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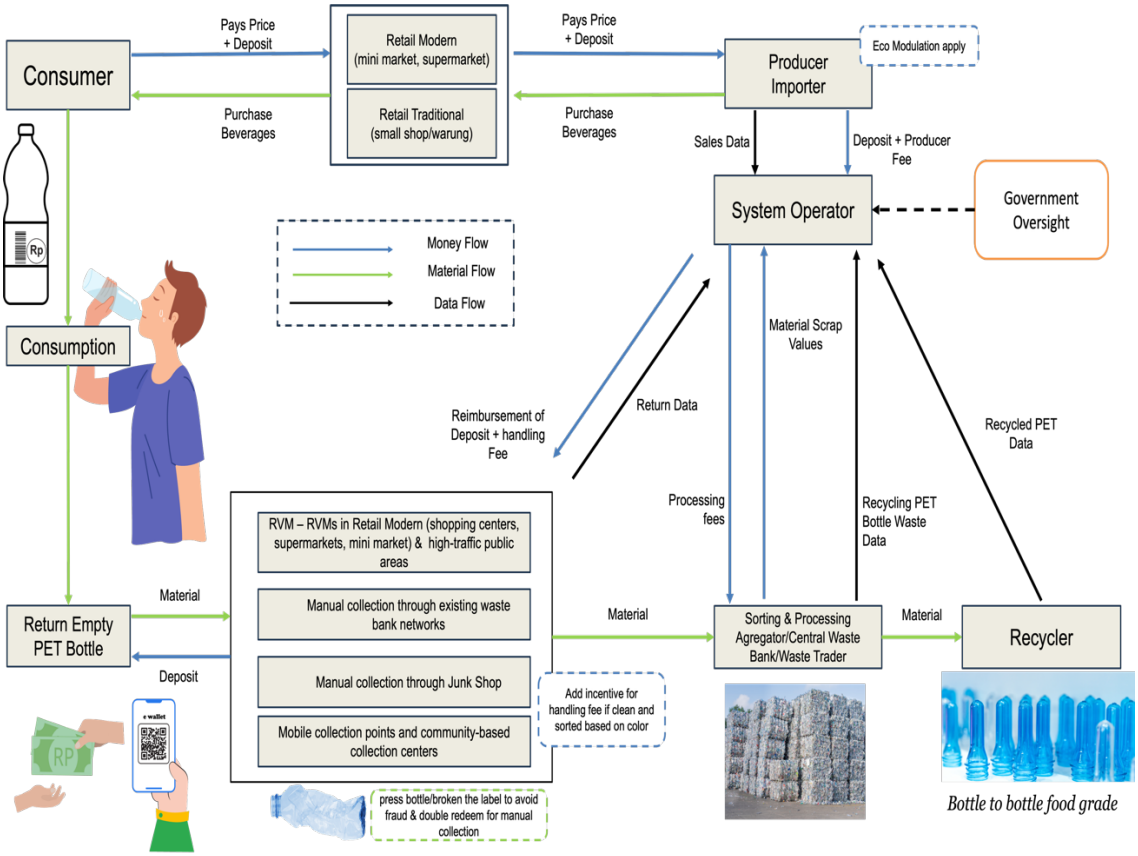
Exploring the Feasibility of Implementing Deposit Return System (DRS) on PET bottles in Indonesia *Lessons for Developing an Effective Extended Producer Responsibility (EPR) Scheme*



Environmental Management and Sustainability Science

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Master Thesis

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Abstract:

Indonesia faces challenges implementing Extended Producer Responsibility (EPR) for packaging waste, with only 20 out of 500+ companies implementing EPR programs. Despite achieving 71% PET bottle recycling, downcycling and poor material quality hinder circular economy goals. This research explores: How can a Deposit Return System (DRS) on PET bottles be implemented to strengthen the Extended Producer Responsibility (EPR) framework for packaging waste in Indonesia? The study employs qualitative comparative analysis of three cases: Dansk Retursystem (Denmark, 93% return rate), Plasticpay, and KIBUMI (Indonesia), using interviews, observations, and document analysis. Findings reveal DRS potential to improve collection quality and EPR compliance through a hybrid model integrating centralised governance with decentralised implementation. Key requirements include strong regulation, multi-channel infrastructure involving informal sectors, adaptive technology, flexible deposit mechanisms, and sustainable financial models with eco-modulation principles. The research proposes a three-phase implementation strategy beginning with pilot projects to build regulatory foundations and stakeholder consensus, potentially strengthening EPR through cost internalisation, enhanced accountability, and high-quality bottle-to-bottle recycling for Indonesia's circular economy transition.

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In the name of Allah, the Most Gracious, the Most Merciful,

To the blue whales that inspired my journey,
To my husband, who gave me the courage to pursue this journey,
To my family who supported me every step of the way,
To my mentor, my best friends who support me,
To my son, who gives me reason to protect our oceans,
And to Indonesia, whose marine life deserves a better future.

This research is more than an academic pursuit,
It is a personal goal that has become a mission,
Will ensure future generations witness the majesty of our oceans
Rather than inherit stories of what once was.

With profound gratitude for the path that led me here,
And for the countless hands that supported me along the way.

I remind myself*: “Dreams have no expiration date, Grow to great, great to humble."*

Preface and Acknowledgements

This Master's thesis was written as part of the 4th semester of the Environmental Management and Sustainability Science programme at Aalborg University, from February to June 2025. The research focuses on the potential implementation of a Deposit Return System (DRS) for PET bottles in Indonesia and explores how such a system could help strengthen the country's Extended Producer Responsibility (EPR) framework. By analysing case studies from Denmark and Indonesia, and learning from global practical experiences, this thesis aims to contribute to the development of more effective and inclusive plastic waste management policies.

The target audience for this thesis includes policymakers, environmental professionals, academic researchers, and others interested in sustainable waste governance, circular economy, and EPR system design.

This thesis would not have been possible without the support, guidance, and generosity of many people.

First and foremost, I wish to express my heartfelt gratitude to my supervisor Henrik Riisgaard and co-supervisor Stig Hirsbak for their invaluable guidance throughout this research journey. Their continuous support, constructive feedback, and encouragement have been essential in shaping the direction and content of this thesis.

I am especially thankful to Stig for arranging the interview and visit to Dansk Retursystem and for making it possible for me to meet Thomas Lindhqvist in Lund, an experience I will never forget. Henrik has also consistently challenged me to sharpen my critical thinking during my studies, and I am truly grateful to have learned from both of you.

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To my mentor, Pak Uso, and colleagues at the Directorate of Waste Reduction, Ministry of Environment, Indonesia, thank you for your continued support and trust. I hope this thesis contributes meaningfully to our shared efforts in strengthening EPR in Indonesia.

My sincere thanks to Mauro Garau for his peer support, insightful discussions, and encouragement throughout this academic journey, to Rima and Zahra for the warmth and friendship we shared while living abroad, and to my host family in Aalborg for their kindness and support during my time in Denmark.

There are many more people whom I wish I could name, but I hope this note reflects my deep gratitude. Every opportunity, conversation, and act of kindness along the way has helped me reach this point.

Signature
Eka Hilda Utami Lasmanatun

Reading Instructions

Document Structure

This research moves step by step from problem identification to proposed solutions. Each chapter builds on previous findings, but readers can use the navigation guide to jump to specific sections based on their interests.

Referencing and Citations

References follow standard academic format. Tables and figures are numbered by order of appearance (e.g., Table 1, Figure 2). A complete list of sources is provided in the Bibliography.

Key Information Locations

Background concepts:

Chapter 5 (Theoretical Framework) explains DRS, EPR, and circular economy principles that guide the analysis.

Research approach:

Chapter 3 and 4 detail how the study was conducted, including interview methods and case study selection.

Main findings:

Chapter 6 presents case studies, Chapter 7 presents analysis results, while Chapter 8 contains the proposed DRS model for Indonesia.

Supporting data:

Interview transcripts, detailed case study information, and additional analysis tables are available via the following link: https://bit.ly/SupportingData_EkaHilda

Abbreviations

Common abbreviations used throughout:
DRS: Deposit Return System
EPR: Extended Producer Responsibility
PRO: Producer Responsibility Organisation
PET: Polyethylene Terephthalate (plastic type)
RVM: Reverse Vending Machine
rPET: Recycled PET

Navigation Tips

Use the Navigation Guide to find the most relevant sections for your needs. Chapter 8 contains the complete proposed system if you want to jump directly to solutions.

Abbreviations

3R	Reduce, Reuse, Recycle
BSI	Bank Sampah Induk (Main Waste Bank)
BSU	Bank Sampah Unit (Waste Bank Unit)
DRS	Deposit Return System
EPR	Extended Producer Responsibility
HDPE	High-Density Polyethylene
IDR	Indonesian Rupiah
HORECA	Hotel, Restaurant and Cafe
IPRO	Indonesia Packaging Recovery Organization
KLHK	Kementerian Lingkungan Hidup dan Kehutanan
MoEF	Ministry of Environment and Forestry (Kementerian Lingkungan Hidup dan Kehutanan)
OECD	Organisation for Economic Co-operation and Development
PDU	Pusat Daur Ulang (Recycling Center)
PE	Polyethylene
PermenLHK	Peraturan Menteri Lingkungan Hidup dan Kehutanan (Regulation of the Minister of Environment and Forestry)
PET	Polyethylene Terephthalate
PP	Polypropylene
PRO	Producer Responsibility Organisation
PVC	Polyvinyl Chloride
rPET	Recycled Polyethylene Terephthalate
SMEs	Local Small and Medium Enterprises
SSP	Solid State Polycondensation
TKDU	Tingkat Kandungan Dalam Negeri (Minimum Recycled Content Requirement)
TPA	Tempat Pemrosesan Akhir (Final Processing Site/Landfill)
TPS	Tempat Penampungan Sementara (Temporary Collection Site)
TPS3R	Tempat Pengolahan Sampah Reduce, Reuse, Recycle (Reduce, Reuse, Recycle Waste Processing Site)
TPST	Tempat Pengolahan Sampah Terpadu (Integrated Waste Processing Site)
WTE	Waste-to-Energy

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1. Problem Analysis: Strengthening EPR for PET Bottle Waste through Deposit Return System in Indonesia

This chapter explores challenges in implementing Extended Producer Responsibility for PET bottles in Indonesia, reviews gaps in Ministerial Regulation P.75/2019, through Environmental evidence. It also introduces the Deposit Return System as a complementary tool to enhance packaging waste recovery and strengthen EPR in Indonesia.

1.1 Extended Producer Responsibility Implementation in Indonesia

Indonesia, ranking fourth globally in population, produced approximately 69.9 million tons of waste in 2023, with plastic waste accounting for 18.7% of total waste generation (MoEF Indonesia, 2024). As one of the largest contributors to marine plastic pollution globally, Indonesia faces significant challenges in managing post-consumer packaging waste.

Indonesia show commitment by targeting 70% reduction of marine plastic waste by 2025 and launched the National Action Plan in 2017 (The Government of Indonesia, 2017). This commitment became the basis for the development of Extended Producer Responsibility (EPR).

1.1.1 PermenLHK P.75/2019 as National EPR Framework

EPR is widely used in Europe, improving waste collection and recycling by shifting costs to producers and promoting sustainable design. It encourages producers to manage products' full lifecycle, supporting circular economy goals (Lorang et al., 2022; OECD, 2016).

Indonesia's EPR development began with Law No. 18/2008, reinforced by Government Regulation No. 81/2012 (Pramiati et al., 2021). The most significant step in implementing EPR occurred in 2019 with the issuance of the Minister of Environment and Forestry Regulation No. P.75/MENLHK/SETJEN/KUM.1/10/2019 (PermenLHK P.75/2019).

PermenLHK P.75/2019 outlines a 10-year roadmap targeting 30% waste reduction by 2029, focusing on Reduce, Reuse, and Recycle principles (Pairunan & Rabbow, 2022). It regulates phasing out plastic bags, straws, Styrofoam, and PVC, covering plastic, paper, aluminium, and glass packaging. Implementation involves packaging restrictions (R1), takeback for recycling (R2), and reuse (R3), with producers required to report progress to the government (Regulation Minister P.75, 2019).

Indonesia's regulations adopt EPR principles without explicitly naming 'EPR,' focusing on producer responsibility to reduce environmental impact across pre- and post-consumption stages (Sulami et al., 2023). This contrasts with general EPR concepts, which centers on producers' contribution and recycling in the post-consumption stage rather than efforts to reduce the amount of packaging marketed in the pre-consumption stage (Neeteson, 2021).

1.1.2 Implementation Challenges: 20 Out of 500+ Companies

PermenLHK P.75/2019 is still in its early implementation, with limited progress since its 2020 launch and ongoing challenges (Arisman & Fatimah, 2023).

Despite technical guidance to over 500 companies (Rahmat, 2024), only 52 submitted roadmaps and 20 implemented EPR programs by the end of 2024, highlighting low producer participation (Mintarsih et al., 2024). The table below shows current implementation levels:

No	Producer Category	Number
1	Producers who have created an account	95
2	Producers who have developed a roadmap (not yet approved)	52
3	Producers with approved roadmaps ready for implementation	21
4	Producers who have implemented	20

Table 1. Producer Participation in the Implementation of PermenLHK P.75/2019 (Mintarsih et al., 2024)

Industry responses to EPR vary. Multinational company like Unilever, Nestlé, and Danone have been more proactive, launching their own EPR projects due to global commitments and national roadmap obligations (Plastic Smart Cities, 2022). These companies have launched individual EPR projects to collect and recycle their packaging waste.

In contrast, medium and small domestic companies are considered to face difficulties in adopting EPR, mainly due to limited resources and lack of technical knowledge regarding sustainability practices. Many companies view regulations as an economic and administrative burden (Plastic Smart Cities, 2022).

1.1.3 Regulatory Weakness and Enforcement Gaps

The implementation of EPR in Indonesia faces various challenges in regulatory, structural, economic, and social aspects. To understand the main obstacles in the implementation of the EPR policy and formulate more effective solutions, it is important to identify these challenges systematically. According to Mintarsih et al., (2024), the implementation challenges can be categorised into four critical areas:

1. Regulatory enforcement gaps: weak monitoring mechanisms and insufficient sanctions
2. Structural barriers: limited infrastructure integration and informal sector exclusion
3. Economic constraints: high implementation costs and lack of clear incentives
4. Social challenges: low awareness and producer resistance

Further details on these implementation challenges are provided in supporting data.

Low participation shows the regulation's limited effectiveness, partly due to its ministerial status, which weakens enforcement. This has led to poor implementation, low producer compliance, and lack of system operators (Mintarsih et al., 2024).

While PermenLHK P.75/2019 establishes mandatory producer obligations, enforcement gaps create an accountability vacuum where producers face minimal consequences for non-compliance. The fundamental issue lies in the absence of structured monitoring mechanisms that can ensure compliance with existing mandatory requirements.

Recognising these shortcomings, the Indonesian Government is considering elevating PermenLHK P.75/2019 to Government Regulation or Law status and developing a formal EPR scheme (Sidik, 2025).

1.2 EPR Gaps and the Environmental Consequences: Branded Packaging Waste in Indonesian Waterways

Although Indonesia has adopted Extended Producer Responsibility (EPR) through Ministerial Regulation No. P.75/2019, branded packaging waste is still found in rivers and waterways (Sungai Watch, 2025). This situation indicates that regulatory provisions are not being effectively translated into improved waste management practices.

1.2.1 Sungai Watch Brand Audit: Brand Packaging Waste Composition Analysis

Sungai Watch's brand audit in specific locations (Bali and Banyuwangi) provides localised evidence that branded packaging waste continues to enter waterways despite existing EPR obligations.

The 2024 brand audit conducted by Sungai Watch analysed 623,021 pieces of branded plastic waste collected from rivers in Bali and Banyuwangi. The results showed that sachets (18%), plastic bottles made from PET (18%), and plastic cups made from PP (17%) were the most frequently found types of branded packaging waste in waterways (Sungai Watch, 2025). The audit also found that the top 10 companies contributed to 47% of all branded plastic waste, while the top 10 brands accounted for 27% of the total items collected (Sungai Watch, 2024). As shown in Figure 2, these three categories represented the largest shares of plastic packaging waste identified in the audit.

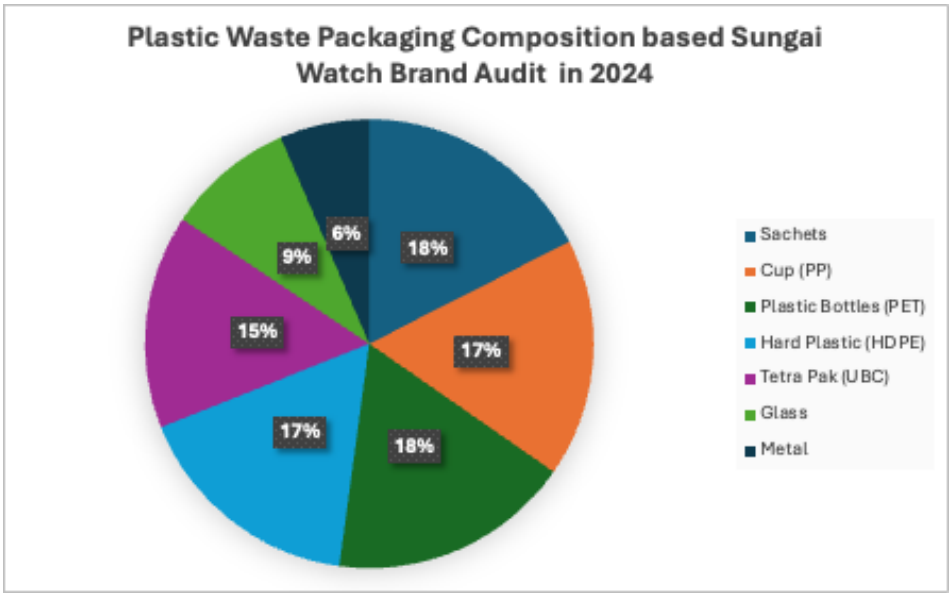

Figure 1. Plastic Waste Packaging Composition in Based Sungai Watch Brand Audit in 2024

While this represents a small sampling area, the presence of branded PET bottles in waterways shows that existing take-back obligations under PermenLHK P.75/2019 are not working effectively. This suggests that current EPR implementation mechanisms need strengthening, particularly for a waste stream with such high recycling potential.

1.3 Indonesia Solid Waste Management Context

The EPR implementation challenges occur within Indonesia's broader waste management constraints. According to a study conducted by the World Economic Forum in 2020, some of the main challenges in the waste management system include the low level of waste collection, the dominance of the informal sector, the low recycling capacity, and the gap in waste management infrastructure between regions (NPAP, 2020).

1.3.1 Infrastructure Challenges and Regional Disparities

NPAP analysis shows that 61% of plastic waste remains uncollected, with only 10% being recycled. Only 39% of waste is successfully collected, 24% through formal collection systems handled by local governments, 7% through informal channels, and 8% is recovered from landfills (NPAP, 2020). Figure 3 illustrates Indonesia’s the Plastic waste flow patterns.

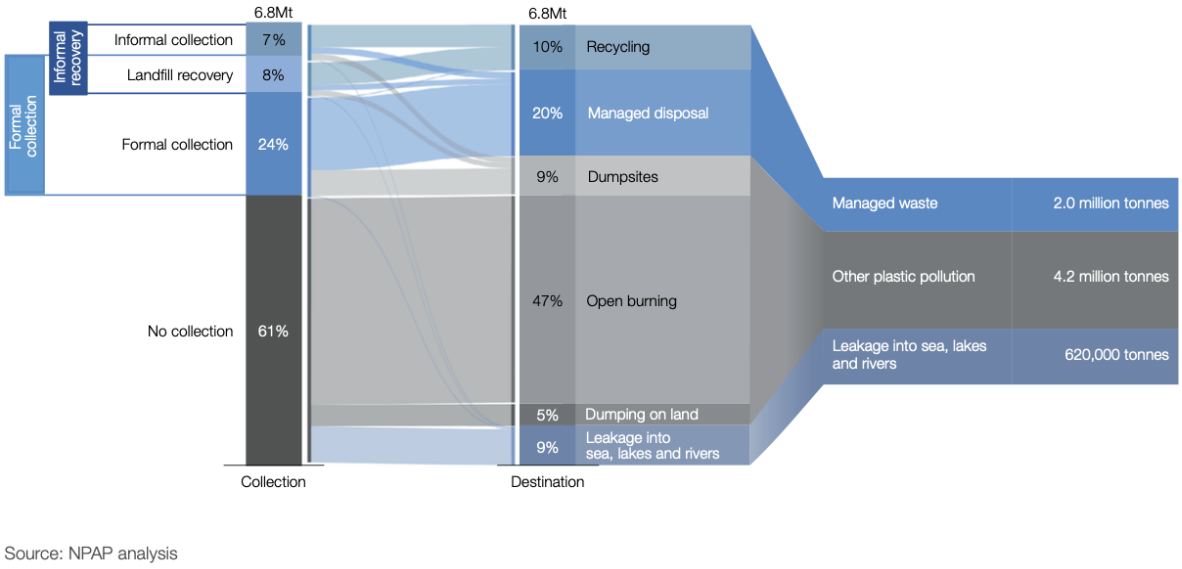

Figure 2. Flow Plastic Waste in 2017 based on NPAP Analysis (NPAP, 2020)

The recycling rate in Indonesia is low, with less than 10% of plastic waste being recycled, and the majority of recycled plastics are downcycled into products with limited economic value (Sari et al., 2023). The country relies heavily on landfills, but only 11% of landfills are categorised as sanitary landfills, and only 3% of them follow this required standard. This causes plastic to leach into the environment, particularly in areas near waterways (Ramadan & Sembiring, 2023).

Furthermore, Indonesia also lacks large-scale waste treatment facilities such as waste-to-energy (WTE) or incineration that could help to significantly reduce waste generation, with only two large-scale incinerators in operation, in Surabaya and Surakarta (Nurofiq, 2025). Gaps in recycling infrastructure are also a challenge, with most facilities concentrated in Java and North Sumatra, while other regions such as Kalimantan, Sulawesi, and Papua still experience limited access to adequate waste management infrastructure (NPAP, 2020).

This geographic disparity creates systematic collection gaps across regions. The inter-island logistics costs and infrastructure limitations present challenges for waste management operations, particularly for centralised collection systems that require coordinated transportation networks across multiple islands.

1.3.2 Informal Sector Dominance

Solid waste management in Indonesia involves both formal and informal actors. The informal sector comprises individuals, groups, and small enterprises engaged in unregistered waste collection and recycling activities (Zahrah et al., 2024).

Informal waste collectors, including waste pickers and small-scale recyclers, play a crucial role in recovering plastic waste (Groot, 2021). Waste pickers at landfills recover approximately 26% of the plastics that arrive at these sites. Combined, landfill and non-landfill waste pickers supply around 1 million tonnes of plastic waste to recyclers annually (Ministry of Environment and Forestry of Indonesia, 2020).

With approximately 2 million waste pickers operating across 29 provinces, handling 80% of plastic collection for recycling (Sustainable Waste Indonesia, 2025). Current EPR approaches operate separately from these existing informal networks, with limited formal integration between the two systems.

In addition to waste pickers and small-scale recyclers, there are Waste banks, part of Indonesia's community-based waste system, follow the 3R (Reduce, Reuse, Recycle) principle and serve as collection points, education hubs, and promoters of circular economy practices (Febriyanti, 2024).

Waste banks work like conventional banks, with customers depositing sorted inorganic waste in exchange for money based on recyclable material prices (Ministry of Environment and Forestry of Indonesia, 2020)

There are two types of waste banks: Waste Bank Units (BSU) at the community level and Main Waste Banks (BSI) at the city or district level as the primary managers (Zahrah et al., 2024). As of 2024, the number of waste bank units in Indonesia is recorded at 20,587 units with 299 Main Waste Bank units (Nurofiq, 2025). Waste banks contribute to reducing waste sent to landfills and support community economic activities.

However, based on data from the Ministry of Environment and Forestry, the contribution of waste banks to national waste management in 2018 was still limited, at around 2.37% of the total national waste generation (Ministry of Environment and Forestry of Indonesia, 2020). Some challenges faced include limited storage space, fluctuating prices of recycled materials, and varying levels of community participation (Zahrah et al., 2024).

In addition to waste banks, there are also TPS3R (Reduce, Reuse, Recycle sites) that manage both organic and inorganic waste through community-based operations. At a larger scale, there are also PDU (Recycling Centres) or TPST which are managed by local governments (Trisyanti et al., 2022).

1.3.3 Financial Constraints

The current financing system for waste management in Indonesia still suffers from a large gap between the needs and available funding sources (NPAP, 2020). According to the Act of Indonesia Solid Waste Management, the responsibility for solid waste management implementation falls under city governments, which are required to allocate sufficient funding from their municipal budget (Vidyaningrum, 2020). However, local government funding for waste management is limited, with an average allocation of only 0.7% of the regional budget. In cities, this proportion is slightly higher at 1.2%, while in regency, it is around 0.4% (Systemiq Indonesia, 2021).

This underfunding results in poor infrastructure maintenance, limited collection coverage, and a lack of long-term planning, especially in geographically remote and economically disadvantaged areas.

1.4 State of the Art PET Packaging in Indonesia

Given that PET bottles represent 18% of branded packaging waste found in Indonesian waterways (as identified in the Sungai Watch audit), understanding the specific dynamics of PET waste management becomes crucial for EPR strengthening.

1.4.1 Current State and Performance

Based on a recent report from Sustainable Waste Indonesia titled "Collection and Recycling Rate Index of Plastic Waste in Indonesia 2024, PET bottle waste contributes 11% of total plastic waste in Indonesia. Although this share is smaller compared to PP (41%) and HDPE (22%), PET has unique characteristics that make it important in the waste management system, especially because of its high recycling potential (Sustainable Waste Indonesia, 2025).

Figure 3 from Sustainable Waste Indonesia (2025), illustrates how recyclable waste flows through various actors in the supply chain from collection to recycling.

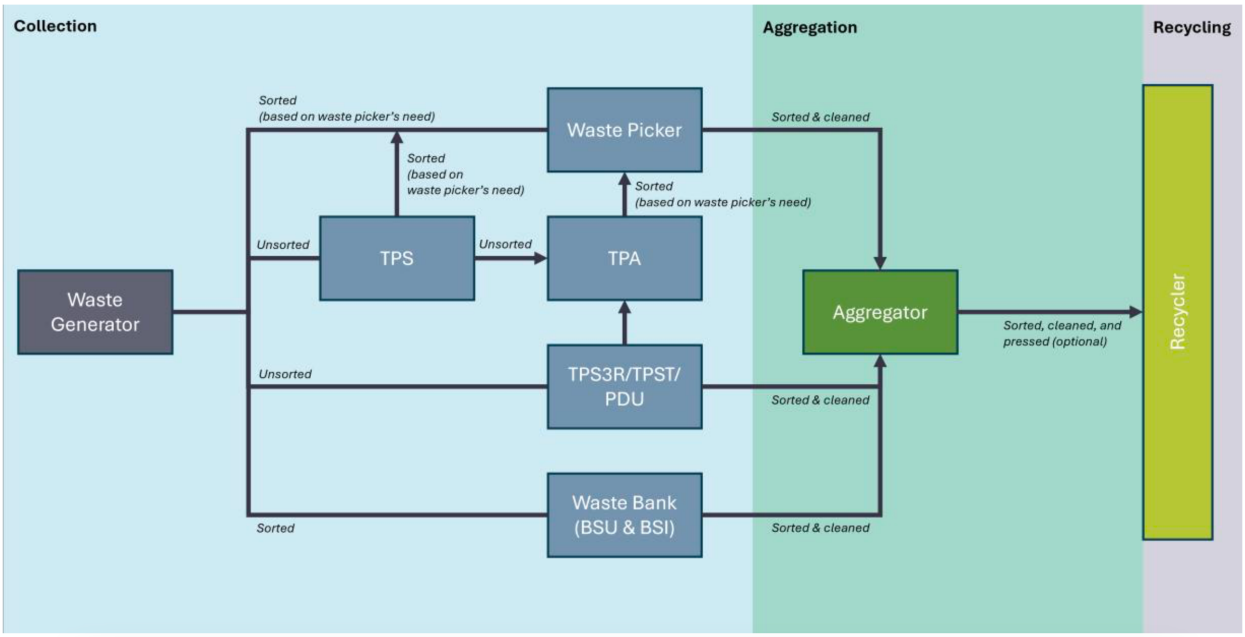

Figure 3. Recyclable Waste Flow in the Supply Chain (Sustainable Waste Indonesia, 2025)

This supply chain reflects a market-based recycling system that heavily relies on informal actors for upstream collection and sorting. The system's effectiveness varies significantly across plastic types, with PET bottles achieving the highest recycling rate at 71%, compared to HDPE rigid (60%) and PP rigid (28%) (Sustainable Waste Indonesia, 2025).

However, despite this high collection and recycling performance, the majority of recycled PET material is not used to produce new bottles. Instead, it is commonly downcycled into lower-value products such as textile fibres (dacron) or non-food packaging (Sustainable Waste Indonesia, 2025).

Along their journey from waste to secondary raw materials, PET bottles pass through several value chain stages involving different actors, from waste pickers and waste banks at the initial sorting phase, through aggregators for cleaning and pressing, to recyclers who process materials into flakes, amorphous forms, and final pellets. Material value increases significantly at each processing stage, from approximately IDR 1,500–5,000 per kg during initial collection to IDR 13,000–18,000 per kg for ready-to-use pellets, with quality of initial sorting directly affecting downstream value (Sustainable Waste Indonesia, 2025). *(For detailed value chain available in supporting data).*

While this value chain demonstrates the economic potential of PET recycling, it also reveals a critical contradiction in Indonesia's waste management performance.

1.4.2 The PET Bottle Paradox: High Recycling Rate vs Environmental Leakage

The presence of PET bottles as branded waste in rivers presents a striking paradox when viewed in the context of Indonesia's plastic recycling performance. Despite achieving the highest recycling rate among all plastic types, PET bottles still represent 18% of branded packaging waste found in Indonesian waterways, according to the Sungai Watch audit. This highlights gaps between recycling infrastructure and real environmental impact.

The total PET bottle consumption in Indonesia reaches approximately 1 million tons annually, with 300,000 tons used by the bottled water industry alone. The increase in PET use is driven by limited access to safe drinking water, growing awareness of hygiene and health, and population growth (Evtriyandani et al., 2025).

However, despite the established recycling infrastructure and relatively high collection rates, several systemic challenges prevent PET bottles from being effectively captured before entering waterways, including:

- **Low Material Quality**
  Although the collection rate is high, the quality of collected PET remains low. This is due to contamination and rough sorting (locally called gabruk). These problems not only reduce the economic value of the material but also cause material loss during the recycling process (Sustainable Waste Indonesia, 2025).
- **Downcycling and Limited Technology**
  There are about 227 recycling facilities in 13 provinces, but only a few are equipped with Solid-State Polycondensation (SSP) technology, which is essential for food-grade bottle-to-bottle recycling. In addition, due to contamination and low technology, most recycled PET is used for non-food products instead of being returned into new bottles (Sustainable Waste Indonesia, 2025).
- **Dependence on the Informal Sector**
  About 80% of plastic collection for recycling is done by the informal sector, involving over 2 million waste pickers in 29 provinces (Sustainable Waste Indonesia, 2025). Trisyanti et al. (2022) This sector also has problems such as unstable income, weak management at waste banks, and low quality input materials.
- **Infrastructure Gap and Geographical Challenge**
  As an archipelago with over 17,000 islands, Indonesia has many logistics problems. Recycling facilities are mostly in Java (76%), while other regions like Sulawesi (3%) and Maluku-Papua (0.3%) have very limited or no access to recycling infrastructure (Sustainable Waste Indonesia, 2025). These gaps make it difficult to implement a national-scale waste management system.
- **PET Export and Market Imbalance**
  Even though the domestic industry needs more PET feedstock, many PET bottles (pressed or unprocessed) are exported because prices abroad are higher. Recycled PET (rPET) can reach IDR 18,000/kg, while virgin PET is only around IDR 14,128 – 14,137 (the price as December 2024), this causes problems for local recyclers, especially small and medium ones, who struggle to compete for raw materials (Sustainable Waste Indonesia, 2025).

These challenges demonstrate that technical recycling capacity alone cannot address EPR implementation failures. Despite having the highest recycling rate among plastic types, PET bottles still require structured collection mechanisms, quality control systems, and producer accountability frameworks to prevent environmental leakage and achieve closed-loop recycling objectives.

1.5 Deposit Return System: Proven EPR Strengthening Instrument

Among the various instruments available to strengthen Extended Producer Responsibility (EPR) frameworks, the Deposit Return System (DRS) has emerged as one of the most effective mechanisms for addressing systematic challenges in waste management systems. As recognised by the OECD, (2022), DRS represents a proven approach for effectively minimising beverage container waste and maximising recycling rates, with successful implementation in various countries demonstrating its potential to foster a "closed-loop" resource cycle (Reloop, 2024b).

DRS schemes for beverage packaging have led to major waste management improvements. Globally, DRS achieves 80–95% collection rates, compared to 40–60% without DRS (Reloop, 2024b), while also addressing littering problems. For example, two years after the introduction, littering problems in Germany fell to almost 0% and in Estonia, decreased to below 10% from 80% (Simon, 2025). In Denmark, 93% of all deposit-marked bottles and cans were returned in 2024, and 99.7% were recycled in a closed-loop system (Dansk Retursystem, 2024).

1.5.1 Early Integration Advantage: DRS as a Complement and Enhancer to EPR

DRS offers particular value in the Indonesian context, where it could address several critical challenges in the current waste management system. DRS is not only compatible with existing EPR frameworks but can enhance their effectiveness (OECD, 2022).

Based on a recent published report from Zero Waste Europe titled "Designing EPR to foster the EU's competitiveness and strategic autonomy", there are three main reasons to prioritise DRS in EPR system development:

1. Implementing DRS from the outset is considerably easier than attempting to integrate it after other EPR systems are already operational
2. DRS infrastructure offers the flexibility to handle both single-use and reusable packaging
3. From a cost coverage perspective, DRS provides a more comprehensive approach than other EPR systems (Simon, 2025)

By positioning DRS as a core element of the EPR framework, Indonesia has the opportunity to build a more efficient, transparent, and effective system for managing beverage packaging waste. Furthermore, such a system could serve as a model for managing other types of waste in the future

1.6 Potential Implementation of Deposit Return System in Indonesia

Indonesia's foundation for implementing a formal Deposit Return System is already emerging through various industry initiatives, technology solutions, and pilot programs. According to the Directorate of Solid Waste Reduction (2025), Indonesia has several initiatives from the beverage producers, startups, and civil society organisations that can serve as a foundation for DRS development. For instance:

- Coca-Cola Europacific Partners (CCEP) has launched bottle-to-bottle recycling practices via the Amandina recycling facility and in collaboration with the Mahija Foundation. Other major beverage producers, such as Danone Aqua and Le Minerale, have also undertaken similar initiatives.
- Plasticpay has developed reverse vending machines and dropboxes for returning PET bottles in exchange for digital points
- Kibumi, in partnership with GIZ, is piloting a Digital Return System (DRS) for dark PET bottles from personal care products, using the Balik.in application and RAWchar technology to recycle dark PET bottle packaging into panels

These emerging practices align with the growing policy momentum to strengthen EPR implementation in Indonesia.

1.7 Momentum for Strengthening EPR in Indonesia

The development of a formal DRS is connected to the growing momentum to strengthen EPR in Indonesia. According to Sidik (2025), this policy momentum can be seen across three main dimensions: legal foundations, recent circular economy measures, and national long-term vision.

Strengthening Legal and Policy Foundations

Ministerial Regulation No. P.75/2019 is the core legal framework for EPR in Indonesia, setting a 10-year roadmap for waste reduction by producers. To accelerate its implementation, the government issued Ministerial Instruction No. S.112/MENLHK/KB.3/PLB.1/11/2024 on 9 November 2024. Additionally, a stronger EPR legal framework is being developed to address gaps and reinforce producer responsibility.

Recent Policy Initiatives (2024–2025)

In the past two years, the government has issued a several of policies that increasing the commitment to a circular economy, including:

- The Circular letter issued on 24 December 2024 (S.62/PLB2/B/12/2024) which encourages all local governments to create action roadmaps under the National Waste Management Acceleration Program.
- Several policy measures to support circular economy practices, including:
  - Promotion of reusable gallon packaging (Circular No. S.81/A/6/PLB-03/B/12/2024)
  - Plans to implement a minimum recycled content requirement (TKDU) for plastic packaging (Circular No. S.80/A/6/PLB-03/B/12/2024)
  - Proposal to ban imports of non-hazardous recycled plastic waste (Circular No. S.114/MENLHK/KB.3/PLB.1/11/2024)

Long-Term Vision

The National Roadmap and Action Plan for Circular Economy 2025–2045 provides a long-term strategic direction for Indonesia's circular transition, with one of its key focus areas being plastic packaging (Sidik, 2025)

Summary of Problem Analysis

The problem analysis shows that Indonesia is still facing challenges in managing plastic waste, which one of post-consumer PET packaging. Although a national EPR has been established through Ministerial Regulation No. P.75/2019, its implementation remains ineffective due to weak enforcement mechanisms and low producer participation. It also discussed how Indonesia's waste management infrastructure is still underdeveloped, with most recycling activities depending on the informal sector, from the analysis, while PET bottles have a relatively high recycling rate of 71%, current practices mostly result in downcycling rather than closed-loop recycling, which limits the achievement of real circularity. Furthermore, Indonesia's geographic as an archipelagic country creates additional logistical challenges for implementing a nationwide waste management system. These challenges highlight the need for alternative approaches with practical solution to strengthen Indonesia's EPR framework, particulary for managing PET bottle waste.

2. Problem Formulation

Indonesia's Extended Producer Responsibility (EPR) framework, established through Ministerial Regulation No. P.75/2019, faces significant implementation challenges that limit its effectiveness in managing post-consumer packaging waste. Despite mandatory requirements for producers to take responsibility for their packaging waste, only 20 out of more than 500 companies that received technical guidance have implemented EPR programs by 2024.

Finding of this EPR implementation limitation is visible in Indonesia's environment, where branded packaging waste continues to appear in waterways despite existing regulations. The 2024 Sungai Watch brand audit documented 623,021 pieces of branded plastic waste in rivers across Bali and Banyuwangi. This indicates that existing take-back obligations are not effectively preventing post-consumer packaging waste from entering natural ecosystems.

The case of PET bottles illustrates this EPR implementation gap. Despite having a relatively high PET recycling rate (71%) and established market-based value chains, PET bottles represented 18% of branded packaging waste in the specific locations studied by the Sungai Watch audit. While this represents a localised sample, it provides evidence that existing collection systems have coverage gaps. Furthermore, the quality of collected material remains poor, resulting in material loss during processing and downcycling rather than closed-loop recycling.

Given these challenges, there is a critical need for complementary policy instruments that can strengthen EPR implementation through enhanced producer accountability and structured collection systems. A Deposit Return System (DRS) appears as a promising solution that could directly address several identified EPR implementation challenges.

PET bottles from beverage packaging represent an ideal starting point for DRS implementation in Indonesia for several reasons. First, Beverage containers are the main focus of successful DRS worldwide, utilising proven technological solutions such as reverse vending machines specifically designed for bottles collection. Second, PET bottles have high recycling value and clear consumer recognition, making them suitable for deposit-based incentive systems. Third, Indonesia's existing PET recycling infrastructure provides a foundation that DRS can build upon to achieve closed-loop recycling objectives. Finally, beverage producers in Indonesia have already initiated voluntary take-back programs, demonstrating industry readiness for more structured producer responsibility mechanisms.

However, limited research has examined how DRS can be effectively integrated into Indonesia's EPR framework, particularly considering the country's unique geographic, economic, and social contexts. Existing studies predominantly focus on developed country experiences, leaving significant knowledge gaps regarding DRS implementation in archipelagic developing countries with informal sector dominance and weak enforcement mechanisms. Furthermore, there is insufficient analysis of how existing industry initiatives and community-based programs in Indonesia could be utilised within a formal EPR-DRS integration model.

Therefore, this research aims to bridge the gap between theoretical recommendations and practical implementation by evaluating current practices and designing an EPR-DRS model tailored to Indonesia's specific conditions for PET bottle waste management.

2.1 Research Questions

Based on the problem analysis and research gaps outlined above, this study aims to explore and formulate a more effective EPR scheme for Indonesia by considering the potential integration of a Deposit Return System (DRS) on PET Bottle as a supporting instrument. Therefore, the following research questions are formulated to systematically and thoroughly guide the direction of the study.

Main Research Questions

How can a Deposit Return System (DRS) on PET bottles be implemented to strengthen the Extended Producer Responsibility (EPR) framework for packaging waste in Indonesia?

Sub Research Questions

1. What are the potential benefits and drawbacks of implementing a DRS on PET bottles in the specific context of Indonesia, considering its geographical, social, and economic factors?
2. What lessons from existing DRS on PET bottle practices and initiatives can inform the development of a suitable DRS model to support EPR in Indonesia?
3. What are the key challenges and enabling factors for the implementation of DRS on PET bottles in Indonesia?
4. What DRS on PET bottle design features are most compatible with Indonesia's specific context?

3. Research Design

This chapter introduces the research design employed to explore the feasibility of implementing a Deposit Return System (DRS) for PET bottles in Indonesia and to identify lessons for an effective Extended Producer Responsibility (EPR) scheme. It presents the overall research approach and structure.

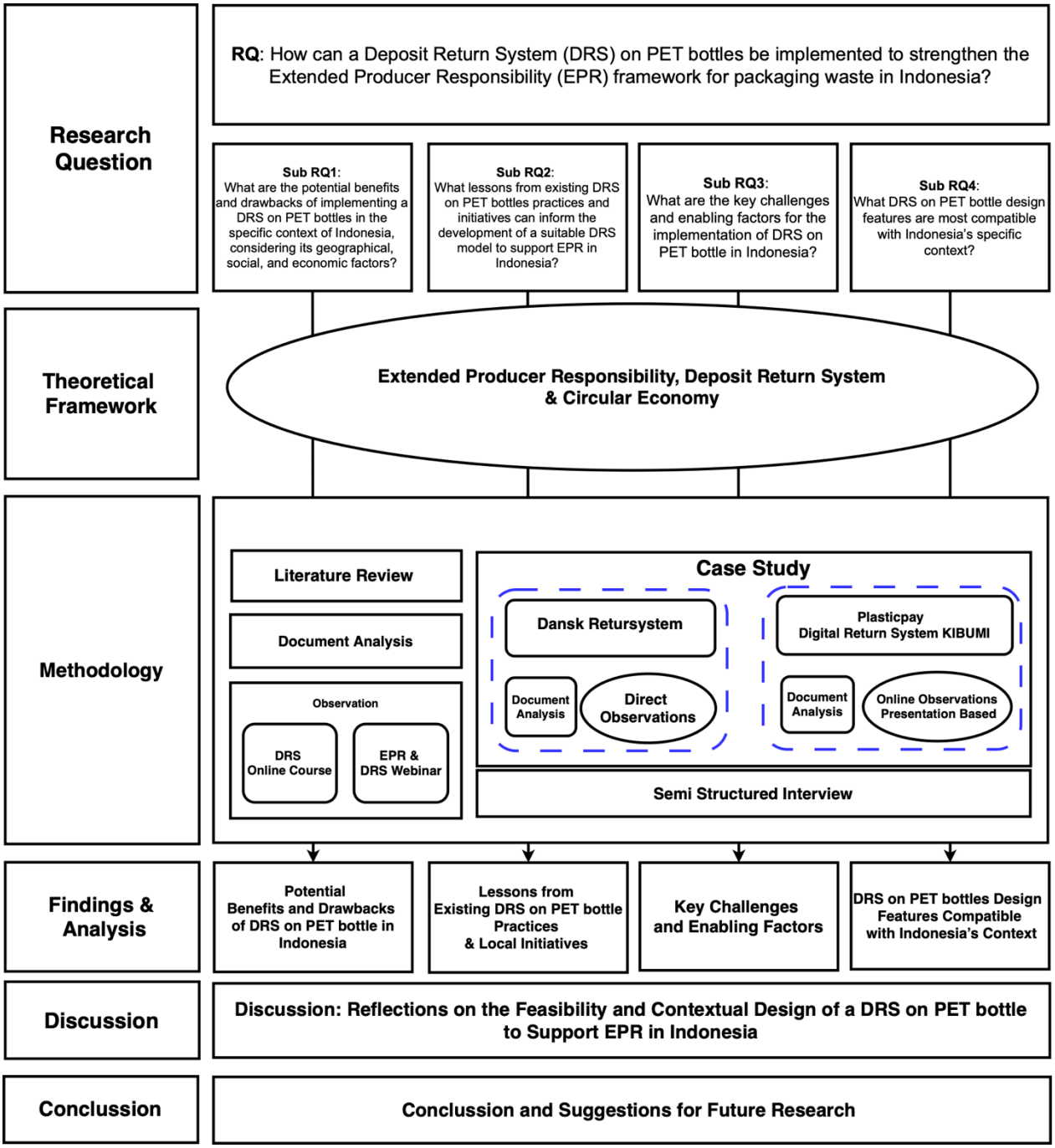

Figure 4. Research Design

The research design in Figure 4 shows the logical structure of different approaches, methods, and analyses used to answer the research question.

This study uses a qualitative research approach to understand how Deposit Return System (DRS) can support Extended Producer Responsibility (EPR) implementation in Indonesia, specifically for PET bottle packaging. The qualitative approach was chosen because it allows for contextual exploration of technical, social, institutional, and consumer behavioral factors through the perceptions and experiences of relevant stakeholders (Creswell & Creswell, 2018).

As explained by (Creswell & Creswell (2018) qualitative research design often combines various data collection methods. This thesis employs case studies, document analysis, semi-structured interviews, and direct and indirect observations. This combination aims to build an understanding of DRS phenomena in relation to EPR.

This research is grounded in a social constructivism epistemological approach, which assumes that there is no single objective truth, but rather that reality is constructed through social experiences and perceptions (Juul & Pedersen, 2012). Therefore, understanding phenomena through the perspectives of field practitioners is essential. In this context, interviews and observations are considered valid methods for exploring the social dynamics and interpretations of EPR-DRS practices.

To maintain internal validity, methodological triangulation was used to examine information consistency from various data sources. Additionally, verification was carried out by involving key informants in the findings validation process, as well as critical reflection on the researcher's position as the main instrument in the interpretation process.

This thesis employs an abductive approach, starting from empirical observations about successful DRS practices in Denmark and concerns about weak EPR systems in Indonesia. This generates the question of whether DRS can provide a suitable solution to strengthen EPR in Indonesia. Following Kovács & Spens (2005) the abductive approach is often used in case study research because it allows researchers to build theory from empirically observed phenomena and view problems from new perspectives.

The conceptual framework was developed based on prior knowledge about EPR and DRS practices and is used to analyse three case studies: Dansk Retursystem (Denmark), Plasticpay (Indonesia), and KIBUMI (Indonesia). This framework enables interpretation and understanding of how DRS design can be adapted to Indonesia's social, economic, and geographical context.

As Bryman (2012) states, the abductive approach is suitable for exploratory and interpretive research because it allows for the formation of new understandings based on connections between theory and data.

To address the research objectives, this study applies several methods. Literature review, Document, Observations and Semi-structured interviews were conducted with representatives from Dansk Retursystem (Denmark), Plasticpay, and KIBUMI (Indonesia) to gather insights on practical implementation, design features, and challenges of DRS models.

Three main case studies are included in this research. Dansk Retursystem (Denmark) serves as a formal national DRS operator. Plasticpay (Indonesia) represents a digital-based DRS model using reverse vending machines. KIBUMI (Indonesia) operates as a digital and community-based DRS initiative connected to waste banks and the informal sector. Each method contributes to better understanding of how DRS functions in practice, and what kind of system design may be suitable to support Indonesia's EPR framework.

4. Methodology

This chapter outlines the methods employed to address the research questions for this project. It elaborates on the qualitative research design and details each method, explaining its relevance in answering the research question

4.1 Literature Review

The literature review provided the basis for understanding DRS and EPR implementation, particularly in Indonesia. As explained by Snyder (2019), a literature review not only reviews existing knowledge but also helps develop policy recommendations by bringing together findings from different studies. The review aimed to understand existing knowledge on EPR and DRS implementation, identify research gaps, and provide context for analysing the Indonesian case. Since there is limited academic research on DRS in developing countries and policies are changing rapidly, this review used a targeted search combined with analysis

For academic literature search, a targeted search was conducted through the SCOPUS database using the query: (TITLE-ABS-KEY("Extended Producer Responsibility" OR "EPR" OR "Producer Responsibility") AND TITLE-ABS-KEY("Packaging") AND TITLE-ABS-KEY(Indonesia)) AND PUBYEAR > 2018, which resulted in 6 documents. This search focused on identifying implementation challenges of PermenLHK P.75/2019 serve as preliminary research.

Additional academic sources were identified through snowball sampling from key references and targeted searches for specific topics such as deposit return systems, packaging waste management, and waste management policies in Indonesia.

Four types of sources were essential for this research.

First, Background Study on the Strengthening of EPR Policies (2024) and Policy Recommendation for Strengthening PermenLHK P.75/2019 (2025) published by GIZ cooperation with Directorate Solid Waste Reduction, Ministry of Environment Indonesia, provided framework in strengthening EPR in Indonesia, this document serve as background of EPR implementation challenges in Indonesia.

Second, the Sustainable Waste Indonesia (2025) report titled "Collection and Recycling Rate Index of Plastic Waste in Indonesia 2024," published on 22 April 2025, provided the most current and comprehensive data on plastic waste recycling rates, PET bottle material flows, and recycling infrastructure in Indonesia. This report was crucial as it offered quantitative baseline data directly relevant to DRS design considerations.

Third, specialised DRS organisations such as Reloop Platform and TOMRA technical reports were prioritised as they represent the leading organisation on DRS implementation globally, providing comparative data and technical expertise based on real-world experience.

Fourth, Indonesian government, industry, Community based/NGO sources, including recent reports from MoEF Indonesia (2024), Sungai Watch brand audit data (2024-2025), and policy documents, were essential for understanding current conditions and policy developments.

The collected literature was organised around six main themes. These included plastic waste conditions in Indonesia, along with brand audit findings; current waste management infrastructure and actors; the EPR policy framework and the implementation of PermenLHK P.75/2019; DRS mechanisms and global best practices; PET material flows and recycling systems in Indonesia; and the potential for DRS implementation which explain as part of Problem Analysis.

Literature selection prioritised recency, with a strong emphasis on publications from 2019 to 2025 due to evolving EPR policies in Indonesia. Relevance was ensured by focusing on direct discussions of Indonesian waste management, EPR implementation, or DRS experiences. Quality was maintained by utilising credible academic sources, government data, and technical reports from recognised organisations. Data availability was considered by selecting sources that provide quantitative data on waste management performance and recycling rates.

The review revealed gaps in empirical research on DRS implementation in developing countries such as Indonesia, particularly concerning integration with informal waste sectors and adaptation to local contexts. This highlighted the necessity for primary research in this study.

4.2 Document Analysis

Document analysis was employed as a complementary method to support the case studies and literature review. The aim was to gain a deeper understanding of legal frameworks, policy contexts, and institutional strategies related to DRS implementation, particularly in Denmark and Indonesia.

4.2.1 Case Study Documentation

For the Dansk Retursystem case study, the analysis was based on publicly available data from Dansk Retursystem's official website, annual reports (Dansk Retursystem, 2024) and a reflective document titled "20 Years of Producer Responsibility Across Sectors: The Story of a Deposit System for a Circular Economy" (Dansk Retursystem, 2022) was analysed as recommended by Hanne Svenningsen (Head of Environment & Climate) from Dansk Retursystem. Direct observations during the site visit, along with questions answered during meetings at the Dansk Retursystem office, provided additional insights. Follow-up email correspondence ensured the validity and accuracy of the content.

These sources provide comprehensive insights into the institutional structure, operational mechanisms, system performance, and challenges faced over two decades of deposit-return system implementation in Denmark.

4.2.2 Legal and Policy Documents

Key documents analysed include the Statutory Order on Deposits and Return System (Denmark), Law No. 18/2008 on Waste Management (Indonesia), and PermenLHK P.75/2019 on the Roadmap for Waste Reduction by Producers. Supplementary documents comprise implementation guidelines and strategic reports (NPAP, SYSTEMIQ).

4.2.3 Strategic Reports and Grey Literature

In addition to formal legal documents, this study also analysed strategic reports, white papers, and various forms of grey literature published by government agencies, non-governmental organisations, and international institutions. These include publications from the Ministry of Environment and Forestry (MoEF), the World Bank, the OECD, the PREVENT Waste Alliance's EPR Toolbox and UNEP, RELOOP and TOMRA.

These documents were analysed to explore strategic objectives and visions related to the circular economy and DRS, stakeholder roles, and recommended steps for implementation, as well as barriers, challenges, and enabling factors for system development. They also include key data and statistics that complement the case study findings and practical implementation in DRS.

4.3 Observation

Observation served as a complementary data collection method to understand the practical implementation of DRS. Two types of observation were conducted: direct observation through field visits and indirect observation through online events and presentations.

4.3.1 Direct Observation

Direct observation was conducted during field visits to Denmark in late April 2025. On 22 April 2025, the visit to Dansk Retursystem began with a presentation by Hanne Svenningsen from Dansk Retursystem, followed by an interview session. After the presentation and interview, a guided tour of the sorting facility in Høje-Taastrup was conducted, where operational processes such as material sorting, quality control, and logistics operations were observed.

A separate visit to a Pantstation (deposit station) was conducted on 1 May 2025 to understand how consumers return large volumes of containers and how the automated processing systems operate. As part of the observation, the researcher also experienced the system as a consumer by purchasing beverages and returning bottles through reverse vending machines (RVMs) in supermarkets.

These field visits provided firsthand insights into the technical and operational aspects of a mature DRS, including infrastructure requirements, material handling processes, and consumer interaction points.

4.3.2 Indirect Observation

Indirect observation was conducted by participating in online events and presentations. Table 2, summarises the observation activities carried out as part of this research.

Date	Activity Description
13 March 2025	Participation in Global Deposit and Return Platform Launch Webinar
21 March 2025	Participation in Deposit Return System Academy Online Course
25 March 2025	Participation in Webinar 'GreenForest Solutions: EPR Implementation'
10 April 2025	Plasticpay presentation (online)
7 April 2025	KIBUMI presentation (online)
22 April 2025	Dank Retursystem presentation & Field site visit

Table 2. Summarises the Observation Activities

The results of indirect observations, particularly from the online presentations by Plasticpay and KIBUMI, were documented through detailed notes, screenshots, and presentation materials. For direct observations, field notes were taken during site visits, photos of infrastructure and processes were captured where permitted, and reflection notes were written to record key insights and comparative observations.

The observational data was analysed thematically and triangulated with interview and document data to enhance understanding of DRS implementation in various contexts. Key themes identified included governance structures, material and financial flows, collection infrastructure, operational mechanisms, technology integration approaches and challenges.

4.4 Case Studies

This study applies a case study approach because it is considered suitable for exploring the Deposit Return System (DRS) in-depth within its real-life setting. As explained by Yin (2009), a case study is used when researchers aim to "investigate a contemporary phenomenon in depth and within its real-life context". This approach fits well with the aim of the research, which is to understand how DRS can strengthen the EPR framework in Indonesia not only from a technical

perspective, but also considering social, policy, and institutional aspects. The case study method helps provide a more holistic and contextual understanding of practices in the field.

This research uses a multiple-embedded case study design, as classified by Yin (2009). The design includes more than one main case (multiple) and within each case, more than one unit of analysis (embedded).

4.4.1 Case Selection Criteria and Rationale

The case selection was purposive and followed an information-oriented strategy (Flyvbjerg, 2006). This approach does not require a large sample but focuses on selecting cases that offer the richest insight to answer the research questions. Dansk Retursystem was chosen because it represents one of the most mature and nationally integrated DRS models in Europe. The system is considered a best practice, consistently achieving return rates of over 90% for beverage containers.

Purposive sampling is widely used in exploratory case study research to examine how and why specific systems function within their context (Yin, 2009). In this case, the Danish system serves as a critical case, demonstrating that if certain challenges arise even in a mature and advanced model, similar or greater challenges may likely appear in developing countries such as Indonesia.

The cases were purposively selected based on their relevance to the research questions and the availability of reliable data. Dansk Retursystem was chosen because it represents a well-established, large-scale DRS with high return rates and strong legal backing. In contrast, Plasticpay and KIBUMI were selected to reflect the emerging innovations in Indonesia, especially those involving the informal sector and digital traceability tools.

Dansk Retursystem was selected as an international example of a well-established and high-performing DRS. It is widely recognised as one of the best practices globally, with strong regulatory support and proven results in collection and recycling rates. This case provides useful insights for evaluating the feasibility and design of DRS in Indonesia.

PlasticPay has been selected as a local initiative that utilises reverse vending machines (RVMs) made in Indonesia and integrates with a mobile application and e-wallet to provide incentives. PlasticPay already has its own collection infrastructure and is part of one of the PET bottle recycling industry groups in Indonesia. It shows how DRS-like mechanisms can be developed in urban areas through private sector initiatives.

KIBUMI was selected for its efforts in developing a digital return system tailored to the Indonesian context. KIBUMI employs a mobile application for tracking and reporting and collaborates with bank sampah and informal collectors. It is part of an NGO that serves as the research and development arm of the Plastic Recycling Association in Indonesia. The initiative also incorporates EPR principles by involving producers in taking responsibility for post-consumer packaging waste.

4.4.2 Case Study Analysis Strategy

The analysis strategy was designed at the beginning of the research to ensure the process remained focused and aligned with the research objectives. One of the main strategies used is relying on theoretical propositions, as described by Yin (2009). In this approach, the case study analysis is guided by the research questions and the findings from the prior literature review. This helps focus the analysis on how the DRS is designed and operated to support EPR framework.

Additionally, a pattern-matching strategy was applied (Yin, 2009). Through this strategy, patterns found in the empirical data from observations, interviews, and document analysis were compared with the expected patterns from theory and the literature review.

These three cases were analysed using a multiple embedded case study design, where each case includes two embedded units of analysis: the institutional structure and regulatory framework governing the DRS, and the operational mechanism and supporting technology, including deposit flows, return methods, and traceability systems.

The findings from each case were then compared systematically to identify patterns of good practice, existing challenges, and key lessons that can inform the development of a DRS model suitable for the Indonesian context.

4.5 Interviews

Interviews were used as a complementary method to support the document analysis, observations, and literature review. The interview process followed the approach of Kvale and Brinkmann (2009), focusing on key stages of qualitative interviews: designing, interviewing, transcribing, analysing, and verifying.

All interviews were conducted in a semi-structured format, allowing a combination of prepared questions and the flexibility to explore emerging points during the discussion. The interview guides were developed based on the main research themes and were sent to interviewees in advance. The semi-structured format enabled interviewees to respond freely, while ensuring that key information aligned with the research framework was addressed (Kvale & Brinkmann, 2015).

Interviews were conducted to explore the implementation of the DRS and its relationship to the EPR framework, particularly in the context of three case studies. Each interview aimed to explore specific aspects that correspond with the sub-research questions. These included understanding the perceived benefits and drawbacks of DRS implementation in different contexts, identifying best practices and relevant lessons learned from existing DRS, particularly in Denmark and Indonesia, exploring the main challenges and enabling factors for implementing DRS in Indonesia, and examining the design elements of DRS that are most compatible with Indonesia context.

Due to different locations, interviews with Plasticpay and KIBUMI representatives were conducted virtually via Microsoft Teams. The interview with Hanne Svenningsen from Dansk Retursystem was conducted in person in Denmark on 22 April 2025, following her presentation at the Dansk Retursystem office as part of the field visit.

The interviews were conducted in the participants' native languages: Bahasa Indonesia for representatives from Plasticpay and KIBUMI, and English for the representative from Dansk Retursystem.

A summary of the interviews conducted is presented in Table 3:

Interviewee	Organisation	Date of Interview	Purpose / Focus Area
Ainun Asifa	KIBUMI	9 April 2025	Exploring the integration of digital and community-based approaches in Indonesia's informal waste collection sector and their relevance for DRS
Andi Manggala Putra	KIBUMI	9 April 2025	Understanding the role of community-based and Digital Return System initiatives in Indonesia's waste management landscape.
Arif Rahman Abidin	Plasticpay	10 April 2025	Exploring the PET Bottle collection through Local Reverse Vending Machine and Digital Application and their relevance for DRS

Hanne Svenningsen	Dansk Retursystem	22 April 2025	Insights into the operation, regulation, and financing of the national DRS in Denmark.

Table 3. Summary Interview Activity

4.5.1 Recording, Transcription and Verification

With the interviewees' consent, all interviews were recorded and subsequently transcribed for analysis. Interviews conducted in Bahasa Indonesia were initially transcribed in the original language and then translated into English by the researcher for analysis and reporting purposes. Every effort was made to ensure that the translation remained faithful to the original meaning and intent of the interviewees.

To ensure accuracy and ethical integrity, key quotations and interpretations were sent back to the interviewees for verification before use in the final analysis. This verification process helped to avoid misinterpretation and ensured the correct representation of the participants' views.

4.5.2 Validation, Reliability, Triangulation

To ensure the validity and reliability of the findings, this study employed several strategies that are commonly used in qualitative research. These include data triangulation, respondent validation (also known as member checking), and systematic documentation, as suggested by Creswell (2014), Yin (2009), and Torrance (2012).

Data analysis employed a thematic approach, coding data from interviews, observations, and documents according to the primary research themes. The analytical process involved reading and re-reading the data, identifying patterns and themes, and comparing findings across various data sources.

Triangulation was done by comparing and connecting several sources of data, including the literature review, document analysis, observation, and interviews. This approach helped to verify the consistency of the findings and enhance the credibility of the analysis. As mentioned by Torrance (2012), triangulation is not only used to find a single version of "truth", but also to expand understanding by looking at the issue from different methods and perspectives.

Respondent validation was conducted by sending selected quotations or summaries of the interview interpretation to the interviewees for confirmation. This step was particularly important as some interviews were carried out in Bahasa Indonesia and translated into English by the researcher. This verification process ensured that the meaning remained accurate and prevented misinterpretation.

Reliability was maintained through clear documentation and consistent procedures during the analysis. All interviews followed a prepared interview guide, and they were recorded with permission, transcribed, and analysed using a thematic approach. An audit trail was also kept to record important decisions made during the research (Yin, 2009).

4.6 Analysis Framework

This study used a structured approach to analyse the data and answer the research questions. The analysis was divided into four main sections, each addressing one of the sub-research questions.

4.6.1 Overview of Analysis Structure

The analysis framework was designed to systematically examine how DRS can support EPR in Indonesia by comparing three different case studies: Dansk Retursystem (Denmark), Plasticpay (Indonesia), and KIBUMI (Indonesia). Each case study provided different perspectives that collectively informed the main research question.

4.6.2 Four-Part Analysis

The analysis consists of four main components:

1. Analysis of the benefits and drawbacks by examining the potential positive and negative impacts of implementing DRS in Indonesia, while considering the country's unique geographical, social, and economic conditions.
2. Lessons from existing practices by identifying key learnings from the three case studies that could inform DRS development in Indonesia.
3. Challenges and supporting factors by analysing the main obstacles and opportunities for DRS implementation in the Indonesian context
4. Compatible design features by determining which elements of DRS design would work best in Indonesia based on the evidence from the case studies and learn from global practice

4.6.3 How the Analysis Was Conducted

The study followed this process for each of the four components. Data from various sources-interviews, observations, documents, and relevant literature were integrated. Additional literature from global DRS practices was included to enhance the analysis. Findings from the three case studies were analysed for patterns and differences. The results were examined in relation to the context and conditions in Indonesia. Conclusions that addressed each sub-research question were drawn.

4.7 Use of Artificial Intelligence (AI)

This study used Generative Artificial Intelligence (AI), especially ChatGPT from OpenAI, as a supporting tool in several parts of the thesis writing process. The AI was mainly used to help improve grammar in English, organise key themes during analysis, clarify concepts from the literature, and summarise some information during the data processing stage.

The use of AI in this research is seen as part of using digital tools in academic work, and it reflects the increasing role of AI literacy in modern research. However, AI was not used to generate original content automatically or to replace the researcher's own analysis and interpretation.

All texts produced with the help of AI were critically reviewed and edited by the researcher and cross-checked with academic sources when needed. AI was not used to create citations or include content from unknown sources. In this way, the use of AI stayed within the ethical boundaries set by Aalborg University.

The researcher also recognises that AI is not fully neutral. As discussed by Singh and Ramakrishnan (2023), although ChatGPT continues to be improved, AI can still produce biased content depending on its training data or how the user interacts with it. For this reason, any result from AI was never used directly but always examined critically.

5. Theoretical Frameworks

This chapter presents the theoretical frameworks that underpin the research on implementing a Deposit Return System (DRS) for PET bottles in Indonesia. It introduces three interconnected theories: Circular Economy, Extended Producer Responsibility, and Deposit Return System.

5.1 Extended Producer Responsibility (EPR)

Extended Producer Responsibility is a principle of environmental policy that extends the responsibilities of producers to the post-consumption stage of the product life cycle. EPR concept was introduced by Lindhqvist (2000) as an environmental protection strategy to make producers responsible for the entire lifecycle of a product, particularly at the end of its lifecycle, where producers are obliged to take back, recycle, and dispose of their products.

In EPR, environmental costs are internalised in the product to encourage producers to make a product more environmentally friendly and sustainable, while also aiming to improve the recycling rate of materials (OECD, 2016). This principle is based on the "polluter pays principle," which shifts waste management responsibilities from government and society to producers, as influential parties that determine packaging design and composition.

In the EPR principle producer has several responsibilities: physical responsibilities (post-consumption material management), financial responsibilities (funding system), informational responsibilities (product information), liability (product effects on the environment), and ownership (Lindhqvist, 2000)

5.1.1 Extended Producer Responsibility Implementation

EPR can be implemented through various models and policy instruments. Based on the organisational approach, EPR can be implemented as individual producer responsibility (IPR), where each producer is responsible for their respective product, or as collective producer responsibility, where producers, through producer responsibility organisations, fulfil their obligation (OECD, 2016)

There are several instrument policies under the EPR policy such as take-back obligation, deposit-refund system, advance disposal fees, and performance standards like recycle target (Walls, 2011). Successful EPR implementation depends on alignment between policy instruments, institutional structure, and local context in which the policy is implemented. There is no single right approach or the most effective model to implement EPR (OECD, 2016) but there are several element that are crucial when designing and implementing EPR system.

5.1.2 Key Elements for EPR Implementation Regulation and Policy

To achieve the purpose of environmental protection, the EPR principle should be implemented through regulations and policy instruments. Transforming the EPR principle into regulations will create a structure for the EPR system, holding businesses accountable and triggering national change towards sustainability. Regulation can also establish an EPR system that is consistent in its application and can be implemented on a broader scale.

Even though there is no one right approach or the most effective EPR model, there are several key elements for effective EPR system (OECD, 2016), it should consist of;

1. **Clear defined objectives of EPR include goals for the EPR system**
   The Objective's purpose is to set the overall outcome of the system. It also include performance target like collection rate, recycling rate or environmental impact reduction

2. **Stating the scope of the EPR system**
   The EPR system defines which products, materials, or categories are subject to EPR regulations. For instance, product categories include packaging and beverage containers, while materials may include plastic, metal, and glass.
3. **Identifying the producers**
   The EPR principle aligns with the polluter pays principle; by identifying producers, we can establish a system that enhances environmental protection by encouraging them to improve their product life cycle, particularly during the end-of-life stage. Identifying producers trough registration is crucial to prevent free riders and ensure fairness within the EPR system.
4. **Established the responsibility of producers**
   Producers' responsibility is the foundation of EPR system. By establishing producers' responsibility, it is important to create a financing mechanism, correct incentives, and also drive more sustainable product and waste management practices.
5. **Stakeholders role and responsibility**
   Stating the roles and responsibilities of all stakeholders helps to create a functional EPR system that help in coordinating and collaborating to ensure the effectiveness and accountability of an EPR system.
6. **Standard Operation**
   One of responsibility of producers is managing their products after consumption. This involves processes such as collection, separation, and recycling. To enhance effectiveness and efficiency, standardised operations are necessary, particularly when many producers and stakeholders are involved at a large scale.
7. **Financial Scheme**
   A financial scheme is essential for EPR system to fund the waste management process, include the administrative process that follows. But the important part of this financial scheme is to incentivise producers to enhance their product at every life cycle to reduce environmental impact of their products.
8. **Oversight**
   In the EPR system, oversight performed by government institutions involves active monitoring, evaluation, control, guidance, and accreditation to ensure the system operates properly, ensure fairness and transparency, and effectively achieves the purpose of the EPR system.
9. **Enforcement and penalties**
   Penalties and enforcement are crucial in the EPR system. They are essential tools to prevent non-compliance, eliminate free-riders, illegal practices, and ensure a level playing field.

5.1.3 EPR in the Developing Country

EPR implementation in developing countries face different challenges from developed countries. Developed country EPR models cannot be implemented directly without significant adaptation. Main challenges in developing countries are dominance of the informal sector in waste management, limited administrative capability, underdeveloped infrastructure and lack of consumer awareness (Akenji et al., 2011). To handle these challenges developing countries need an EPR approach that is tailored with local context conditions. Akenji et al. (2011) suggest gradual implementation of EPR starting with a basic element, to gradually develop capability and infrastructure.

5.2 Deposit Return System

5.2.1 DRS Concept and Mechanism

Deposit Return System (DRS) is a specific policy instrument under broader EPR. DRS applies at the time of purchase, which is then returned upon return of the container (Walls, 2011). DRS operates through 3 main mechanisms: deposit collection (Deposit fee charge into product price), return process (return of empty container), and refund system (return of deposit). DRS create direct economic incentives to encourage container return, reduce littering, and produce high-quality recycled material (Hogg et al., 2010).

5.2.2 DRS Model Variation

DRS can be implemented for various products, depending on the local context and policies. Hogg et al. (2010) has found other implementations of DRS for products other than beverages such as; car, batteries, e-waste, tyres, lubricant oil.

Key design factors influencing the effectiveness of DRS include the deposit fee amount, ease of the return system, and clear compensation mechanism for retailers (Hogg et al., 2011). Design variation enables adaptation to market conditions, infrastructure, and consumer preferences.

Reloop (2023) identifies 10 essential practices for modern DRS to be effective, which categorise into three aspects include Regulation (foundation of the system), Standard (operational backbone), Operation (function for system longevity). The 10 essential practices are:

Aspect	Principle
Regulation	1.Meaningful target and penalties
	2.Easy access return point
	3.Compliance and reporting
	4.Monitoring and enforcement
Standard	5.Design, Marking and Packaging registration
	6.Efficient collection
Operation	7.Mass return collection point
	8.Optimise logistic
	9.Material management and service fee
	10.Material flow management and finance data

Figure 5. 10 Essential Practice for Modern DRS (Reloop, 2023)

These 10 practices become a framework to critically evaluate components of DRS design and implementation.

DRS is primarily employed by beverage producers to manage packaging waste made from aluminum, PET, and glass. According to OECD (2022), there are several core mechanisms in DRS to encourage a high collection and recycling rate:

1. **Deposit Collection**
   A deposit is collected when a consumer buys a beverage. This deposit is added to the price of the beverages, but it must be clearly disclosed as a separate item from the price to inform the consumer that the deposit can be refunded when consumers return the packaging. This deposit functions as a direct incentive to encourage consumers to return the packaging, thus participating in the scheme.
2. **Return Process**
   In the DRS scheme, there is a designated place for returning the packaging; most common practice is to return the packaging to a reverse vending machine, but there is also a manual collection point involving retailers. The designated place for the return process should be accessible and convenient for consumers, and the retailers that sell the beverages are obliged to accept the empty packaging. Using retailers that sell the product as a return point gives consumers convenience in returning the packaging since it aligns with their shopping habits. This second mechanism is one of the reasons that drives the high collection rate using the DRS scheme.
3. **Refund System**
   After returning post-consumption packaging, consumers receive direct incentives in the form of cash, direct bank transfers, or vouchers for future purchases. These incentives motivate consumers to return empty packaging, resulting in higher collection rates. This mechanism also serves as a tool to educate consumers about recycling and sustainability (OECD, 2022).

5.2.3 DRS in Developing Country Context

In developing countries, DRS implementation in developing countries needs to consider contextual factors such as the informal sector, retail infrastructure, and socio-economic conditions (Talbott et al., 2022). Given its significant role in waste collection and recycling, the informal sector should be integrated into the EPR system rather than replaced.

Chikarmane (2012) suggests an Inclusive DRS approach design that involves waste pickers and informal waste collectors in a formal system. This approach acknowledges the roles of waste pickers in the value chain and seeks to enhance efficiency and working conditions without removing their source of income.

5.3 Interplay Circular Economy, EPR and DRS

5.3.1 Circular Economy

The Ellen Macarthur Foundation describes a circular economy as a system in which materials are never wasted, and nature is regenerated, Products and materials remain in circulation through processes such as maintenance, reuse, refurbishment, recycling, and composting (Ellen MacArthur Foundation et al., 2016).

Based on the Ellen MacArthur Foundation et al. (2016) three principles of circular economy, namely Waste and pollution elimination, circulate product and material; and Nature regeneration

Ellen MacArthur Foundation et al. (2016) view waste causes by a design flaw, it is not designed with how it should be treated at the end of it life cycle, by the end of their life cycle it become waste that piled up, without any possible way to be used again.

To tackle this, Ellen MacArthur Foundation et al. (2016) suggests to focus on design products, where the material can re-enter economy at the end of their cycle. By first focusing on designs that can re-enter the economy, it implements the first principle of circular economy to eliminate waste and pollution.

The second principle of a circular economy focuses on maintaining products and materials at their highest value. This principle is to keep material in the economy for as long as possible, whether as products, components, or materials once the product's value can no longer be maintained anymore. The effort to keep the product in the economy can be achieved through a technical cycle, which includes reusing products for their intended purpose, repairing them when they break down, or remanufacturing components. Lastly, the materials from these products can be recycled to make the same product creating a closed-loop system (Ellen MacArthur Foundation et al., 2016).

The third principle of circular economy, by Ellen MacArthur Foundation et al. (2016), regenerating nature focuses on improving ecosystem, soil quality, biodiversity and return of biological material to nature.

5.3.2 DRS and EPR Contribution to the Circular Economy

DRS and EPR are policy instruments that facilitate and promote a circular economy. The Deposit Return System ensures high-quality post-consumption materials and their re-entry into the production cycle. It motivates customers to participate in the system by giving the incentive to boost collection and recycling rates of packaging waste.

EPR makes producers responsible for the end-life management of their products physically and financially and encourages them to design their products to be easier to reuse, repair,

remanufacture, and recycle. Both EPR and DRS support the circular economy by closing the loop. Keeping material in the system minimises the use of virgin resources and environmental impact.

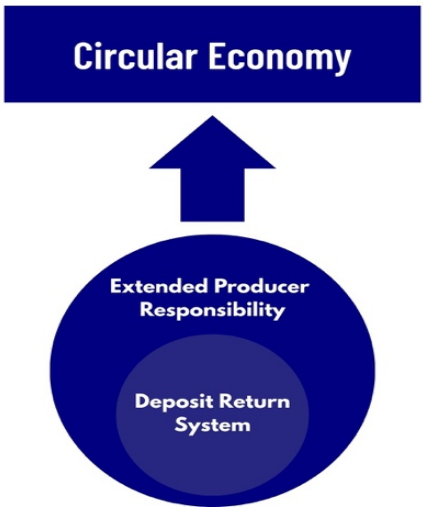

Figure 6. Interplay of Extended Producer Responsibility, Deposit Return System and Circular Economy)

Packaging waste is a major environmental issue worldwide, including in Indonesia. Most packaging in Indonesia is created from non-renewable resources, leading to rapid resource depletion. The linear economy model, where packaging is produced, used, and then discarded, results in the continuous extraction of non-renewable resources with each new item made. This approach also leads to overflowing landfills filled with post-consumption packaging waste that is difficult to decompose and often contaminates the environment. One of the common packaging waste in Indonesia is PET water bottles.

This research aims to address the PET packaging waste issue in Indonesia by exploring the implementation of the Deposit Return System. This system can serve as a tool to enhance Extended Producer Responsibility in tackling PET packaging waste. The study will be guided by three theories: Circular Economy, Extended Producer Responsibilities, and Deposit Return System theory.

This research combines these 3 theories to find a comprehensive solution to the packaging waste problem in Indonesia. The first theory, Circular economies, will become an umbrella to create a sustainable packaging waste management system that minimises resource extraction and waste generation and ensures material remains in circulation as long as possible.

Extended Producer Responsibility enforces producers to take responsibility for their post-consumption packaging, encouraging them to design and manage their post consumption packaging to be inline with circular economy goals.

Deposit Return System ensures packaging waste is collected and ensures their re-entry into the production cycle. It motivates customers to participate in the system by providing incentives to enhance both the collection and recycling rates of packaging waste.

(Conceptual diagram were developed by Author to illustrate theoretical relationship)

6. Case Studies

This chapter presents empirical data from three Deposit Return System case studies: Denmark's Dansk Retursystem and two Indonesian initiatives, Plasticpay and KIBUMI. Drawing on document analysis, observations, and interviews, it documents the operational models, governance structures, and performance metrics of each system, providing a factual foundation for subsequent analytical discussions.

6.1 Case Study Dansk Retursystem

The Dansk Retursystem case study presents a beverage packaging management model that has proven successful in Denmark with a return rate of 93% and recycling rate of 99.7%. This section outlines the institutional model, key success features, and implementation challenges relevant for the Indonesian context, compiled from official documents, annual reports, and interviews with Dansk Retursystem representatives.

6.1.1 Brief Profile of Dansk Retursystem

Established in 2000, Dansk Retursystem developed through phased implementation, initially covering beer and soft drinks, then gradually expanding to include water (2008) and juices (2020). This approach achieved operational cost reduction of 92% since initial implementation while handling over 62,000 different product types.

The system operates as a non-profit company with exclusive rights from the Danish Ministry of Environment. Ownership reflects industry structure with A 13-member board ensures stakeholder representation from producers, retailers, and industry organisations. Non-profit status ensures surplus revenue is reinvested or used to reduce producer costs, avoiding conflicts of interest.

6.1.2 Organisational Structure and Governance

The institutional structure of Dansk Retursystem combines business and environmental interests within a non-profit framework that can serve as a reference for Indonesia. This organization was formed as a non-profit company given exclusive rights (eneret) by the Danish Ministry of Environment to operate the national deposit-return system.

The ownership composition reflects the beverage industry structure: Dansk Retursystem Holding A/S (85.6%), Harboes Bryggeri A/S (14.3%), and Bryggeriet Vestfyen A/S (0.1%). The governance model ensures representation of all key stakeholders through a 13-member board of directors representing beverage producers, retail associations, and industry organizations.

Non-profit status is key to success, as all surplus revenue is reinvested or used to reduce producer costs. This approach avoids conflicts of interest and ensures focus on environmental sustainability and operational efficiency. Success is supported by Pantbekendtgørelsen (Deposit Regulation) as a legal foundation that regulates product coverage, rights and responsibilities, operational requirements, and governance structure

As the system operator, Dansk Retursystem has the authority to:

- Register Products by managing the product database and setting packaging requirements for system inclusion.
- Manage Finances, including collecting deposits and EPR fees from producers and paying back deposits and handling fees to retailers.
- Set Operational Standards, including quality requirements for collection, sorting, and recycling.
- Develop the System, by investing in new infrastructure and technology to improve system performance.

The Ministry of Environment evaluates Dansk Retursystem's exclusive right every three years. This evaluation covers operational performance, cost efficiency, stakeholder satisfaction, and environmental achievements.

6.1.3 Material and Financial Flows

Dansk Retursystem operates a closed-loop system involving producers, retailers, consumers, and recycling facilities. Its collection infrastructure consists of several channels:

1. Reverse Vending Machines (RVMs) in supermarkets and large stores for automatic collection
2. Pantstation - 14 deposit stations for large volume returns
3. Manual Collection in small shops, kiosks, and restaurants
4. Special HORECA system for hotels, restaurants, and cafes

System Flow

The process involves eight stages from product registration to new package production. Producers register products and pay deposits plus administrative fees. Consumers pay deposits (1-3 DKK) at purchase and receive refunds upon return to reverse vending machines or deposit stations. Retailers receive handling fee compensation, while Dansk Retursystem manages collection, sorting, and recycling partnerships. The key to success lies in full integration between physical packaging flows and financial flows that ensure all parties receive fair compensation. A visual of the deposit and material flow in Dansk Retursystem can be seen in Figure 7.

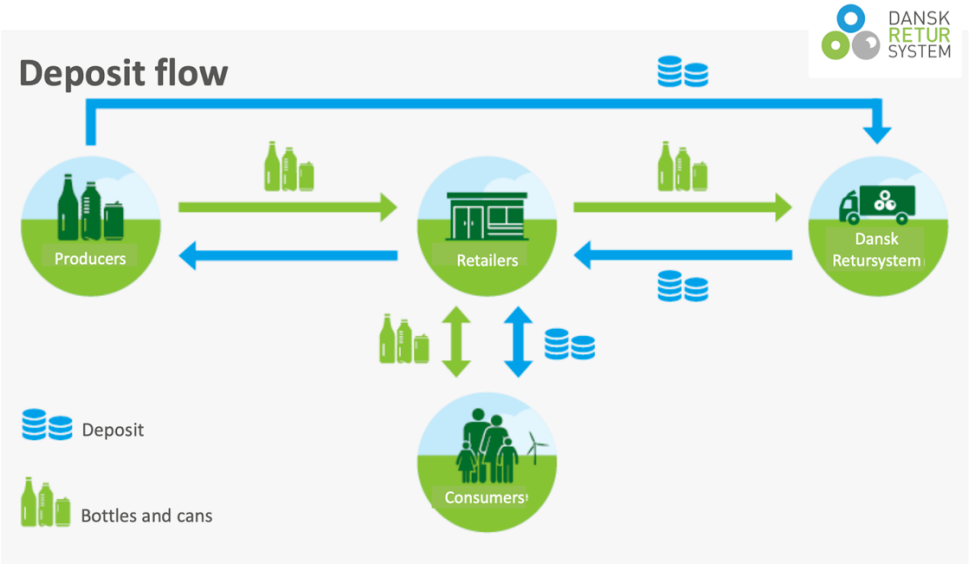

Figure 7. Deposit and Material Flow in Dansk Retursystem

Financial Flow in the System

Financial flow in Dansk Retursystem runs parallel to the physical package flow:

1. Producers to Dansk Retursystem: Producers pay deposits and producer fees to Dansk Retursystem.
2. Retailers to Consumers: Retailers charge deposits to consumers when products are sold
3. Consumers to Retailers: Consumers receive deposits back when returning empty packages
4. Dansk Retursystem to Retailers: Retailers receive compensation from Dansk Retursystem for their services (handling fees)
5. Dansk Retursystem to Recycling Partners: Sorted materials are sold to recycling partners, creating additional revenue

This model ensures package collection does not become a financial burden for retailers, an important lesson for implementation in Indonesia. A visual of the funding and compensation flow in Dansk Retursystem can be seen in Figure 18.

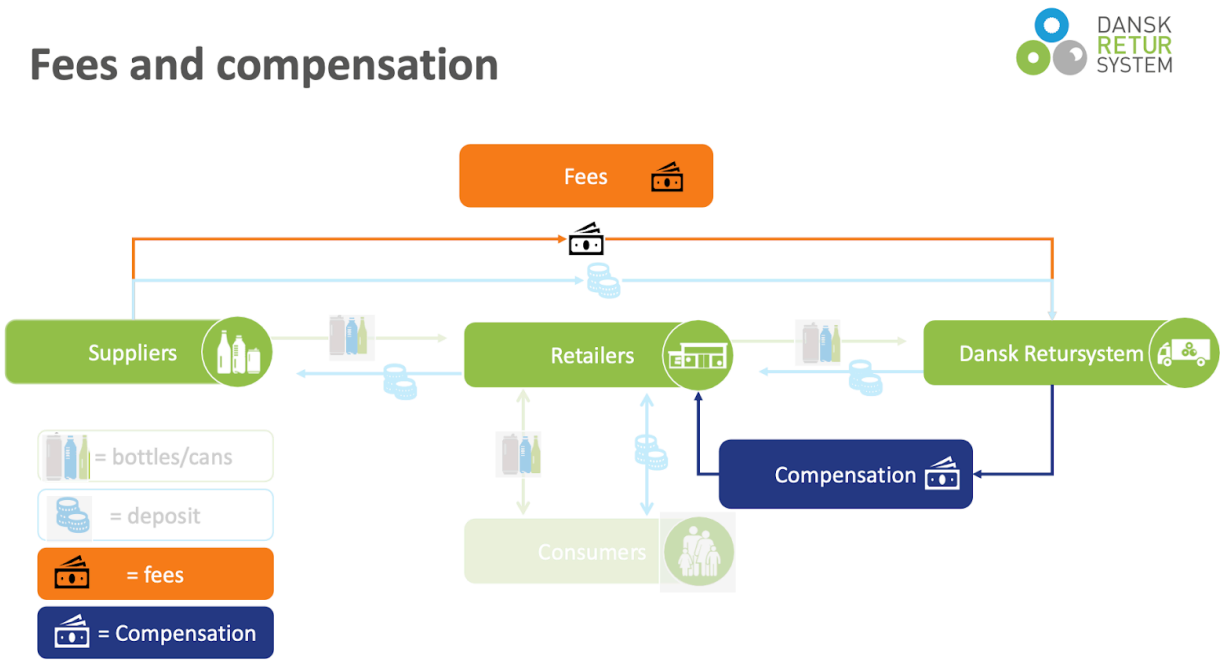

Figure 8. Fees and Compesantion Flow in Dansk Retursystem

6.1.4 Key Success Features

Analysis of Dansk Retursystem key features identifies four elements that can be adapted for the Indonesian context:

1. Sustainable Financial Model

Dansk Retursystem demonstrates how deposit-return systems can combine environmental sustainability with financial viability through four revenue streams: material sales, producer fees (EPR fees), unclaimed deposits, and recycled material sales.

The deposit structure uses a size and material-based approach ranging from 1 DKK (small glass/metal packages) to 3 DKK (large packages over 1 liter), with plastic packages under 1 liter charged 1.5 DKK. Producers pay additional fees averaging 1 øre per package in 2024, while retailers receive negotiated handling fee compensation for collection services. This creates win-win solutions ensuring financial sustainability for all stakeholders while maintaining environmental objectives.

2. Technology Infrastructure and Information Systems

Dansk Retursystem's operational efficiency relies on integrated technology infrastructure including a central product registration database, advanced packaging recognition systems in reverse vending machines with fraud detection, optimised logistics management for vehicle fleets, digital payment integration with mobile applications, and automated optical sorting technology for material separation. These technology investments enable high operational efficiency, transparency, and accountability throughout the system.

3. High Return and Recycling Rates

Dansk Retursystem achieves 93% return rate and 99.7% closed-loop recycling, with material-specific performance of PET (94%), Glass (98%), and Aluminum (98%) recycling rates. Most materials become new packaging of the same type, demonstrating successful circular economy implementation through deposit-return systems.

4. Strong Public Support

One of the main strengths of Dansk Retursystem is the very high level of public support. Surveys show that 92% public support is built through system convenience (77% say it's easy), perception of positive impact (86%), and clear cost-benefit (81%). This lesson is important for building Indonesian public acceptance of DRS.

6.1.5 Learning from Challenges and Solutions in Implementation

Although Dansk Retursystem has operated successfully, its development over more than two decades has faced several challenges. Understanding these issues and how they were addressed can offer useful lessons for Indonesia when designing a similar system.

The information in this section is based on the reflective document “20 Years of Producer Responsibility Across Sectors: The Story of a Deposit System for a Circular Economy”, which was prepared by Dansk Retursystem based on their operational experience.

1. Policy Debates and Long Negotiations

Early challenges included Denmark's beverage can ban conflicting with EU free market policies. The solution was a compromise: maintaining environmental goals through strict deposit systems while gradually removing the total ban, aligning with EU rules while preserving environmental ambitions.

2. Multi-Stakeholder Coordination

Setting up the system required a long negotiation process with different actors, including producers, retailers, and public authorities. These discussions were not always easy due to conflicting interests. To manage this, a special committee was formed, involving representatives from industry and retail to develop a shared agreement. An open approach and good documentation helped to build consensus and a cooperation structure that was accepted by all parties.

3.Business Model and Structural Challenges

In the early stages, some large retail chains in Denmark considered creating their own collection systems. However, such separate systems would disadvantage small shops and make it harder for consumers, who would have to return packaging to the same store where they bought it. The solution was to create a regulated monopoly under strict supervision. A national system was agreed upon to ensure that all businesses, big or small, could participate on equal terms. Although monopoly structures often raise competition concerns, this model allowed for large infrastructure investments and ensured universal access for all producers and retailers.

4.Technical and Infrastructure Complexity

Building nationwide deposit systems required major investments in packaging identification, logistics, and sorting facilities. Solutions included installing thousands of scanners, tamper-proof labels, dedicated truck fleets, and connecting return points through digital infrastructure.

5.Trust and Legitimacy Issues

Not long after implementation, Dansk Retursystem faced a trust crisis after being accused of sharing sensitive business data with board members. Although the company won the legal case and the accusations were proven false, the incident had a serious impact. To restore trust, the company introduced independent audits, strengthened data security, and increased public transparency. These steps helped reinforce the integrity of the system and showed the importance of building a strong, independent governance structure from the beginning.

6.Financial Sustainability Risks

Deposit systems have a unique financial logic: the higher the return rate, the lower the income from unclaimed deposits. This creates a financial challenge if it is not balanced with operational efficiency. Dansk Retursystem responded by applying strict efficiency strategies, process automation, and maximising the value of recycled materials. During the 2020 strategy period, the average cost per item was reduced by 58%, even though the system's volume and return rate increased.

7. Achieving High-Quality Recycling

Creating closed-loop recycling that preserves material value was challenging, especially for colored plastics initially unsuitable for new bottles. Strategic partnerships with packaging producers and advanced sorting technology investments gradually expanded closed-loop materials, including breakthroughs for light green plastic bottles in 2021.

8. Tackling the "Missing 7%"

Capturing remaining 7% of unreturned packaging found in household waste, business waste, and public bins required targeted communication campaigns, more accessible bulk return stations, and cooperation with waste managers to extract deposit packaging from general waste streams

9.Ongoing and Emerging Challenges

Mature systems face continuous adaptation including material price fluctuations affecting economics, evolving regulatory requirements, and cross-border fraud from neighboring countries with lower deposits. These are addressed through cost-adjustment mechanisms, regulatory collaboration, and enhanced security features.

6.2 DRS Initiatives in Indonesia

The following case studies examine two packaging return initiatives developed in Indonesia with different approaches. Plasticpay is a technology-based initiative, utilising local Reverse Vending Machines (RVM) and digital applications to offer incentives for consumers who return PET bottles. Meanwhile, KIBUMI presents an alternative approach that incorporates the informal sector. Both models offer complementary lessons on how DRS can be developed within the Indonesian context. The analysis is based on online presentations and interviews with representatives from each organisation, further supported by an analysis of presentation documents, project documentation, and resources from official websites.

6.2.1 Plasticpay: RVM and Digital Technology-Based DRS

Plasticpay is a technology-based initiative from the private sector that aims to change the plastic waste management paradigm in Indonesia through a circular economy approach. Indonesia has high consumption of bottled drinking water due to limited access to tap water. As a result, plastic bottle volume continues to increase, while waste management infrastructure is still considered inadequate both in terms of quality and capacity. This program was initiated based on awareness of low recycling rates, lack of separate collection infrastructure, and public confusion about how and where to recycle.

Plasticpay operates under PT. Plasticpay Teknologi Indonesia, a subsidiary of a large company in plastic recycling and was created as a response to plastic waste management challenges in Indonesia, especially the low quality of post-consumer PET bottle collection from the community.

Operational Model: RVM and Digital Application

Plasticpay operates around 189 RVM units, each with capacity to store up to 700 PET bottles, located in Jabodetabek area and major cities in Java and Bali. These machines are strategically placed in public spaces such as shopping centers, train stations, gas stations, and campuses.

Unlike typical DRS that use deposits, this system does not use deposits but offers incentives. Plasticpay uses an RVM-based system that allows people to return PET bottles and receive digital points, which can be exchanged for e-money, credit, or goods.

The system operates through three simple stages: (1) automatic collection via optical sensors without barcodes, (2) point distribution to mobile applications, and (3) direct transportation to recycling facilities without going through aggregators. This approach ensures material quality is maintained for food-grade recycling.

An illustration of the PET bottle collection and recycling process using RVMs and the digital application can be seen in Figure 9 below.

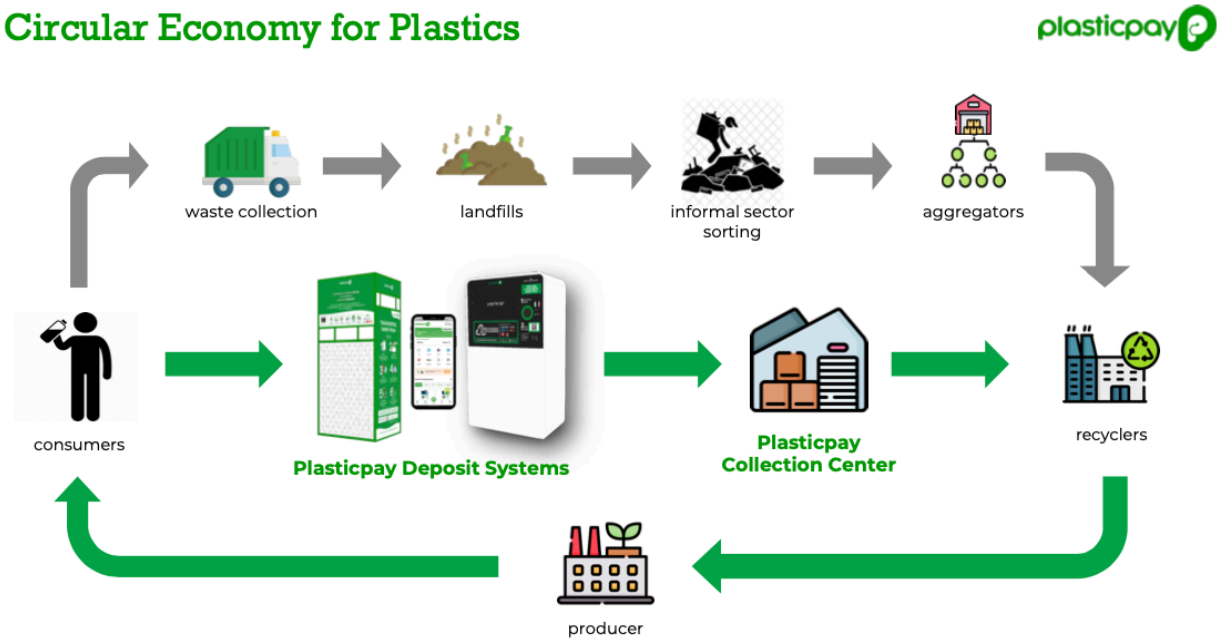

Figure 9. Scheme for collecting and recycling PET bottles using RVM and the Plasticpay digital application

Processing and Economic Value Creation

The bottles collected from the machines become the physical property of Plasticpay, while the data on the number of collected bottles belongs to the corporate partner whose machine is used. The collected bottles are then sent to the recycling facilities owned by the same business group.

Bottles that meet food-grade quality are processed back into new bottles (closed-loop recycling), while the rest are turned into open-loop products such as dacron and polyester linings used in the textile or infrastructure industry.

Plasticpay also applies the upcycling concept, working with local small and medium enterprises (SMEs) to produce value-added products from recycled materials. These products are then sewn by SMEs into merchandise or functional household items that are affordable and practical, and used by corporate partners in their recycling campaigns.

Business Scheme: B2B2C Green Enabler

Unlike DRS in developed countries that are usually regulation-based, Plasticpay has developed in a policy environment that is not yet fully supportive. Currently, there are no regulations governing DRS implementation in Indonesia. Plasticpay operates as a "Business to Business to Consumer Green Enabler", using an approach that bridges consumer and corporate interests.

Plasticpay implements a rental-operation partnership model with corporate partners, where machines are not sold, but rented for certain periods (1-5 years). In return, data about collected bottles is provided to partners and can be used in sustainability reports or ESG disclosures. Corporate partners involved include Aqua, Wings, Unilever, Grab, BSI, Pertamina, and several government ministries. The reward model offered to users also varies based on partnership schemes. Through this scheme, this model provides clear benefits to all parties involved, where consumers get incentives, corporations get sustainability data, and Plasticpay gets sustainable revenue streams.

Learning Result from Achievements

Since the program launched in December 2019 until December 2024, Plasticpay has collected around 20,000,000 plastic bottles, or about 300 tons, and reached 180,000 application users. Although incentive values are not yet based on official deposit systems, 100% of collected PET bottles are directly managed by Plasticpay, without going through aggregators, and sent to recycling facilities owned by PT Inocycle Technology Group, Tbk.

From the technology side, besides using RVMs, the Plasticpay mobile application has been downloaded by more than 111,559 users, with ratings of 4.8 on App Store and 4.5 on Google Play. This application allows users to view transaction history, find nearest RVM locations and their current status, check and exchange Plasticpay points, convert points to e-wallet balance, bank account transfers, mobile credit, or loyalty points from partner programs and share their recycling achievements on social media

For its innovative approach and impact, Plasticpay has received various international awards, including Hyundai Startup Challenge and sustainable business model competition in South Korea. Plasticpay has also been invited by G20 and other international institutions to present this solution as an example of green initiatives from Indonesia.

Structural and Contextual Challenges

In implementing its programme, Plasticpay faces several challenges. One of the main issues is the absence of a DRS regulatory framework in Indonesia. As a result, the system is not based on official deposits, but rather on voluntary incentives, which are relatively low compared to DRS in other countries. Therefore, Plasticpay needs to compensate for this by using strategic campaigns to increase participation.

Other challenges include low public awareness and the high cost of logistics and operations. Logistics is considered the most critical challenge, as Plasticpay has to cover the full cost of collection, machine maintenance, and operational activities.

Public education remains a challenge, particularly as the digital incentive system is not yet familiar to all segments of the population. Moreover, there is potential for misuse of the system by

users, such as attempts to insert bottles repeatedly or manipulate sensors. This has required Plasticpay to develop more advanced security and validation features in Plasticpay's system.

6.2.2 KIBUMI: DRS Integrated with Informal Sector

In collaboration with GIZ Indonesia, KIBUMI implements a digital packaging return system pilot project in Bandung City, Indonesia. This project is carried out together with waste management partner Parongpong, and involves key collectors such as waste banks and lapak (informal waste collection point). This scheme is designed to address the low recycling rate of dark-colored plastic packaging, which usually has no market value and often ends up in landfills or is burned.

This project started from understanding that DRS applied in developed countries might not be directly applicable in Indonesia. Therefore, this project aims to adapt the DRS model to local context, by working with existing collector actors such as waste banks and informal collectors. Unlike other systems using Reverse Vending Machines (RVMs), this Digital Return System builds a digital-based collaborative model that directly involves the informal sector.

Inclusive Approach: Integration of Waste Banks and Lapak

In this project, three local UMKM brands were selected as partners: Botanina, Rumah Atsiri, and Yagi. These brands produce skincare products and are known for strong environmental awareness and flexibility as small businesses to participate in small-scale pilot projects. Most of their products are packaged in dark-colored PET bottles, so this project also aims to return low-value materials from waste streams.

KIBUMI's Digital Return System focuses on three main objectives:
1. Connecting producers/brand owners with waste collectors and recycling processors
2. Improving welfare of collector partners such as waste banks and lapak
3. Increasing collection and recycling of post-consumer PET bottles, especially dark-colored ones with low market value

The project was developed through several stages: assessment, scheme design, MoU preparation, limited implementation for two months, and final workshop. During the assessment stage, KIBUMI studied the condition of each brand, previous initiatives, willingness to pay, and readiness of lapak and waste banks. Based on this, a flexible DRS scheme was designed, including development of a digital platform called "Balikin".

“Balikin" Digital Platform and Operational Mechanism

The DRS model developed by KIBUMI is designed considering local conditions in Indonesia. Unlike systems in developed countries that rely heavily on large retail networks, this project involves waste banks and informal collection points (lapak) as main return locations.

Each brand registered the number of bottles they wanted to collect: Botanina and Rumah Atsiri each targeted 1,000 bottles, while Yagi targeted 500 bottles. The total collection target was 30%, or 750 bottles. Brands pay EPR fees of Rp1,000 per bottle, which is used to cover incentive payments to collectors and processing costs paid to recycling partner, Parongpong.

Collection is done through five collection points (four waste banks and one lapak) with a system designed based on a digital application called Balikin, which is used to record packaging return activities. The process works as follows:
1. Brands register their packaging and pay corresponding EPR fees.
2. Consumers buy products and can return empty packaging to designated stores, waste banks, or lapak. In return, they receive incentives in the form of points for each returned item.
3. Collection point staff use the Balikin application to record return activities (including number of items, packaging types, and collection locations).

4. EPR fees are distributed to waste banks and lapak according to their roles as collection partners.
5. KIBUMI, as a collection hub, arranges logistics and sends returned packaging to Parongpong recycling facility.
6. Collection reports are submitted to each brand, showing program results.

An illustration of the KIBUMI Digital Return System scheme can be seen in Figure 10.

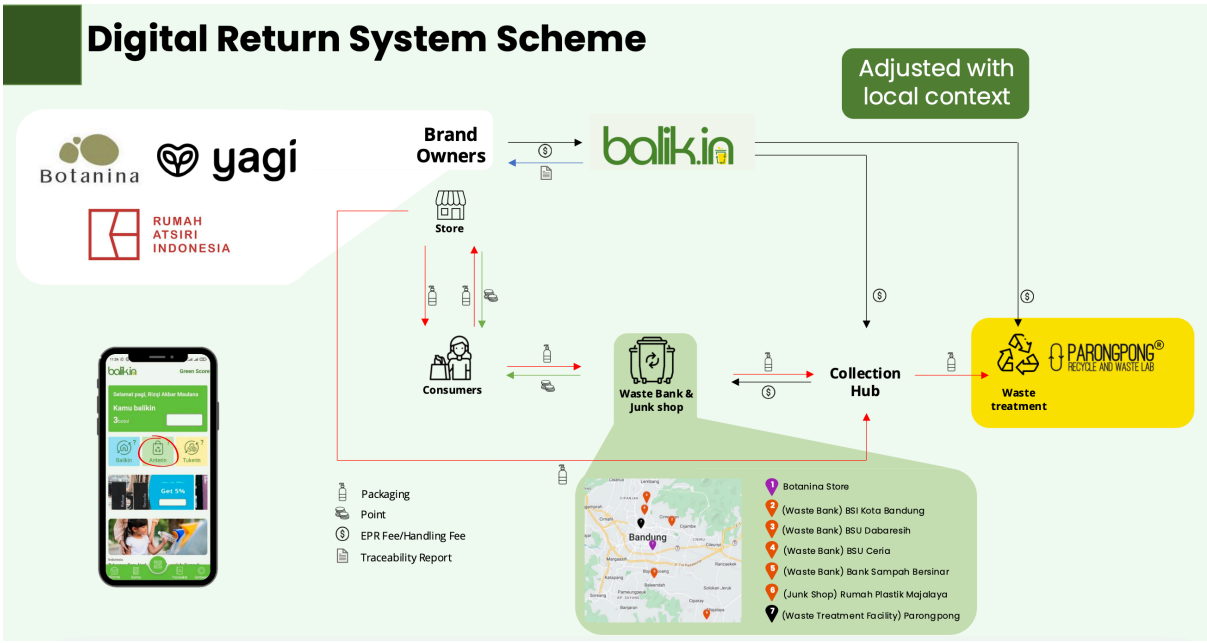

Figure 10. KIBUMI Digital Return System Diagram

Learning Results: Application of Community-Based Model

The project successfully collected 985 PET bottles, exceeding the initial target of 750 units. The majority of the bottles came from offset sources (collection by Lapak and waste banks from outside direct consumer returns). The collected bottles were processed into construction sandwich panel materials by recycling partner Parongpong.

The Balikin application successfully recorded transaction data and tracked returned packaging, although its launch on Google Play was delayed. During the project period, EPR fees given to collection partners were not calculated based on bottle numbers but given as service-based incentives.

An important additional note from this project is that, besides direct collection from consumers, many bottles were collected by waste banks, small lapak, or waste pickers, meaning not all collected dark-colored PET bottles came from participating brands.

Furthermore, incentives given to collectors were not limited to Rp1,000 per bottle, as they were still partially subsidised by project funds. This shows that EPR fees paid by brands are still too low to fully cover actual collection and processing costs.

Challenges and Limitations

Several challenges emerged during the project, including:

- Absence of regulations, making brand participation purely voluntary.

- Rejection of deposit fee system, no brands willing to increase their product prices to include deposit fees due to concerns about reduced competitiveness. As a result, the system only relied on voluntary EPR contributions from brands.
- Different point schemes between brands, some brands preferred "1 bottle = 1 point" system, while others wanted points given per visit, regardless of bottle number. This made system integration in the application difficult.
- Very limited implementation time, which only lasted two months, while behavior change among consumers and communication with brands requires longer engagement periods.
- Most UMKM products lack barcodes, meaning data must be entered manually, making automatic tracking more difficult.

6.3 DRS Model Comparison

Following analysis of the three case studies, the table below compares key features across eight critical aspects

Aspect	**Dansk Retursystem**	**Plasticpay**	**KIBUMI**
Regulatory Framework & Governance	Non-profit with exclusive government rights; Multi-stakeholder board with producer and retail representation	Private sector-led; B2B2C partnerships	NGO-led with GIZ support; Partnerships with local brands (UMKMs)
Deposit Value & Mechanism	Regulation-based deposit (1-3 DKK/Rp2,300-7,000)	Digital point incentives (±Rp56/bottle)	EPR fee (Rp1,000/bottle) without consumer deposit
Collection Infrastructure	Multi-channel: RVM, Pantstation, Manual, HORECA	RVMs in strategic public areas	Existing waste banks and small collectors
Technology & Information Systems	Centralised product registration system; Advanced RVM technology with fraud detection	RVM with optical sensors; Integrated mobile application	"Balikin" digital application; Manual scanning
Financial Model	Self-sufficient: Producer fees + Material sales + Unclaimed deposits	Operational rental (KSO) with corporate partners	EPR fees from brands; GIZ grants
Scope & Scale	National; >2 billion packages/year	Limited to urban areas; 20 million bottles collected (2019-2024)	Pilot project; 985 bottles collected
Informal Sector Integration	Minimal	Indirect	Direct (waste banks & small collectors)
Material Coverage	Multi-material (PET, glass, aluminum)	PET bottles only	Dark-colored PET bottles only

Table 4. Comparison Model DRS

Through this comparison, significant differences are visible between Dansk Retursystem as an established system in developed countries and Plasticpay and KIBUMI as developing initiatives in Indonesia that adopt different approaches. Plasticpay shows a technology-based approach with private sector drive, while KIBUMI offers a community-based model that integrates the informal sector. Differences in scale, material coverage, and incentive mechanisms reflect different contexts and development stages of each initiative.

6.3.1 Analytical Implications for Indonesian DRS Development

Comparison reveals three critical lessons. First, no universal model, each approach reflects a specific socio-economic context. Denmark succeeds with its comprehensive system because supported by strong regulation and formal infrastructure, while the Indonesian initiative develop adaptive strategy in the absence of a regulatory framework.

Second, informal sector integration become key differentiator from the Indonesian model. KIBUMI show potential of an inclusive approach, while Plasticpay operates parallel to the existing system. Indonesia dependence on informal, an integration strategy becomes key for the sustainability of the system.

Third, the choice of technology and the scale of implementation must adjust with financial capacity and infrastructure. Plasticpay rely on sophisticated technology and corporate partnerships, while KIBUMI optimises existing infrastructure with appropriate scaled technology.

This analysis shows that DRS development in Indonesia requires integrating elements from various models adapted to the specific challenges and opportunities in the Indonesian context. The Dansk Retursystem model, with a highly effective 93% return rate and 99.7% recycling rate, needed more than 20 years of continuous improvement to achieve current efficiency level. Meanwhile, Plasticpay's innovative technology approach and KIBUMI's inclusive informal sector integration both provide valuable lessons despite facing challenges such as a lack of regulatory framework, high operational costs, and limited implementation time. Together, these three case studies offer complementary insights that will be integrated into the next analysis to identify optimal design features for the Indonesian DRS.

7. Analysis of Feasibility Deposit Return System Implementation for PET Bottles in Indonesia

This section will address four research sub-questions by examining: (1) potential benefits and drawbacks of DRS for PET bottles in Indonesia, (2) practical lessons from existing DRS initiatives, (3) key challenges and supporting factors for implementation, and (4) design features most compatible with Indonesia's specific conditions. By connecting the theoretical framework with case study evidence, this chapter aims to answer the main research question regarding how DRS can be developed effectively as an instrument within EPR to achieve circular economy goals in Indonesia context.

7.1 Potential Benefits and Drawbacks of DRS Implementation for PET Bottles in Indonesia

7.1.1 Potential Benefits of DRS Implementation

Environmental Benefits

DRS implementation offers three key environmental benefits. First, it increases packaging collection and recycling rates. Dansk Retursystem in Denmark shows impressive results with a 93% return rate and 99.7% closed-loop recycling. In Indonesia, the KIBUMI initiative successfully exceeded its collection target for dark PET bottles, while Plasticpay has collected tens of millions of plastic bottles.

Second, waste and environmental impact reduction. Denmark's system demonstrates significant carbon reduction potential. KIBUMI specifically designed its system to address low recycling rates for dark-coloured plastic packaging, which has low value and often ends up in landfills or is burned.

Third, improved recycling quality through closed-loop systems. Materials collected through DRS maintain higher purity and selling value compared to conventional waste streams, as Plasticpay illustrates by achieving bottle-to-bottle recycling that meets food-grade standards. This enables circular economy goals by maintaining materials at their highest value.

Social Benefits

DRS implementation could drive behavioural change and increase community participation in waste management. Plasticpay identifies widespread public confusion about recycling methods and locations, indicating the scale of educational impact that systematic DRS could achieve through direct consumer engagement.

The opportunity for integration with Indonesia's informal sector represents strategic benefit. KIBUMI demonstrates how DRS can improve collector welfare through equipment provision and incentives. Given that 80% of recycling collection is managed by the informal sector, this approach would be more efficient than creating parallel systems, reflecting inclusive EPR principle (Chikarmane, 2012) that effective producer responsibility must work with rather than replace existing collection networks.

Economic Benefits

DRS implementation could create jobs and develop circular economic value chains in Indonesia. Plasticpay shows value flow systems connecting community bottle returns with economic and recycling sectors, involving SMEs in recycled material production. This indicates the potential to enhance domestic recycling value chains and promote SMEs involvement in value creation, aligning with national economic development goals.

Corporate partnerships in Plasticpay provide collection data for sustainability reporting, suggest additional revenue streams beyond traditional DRS models as global supply chains increasingly demand environmental transparency and producer accountability.

7.1.2 Drawbacks of DRS Implementation

Despite these potential benefits, DRS implementation in Indonesia would face several challenges. KIBUMI reveals that no brands were willing to increase prices to include deposit fees due to competitiveness concerns, highlight the EPR implementation challenge where individual producer action faces competitive disadvantage without regulatory frameworks ensuring industry-wide participation.

Consumer behaviour changes would be required regarding packaging storage and return to collection points. Plasticpay identifies widespread confusion about recycling locations and methods among Indonesian consumers, suggesting that public education will need systematic information systems that current voluntary EPR approaches have not established.

Infrastructure challenges would present major barriers, as retail structure analysis shows that 75% of retail sales occur through informal networks like warungs or small kiosks with limited space. This contrasts with Denmark's formal retail infrastructure, where adequate space is available for DRS facilities. The infrastructure requirements for national DRS including identification systems, logistics networks, and sorting facilities also demand significant investment. However, KIBUMI proposes an adaptive approach that utilises existing infrastructure, noting that waste banks and collectors are ready to participate.

7.1.3 Indonesia-Specific Context

Indonesia is an archipelagic country with over 17,000 islands. Recycling infrastructure is primarily concentrated in Java and is unevenly distributed across other regions. This geographical condition becomes a factor that must be considered when designing DRS for Indonesia's context.

Regulatory aspects present a fundamental challenge. Unlike Denmark, which has a comprehensive legal framework, Indonesia has yet to establish specific regulations for DRS. The Dansk Retursystem case study emphasises the importance of institutional structure involving all stakeholders and ensuring producer ownership and funding, it highlight the regulatory foundation gap that producer responsibility requires but Indonesia must still develop.

Indonesia also lacks a Producer Responsibility Organisation (PRO) for coordination, with KIBUMI noting the absence of clear incentives and disincentives, resulting in largely voluntary implementation. On the positive side, Indonesia has potential strengths, including smartphone penetration, which creates opportunities for technology-based approaches, as demonstrated by Plasticpay. The existing informal collector network can also be integrated into the system, as KIBUMI shows.

Sub-conclusion

This analysis shows that DRS implementation offers benefits for the environment, society, and economy in Indonesia. However, it faces challenges from economic barriers, infrastructure limitations, and regulatory gaps. Implementation requires careful adaptation to Indonesia's unique geographical, social, and retail characteristics, and sufficient policy support to optimise potential benefits while addressing specific challenges.

7.2 Lessons from DRS Practices and Initiatives for Developing Suitable Models in Indonesia

7.2.1 Regulatory Foundation and Governance

Successful DRS implementation requires a comprehensive regulatory foundation providing long-term certainty. Dansk Retursystem operates under a detailed legislative framework with exclusive rights and regular evaluation mechanisms.

Hanne from Dansk Retursystem explained the importance of strong regulatory framework: *"We have exclusive rights, we are evaluated... the minister can take over the company if we have bad results."* (H. Svenningsen, personal communication, 22 April 2025)

This is supported by Picuno et al., (2025), who identified that core DRS principles depend on well-defined legal structures regulating deposit and refund mechanisms. In Indonesia, the absence of specific DRS regulations has limited initiative development to voluntary approaches, as both KIBUMI and Plasticpay experiences demonstrate.

The Dansk Retursystem case study shows successful producer ownership models with retailer participation and neutral board governance, ensure stakeholder representation while maintaining operational independence. The lesson for Indonesia involves establishing a non-profit Producer Responsibility Organisation (PRO) with multi-stakeholder governance, producer ownership, and regulatory support.

7.2.2 Integration with Existing Infrastructure

Integration with existing collection infrastructure is a suitable approach for Indonesia. KIBUMI demonstrates this potential by successfully utilising existing collector actors, such as waste banks and lapaks, instead of relying on reverse vending machines.

This is supported by Reloop (2023), which emphasises that exchange systems must be accessible to all groups and utilise existing infrastructure, allowing consumers to return packaging to the nearest convenient location.

Picuno et al. (2025), emphasises the role of informal collectors, explaining how DRS can support the livelihoods of economically disadvantaged individuals. KIBUMI successfully integrated four waste banks and one lapak into its system, show how DRS can utilise existing infrastructure and expertise while creating opportunities to enhance the role of the informal sector in recycling value chains.

The lesson for Indonesia is that designing DRS with partnership model involving existing infrastructure and informal sector can reduce investment cost while solving social and operational challenge. This approach requires training and certification for waste collector, and also integration with digital tracking system, to create inclusive and appropriate collection network in Indonesia.

7.2.3 Adaptive Technology Approach

Analysis indicates that Indonesia requires more adaptive product identification systems than Denmark. KIBUMI encounters challenges because many products, particularly those from SMEs, lack standard barcodes, making automatic tracking difficult, while The Dansk Retursystem shows comprehensive security through packaging registration, deposit labels, and security features.

In Indonesia, different security challenges emerge, as Plasticpay reveals user attempts to manipulate systems for multiple rewards, highlight the need for context-specific solutions adapted to local conditions rather than direct technology transfer from developed country DRS models.

Studies about Digital Return System from Reloop explain that digital transformation is important in modern DRS, enabling accurate tracking and minimising potential fraud (Reloop, 2024a). Research indicates that automatic technology, such as reverse vending machines, plays important in validating return data and preventing fraudulent activities within the system (Malindzakova et al., 2022).

KIBUMI case study recognises digital ecosystem development as more important than physical infrastructure development, suggest that for Indonesia, combining digital platforms with alternative access methods becomes important to ensure inclusivity while utilising developing digital infrastructure that accommodates varying technology readiness levels.

7.2.4 Independent Financial Sustainability and System Funding

Successful DRS implementation is building financial sustainability without reliance on public funding. Denmark's experience illustrates how this can be achieved through various revenue streams. The Dansk Retursystem case study operates independently without government funding, with breweries providing initial and ongoing support.

When asked about financial support from government, Hanne from Dansk Retursystem explained clearly: *"You asked if whether the state of Denmark are paying anything to the system? No, we have never done it. Not nor the start of the company. It was paid by the breweries."* (H. Svenningsen, personal communication, 22 April 2025).

The Danish system maintains financial sustainability through three revenue sources: producer/supplier fees, recycled material revenue, and unclaimed deposits, with strict material-based cost accounting ensuring each packaging type covers its own costs without cross-subsidies between different materials, reflecting true cost internalisation principles.

Indonesian case studies show innovative adaptations to local economic conditions that maintain sustainability principles. Plasticpay implements operational rental schemes with corporate partners, where collection data becomes additional value for sustainability reporting, while KIBUMI uses direct EPR fees from brands (Rp1,000 per bottle) to fund operations. These variations demonstrate the importance of adapting financial models to local economic conditions while maintaining the core principle of industry-funded sustainability.

7.2.5 Incentive Models for Producers and Consumers

Effective DRS require carefully balanced incentives for both producers and consumers, but approaches must be adapted to local economic conditions and price sensitivity. The Danish system demonstrates how environmental goals can be financially incentivised through eco-modulation that encourages sustainable packaging design. The Dansk Retursystem case study shows differentiated fee structures: zero fees for aluminium cans, low fees for clear PET, and higher fees for coloured PET bottles.

In Denmark, deposits of 1 – 3 dkk (Rp2,300 - 7,000) drive 93% return rates, but Indonesian initiatives show alternative models that adjust to local price sensitivity and regulatory limitations. KIBUMI provides incentives through point applications and direct producer contributions without involving consumer deposits, preventing price increases for price-sensitive consumers while maintaining producer responsibility principles.

Plasticpay developed digital incentives of Rp56 per bottle connected to e-wallets, combining with platform partnerships for enhanced rewards through user acquisition campaigns. The key lesson emphasises incentive compatibility with local socio-economic conditions, where producer incentives through eco-modulation can encourage better packaging design, while consumer incentives through producer contributions and digital partnerships can accommodate diverse purchasing power across regions.

Lessons for Indonesia highlight incentive compatibility with local socio-economic conditions. Producer incentives through eco-modulation can encourage better packaging design, while consumer incentives through producer contributions (KIBUMI) and digital partnerships (Plasticpay) accommodate diverse purchasing power and preferences across regions.

While current initiatives use voluntary incentives, the Dansk Retursystem case study shows deposit values as political decisions requiring parliamentary regulation. Without clear regulation regarding deposit values, implementation remains voluntary and uncoordinated. Therefore, future DRS development in Indonesia requires economic study to identify appropriate deposit level for different areas and a regulatory framework that officially establishes these values.

7.2.6 Focus on High-Quality Recycling

Successful DRS must prioritise achieving high-quality recycling outcomes rather than only focus on maximising collection volumes, aligning with circular economy principles of maintaining material value. Dansk Retursystem emphasises achieving circularity through bottle-to-bottle and can-to-can recycling, targeting 93% reuse by 2025, while Plasticpay emphasises collecting clean bottles suitable for food-grade use.

Reloop (2023) supports this approach, stating that high-quality materials generate greater economic value and strengthen domestic recycling industry. Data from the Reloop Global Deposit Book demonstrate the effectiveness of the DRS in enhancing both collection quality and quantity, it indicates collection rates of 80-90% in countries with DRS, compared to only 40-60% in those without it (Reloop, 2024b).

The European Union, through the Packaging and Packaging Waste Regulation (PPWR), established minimum separate collection targets of 90% for single-use plastic bottles and metal beverage containers by 2029. Member countries that fail to meet these targets are required to implement DRS (Reloop, 2024a).

Indonesia must prioritise quality of recycling over quantity. Problem analysis show that PET bottles in Indonesia have poor quality due to contamination and the sorting method known as 'gabruk' (Sustainable Waste Indonesia, 2025). From many recycling facilities in the country, very few facilities produce food-grade bottle-to-bottle recycling. With government plans to require minimum recycled content in packaging, the finding supports aligning DRS with recycled content target policies to create stable market demand for high-quality recycled materials, strengthening domestic recycling industry capacity and supporting circular material flows.

7.2.7 Gradual Implementation Strategy

Successful DRS implementation benefits from gradual, phased approaches that allow for system refinement and stakeholder adaptation, reflecting best practices in EPR system development. Dansk Retursystem shows successful gradual expansion from beer and carbonated drinks to include alcoholic beverages, mineral water, juice and squash over time, KIBUMI emphasises the value of piloting in focused areas to identify pros and cons.

Reloop notes that many DRS begin with small scope gradually expand to cover more areas or product types. This gradual approach help reduce stakeholder concerns, allows for testing the system on a smaller scale first, and helps the public understand the system before implement it in whole country (Reloop & Container Recycling Institute, 2023).

For Indonesia, the lesson emphasises that DRS implementation should proceed gradually, starting with specific product types in areas with relatively developed collection infrastructure, then expanding coverage over time in alignment with adaptive EPR approaches for developing countries.

Sub-conclusion

While the Danish system offers examples of mature and comprehensive DRS, Indonesia's context requires careful adaptation, not just direct replication. Lessons from three case studies show the importance of clear regulations with focus on high quality recycling, integrating existing infrastructure, especially informal sector, adaptive technology, a self-sustaining financial model, and gradual implementation to develop effective DRS models in Indonesia.

7.3 Main Challenges and Enabling Factors for DRS Implementation for PET Bottles in Indonesia

7.3.1 Main Challenges for DRS Implementation in Indonesia

Potential DRS implementation in Indonesia would faces several complex challenges that must be addressed. The archipelagic geographical conditions, lack of a specific regulatory framework, and dependence on informal sector would require structured approaches in developing this system.

A. Regulatory Framework Gaps

Regulatory framework gaps would represent fundamental barriers to DRS scaling in Indonesia, reflecting broader EPR implementation challenges in developing countries. Unlike Denmark's comprehensive framework, no regulations explicitly govern potential DRS implementation in Indonesia.

Current PermenLHK P.75/2019 provides only basic EPR guidelines without clear incentives or disincentives. KIBUMI findings confirm the absence of clear implementation incentives, resulting in largely voluntary programs. This regulatory gap manifests in limited industry participation: only 52 companies submitted waste reduction roadmaps with only 20 implemented actual programs.

Stakeholder analysis reveals regulation as the critical success factor, with "*mandatory EPR needed so there are no free riders"* (A. M. Putra, personal communication, 9 April 2025).

This aligns with TOMRA (2021) analysis that systems without clear performance targets and enforcement mechanisms risk failure, as demonstrated by Massachusetts' low return rates due to insufficient producer incentives. This indicates that, without comprehensive regulatory foundations, implementation efforts would remain fragmented and limited, consistent with international experience showing the importance of enforcement mechanisms.

B. Geographical and Logistical Complexity

Indonesia's geographical challenges would have specific implications for DRS implementation, Indonesia's archipelagic conditions would affect DRS design in several aspects: (1) collection point placement strategy based on population density, (2) efficient material transportation logistics, and (3) compaction technology for inter-island transportation optimisation.

Plasticpay explains: *"Logistics becomes the biggest challenge, considering Plasticpay must bear pickup costs, maintenance, and full operational costs."* (Arif Rahman Abidin, personal communication, 10 April 2025). This illustrates the operational difficulties that national-scale DRS would face, particularly outside Java's more developed infrastructure.

Current geographical coverage shows limitations, as Plasticpay operates 189 RVM machines primarily in Java and Bali, which show limited geographical coverage focusing on most densely populated areas. TOMRA (2021) emphasises the importance of the convenience factor in effective DRS, with recommendations to consider population density when designing exchange networks. They noted that in Norway, the number of collection points per square kilometre

nationally is 0.3, while in the capital, Oslo, it reaches 11 (TOMRA, 2021), demonstrating how effective systems adapt infrastructure according to population density.

This indicates that Inter-island transportation costs would dominate operational expenses, and would require compact technology and and region-specific approaches.

C. Integration with Existing Waste Collection Systems

Transitioning to formal DRS would present significant challenges in sustaining informal sector livelihoods while improving system efficiency, this highlight the complex social dimensions of EPR implementation. With 80% of recycling collection managed by informal sector, integration becomes critical.

KIBUMI explains: *" ..many of our retailers are informal, there are many small shops with very limited space, and they're not focused [on waste collection]. They only focus on selling... We tried to empower the existing sectors that are already focused on collection, namely junk shops and waste banks."* (Ainun Asifa, personal communication, 9 April 2025).

Plasticpay also notes: "*Our challenge is that Indonesia still has many informal shops as well. Roughly speaking, small shops that perhaps even in terms of numbers, are much larger compared to modern retail"* (Arif Rahman Abidin, personal communication, 10 April 2025).

This highlights how small retailers have space limitations, lack formal cash flow records, and limited capacity to manage bottle waste, becoming main barrier. In addition, Warungs that also sell food would encounter hygiene issues if they must store used packaging.

Bünemann et al. (2018) identify the potential for integrating existing collection systems, such as waste banks, as alternative collection stations in DRS. In Indonesia, there are 20,587 waste bank units and 299 Main Waste Banks (Nurofiq, 2025) that would have potential to be integrated into these systems.

However, integration would face complex ownership challenges as KIBUMI notes: *"In Indonesia, currently whoever collects first has ownership, right? So the waste picker then transfers this ownership through monetary means by selling it. The ownership transfers like that, moving continuously from first hand to junk dealer to recycler"* (A. M. Putra, personal communication, 9 April 2025)

KIBUMI stresses non-disruptive approaches: *"We don't want to disrupt the ecosystem. We don't want to create conflict. What's important is that it's more optimal and can support better EPR implementation"* (A. M. Putra, personal communication, 9 April 2025). This indicates that integration challenges would involve technical design, social and economic dimensions, as millions of people's livelihoods depend on existing systems.

This emphasises that potential DRS in Indonesia would require inclusive approaches that not only consider technical efficiency but also protect the livelihoods of the informal sector and develop collection models suitable for local characteristics.

D. Building Technology Infrastructure and Security Systems

Developing adequate technological infrastructure and security systems would pose significant challenges for potential DRS implementation in Indonesia. Success would heavily rely on advanced technological infrastructure and information systems that support three main aspects: operational efficiency, material tracking, and transaction security (Dansk Retursystem, 2022).

KIBUMI emphasised *"The digital ecosystem is what we consider most important before the physical infrastructure. So to ensure traceability, the data can be claimed and accountability can*

be accounted for more accurately" (A. M. Putra, personal communication, 9 April 2025). This recognition that strong digital systems must come before physical collection infrastructure.

This main challenges in Indonesia include:
First, there is a need for a substantial investment in technology infrastructure. OECD (2022) discusses significant initial setup costs for DRS, including investment in physical infrastructure such as automatic collection machines, transportation, and central systems. Systemiq Indonesia (2021) noted that one of the constraints in waste management in Indonesia is a limited budget. This potentially becomes an inhibiting factor for DRS implementation.

Second, Technical barriers emerge from the KIBUMI revealing *"absence of barcodes on products" and that "most SME products don't use barcodes yet,"* (Ainun Asifa, personal communication, 9 April 2025), this creating obstacles to automatic tracking required for efficient DRS.

Third, security concerns add complexity, as Plasticpay notes fraud risks from people potentially buying empty bottles to return for deposits, leading to consideration of blockchain technology solutions that must balance security with accessibility.

These findings indicate technology readiness gaps between Indonesian conditions and DRS operational requirements, necessitating adaptive approaches that accommodate varying digital capabilities while maintaining system integrity.

E. Setting Appropriate Deposit Values

Appropriate deposit values must balance two conflicting needs: they should be high enough to encourage returns but not burdensome for consumers and producers. The Global Deposit Book 2024 shows "clear correlation between deposit value and return rates". Systems with minimum deposits less than USD$0.07 (about Rp1,100) achieve 69% return rates, while deposits ≥USD$0.15 (about Rp2,400) achieve 92%(Reloop, 2024b). Denmark deposit values range from 1-3 DKK (about Rp2,300 - Rp7,000) drive 93% return rates with wide acceptance.

Indonesian reality presents different challenges, reveals price sensitivity challenges. KIBUMI encountered brand resistance to deposit fees due to competitiveness concerns, with *"no brands willing to increase their prices to include deposit fees"* (Ainun Asifa, personal communication, 9 April 2025). This resistance reflects fundamental market realities where even pilot-scale price increases create perceived sales risks.

While, Plasticpay operates with minimal incentives of Rp56 per bottle, far below effective global thresholds. These findings highlight fundamental implementation barriers where traditional deposit approaches may be unsuitable for Indonesian economic conditions.

Bünemann et al. (2018) emphasises adapting systems to local conditions to ensure cost-effectiveness and efficiency. This significant gap between effective global deposit ranges and current Indonesian approaches, combined with brand resistance and inflation concerns, suggests that traditional deposit approaches may face implementation barriers requiring careful consideration of local economic conditions and consumer affordability and highlight need for gradual approaches in setting deposit values.

F. Business Model and Material Ownership Changes

Potential DRS implementation would change economic dynamics in recycling value chains, requiring transition management that addresses social and economic disruption concerns. KIBUMI explains: "*Business model changes, which was originally selling materials becomes collection as a service, becoming an extension of DRS.*" (Andi Manggala Putra, personal communication, April 9, 2025). This represents a significant transformation, as current

informal sector actors generate income through direct material sales, whereas DRS would shift compensation to service-based models.

High-performing DRS typically employ models in which producers finance system management through non-profit organisations, which then manage revenue from unclaimed deposits and sales of collected materials (TOMRA, 2021). This model differs from current waste management systems in Indonesia, where the economic value is obtained directly by waste pickers and collectors through sales to recycling markets.

If DRS is implemented in Indonesia, this change would shift the systems from being material value-based (where waste pickers earn income from material sales) to being collection service-based systems (where compensation is given for collection services). This change in revenue flow could potentially impact the livelihoods of around 2 million waste pickers who currently depend on material sales as their main of income.

Reloop (2023) emphasises legally recognising and protecting scavenger rights in DRS, particularly in areas with active informal sectors. The guide stresses need for human-centred systems with direct cash payment mechanisms and scavenger (canners) -friendly return facilities, especially for large-volume returns (Reloop, 2023).

Based on these findings, the transition of business models in potential DRS would require careful management to prevent resistance from the informal sector. According to Reloop (2023) recommendations, legal recognition, protection of scavenger rights, and inclusive system design can ensure that all parties receive fair compensation and maintain their roles in new systems.

G. Consumer Behavior and Socio-Cultural Aspects

Changing consumer would be the determining factor for the successful implementation of DRS in Indonesia. Analysis reveals Indonesia faces greater consumer education challenges than developed countries, requiring extended transition periods.

Plasticpay findings demonstrate widespread recycling confusion among Indonesian consumers, indicating substantial educational intervention needs. This fundamental lack of recycling awareness presents significant barrier to potential DRS adoption.

KIBUMI emphasised adequate time allocation for adaptation, noting that implementation time was only two months, while consumer behaviour change requires longer time. This experience shows that DRS implementation in Indonesia requires long-term planning with sufficient transition periods to build awareness and change community habits.

From Denmark's experience, Hanne noted that consumer motivation has evolved beyond just financial incentives: *"We do map the consumer satisfaction now and we also know that they are not that much driven by the deposit. They are also more driven by doing good in terms of environment*" (H. Svenningsen, personal communication, 22 April 2025). This suggests that while financial incentives remain important in early stages, environmental education can strengthen long-term participation.

For Indonesia, careful balance between financial incentives, education, and convenience will be necessary to promote consumer participation in potential DRS initiatives.

H. Material Market Imbalance and Export Flows

The PET recycled material market imbalance would have specific implications for DRS implementation in Indonesia. DRS would produce higher quality materials, but without supporting policy, these materials may end up being exported rather than utilised domestically.

Majority of recycled PET bottles in Indonesia are exported abroad, such as to Europe and Australia, due to high demand. PT Amandina Bumi Nusantara, for instance, exports nearly 50% of its recycling output (Pamela, 2024). In the context of DRS, this show that investment in collecting high-quality materials through deposit systems does not always correlate with an increase in quality materials for the domestic industry.

From producers perspectives, higher rPET prices compared to virgin PET can become economic disincentive to using recycled materials in new products. Tetra Pak Indonesia acknowledged that higher prices recycled materials compared to virgin materials impose a burden on producers transitioning to sustainable packaging (Wardani, 2023).

Based on that, effective DRS implementation in Indonesia will require supporting policies, such as minimum recycled content requirements and regulations that limiting recycled raw material exports. This will ensure that high-quality materials collected through deposit systems can be processed domestically and support local circular economy, this align with the recommendations submitted in the Sustainable Waste Indonesia (2025) report.

7.3.2 Enabling Factors for DRS Implementation in Indonesia

Analysis reveals that despite various challenges in implementing DRS, Indonesia has several supporting factors that could serve as catalysts for this system.

A. Policy Momentum as Implementation Foundation

Despite lacking specific DRS regulations, Indonesia experiences conducive policy momentum for strengthening EPR frameworks that could support systematic DRS development. Plasticpay notes that current initiatives could be integrated as EPR implementation components through PermenLHK P.75/2019 regulatory framework development, while growing global focus on marine plastic waste management creates supportive policy environments. This policy momentum creates opportunities for DRS advancement within broader EPR development, reflecting increasing recognition of producer responsibility principles.

B. Industry Participation and Initiatives

Industry participation represents a significant supporting factor for potential DRS development, demonstrating readiness for enhanced producer responsibility mechanisms. Plasticpay has established partnerships with several large companies through Business with corporate partnership models creating mutual benefits through operational rental cooperation schemes where collection data becomes additional value for sustainability reporting.

SMEs engagement shows promise, as KIBUMI worked successfully with SMEs like Botanina, Rumah Atsiri, and Yagi, with their pilot project demonstrating: *"From the registered amounts, Rumah Atsiri registered 1000, Botanina 1000, Yagi 500. So the collection target was 30% of that, 750 bottles, and here we collected 985 bottles."* (Ainun Asifa, personal communication, 9 April 2025),

Plasticpay notes growing producer participation: "*Many producers, it turns out, have already participated. But sometimes here, those who participate, thank you, those who do not participate have not been given any consequences"* (Arif Rahman Abidin, personal communication, 10 April 2025). This indicates producer willingness already exists, though stronger regulatory framework would increase participation.

Several major beverage companies including Coca-Cola Europacific Partners, Danone Aqua and Le Minerale have taken initial steps, while producer groups have formed Indonesian Packaging Recovery Organisation (IPRO) as initial collaborative effort (Plastic Smart Cities, 2022). This finding demonstrates broad industry interest exists across different scales, indicating readiness for more systematic producer responsibility implementation.

C. Integration Potential with Existing Collection Infrastructure

Indonesia has existing infrastructure that could support DRS implementation and build upon established collection networks. Plasticpay operates around 189 RVM machines strategically placed in public locations such as shopping centres, stations, gas stations, and campuses, provide potential foundations for expanded collection networks.

KIBUMI demonstrates successful integration approaches: "*We tried to empower the existing sectors that are already focused on collection, namely junk shops and waste banks,"* (Ainun Asifa, personal communication, 9 April 2025) showing how established systems can be utilised rather than replaced. Indonesia possesses 20,587 waste bank units and 299 Main Waste Banks with potential as collection points, plus other available infrastructure like TPS3R, PDU, and TPST facilities. This scale of existing infrastructure represents available foundations that could reduce new infrastructure investment requirements while supporting inclusive implementation approaches.

D. Digital Technology Initiatives in Waste Management

Digital technology potential shows promise for DRS implementation, particularly in enabling system coordination and consumer engagement. Plasticpay's application has been downloaded by 111,559 users, while KIBUMI developed the Balikin application for packaging return systems. Although currently limited in scale compared to established systems like Denmark's, these initiatives demonstrate potential for using digital technology in managing collection and tracking, with user engagement levels and positive ratings suggesting public receptivity to digital waste management solutions.

E. International Cooperation and Multi-stakeholder Support

Established international cooperation frameworks provide supportive environments for knowledge exchange and capacity building in EPR and DRS implementation. Indonesia established strategic cooperation with Denmark in circular economy and waste management since 2018, with the second phase (2023-2026) including policy dialogue about circular economy, regulatory framework development, and EPR implementation (Danish EPA, 2023). Such cooperation could support developing more effective packaging waste management systems by leveraging international expertise and best practices, facilitating knowledge transfer adapted to Indonesian conditions.

Sub-conclusion

Analysis shows potential DRS implementation in Indonesia would face challenges including regulatory gaps, geographical complexity, informal sector integration, technology requirements, appropriate deposit value setting, business model transitions, consumer education needs, and material market imbalances. Supporting factors include EPR policy momentum, industry participation, existing collection infrastructure, digital technology initiatives, and international cooperation. For success, DRS in Indonesia would need to develop with inclusive approaches that protect informal sector livelihoods, gradual implementation prioritising high-density areas, and locally appropriate models that consider Indonesia’s retail structure and socioeconomic conditions.

7.4 DRS Design Features for PET Bottles Compatible with Indonesian Context

The analysis focus identifies key components in designing practical, inclusive, and sustainable DRS while considering national characteristics and global best practices.

7.4.1 Regulatory Framework & Governance

Based on global evidence and Indonesia's unique conditions, hybrid governance structures combining national coordination through PRO with decentralised implementation at regional levels emerge as the most relevant approaches for effective EPR implementation.

Reloop (2023) identifies three main components in effective regulatory frameworks: legislation setting high collection targets with compliance sanctions; comprehensive reporting requirements; and oversight by government agencies including regular audits, while the Global Deposit Book 2024 emphasises measuring quality of recycled material, not just quantity collected (Reloop, 2024b).

From a governance perspective, the Global Deposit Book 2024 identifies three main models: (1) government-operated systems, (2) industry-managed systems through Producer Responsibility Organisations (PRO), and (3) hybrid models with shared responsibility (Reloop, 2024b), suggesting selection of the ideal model selected depends significantly on each country's social, economic, and geographical context.

The Dansk Retursystem demonstrates centralised PRO model success "It was established by the Minister of Environment... and it was actually the typical Danish model. You bring all the stakeholders together, then you have a talk about how to design" (H. Svenningsen, personal communication, 22 April 2025).

However, Indonesia conditions are different. Indonesia would encounter logistical challenges requiring adaptive approaches. Global Deposit Book 2024 notes that countries with complex geographical challenges like Canada tend to implement hybrid models allowing local adjustments while maintaining national standards (Reloop, 2024b), suggesting adaptation for Indonesia's archipelagic conditions that require flexible EPR approaches for developing countries. Furthermore, considering this complexity, hybrid governance structure that combine national coordination through PRO with decentralised implementation at regional levels emerges as most relevant choice for Indonesia.

Stakeholder dialogue must be central to governance design. As Hanne noted: *"Regardless of where you are in the world, stakeholder dialogue is important. Know your stakeholder, know who's the powerful... where can you cross the line and not and have them suddenly from being a supporter to not supporter"* (H. Svenningsen, personal communication, 22 April 2025). This principle becomes particularly relevant for Indonesia's multi-stakeholder context require consensus-building across diverse regional conditions.

Although Indonesia currently lacks specific DRS regulations, EPR policy momentum through planned PermenLHK P.75/2019 revision can serve as basis for developing integrated DRS legal frameworks.

Based on the above analysis, suitable features include:

1. Hybrid governance structure combining national coordination with decentralised regional implementation.
2. Comprehensive regulatory framework featuring realistic ambitious collection targets.
3. Integrated reporting system tracking not only collection rates but also material quality and post-collection flows.
4. Robust enforcement mechanisms featuring sanctions and transparency
5. Gradual implementation strategy starting with pilot programmes.

6. DRS positioning as a specific instrument within the national EPR framework to enhance PET bottle management effectiveness

7.4.2 Deposit Value & Mechanisms

Based on global evidence and Indonesian realities, deposit value approaches require careful adaptation to local conditions while maintaining core DRS effectiveness principles. Global practice shows that deposit amounts significantly affect return rates, with Reloop (2023) identifying minimum deposits of $0.10 USD (about Rp1,500-1,600) as thresholds encouraging higher return rates, while Global Deposit Book 2024 shows systems with minimum deposits ≥$0.15 achieving 82% average return rates (Reloop, 2024b). Massachusetts case, TOMRA (2021) noted that the $0.05 deposit value (about Rp750-800), unchanged since 1983, has decreased participation incentives, contributing to low return rates (50% in 2019).

Danish success demonstrates this principle, as Dansk Retursystem employs tiered systems ranging from 1 DKK (about Rp2,300) to 3 DKK (about Rp7,000), contributing to 93% return rates. However, Indonesian initiatives show different approaches adapted to local constraints. Plasticpay provides digital incentives (±Rp56/bottle), while KIBUMI employs producer contribution models with EPR fees of Rp1,000 per bottle without consumer deposits.

Research by Amirudin et al. (2023) shows potential consumer acceptance, with 85% considering deposits in Rp1,500 to Rp6,500 range acceptable, though methodological limitations suggest further comprehensive research is needed since DRS does not exist in Indonesia.

Case studies and global practice demonstrate the importance of flexibility in deposit return mechanisms. Plasticpay has demonstrated a digital approach with e-wallet payments in Indonesia. Ministry of Information indicates that 89% of Indonesian population (167 million) uses smartphones with 204.7 million internet users in Indonesia. However, digital gap between urban areas (83% smartphone penetration) and rural areas (over 50%) (Adisty, 2022) shows that DRS in Indonesia need to accommodate diverse deposit return methods.

Based on this analysis, deposit features include:
1. Tiered deposit structure based on packaging size and material type, as implemented in Denmark. This approach offers flexibility and can motivate producers to design more recyclable packaging.
2. Gradual implementation, starting with incentive models like Plasticpay before transitioning to formal deposit systems. This can reduce market resistance and producer concerns regarding competitiveness.
3. Diverse return mechanisms combining digital options (e-wallet) with traditional methods (cash). This approach bridges the digital gap between urban and rural areas, ensuring access for all community groups.

7.4.3 Collection Infrastructure

Collection infrastructure design must adapt to Indonesia's unique retail structure and geographical conditions, requiring approaches that integrate existing systems rather than replacing them. Global practice shows no "one-size-fits-all" approach exists, with successful DRS countries like Germany and Scandinavia utilising RVMs as primary infrastructure (Reloop, 2023), while Global Deposit Book 2024 finds return-to-retail systems consistently outperforming return-to-depot models with 84% versus 69% median return rates (Reloop, 2024b).

In Denmark, Dansk Retursystem operates multi-channel systems that include RVMs, Pantstation for bulk collection, manual collection in small shops, and special systems for the HORECA sector. This infrastructure is supported by advanced sorting and processing facilities that handle packaging before materials are sold to partners in the recycling industry. This integrated system

is managed by Dansk Retursystem as PRO, supported by government regulations, and demonstrates high effectiveness.

Indonesia requires significant adaptation, as geographical challenges as an archipelagic country and 75% of retail sales occurring through informal networks present different conditions from European models. KIBUMI demonstrates community-based approaches by building partnerships with collectors and waste banks, achieving collection targets without large infrastructure investments, while Plasticpay identifies strategic public locations as points with highest participation rates.

Indonesia possesses existing infrastructure, with more than 20,000 waste banks and informal sector networks handling sorting and recycling activities. The community-based approach demonstrated by KIBUMI shows compatibility with local conditions, while the scale of existing waste bank infrastructure represents a foundations that could reduce investment requirements while supporting inclusive EPR implementation that recognises existing collection networks.

Equal access is also an important consideration in designing collection infrastructure. Different countries implement various approaches in their DRS to ensure equal access. For instance, Norway and Finland utilise different standards for collection point density in urban and rural areas, while Estonia enforces accessibility standards for disabled individuals (Reloop, 2024b).

In Indonesia, with diverse geographical conditions, KIBUMI shows a community based approach by using waste banks and lapaks as local collection points. This model reflects the compatibility of collection systems, considering local conditions and infrastructure.

Large volume processing infrastructure is also crucial in DRS. Global Deposit Book 2024 notes that Denmark operates Pantstation for bulk returns, while Oregon (US) implements redemption centres (Reloop, 2024b). Based on direct observation at the Pantstation facility in Høje-Taastrup, Denmark, this system features automatic sorting machines capable of processing hundreds of bottles and cans simultaneously, allowing consumers and collectors to return large volumes efficiently.

In Indonesia, several stakeholders, such as HORECA sector, informal collectors, and institutions, generate significant volumes of packaging. Infrastructure like Main Waste Banks (Bank Sampah Induk) and large lapaks have experience in handling recycled materials in large volumes. This highlights the need to integrate large volume management approaches with existing systems instead of creating new infrastructure.

However, technology like Pantstation should be considered for future development. Such automated bulk processing technology could be implemented gradually in high-density urban areas where volume justifies investment, while maintaining integration with existing informal networks for social inclusion.

Based on this analysis, collection infrastructure features include:

- Multi-channel approach integrating various collection points, including waste banks, informal lapaks, reverse vending machines in strategic urban locations, and community collection centres.
- Collection point distribution system based on population density, featuring higher densities in urban centres and communal/community-based approaches for rural areas.
- Integration with existing networks that already possess sorting and transportation capacity to reduce initial infrastructure investment.

7.4.4 Technology and Information Systems

Technology system design must accommodate Indonesia's diverse producer scales and digital infrastructure gaps while ensure system effectiveness and inclusivity. Global systems universally use barcode-based recording systems (Reloop, 2023), while new DRS explore alternative identification methods such as QR codes, as demonstrated in the planned Goa system (Reloop, 2024b), which provides flexible solutions for small producers lacking international barcode access.

Indonesia presents specific challenges, as many products, particularly from SMEs, lack standard barcodes and require manual data entry that hinders automatic tracking. This disparities in technological capacity between large producers and SMEs highlight the need for consideration in packaging standardisation and registration systems that can accommodate various scales of producers

Digital technology has transformed DRS globally. Digital technology uses is increasing, as seen in South Korea implementing digital payment systems, allowing consumers to receive deposit returns through electronic fund transfers (Reloop, 2024b). Plasticpay demonstrates mobile application-based approaches allowing users to track activities and exchange incentives through digital payment platforms, while KIBUMI developed digital solutions with 'Balikin' application and Modular scheme approaches that accommodate varying technology readiness levels. This examples show that Indonesia has a foundation for implementing digital technology in DRS.

Digital gap between urban and rural areas in Indonesia, poses a challenge to the implementation of DRS technology. The BottleDrop system in Oregon (US) has developed a "Green Bag" option, allowing consumers to register digitally and deposit bags containing packaging at drop-off locations without the need to scan each item (Reloop, 2024b). This shows that models which accommodate varying levels of technology access are relevant to digital infrastructure gaps between Java and outer Java regions.

Reloop identifies that the integrity of the DRS closely relates to the ability to control potential fraud. Anti-fraud mechanisms become important components in maintaining system's financial viability (Reloop, 2024a). This shows that various security approaches implemented in different countries demonstrate diversity in addressing fraud risks.

In Norway, DRS utilise barcode reading capabilities, shape recognition, metal detection, and weight detection in RVM machines to prevent fraud. The use of unique barcodes also helps minimise fraud risks related to cross-border returns (Reloop, 2023), while California, whose system does not utilise barcodes, reported vulnerability to fraud, particularly from containers from outside states returned based on weight (TOMRA, 2021).

Global practice analysis indicates that security and anti-fraud measures in DRS require adjustment to specific risk profiles and geographical characteristics of each country, In the Indonesian context, security challenges will show different characteristics. As an archipelagic country, risks of cross-border fraud may be lower compared to those faced by mainland European countries, but challenges in packaging validation would remain important. KIBUMI case study illustrates that limited identification systems result in difficulties in verifying packaging authenticity, while Plasticpay employs optical sensors for material verification.

Data management and transparency are important components of effective DRS. Dansk Retursystem conducts regular evaluations and employs independent third parties to oversee market data, ensuring neutrality and preventing conflicts of interest, also highlight the need for independent of audits.

Based on the this analysis, technology and information system features include:

- Adaptive product identification system that accommodates diverse producer scales, combining standard barcodes for large producers with alternatives like QR codes for SMEs.
- Digital platform featuring inclusive access options that bridge digital gaps, providing advanced technology solutions for urban areas alongside conventional alternatives for areas with limited digital access.
- Centralised data management system that guarantees transparency and accountability, maintains consistent reporting standards, and undergoes regular independent audits.

7.4.5 Financial Model Features

Financial model ensures the sustainability of DRS. Analysis of various financial models from case studies and global practices identifies several features relevant and compatible with the Indonesian context.

Producer Fees with Eco-Modulation

Financial model design must ensure long-term sustainability while accommodating Indonesia's unique economic conditions and informal sector integration needs. Global practice identifies three main revenue sources: producer fees, material revenue, and unclaimed deposits (Reloop, 2024b), with Dansk Retursystem providing successful implementation examples that maintain operations through these sources without government funding, demonstrating EPR's financial responsibility principle.

Producer fee structures show potential for eco-modulation adaptation, as Dansk Retursystem implements material-based cost structures where easier-to-recycle packaging receives lower fees, while KIBUMI demonstrates producer contribution models with fixed fees per bottle. This suggests gradual approaches to eco-modulation implementation could encourage Indonesian producers to enhance packaging design in alignment with circular economy principles.

Revenue Stream Diversification

Revenue diversification opportunities emerge from the Plasticpay case study which incoporates sustainability reports as additional system services. This indicates that Indonesian DRS development should consider traditional revenue sources plus additional value service potential that responds to increasing corporate sustainability reporting demands.

Inclusive Compensation Mechanisms

Inclusive compensation mechanisms become particularly relevant for Indonesia's informal sector integration. The Global Deposit Book 2024 reveals that efficient DRS use varying compensation rates depending on the type of collection. In Romania, these systems charge different handling fees for manual returns, RVMs, and specialised HORECA services (Reloop, 2024b). This tiered payment structure accounts for the diverse operational costs associated with each collection channel.

In Denmark, Dansk Retursystem has a clear compensation principle: the more manual work needed, the greater the compensation given. According to the Dansk Retursystem website, smaller stores that engage in manual handling receive higher per-unit compensation than supermarkets that use automated systems. Furthermore, Dansk Retursystem also links compensation payments to fulfilment of quality standards and proper sorting practices. Payments may be suspended if excessive sorting errors occur, ensuring consistent material quality (Dansk Retursystem, n.d.).

DRS for Indonesia must consider various collector types (individual waste pickers, small lapaks, waste banks) and operational costs they face. Waste pickers and small collectors engaged in more manual work can be allocated higher handling fees per unit collected, along with additional

incentives for sorting capability and maintaining material cleanliness. This strategy not only ensures fair compensation but also promotes enhanced quality in collected materials, aligning with the recycling industry's requirements for high-quality materials.

Given informal sector dominance, inclusive and performance-based compensation mechanisms will support a just transition to formal DRS and promote high-quality collection.

Based on this analysis, the optimal financial model for Indonesia would need to integrate the three identified features:

- Producer fees with eco-modulation can encourage sustainable packaging design.
- Revenue stream diversification will ensure long-term financial sustainability.
- Inclusive compensation mechanisms that integrate the informal sector and provide material quality incentives to facilitate the transition to effective and sustainable DRS.

Sub-Conclusion

Analysis of five DRS components identifies design features compatible with Indonesian context. Different geographical conditions, retail structures, and socio-economic dynamics in Indonesia, compared to countries like Denmark, necessitate adaptations of DRS models used in developed nations.

Compatible design features for Indonesia include:

1. Hybrid governance structure featuring central coordination and decentralised implementation, supported by a regulatory framework that offers long-term certainty, including performance target systems and effective enforcement mechanisms.
2. Flexible deposit mechanisms that consider local purchasing power, starting with incentive approaches before shifting to formal deposit systems, along with deposit value adjustment mechanisms to ensure long-term effectiveness.
3. A multi-channel collection infrastructure that integrates current networks such as waste banks, informal collectors, and reverse vending machines (RVMs in strategic locations, with collection point density standards varying between urban and rural areas and facilities for large volume returns.
4. Adaptive technology systems with inclusive access options, combining digital solutions with traditional alternatives to address digital gaps, supported by product identification systems accommodating large producers and SMEs.
5. Sustainable financial model with producer fee eco-modulation, revenue stream diversification, and inclusive performance-based compensation mechanisms recognising differences in collection methods and scales while encouraging material quality improvement.

This analysis shows that DRS can be developed effectively as an EPR instrument for circular economy goals in Indonesia through adaptation of global practices to local conditions. Success requires comprehensive regulatory frameworks, inclusive approaches integrating existing networks, and gradual implementation from pilot projects to national coverage, considering Indonesia's unique complexity.

8. Discussion: Proposed Deposit Return System (DRS) Model for PET Bottles in Indonesia

This discussion focuses on implementing a Deposit Return System (DRS) for PET bottles within Indonesia's Extended Producer Responsibility (EPR) framework. The analysis addresses the research question: How can DRS for PET bottles be implemented to strengthen the EPR framework in packaging waste management in Indonesia?

This research deliberately limits its scope to PET bottles from beverage products because of their environmental impact, high consumption volume in Indonesia, and promising recycling potential to achieve a circular economy through the implementation DRS.

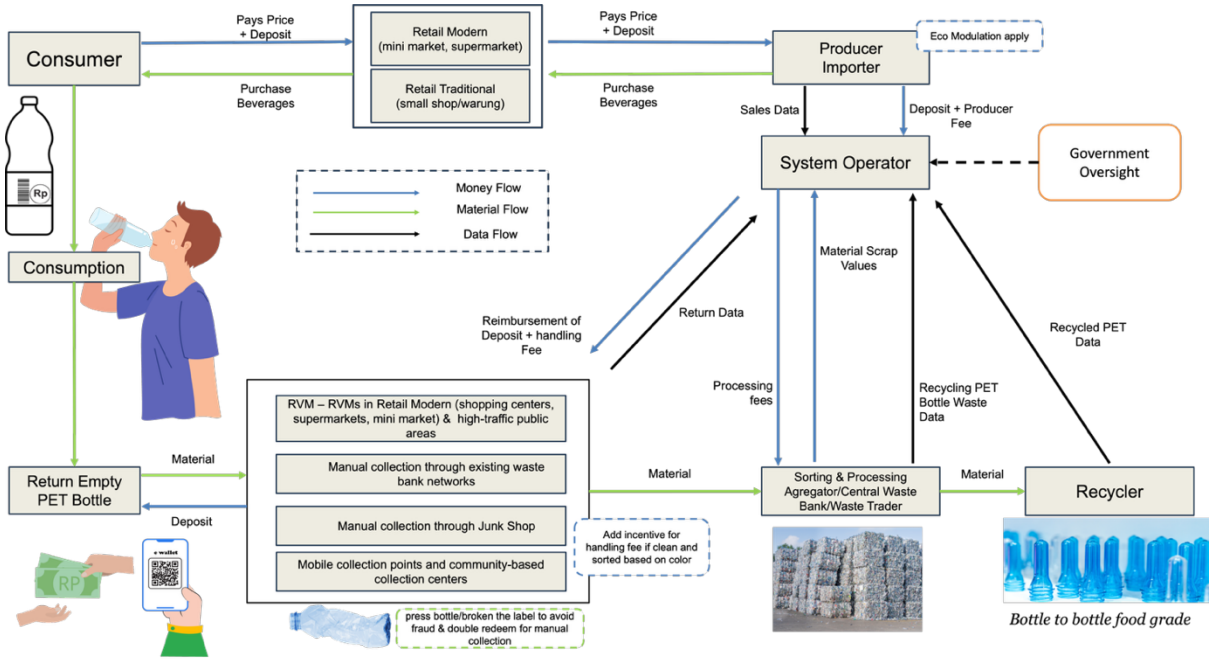

Figure 11. Indonesia Deposit Return System Model (propose)

Figure 11. Indonesia Deposit Return System Model (proposed). Figure showing the complete DRS framework with material flows (green arrows), financial flows (blue arrows), and data flows (black arrows). Framework inspired by Global Deposit Book 2024 DRS Model (Reloop, 2024b)*, adapted for Indonesian conditions.*

The proposed system diagram becomes the foundation for this discussion. The diagram illustrates a framework combining lessons from Denmark's best practices with local Indonesian initiatives, showing material flows, financial transactions, and data exchange needed for a DRS model adapted to Indonesian conditions

8.1 Overview of the Proposed DRS

The proposed DRS model aims to create a closed loop in PET bottle management, from production to recycling back into new food-grade bottles (bottle-to-bottle recycling). At the centre of the system is the System Operator (PRO - Producer Responsibility Organisation), a non-profit entity responsible for coordinating the entire system, managing financial flows, and ensuring accountability. This system shows the complete lifecycle of PET bottles, from production and consumption to collection and recycling, with three types of flows indicated: material flows, financial flows, and data flows.

The system integrates three interconnected flows:

1. **Material Flow**
   Beverage producers distribute products in deposit-bearing PET bottles, consumers consume and return empty bottles through various collection channels, and collected materials are processed by sorting and processing entities and recycled into food-grade materials to make new bottles.
2. **Financial Flow**
   Consumers pay deposits when buying products and get full refunds when returning bottles through various methods (cash, e-wallet, vouchers). Producers pay initial deposits and producer fees to PRO. PRO then reimburses deposits and handling fees to collection points, processing fees to sorting entities, and receives income from material sales to recyclers.
3. **Data Flow**
   Consists of sales reporting by producers, return data from collection points, processing data from sorting entities, and recycling data from recycling facilities, all integrated by PRO for system monitoring and optimisation.

This model is built on five basic principles that form the system foundation:

1. Hybrid governance combining centralised coordination with decentralised implementation
2. Inclusivity, integrating existing infrastructure and actors, including the informal sector
3. Financial sustainability through diversification of revenue streams
4. Focus on material quality to support bottle-to-bottle recycling
5. Gradual implementation starting from pilot projects for learning and adjustment

This approach adapts global best practices to Indonesia's local context. Instead of relying on the return-to-retail model standard in developed countries, this system develops a multi-channel strategy that utilises existing collection networks such as waste banks and lapaks, while adding modern technology like RVMs in strategic locations. This approach considers the dominance of traditional retail in Indonesia with space limitations in small shops, and the critical role of the informal sector in the recycling value chain.

Detailed implementation of each principle is discussed in section 8.2.1 – 8.2.5.

8.2 Key System Features and Justification

8.2.1 Comprehensive Regulatory Framework and Multi-stakeholder Governance

The regulatory framework and governance structure form the foundation for an effective DRS. In the Indonesia, weaknesses in technical regulations for EPR implementation have been one of the limiting factors, as reflected in the limited implementation of PermenLHK P.75/2019. This addresses regulatory gaps identified in Section 7.3.1 where stakeholders consistently identify regulations as important factor for DRS success.

The Dansk Retursystem case study shows that DRS success depends on legal certainty and a clear institutional structure. Dansk Retursystem operates as a non-profit entity with exclusive rights based on national regulations covering 108 technical clauses. These regulations set performance targets, efficiency standards, reporting procedures, and annual evaluation mechanisms. This ensures that the system's main objectives remain on efficiency and environmental sustainability, not commercial profit.

Stakeholder Engagement in Regulation Development

Building an effective regulatory framework requires inclusive stakeholder engagement process during the development phase. Denmark’s experience demonstrate importance of multi-stakeholder consultation where all parties have a voice in system design.

The regulation development process must involve systematic consultation with producers/Producers Association, government agencies, retailers, informal sector representatives, waste bank associations, community organisations, recycling industry, and consumer/environmental groups.

Proposed Governance Structure for Indonesia

Based on these lessons, the Indonesian model proposes a hybrid governance structure, combining national coordination by PRO with decentralised technical implementation through local partners. This approach aligns with DRS models in countries like Canada, which combine national standards with locally adapted implementation to address Indonesia's varied geography condition infrastructure capacity.

The system operator role would carried out by a Producer Responsibility Organisation (PRO) with non-profit legal status. This PRO will be managed by a supervisory board consisting of producers, the government, retailers, waste management actors, informal sector representative, and community representatives. Following Denmark's model, all surplus revenue must be reinvested into the system for infrastructure improvement, logistics efficiency, or producer cost reduction. This approach is important to avoid conflicts of interest and ensure the system remains focused on environmental and social goals.

However, the hybrid structure's success depends on strict regulations with clear role division and inter-institutional coordination mechanisms to avoid overlapping authority between central and regional levels.

Key Regulatory Requirements

The aspects that need to be strictly regulated in DRS regulations include:

Product Coverage & Targets • Setting national collection and packaging recycling targets, recycling content target with closed-loop directions and gradual approach • Producer classification and threshold determination based on packaging volume to ensure proportional responsibility	**Rights & Responsibilities** • Legal recognition of PRO as official implementing body • Registration obligations for producers • Clear stakeholders roles • Sanction and incentive mechanisms for business actors based on performance
Governance Structure • Multi-stakeholder governance structure • External audit obligations and regular public reporting • Periodic evaluation of DRS performance by relevant ministries • Formal provisions regarding DRS implementation and integration in regions • Government approval procedures for significant system investments	**Operational Requirements** • Setting initial deposit values and adjustment mechanisms • Provisions regarding EPR fees, handling fees, and processing fees evaluated periodically • Transparent management of unclaimed deposits • Data protection and management in DRS information systems

Legal Foundation Requirements

The current momentum for revising PermenLHK P.75/2019 provides strategic opportunities to establish a legal basis for a national DRS. This regulatory revision can become an entry point to introduce a more structured DRS framework compared to the current EPR approaches.

However, critical aspect that need emphasis is that DRS in Indonesia require legal foundation at law level/government regulation, not just at ministerial regulation level. The weakness of current

EPR implementation is largely due to the limited binding power of existing regulations. In countries with successful DRS, like Denmark, systems are protected by high-level regulations that not only "encourage" but also "force" industry to participate.

8.2.2 Deposit Mechanism and Value

Deposit value is one of the most strategic and sensitive elements in DRS design, because it directly affects consumer behaviour and packaging return rates. Deposits that are too low do not create sufficient motivation for participation, while deposits that are too high can cause resistance from society and business actors.

Therefore, setting deposit values needs to consider the balance between environmental incentive effectiveness and socio-economic acceptance, especially in the Indonesian context, which has diversity in purchasing power and consumer price perceptions. This address challenges identified in Section 7.3.1 about setting appropriate deposit values.

Deposit Value Determination

Deposit values in DRS are generally set based on packaging type and size, and adjusted to be attractive enough for consumers to return packaging. Based on results from previous analyses, this approach can be adapted in Indonesia. However, in the local context, further studies are needed to determine appropriate values and understand consumer price sensitivity toward deposit schemes.

International studies show clear correlation between deposit values and return rates. Systems with minimum deposits less than USD 0.07 (around Rp1,100) achieve median return rates of 69%, while systems with minimum deposits USD 0.10 - 0.14 (around Rp1,600 - Rp2,200) achieve 88%, and systems ≥USD 0.15 (around Rp2,400) achieve 92% (Reloop, 2024b).

However, these figures are quite high compared to the retail prices of beverage products in Indonesia. As an illustration, the price of 330 ml bottled drinking water in the market ranges from Rp2,000 to Rp3,500 (USD 0.12 – 0.21), while for 600 ml bottles, cost around Rp2,500 to Rp4,000 (USD 0.15 – 0.23). In this context, deposit values that approach or exceed half of the product price potentially create resistance from consumers, especially low-income groups.

Besides consumer concerns, producers also worry that implementing high-value deposits can affect people's purchasing power and harm product marketing. On the other hand, It is important to understand that the concept of deposits is still relatively foreign to most Indonesian consumers.

Although Amirudin et al. (2023) have tried to measure public acceptance levels toward specific deposit amounts, actual DRS implementation in Indonesia has not occurred. Therefore, it's important to emphasise the need for further studies that consider consumer behaviour, local price contexts, and effective public communication strategies.

Gradual Implementation Strategy

The system can start with incentive models like current Plasticpay approach, provide rewards without upfront deposit approach to reduce market resistance and producer concerns about competitiveness while building consumer familiarity with bottle return system. As consumer awareness grows and the regulatory framework strengthens, the system can transition to formal deposit mechanism with value determined through pilot testing and economic studies.

Flexible Return Mechanisms

The proposed system allows several deposit return methods, including cash, vouchers, e-wallets, and bank transfers. These choices accommodate consumer preferences and bridge digital access

gaps in various regions. This address diverse return mechanisms compatible with Indonesian context as recommended in Section 7.4.2.

Cash disbursement through community points can be realistic option in areas not yet reached by formal banking services, while the digital option can be utilised by urban consumers familiar with technology-based solutions.

Transparency and Public Communication

Robust tracking and verification processes are essential for ensuring the system functions efficiently. It is crucial that each return transaction is documented and verifiable to prevent fraud, double claims, or payment delays. The next challenge is ensuring that reimbursement mechanisms from PRO to collection points can run smoothly. Therefore, an integrated digital system is needed that allows real-time tracking and automated reimbursement to all stakeholders in the collection chain.

Deposit transparency and public information openness are key components in building trust and participation. The deposit system introduction must be listed on product labels, including special marks and deposit values, like lessons from Denmark's DRS using "pant system" logos. Deposit values must be listed separately from product prices on packaging labels and purchase receipts. This to clarify that deposits are not part of product prices, but refundable funds. These provisions must be regulated explicitly and strengthened through consistent and easily understood public communication.

The success of deposit and return systems depends not only on nominal values or collection point numbers, but on public acceptance and understanding of the system. Further study and a pilot project to test deposit value need to be set up during the regulation formulation.

8.2.3 Multi-channel Collection Infrastructure

Collection infrastructure becomes crucial component in DRS, because it determines how easily society can access efficient and inclusive return points. In the Indonesian context, DRS implementation requires a collection approach that not only considers technical efficiency but also protects informal sector livelihoods and develops models suitable for local characteristics. This address integration challenges identified in Section 7.3.1 about existing waste collection systems.

Propose Multi-channel Collection Strategy

The Indonesian DRS proposes multi-channel collection that integrates four types of collection points: (1) Reverse Vending Machines (RVMs) in modern retail and strategic urban locations, (2) waste banks and (3) informal waste traders (lapaks) as community-based local nodes, and (4) community collection centers or mobile units to reach areas with limited access.

This approach build on enabling factors identified in Section 7.3.2 about integration potential with existing collection infrastructure. KIBUMI case study shows that using waste banks and waste trader/lapaks networks as local collection points prove compatible with local infrastructure conditions, while opening collaboration space with informal actors active in recycling chain.

For Indonesian context, return-to-retail model commonly used in developed countries cannot be fully applied. Considering that most retail stores in Indonesia are traditional retail, small shops and grocery stores not proposed as direct return points. Besides space limitations and potential hygiene issues, traditional retail not have adequate transaction recording systems.

Collection Point Selection Criteria

To avoid contamination with organic waste and ensure material quality, proposed DRS collection stream is limited to waste banks and lapaks that have already experienced in collecting plastic

waste separately. Facilities like TPS3R, PDU and TPST are not proposed in this model because these facilities typically handle mixed waste streams that can cause to contamination and compromise bottle-to-bottle recycling quality requirements.

This selective approach ensure that collected PET bottles maintain quality standards needed for food-grade recycling while working with actors who already understand plastic waste handling and sorting practices.

Access and Distribution Standards

The effectiveness of DRS is determined by how easily society can access return points. Following Reloop Guildelines "no one left behind" principles in DRS design (Reloop, 2023), the systems in Indonesia need to ensure several key aspects, including collection points are physically accessible, including for people with disabilities, collection point distribution follows population density-based standards, flexible operating hours, public communication that is easily understood

Large Volume Collection

Besides individual returns, DRS must also address extensive volume collection needs from informal collectors, HORECA businesses, institutions like schools and offices, and event organisers. In the Indonesian context, an effective model is a large-scale collection depot integrated with existing infrastructure, including Main Waste Banks and large waste traders/lapaks.

Sorting and Processing Integration

In the proposed Indonesian DRS model, PRO is still in the formation stage and does not yet have processing facilities like Dansk Retursystem. Sorting and processing entities are needed as links between collection points and recycling facilities. These entities handle further sorting based on packaging type, colour, and quality, cleaning processes to meet recycling standards, quality control, volume consolidation (pressing) for shipping efficiency and documenting material movement from collection to sales.

These entities can be specialised companies contracted by PRO, aggregators with enhanced capacity, or Main Waste Banks with improved processing capabilities. With this approach, material flow in the Indonesian DRS will generally follow the path: **Consumers → Collection Points → Sorting and Processing Entities → Recyclers.**

This approach ensures collection points focus on public service, sorting entities maintain consistency and raw material quality, recyclers receive ready-to-process materials, and PRO can focus its role on system design and oversight functions.

Multi-channel approaches face several challenges. Many collection points, like waste banks and waste traders/lapak, still have limited capabilities in accurately recording and sorting materials. Informal collectors are not accustomed to incentive systems based on volume and quality, so transparent and equitable mechanisms are required for their participation.

Coordination among stakeholders, such as between PRO, regional governments, and local collection actors, remains challenging. Integration between formal systems and informal actors still faces trust challenges, especially regarding the transparency of material flows and compensation.

By adopting multi-channel approaches based on existing structures, Indonesian DRS model can strengthen inclusivity, improve cost efficiency, and reach wider society without creating overlaps with existing recycling systems. Thus, collection infrastructure supported by professional sorting

and processing entities will become an essential foundation for ensuring the success and sustainability of contextual DRS in Indonesia.

8.2.4 Technology and Information Systems

Technology and information systems are strategic elements in building an efficient, transparent, and accountable DRS. In modern DRS, technology functions becomes the foundation for tracking material flows, financial transactions, and comprehensive system performance monitoring (Reloop, 2024a). The proposed DRS model includes three main features designed to address system functional needs while considering local conditions.

Product Identification Systems

Flexible product identification systems. This system allows large producers to utilise standard barcodes or GTINs, while SME actors can use alternatives such as QR codes or manual registration codes provided by PRO. This addresses findings in the KIBUMI case study, showing that many SMEs products still lack digital labelling systems, making automatic tracking processes difficult. This system serves as the basis for product registration processes, packaging tracking, and return transaction validation.

Digital Platforms with Inclusive Access

Digital platforms with inclusive access options combines digital solutions like mobile applications, Reverse Vending Machines (RVMs), and real-time dashboards for urban areas ready infrastructurally, with semi-manual approaches like conventional recording, photo-based reporting, or punch card systems for areas with digital limitations. This platform functions to record transactions, manage deposit claims, and facilitate incentive cashing through e-wallets, vouchers, or cash transfers.

Centralised Data Management Systems

Centralised data management systems. PRO manages this system to record and analyse return data, collection point performance, and financial flows. This system includes regular reporting, independent audits, and early abuse detection, such as double claims or fictitious transactions. For manual collection points, simple procedures like crushing bottles or deleting labels can be used to prevent fraud. System security is adjusted to each point's capacity, from simple visual validation to automatic sensors.

Experience from Dansk Retursystem shows how digital information system integration can ensure operational efficiency and reporting accuracy. RVMs in Denmark scan packaging, record transactions automatically, and connect directly to central systems. Meanwhile, local practices like Plasticpay show that mobile application-based approaches and digital incentives through e-wallets can already be implemented in Indonesia, especially in urban areas. This case study shows that technology systems in DRS can be designed considering different readiness and capacities.

However, implementing information systems in the Indonesian context still faces several challenges. First, digital gaps between regions, especially outside Java Island and archipelagic areas, limit access to internet-based technology. Second, standardisation of identification systems is not yet fully implemented among SMEs. Third, data integrity becomes issue, particularly at collection points lacking digital recording systems. Fourth, system security must prevent abuse without burdening field operators. Finally, supporting infrastructure like connectivity, hardware, and human resource capacity remains very varied.

In response to these challenges, information systems within Indonesian DRS need to be designed gradually. Regions that are already digital-ready can immediately adopt real-time application-based systems, while other areas can start with semi-manual approaches that can be synchronised periodically.

Collaboration with technology startups, logistics companies, and local training institutions is essential to enhance digital capacity at operational levels, particularly for improving informal sector capacity. With flexible technology approaches, Indonesian DRS can increase efficiency, ensure transparency, and build public trust in sustainable packaging return systems.

8.2.5 Sustainable Financial Model

A solid and transparent financing model is needed to ensure that all actors in the system, including producers, retailers, collection points, and system managers, can carry out their functions effectively without burdening consumers or creating incentive imbalances.

The proposed financial model for Indonesian DRS follows Extended Producer Responsibility (EPR) principles, where producers bear financial responsibility for post-consumer packaging management. The system has three main funding sources: (1) deposits paid by consumers and returned when returning packaging, (2) producer fees (EPR fees) submitted to PRO, (3) revenue from recycling material sales.

This system is designed to ensure that all operational costs, from collection and logistics to processing and information systems, can be covered independently without relying on government subsidies.

Eco Modulation Fee

To enhance producer responsibility in reducing packaging environmental impacts, the DRS model adopts modulated EPR fee principles. Producers utilising packaging with high recycling rates and clear labels will be charged lower costs. Conversely, packaging that is difficult to recycle or fails to meet ecodesign standards will be charged higher fees.

This approach encourages more circular packaging design and internalises environmental costs from the design stage. In the Dansk Retursystem case study, the cost structure is based on material types, where aluminium cans are charged lower costs than colored PET bottles because of their recycling ease.

Non-Profit Model and Surplus Management

Experience from Dansk Retursystem in Denmark shows that non-profit financial models with transparent and efficient fund flows can produce robust and trustworthy systems. Operation surpluses are used to reduce costs in the following year or for system investments, not for capital owner profits. In the Indonesian DRS model, this principle is proposed, PRO as a non-profit organisation, reinvests all surplus funds back into the system for purposes such as expanding collection points, enhancing technological capabilities, or training partner managers.

Compensation Structure

This model also regulates compensation through handling fees for collection points and transportation incentives for large-volume collectors to ensure financial sustainability at operational levels. These costs are calculated based on volume, material quality, and logistics efficiency.

In Denmark, small retailers handling manual collection get higher costs than supermarkets using automatic RVMs. The principle "the bigger the effort, the bigger the compensation" becomes relevant for application in Indonesia. Thus, small waste banks, waste traders/lapak, and waste pickers doing manual work can be given higher fees per packaging unit.

The system also sets processing fees for entities running sorting and material preparation functions before sending them to recycling facilities. These entities, such as aggregators, main

waste banks, or PRO-appointed partners, play important roles in maintaining recycling material quality and system logistics efficiency. Processing fees are calculated based on processed material volume and quality standards achieved, and can be linked to performance-based incentive systems.

Material Based Cost Accounting

DRS models also adopt material-based cost accounting principles for different PET packaging types. Operational costs are calculated separately for clear PET and colored or opaque PET. This is important because collection, sorting, and processing costs for colored PET are generally higher, and their selling values are lower than those of clear PET. With this approach, systems can avoid cross-subsidies between PET packaging types and allow evaluation and annual EPR fee adjustments more fairly based on the actual performance of each type.

Revenue Stream Diversification

In addition to revenue from recycling material sales, funding sources may arise from unclaimed deposits from packaging not returned by consumers. These funds can be utilised to support system operations, enhance collection access, or support public education programmes, such as campaign and clean up activity. However, return targets must remain high, and PRO must audit and transparently report on the use of these funds.

DRS can also explore other value-added sources, like Plasticpay, which provides sustainability reports to corporate partners as part of their services. This approach shows that financial innovation and integration with market needs can create revenue diversification that strengthens systems.

Fair Compensation

Create inclusive and fair financing mechanisms for the informal sector, as it manages 80% of waste collection in Indonesia. The implementation of DRS has the potential to shift scavenger income models from being reliant on material selling value to being centred on collection services. Consequently, compensation systems must consider manual efforts, sorting quality, and the capacity of local actors. The KIBUMI case study demonstrates that welfare-based approaches, such as providing equipment, training, and productivity incentives, contribute to fair transitions.

Several challenges require careful management, include price competition with virgin plastic reducing recycling incentives, high-quality PET exports limiting domestic material availability, market volatility creating revenue uncertainty, and complexity in setting accurate eco-modulated fees. Therefore, regulations must govern EPR fee calculation mechanisms, compensation standards, material classification, and regular financial audits.

With accountable financial design, the proposed model ensures economic sustainability while enabling fair transitions toward transparent and performance-based recycling systems.

8.3 System Performance and Policy Integration

8.3.1 EPR Framework Strengthening

The proposed DRS model has the potential to strengthen the EPR framework in Indonesia. One of its main contributions is internalising environmental costs previously borne by society and government. Through structured deposit mechanisms and producer fees, DRS creates concrete implementation pathways for producer responsibility. This includes mandatory participation, measurable performance indicators, and financial accountability.

DRS transforms producer responsibilities beyond administrative commitments into active roles in system management and financial contributions. It can increase transparency and accountability

through material tracking, standardised reporting systems, and multi-stakeholder governance. Digital platforms enable real-time monitoring of material flows, collection performance, and financial transactions. This directly addresses critical EPR implementation gaps where monitoring and verification have been challenging.

Furthermore, DRS can function as a core program in future EPR development. DRS provides measurable foundation starting with PET bottles that can be gradually expanded to other packaging types. The system builds public visibility and directly engages consumers, thereby increasing awareness of producer responsibilities in waste management.

Zero Waste Europe reports (Simon, 2025) support this approach, emphasising that DRS should be prioritised in EPR development because early implementation proves more effective than later integration. Therefore, DRS functions not merely as complement but as central pillar for developing robust and sustainable national EPR systems.

Although potentially strengthening EPR frameworks, DRS implementation faces structural and social challenges. Environmental cost internalisation will likely cause product price increases sensitive to consumers. Packaging design and operational system adjustments will become additional burdens, especially for SME producers.

8.3.2 Circular Economy Contributions

The DRS model potentially makes important contributions to developing the circular economy in Indonesia. Its main benefit is improving the quality of collected material. With systems that separate PET bottles from the beginning and maintain their purity, DRS opens paths for closed-loop recycling, from bottles back to bottles. This can address challenges where most collected PET ends up in downcycling processes.

This system also supports government plans to implement recycled content requirements. By producing stable food-grade recycled PET, producers can meet these policies without sacrificing product quality. This simultaneously creates strong market demand for recycled PET (rPET) domestically.

DRS aligns with national circular economy policy directions. This system not only helps manage waste, but also strengthens more closed and resource-efficient production systems.

DRS infrastructure is also flexible to support system reuse. Collection points and tracking systems can be adapted to support refillable bottles, providing more diverse policy and business model options in the future. This allows Indonesia to move up one level in the waste management hierarchy from recycling to waste reduction (reduce) and reuse.

However, there are practical challenges that need anticipation. The recycling industry's capacity to produce food-grade PET is still limited and requires large investments. DRS success depends on consumer participation levels that can fluctuate. An excessive focus on recycling risks blurring higher priorities in the circular economy hierarchy, namely, reduce and reuse. Domestic demand for rPET is also still limited, creating a risk that high-quality materials will be exported again.

8.4 Phased Implementation Plan Proposed and Approach

The implementation of a DRS for PET bottles in Indonesia should proceed gradually, considering geographical challenges, varied infrastructure capacities, and the important role of the informal sector in existing waste management systems. This approach aims to reduce the risks of failure in the early stages while fostering institutional capacity and gaining stakeholder acceptance.

The implementation strategy is designed in three major phases: foundation building, regional expansion, and national integration.

Phase 1: Foundation Building

The first phase (propose Years 1-2) is focused on deep learning processes, building consensus among stakeholders, and developing evidence-based regulatory frameworks.

Stakeholder Engagement

Socialisation programs should introduce the DRS concept to key stakeholders: producers, retailers, consumers, waste banks, informal sector, and recyclers through targeted workshops and training. The primary objective is to build shared understanding about respective roles and responsibilities, identify potential resistance or concerns, and formulate collaborative solutions from the beginning.

Participatory and Evidence-Based Regulation Development

Regulation development is conducted through a collaborative approach, establishing multi-party working groups, conducting public consultations, and testing initial provisions (drafts) in pilot projects to assess implementation feasibility.

Formation and Operationalisation of PRO Institution

The PRO institution is established as the backbone of the DRS, with a legal structure that enables multi-party governance. Key activities include establishing a PRO founder working group representing diverse stakeholders, designing business and operational models, developing fundamental information systems, and preparing work procedures and reporting mechanisms.

Pilot Project Implementation as Learning Laboratory

Pilot locations are selected based on criteria that include the readiness of waste management infrastructure, presence of active waste bank and collector networks, local government commitment, and a diversity of socio-economic and regional conditions (urban-rural). For example, the pilot proposed in Jakarta (urban), Bali (Tourist Destination) and Yogyakarta (traditional culture). The pilot serves as a learning laboratory to test deposit values with various scenarios to observe price sensitivity regarding return rates. Additionally, incentive schemes, such as cash, e-wallets, and vouchers, are examined to better understand user preferences.

Communication strategies and labelling are tested through various approaches to evaluate consumer understanding of deposit concepts. Additionally, informal sector involvement is conducted through mapping, capacity strengthening, and development of fair compensation schemes.

Monitoring and Adaptation

The pilot includes comprehensive monitoring of consumer behaviour, operational efficiency, financial flows, and environmental impacts, with regular assessment and adjustment mechanisms to ensure continuous system optimisation.

Transition Criteria to Next Phase

Phase 2 begins only when Phase 1 demonstrates convincing results. Indicators of readiness include enacted regulations that have received stakeholder support, PRO design demonstrating ability to manage operational challenges, pilot project showing promising return rate, stakeholder satisfaction during the pilot and tested deposit value. These criteria ensure that expansion only proceeds when solid foundations have been established and validated through practical implementation experience.

8.5 Research Reflection

This study acknowledges several limitations that should be considered when interpreting the findings and proposed DRS model for Indonesia.

Methodological Limitations

The research relies on three primary case studies (Dansk Retursystem, Plasticpay, and KIBUMI), which provide valuable insights but represent a limited sample of global DRS approaches. Denmark's selection as the primary international reference reflects its success and relevance to Indonesia, but other successful systems in other developed countries may offer different lessons.

Data were mainly collected through expert interviews, with limited consumer surveys and stakeholder consultations. Consumer behaviour data remains limited as DRS has not yet been implemented in Indonesia.

KIBUMI's pilot project ran only for two months, limiting understanding of long-term operational issues, stakeholder adjustments, and system optimisation that during longer implementation phases.

Contextual and Operational Limitations

Since Indonesia does not yet have an operational DRS, the model relies on international experiences and small-scale pilots. While these offer important guidance, they cannot fully reflect challenges during nationwide implementation. Financial projections, such as deposit values are based on international benchmarks and may differ from actual conditions in Indonesia, especially in terms of consumer acceptance and local market structures.

Scope and Coverage Limitations

This study focuses only on PET bottles from beverage products, which allows for detailed analysis but limits insights on other packaging types. The geographical focus is primarily on Java and urban centres, while conditions in remote areas may require different strategies. Although KIBUMI’s experience provides informal sector insights, broader engagement with waste pickers, lapaks, and waste banks across regions would enrich the understanding of integration challenges.

Implications for Future Research

These limitations suggest several areas for future research. Broader studies on consumer behaviour and extended pilot projects across diverse regions would help to strengthen the evidence base. More detailed economic modelling tailored to Indonesian cost structures and stakeholders is needed. Comparative studies with other developing countries could provide additional lessons that are more relevant to Indonesia’s context.

Despite these limitations, this study provides a starting point for exploring how DRS could support EPR in Indonesia. The findings highlight the importance of pilot projects, inclusive stakeholder engagement, and gradual system development to ensure that future implementation is both practical and adaptive.

9 Conclusion

This research addresses the main research question: How can a Deposit Return System (DRS) on PET bottles be implemented to strengthen the Extended Producer Responsibility (EPR) framework for packaging waste in Indonesia?

In the first analysis, the potential benefits and drawbacks of implementing DRS for PET bottles in Indonesia were explored. The benefits include environmental improvements through increased collection rates (93% in Denmark) and bottle-to-bottle recycling, social benefits through informal sector integration, and economic benefits through job creation and circular value chains. DRS creates cleaner waste streams with less contamination, enables closed-loop recycling for food-grade bottle-to-bottle production, and reduces littering by providing economic incentives for proper disposal. However, drawbacks include consumer price sensitivity to deposit values, infrastructure challenges in Indonesia's archipelagic geography, and substantial initial investment requirements. The findings show that DRS has potential for Indonesia, but success depends on addressing identified concerns and infrastructure limitations that are different from developed countries.

In the second analysis, lessons from existing DRS practices were examined through comparison of Dansk Retursystem, Plasticpay, and KIBUMI. Key lessons include the importance of comprehensive regulatory foundations, integration with existing infrastructure rather than replacement, adaptive technology approaches accommodate various producer scales, independent financial sustainability, and gradual implementation strategies starting with focused pilot projects. These cases show that DRS implementation needs to be adapted to local conditions, especially when working with informal waste systems that handle most recycling in developing countries.

In the third analysis, key challenges and enabling factors for DRS implementation in Indonesia were identified. Main challenges include regulatory framework gaps, geographical complexity, integration difficulties with informal waste systems, technology infrastructure requirements, deposit value determination, business model transitions, and consumer behavior change. Enabling factors include EPR policy momentum, industry participation, integration potential with existing collection networks, digital technology capabilities, and international cooperation frameworks. This analysis shows that implementing DRS in Indonesia is complex but there are opportunities to build on existing waste management systems and current policy developments.

In the fourth analysis, compatible DRS design features for Indonesia were determined. These include hybrid governance combining national coordination with decentralised implementation, flexible deposit mechanisms transitioning from incentive models to formal systems, multi-channel collection infrastructure integrating waste banks and informal collectors, adaptive technology systems bridging digital gaps, and sustainable financial models with eco-modulated producer fees and inclusive compensation mechanisms. This design features may offer insights for other developing countries with similar informal waste systems and infrastructure challenges.

Based on these analyses, a proposed DRS model specifically adapted to Indonesian conditions was developed. The system centers around a Producer Responsibility Organisation (PRO) operating as a non-profit entity with multi-stakeholder governance, coordinating material flows through multi-channel collection networks, financial flows with graduated deposit values and eco-modulated producer fees, and data flows accommodating varying technological capabilities across regions. The proposed implementation follows a three phases approach: Foundation Building (regulatory framework and pilot projects), Regional Expansion (scaling to urban centers), and National Integration (comprehensive coverage with closed-loop recycling).

The proposed system could potentially strengthen Indonesia's EPR framework by addressing current implementation weaknesses, where only 20 producers implement the EPR program with

existing regulations. DRS could provide concrete mechanisms for producer responsibility through mandatory participation, measurable performance indicators, and financial accountability, potentially creating more systematic approach to packaging waste management.

The key environmental benefit of DRS is its ability to create cleaner waste streams that enable high-quality, closed-loop recycling from bottle-to-bottle food grade, while it reduces littering by offering economic incentives for proper return behaviours. This approach tackles the current issue where much collected PET ends up in lower-quality applications due to contamination in mixed waste streams.

This research provides insights on how to adapt DRS for developing countries by showing that policy tools need to work with existing informal systems rather than replacing them. The multi-channel collection approach and informal sector integration strategies could be useful for other developing countries with similar challenges.

The findings suggest that Indonesian policymakers need to focus on establishing regulatory frameworks that integrate with existing informal waste systems rather than replacing them. The gradual implementation approach offers a way to manage risks while building support from different stakeholders.

All stakeholders play important roles throughout implementation. Government provides regulatory oversight and inter-agency coordination. PRO manages system operations and stakeholder integration. Producers ensure product registration and pay graduated fees while optimising packaging design. Retailers support collection infrastructure placement and consumer education. Consumers participate through packaging returns and behavioral change. The informal sector receives formal recognition with performance-based compensation. Waste banks and collection points serve as community-based return locations. Recycling industry ensures high-quality material processing for closed-loop systems.

This research contributes to knowledge by demonstrating how DRS can be adapted for developing countries with strong informal waste sectors. While acknowledging research limitations discussed in Section 8.5, the findings provide basic foundation for DRS development in Indonesia and offer insights for other developing countries facing similar challenges.

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