

A PLATFORM PROPOSAL FOR THE EVALUATION OF CONSTRUCTION AND DEMOLITION WASTES WITHIN THE CONCEPT OF ZERO WASTE IN İSTANBUL

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Abstract

This research investigates the economic benefits of zero-waste strategies in İstanbul's construction and demolition (C&D) waste sector. Current waste management practices, challenges, and stakeholder perspectives are analyzed to identify improvement opportunities. A case study demonstrates the potential of zero-waste principles in the C&D sector, emphasizing financial savings. This research introduces the Zero Waste Construction Material Exchange (ZWCME) platform, a digital solution connecting waste generators with potential users and recyclers, promoting reuse, recycling, and upcycling of C&D waste materials. The research explores industry implications, identifies enablers and barriers to zero-waste adoption, and examines the policy and regulatory framework needed to support the ZWCME platform. Results highlight significant potential for economic benefits through zero-waste strategies in İstanbul's C&D waste sector, emphasizing stakeholder collaboration, supportive policies, and innovative solutions like the ZWCME platform.

Keywords: Zero-waste strategies, Construction and Demolition (C&D) waste management, Stakeholder perspectives, Economic benefits, Zero Waste Construction Material Exchange (ZWCME) platform.

İSTANBUL DA SIFIR ATIK KAPSAMINDA İNŞAAT VE YIKITINTI ATIKLARININ DEĞERLENDİRİLMESİ İÇİN ÖRNEK BİR PLATFORM ÖNERİSİ.

Özet

Bu araştırma, İstanbul'un inşaat ve yıkım (İ&Y) atık sektöründeki sıfır atık stratejilerinin ekonomik faydalarını incelemektedir. Mevcut atık yönetimi uygulamaları, zorluklar ve paydaş perspektifleri, iyileştirme fırsatlarını belirlemek amacıyla analiz edilmektedir. İki uluslararası vaka çalışması, İ&Y sektöründe sıfır atık ilke ve yöntemlerinin potansiyelini, finansal tasarruf, istihdam yaratma ve çevre koruma açısından vurgulamaktadır. Çalışma, İstanbul için Sıfır Atık İnşaat Malzemesi Değişim (ZWCME) platformunu tanıtmaktadır; bu platform, atık üreticilerini potansiyel kullanıcılar ve geri dönüşümcülerle bağlantılandırarak, İ&Y atık malzemelerinin yeniden kullanımını, geri dönüşümünü ve geri kazanımını teşvik eden dijital bir çözümdür. Araştırma, endüstriye yönelik çıkarımları incelemekte, sıfır atık uygulamalarının benimsenmesine yönelik destekleyici ve engelleyici faktörleri belirlemekte ve ZWCME platformunu desteklemek için gerekli politika ve düzenleyici çerçevenin incelenmesini sağlamaktadır. Sonuçlar, İstanbul'un İ&Y atık sektöründe sıfır atık stratejileriyle önemli ekonomik faydalar elde etme potansiyelini vurgulamakta, paydaş işbirliği, destekleyici politikalar ve ZWCME platformu gibi yenilikçi çözümlerin önemine işaret etmektedir.

Anahtar Kelimeler: Sıfır atık stratejileri, İnşaat ve Yıkım (C&D) atık yönetimi, Paydaş perspektifleri, Ekonomik faydalar, Sıfır Atık İnşaat Malzeme Borsası (ZWCME) platformu.

1. Introduction

The construction and demolition (C&D) industry is a crucial contributor to Türkiye's economy, particularly due to the nation's significant investments in housing and infrastructure. With a growing population, there is an increasing need for safe and sustainable housing, particularly in areas at high risk of earthquakes (Demir et al. 2016). However,

such construction activities generate significant waste, leading to concerns regarding effective waste management practices (BULUT and ŞENGÜL 2023). Moreover, limited landfill space and environmental impacts make sustainable waste management a critical concern in Türkiye, particularly in cities like Istanbul. As a potential solution, the concept of zero waste emphasizes waste reduction, resource efficiency, and minimizing environmental impact (Sönmez and Kalfa 2023). However, there is a lack of comprehensive research on the economic benefits and practical implementation of zero-waste strategies in the C&D sector in Istanbul. Therefore, this study aims to address this gap by exploring the current state of C&D waste management practices in Istanbul, investigating stakeholders' perspectives, estimating potential economic benefits of zero waste techniques, and proposing a Zero Waste Construction Material Exchange (ZWCME) platform to facilitate sustainable waste management practices in the C&D sector. The research aims to provide valuable insights into the potential of zero waste principles to address Istanbul's C&D waste management challenges and promote sustainable waste management practices in the city.

2. Literature Review.

2.1. Construction and Demolition Waste Management.

Construction and demolition (C&D) waste refers to the debris generated during the construction, renovation, and demolition of buildings and infrastructure (Lundie, Peters, and Beavis 2004). With rapid urbanization and population growth, the generation of C&D waste has significantly increased, posing numerous environmental, social, and economic challenges (Silva, De Brito, and Dhir 2014). The traditional approach to C&D waste management has been landfilling, but with limited landfill space and the increasing emphasis on sustainable development, alternative waste management strategies are being explored (Yuan and Shen 2011). Several studies have investigated various aspects of C&D waste management, including waste generation factors, recycling and recovery techniques, and disposal methods (Gálvez-Martos et al. 2018; Yuan and Shen 2011).

2.2. Zero Waste Concept and its Application in C&D Industry.

The zero-waste concept aims to minimize waste generation, maximize resource efficiency, and reduce the environmental impact of waste disposal (Zaman 2016). In the C&D industry, zero waste principles focus on waste prevention, reduction, reuse, recycling, and upcycling (Kibert 2016). Several studies have highlighted the potential benefits of adopting zero waste strategies in the C&D sector, such as reduced waste generation, cost savings, job creation, and lower environmental impacts (Osmani, Glass, and Price 2008; Tam and Tam 2006). The diagrammatic representation of the zero-waste approach for construction and demolition (C&D) waste management is represented in Figure 1.



Figure 1 - Zero-Waste Approach For Construction And Demolition

2.3. Economic Benefits of Zero Waste Strategies.

Research has shown that the adoption of zero-waste strategies can lead to significant economic benefits in the C&D sector. These benefits include cost savings from reduced waste disposal, revenue generation from recycled materials, job creation, and reduced reliance on virgin materials (Kibert 2016). Furthermore, the implementation of zero-waste strategies can contribute to the circular economy, promoting resource efficiency and long-term sustainability (Ghisellini, Cialani, and Ulgiati 2016).

2.4. Stakeholder Perspectives and Factors Influencing Zero Waste Adoption Understanding.

stakeholder perspectives are crucial for the successful implementation of zero-waste strategies in the C&D sector. Studies have explored the views of various stakeholders, such as contractors, architects, engineers, and policymakers, on the adoption of zero-waste principles (Kajikawa et al. 2016; Lu and Yuan 2011). Factors influencing the adoption of zero-waste strategies include knowledge and awareness, financial incentives, regulatory support, market demand, and technological innovation (Akinade et al. 2017; Lu et al. 2011).

2.5. Policy and Regulatory Framework for Zero Waste Implementation.

Zero-waste policies and regulations are needed for C&D waste management. Studies recommend integrated building sector waste reduction, resource efficiency, and sustainable waste management regulations. Rules and regulations create waste reduction targets, sort and classify waste, and promote recycled and upcycled products. The regulatory framework must include inspections and penalties. Policymakers, waste management companies, and others must support C&D zero-waste strategies. Policy and regulation can promote zero-waste practices for economic, environmental, and social benefits (Gálvez-Martos et al. 2018; Yuan and Shen 2011).

2.6. Evaluation of Demolition Wastes Management According to the National Regulation in Türkiye.

The National Regulation of Demolition Wastes in Türkiye (Hafriyat Toprağı, İnşaat Ve Yıkıntı Atıklarının Kontrolü Yönetmeliği), which aims to manage demolition wastes through waste reduction, collection, temporary storage, transportation, recycling, evaluation, and environmentally friendly disposal. The regulation imposes obligations on waste generators, requires waste management plans, and enforces penalties for non-compliance (Anon n.d.-a). Although the regulation provides a comprehensive framework, incorporating zero waste principles and international best practices, such as promoting circular economy and sustainable materials, could enhance its effectiveness. Further research is needed to quantify the regulation's impact on the demolition waste management sector, and recommendations for improvement include strengthening waste reduction strategies, enhancing public awareness campaigns, and encouraging stakeholder collaboration.

2.7. Best Practices and Lessons Learned from Successful Zero Waste Initiatives.

Due to environmental and public health concerns, C&D waste management is a global issue. The zero-waste method has decreased environmental consequences and saved businesses and communities money in several nations. Researchers have learned how to apply zero-waste solutions in various contexts, including Istanbul's C&D sector, from these successful experiences. Zero-waste C&D waste management in the US and Europe saves money. Advanced trash separation technology has helped San Francisco recycle up to 80%, saving the city and building businesses money (United States Environmental Protection Agency, n.d.). The EPA estimates that recycling C&D trash saves \$5–\$30 per ton compared to landfilling (United States Environmental Protection Agency, n.d.).

3. Research methodology.

The research approach utilized in this investigation aims to provide a comprehensive understanding of the economic benefits of zero waste techniques in demolition waste and the implementation of the Zero Waste Construction Material Exchange (ZWCME) platform in Istanbul. The methodology consists of the following steps:

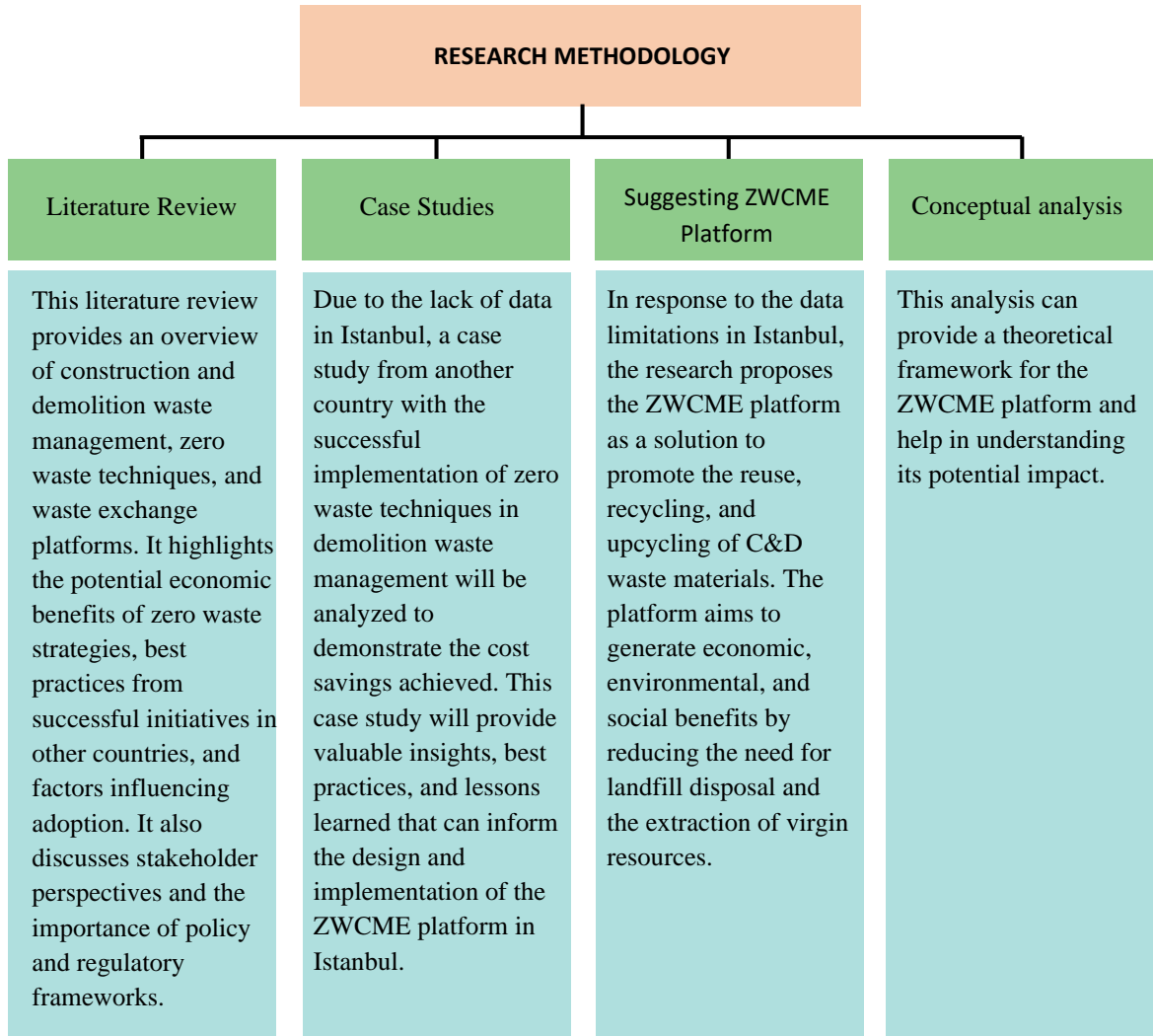


Figure2: Implementation Steps for ZWCME Platform

3.1. Case Study

This case study evaluates the economic implications of seven waste minimization strategies for a construction project, comparing their performance in terms of cost savings, environmental benefits, and overall project economics (Tran 2017). The strategies range from landfilling (Strategy 1) to a comprehensive zero-waste approach (Strategy 7), with waste reduction rates varying from 0% to 100%. The study aims to provide insights into the effectiveness of each waste minimization strategy in the context of a construction project. Table 1 represents the waste reduction rates for each strategy (Tran 2017).

This case study explores the economic aspects of minimizing brick waste in an office renovation project located in Auckland Central. The project used a genuine dataset with altered values to maintain confidentiality. It involved the renovation of a light commercial building with a land area of 691 m2 and a building footprint of 622 m2. The project involved managing the demolition and construction work in-house and using recycled bricks salvaged from a

demolition job, resulting in cost savings and improved waste minimization credentials. A total of 11.74 tons of brick waste was generated during the process. Cost savings and benefit-cost ratios were calculated for different levels of waste reduction, with the zero-waste approach having the highest values, indicating that managing C&D waste with a zero-waste approach is economically beneficial. The findings are supported by Table 2 showing the cost savings and benefit-cost ratios at different levels of waste reduction, and Chart 1 shows the displayed outcomes (Tran 2017).

Table 1 -Waste reduction strategies and associated reduction rates.

Strategy	Description	Waste Reduction Rate
1	Landfill Disposal	0% reduction
2	Minimal Reduction	5%-10% reduction
3	Low Reduction	11%-30% reduction
4	Moderate Reduction	31%-50% reduction
5	High Reduction	51%-70% reduction
6	Intense Reduction	71%-95% reduction
7	Zero Waste	100% reduction

Table 2 -Cost Savings And Benefit-To-Cost Ratios For Different Waste Reduction Levels.

Waste Reduction Level	Total Cost of Waste	Cost Savings (\$)	Benefit-to-Cost Ratio (%)
LEVEL 1	\$11,842	\$7,000	60%
LEVEL 2	\$12,148	\$7,281.94	61%
LEVEL 3	\$12,211	\$7,620.28	63%
LEVEL 4	\$11,746	\$8,748.06	76%
LEVEL 5	\$11,314	\$9,875.83	89%
LEVEL 6	\$11,725	\$11,003.61	95%
LEVEL 7 (Zero Waste)	\$13,057	\$12,638.89	97%

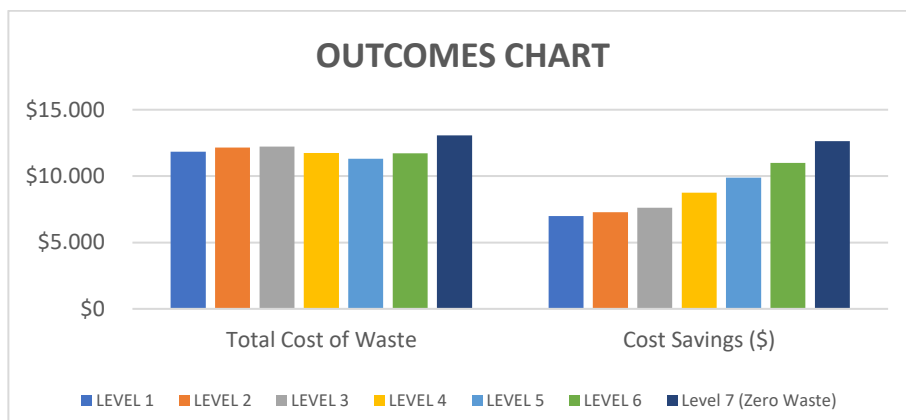


Figure 3 . Displaying Outcomes Char

That table illustrates the increasing cost savings and benefit-cost ratios as the level of waste reduction increases, with the zero-waste approach (Level 7) having the highest values in both categories. This provides support for the conclusion drawn from the case study, which is that a zero-waste approach in the management of C&D waste is beneficial economically for the construction industry. Table 3 shows the cost savings breakdown at each level. While, chart 2 shows benefits and costs (Tran 2017).

Table 3. Cost Savings Breakdown At Each Level.

Reduction Level	Intangible Benefits (\$)	Savings from Reuse (\$)	Savings from Recycling (\$)	Savings from Non-Disposal (\$)	Revenue from Sold Recycled Materials (\$)	Total Savings (\$)
Level 1	7	-	-	-	-	7
Level 2	7	126.29	126.29	88.11	29.37	7,281.94
Level 3	7	277.83	277.83	193.84	64.61	7,620.28
Level 4	7	782.98	782.98	546.27	182.09	8,748.06
Level 5	7	1,288.13	1,288.13	898.70	299.57	9,875.83
Level 6	7	1,793.29	1,793.29	1,251.13	417.04	11,003.61
Level 7 (Zero Waste)	7	2,525.75	2,525.75	1,762.15	587.38	12,638.89

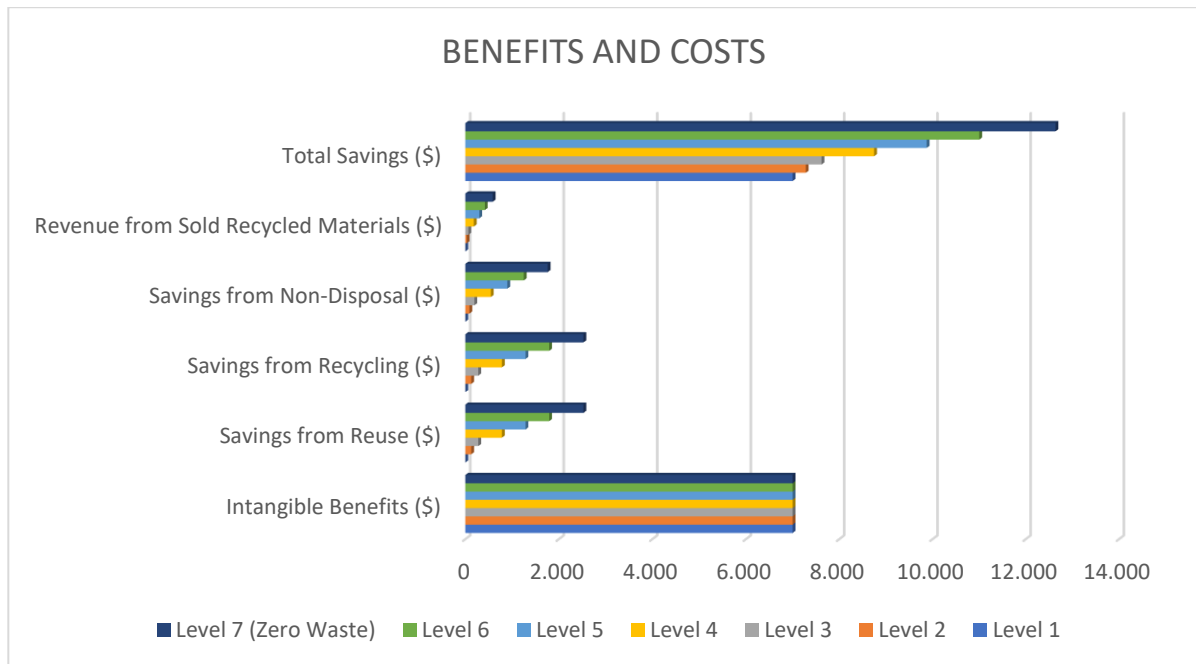


Figure 4. Benefits And Costs - Case Study.

3.2. ZWCME Platform Proposal:

This research Proposed the ZWCME platform as a solution for Istanbul to promote the reuse, recycling, and upcycling of C&D waste materials, generating economic, environmental, and social benefits.

3.2.1. Description of the Zero Waste Construction Material Exchange (ZWCME) platform and how it can address the data limitations.

Istanbul's lack of data and case studies can be remedied by studying successful garbage exchange platforms and projects in other countries. These examples can offer insights and best practices that can be used locally. Waste exchange platforms connect C&D waste generators with potential customers and recyclers. The Zero Waste Construction Material Exchange (ZWCME) is a digital platform that promotes the reuse, recycling, and upcycling of C&D waste in Istanbul. Economic, environmental, and social benefits would result from this platform's reduction of landfill disposal and virgin resource extraction. This will create a data-driven C&D waste management ecosystem in Istanbul, addressing the data gap. The ZWCME platform can improve waste tracking and reporting, data sharing, and stakeholder collaboration in Istanbul's C&D waste management. It can centralize C&D waste data tracking and reporting, improving resource usage and waste reduction. Figure 2, is a description of the Zero Waste Construction Material Exchange (ZWCME) platform and how it can address the data limitations.

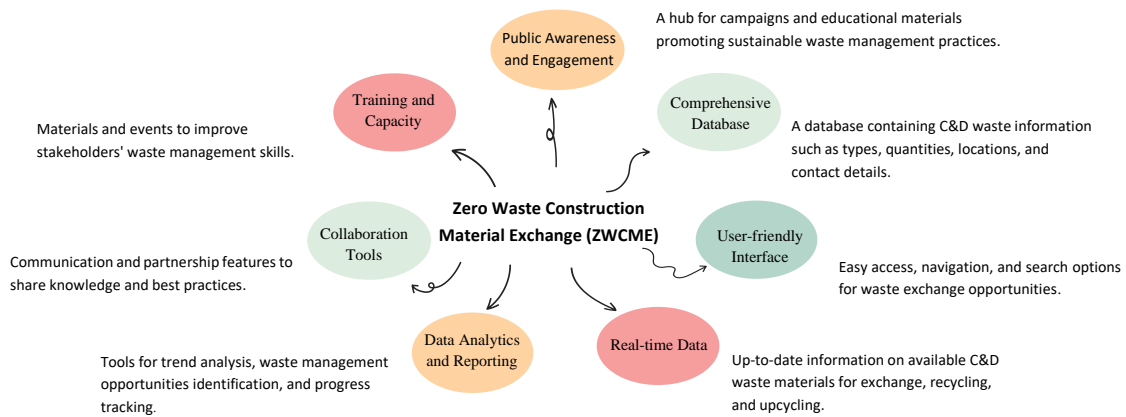


Figure 5 - Description Of The Zero Waste Construction Material Exchange (Zwcme) Platform And How It Can Address The Data Limitations.

3.2.2. Case studies and best practices from around the world that demonstrate the successful implementation of waste exchange platforms and initiatives

3.2.2.1. The Netherlands - Materialenbank (Materials Bank).

The Materialenbank is a Dutch online platform that connects suppliers and buyers of surplus construction materials. The platform aims to promote the circular economy within the construction industry by facilitating the reuse and recycling of building materials, thereby reducing waste and the demand for virgin resources. The Materialenbank has already facilitated the exchange of more than 10,000 tons of building materials, resulting in substantial cost savings and environmental benefits for its users (Anon n.d.-b)

3.2.2.2. United States – The ReUse People of America (TRP)

TRP is a non-profit organization that operates in various cities across the United States, promoting the reuse and recycling of building materials through its network of retail warehouses and online marketplace. TRP's services include deconstruction, material salvage, sales of reclaimed materials, and training and certification programs for deconstruction professionals. Since its inception, TRP has salvaged over 500,000 tons of building materials, preventing them from going to landfills and promoting a more sustainable construction industry (Anon n.d.-c). These case studies and best practices can serve as valuable examples and sources of inspiration for the design and implementation of the Zero Waste Construction Material Exchange (ZWCME) platform in Istanbul.

3.2.3. ZWCME Platform Features and Tools Diagram

ZWCME Platform Features and Tools Diagram shows the platform's main features and tools. Figure 3 illustrates the platform's functioning to help stakeholders understand it. The ZWCME platform's stakeholders, users, and beneficiaries can use this diagram as a reference

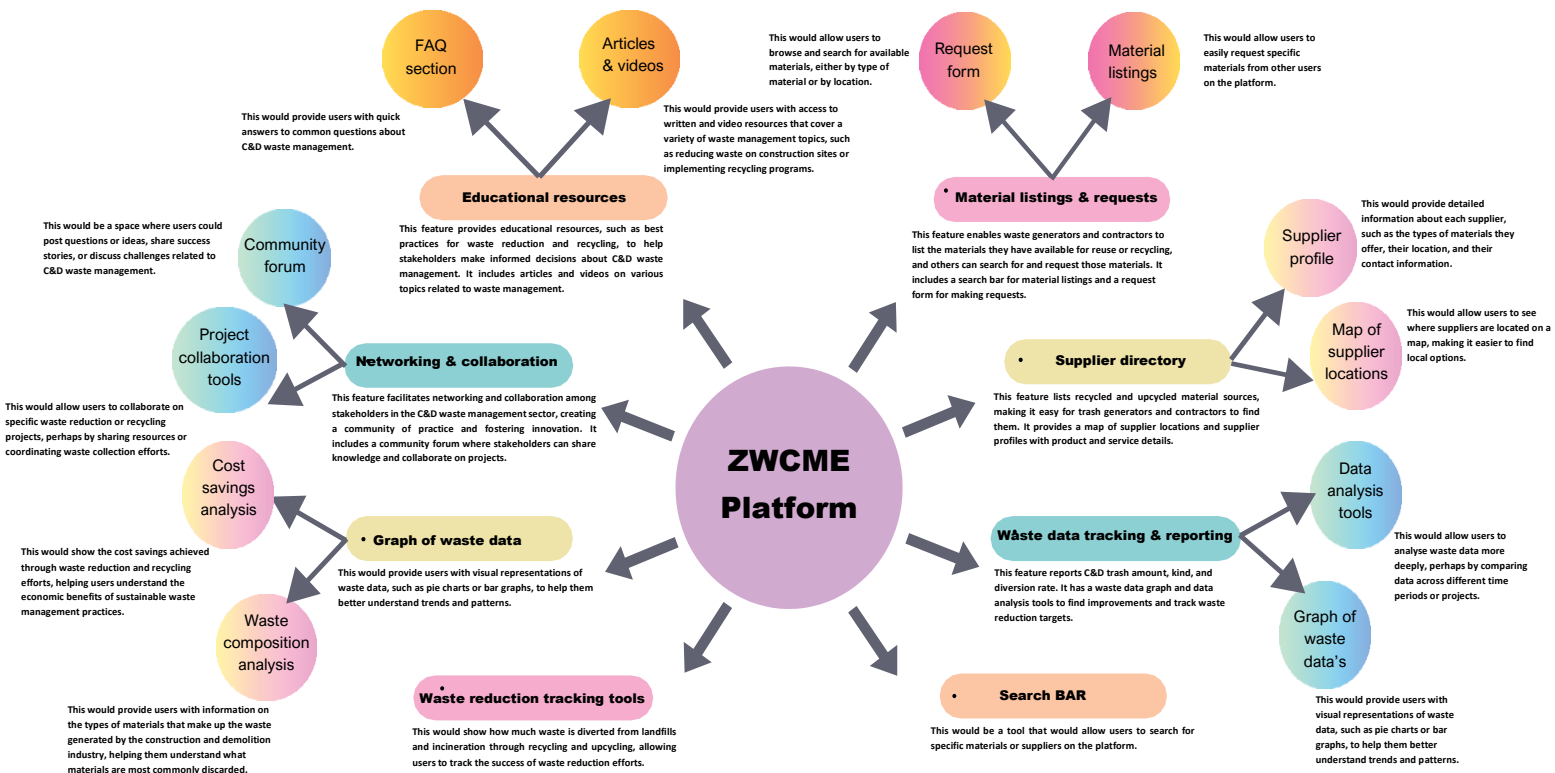


Figure 6. Zwcme Platform Features and Tools Diagram

The success of the implementation hinges on factors such as stakeholder engagement, legal frameworks, financial resources, technology, and the ability to scale. The platform has the potential to serve as an inspiration for other cities globally. By employing a cost-benefit analysis approach, those responsible for managing the platform can

pinpoint areas for optimization to maximize the benefits. By following the processes outlined in Figure 4, they can assess the costs and advantages of the platform and determine its feasibility and effectiveness.

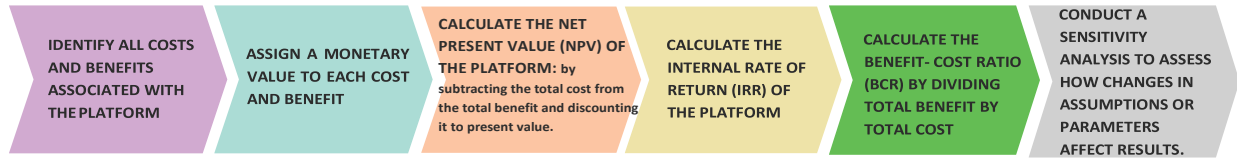


Figure 7. A Process Diagram for the Steps Involved in Conducting a Cost-Benefit Analysis

3.2.4. Strategies for Sustainable Implementation.

ZWCME's long-term success depends on sustainable implementation strategies. Without these techniques, the platform may struggle to succeed. The ZWCME platform can solve data limitations and improve waste management in Istanbul by designing and implementing sustainable implementation strategies as shown in Figure 5.



Figure 8. Strategies For Sustainable Implementation Of The Zwcme

3.3. Summary of Findings.

The case study demonstrates the application of the economic evaluation framework in a real-world office refurbishment project. By using recycled and reused bricks, the project not only saved money on materials but also contributed to C&D waste minimization efforts. The framework developed in previous case studies can be applied to various situations to provide a good understanding of the economic costs and benefits associated with minimizing waste streams, such as brick waste, in construction and refurbishment projects.

The results of this study demonstrate the effectiveness of the Zero Waste Construction Material Exchange (ZWCME) platform in achieving the research objective of establishing a comprehensive database for the country. This database encompasses all demolition projects and new building constructions, ensuring efficient waste management for all construction endeavors.

By connecting demolition companies with recycling firms, contractors, and municipalities, the ZWCME platform promotes seamless collaboration and coordination between these entities. This interconnectedness ensures that no waste is generated from any demolition or construction project, as all stakeholders work together to minimize waste and maximize resource efficiency.

The ZWCME platform offers significant economic, environmental, and social benefits. Its success relies on stakeholder involvement, policy and regulatory frameworks, financing mechanisms, technology integration, and monitoring and evaluation. Furthermore, the platform fosters a strong relationship between the companies, municipalities, and the government, enabling the implementation and enforcement of effective waste management policies, which ultimately contribute to the nation's commitment to sustainable development and environmental conservation.

The ZWCME platform also demonstrates the potential for scalability and replicability in other cities, serving as a model for promoting sustainable waste management practices globally. In conclusion, the platform serves as a vital tool in realizing the research objective of creating an all-encompassing database for demolition and construction projects, ensuring waste minimization and efficient resource utilization across the construction industry.

4. Conclusion.

Building drives Türkiye's economy. Due to nationwide housing and infrastructure investments, the construction business has grown significantly in recent decades. For individuals at high risk of earthquakes, rigorous retrofitting, strengthening, and demolition have continued. 66% of Türkiye, home to 71% of its population, is in the first and second earthquake zones. Due to significant seismic risk, most of Türkiye's housing stock must be modified through destruction, retrofitting, and strengthening in the short term. Consequently, all these operations will raise C&D waste, making waste stream management more vital throughout this transition to sustainable housing stock with legal construction requirements. This study highlights the potential of adopting the zero-waste concept to address the challenges posed by C&D waste in Istanbul's construction industry. Through analyzing the current waste management practices, identifying the impact of C&D waste, and understanding stakeholders' attitudes, the study proposes the Zero Waste Construction Material Exchange (ZWCME) platform as a solution to facilitate sustainable

waste management practices in the sector. The research also identifies significant economic benefits associated with zero-waste practices, including job creation, financial savings, and environmental conservation. These findings contribute to the ongoing efforts towards a sustainable future, with the ZWCME platform offering a scalable and replicable solution that can be implemented in other urban areas, extending the economic benefits associated with zero waste principles to a wider range of contexts. Therefore, the study has important implications for policymakers, government agencies, and waste management service providers, emphasizing the need for a comprehensive and coordinated policy and regulatory framework to promote sustainable waste management practices in the construction industry.

İnşaat sektörü, Türkiye ekonomisi için kritik bir rol oynamaktadır. Ülke genelinde konut ve altyapı yatırımlarının artmasıyla, bu sektör son yıllarda büyük ölçüde büyümüştür. Deprem riski yüksek bölgelerde ise, geri dönüşüm, güçlendirme ve yıkım çalışmaları titizlikle sürdürülmektedir. Türkiye'nin birinci ve ikinci deprem bölgeleri, ülkenin %66'sını ve nüfusunun %71'ini kapsamaktadır. Büyük sismik tehlikeler nedeniyle, Türkiye'nin konut stokunun önemli bir kısmı yakın gelecekte yıkıma, geri dönüşüme ve güçlendirmeye tabi tutulmalıdır. Bu süreçler, inşaat ve yıkım atıklarının artmasına yol açacak ve bu geçiş sürecinde etkili atık yönetimi daha da önemli hale gelecektir.

Bu çalışma, İstanbul inşaat sektöründeki inşaat ve yıkım atıklarıyla ilgili zorlukları ele almak için sıfır atık yaklaşımının benimsenmesi avantajlarını incelemektedir. Mevcut atık yönetimi uygulamalarını inceleyerek, inşaat ve yıkım atıklarının etkisini değerlendirerek ve paydaşların görüşlerini araştırarak, çalışma sektörde sürdürülebilir atık yönetimi uygulamalarını teşvik etmek için Sıfır Atık İnşaat Malzemesi Değişim Platformu (ZWCME) önermektedir. Araştırma ayrıca, sıfır atık girişimleriyle ilişkili önemli ekonomik avantajları vurgulamaktadır; bunlar arasında iş yaratma, mali tasarruf ve çevre koruma bulunmaktadır.

Bu bulgular, sürdürülebilir bir geleceğe yönelik devam eden çabalara katkıda bulunurken, ZWCME platformu diğer kentsel alanlarda uygulanabilecek ölçeklenebilir ve tekrarlanabilir bir çözüm sunmaktadır. Bu nedenle, çalışma politika yapıcılar, hükümet ajansları ve atık yönetimi hizmet sağlayıcıları için önemli sonuçlar doğurmaktadır; inşaat sektöründe sürdürülebilir atık yönetimi uygulamalarını teşvik etmek için kapsamlı ve koordineli bir politika ve düzenleyici çerçeve gerekliliğini vurgulamaktadır.

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