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THE APPLICABILITY OF REGULATIONS FOR THE DISPOSAL OF CONSTRUCTION AND DEMOLITION WASTE IN SRI LANKA

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ABSTRACT

Effective and efficient waste management plans/systems are vital in reducing and maintaining the generation of construction and demolition waste. It was proved in previous research, proper rules and regulations affect the effectiveness of the waste management strategies used in disposing of construction and demolition waste. Therefore, this research aim is to identify the regulations applicable for the disposal of construction and demolition waste in Sri Lanka to propose improvements in the available rules and regulations. Comprehensive literature and document review were conducted to approach the aim of this research. Questionnaire surveys and expert interviews were carried out to validate the findings of the literature survey and to gather required data in identifying the issues related to current rules and regulations and proposing improvements. The findings revealed that many gaps can be identified with the current regulations used in the disposal of construction and demolition waste. The results of the research identified a lack of intention in government regarding recycling, avoiding improper landfilling, and avoiding illegal dumping of construction and demolition waste as major issues. The study finally concluded the necessity of modified rules and regulations regarding the disposal of construction and demolition waste.

Keywords: *Construction Demolition Waste; Law and Regulations; Waste Management.*

1. INTRODUCTION

The Construction industry holds a major role in Sri Lankan national economy while being the fourth largest industrial division with 6-7% of Gross Domestic Product (GDP) (Jayalath and Gunawardhana, 2017). Sri Lankan construction industry has contributed about 50% of the total GDFCF (Gross Domestic Fixed Capital Formation) with other benefits like tax revenue, profits, employment, etc. (Shen and Liu, 2003). At present, an increase in the number of commercial, industrial, and national scale mega projects can be seen all over the country which proves the contribution of the construction industry towards the national economy of Sri Lanka (Chanudha, et al., 2017).

According to Asgari, et al., (2017) construction industry is ranked as a top user of natural resources and generator of waste materials where 25% of timber resources and 40% of

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natural raw materials are being utilized by the construction industry worldwide. It is evident that a significant quantity of waste is produced worldwide due to construction-related activities (Omoniyi, Akinyemi and Nwosu, 2014) However, Sapuay, (2016) claims that much attention should be given to waste materials as improper management of waste materials can cause adverse effects to the environment and lifestyle of people and other living beings. Due to the enormous development processes and increase in human population worldwide, the demand for construction activities increases causing the amount of construction and demolition waste to increase. Previous studies reveal that 35% of municipal solid wastes in developed countries are due to construction activities, while it is 50% in developing countries (Ansari and Ehrampoush, 2018).

Sapuay (2016) stated the management, controlling, and disposal of construction and demolition waste is very crucial. Further, it is the main responsibility of a contractor of a construction project to maintain a sanitary working environment by acceptably disposing of the waste. Therefore, considering a disposal method, the first concern should be given to statutory framework/regulations available within the certain country related to the construction and demolition waste disposal (Asgari, et al., 2017). Hence, this research is based on regulations applicable for the disposal of construction and demolition waste in Sri Lanka.

2. LITERATURE REVIEW

The related literature review was carried out to identify the regulations applicable for the disposal of construction and demolition waste in Sri Lanka

2.1 WASTE MATERIALS AND METHODS

Construction waste materials and methods are presented here.

2.1.1 Construction and Demolition Waste

Construction and demolition waste is generally a mixture of additional materials produced during a construction project or the waste generated through a demolition activity of a constructed facility (Chowdhury, et al., 2016). Generally, the generation of waste due to demolition activities is more than the waste generated during the construction of a structure. The demolition waste can be defined as an assemblage of an unusable set of materials that priory benefits the demolished structure.

A Significant quantity of waste is produced worldwide due to construction-related activities (Omoniyi, Akinyemi and Nwosu, 2014). According to the reports of the Department of Sustainability, Environment, Water, Population and Communities (DSEWPC), from all the materials produced or manufactured, 50% is utilized for building materials and results in generating about 50% of solid waste in the world (Omotayo and Akingbonmire, 2017). It is reported that in the United States of America, about 136 million tons of construction wastes are produced annually due to construction-related activities. Similarly, in the United Kingdom, about 70 million tons of waste are collected and that amount is 10-15% out of the total waste materials collected in the United Kingdom (Ghafourian, et al., 2016). Further, through surveys carried out worldwide, it has been identified that China generates about 48% of waste out of the total construction and demolition waste generated in the world, while Japan, South Korea, and China are generating waste margins of about 21%, 7% and 4% respectively (Amirthakadesharan

and Kalpana, 2017). Hence, Construction and demolition waste has converted into a worldwide problem with the current modernization period.

2.2 CAUSES OF CONSTRUCTION WASTE

The industry of construction is well known for waste produced during the production stage and the abstraction of raw materials in the implementation of construction projects (de Magalhães, Danilevicz and Saurin, 2017). The concerning fact is that construction waste is existing in many different forms and various quantities (Salgin and Cosgun, 2018). This has become a major challenge as these waste materials produced throughout the construction process is an issue in achieving the required performance and the sustainable goals of the project (Kulatunga, et al., 2006). Causative factors for the generation of these amounts of waste can be classified and described in many ways. Some of the main sources which contribute to the generation of construction-related waste materials can be categorized as given in Table 1.

Table 1: Causative factors for the generation of waste

Phases	Causative factors	Reference
Design stage	Design errors, Poor design quality, Frequent changes in design after construction is in progress, Complexity of the design, Inexperience of the designer, Lack of information to design	Nagapan, Rahman and Asmi (2011)
Handling	Improper handling & storage of materials, Damages, and delays during transportation, Equipment failures	Akhund, et al. (2019).
Working stage	The attitude of the workforce, absence of a proper reward, and a controlling system. Lack of experience of workers, and Skilled workers, Improper handling of tools and equipment, Irregular wear of equipment, and Working conditions and time.	Nagapan, Rahman and Asmi (2011)
	Lack of training among the workforce and the negative attitude towards the subordinates by the higher management	Kulatunga, et al. (2006)
Management	Poor planning, control, and supervision., Lack of interrelatedness between parties, lack of communication, Poor awareness of environmental conditions waste management plans	Akhund, et al. (2019)
Due to Procurement methods	Errors in ordering and under/over-ordering, shipment errors, ignoring provided specifications, waiting for any replacement's orders.	Akhund, et al. (2019)

2.3 CATEGORIZATION OF WASTE

At present, the growth in the construction industry influences the generation of enormous amounts of waste due to construction and demolition activities. Rajendran and Pathrose (2012) define construction waste as any damage caused by construction activities that cause both direct and indirect costs where it does not add any value to the final product from the client's point of view. The waste materials can be grouped according to many facts and areas. Common types of construction waste are given in Table 2.

Table 2: Common types of construction waste

Fact	Description	Reference
Natural Waste	Can be defined as the minimum amount of waste that will always occur, despite the type of the project	Khaleel and Al-Zubaidy, (2018)
Potential Waste	Potential waste is defined as avoidable waste materials.	Akhund, et al., (2019)
Physical Waste	Physical waste is the waste that can be seen in any kind of construction project due to activities like construction, renovation, and demolition.	Khaleel and Al-Zubaidy (2018)
	Physical waste can be further subdivided as structure waste and finishing waste.	Akhund, et al. (2019)
Non-physical Waste	The major forms of nonphysical waste in construction projects are time and cost overruns.	Khaleel and Al-Zubaidy (2018)
Inert Waste	Inert waste is chemically inactive and less harmful waste materials.	Poon, et al. (2013)
Non-inert Waste	Non-inert waste materials are chemically active materials.	Poon, et al. (2013)

2.4 CONSTRUCTION AND DEMOLITION WASTE DISPOSAL/MANAGEMENT SYSTEMS

Through the construction industry, massive quantities of waste are generated as by-products of rapid urbanization activities in most of the developing countries (Mah, Fujiwara and Ho, 2018). A major risk to the environment arises due to the illegal dumping of construction and demolition wastes. Therefore, to mitigate the negative effects caused by construction and demolition waste, it is vital to ponder the proper waste disposal systems in Sri Lanka.

The most common form of construction waste disposal method used around the world is landfilling in which, more than 50% of the waste generated ended up in landfills (Al-Hajj, Iskandarani, and Al-Hajj, 2012). Studies show that about 13-26% of wastes collected in landfills are waste materials related to construction works (Nagapan, Rahman and Asmi 2011). According to Devia, et al (2017) construction and demolition waste in landfills can cause effects on soil and groundwater as leaching of toxic materials can occur.

Another widely used system in managing construction and demolition waste is recycling, which can be defined as a simple treatment given to the construction waste materials, where the physical properties may slightly change (Asgari, et al., 2017). Generally, 50 to 80% of construction and demolition waste is recyclable (Asgari, et al., 2017). In developed countries, recycling of construction and demolition waste is regulated under laws and policies, where the recycling rates should be greater than 90% in most cases. Studies show that 90% of construction waste materials are recycled in Australia while Japan has achieved a 99.5% recycling rate in 2012. The highest recycling rate was reported by Singapore where the rate is 99.9 % (Mah, Fujiwara and Ho, 2018).

Another concept in managing the construction and demolition waste is reusing. Reusing does not need any processing to utilize the certain material. The items can be directly used after being collected through, without any conversion or energy input (Bansal and Singh, 2014). Reusing construction and demolition waste leads to saving natural

resources, reducing negative environmental impacts, reducing adverse effects to CO_2 footprint, reducing large spaces required for waste dumping sites, and creating job and business opportunities across the world. Useful materials like mild steel, reinforcement, structural steel, doors and windows, bricks, and other metal items can be reused easily with minimum processing. Asphalt toppings can also be used as the base for new asphalt pavements (Kumbhar, Gupta and Desai,2013).

Researchers have also identified the importance of using construction and demolition waste materials as aggregates for new construction projects. Deiyagala, et al (2017) identified the potential of using crushed construction and demolition waste material like demolished concrete aggregate, ceramic tile coarse aggregate, demolished block fine aggregate as substitutions for mineral rock and sand in the preparation process of concrete mixtures and mortar (Deiyagala, et al., 2017).

2.5 CONSTRUCTION AND DEMOLITION WASTE IN SRI LANKA

The generation of construction and demolition waste has become a major issue in the Sri Lankan construction industry as it has surpassed the acceptable limits. Therefore, many researchers have considered researching construction waste management in Sri Lanka to propose effective waste management methods (Rameezdeen, Kulatunga and Amaratunga, 2004).

According to Jayawardane (1994), concrete and mortar wastage takes up to 21% and 25% of wastage in sites. The research was undertaken by Rameezdeen, Kulatunga and Amaratunga (2004) in Sri Lanka for quantifying construction material waste in Sri Lankan sites. According to the results, Sand is considered as the material to be having the highest wastage in Sri Lankan construction sites amounting to 25% out of the total collected waste amount. Respectively, Lime waste (20%), Cement waste (14%), Brick waste (14%), Ceramic Tile waste (10%), Timber waste (10%) are generated. The study further stated that material cutting processes and improper management are the major causes for waste generation.

2.6 LAWS AND REGULATIONS APPLICABLE IN THE DISPOSAL OF CONSTRUCTION AND DEMOLITION WASTE

The construction industry is a major generator of waste (Mah, Fujiwara and Ho, 2018). The contractor for a project is responsible for maintaining a sanitary working environment through disposing of waste generated through construction-related activities (Asgari, et al., 2017). As the period of a contractor is limited to the construction period, the common practice is the disposal of waste in the most convenient method, which will not be a considerable expense for the construction project. Therefore, minimum consideration is given to future consequences and proper waste disposal methods (Sapuay, 2016).

Legal policies and regulations become the basis for the project participants to perform construction, supervision, and management properly and effectively (Sapuay, 2016). When standard regulations and policies are applicable, implementation will affect all the participants of the project where all are responsible and liable under the regulations and policies up to a certain extent (Nguyen, 2016).

2.6.1 Laws and Regulations: Sri Lankan Context

The management of construction and demolition waste is governed under the National Environment Act of Sri Lanka. The title of the National Environment Act (1988) is, "for the protection, management, and enhancement of the environment, for the regulation, maintenance, and control of the quality of the environment; for the prevention, abatement, and control of pollution".

Under part iv A, Environmental protection section of the Act, no person is allowed to deposit, discharge, or emit waste into the environment unless the person holds a license for issuing waste. The Authority has the power to issue a license for persons who applies under the standards and criteria prescribed in the Act. At any time, the authority can suspend or cancel the license in case of violation of any terms, standards, and conditions of the license given.

Under part iv B, Environmental Quality section of the Act, the following offenses and penalties tabulated in Table 3 are applied.

Table 3: Offences and Penalties under Part iv B Environmental Quality Section of the Act

Violence	Punishable Offence	Penalty
Polluting inland waters	Releasing any harmful solids, liquids, or gases to water bodies. Releasing any waste material in the form of solids, liquids, or gases to water bodies. Causing the temperatures of inland, coastal or offshore water bodies to increase or decrease more than acceptable limits.	A fine not less than Rs.10,000 and not greater than Rs.100,000
Polluting atmosphere	Discharging of odors that are harmful to people Burning of prohibited fuels Burning waste materials at unsuitable times or places	A fine not less than Rs.10,000 and not greater than Rs.100,000.
Soil pollution	Illegal dumping makes the soil poisonous or impure Keeping waste in private lands or places that may be offensive to others	A fine not less than Rs.10,000 and not greater than Rs.100,000
Sound pollution	Emitting noises greater in volume, intensity, or quality than acceptable limits	A fine not less than Rs. 10,000 and not greater than Rs. 100,000

The authority has the power in issuing notices to remove waste or litter piles collected. Any person who fails to fulfill the requirements of the notice will be guilty and the authority can remove the litter and collect the spent amount in removing the litter by the person responsible (National Environment Act, 1988).

It has been identified that the general rules and regulations applicable for Construction and demolition waste management are not appropriate as the available regulations are not directly supportive enough in increasing the rates of recycling, reusing, and decreasing the rate of illegal disposal of waste. Although certain amendments were made regarding the act from time to time, no amendment includes clauses on recycling, reusing, or illegal disposal of construction and demolition waste.

3. RESEARCH METHODOLOGY

Considering the in-depth investigation required in this study, a mixed approach was used for this study. Data were collected using questionnaire surveys and expert interviews. The questionnaire was pre-tested through the pilot test. A pilot test was applied to identify the validity of the developed questions and was conducted by analyzing the results of the questionnaires gathered through five construction industry professionals. Afterward, the required modifications were applied and the questions were finalized.

Both quantitative and qualitative data were gathered through the questionnaire survey from thirty construction industry professionals including Project Managers, Engineers, and Quantity Surveyors. Six expert interviews were arranged with construction industry professionals to gather qualitative data in achieving the research aim. Interviewees were selected using the non-probability sampling technique. The sample is limited to the Colombo district as the number of ongoing construction projects was very high compared to other districts, which leads to the generation of an enormous amount of construction and demolition waste. The quantitative data collected through the questionnaire survey were analyzed using the descriptive analysis method. The collected qualitative data were analyzed using the content analysis method.

4. ANALYSIS AND RESEARCH FINDINGS

4.1 ANALYSIS OF QUESTIONNAIRE SURVEY

Data collected through a questionnaire had 30 professionals participating from the construction industry which comprised 10 Engineers, 6 Project Managers, 9 Quantity Surveyors, and 5 Technical Officers. 5 professionals had over twenty-year of working experience. 7 respondents had 10 to 15 years of experience while most of the professionals had 5 to 10 years of experience.

4.1.1 Construction Waste

Based on the construction site: 24 respondents out of 30, confirmed that Building projects produce the highest amount of waste, where 1 respondent has chosen Road projects and 4 respondents agree on Bridge construction. Based on Causes of Waste Generation: most have agreed that more waste is generated at the working stage of a project. And no respondent considered that management leads to generating higher amounts of waste. The respondents were provided with 10 common construction waste materials which can be seen in Sri Lankan construction sites to identify the 3 most abundant waste materials (refer Figure 1).

Note: • A - Timber, Concrete, Tile • B - Timber, Bricks, Steel • C - Concrete, Mortar, Tile • D - Concrete, Tile, Bricks • E - Concrete, Tile, Steel • F - Concrete, Bricks, Mortar • G - Bricks, Steel, Tile • H - Bricks, Mortar, Tile

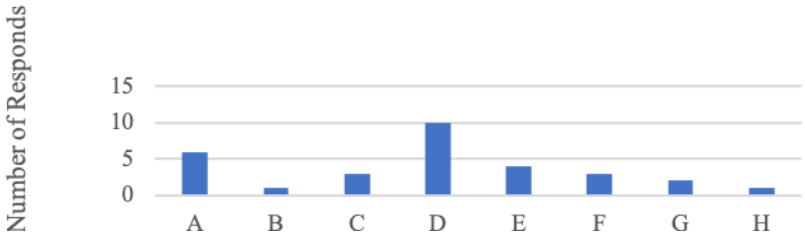

Figure 1: Construction waste materials

According to Figure 1, most of the professionals have agreed that category D which is concrete, tiles, and bricks can be considered as the most abundant waste materials which are being disposed of as waste at construction sites.

4.1.2 Construction Waste Management Systems

According to the analysis, landfilling has been considered by the respondents as the most utilized method in disposing of construction and demolition waste materials. However, on the contradictory, out of the 30, 21 respondents then recommended that, recycling as the best possible method to be applied on construction and demolition waste materials in Sri Lanka. Figure 2 details the responders' opinion on the suitable waste management for the Sri Lankan Context.

Figure 2: Waste management methods (Recommended)

4.1.3 Awareness on Environmental Act

Out of the 30 despondent, 70% of the respondents conveyed the fact that they have a general understanding of the environmental act thus a 30% which includes a project manager, 3 Engineers, and 5 QSs conveyed their unawareness regarding the act.

4.2 Analysis of Expert Interviews

6 current industry practitioners who are having more than 5 years of experience in their relevant profession had contributed their knowledge for the interviews. Expert interviews were carried out to gather required information on achieving the knowledge were improvements that need to be implemented in current regulations.

4.2.1 Identification of Problems in Current Regulations

All the interviewees pointed out that proper waste segregation upon disposal needs to be highly considered. Waste materials collected on most of the sites are piled up without any prior classification of the materials. Because of that, waste materials that can be recycled or reused will directly be discarded. Moreover, the responsible authorities for collecting and disposing of the wastes, do not attempt the task properly as they tend to ignore the separation of material. Furthermore, improper supervision at dumpsites owned by municipal councils results in heavy pollution which also will result in creating adverse effects on human lives. Further, the wastes that end up in marshy lands could potentially cause adverse effects like floods, soil pollution which impacts directly on the environment and human activities.

The government's concern in providing necessary landfill locations to dump construction and demolition waste is another critically unaddressed factor. According to the ideas of interviewees, the available landfills which are owned by municipal councils are not sufficient to dump all the waste which generates in construction sites. Moreover, the approval process in getting permissions to dump waste to a landfill of the municipal

council is time-consuming whereby it causes unnecessary delays in project completion. One of the professionals significantly doubted the authenticity of the approvals as the disposals are not monitored during the dumping process. The delays in permission prompt the contractors to dump waste illegally which will be resulting in saving money and time.

Recycling is considered the best option in managing construction and demolition waste in both questionnaire surveys and expert interviews thus less intention is given by the government in the recycling of construction waste. The expert's opinion behind the idea is that there would be a reduction of waste in a considerable amount as the waste can be processed and used again for construction-related activities, causing the quantities of waste in landfills to decrease. The government's involvement in providing required backgrounds for improving the recycling of construction waste is at a minimum level. In Sri Lanka, only one construction and demolition waste recycling plant available named COWAM (Construction Waste Management) which is situated in Galle, Sri Lanka, and is operated by the Galle Municipal Council. The main services provided by them are recycling of construction and demolition waste, guidance services for the management of construction and demolition waste, and arranging training sessions on construction and demolition waste management. According to the expertise, the functionality of the recycling Centre is limited to Galle area, due to high transportation costs which should be incurred by the contractors and vice versa by the Galle municipal council to transport the generated waste to the recycling center.

As confirmed by the literature previously, there are no separate laws or regulations related to construction and demolition waste management nor regular amendments in strengthening the law and acts. Management of Construction and demolition waste materials are governed under regulations applicable for ordinary waste which is coming under the national environment act of Sri Lanka. Interviewees point out the need in improving or modifying the available regulations in favor of a better management plan for construction and demolition waste.

5. DISCUSSION

5.1.1 Identification of Probable Suggestions through Expert Interviews

Implementation of waste sorting during collection and disposal is a critical activity as unsorted construction and demolition waste is a direct threat to the environment in the disposal. Therefore, the regulatory authorities need to appoint adequate personnel to monitor landfills and evaluate waste statistically during the dumping process. A statistical evaluation process will help the government in amending any regulation related to waste materials or to identify the need for alternate methods for construction waste disposal. Furthermore, through statistical data, the government can identify the areas where high amounts of waste are discarded and take necessary regulatory steps in managing the waste quantities. Further, the waste-collecting units of the municipal councils should have the right to reject waste, which is not segregated. The implication of these suggestions could be effective in reducing environmental pollution and increasing the rate of recycling and reuse of construction and demolition waste.

Illegal dumping of construction and demolition waste is environmentally unfriendly. The main suggestion proposed by the interviewees was that the amount of penalties should be increased to discourage people from doing illegal dumping. Moreover, proposing a tax system for dumping construction and demolition waste at landfills could also be

considered as a suggestion to be used, as the people who are going to dump waste will have to find more cost-effective alternatives like recycling. Implementation of these actions by the regulatory bodies can aid in reducing the quantities of illegally disposed of construction and demolition waste.

As per the expertise, improving regulations on recycling and recycled products of construction and demolition waste is a much-needed alternative to Sri Lanka. The fabrication of construction and demolition waste recycling centers across the country would be a good initiative. With proper regulations, the wastes then could be transported to the nearest facility for processing. where the contractors could be financially provided as well. As the process is involved with the government, regulatory arrangements can be made, and utilizing recycled materials for the government's construction projects will create a market for the recycled products. As the government is a main stakeholder in the construction industry, the increasing trend of recycled products will prompt private parties in purchasing recycled materials due to the quality assurance as the government is involved. With that, the involvement of private parties in the recycling industry also can be expected, which will allow diversified technologies related to recycling of construction and demolition waste to reach Sri Lanka. To get the participation of local people in this recycling process, it was suggested that the people should be encouraged by the government by regulating prices for different construction and demolition waste materials to be collected publicly. The initiative will result in massive reductions in construction waste quantities due to the involvement of both contractors and local people.

Central Environmental Authority is responsible for solid waste management in Sri Lanka and all rules and regulations which govern solid waste management are mentioned under the National Environment Act. According to the literature and the findings of interviews and questionnaires, no provisions in the National Environment Act separate construction and demolition waste. According to the perception of interviewees, the government should implement new/modified rules and regulations related to construction and demolition waste through introducing amendments in the National Environment Act. All the above-mentioned suggestions are needed to be included in the National Environment act to be validly active in Sri Lanka.

5.1.2 Identification of Probable Suggestions through Questionnaire survey

Building construction projects were identified as the highest waste generated type of projects through the questionnaire survey. Analysis suggests that the government should pay more concern to waste materials collected from building construction projects on dealing with regulatory activities regarding waste management processes. According to the findings, the respondents' insight was that more waste is generated at the working stage of a construction project. To reduce waste generation at the working stage, the concern should be given to identify the most effective causes where waste can be generated on the working stage of a construction project. After analyzing these causes, the government can provide guidelines to be followed in operating a construction project, where waste can be minimized through properly following the provided guidelines. The questionnaire identified the most abundant waste materials in Sri Lanka as concrete, tile, and brick. The government could pay attention to real quantities of waste generated due to construction activities to statistically analyze the required solutions whereby uplifting the constructions along with sustainable construction with fewer wastages. The questionnaire also revealed that about 30% of the professionals were not aware of the

Environmental Act. The awareness of these available rules and regulations is very important for industry professionals to properly carry out disposal works and to assess any situation related to construction and demolition waste. Therefore, workshops alongside professional development should be arranged to uplift the knowledge levels.

6. CONCLUSIONS

In conclusion, it can be said that the environment act governs all the regulations related to waste management including the construction and demolition of waste is not sufficient in minimization of construction waste. Building construction generates the highest percentage of waste during construction and demolition activities in Sri Lanka and identified that work implementation on site is the main cause for waste generation during a project. The study proved that Landfilling as the most used waste management system in Sri Lanka and it was found that recycling was suggested to be used in the future instead of landfilling to manage construction and demolition waste. Further, this research proved that the main issue is in current rules and regulations related to the disposal of construction and demolition waste. No actions were taken place to sort and classify the construction and demolition waste at the collection process and dumping process to landfills. Therefore, it is highly recommended to improve recycling as a management method of construction and demolition waste to reduce waste quantities and its effects along with well improved, prioritized governance acts.

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