

Research article

An improved strategy for effectively managing the transboundary movement of waste based on the basel convention: A case study in South Korea

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ABSTRACT

Despite the efforts made to minimize the illegal trafficking of hazardous waste and prevent environmental pollution worldwide in accordance with the 1989 Basel Convention (BC), the illegal transboundary movement of waste and associated environmental pollution are ongoing. This study proposes a three-stage theoretical approach to effectively managing this waste. In stage one, the Convention, including its 2019 revisions, stipulates six primary requirements: clear declaration, hazardous waste, onsite inspection, responsibility, transport management, and final disposal after import. In stage two, the export and import management system is divided into four facets: customs preprocessing, customs processing, follow-up, and law. The challenges are presented of how to align the waste disposal with the Basel Convention's main requirements. Stage three presents a discussion of the effectiveness of the countermeasures derived in stage two for disposing of waste both within individual nations and internationally. Then, the theoretical approach was applied to analyzing South Korea Ministry of Environment's Act on the Transboundary Movement of Hazardous Waste and Their Disposal (revised in 2017). The strategy was demonstrated to be an improvement, and these study results can be foundational data to newly establish laws or revise existing acts on transboundary movement of waste (TMW) in each country.

1. Introduction

Waste is harmful to human health and the environment but can be valuable alternative resources [1,2], and all nations are concerned about effectively handling and managing their domestic waste [3–5]. However, many countries have increased their dependence on waste exporting and importing for many reasons, including the inability to process the rapid increases in waste around the world, the need to secure alternative resources because of the depletion of natural resources, and the possibility of waste usage for corporate profit [6–8]. Consequently, problems with the transboundary movement of waste (TMW) occur.

For example, the dioxin leakage accident in Seveso, Italy, in 1976 and the Greenpeace's 1983 discovery of 41 barrels of dioxin waste from Seveso, France, created international scandals related to the environmental damage caused [9,10]. Additionally, developed nations indiscriminately export hazardous waste to places such as Africa and Latin America to avoid the costs and difficulties of managing their own waste [11–13]. The Basel Convention (BC) was adopted in 1989 for international cooperation to protect the

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environmental conditions in developing and underdeveloped countries from waste [14].

The BC issued a compliance manual that defined hazardous waste and illegal trafficking, strengthened regulations, presented technical guidelines for effective waste treatment and improving recycling efficacy, and promoted international cooperation; signatories to the Convention must enact laws and regulations related to TMW [15]. In June 2006, the EU proposed a Commission Regulation (EC) No.1418/2007 for regulating shipping waste [16]. Germany's waste shipment regulation was Regulation (EC) No. 1013/2006 [17], and China established a regulation related to inspecting raw materials and permissions to examine waste exports and imports, both following the Convention guidelines [18]. Japan enforced the Basel law, which included regulations on the export and import of specific hazardous waste [19,20], the United States enacted the Resource Conservation and Recovery Act to regulate hazardous waste export and import [21], and South Korea enacted the Act on the Control of Transboundary Movement of Hazardous Waste and their Disposal [22].

However, despite the national efforts to adhere to the Convention, illegal transport persists. For example, it is estimated that around 2 million tons of e-waste illegally leave the EU each year [23]. China banned the import of hazardous waste after multiple cases of illegal hazardous waste mixed with imported wastes [24,25], and Brazil began returning waste to the exporting country after hazardous waste materials were being mixed with the plastic waste the country accepted [26]. In Palestine, waste materials containing ink, dyes, and heavy metals were illegally imported and dumped into the soil [27], and South Korea illegally exported its domestic waste to the Philippines [28].

All of these countries have in common that they lack ways to manage their imports of hazardous waste, such as ambiguous classifications of hazardous waste, problems with onsite inspection, exporters' and importers' evasion of responsibility, transport problems, and unclear final waste disposal. This study proposes a theoretical approach to effectively managing TMW that involves three stages: understanding the BC's requirements; suggesting four strategies for waste export and import management; and addressing pending issues related to TMW. In the second part of the paper, the theoretical approach is applied to South Korea's waste management processes.

2. Literature review

2.1. Background of the BC

The BC requires all parties to follow the manual, which comprises the foreword, main text, and annexes [15,29]. The foreword discusses the aim of minimizing hazardous waste traffic to prevent environmental pollution through cooperation between Convention signatories. The main text comprises 29 articles, including the scope and definition of hazardous waste. The annexes include detailed matters, such as the designation of hazardous waste, how to handle waste, and information about procedures related to export and import documents. Table S1 (Supplementary Information) presents the text and annexes of the Convention [15]. The Convention can be revised, or new provisions registered, at the Convention conference held every two years. The signatories at the conference discuss three agenda items: strategic issues, scientific and technical matters, and legal, compliance, and governance matters (Table S2) [30].

The annexes govern how the parties must manage their waste containing hazardous characteristics. For example, Annex I lists 18 waste streams and 27 constituents that exhibit hazardous characteristics and must be controlled (Table S3) [15], and Annex III presents 13 hazardous characteristics (Table S4) [15]. Wastes that contain the constituents in Annex I to the extent that they have hazardous characteristics in Annex III are designated as hazardous waste. Annex VIII contains 62 types of hazardous waste (referred to as List A in the Convention) (Table S5Table S8) [15]. Additionally, Annex II presents three hazardous waste categories that require special consideration: wastes collected from households, residues arising from incinerating household wastes, and plastic waste including mixtures of other wastes [15].

2.2. TMW in South Korea

South Korea joined the BC in February 1994, and Korea controls its TMW with the Act on the Transboundary Movement of Waste and Their Disposal and related enforcement ordinances [22]. South Korea strives to handle waste domestically as much as possible rather than exporting it, but the nation does import waste of high value (i.e., containing useful resources) that can serve as new resources because South Korea must import a large amount of natural raw materials: In fact, in 2019, the country imported 10 times more than it exported: 2347 metric tons compared with 151 in exports [31].

Most of the imported waste is waste tires, synthetic polymer compound waste, waste scrap metals, waste batteries, and coal ash [31]. However, it is more difficult to verify the safety of imported waste than waste generated in South Korea, and illegal importation has generated problems such as environmental pollution, conflict with nations, and conflicts of interest among related companies. Given these circumstances, it is necessary for leaders of South Korea to develop improved strategies for managing its TMW.

3. Methodology

As discussed above, the BC lays out six requirements for waste disposal including transnationally. The first is the clear declaration of all waste. The descriptions of exported and imported waste can differ from what is declared; for instance, materials can have hazardous waste hidden within them, whether intentionally or not [32,33]. Second, the Convention clearly classifies hazardous waste (definition, scope, ingredients, and characteristics) [34]. However, it does not detail standards or procedures, and therefore, it is difficult for nations to know how to process their hazardous waste.

Third, the BC requires onsite regulations on illegal waste traffic to be strict, and inconsistent or false declarations are regarded as illegal [15]; onsite inspection is one of the most effective methods of solving the issue. Fourth, the BC specifies that parties should cooperate in waste damage liability and compensation [35]. Fifth, the Convention directs that nations' management of illegal dumping transport be more transparent [36]. Sixth, the Convention directs that countries effectively dispose of any imported waste to prevent environmental pollution. Fig. 1 presents the theoretical approach discussed in this study that each country should follow to develop or update waste management system and establish an improved strategy if needed.

4. Results and discussion

4.1. Theoretical approach for effective TMW management

As Fig. 1 shows, the proposed theoretical approach for effectively managing nations' TMW consists of three stages. Stage one entails understanding the Convention's purpose as laid out in the six requirements. Stage two includes step 1, 2, and 3. Step 1 offers four facets for complying with the Convention. The first is addressing and, if needed, repairing customs preprocedure, when exporters or importers prepare their shipment documentation and applies for permission.

The second facet refers to countries' developing or revising their procedures related to loading and unloading waste at the customs site, and all activities in domestic transport. The third facet is developing or revising waste transport follow-up procedures, that is, how waste is disposed of once it enters a country and passes through customs. In fourth facet, countries develop legal measures for enforcing TMW disposal laws and regulations. In step 2 and 3, the problems of each of the four facets are checked, considering the six requirements of the BC confirmed in stage one, and countermeasures are proposed to solve them. Table 1 presents the current problems

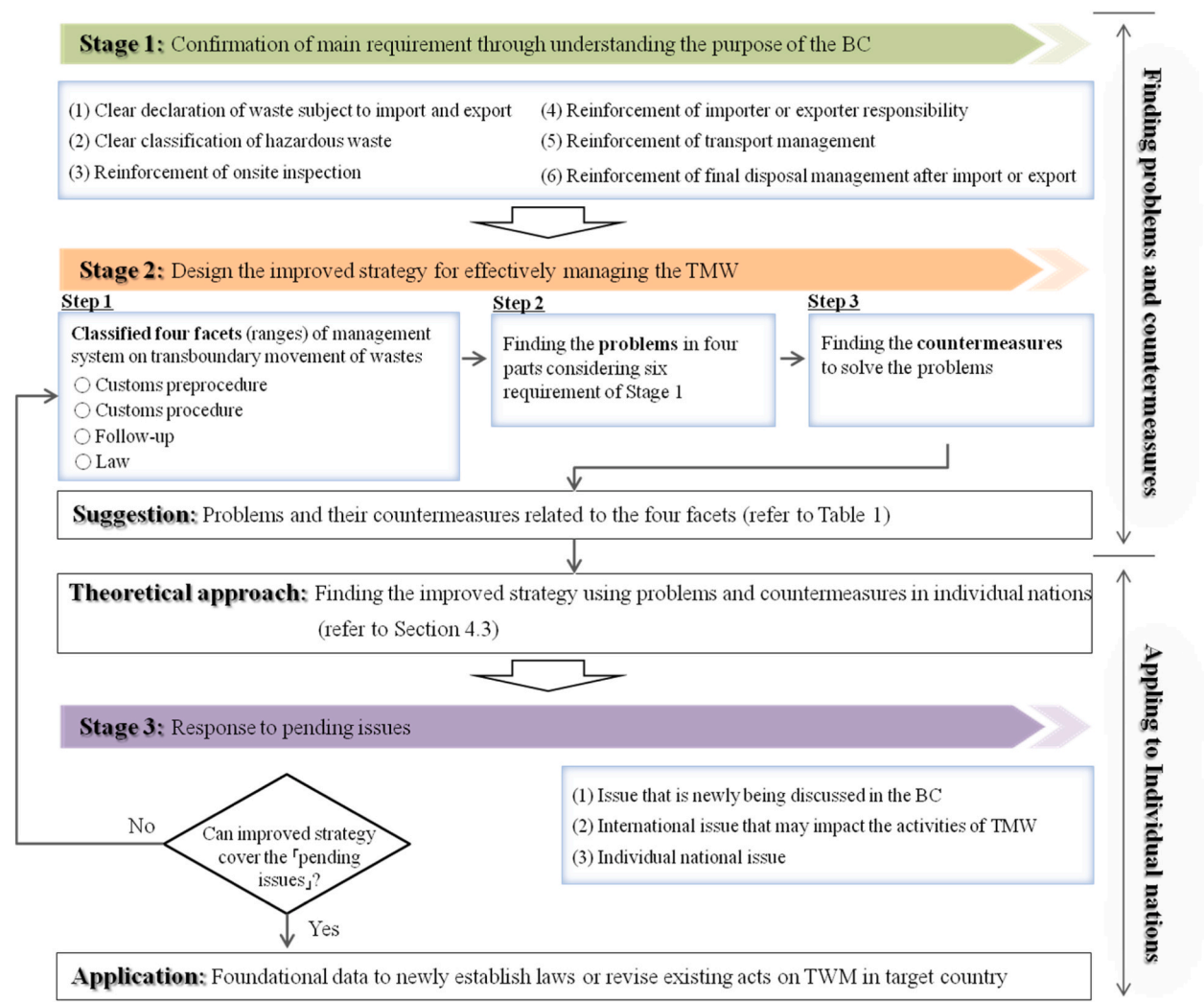


Fig. 1. Proposed theoretical approach for effectively managing nations' TMW consists of three stages.

Table 1

Current problems and their countermeasures related to the four facets with customs preprocedure, customs procedure, follow-up, and law.

Part	Range	Related BC's requirements	Current problems	Countermeasures
Customs preprocedure	<ul style="list-style-type: none"> ■ All activities in which an exporter or importer prepares the document and applies for permission to exported and imported wastes - The document including waste type, type of List A²⁾ or List B³⁾, related harmonized system (HS) code³⁾, transport plan, treatment plan, etc. 	<ul style="list-style-type: none"> (1) Clear declaration (4) Reinforcement of exporter or importer responsibility 	<ul style="list-style-type: none"> ○ Insufficient subdivision of waste-related code in the List of HS code: <ul style="list-style-type: none"> - the current HS codes insufficiently classify or unequally distribute some waste types - exporters (or importers) may accidentally or intentionally include wrong codes in the documents, thereby inducing illegal waste trade ○ Weak responsibility of the exporter (or importer) for trading the waste <ul style="list-style-type: none"> - the lenient responsibility system against exporters (or importers) can be a problem 	<ul style="list-style-type: none"> ▶ suggesting new HS code related to exported and imported waste ▶ suggesting guidelines to correctly identify HS codes for waste on TMW ▶ adopting new system of license and guaranty insurance
Customs procedure	<ul style="list-style-type: none"> ■ All activities, in which the waste is loaded onto the vessel or unloaded from the vessel, at the customs site - It includes other procedures such as customs declaration, customs permission, document confirmation, etc. ■ In addition, all activities in domestic transport 	<ul style="list-style-type: none"> (3) Reinforcement of onsite inspection (5) Reinforcement of transport management during TMW 	<ul style="list-style-type: none"> ○ Limitation to checking all waste trade in the customs clearance areas because of the large volume of trade - Especially, the absence of the specialized field inspector and relevant inspection center ○ Difficulty to check the waste transportation progress from the exporter (waste generation or storage place) to the customs clearance area or from the customs clearance area to the importer (waste disposal place) 	<ul style="list-style-type: none"> ▶ strengthening onsite inspection with professional onsite inspectors ▶ establishing center for safety inspection ▶ establishing tracking system
Follow-up	<ul style="list-style-type: none"> ■ the procedure for the importer to treat the imported waste after Customs procedure using the adequate disposal method as planned 	<ul style="list-style-type: none"> (6) Reinforcement of final disposal management after TMW 	<ul style="list-style-type: none"> ○ Unclear to confirm whether imported wastes were correctly disposed of according to the declaration plan of the importer 	<ul style="list-style-type: none"> ▶ strengthening disposal- onsite inspection ▶ mandating follow-up report system
Law	<ul style="list-style-type: none"> ■ Laws with acts, enforcement ordinance, notification, etc. for controlling the TMW 	<ul style="list-style-type: none"> (2) Clear classification of hazardous waste 	<ul style="list-style-type: none"> ○ Difficulty to interpret the exported and imported waste as the hazardous waste using only the definition of hazardous waste proposed in the BC 	<ul style="list-style-type: none"> ▶ suggesting related standards that can effectively specify the definition of hazardous waste in the BC ▶ suggesting analysis method to verify that proper standards being met

¹⁾List presented in Annex VIII in Basel Convention [15].

²⁾List presented in Annex IX in Basel Convention [15].

³⁾HS (Harmonized System) code of tariff nomenclature, also known as the Harmonized Commodity Description and Coding System is an internationally standardized system of names and numbers to classify traded products.

and their countermeasures related to the four facets. The scope of the customs preprocedure emphasizes declarations of waste contents and responsibility for waste. Currently, the World Customs Organization has proposed a harmonized system (HS) for coding waste, but the list of codes only addresses a limited number of waste types [37].

The HS codes are internationally accepted numeric code for export traded transactions [38]. Shippers can accidentally or intentionally miscode waste with the existing codes, and an effective countermeasure would be make the HS codes related to waste more detailed. Additionally, under current procedures, national governments bear the responsibility for environmental damage caused by TMW when companies' contracts do not assign specific responsibilities to the parties to waste transport contracts. This irresponsibility can encourage illegal trade by companies.

A new system of license and guaranty insurance must be adopted for all related exporters and importers that emphasizes onsite inspection and transport. Currently, there are limitation on the ability to check all incoming waste in customs clearance areas or ensure its proper disposal once it leaves the customs site; given these limitations, facilities, policies, and staff for professional onsite inspection

need to be installed and enforced. Additionally, given current volumes of waste, it is necessary to incorporate technology and automation into customs site TMW inspection processes.

The scope of follow-up covers the ultimate disposal of transnational waste in terms of compliance with the BC and the enforcement of appropriate customs site policies [39]. In the scope of law, the BC requires that countries clearly classify their hazardous waste; the current BC definitions are currently difficult to interpret, and clearer definitions should be suggested [40]. In stage three of the BC's TMW, nations should examine the effectiveness of the countermeasures they instituted in stage two and revise them where needed. The next section presents a discussion of pending issues relating to countries' TMW.

4.2. Pending issues

Here, examples are offered that illustrate the pending issues in detail. The first issue is the Ban Amendment, which was added to the BC (IPEN, 2020) [41]. The amendment prohibits transboundary movements of hazardous waste for final disposal by signatory countries to nonsignatory countries. There are 43 countries on the list, including OECD and EC member nations; more details can be found in the Supplementary Information, Table S6. Another BC agenda item is plastic waste. It was not recognized as hazardous waste in the past because plastic is generally a low-reactive and stable material, but some types of plastic waste are now classified as hazardous [42–44]. Table S7 compares the existing and revised classifications of plastic waste in the BC.

Another TMW issue is international regulations. For example, China has continuously strengthened its waste import regulations and has now banned solid waste [45,46], and other countries are banning waste importation or tightening regulations. In particular, Asian countries with few waste treatment facilities and technologies, such as Vietnam, Malaysia, and Thailand, strive to prevent environmental pollution by banning waste importation [47–49].

A third is individual national' waste disposal conditions. For example, South Korea has a high volume of import waste, in particular coal ash, which is imported from Japan and accounts for about 57% of South Korea's TMW [50]. However, both the National Assembly and private institutions doubt the safety of coal ash imported from Japan, which has been contaminated with radioactive waste from the 2011 tsunami and its impacts on nuclear reactors [51,52].

4.3. Applying the theoretical approach in South Korea

South Korea's current system for managing TMW requires revisions in order to comply with the countermeasures proposed in Table 1. As noted earlier, Korea's system complies with the Act on the Transboundary Movement of Hazardous Waste and Their Disposal (revised in 2017) (Ministry of Environment, 2017). Fig. 2(a) shows that the system can be categorized into the following roles: import or export company, customs, Korean Customs Service (KCS), Korean Environment Corporation (KEC) and the Allbaro System, and the Ministry of Environment (MoE).

The MoE manages all legal areas and approves exported and imported wastes. KCS conducts customs clearance procedure, and the KEC manages declarations and documentation using its comprehensive Allbaro System. For example, when a shipper applies to import waste through the Allbaro System (1), the MoE confirms the application (2), and receives the confirmation from the exporting country and exporter (3). If no problem exists, the importer receives an approval document (4). When the relevant waste is brought to the customs clearance (5), the importer requests a customs clearance confirmation from the KCS (6). Here, the KCS requests that the MoE confirm related information and consent to customs clearance (7), and if no problem exists, the company receives permission (8) and imports its waste into South Korea (9).

However, South Korea has the problems depicted in Fig. 1 and Table 1. For example, it is difficult to check a clear declaration before customs clearance, inspections of waste for hazardous content are not always accurate, and the tracking of waste for correct handling after it leaves customs has been inadequate. Fig. 2(b) shows the potential management system South Korea could implement by following certain steps.

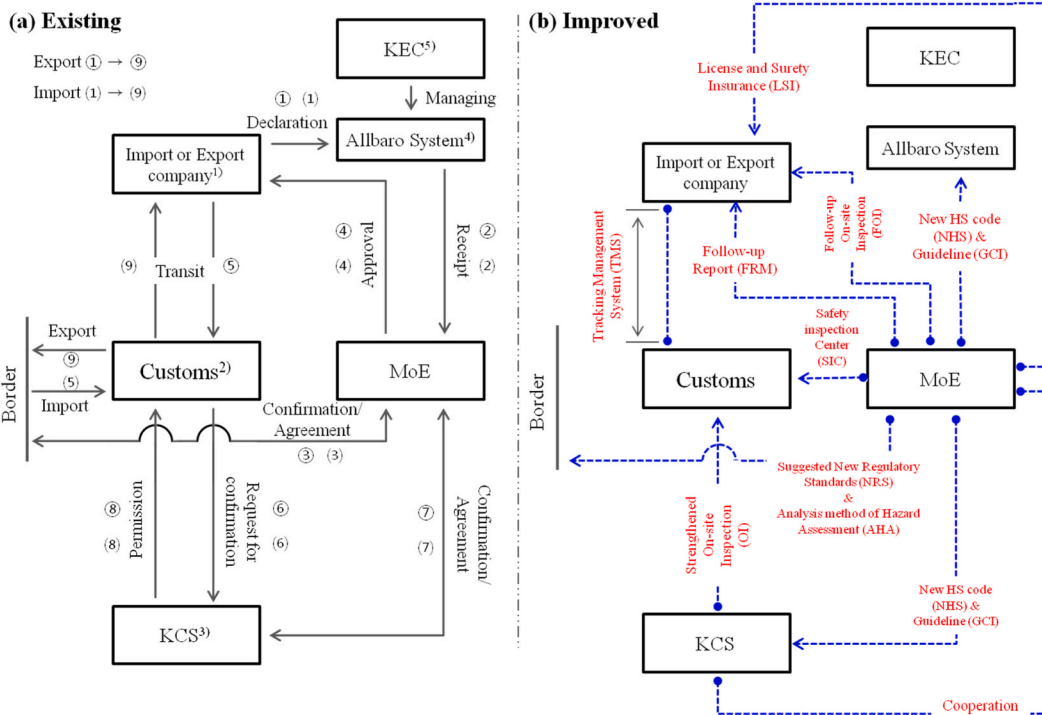
First, the MoE should devise new HS codes that allow for more detailed declarations at customs along with clear instructions to shippers on correctly using the codes (i). The second step introduces license and surety insurance systems because if shippers have clear obligations and responsibilities, illegal traffic and accidents could decrease (ii). Third, the KCS needs to strengthen the onsite inspection by establishing safety inspection centers staffed by specialized inspectors who are experienced with the various equipment involved in verifying the safety of shipments (ii, iv).

The MoE also needs to institute a real-time tracking system for ensuring the safe transit of incoming wastes to appropriate final disposal sites, using weight sensors or GPS for instance (v). Disposal site inspections are also needed to ensure that wastes remain appropriate (vi), and follow-up reporting should be mandatory including any difficulties with waste shipments (vii). The MoE should rearrange laws proactively regarding the standards to determine whether wastes are hazardous or non-hazardous (vii). The following sections describe in detail how South Korea could implement these recommendations to improve its TMW procedures.

4.3.1. Revised HS code

The international Harmonized System is a set of standardized codes for classification of all products traded between countries. The first two digits represent the section, the third and fourth digits represent the heading, and the fifth and sixth digits represent the subheading (Fig. 3(a)) [38]. Each country customizes the standard HS codes to reflect the products that are most frequently transported; South Korea's HSK comprises 10 digits.

As one example, HS section 39 relates to plastics, heading 3915 indicates plastic waste (Fig. 3(b)), and subsection 3915.10 refers to plastic waste made of ethylene polymer. The current waste-related HS codes are generally insufficient for accounting for the many



- ¹The company has one or more of facilities such as the disposal, discharge, and storage.
- ²Customs is collecting tariffs on import and export wastes and controlling the flow of waste, into and out of a country.
- ³KCS is the official customs department of South Korea which works under the Ministry of Strategy and Finance. Importers or exporters can make an import or export declaration under the control of this service.
- ⁴Allbaro System (waste disposal verification system) was introduced by the Korean MoE to manage domestic waste and prevent illegal waste disposal [31].
- ⁵KEC is an agency affiliated with the Korean MoE and is managing Allbaro System.

Fig. 2. Existing (a) and improved (b) management system of South Korea categorized into the following roles: import or export company, customs, Korea Customs Service (KCS), Korean Environment Corporation (KEC) and Allbaro System, and the Ministry of Environment (MoE).

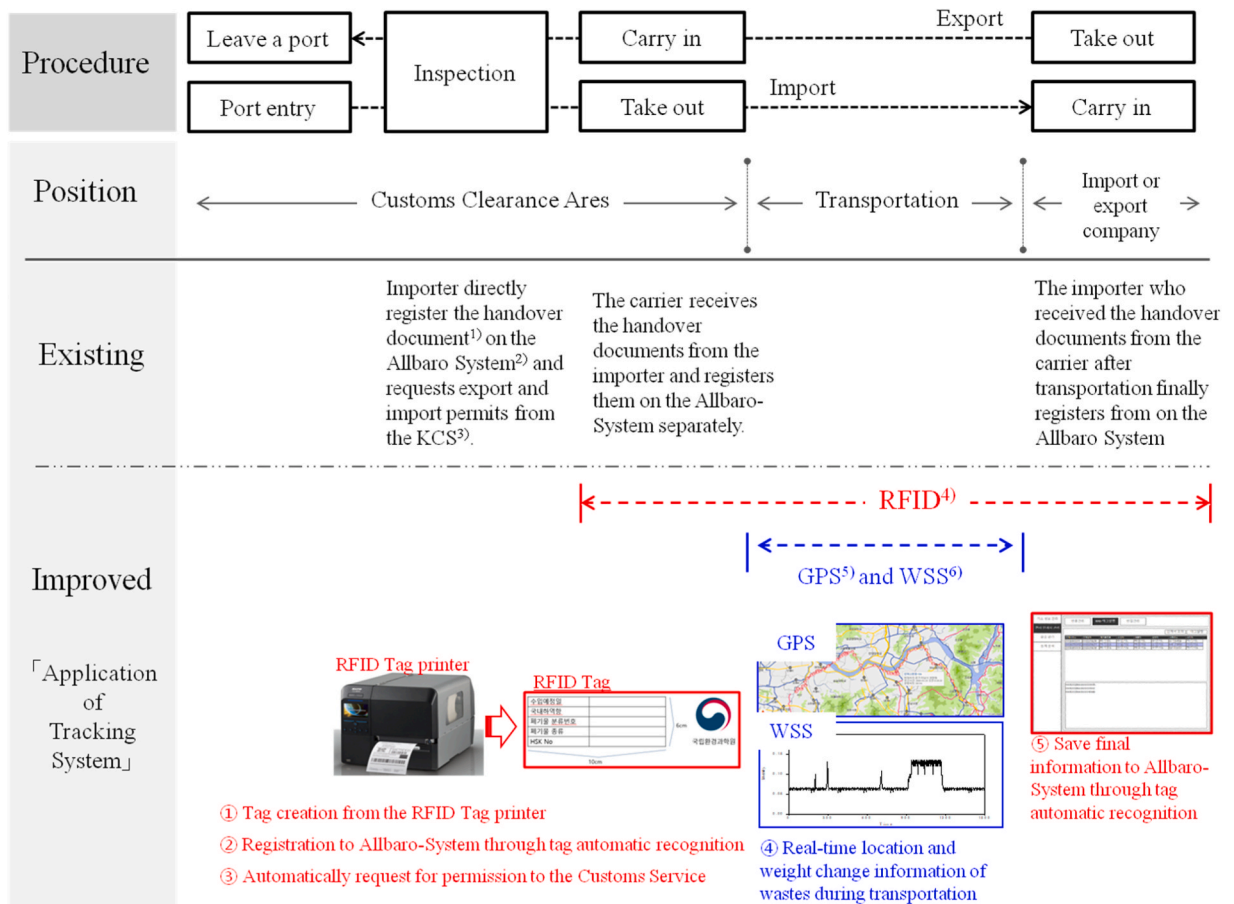
different waste types that exist now. Companies should voluntarily fill out the HS code when declaring transnational waste, but because the codes lack sufficient detail, it is easy for shippers to use the wrong codes intentionally or unintentionally. The wrong assignment can in turn cause the improper handling of waste.

To solve this problem, new, more detailed HS codes and guidelines are needed that can be devised according to the four steps in Fig. 3(c). Step 1 is checking all current waste-related HS codes; the HSK system contains 339 waste-related codes out of 18,135 total codes [53]. Step 2 involves aligning the HSK codes with the waste types specified in the Acts for waste management and waste-related HS codes and developing new codes for waste that is not currently addressed. Currently, South Korea recognizes 294 types of waste: 101 hazardous waste, 167 industrial waste, and 26 domestic waste categories [54]. However, about 108 waste types exist that are difficult to categorize with HSK codes, 29 for hazardous waste and 79 for industrial waste.

For example, coal ash in South Korea is categorized as a type of combustion residue (Fig. 3(d)), but there is no HS code for this; to date, shippers have been categorizing coal ash as “other slag and ash, including seaweed ash (kelp), ash and residues from the incineration of municipal waste”. The current HS codes also do not contain accurate codes for waste catalysts, waste wood, waste soil, and waste glass. The World Customs Organization, an independent international organization, is responsible for the baseline six-digit HS codes, and these cannot be easily changed, hence each country’s modifications with additional digits.

In Korea, for example, the current World Customs Organization HS code for ash, 2621.90, could be modified for coal ash as HSK code 2621.90.10.30, as shown in Fig. 3(d).

The procedure for implementing these code changes could be as follows: The MoE would draft HSK new codes through the



¹)It is a document required for customs procedures when importing and exporting waste. It includes importer (or exporter) information, date, port name, waste amount, type, and HS code, carrier information, vehicle number, etc.

²)Allbaro System (waste disposal verification system) was introduced by the Korean Ministry of Environment (MoE) to manage domestic waste and prevent illegal waste disposal.

³)Korea Customs Service (KCS) is the official customs department of South Korea which works under the Ministry of Strategy and Finance. Importers or exporters can make an import or export declaration under the control of this service.

⁴)Radio Frequency Identification (RFID)

⁵)Global Positioning System (GPS)

⁶)Weigh-Sensing System (WSS)

Fig. 4. Application of tracking system for whole process, from carrying in and taking out waste to transportation, takeover and handover to the customs clearance area.

4.3.3. Necessity for determination standards of hazardous waste

All parties to the BC categorize hazardous waste according to Convention definitions [15]; Fig. 5 shows South Korea’s categorizations according to its TMW governing act [22]. Categorizing waste follows three steps. In step one, the shipment is checked for any prohibited waste materials (e.g., asbestos, polychlorinated biphenyls, medical waste, and waste prohibited for recycling; BC, 1989). In

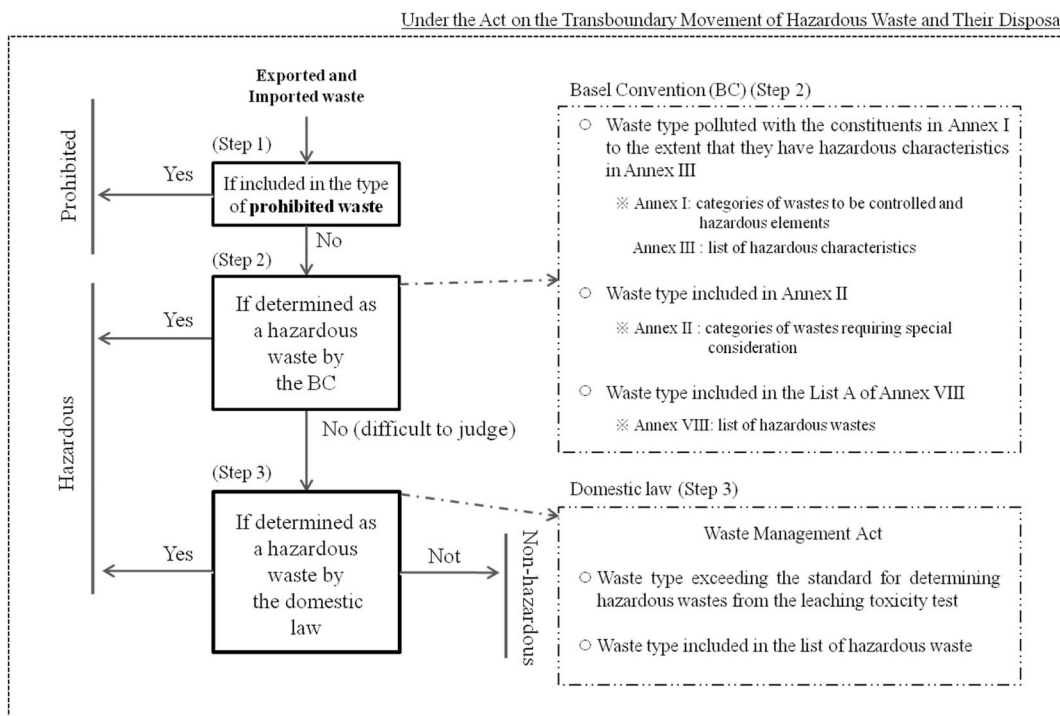


Fig. 5. Procedure for determining prohibited, hazardous, and non-hazardous types on transboundary movement of waste (TMW) under the Act on the Transboundary Movement of Hazardous Waste and Their Disposal, in South Korea [22].

step two, waste is checked for whether or not it is hazardous according to the BC’s definitions, which are divided into its three annexes (BC, 1989). Annex I refers to waste constituents that contain the hazardous material characteristics listed in Annex III (BC, 1989). Annex II presents transnational waste that requires special consideration, and Annex VIII lists 62 hazardous waste items (BC, 1989). If it is difficult to determine whether the waste is hazardous according to the BC, a country’s domestic law governs the categorization of waste as hazardous or not (BC, 1989).

However, the BC’s categories are limited for determining whether wastes are hazardous because the standards are unclear, which is where each country’s law becomes relevant. For example, no determination standards exist for hazardous waste belonging to [Annexes I and III](#) or for 19 of the 62 items proposed in Annex VIII ([Table S8](#)). These 62 items can be largely divided into four types: (1) waste with characteristics defined in Annex III, (2) waste that contains specific hazardous components (such as Pb, Hg, Cd, and As), (3) specific industrial waste or waste from specific locations, and (4) hazardous waste designated on List A. Among these, there are no clear standards for determining whether 19 of the 62 types belong to categories (1) or (2) above ([Table S8](#)). [Table S9](#) presents the nine characteristics South Korea uses to determine if material is hazardous: explosiveness, flammability, combustibility, reaction with water, oxidation, infectiousness, corrosiveness, leaching toxicity, and ecotoxicity [61].

5. Conclusions

As of 2021, 192 countries were signatories to the 1989 Basel (Switzerland) Convention, although each country operates its own TMW systems. Japan’s Basel Law guides its TMW processes, and much of Europe follows the same guidelines, albeit with slight differences among countries. China follows its own rather than the BC’s designations, and other nations have found China’s policies controversial. Despite international efforts, however, illegal waste is still being shipped internationally causing environmental issues.

Countries need to update their HS codes if they regularly receive material that cannot currently be easily categorized with existing codes and deploy these new codes in improved field inspections during customs clearance, including distributing clear guidelines for their application. Countries also need systems for tracking waste shipments once they clear customs to ensure that they remain on their designated routes and that waste materials are not leaking or being illegally disposed of. Tracking materials all the way through their journey increases the efficiency and safety of managing transnational waste. This study proposes both a theoretical approach to improving TMW procedures and methods for their practical application using waste management in Korea as a case study. Leaders of other countries can follow this theoretical approach to assessing and revising their own TMW procedures where needed.

Author contribution statement

Analyzed and interpreted the data: Namil Um, Yoon Soo Park, Tae-Wan Jeon.

Contributed reagents, materials, analysis tools or data: Namil Um, Yoon Soo Park, Tae-Wan Jeon.
Wrote the paper: Namil Um.

Data availability statement

Data included in article/supp. material/referenced in article.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e16496>.

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