Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454

Vol. 22 | No. 1 | pp. 29-38 | 2023

Original Research Paper

https://doi.org/10.46488/NEPT.2023.v22i01.003

Open Access Journal

Rethinking Waste Management in Indonesia Using Public-Private Partnership Framework: A Case Study of PET Bottle Waste Management

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 31-05-2022
Revised: 21-06-2022
Accepted: 22-06-2022

Key Words:
Plastic waste management
Role analysis
Stakeholder integration
Deposit refund system
Waste bank

ABSTRACT

Municipal solid waste (MSW) continues to be a major challenge in almost every country. In Indonesia alone, approximately 64 million tons of MSW are produced on an annual basis. While polyethylene terephthalate (PET) bottles account for 12% of all plastic products, the waste is not well managed. Many stakeholders are involved in PET bottle waste recycling but no forum for stakeholders has been established. In this study, the aim is to identify an acceptable system for PET bottle waste, to determine the role and function of each stakeholder, and to propose a framework under the perspective of public-private partnerships. The study's novelty is the elaborate roles and schematic framework for various stakeholders in PET bottle waste. The aim is to identify an acceptable scheme for PET bottle waste and determine each stakeholder's role and function. Data was generated from electronic databases (2017 to December 2021) a systematic literature review methodology followed by Preferred Reporting Items for Systematic review. The data were analyzed by the Meta-Analysis (PRISMA) approach. This study found that the laws and regulations for waste management in Indonesia are not suitable for dealing with PET bottle waste, and the government carries out limited tasks and dedicates few resources to managing the waste. A public-private partnership framework was proposed to divide the role, commitment, goal, and activities of each stakeholder to properly manage PET bottle waste.

INTRODUCTION

In Indonesia, PET bottle waste is mostly managed by multiple stakeholders in accordance with their own interests. The lack of integration between stakeholders has been acknowledged to lower the optimization of the recycling process in a number of ways: 1) the Indonesian government typically treats PET bottle waste as municipal solid waste; 2) waste collectors and waste pickers treat PET bottle waste as a valuable material that can be sold to industry or processed into other raw materials; 3) waste banks treat PET bottle waste as a valuable waste to obtain higher recycling profit; and 4) producers manage the PET bottle waste without considering the environmental impacts (Putri et al. 2018). Under Law No. 18 of 2008 on solid waste management, the government introduced a mandate to significantly reduce the negative impact on the environment and health. As yet, however, there is little evidence that the law is having an impact on the current conditions (Sondang Siagian et al. 2019).

It has been reported that the involvement of the private sector is likely to be more efficient in providing waste management services rather than relying on the government. By following a simpler administration protocol, the private sector functions more efficiently and flexibly (Adib & Mahapatro 2022, Amirudin et al. 2022). Several private companies in Indonesia, including Danone and Plastic Pay, have taken measures to address the problem related to PET bottle waste by developing a deposit system (Eloksari 2019). However, a lack of support from the government has complicated the management of PET bottle waste, and the system proposed by the private sector has not been well integrated into existing policies. Another major problem is the low collection rate and low awareness among authorities. Thus, in addressing these barriers and finding the best solution to the liabilities related to the environment, it is important to identify a better strategy to manage PET bottle waste.

Therefore, this study emphasizes the importance of public-private partnerships (PPP) to overcome the issues related to the management of PET bottle waste. In several developing countries, PPP has been implemented to strengthen the role of different sectors in waste management (Jotaworn et al. 2021, Sondang Siagian et al. 2019, Sukholthaman et al. 2017). Through this framework, different stakeholders are allowed to cooperate under long-term contractual models and shared risks (Batista et al. 2021). The parties involved are responsible for the planning, financing, construction, and management of government targets (Yang et al. 2013). The implementation of PPP can promote the engagement between private and public sectors to benefit each party in projects (Batista et al. 2021).

However, it has been reported that the implementation of PPP has not met the stated goals both from a theoretical perspective and a policy perspective (Sondang Siagian et al. 2019). For instance, the key infrastructure required to increase the effectiveness of waste collection was not provided by the public sector (Makamté Kakeu–Tardy & Véron, 2019). The unpacking problem of PET bottles shows the complexity of the various stakeholders involved in solving plastic bottle waste. Gerassimidou et al. (2022) evaluated the role of various stakeholders involved in PET bottle waste in the United Kingdom. At the same time, Putri et al. (2018) broke down the material flow in plastic bottle waste in Indonesia. However, little research describes the collaborative roles of these various stakeholders. Therefore, the research will explore roles and schematic frameworks for various stakeholders in PET bottle waste. Thus, the optimization of waste management remains low.

Public-private partnership research will help provide a clearer picture for policymakers to share the integrated roles of various stakeholders. It is urgent to do so that every

Table 1: Search results for combining keywords from the database.

Search results for combining keyword	Boolean keywords	Base	Gross Result	Net Result
Public-private partnership waste management	"Public-private partnership" AND "waste management"	Science-direct	142	104
		Plos-one	71	71
		Taylor and Francis Social Sciences	86	86
		Wiley Online Library	68	50
Public-private partnership solid waste management	"Public-private partnership" AND "solid waste management"	Science-direct	44	31
		Plos-one	21	21
		Taylor and Francis Social Sciences	28	28
		Wiley Online Library	20	19
Public-private partnership project for waste	"Public-private partnership" AND "project for waste"	Science-direct	4	2
		Plos-one	69	63
		Taylor and Francis Social Sciences	0	0
		Wiley Online Library	0	0
Public-private partnership plastic waste	"Public-private partnership" AND "plastic waste"	Science-direct	9	6
		Plos-one	9	9
		Taylor and Francis Social Sciences	7	7
		Wiley Online Library	9	7
Public-private partnership plastic bottle waste	"Public-private partnership" AND "plastic bottle waste"	Science-direct	1	1
		Plos-one	0	0
		Taylor and Francis Social Sciences	0	0
		Wiley Online Library	0	0
Management PET bottle waste	"Management" AND "PET bottle waste"	Science-direct	37	16
		Plos-one	3	3
		Taylor and Francis Social Sciences	0	0
		Wiley Online Library	3	3
		other relevant sources	5	5
Total			636	532

Source: Science-direct, Plos-One, Taylor and Francis Social Sciences, and Wiley Online Library database

stakeholder's interest can be fulfilled and still pay attention to environmental protection. This study aims to identify an acceptable scheme for PET bottle waste, to determine the role and function of each stakeholder in the management of PET bottle waste, and to propose a framework for public-private partnerships to improve the management of PET bottle waste.

MATERIALS AND METHODS

This study adopted a systematic literature review (SLR) method to generate information related to the management of PET bottle waste. Through this method, all of the relevant studies that meet the pre-identified inclusion criteria are identified, appraised, and synthesized. The results are extracted to address the specific research questions. An electronic database was employed to identify all relevant prior studies. Inclusion/exclusion criteria were used for specified types of publications: 1) searches in subject indexes were specified to the index of Science-direct, Taylor and Francis Social Sciences, Plos-One, and Wiley Online Library; 2) literature from the reference list of relevant articles was added; 3) the search was centered on the period between December 2017 and December 2021; and 4) only selected scientific articles were investigated, and all proceedings and conferences with multidisciplinary focus outside PPP related to waste management were removed. The study lists the combinations of Booleans with keywords. The gross results were defined as all types of articles (articles, conference, and book chapters) and the net results include the referred articles only.

By using pre-identified keywords, this study yielded 532 articles from selected publishers as population, and the sampling is 27 studies included in the review (detailed data in Table 1). After removing duplicate documents in searches, the screening process was begun by reading the title and abstract. At the end of the eligibility steps, only articles that met the inclusion criteria remained in the literature review.

Studies Categorization

This study retained 27 articles from the SLR method. Predominately, the most-discussed topic was the role of actors and stakeholders related to waste management (n = 14 or 54%), followed by disposal techniques (n = 7 or 27%), and existing legal policy (n = 5 or 19%). The greatest number of publications (n = 10 publications) was observed in the year 2020. Out of the 26 studies, there were 3 studies conducted in developed countries (n=3), only one study was cross-country research, and most studies were conducted in developing countries, more detailed categorization can be seen in Fig. 1.

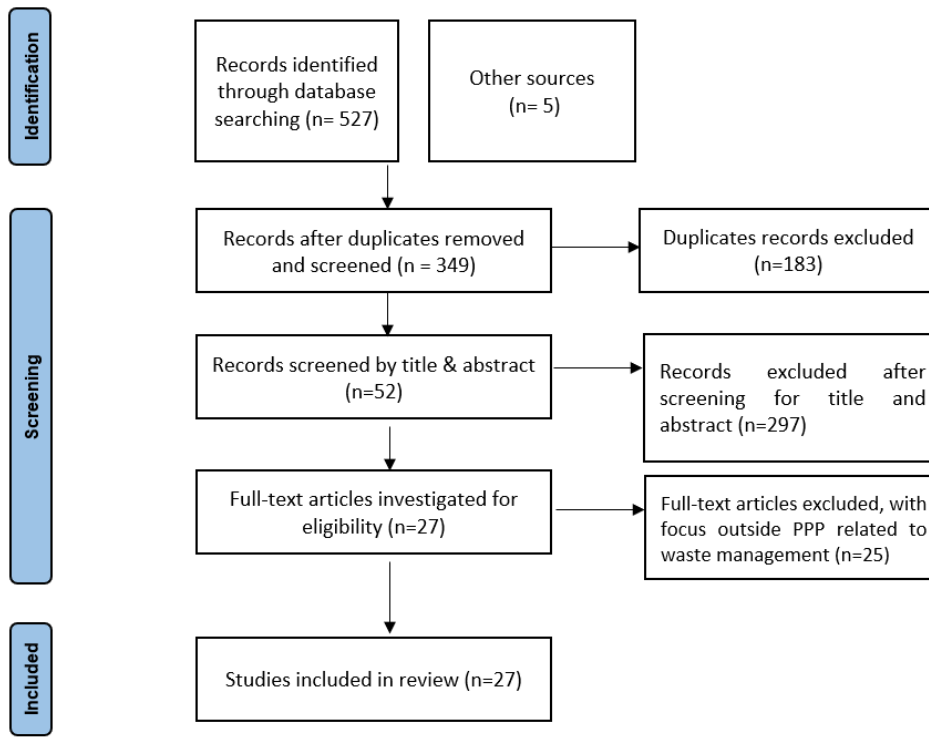

Fig. 1: Data extraction according to the PRISMA guidelines

Role of Actors and Stakeholders Related to Waste Management

In multiple studies conducted in developing countries, the focus was on the involvement of the government, the private sector, the public sector, and individual households in managing municipal solid waste. Under the route of PPP, the central and local governments are the most essential stakeholders that play a role as accountable regulators and environmental factors (Makamté Kakeu-Tardy & Véron 2019). The public sector is responsible as the facilitator while the private sector is authorized to handle the significant responsibilities and risks transferred from the public sector (Dolla & Laishram 2019). Another important factor in the success of solid waste management is the participation of households as key stakeholders in the waste collection (Dolla & Laishram 2019, Makamté Kakeu-Tardy & Véron 2019, Phonchi-Tshekiso et al. 2020). The potential for households to contribute to the costs of solid waste collection was also discussed (1). The focus of research in Indonesia is associated with the formation of waste-pickers with the role of collecting and transacting recyclables (Colombijn & Morbidini 2017, Sasaki et al. 2018).

The research design was developed to get good research. Following the problems described in the background, the research design begins with identifying problems in PET bottle waste management, namely various stakeholders who manage it according to their interests without having an integrated framework. The systematic literature review method is used to get the right literature to be used as the basis for analysis and developing research solutions. The literature obtained is specified on public-private partnerships, especially on the division of roles, obligations, targets, and activities of each stakeholder. Finally, an elaboration of the Schematic of public-private partnership for Stakeholders in PET bottle waste. For more details, the research design is presented in Fig. 2.

RESULTS AND DISCUSSION

Laws and Regulations Relating to Waste Management in Indonesia

To ensure the optimization of waste management in every process from their formation to disposal, it is necessary to investigate the existing laws and regulations, especially the regulation related to plastic bottles. Government, business

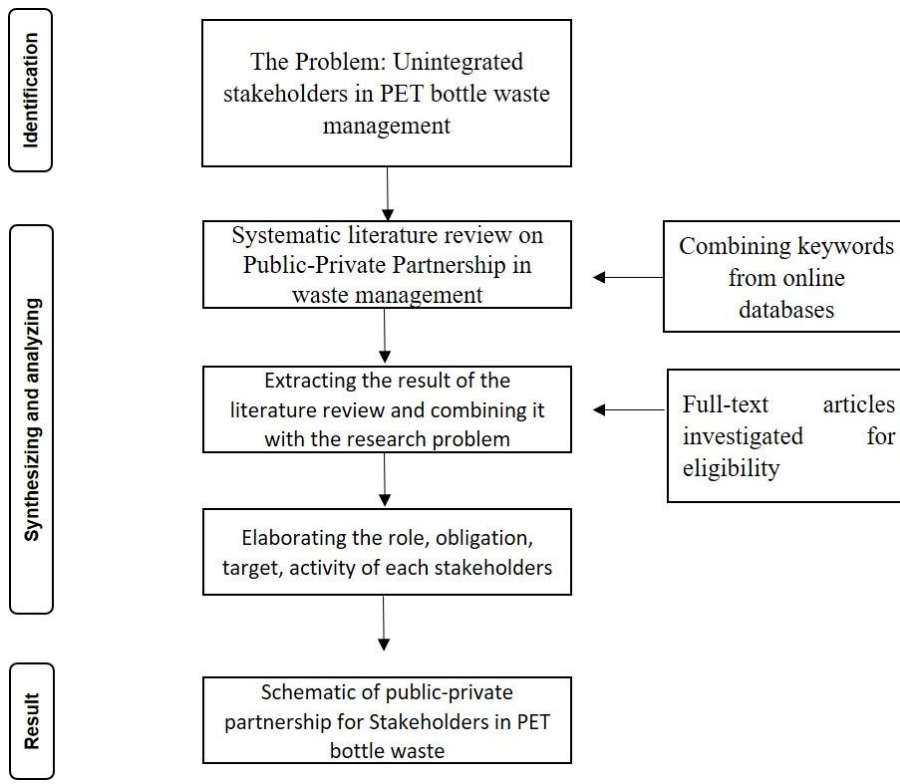

Fig. 2: Research design.

actors, and members of society, in general, are required to comply with the policy. This section will discuss the laws and regulations of waste management in Indonesia at a national level, consisting of government regulations, presidential regulations, and ministerial regulations (see Table 2).

A review of the 12 laws and regulations on waste management revealed that PET bottle waste management was only mentioned in Decree No. P.75/2019 of the Ministry of Environment and Forestry on a Roadmap for Waste Reduction by Manufacturers. Through this regulation, manufacturers are instructed to use transparent material for bottles, use 100% recyclable material, ensure a 50% yield of raw material should come from the recycling process, and implement closed or open loops. However, several problems have arisen since the manufacturers are not able to meet all the requirements. This is due to several stages in the decree which are not the responsibility of manufacturers, including the immediate collection of PET bottle waste from customers and households.

Policy Recommendation

Xevgenos et al. (2015) discussed several options for PET bottle waste management and distinguished three main instruments to improve its management. As shown in Fig. 3, they include technical instruments, economic instruments, and legal instruments. By considering these instruments, the

Table 2: Laws and regulations of waste management in Indonesia.

National Law	Law No. 18/2008 about Solid Waste Management	Law No. 32/2009 about Environmental Protection and Management		
Government Regulation	Government Regulation No. 81/2012 about the Management of Household and Household-like Waste	Government Regulation No. 101/2014 about Hazardous Waste Management	Government regulation No 27/2020 about Specific Waste Management	Draft of Regulation about Plastic Tax
Presidential Regulation	President Regulation No. 97/2017 about National Policy and Management Strategy of Household Waste and Household-like Waste	President Regulation No. 83/2018 about Marine Debris Management	President Regulation No. 35/2018 about Acceleration of Development for Waste to Energy Installation using Environmental Technology	
Ministerial Regulation	Ministry of Trade Regulation No. 31/2016 about Non-Hazardous Waste Import	Ministry of Public Works Regulation NO. 3/2013 about the Implementation of Solid Waste Infrastructure and Facilities	Ministry of Environment and Forestry Regulation No. P.75/2019 about Roadmap to Waste Reduction by Producers	

Source: Adopted from several sources by the researcher.

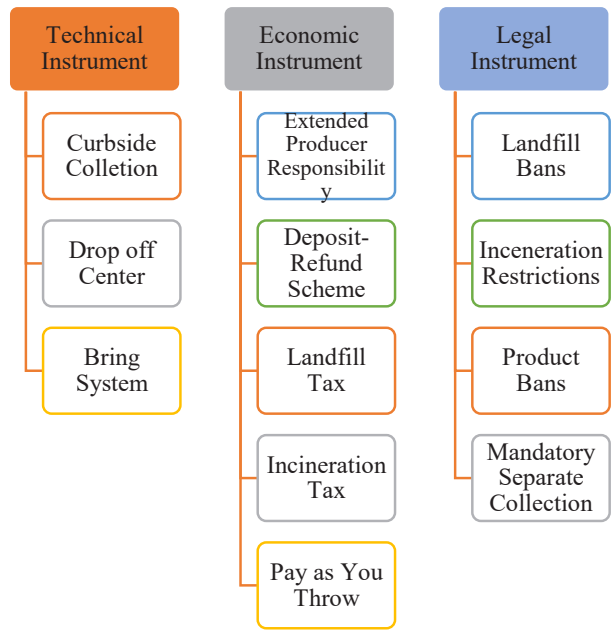

Fig. 3: Instruments to increase waste performance. Source: Adopted from (Xevgenos et al. 2015).

government may formulate new regulations with the support of many stakeholders to ensure better waste management.

Formally, plastic bottle waste management in Indonesia is equated with municipal solid waste management where municipalities and other local governments play a major role (Putri et al. 2018). Informal management is required to ensure that the waste collected by various types of waste collectors is sorted and that the valuable material is sent for recycling. That is, these materials need to be sent to factories that can use them as raw materials or to other processing plants. The first step in ensuring this process is to encourage householders to take the waste to a temporary collection point. At present, however, no waste segregation is the norm in the disposal of household waste (Kristanto et al. 2021). From this perspective, the waste disposal system in Indonesia suffers from the absence of a clear system, and this must be addressed as the first step in ensuring the recycling of PET bottle waste. Sharma and Jain (2019) emphasized that to achieve sustainability in waste management. It is mandatory to regulate all stakeholders involved, so waste management has the same goal and is more effective and efficient.

The implementation of PPP provides a framework for the interaction between private companies and public authorities. As pointed out in one study, this is especially important when obstacles related to time limitations of traditional procurement measures need to be overcome (Batista et al. 2021, Dawodu et al. 2021). In a study of the PPP approach to waste management in India, it was reported that project delivery times can be accelerated and creative and innovative solutions are delivered by the private sector (Dolla & Laishram 2021). The findings of this study are consistent with the finding that PPP has the potential to benefit many sectors as reported in many other studies (Dolla & Laishram 2021, Lee et al. 2021, Sondang Siagian et al. 2019). However, in the absence of strong policy implementation and sufficient funding, it is difficult to achieve the desired outcomes. Other problems which would make it difficult to ensure the success of a PPP for PET bottle waste management include poor task contributions, and the lack of a clear framework. For this reason, the study proposes a clear framework (Fig. 4) for the management of PET bottle waste in Indonesia, which stipulates the extent of the involvement of the actors.

To ensure that a public-private partnership for PET bottle waste management in Indonesia works efficiently, this study divides the roles, commitments, goals, and activities of each stakeholder. As shown in Table 3, seven stakeholders were identified in the system: government agencies, manufacturers, households, waste banks, landfill operators, retailers, and waste recyclers.

Government agencies are tasked with developing a framework based on mandatory separation in managing PET bottle waste that involves stakeholders in PET bottle waste management. Hosseini-Motlagh et al. (2022) emphasized the importance of the government's role in deciding the legal framework for specific types of waste. The results of this study indicate the requirement for binding legal regulations in the framework which must be followed by stakeholders. Pati & Dash (2022) specified the role of government in deciding the regulatory framework for waste and providing promoting the framework to all stakeholders, and Gerassimidou et al. (2022) divided the government role into national government should regulate and encourage the supply of PET drinks bottles and PET bottle waste management and local government is responsible for the collection of the waste. These regulations should clarify the roles, obligations, targets, and activities of each of the stakeholders, and serve as the basis of the establishment of the 'bring system'. The 'bring system' requires households to separate PET bottle waste and includes a "deposit-refund system" as an instrument in the transaction of various products using PET bottles. The framework of the 'bring system' will also provide requirements for the monitoring and evaluation its implementation.

Manufacturers apply PET bottle materials that can be recycled and minimize the use of waste in various products. Manufacturers can also implement a system where their products can be purchased by refilling PET containers or other types of containers. Singh & Ordoñez (2016) mentioned that manufacturers should avoid virgin extraction and support the raw material from the recycling process. It will encourage circularity in waste management. Gu et al. (2017) also suggested that manufacturers of plastic waste are responsible for purchasing the proceeds from the plastic waste recycling process. The implementation of the role will be extended the manufacturer's responsibility and behavior, and the manufacturer also could support further research in the development of recycling in the field of PET bottle waste which may contribute to further advancements in the technology of recycling or providing recycling technology.

In their study focused on the development of a PET recycling model, Egun & Evbayiro (2020) stress that households must be empowered in the recycling process since proper waste management potentially has both direct and indirect benefits to households. Amheka et al. (2015) point out that household behavior should support the recycling system because it plays a significant role in plastic waste management as a customer and main contributor to waste collection. To maximize compliance among households, governments can run media campaigns that stress the responsibility of householders to separate waste

Table 3: The schematic framework of the public-private partnership for PET Bottle Waste.

	Government Agencies	Manufacturers	Household	Waste Bank	Retailer	Waste Recycler	Landfills Operator
Role	Designing a suitable framework for PET bottle waste. Monitor and evaluate PET bottle waste management	Apply PET bottle material that can be recycled, and accept the recycling material from the recycler and waste bank.	Separate and collect PET bottle waste and take it to the collection point	Provide collection points for the deposit refund scheme	Sell the PET bottle product with an added extra cost, as a deposit	Receive PET bottle waste from waste banks and convert it to raw material	Collect wrongly disposed PET bottle waste from landfill
Obligation	Control the negative Impact of PET bottle waste on the environment, human health, and biodiversity.	Avoid virgin PET bottle extraction. Provide research funds to develop recycling in PET bottle waste. Provide recycle technology	Ensure not to dispose of PET bottle waste	Compile PET bottle waste as much as possible and operate a deposit refund system. Operate modest technology in separation.	Manage deposit money and ensure it is returned to the household or waste picker	Convert PET bottles to valuable material	Separate PET bottle waste from solid waste
Target	Minimize the negative impact of PET bottle waste	Minimize virgin material to produce PET bottle waste	Minimize disposal of PET bottle waste in the wrong places	Increase the number of participants from household and waste picker	Promote the deposit refund scheme	Minimize the negative impact of converting the process	Minimize uncollected PET bottle waste
Activity	Conduct monitoring and evaluation regularly	Conduct a circular economy model in their business process.	Deliver PET bottle waste to the collection point	Quantify PET bottle waste regularly and convert the waste to money	Transfer the deposit to the waste bank regularly	Convert reproduced PET bottle waste regularly	Patrol to selected area
Reference	(Gerassimidou et al. 202, Hosseini-Motlagh et al. 2022, Pati & Dash 2022)	(Gu et al. 2017, Singh & Ordoñez 2016)	(Amheka et al. 2015, Egun & Evbayiro 2020)	(Sekito et al. 2019, Wijayanti & Suryani 2015)	(Numata 2009)	(Tong et al. 2021)	(Feil et al. 2017, Kieckhäfer et al. 2017)

and include this message in the teaching of children in the school system. Another layer of encouragement to ensure the householders comply is to implement a "deposit-refund system" for the delivery of PET bottle waste to the retailer, who adds to the waste bank at this collection point. Increased public awareness and economic incentives are essential to increase the collection rate of PET bottle waste.

A study by Sekito et al. (2019) concludes that a waste bank can be a waste converter into income that connects households and recyclers. Meanwhile, Wijayanti & Suryani (2015) assert that the capacity of the waste bank can still be increased by managing a more modern recycling technology to support the recycling process. A system of collection points, which serve as waste banks, needs to be established in each region. Local government is responsible for establishing this type of network, which will serve as the bridge between the separation of PET bottle waste done by householders and the actual conversion of this step into monetary gain. That is, waste banks, as collection points for PET bottle waste, become the operators of the "deposit-refund system". Waste banks are also expected to be able to operate simple recycling technology, at least by separating PET bottle waste into labels caps and PET. Potentially, these waste banks could also engage in the more advanced steps in the recycling of PET, such as pelletizing and granulate production. In their study of the potential of waste banks, Sekito et al. (2019) showed the importance of ensuring that converting the waste becomes income for households and for these waste banks to engage in modest recycling technology.

In the "deposit-refund system", which is central to the success of the "bring system", the retailer plays a vital role as the connection point between the customer (householder), the waste bank, and the waste recycler. It is the retailer who is responsible for setting the price and providing a payment and collection schem e (Numata 2009). To maximize compliance with the "bring system", retailers are required to comply with and promote the "deposit-refund system" scheme. As such, the pricing system and the supporting facilities are the responsibility of the retailer. The role of the informal sector in waste management is significant in developing countries since it is this sector which fills the gap which exists because of the lack of formal institutional infrastructure and technology in the recycling of plastics (Tong et al. 2021). That is, the informal sector plays the role of waste recycler, and therefore is responsible for operating modern technology in the recycling of PET bottle waste. These local waste recyclers must have the capability of carrying out the glycolysis, hydrolysis, and methanolysis steps of PET waste recycling.

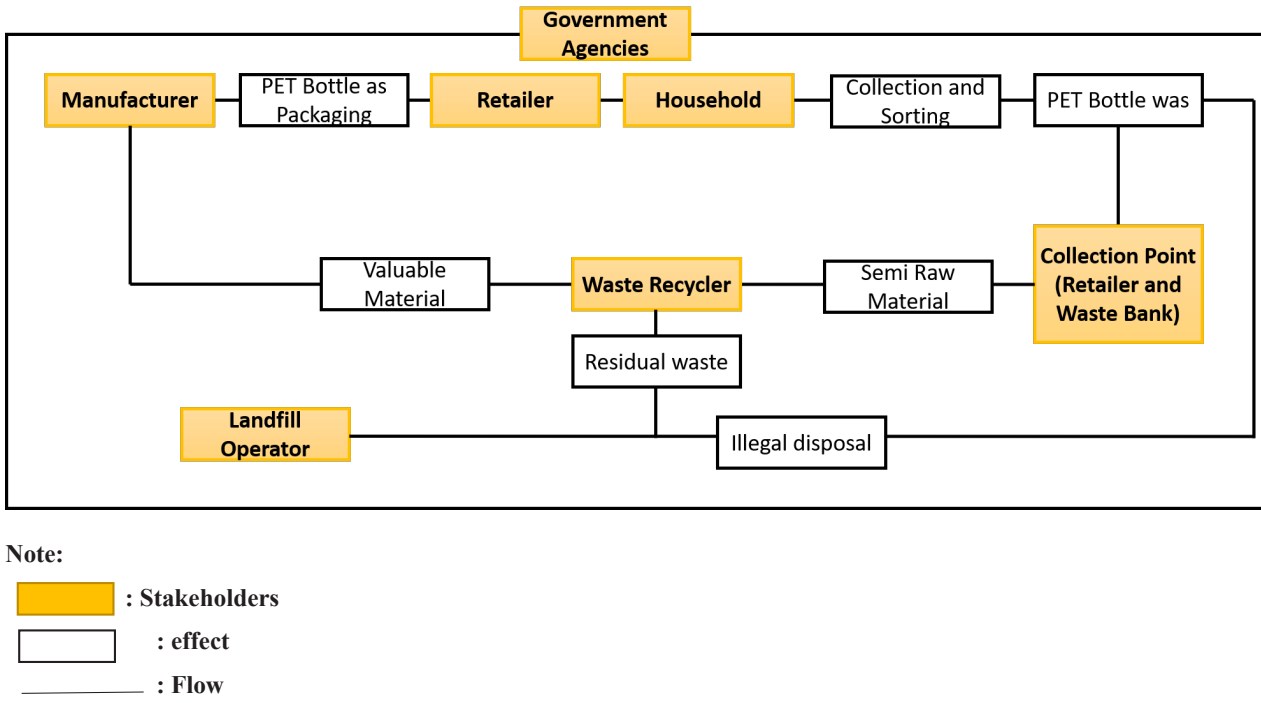

Fig. 4: Flow of PET waste management.

As a final resort, a landfill operator is a necessary disposal option. Feil et al. (2017) recommended a pre-double separation for plastic waste in landfills because there may still be households that do not comply with the separation process. Kieckhäfer et al. (2017)also recommended a landfill mining concept to tighten the waste that comes to the final disposal. PET recycling inevitably results in a residue that degrades the quality of PET at every recycling step. At some point, the PET would be considered unworthy of further recycling. In such cases, the only option available for the disposal of this PET is a landfill. In these cases, it is necessary for the PET bottle waste to be separated before the waste is buried.

The importance of the findings of this study cannot be understated. The PET bottle waste management situation in Indonesia at present is unsustainable and needs to be overhauled. The study by Amheka et al. (2015) concluded that a schema that can divide roles and responsibilities between stakeholders in management is very important to avoid overlapping roles and minimize waste from the recycling process. The schema proposed in this study includes scavengers, collectors, recycling firms, markets, and consumers' waste. This study finding is more complex and encourages the circularity of waste management compared to the previous study. To our knowledge, this is the first comprehensive study that is focused on PET bottle waste management in Indonesia. Based on the findings of numerous studies in the literature, the study was able to devise a framework for the public-private partnership management of PET bottle waste. The proposed framework details the roles and responsibilities of the stakeholders related to the management of PET bottle waste.

There are limits to this study that need to be acknowledged. This study is based solely on a systematic literature review to elaborate on the scope of the problem presented by the challenge to provide a better system for the management of PET bottle waste. Other factors, including the legal aspect and the potential to recover energy through the recycling of PET plastics, were not taken into consideration. While these are important considerations for further study, they are beyond the scope of this study.

CONCLUSION

In this study, a comprehensive analysis of existing literature was conducted to reveal the details of the current waste management systems in place for PET bottle waste in many countries. The potential of public-private partnerships to address the issues related to PET bottle waste was also revealed through the literature review. These findings were then considered in the context of the need for a better waste management system for PET bottles in Indonesia. The main contributions of this study can be summarized as follows:

An effective PPP framework must clarify the role, commitments, goals, and activities of all stakeholders, including government, private sectors, public sectors, and individual households, and ensure cooperation among these stakeholders.

Laws and regulations for waste management with a focus on PET bottle waste are required in Indonesia. Recommendations to improve waste management in Indonesia included a requirement for the public to deliver their separated PET bottle waste for collection, with a deposit refund system as an economic incentive, and that mandatory separate collection is legally enforced.

The implementation of Public-private partnerships in waste management could be improved with information and technology, and it could be reached by more users and is effective in monitoring and evaluation. And waste can also contribute to the gross domestic product if it can be recycled optimally and reach the export market. The findings of this study are expected to assist policy-makers and local governments in Indonesia to strengthen the implementation of the PPP framework in managing PET bottle waste. They can also serve as a reference for other countries with poorly developed formal waste disposal and recycling infrastructure which face similar challenges with PET bottle waste management.

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