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# An Integrative Approach for Sustainable Management of Construction and Demolition Waste in Antipolo City, Philippines

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ABSTRACT

Infrastructure projects have always been a significant opportunity for the government to foster social and economic development. However, infrastructure project results accumulate substantial waste. Defined operationally as construction and demolition waste (CDW), they account for 30% of waste sent to landfills. Focusing on the urban areas in Antipolo City as a specific case, this study provides an integrated framework for sustainable CDW management. Corroborating data results from the Delphi method, this framework comprises three approaches including the development of specific regulations on CDW management, implementing the circular economy waste management strategies in every stage of the project life cycle, and improving the current waste collection and disposal system in the city. Results also showed that 53% of construction stakeholders entrust private haulers with CDW collection and disposal. This system poses the question of who shall be responsible for managing the waste produced from the project. Recommendations are therefore provided that will serve as a foundation to establish a policy addressing the issues and concerns of CDW management.

## INTRODUCTION

The latest projection on urbanization has revealed that 68% of the world's population will be urbanized by 2050 (United Nations - Department of Economic and Social Affairs, 2018). Rapid urbanization demands increased infrastructure growth to primarily support education, health, and other social services. Heeding the call to respond immediately to the infrastructural challenges of urbanization, the Philippine government has strengthened its national infrastructure through House Bill No. 8151, entitled "An Act Adopting a 30-year National Infrastructure Program," which institutionalizes the Build, Build, Build program from 2023 to 2052. The program has been considered a mechanism to realize the golden age of Philippine infrastructure (Aguja, 2020; Ocampo, 2018; Uy, 2021). It envisions accelerating the economy's productive capacity, creating jobs, and increasing investment opportunities, leading to sustained, inclusive growth (Coracero et al., 2021).

With the increasing number of infrastructure projects, concerns about sustainability in the construction industry have brought the issue of waste management to the fore. As estimated, 553,406t of waste is being produced annually from constructing critical infrastructures, such as residential buildings (Ehtasham, 2022; Umar et al., 2018), and building renovation accounts for 1.65 to 2.3 tons (per 100m²) amount of waste (Ding et al., 2019). Worse, demolition projects often produce 20-30 times more waste material per square meter than construction projects (Lauritzen, 2018). These circumstances have increased environmental pollution and indicated that effective strategies are worthy of exploration for mitigation.

Although construction and demolition waste (CDW) is generally considered an integral part of municipal solid waste and regulated under the Philippine Ecological Solid Waste Management Act of 2000 (RA 9003), this law does not have any discussion on the topic of CDW management and construction materials is directly disposed of in landfill at the end of their life (Antipolo City's Ten Year Ecological Solid Waste Management Plan [2020-2030], 2020); Orozco & Maningas, 2014).

Notably, if the current landfilling practice continues by 2025, human health damage will increase by 20.6%, ecosystem damage by 26.6 %, and damage to resources by 18.7 % (Mah et al., 2018).

Antipolo City is one of the urban cities in the Philippines that has allocated much higher spending to infrastructure projects. Expenditure data shows a consistent increase in the city's appropriation for repairing and constructing infrastructure facilities. While it is true that sufficient infrastructure is essential for a thriving local economy and high-quality public services, Antipolo has not yet established clear guidelines on how the waste generated from said infrastructure projects would be controlled, reduced, or disposed of. There is also an absence of available data focusing on the current state of CDW management in the city despite the environmental implications of construction activities. As infrastructure development is unlikely to abate in the city, there is, therefore, a need to implement an integrative approach, backed by an effective and contextualized framework, to address the issues associated with CDW generation.

This study, guided by the circular economy principles, aims to develop an integrated framework for sustainable CDW management in every stage of the project life cycle. Circular economy (CE) has been considered an effective approach to optimizing the value of materials throughout the phases of the project life cycle and an essential element in sustainability transitions, which integrate all three dimensions of sustainable development–environment, society, and economy (Kirchherr, et al., 2017; Ruiz et al., 2020). Unfortunately, research that examined the potential of applying the CE principles to sustainably manage CDW has not been extensive. What has been accessible to date are recent studies that developed a CE model based on the 3R (reduce, reuse, recycle) principles (Ali, 2018; Esa, 2017; Nur et al., 2024; Ogunmakinde, 2019). While these studies provide effective strategies for CDW management, it mainly centered on the 3R principle as a waste management strategy, rather than analyzing the integrative approach that considers the application of CE strategies in multiple stages of the project life cycle. Given the complexity of the construction environment and operation, the processes undertaken in a much larger domain recognized the need for a systematic and broader assessment of CDW management strategies that are not limited to a specific strategy.

For such framework development, the present study utilized a four-stage Delphi method to examine the practices in CDW management and determine the effective CE waste management strategies suitable to be adopted in every stage of the project life cycle such as the pre-, construction, and post-construction phases. The data triangulated are then validated to determine the primary elements used in modeling the final framework. The results of the study should guide local authorities and construction professionals in selecting the strategies for sustainable management of waste generated from the construction and demolition of vertical infrastructure projects.

## METHODS

The study employed a mixed-method research design emphasizing the Delphi method. A quantitative approach was utilized to ascertain the collected opinions on the CE waste management strategies suitable to be adopted in every stage of the project life cycle while a qualitative approach was used to collect the relevant information central to the insights and practices of managing the waste generated from the construction and demolition of vertical infrastructure projects.

### Research Method and Instruments

Adhering to the Delphi characteristic of anonymity and controlled feedback, two rounds of pen-and-paper surveys, preceded by quantitative and qualitative data analysis, were employed to collect the primary data. Consent forms were provided to inform the participants about the scope of the study, the benefits, and the risks of participation. They were also allowed to withdraw from the study freely, and the questionnaire was designed to avoid identifying any individuals, projects, or the naming of organizations. The prospective participants were informed formally through a letter requesting permission to conduct the study.

The survey questionnaire was initially pilot-tested among seventeen practicing construction professionals in Antipolo City for its content validity and identification of multiple choices that should be considered in the final questionnaire. Content validation was conducted face-to-face and clear instructions were provided to facilitate the validation process. This process is suggested to determine the reliability and comprehensibility of the final instrument (Fernandez et al., 2020).

After analyzing the results of the pilot survey, participants were provided a survey questionnaire that included a combination of closed- and open-ended questions and consisted of four sections. The first section covers the expertise background of the participant, specifically the position and years in practice. The second section seeks to elicit information on the current practices in CDW management. The third section presents the CE waste management strategies derived from the pilot survey and rated on a nine-point scale (1 being "equally important" and 9 being "extremely important"). The final section of the questionnaire consists of a general open question that seeks to determine the other key points necessary for developing sustainable CDW management in Antipolo City.

**Research Participants**

Due to the large number of stakeholders involved in most infrastructure projects, it is essential to determine which of these stakeholders greatly influence waste generation and management. Recognizing the stakeholder's role, the primary participants were experts from private construction firms that have recently constructed and demolished vertical infrastructures in Antipolo. They were identified from the list of contractors and building permit applicants requested by government agencies involved in waste management and infrastructure development.

A total of twenty experts who hold senior positions concerned with CDW management and have an in-depth understanding of the CE waste management strategies were carefully selected to enable the gathering of data from multiple perspectives. The majority of experts were civil engineers (65%) and bachelor's degree holders (73%). In terms of experience in CDW management, as much as 59% of the participants have working experience of more than 10 years, and 24% possess working experience of 5 to 10 years. This profile information reflects the experts' capabilities in providing the appropriate data needed to accomplish the study's objectives.

**Data Gathering Procedures**

Driven by the goal of developing an integrated framework for sustainable CDW management, a research process consisting of four stages was undertaken. The research began with the collection of primary data utilizing the Delphi method to address the problems covered in the study. Starting with the pilot testing of the questionnaire, and then conducting the actual survey, this method ends with the analysis of the data gathered. The considered pilot survey questions were identified through a review of existing literature and all relevant documents, such as academic and government reports. The raw data from the primary data collection was then validated and further analyzed. The process includes checking the accuracy and quality of the data before importing it into the final framework. This way, errors were corrected, and the reliability of the results was attained.

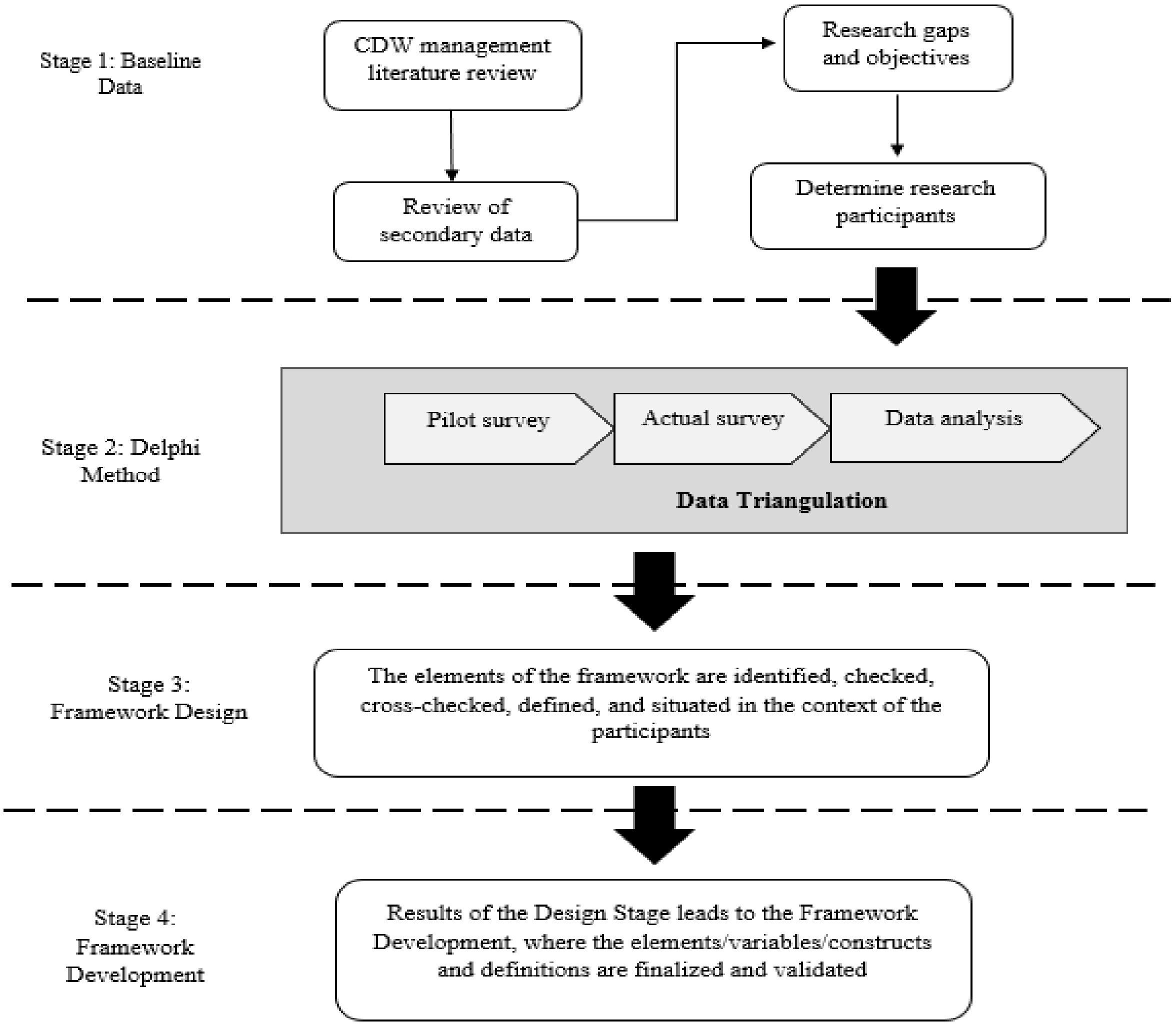


Figure 1. Study Methodology

**Data Analysis**

A thematic analysis approach was used to identify and report themes of the practices in CDW management, while the analysis of the effective CE waste management strategies was carried out using the pairwise comparison method of the Analytical Hierarchy Process (AHP). As a general form of the AHP structure, a hierarchy with four levels was developed, which included: (1) evaluation of CE waste management strategies was set as the main goal (level 1); (2) in the second level, the applicable strategies in every project life cycle stage were defined; (3) given the appropriate criteria set, the CE strategies will be selected based on participants' judgment (level 3) and;(4) the alternatives were ranked based on the nine-point ratio scale. The AHP hierarchy of the main goal, sub-objectives, criteria, and alternatives is presented in Figure 2.

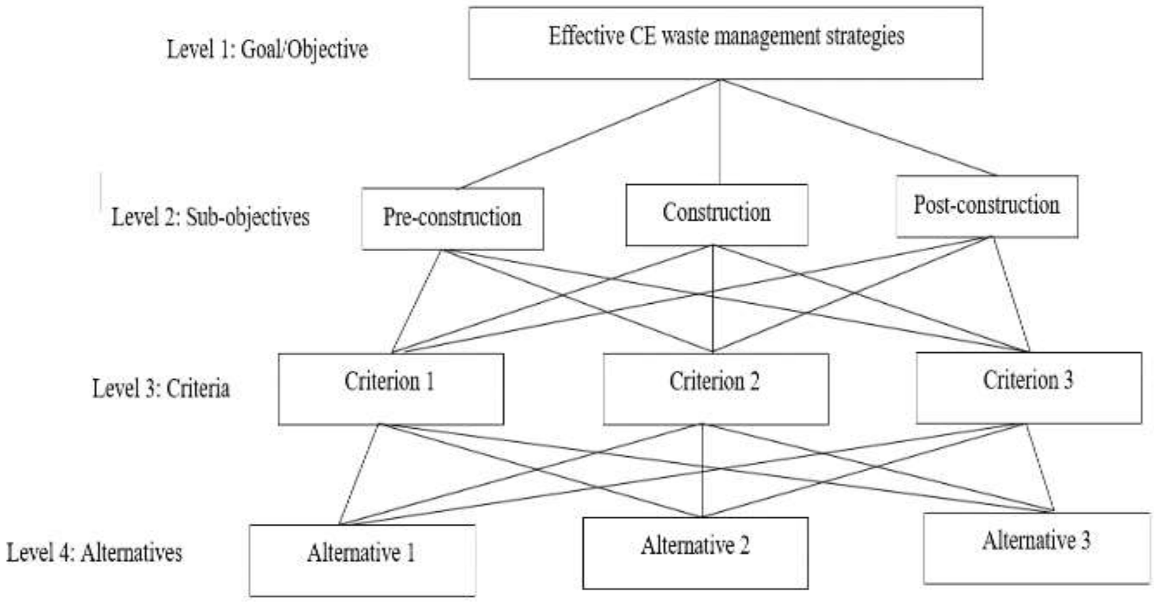


Figure 2. AHP hierarchy structure

A pairwise comparison matrix was constructed to obtain the relative importance of one strategy to another. Initially, the participants' responses were tabulated into a cross table of criteria and alternatives, using the following rules: (1) actual value will be put if the judgment value is on the left side of 1 and; (2) if the judgment value is on the right side of 1, inputs should be the reciprocal value. Each entry was then divided with the sum of the column's cell values to yield its normalized score. These normalized weights were multiplied by the weights of the criteria to get the local weight value concerning each criterion. The local weights were then multiplied by the weights of the criteria to obtain the global ratings for the ranking of all alternatives. If the alternative yielded the same value, the one with a higher local weight value was considered more effective.

For the analysis of the matrix consistency, the participants' preference was computed in the form of a consistency index (CI) utilizing the equation:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

where $\lambda_{max}$ is the eigenvalue scalar that could be calculated from the matrix and n is the number of matrixes. From CI, a consistency ratio (CR) was derived using a randomized index (RI). The CR is a result of the division of CI by RI as given in the equation: *CR=CI/RI*. The RI value was referred to the random consistency index table proposed by Saaty in the AHP method, as shown in Table 1.

Table 1. Random Consistency Index

| Matrix index ($n$) | RI value | Matrix index ($n$) | RI value |
|---|---|---|---|
| 1 | 0 | 6 | 1.24 |
| 2 | 0 | 7 | 1.32 |
| 3 | 0.58 | 8 | 1.41 |
| 4 | 0.9 | 9 | 1.45 |
| 5 | 1.12 | 10 | 1.49 |

The lambdamax value ($\lambda_{max}$) solved the characteristics equation of the input comparison matrix. Ideally, it should equal the number of criteria in the comparison (n=3) for total consistency. The CI measures the degree of logical consistency among pair-wise comparisons, while the CR indicates the amount of allowed inconsistency (0.10 or 10%).

## RESULTS AND DISCUSSION

### Methods in CDW Management

The results indicated that it is customary to delegate the duty of CDW collection and disposal to private haulers. More than half (53%) of participants mentioned hiring private haulers to remove the waste from project sites. This method reflects how nonchalant are the participants about the endpoint of the waste generated from their project. The transfer of responsibility from construction firms to private haulers has been correlated with the absence of specific guidelines on proper CDW management. A large number of participants (83%) believed that there is an absence of ordinance or governmental regulations that will determine their role and responsibility in managing the waste produced from the project. Notwithstanding that CDW is governed under RA 9003, this policy could not appropriately guide local authorities and construction companies to manage CDW adequately.

Figure 3. Waste materials on the Roadside in Antipolo City

Figure 3 shows the prevalence of roadside CDW dumping in Antipolo. Two of ten (25%) of the participants confirmed this observation, mentioning that they dump their waste in a designated area for onward collection by the city's garbage trucks. These collected wastes are then transported to material recovery facilities (MRF), which are mostly not consistent in reportorial compliances, such as the provision of adequate containment for the efficient and safe processing of various types of waste (Figure 4).

Figure 4. Picture of Functional MRF

**CE Waste Management Strategies Applicable in Every Stage of the Project Life Cycle**

Based on the literature reviewed and results obtained from the pilot survey, three criteria were determined to be included in the AHP hierarchy, such as Material Circularity (MC), Social Inclusion (SI), and Economic Viability (EV). Material circularity describes the processes and strategies that help preserve natural resources and reduce adverse environmental effects. Social inclusion refers to a participatory approach that improves the workers' conditions, increases employment equity, and integrates all stakeholders in the CDW management system. These stakeholders included government authorities, the general public, and private construction firms that play a significant role in ensuring proper waste management throughout the project life cycle. Meanwhile, economically viable strategies provide financial benefits to construction companies that should be substantial enough to cover the cost of investment.

Criteria were further broken down into their alternatives. Twenty-seven alternatives were considered and rated by the participants to compare the prioritization of the alternatives in each criterion. After identifying the criteria and alternatives, the AHP hierarchy was constructed, as shown in Figure 5.

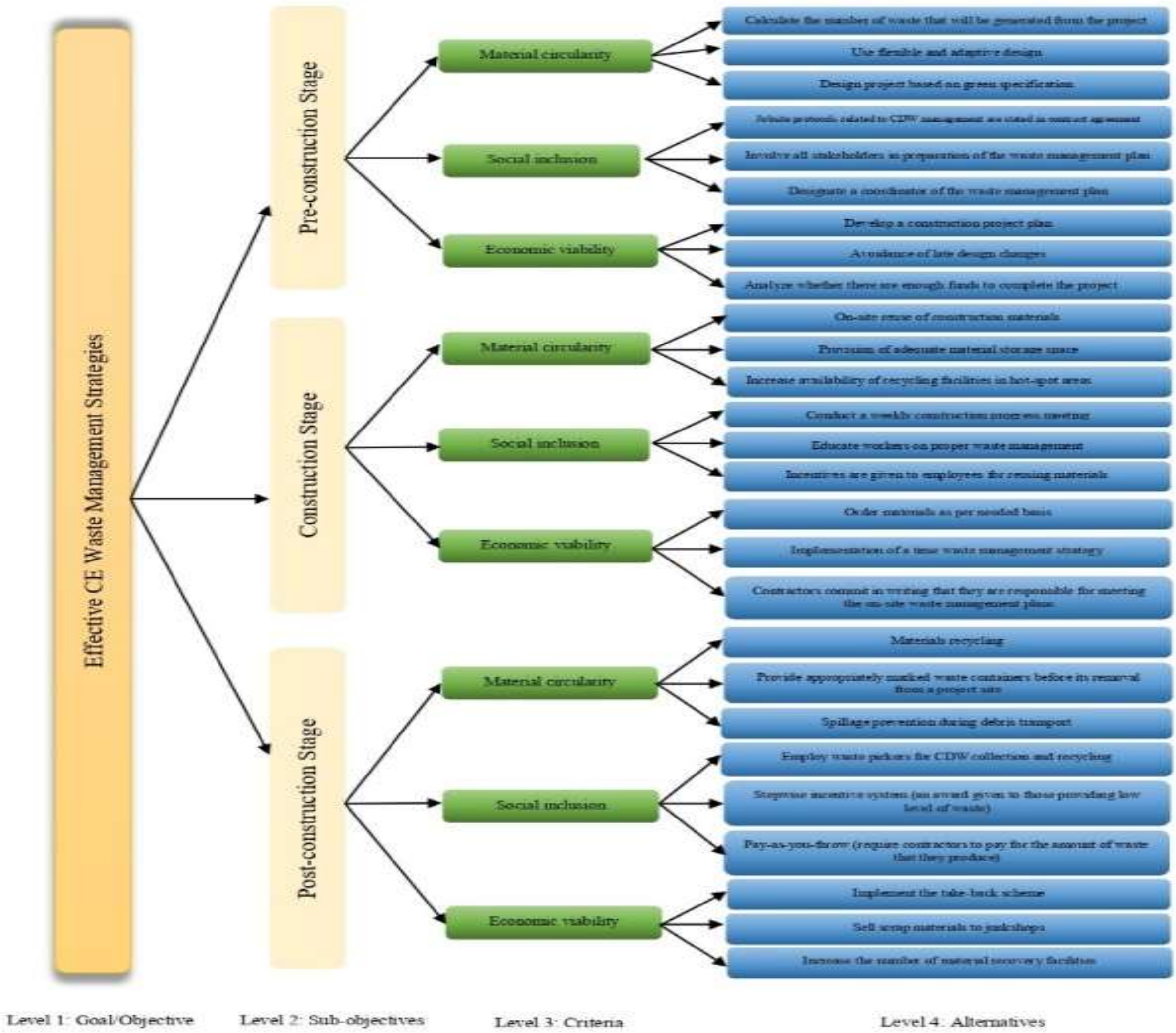


Figure 5. AHP hierarchy of objective, sub-objectives, criteria, and alternatives

**Ranking Analysis**

With a global weight value of 0.4871, the development of a construction project plan is considered an effective strategy to sustainably manage waste in the pre-construction stage. Developing a construction project plan directly influences the practical application of time management strategy throughout the construction phase. It consists of precisely written documentation that describes the project timeline, costs incurred in the performance of construction activities, and the resources needed to ensure that a construction project runs smoothly and meets all its deadlines, budget constraints, and quality standards (Gupta, 2022). Other strategies in key positions involved analyzing whether there are enough funds to complete the project and avoiding late design changes. This supports the findings from previous studies that associate poor design practices and CDW generation at the early stages of the project (Galvez et al., 2018). To reduce the changes, milestone meetings with all stakeholders should be organized to keep them informed and aligned with strategic decisions and formal approval (Wang et al., 2022).

At the construction stage, implementing a time waste management strategy is ranked the most effective CE waste management strategy. This finding suggests that the timely completion of the project and following the period specified in the contract is a particular area of concern in the construction sector. Results also show that participants prioritize the provision of adequate material storage space and material reuse. Site storage involves the provision of adequate space and protection for materials to be kept on-site during the construction process. It is noticeable however that there is an absence of adequate storage in most project sites in Antipolo. Materials are often stacked improperly and mixed with other items at the site. The limited space in construction sites is one of the principal reasons for such poor material storage.

Finally, in the final disposal stage, strategies such as spillage prevention, increasing the number of materials recovery facilities, and adoption of the take-back scheme shall be considered to control CDW disposal. This scheme requires the manufacturers to take back the waste materials from construction companies, which contributes to pollution reduction and decline in the extraction of natural resources (Shooshtarian et al., 2021).

Despite its definite benefits, the participants show low regard for recycling. Although materials recycling would decrease the environmental impact of the construction industry by up to 65% (Papadaki et al., 2022), legislation governing the design and construction of infrastructure projects enforces restrictive and complex regulations that limit the possibilities for its application. Preference to construction materials is likewise bound to industry standard-setting organizations (e.g., the Philippine Standard Council) which mandate the standards that more often do not favor the recycling of construction materials, due to issues associated with the infrastructure's structural capacity. Hence, eliminating the legal gaps for the recycling and reuse of CDW shall be considered. This approach, however, necessitates comprehensive scientific research on the viability of recycled and reusable construction materials as primary structural components. It is necessary to conduct a strength and durability analysis to determine the suitability of such materials, given that construction is one of the most heavily regulated industries.

**Framework for Sustainable CDW Management**

Figure 6 depicts the integrated CDW management framework and its elements to achieve sustainable CDW management in Antipolo City. As a result of the previous stages, the framework focuses primarily on the economic and environmental CE waste management strategies. This result suggests that society may not be a critical contributor to developing an integrated and sustainable waste management system. However, it serves as an encouraging result for construction companies to increase profitability and outweigh the costs of CDW management.

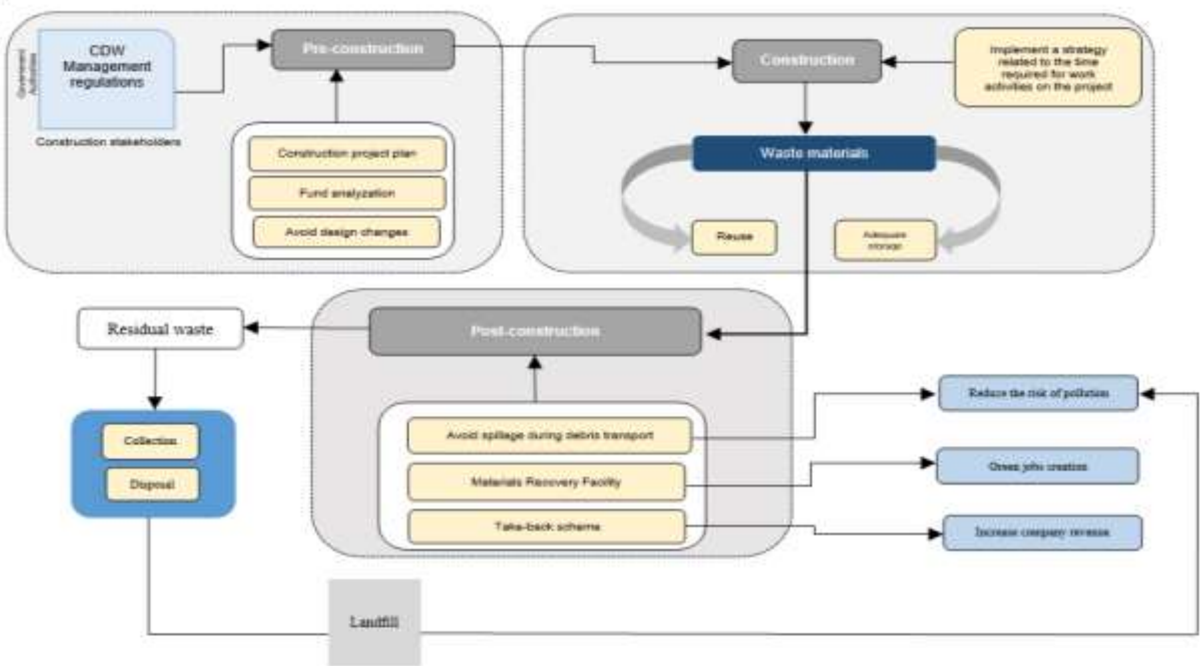


Figure 6. Sustainable CDW Management Framework

As a result of the data triangulation, three key components were identified and integrated into the proposed framework. First is the formulation of specific regulations for CDW management. As for any environmental regulations, an advisory committee shall consist of public officials and representatives from the construction sector who can provide valuable input on waste management issues. This committee shall advise the possible measures and processes for sustainable CDW management. Ensuring effective implementation of such regulation demands the discussion of the following aspects: (1) roles and responsibilities of key players, such as the government and construction firms, (2) procedures on the application of pre-construction waste management strategies, (3) guidelines on on-site waste storage and handling, and (4) standardization of CDW destinations and transportation system. It is also necessary that these rules and regulations are stipulated in contract agreements to legally bind the waste management system throughout the different phases of construction.

The second key element emphasizes the application of the CE waste management strategies in every stage of the project life cycle. As a result of its effective implementation, useful outputs are identified: (a) pollution reduction, (b) green jobs creation, (c) increased revenue, and (d) lowering the negative impacts of construction and demolition activities on the environment. These outputs are expected to develop a sustainable CDW management system since it covers the aspects of sustainability such as the environment, society, and economy. With the integration of CE principles in the CDW management system, it is attainable to develop new revenue streams and create employment opportunities that contribute to preserving and restoring the environment.

Another key element integrated into the proposed framework is improving the current system of CDW collection and disposal. As there is a deliberate littering of waste in Antipolo, an effective collection and disposal system shall be fostered using increasing the number of waste collection vehicles and a comprehensive review of ready-planned collection routes. Optimizing waste collection routes has been recommended to reduce the environmental impacts of CDW generation (Akinradewo et al., 2019; Zhang et al., 2022). For collected CDW that cannot be reused or recycled, landfill disposal occurs. Generally sorted, residual waste from construction and demolition activities has to be cleaned and deposited in a landfill following the related disposal policy so as not to cause unreasonable risk to health and the environment.

Realizing the need to improve the quality of the construction industry's waste management practices, the developed framework is expected to provide more sustainable ways of CDW management. However, it may have less applicability to other cities considering the study is geographically limited in Antipolo. Moreover, the study centers on analyzing the approaches to managing waste generated from vertical infrastructure projects and does not delve into post-disaster CDW management. Future studies should therefore focus on exploring sustainable strategies for managing all forms of CDW. A larger sample from multiple areas may ensure the effectiveness of these strategies and their efficient use.

## CONCLUSIONS

For developing a sustainable CDW management in Antipolo, this study proposed an integrated framework with three key elements: (1) formulation of specific regulations for CDW management, (2) implementation of the CE waste management strategies, and (3) enhancement of the methods of waste collection and disposal. These elements were ascertained from the data triangulation and could help the city improve its current CDW waste management system which was observed to be poorly organized. As the results of the study have shown, Antipolo has not yet developed an intervention focused on managing the waste produced from vertical infrastructure projects. There is also an unclear distribution of responsibilities among construction stakeholders, which poses the question of who shall held accountable for CDW collection and disposal. As such, the developed framework could be adopted by policymakers and construction firms as it provides a precise and unified method of addressing the issues associated with CDW management.

## REFERENCES

Aguja, A. (2020). *PH golden age of infrastructure and growth*. https://wheels.ph/news

Ali, A. (2018). *Development of a framework for sustainable construction waste management. A case study of three major Libyan cities* (Unpublished master's thesis). University of Wolverhampton.

City Environment and Waste Management Office, *Antipolo City's Ten Year Ecological Solid Waste Management Plan (2020-2030)*. 2020.

Coracero, E. E., Gallego, R. J., Frago, K. J. M., & Gonzales, R. J. R. (2021). A Long-Standing

Problem: A Review on the Solid Waste Management in the Philippines. *Indonesian Journal of Social and Environmental Issues* (*IJSEI*), 2(3), 213-220.

Ding, Z., Shi, M., Wu, Z., Chong, D., & Gong, W. (2019). Predicting Renovation Waste Generation Based on Grey System Theory: A Case Study of Shenzhen. *Sustainability*, 11 (16), 4326.

Ehtasham, L. . (2022). An Overview of Municipal Solid Waste Collection in Singapore, Mongolia, and Nepal. *Indonesian Journal of Social and Environmental Issues* (*IJSEI*), 3(2), 122-127.

Esa, M.R. (2017). *Moving towards sustainable construction in Malaysia: a holistic model for construction and demolition (C&D) waste management* (Doctoral dissertation, School of Earth and Environmental Sciences, The University of Queensland).

Fernández-Gómez, E., Martín-Salvador, A., Luque-Vara, T., Sánchez-Ojeda, M. A., Navarro-Prado, S., & Enrique-Mirón, C. (2020). Content validation through expert judgement of an instrument on the nutritional knowledge, beliefs, and habits of pregnant women. *Nutrients*, 12(4), 1136.

Gálvez-Martos, J., Styles, D., Schoenberger, H., & Zeschmar-Lahl, B. (2018). Construction and demolition waste best management practice in Europe. *Resources, Conservation and Recycling*,136, 166-178.

Gupta, S. (2022, September 27). What Is Construction Planning? 5 Steps to the Perfect Process.https://www.softwareadvice.com/.

Kirchherr, J., Reike, D., &Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation & Recycling*, (127), 221–232.

Lauritzen, K. E. (2018). *Construction, demolition and Disaster Waste Management*. Boca Raton: CRC Press.

Mah, C.M., Fujiwara, T., & Ho, C.S. (2018). Environmental Impacts of Construction and Demolition Waste Management Alternatives. *Chemical Engineering Transactions*, 63, 343-348.

Nur, M. S., Husen, A., & Purwandari, D. A. (2024). Waste Management Based On Waste To Energy Technology In Palopo City. *Indonesian Journal of Social and Environmental Issues* (*IJSEI*), 5(1), 50-62.

Ocampo, K. (2018). *To Realize Duterte's 'Golden Age of Infrastructure' in Philippines, Better Roads a Must*. https://asiafoundation.org

Ogunmakinde, O. E. (2019). *Developing a Circular-Economy-Based Construction Waste Minimisation Framework for Nigeria* (Doctoral Dissertation). University of Newcastle.

Orozco, C. R., &Maningas, S. D. C. (2014). Industry perception on the benefits of construction waste management strategies in the Philippines. *Philippine Engineering Journal*, 35(2), 19–28.

Papadaki, D., Nikolaou, D.A. & Assimakopoulos, M.N. (2022)'Circular environmental impact of recycled building materials and residential renewable energy', *Sustainability*, 14(7),

Ruiz, L. A., Roca Ramón, X., & Gassó Domingo, S. (2020). The circular economy in the construction and Demolition Waste Sector – a review and an integrative model approach. *Journal of Cleaner Production,* 248,119238.

Shooshtarian, S.; Maqsood, T.; Wong, P.S.P.; Khalfan, M., & Yang, R.J. Extended Producer Responsibility in the Australian Construction Industry (2021). *Sustainability*, 13, 620.

Umar, U., Shafiq, N., & Isa, M. (2018). Investigation of construction wastes generated in the Malaysian residential sector. Waste Management Research*: The Journal For A Sustainable Circular Economy*, 36 (12), 1157-1165.

United Nations - Department of Economic and Social Affairs (2018). *World Urbanization Prospects: The 2018 Revision*. https://population.un.org

Uy, A. (2021). *Duterte's Legacy:Golden Age of Infrastructure.*https://theaseanpost.com.

Wang, R., Samarasinghe, D. A., Skelton, L., & Rotimi, J. O. (2022). A study of Design Change Management for infrastructure development projects in New Zealand. *Buildings*, 12(9), 1486.