mechanism to assess associated risks.

The lack of transparency and traceability of the systems can be a problem in the long run. Improving these measures can help reduce future risks such as contamination risks (Knapp et al., 2017), improve accountability (Faiz et al., 2020), and ensure that materials labeled as recycled truly originate from recycling processes. In addition, according to Leslie et al. (2025), recent research has identified inconsistent, incomplete, and misunderstood waste management data as critical barriers to effective public reporting and accountability, with conflicting data sources and incomplete disclosures preventing even basic material flow analysis in major urban centers.

Implementing blockchain-based traceability systems offers a promising pathway to strengthen the recycled materials supply chain. Through its capacity to enhance transparency and traceability, blockchain technology delivers the assurance that has been consistently absent in recycled material supply chain management (Centobelli et al., 2022). This recognition underscores the need for empirical studies that examine how blockchain-based traceability models can support transparency and sustainability within the recycled raw material supply chain, particularly in the context of the greater Jakarta area, where such research remains scarce.

1.2 Research Problems

In recent years, the steady increase in consumption has led to growing concern over the surge of waste. By 2050, global waste production is forecasted to increase by 70%, escalating from 2.01 billion tonnes per year in 2016 to 3.40 billion tonnes annually (Kaza et al., 2018). Waste management in Jakarta relies heavily on the informal sector, where individuals collect materials from scraps from houses, grocery shops, companies, workplaces, schools, parks, dump sites, and landfills that are effectively collected (picked, purchased) by informal garbage workers (Duong et al., 2024). Within this system, there is no traceability regarding the materials collected; the origin of the materials remains unknown, and there is no mechanism to assess associated risks. As Gazeau et al. (2025) observe, the adoption of high-quality recycled materials is constrained by several persistent challenges: limited traceability systems, inadequate data standards, contaminated input streams, and inconsistent material quality. Once collected, data on recycled materials are recorded separately within each department that receives them, further fragmenting information and obscuring the overall material flow. According to Kirana et al. (2025), the scattered operations of temporary waste stations (TPS) around the nation present difficulties for waste management in Indonesia.

The broader supply chain management landscape in Jakarta has also been a persistent concern. Existing systems are not centralized but are instead distributed across various departments, each operating in isolation. Having a knowledge-driven, decentralized management and low efficiency has been the limitation of conventional recycling framework (Zuo & Cui, 2026). This fragmented structure creates “data silos,” where information is scattered across departments, lack of standardization in SCT (Sonar et al., 2025) and separate databases. Such fragmentation leads to a profound lack of visibility, fostering information asymmetry, operational inefficiencies, and an environment where fraudulent practices can thrive. In the case of supply chain finance (SCF), conventional SCF frequently faces information asymmetry that fosters an environment deemed

favourable to financial fraud, adverse selection and moral hazards (Jiang et al., 2025). Traditional systems exhibit critical flaws, including the inability to track historical data, reliance on a single administrator, vulnerability to unauthorized data manipulation, and the absence of real-time updates across parties. Hence, there are current challenges that are being faced such as the need for route optimization, data integration, intelligent classification and supply-demand (Zuo & Cui, 2026). In addition, according to Tytko & Alwaeli (2025), incorrect material categorization is a common problem for traditional waste collection systems, which lowers efficiency and increases contamination in recycling procedures. Consequently, transparency is compromised, as not all departments have real-time access to data, and unauthorized alterations can occur without detection.

To address these systemic shortcomings, there exists a significant opportunity to adopt technologies that prioritize decentralization and data integrity. Blockchain technology, in particular, offers a promising solution by enabling the establishment of a shared, tamper-proof ledger accessible to all authorized participants (Dong et al., 2023). Blockchain has already been successfully implemented across various sectors. In the food industry, it is used to trace products from the start (in the farm) to the end (being served), enhancing food safety and accountability.According to Rejeb et al. (2020), the integrity of credence claims (including sustainably sourced, organic, and faith-based labels such as kosher and halal) can be improved through blockchain by recording the authoritative source of the claim, which in turn reassures business clients and end users. Additionally, the model (blockchain-based traceability system) implementation offers real-time assurance, it will strengthen the market's claim of halal guarantee (Alamsyah et al., 2022). In healthcare, it facilitates the secure sharing of patient data across institutions. According to Xi et al. (2022), blockchain's decentralized and tamper-proof characteristics make it an effective instrument for managing healthcare data. Furthermore, data of patience are sensitive and could be the prime target of a cyber attack, securing these data is important in the healthcare industry (Hölbl et al., 2018). In logistics (Ar et al., 2019),

architecture (Kassem et al., 2025), and engineering (Kasten, 2020), blockchain has similarly helped revolutionize operations by introducing transparency, security and assurance into complex multi-party processes. These successful implementations demonstrate blockchain's potential to overcome key limitations inherent in traditional supply chain systems through its decentralized, tamper-resistant architecture that records every transaction in a transparent and verifiable manner.

Despite its growing adoption across industries, the application of blockchain in the supply chain of recycled materials remains underexplored, particularly within the context of developing regions and emerging markets. Recycled material supply chains are inherently complex, involving multiple stages such as collection, sorting, processing, and reselling the recycled materials (WasteMinz, 2025). Effective management of these processes requires accurate tracking to verify the origin, quality, and lifecycle of recycled inputs. However, existing systems consistently fail to provide the necessary level of transparency. This gap gives rise to a critical research problem: although blockchain technology offers theoretical advantages in enhancing traceability and transparency, its actual impact on the value of recycled material supply chains is not yet fully understood.

Recognizing the transformative potential of blockchain, this study aims to explore the perceived usage of blockchain technology in the supply chain management of recycled materials within the Jakarta Greater Area. By investigating stakeholder perspectives and current practices, this research seeks to contribute to a deeper understanding of how blockchain-enabled traceability and transparency can support waste management systems in developing urban contexts.

Table 1. Key theories of research importance

Author	**Title**	**Place of Publication**	**Main Findings**
Chittipaka et al. (2023)	Blockchain Technology for Supply Chains operating in emerging markets: an empirical examination	Annals of Operations Research	Adoption of blockchain technology in supply chains has the potential to greatly boost business

	of technologyorganization-environment (TOE) framework		performance by enhancing security, transparency, and trust among supply chain participants.
Park & Li (2021)	The Effect of Blockchain Technology on Supply Chain Sustainability Performances	Sustainability	Blockchain technology will become more widely used in supply chain management since it has the potential to enhance supply chain sustainability performance.
Centobelli et al. (2022)	Blockchain technology for bridging trust, traceability and transparency in circular supply chain	Information & Management	Blockchain's purpose as a technical tool for enhancing waste management and product return operations.
Dutta et al. (2020)	Blockchain technology in supply chain operations: Applications, challenges and research opportunities	Transportation Research Part E: Logistics and Transportation Review	Analyze 178 studies on supply chains using blockchain technology. Several Industries can be succesfully revamped with blockchain based technologies.
Bai & Sarkis (2020)	A supply chain transparency and sustainability technology appraisal model for blockchain technology	International Journal of Production Research	Blockchain technology holds potential for sustainable supply chains and supply chain management.
Bułkowska et al. (2023)	Implementation of Blockchain Technology in Waste Management	Energies	Blockchain with the poer of IoT can enchance efficiency and transparency of waste management systems Blockchain ensures transparancys among

			all stakeholders and the accuracy of tracking every products lifecycles.
Shojaei et al. (2021)	Enabling a circular economy in the built environment sector through blockchain technology	Journal of Cleaner Production	Blockchain is demonstrated to be a workable strategy for implementing a circular economy in the built environment. A circular economy in the built environment is suggested to be made possible by a blockchain network.

1.3 Research Question

Based on the research background and problem, the main questions surrounding this research are as follows:

1. How can technological factors influence blockchain-driven traceability adoption?
2. How do organizational factors influence blockchain-driven traceability adoption?
3. In what way can environmental factors influence the blockchain-driven traceability adoption?

1.4 Research Objective

To answer the research question, there are objectives that should be used to analyze in the study. The objectives are specifically:

1. To analyze the technological factor that influenced blockchain-driven traceability adoption.
2. To determine the organizational factor that influenced the blockchain-driven traceability adoption.

3. To examine the environmental factor that influenced blockchain-driven traceability adoption.

1.5 Hypothesis

These are the proposed hypotheses for this study:

H1: Technological Factor positively influenced the blockchain-driven traceability adoption in greater Jakarta

H2: Organizational Factor positively influenced the blockchain-driven traceability adoption in greater Jakarta

H3: Environmental Factor positively influenced the blockchain-driven traceability adoption in greater Jakarta

1.6 Research Outline

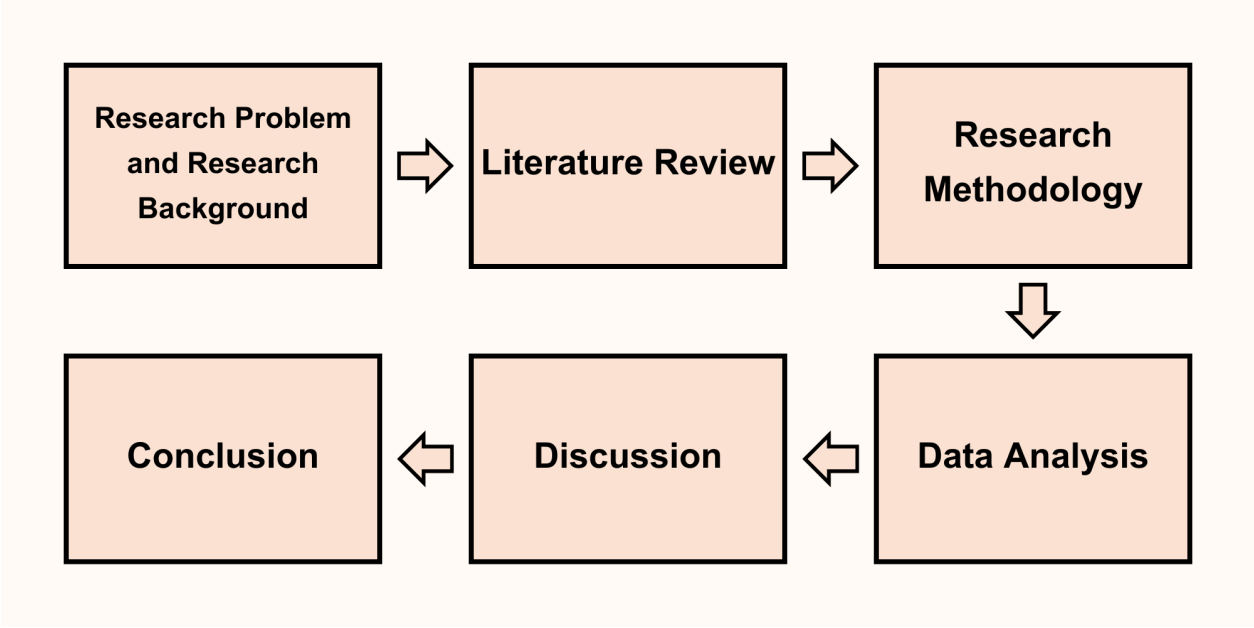

Figure 1. Research Outline