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Applying the extended producer responsibility towards plastic waste in Asian developing countries for reducing marine plastic debris

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Abstract

The extended producer responsibility (EPR) has been adopted in many countries throughout the world to give producers responsibility to manage their products until the post-consumer stage. On many occasions in developing countries, the system is mostly implemented for electronic waste. However, with the rising concern on the marine plastic issue, developing countries, including those in Asia, have started to apply EPR for package and container waste. In practice, developing countries show significant differences in their EPR implementation compared with developed ones due to contrasting conditions of several factors, including social, economic, and technology. This paper aims to explore the challenges of developing countries to apply EPR as well as determine possible measures to overcome the challenges. Results show that applying EPR system for plastic waste in developing countries faces many challenges, such as the existence of a market-based collection system of recyclables, high transportation cost, lack of waste collection services in rural areas, a limited number of facilities to manage certain types of plastic waste, insufficient pollution control, and free riding and orphan

products. The challenges, furthermore, can be minimised by differentiating the responsibility of producers, focusing on rural and remote areas, involving informal sectors, creating joint facilities in recycling parks, expanding waste management collection services, increasing the use of EPR, and minimising free riding.

Keywords: extended producer responsibility; producer responsibility; plastic waste; marine plastic debris, recycling industry; Asian countries.

1. Introduction

The extended producer responsibility (EPR) is defined as "An environmental policy in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle (OECD 2001, p. 9)." While the conceptualisation of the EPR began in the early 1990s (Lindhqvist 2000), several local and national governments have introduced the system since the early 1970s. According to the list of EPR policies compiled by the Organisation for Economic Co-operation and Development (OECD) (2013) and Kaffine & O'Reilly (2015), the first five EPR policies were introduced by four states in the United States and a state in Canada in the form of deposit and refund schemes on beverage containers. Meanwhile, in Germany, the EPR was introduced by the German Packaging Ordinance in 1991 (Manomaivibool 2008), which requires producers to establish separate management and recycling of all types of packaging outside the public waste disposal system, to satisfy mandatory quotas for recycling. Following Germany, many developed countries, such as France, Austria, and Belgium, introduced the EPR system. In Asia, Japan was the first to introduce the EPR policy by enacting the containers

and packaging recycling law in 1995.

Some developing countries have introduced or tried to introduce EPR policies since around 2000. India applied EPR to lead-acid batteries in 2001, where manufacturer, importer, assembler and re-conditioner are required to collect the batteries. Besides lead-acid batteries, India also applied EPR to plastic waste and e-waste in 2011 (Government of India, 2011). Regarding plastic waste, municipal authorities are responsible for setting up, operationalising, and coordinating the waste management system. The municipal authority may design the modalities of mechanism based on EPR. Amendment of the rules in 2016 put the responsibility of collection of used multilayered plastic sachet or pouches or packaging on producers (Government of India 2016).

Regarding e-waste, China enacted Regulations on the Management of the Recovery and Treatment of Waste Electronic and Electrical Products in 2009, which targeted large waste appliances including TVs, refrigerator, air-conditioner, washing machine and personal computers. The government imposed a recycling fee from producers and distributed the fee to recyclers. Viet Nam also applied EPR in 2013 by issuing a Prime

Ministers Decision on the recovery and disposal of discarded products, especially e-waste and automobiles. The decision was revised to be called the Decision Providing Regulations on Recall and Treatment of Discarded products in 2015. Ecuador also established EPR policy for waste tyres from cars, trucks and buses in 2013. Producers must fulfil the government's tyre recovery goals up to 20%, 30%, 30.8%, and 35% in 2014, 2015, 2016, and 2017, respectively (Cecchin et al. 2019).

From 2000 to 2015, electronic waste (e-waste) became the main target of the EPR system introduced in developing countries, such as Malaysia, Thailand, and Viet Nam. This is because this type of waste became a primary concern in the region at that time. International organisations and developed countries provided some support to introduce an EPR system on e-waste. However, due to increasing concern on the marine plastic issue, many developing countries seek opportunities to apply EPR to package and container waste. Although some other wastes, such as e-waste and end of vehicles, also contain plastics, packaging and containers are regarded as an enormous volume in plastic wastes (Geyer et al. 2017).

As mentioned above, EPR has been gradually introduced by developing countries. Nevertheless, some studies, including Kojima et al. (2009), pointed out that developing countries should take into account different conditions in social, economic, technological and other conditions between developed and developing countries when they try to introduce the EPR system. For example, Kojima et al. (2009) pointed out the difficulties of applying EPR to e-waste, such as difficulties in identifying producers and competition with informal recycling industries. Furthermore, waste collection services are still limited in urban areas and extremely limited or unavailable in rural areas. The result is open burning or waste leaking into waterways. Meanwhile, in developed countries, household waste is regularly collected.

Some households in developing countries also segregate valuable recyclable waste to sell, which is less often seen in developed countries. The informal sector in developing countries actively collects this recyclable waste for its financial value. The informality of developing countries described here presents challenges in the application of EPR in these contexts. Overall, developing countries do not have well-established waste management

as well as good engagement among key stakeholders, therefore leads to some difficulties in EPR application.

Therefore, this study aims to explore the challenges in applying EPR system towards plastic waste, especially plastic packaging and container, in selected Asian developing countries. We propose possible measure to overcome the challenges.

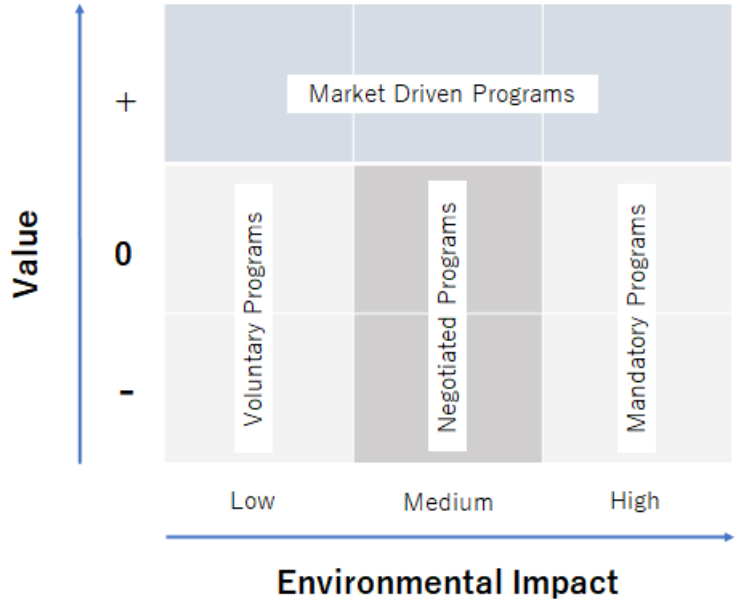
2. Framework of analysis

2.1 Why did Asian developing countries start to introduce EPR on plastic waste?

Previous studies have attempted to analyse the challenges of applying the EPR policies in Asian developing countries by conducting interviews and hosting policy discussions (Akenji et al. 2011, Hotta & Kojima 2018). Research focused on EPR policies in Asian developing countries show that a focus on e-waste has taken priority. However, these previous studies do not clearly analyse the differences among the target products of the EPR policies. Therefore, this paper introduces a framework for analysing why the EPR policies have recently been promoted for plastic materials.

Originally, the OECD (2001) cited an application matrix for EPR program presented by Michale Bennett in 1999 at the Paris EPR Workshop (OECD 1999). This matrix provided a screening tool to help policymakers select a course of action. The matrix examines appropriate EPR programs, examining the value of recovery, recycling and disposal from recovered components, and environmental impact (see Fig. 1).

Fig. 1. Application matrix for EPR programs



Source: Authors, based on Box 4 of OECD (2001, p. 32).

Where recyclable waste has a positive value, governments do not need to intervene. The OECD (2001) pointed out that intervention by governments should be carefully considered to prevent monopolistic practices and other market distortion; in this case, a market-driven program might be considered. On the other hand, with high environmental impact waste with no or negative value, a mandatory program is appropriate. For example, e-waste contains some hazardous substances, such as lead, chlorofluorocarbon (CFC), and polybrominated diphenyl ethers (PBDE). E-waste also contains precious metal such as gold. The extraction of valuable metals from e-waste by the informal sector in developing countries causes pollution. In this case, a mandatory program, including the EPR system, can be justified.

Globally, more than 40 developing countries adopted e-waste legislation/policy either at a national or regional level. In Asia, EPR for e-waste was applied in developing countries such as China, India, and Viet Nam. At first, China applied EPR to five types of e-waste: televisions, washing machines, air conditioners, refrigerators, and personal computers. Thereafter, nine more types of e-waste were added (Forti et al. 2020).

Meanwhile, other countries in Asia, such as Indonesia, Malaysia, and Thailand, are in the preparatory stage to apply EPR for e-waste (UNEP 2017).

The developed countries have experienced an increased cost of waste treatment due to increasing waste volumes, including plastic waste. In some cases, a higher volume of waste, which potentially causes environmental impacts, can be addressed by tightening emission and effluent standards. For instance, in Japan, standard dioxins generated from waste incineration plants have been tightened (Government of Japan n.d.). However, this effort inevitably leads to a higher cost of waste disposal. Simultaneously, some other waste treatment activities, such as recycling. Thus, based on financial and environmental reasons, developed countries have opted to apply EPR to plastic package and containers.

However, since the 2010s, the recognition of marine plastic debris has shifted to be a global issue (STAP 2011). Jambeck et al. (2015) estimated that significant sources of marine plastic debris were rapidly growing in countries such as China, Indonesia, the Philippines, and Vietnam, where plastic is increasing while waste collection and proper disposal were limited. As a response, some Asian developing countries have applied or

are planning to apply EPR to plastic waste, especially packaging and containers. This is because, in the ocean, plastic can be broken into smaller pieces by ultraviolet radiation, resulting in the ingestion of plastic debris by marine organisms (Thompson et al. 2009). This causes a variety of physical damage, such as wounds, ulcerating sores, blockage of digestive systems, and ruptured bladders for marine species (Ryan 2016). Besides that, additives in plastic, such as brominated flame retardants and phthalates, can serve as potential endocrine disruptors, making the marine organisms suffer from developmental, reproductive, neurological, immune, and metabolic diseases (Ingre-Khans et al. 2017, Hermabessiere et al. 2017).

In case a positive value is observed, market forces will generate programs to collect plastic waste. In most Asian cities, thermoplastic wastes, such as PET bottles are collected in urban areas and areas close to industry, without any government intervention. On the contrary, the collection rate in rural areas is low because of multiple factors such as scattered housings, low population density, poor social and economic conditions, low collection frequency, and great distances from waste management facilities (Mihai and

Grozavu 2019). In addition, some plastic waste, such as multi-layer plastic and styrofoam, requires specific processes or facilities, and may not be able to be recycled. Policy intervention may be necessary in these cases (OECD 2001).

2.2 Economic feasibility of EPR policy

Referring to the recognition shifts towards introducing EPR policy in some Asian developing countries, one of the obstacles is the economic feasibility (Kojima et al. 2009, Akenji et al. 2011, Hotta & Kojima 2018). Some studies emphasise the economic aspects of EPR policy programs (Walls 2006, Atasu 2009, Wiesmeth & Häckl 2011). These studies focus on the incentive mechanism of implementing EPR policies for both consumers and producers, including a refund program at collection points and incentivising design for the environment (recyclability) of products (Wiesmeth & Häckl 2011). Another discussion is to combine taxation and subsidy to optimise social welfare (Walls 2006). However, in developing countries, there are some difficulties on EPR before incentivising the producers and consumers, and several challenges need to be

addressed before EPR programs are introduced. Most previous studies, the authors found, focus on cases of developed counties and lack another viewpoint on economic feasibility (a few exceptions, including Nahman (2010)).

Based on our framework of analysis of previous studies, EPR programs for plastic waste could be applied in Asian developing countries. In the following sections, the authors categorise the challenges of applying EPR policies and analyse how EPR could be applied to plastic waste management in Asian developing countries.

3. Challenges in applying EPR in Asian developing countries

3.1 Existence of market-based collection system of recyclables

In particular, a market-based collection of recyclables may become a competitor to PRO, which is established under the EPR system. In many developing countries, the market-based collection system involves informal waste pickers who collect saleable recyclable waste. They work by picking up recyclables from waste bins on the road and dumping site. The waste collection workers pick up saleable recyclable waste during

collection and transportation. After that, they sell the recyclable waste to junk shops on the way to the dumpsite. To get the cooperation of waste collection workers, a part of revenues generated from recyclable waste should be allocated to waste collection workers. This indicates that the relation between the developing countries and the informal waste pickers is a win-win solution. On one hand, with limited waste management, the developing countries are greatly assisted by the informal waste pickers to collect the recyclable waste. On the other hand, by working on this sector, the informal waste workers have a source of income for their livings. However, the existence the EPR system will create a competition with informal waste pickers to collect valuable materials (OECD 2016). This might leave the informal waste pickers lose their source of livelihoods.

In another case, there are some initiatives to buy recyclable waste not only from waste pickers but also from waste generators. In Thailand, *Wongpanit*, a franchise chain collecting recyclable waste, advertises prices directly on shopfronts as well as through its website to encourage consumers to bring their recyclables (Kojima 2019). It was established in 1974, *Wongpanit* bridges waste generators, informal waste collectors and

scavengers, and formal recycling facilities.

In Indonesia, the waste bank (*bank sampah*) is another example of a market-based collection system. The system is supported by local governments (Kojima 2019). In Surabaya City, waste banks support the community's livelihood and encourage people's self-reliance in environmental management (Wijayanti & Suryani 2015). The number of waste banks has been increasing by up to 50% annually, especially after the issuance of Regulation of State Minister of Environment No. 13/2012 on Guidelines for the Implementation of Reduce, Reuse Recycle through Waste Banks (Wijayanti & Suryani 2015). Waste banks in other regions, such as Malang City, post their buying prices of up to 70 types of recyclables (including plastic, paper, metals, and glasses) in their online platform to attract local household to sell their segregated recyclables (Bank Sampah Malang 2018).

Thailand also developed a similar market-based collection system as waste banks, called zero-baht shops. The zero-baht shops allow customers to exchange their recyclables for consumer goods or they can contribute to a savings plan. Under this

scheme, waste pickers can choose three savings options to receive their economic benefit: (1) crediting recyclables at zero-baht shops, (2) depositing two glass bottles per day, or (3) depositing 1 baht per day, continuously for two months (Kashyap and Visvanathan 2014). The saved funds will be utilised for medical insurance, educational loan, and rice provision for older people. Moreover, waste-pickers also receive their identity card from varied collection points in Bangkok Metropolitan Administration areas, which legitimises their waste picking occupation (Kashyap & Visvanathan 2014).

In the Philippines, local governments operate such a market-based collection system, for instance, in Marikina City (Kojima 2019). The government operates junk shops under the Eco-Savers Program that aims to educate households in Marikina City to practice proper waste management and serve as an additional income source directly earmarked for the purchase of necessary educational supplies basic household needs. The program requires students to collect recyclables from their respective households during an assigned Eco Day—the day when the recyclables will be weighed and credited to their issued eco-passbooks (Antonio 2010).

Unfortunately, such a market-based collection system cannot deal with some other waste that does not have a high economic value. Waste banks, junk shops, or buy-back centres only receive resaleable wastes that have a high economic value. P. Meanwhile, the waste with low economic value will experience mismanagement and end up being irresponsibly disposed, which can lead to environmental impacts (Akenji et al. 2011).

3.2 High transportation cost of recyclable waste to recycling facilities

Collected recyclable waste should be sent to companies which produce intermediate products, such as plastic pellet for plastic products, or to producers of plastic products. Factories for intermediate processing and producing plastic products are usually located in an industrial area. In some rural and remote areas, the cost of transporting recyclable waste to factories are too expensive. This is because in rural areas, the waste management budget is very limited (Mihai and Taherzadeh 2017). Besides that, the distance between one house to another in rural areas tends to be farther than in urban areas, so that the transportation cost to collect the waste is more expensive (Beitsch 2019). . World

Economic Forum (2020) estimated the recycling rate of plastics waste in megacities, medium and small cities, rural areas, and remote areas. The research shows that the recycling rate in megacities reached up to 20%, while in the rural and remote area were only 5% and 0% accordingly.

Some smaller Asian developing countries, such as Cambodia, Myanmar and Brunei Darussalam, do not have sufficient industries producing a recycled product from plastic waste. These countries have been a net exporter of plastic wastes[1]. In these countries, the amount of recyclable waste is limited due to the smallness of product demand and limited industries. Therefore, they may not be able to recycle by themselves, as relatively high costs of building recycling facilities within nations. For instance, in Vientiane (Lao PDR), waste that the Vientiane City Office formally collects for Management and Service or any of eight private companies is not subject to any form of treatment or processing (GGGI 2018). Some recyclable waste is also informally collected for further sold to buying centres. The buying centres will then sell it to another buyer at a higher rate with limited

[1] Based on UNCOMTRADE date, these three countries are net exporter of plastic waste and net importer of semi-manufacture and article of plastics between 2016 to 2019.

added value. This kind of value chain is vulnerable to any fluctuation of recyclable prices. Although the country does not have big recycling industries, it has had some small and medium-sized industries, such as Lantieng Recycling Company. Unfortunately, the company only covers limited processes, including washing, crushing, and breaking the recyclables into smaller pieces. Due to the limited capacity of the domestic recycling companies, the recovered recyclable waste is then usually exported to neighbouring countries for final processing or treatment, making the transportation cost is more expensive.

In short, the long proximity and the limited domestic recycling facilities lead to high transportation cost of recyclable waste. In EPR system, such transportation cost should be borne by the affiliated companies, therefore become a discouraging factor for the companies to comply with the EPR system.

3.3 Limited waste collection services by local government in a rural area

Another difficulty is to develop waste collection services and required infrastructures for

waste management, especially in rural areas. There are multiple drivers that make rural areas are overlooked by formal waste management. Some of them are geographical boundaries, scattered housings, low inhabitant densities, severe social and economic condition, long distances from urban areas, and high transportation cost (Han et al. 2018, Mihai and Taherzadeh 2017). Those are exacerbated by lack of funding from local governments (Mihai and Taherzadeh 2017). Most EPR systems for packaging and container depend on government waste management services for collecting target items[2]. Section 1.3.1 of OECD (2016) stated that, "While in many EPRs, municipalities continue to have an active operational role in the collection and treatment of waste, in some systems they do not necessarily have any role." However, the rural and remote areas suffer from severe environmental pollutions due to a lack of collection, of disposal facilities and recycling facilities. For example, in Indonesia, 68% of mismanaged plastic waste comes from rural and remote areas. The collection rate is only 20% and 16% in rural and remote areas, respectively, compared to 74% in megacities. The megacities, while the plastic

[2] Dual system in Germany is an exception, which PRO arrange collection program.

waste ends up as open burning (61-64%), leakage in water bodies (12-13%), and dumping on land (8%) (WEF 2020). It may be difficult for PRO to establish waste collection services for target items where municipalities do not provide waste collection services.

3.4 Limited number of facilities to accept certain types of plastic waste

Some plastics, especially multi-layer plastics, are challenging to recycle, even in urban areas. Most developing countries' facilities focus on treating recyclables; however, they refuse to address the multi-layer plastic waste, which often leaks to the marine environment. This is also applied for the EPR implementation in developing countries, which is mainly still in the initial stage. In these countries, the EPR system excludes the treatment for multi-layer plastic waste (Kojima 2019, PRAISE 2020b). Technology to recycle multi-layer plastic waste exists, but it is costly. Such multi-layer plastic waste is sent to the waste-to-energy plant in developed countries rather than recycling facilities. For instance, in Denmark, most municipal waste, including multi-layer plastic waste, are incinerated to generate energy for district heating in houses and industry. The energy

generated contributes up to 25% of the central heating system's total energy generation (Hansen 2020).

Another example of a plastic that needs a specific facility is expanded polystyrene (EPS), commonly known as styrofoam. UNEP (2018) pointed out, "Styrofoam products present challenging recovery dynamics, making recycling – although technically possible – often financially unviable" (UNEP 2018, p. 15). In addition to specific and advanced technology required, transportation cost also becomes another barrier to recycling EPS. Such requirement and cost shall be allocated by the companies under the EPR system.

3.5 Insufficient pollution control by recycling industries

Recycling industries, especially small-scale recycling industries, often run the recycling process without a proper pollution control mechanism. Many of those exist in Asian developing countries as informal recyclers. The government can enforce the relevant compliance policies to the large formal recyclers. At the same time, it is tough to enforce those to such informal recyclers. Financial and technological constraints are the main

barriers to install a sufficient pollution control mechanism. Strict enforcement will only move them to another area without avoiding doing a similar business (Kojima & Jain 2008).

Moreover, informal recyclers usually dominate the recyclables market in the region due to their lower cost of recycling compared to the formal ones (Wilson et al. 2006). The cost of washing and pelletizing by informal recyclers, who do not bear the cost of pollution control, is lower than the cost by formal recyclers, who bear the cost of pollution control. Therefore, formal recyclers might find it difficult to find enough recyclables to run and expand their business. Under the EPR system, producer should bear such additional cost of pollution control for competing with informal recyclers. Simultaneously, the enormous amounts of recyclables processed by the informal sector operators leads to a high potential of plastic leakage (The Pew Charitable Trusts and SystemIQ, 2020). Most operators do not have wastewater treatment plant to filter the wastewater from the process. Even if they have installed wastewater treatment plants, most do not have enough capacity plants are not adequate and sufficient to remove the

microplastics (RKC-MPD 2020a). Such effluent from insufficient wastewater treatment plants is one of the microplastic leakage pathways mentioned by the World Health Organization (2019). In addition, improper disposal of the leftover sorting process might be another source of leakage of plastics to the environment.

To prevent leakages from recycling plants, it is essential to engage local people near the informal recyclers to force the investment on sufficient pollution control facilities (Kojima & Jain 2008). To do this, scientific and technological studies should be conducted earlier to identify the impact of improper management and the feasibility of the investment. Local governments should also provide incentives or other financial supports to enhance investment.

Recycling parks might be an excellent alternative to share the cost-burden among informal recyclers. Shared pollution control facilities in recycling parks in China have reduced cost and space (Geng et al. 2007, Yu et al. 2014). Although some ASEAN countries have tried to copy Japan's success in the eco-town projects, a gap still exists between current policies, especially supporting a circular economy through the recyclers.

There is still a lack of policies for expanding and upgrading recycling (RKC-MPD 2020b), especially providing incentives such as a low-interest loan or designated area for recycling companies. Emerging policies should bridge the gap between the EPR and the recyclers' capacity.

Asian developing countries also face another challenge to mitigate Polybromodiphenyl Ethers (PBDEs) contamination from an e-waste recycling area. The PBDEs are plastic components released from the e-waste, contaminated in the dust near the e-waste recycling area. Without sufficient pollution control, the dust will be easily ingested by humans and land and marine biota and cause harmful impacts due to their ability to modulate the endocrine system (Talsness et al. 2009).

The highest PBDE concentration was detected in the dumping site in the suburbs of Viet Nam's major cities, followed by Cambodia, India, Indonesia, and Malaysia (Eguchi et al. 2009). The concentrations were comparable with those reported from e-waste dismantling areas in the United States and European countries, as well as in the Pearl River delta, China (Eguchi et al. 2012). The dust should be collected to separate any

plastic components, including PBDEs further. Furthermore, regular monitoring is needed to control the PBDEs concentration.

Insufficient pollution control also happens in some industries that utilise plastic waste as their energy source. For example, in the areas of Tropodo and Bangun (East Java, Indonesia), plastic waste is burned for fuel to run local tofu industries. Chickens pick food from the soil around the industries that have been contaminated by toxic chemicals, known as persistent organic pollutants, which may further accumulate in their eggs. A report shows that the chicken eggs sampled in those areas contain significant levels of very hazardous chemicals, including dioxins, polychlorinated biphenyls (PCBs), PBDEs, short-chain chlorinated paraffin (SCCPs), and perfluorooctane sulfonate (PFOS) (Petrlick et al. 2019). In Tropodo, dioxin contamination in eggs is so far considered as the second highest in Asia. The dioxin level is 200 pg TEQ g-1 fat, which is close to the highest recorded level in Asia (248 pg TEQ g-1 fat) found in Bien Hoa (Viet Nam) (Hoang et al. 2014, Petrlick et al. 2019). This dioxin level is 90-fold higher than Indonesia regulatory limit. Meanwhile, eggs sampled from a rural plastic waste dumpsite in Bangun contain a

severe level of PFOS. Adults who eat one egg per week from chickens foraging around the dumpsite would exceed the proposed European Food Safety Authority tolerable weekly intake of PFOS by approximately 1.3-fold (Petrlick et al. 2019).

3.6 Free-riding and orphan products

The e-waste EPR scheme, especially in Asian developing countries, is facing a challenge in identifying producers. Most producers, especially in developing countries, are small unregistered manufacturers called free riders in the EPR system (Kojima et al. 2009). The packaging and container recycling system in Japan exempts small-scale producers from such responsibility. If many unregistered small-scale traders import or small industries produce or use packaging and containers, it may be difficult to require them to participate in the EPR system. If the share of unregistered traders and producers are large, it may be challenging to implement EPR. The challenges of free-riding and orphan products are often present during the first year of the EPR scheme (OECD 2014), which is relevant to the current status of EPR implementation in the majority of Asian developing countries,

as described in Table 1.

Table 1. EPR implementation in Asian developing countries

Country	Legal framework	Material or waste stream	Stage of implementation
The Philippines	No specific legal basis is in place. Following are some relevant laws: Ecological Solid Waste Management Act of 2000 (Republic Act 9003) Final Draft: Guidelines on the Environmentally Sound Management (ESM) of Waste Electrical and Electronic Equipment (WEEE) in 2015	Solid waste, electrical and electronic waste	No EPR system in place. However, private companies conducted voluntary initiatives to foster recycling through the Philippine Alliance for Recycling and Material Sustainability (PARMS).
Indonesia	Regulation of the Minister of Environment and Forestry regarding Road Map to Waste Reduction by	Products, product packaging, and/or containers made from plastics, aluminium can, glass, and paper.	EPR is still in the stage of preparation of a waste reduction plan document by producers. In addition, the Packaging and Recycling Association for

	Producers 2019.		Indonesia Sustainable Environment (PRAISE) established the Indonesia Packaging Recovery Organization (IPRO), which aims to manage the supply of recyclables to the contracted recyclers.
Thailand	Specific EPR laws on packaging waste are still at the drafting stage. Plastic waste management, in general, refers to Thailand's Roadmap on Plastic Waste Management 2018–2030.	Packaging waste	No EPR system in place. However, the Thailand Institute of Packaging and Recycling Management for a Sustainable Environment (TIMPSE) has been commissioned to develop a capacity building on the comprehensive management of used packaging and recycled materials. TIMPSE is to become the centre for a database on used packaging.
Malaysia	No specific legal basis is in place. Following are some relevant laws: Environmental Quality	Solid waste	Malaysian Plastics Manufactures Association (MPMPA) actively proposes the EPR system for plastics packaging to the government since the

	Act 1974 Solid Waste and Public Cleansing Management Act 2007		system still becomes a legislative concept without any legal framework for enforcement.
Viet Nam	The decision on Prescribing Retrieval and Disposal of Discarded Products in 2013, which is revised by Decision on Providing Regulations on Recall and Treatment of Discarded Products in 2015	Battery and battery cell, electronic, civil, and industrial electric equipment, a chemical used in industry, agriculture, fishery, and medicine for human, lubricant, grease, inner tube, tyre, and means of transport.	The implementation of the decision about EPR in Viet Nam still meets some challenges, including a lack of recycling capacity, supporting regulation, and benefit to maintain the system. Meanwhile, PRO Viet Nam is expected to be a driver to foster an EPR system for packaging.
India	Plastic Waste Management Rules, 2016.	Carry bags, plastic sheets, cover made of plastic sheet, and multilayered packaging.	In practice, the Plastic Waste Management Rules 2016, especially about the EPR was evaluated by a specific committee. The Ministry of Environment, Forest, and Climate Change has also created models to uniform the

			EPR framework.

Source: Compiled by authors based on Environmental Management Bureau (2015), Thang (2017), Government of Viet Nam (2013), Government of Viet Nam (2015), Nguyen et al. (2017), Renaud and Quertamp (2020), Forti et al. (2020), Government of India (2016), Ministry of Environment, Forest, and Climate Change (2020), UNEP (2017), Bünemann and Brinkmann (2019), Agamuthu and Victor (2011), Government of Malaysia (2007), Toloken (2019).

Free-riding products could also refer to non-compliance, including producers who do not provide accurate data about the quantities of products put on the market (OECD 2014). These situations usually happen in a collective responsibility scheme, where responsibility is shared. In Germany, for instance, a PRO for packaging waste nearly collapsed in 1993 since the license fee of the Green Dot symbol was paid by only 55–60% of all participated producers under a collective responsibility scheme (OECD 2014).

4. Possible measures to overcome the challenges

As explained in the previous section, there are some challenges to implementing EPR in developing countries than in developing countries. Similar challenges may be observed in developed countries, but the magnitude of these challenges in developing countries may not be neglected. There are some measures to overcome these challenges.

4.1 Differentiating the responsibility of producers depending on recyclability

Section 3.1 mentioned various plastics waste are collected and recycling in Southeast Asia. In contrast, section 3.4 stated that some plastics such as multilayered plastics and styrofoam are not well recycled in Southeast Asia. There are some options of an obligation of producers depending on the recyclability.

The Indian Plastic Waste Management Rule 2016 requires producers of multilayered plastics (MLP) to collect used multilayered plastics. Other producers must develop a collection system either individually or collectively through their distribution channel or the local government.

In India, most plastic waste is dominated by MLP, accounting for 19% of the total

plastic waste composition. This number is even higher than bottle caps and lids as well as PET bottles that account for 12% and 10%, respectively. In the country, MLP is primarily used to wrap chips, biscuits, and chocolate. Unlike other plastic waste, such as water bottle, soft drink bottles, and shampoo containers sent to the recycling centre to be shredded and turned into clothing, toys, and other useful goods, the MLP cannot be recycled (Seetharaman 2019). This is because it consists of multiple layers of materials, such as paper, paper board, polymeric materials, and aluminium foil, requiring a high cost to be separated (Fine Train 2019).

Although some environmental experts perceive that the EPR regulation in India is still not sufficient and needs more enforcement, monitoring, and evaluation (Sharma 2019), the case of EPR in India can be an excellent example to differentiate the responsibility, depending on the recyclability or market value of plastic waste.

4.2 Focusing rural and remote area far from industries utilising plastic waste

The market-based collection of recyclables works in an area with high population density

and close to industry. On the other hand, in rural and remote areas where the transportation cost to send recyclable waste to recycling industries is likely too expensive, some of the plastic waste with the lower value may not be collected by junk shop or traders. Investment for reducing the transportation cost, such as the instalment of shredding, baling, and compressing machine, is needed (Kojima 2020a). To facilitate such investment, the government may provide a low-interest loan, subsidy, or tax exemption, under the EPR scheme for investing such equipment. Another policy is to establish a recycling park with such facilities used by recycling companies jointly. Through such recycling park, investment cost and space could be reduced by the companies, thus reducing the financial burden of the companies in implementing EPR.

The high transportation cost is usually borne by the households in the form of a relatively high collection fee, for instance, in Vientiane, Lao PDR. To reduce the collection fee, the waste collection services could be organised by a community itself at more affordable prices, for example, by establishing micro-enterprises involving existing networks of informal sectors (GGGI 2018) under the EPR scheme. Such decentralised

waste collection has been successfully implemented in several cities in developing countries, including in Surabaya, Indonesia (Premakumara 2012). Under the EPR system, the micro-enterprises would be managed by the PRO. To run it effectively, the government needs to ensure the income of the micro-enterprises, that could be in form of direct incentives which are allocated from local budget and charges collected from households through electricity or water bill (GGGI 2018). Furthermore, micro-enterprises should be financially supported through the fees collected by the PRO. The collected waste is then transported to the landfill through transfer stations. In Laos for example, Vientiane's transfer station only functions as an unloading and reloading point (GGGI 2018). The transfer station shoulcover some added values; for instance, the transfer station in Guangzhou, China, also segregates and sends recyclable waste to the recycling facility, reduces water contents, and treats the collected wastewater (Kojima 2020b). Transfer station can become a collection point for EPR system. Meanwhile, the rest of the waste could be sent to a waste-to-energy plant or landfill. Such a decentralised waste collection system, which is integrated into the multifunctional transfer stations, becomes

the key to overcome the high transportation cost in managing plastic waste from rural and remote areas. By lowering the transportation cost, the burden for producers who bear the cost for EPR compliance will be reduced.

4.3 Informal sectors involvement

Informal sectors take most of the responsibility for waste management in developing countries. For instance, 95% of waste in India is managed by the informal sector (Henzler et al. 2017), while in Indonesia, the number of scavengers accounts for up to 600.000 people (VOA Indonesia 2020). Regardless of the health and social issue generated from informal waste management (including informal recycling), the activity generates economic benefit for developing countries because it becomes a reliable income source for the people who cannot find formal jobs due to their low education or physical disability (Wilson et al. 2006, Liebenberg 2007). As poverty still exists and the wastes are accessible, the informal sectors will keep surviving in developing countries (Wilson et al. 2006). This indicates that the integration of the informal sector into waste management

planning and development is fundamental. Henzler et al. (2017) discovered that long term partnerships between formal and informal waste management sectors are required to enforce wider local actors' engagement. However, to ensure their long-term implementation, the efforts must be accompanied by additional financial support from producers or other sources. In this regard, incentives from EPR can help promote long-term partnerships between informal and formal sectors of waste management.

To promote such partnerships, it is critical to include the informal sector in the EPR system in Asian developing countries and formalise them as one of the key actors in the system. One of the ways to formalise them is by establishing an institutional mechanism to legitimise their voice. In other words, a legal mechanism shall be formed for them to express their true opinions without any pressures or threats from others. Protection from stigmatisation is also essential. To support such an institutional mechanism, the society shall show respect and appreciation for their meaningful contribution to the entire waste collection system (Kojima et al. 2020). Not only as a means to express their voice, but such an institutional mechanism also facilitates their formal registration so that they will

be able to receive any social benefits, such as job protection and health insurance. In Indonesia, for instance, about 6,000 scavengers have been registered and assisted by the Indonesian Scavenger Association since 1991 (IPI 2020). Through this formalisation, they may enhance their welfare and fight for their rights. In addition, they also receive the job and health insurance from the government of Jakarta for free.

Another way to formalise them is by considering their work as essential work. In Indonesia, some NGOs have supported to escalate the informal sector work by utilising technology, which can be accessed merely through smartphones (Octopus 2020). Through a free downloadable app called Octopus, users are encouraged to clean and segregate their waste so that the scavengers could receive more value-added waste and consequently receive more income with less work. The scavengers are well connected through this app and collaborated with the households to generate a win-to-win solution. Although the Octopus app is still a pilot project in Makassar City, so far, the responses and feedbacks are positive. As of 9 August 2020, 434 scavengers, 301 volunteers, and 96 waste banks registered and cooperated to help recycle more than 87 tons of waste (Octopus 2020).

There is a promising opportunity; if this project runs smoothly, the range of service coverage of this app can be expanded in other cities in Indonesia or even in other cities among ASEAN developing countries.

The formalisations and informal workers can be considered an essential entity towards long-term informal and formal sector partnerships under the EPR system. Involving informal sectors as the dominating actors is the key to successful EPR implementation.

Degrading or eliminating the role of the informal sector will threaten the whole waste management system. For instance, in Cairo, Zabbaleen people collect waste by offering an individual door-to-door waste pickup from one house to another for a small fee (Environmental Justice Atlas 2018). They served as one of the most efficient and sustainable informal based waste-recycling systems. In 2002, the government started privatising the waste management system and contracted national and international companies for providing integrated waste management services for the next 15 years (Environmental Justice Atlas 2018). The Zabbaleen could keep their jobs as wage workers

with these companies; however, the salaries offered are less than what they used to earn independently. Their involvement in the new system is also significantly lacking. The good news is that the contract was ended in 2017. Egypt's Minister of State for Environment Affairs acknowledged that their approach had been failed. The government admitted the Zabbaleen's experience and started empowering their capacity. The Zabbaleen's work has been formalised; they are taxed and receive higher fees, uniforms, official vehicles, as well as training programs (Environmental Justice Atlas 2018).

4.4 Joint facilities in recycling parks

Optimised wastewater treatment plants are fundamental in removing microplastics from discharge in water bodies. With three steps removal, wastewater treatment plants in Japan can remove up to 99.6% of microplastics (Nakao et al. 2019). Investment in such advanced technologies is critically required to prevent microplastics discharge. Identifying each appropriate technology based on the characteristics of microplastics is critical to ensure the efficient removal of microplastics. Japan, China, and the Republic

of Korea have proven that an optimised wastewater treatment plant can be achieved by utilising the appropriate technology and considering microplastics' characteristics in the comprehensive treatment of wastewater (Hidayaturrahman and Lee 2019, Long et al. 2019, Nakao et al. 2019).

However, investments in optimised wastewater treatment plants are considered very expensive, especially for small-scale recycling industries. Unlike Japan, China, and Korea, most Asian developing countries' treatment plants have limited technological intervention and treatment coverage. As a result, the level of microplastics leakage remains high even after treatment in wastewater treatment plants. In contrast, microplastics from recycling industries, as well as from landfill leachate, tire wear, artificial turf, or polymer-coated fertiliser, are released without treatment.

To address this gap, recycling parks can be a potential alternative to share the cost burden among recycling industries. The recycling parks adopt the concept of the eco-industrial park developed at the beginning of the 1990s by the United States Environmental Protection Agency. The concept recognises that industrial collaboration

yields better economic, environmental, and social performance than industries acting independently (Veiga et al. 2004). Japan, China, and Singapore have been at the forefront of developing the eco-industrial park concept, inspiring Asian developing countries. In Sarimbun Recycling Park, Singapore, about 13 recycling industries utilised the joint facilities to treat up to 25% of total waste recycled in Singapore (National Environment Agency [NEA] 2020). Faced with scarce land, Singapore is planning to promote recycling collaboration under one roof through a multi-storey recycling facility in their recycling park. According to the senior executive for the marketing of the recycling industry, such collaboration can eliminate logistics cost, which is 20% of total costs (Jianyue 2014). For instance, by jointly investing on the optimised wastewater treatment plant in a recycling park, the companies can contribute to the EPR compliance without spending too much cost and space. Such joint facilities include not only the optimised wastewater treatment plants but also other facilities, as necessary. In Asian developing countries, the government shall take a critical role in escalating the recyclers' capacity through incentives for developing such recycling parks.

4.5. Expand waste management collection services and EPR

The private companies in developing countries may not collect plastic waste in rural and remote areas. Similarly, governments may not be able to do the same thing. In this case, the central government should have a strategy to expand waste collection and proper waste disposal. The central government should also create a platform to have a dialogue between local government and PRO to discuss ways to cooperate for recycling programs.

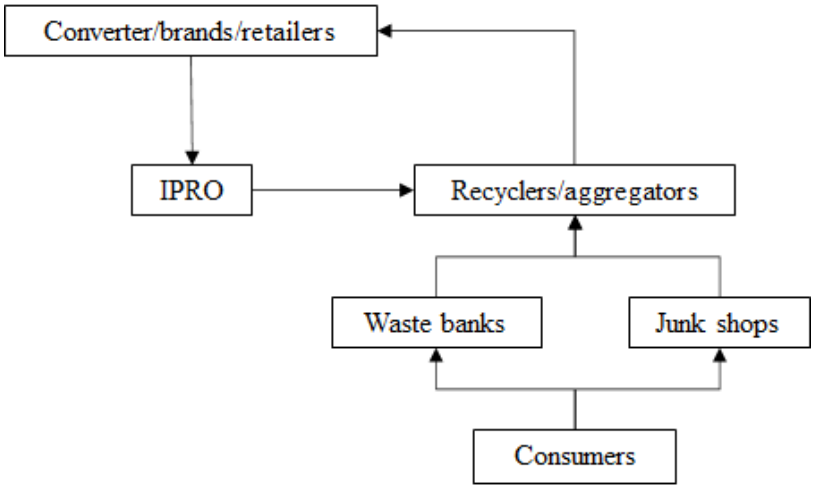
In Thailand, a decentralised waste management system is criticised as a root of many waste management issues; therefore, since 2014, Thailand decided to promote the centralised system to replace the decentralised system (Petkanjanapong 2020). Clustering is a kind of centralised system adopted, where multiple municipalities that manage waste in their areas cooperate, especially by sharing waste treatment facilities. There are economies of scale and cost-saving to shift to this centralised system, especially at the collection stage (Sasao 2020). However, policymakers should consider increasing collection costs due to an increasing area of services (Sasao, 2020). During the transition

to the clustering system in Thailand, the central government motivates local administrative organisations (LAOs) to group together and cooperate. Each cluster has a host organisation, usually the biggest LAO in the cluster or the provincial administrative organisation (PAO), responsible for managing the waste treatment facilities (Petkanjanapong 2020). The success of expanding waste management collection services to rural and remote areas through a clustering system depends on the awareness of local government in those areas as well as the proactive effort of the host to propose cooperation with neighbouring rural and remote areas. By expanding such services, the companies or governments could reduce the transportation cost incurred during EPR implementation and overcome the budget and technical issues in rural and remote areas.

Furthermore, local governments, especially in rural and remote areas, shall also work closely with PRO related to recycling programs under the EPR system. In Indonesia, the recycling program developed by Indonesia Packaging Recovery Organization (IPRO) initially begins with the collection of PET bottles in big cities (Surabaya, Bali, and Lombok). As the pioneer of IPRO, PRAISE calls for tender for recyclers or aggregators

with a minimum collection capacity of 4000 tons/year. PRAISE is trying to generate a closed-loop recycling market among the IPRO, recyclers/aggregators, and converter/brands/retailers (PRAISE 2020a). As illustrated in Fig. 2, the IPRO will further involve a market-based collection system, through waste banks and junk shops, in the loop. The waste banks and junk shops will be directly connected to the recyclers/aggregators contracted by the IPRO to supply recyclables. Through this scheme, such as waste banks and junk shops, especially those located in rural and remote areas, can be more empowered as important actors in the entire collection system.

Fig. 2. EPR collection system in Indonesia



Source: PRAISE (2020b).

4.6 Minimising free-riding

While the smuggled and unregistered products have a large share in the market, collecting funds from the registered producers and importer will be difficult (Kojima et al. 2009). Therefore, it will be better for the government to understand the market share of registered producer and volume produced by unregistered producers and smugglers. By understanding the market share, the government can decide the effective measure to address this challenge. If the market share is large, the EPR system shall adopt financial measures to collect and treat such "orphan" products. To avoid smuggled products, customs regulation must be enforced (Kojima et al. 2009). Regarding unregistered products, consumers and local governments are candidates to bear the cost of collection and treatment (Kojima et al. 2009).

5. Conclusion

This paper explores some challenges in applying EPR system on packaging and plastic

materials in Asian developing countries. The challenges we identified are (i) existence of a market-based collection of recyclables with high population density and close to industry, (ii) high transportation cost of recyclable waste to a recycling facility, (iii) limited waste collection service in a rural area, (iv) limited facility to accept plastic waste which is difficult to be recycled, (v) insufficient pollution control by the recycling industry, (vi) free riding and orphan.

Although such challenges can be observed in developed countries, the impact and prevalence of these challenges are greater in developing countries. To reduce plastics leakage to the ocean from developing countries and to promote a circular economy on plastics, it is essential to apply some measures, such as (i) differentiating the responsibility of producers depending on recyclability, (ii) focusing on rural areas, (iii) involving informal sector, (iv) joint facilities in recycling park, (v) expanding waste collection services, and (vi) minimising free riding, when EPR system is applied.

Not only optimising the implementation of EPR, there are other related measures to ensure the circularity of plastic waste in Asian developing countries. For instance,

governments or private companies shall facilitate investment to reduce transportation cost of the collected recyclables, enhance design for recycling, develop industrial standard for recycled products, as well as stimulate green public procurement.

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