Life Cycle Environmental Impact and Cost Assessment of Waste Management Practices on Selected Construction Sites in Morgan State University, MD

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DOI: https://doi.org/10.51584/IJRIAS.2025.100700065

Received: 22 June 2025; Revised: 11 July 2025; Accepted: 13 July 2025; Published: 11 August 2025

ABSTRACT

The construction activities at Morgan State University (MSU) produce a substantial amount of waste, such as concrete, wood, drywall, asphalt, and metal. However, poor attention is directed to managing these waste streams; most of them end up in landfills because of the low operational costs and convenience associated with landfilling. This approach is environmentally unsustainable, while also stripping away potential economic opportunities, compromising the university's green campus initiatives, and revealing a lack of systematic infrastructure that integrates sustainable practices. This study investigates the life cycle environmental and cost implications of construction waste management strategies of MSU. It employs a mixed-methods design utilizing survey data collected from construction professionals, literature, and case study analysis. To assess the current practices of landfilling, reusing, and recycling waste, a life cycle approach was used. Results indicate that while landfilling is the most common practice because it is cheap, it has the greatest risk to the environment in the long run. Material reuse and recycling on the other hand, offer more sustainable and economically beneficial alternatives. This study suggests the integration of life cycle approaches in conjunction with policy changes to enhance considerate waste management policies towards sustainable campus development.

Keywords: Life Cycle Assessment, Construction Waste Management, Environmental Impact, Waste Recycling, Sustainable Management

INTRODUCTION

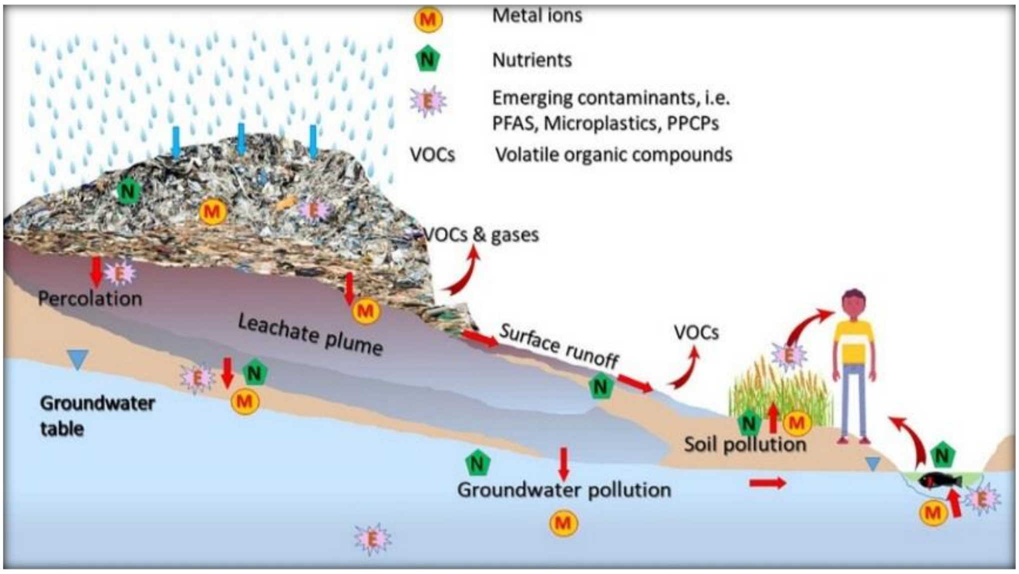
The global construction industry simultaneously serves as an indicator of progress for any economy while consuming unparalleled amounts of resources and producing immense waste. In 2020, the United States alone surpassed 600 million tons of Construction and Demolition (C&D) waste, which includes concrete, wood, asphalt, metal, drywall, and other materials in excess of 30% of the global waste. This waste volume presents extraordinary challenge to environmental sustainability, causing a significant contribution to greenhouse gas emissions, habitat destruction, and landfill depletion (EPA, 2020; 2023). This substantial waste generation is often exacerbated by factors such as improper planning, over-ordering of materials, poor storage, and inefficient recycling practices, although early-phase design, prefabrication, modular construction, and precise material estimation can significantly reduce waste generation (Tam & Le, 2010; Liu et al., 2019a).

Despite the evidence that abounds in the literature highlighting the principles of Sustainable Materials Management (SMM) and the transformative potential of digital waste tracking and Life Cycle Costing (LCC) on efficiency and resource wastage (Liu et al., 2019b; WRAP, 2021 WorldGBC, 2023), the Reduce, Reuse, Recycle (3R) model remains unimplemented at the local level. Predominantly, the construction industry adheres to the "extraction, use, and dispose of" model, which is extremely wasteful and harmful to the environment. Today, landfilling remains the most common way to dispose of construction and demolition (C&D) waste. This includes C&D waste-specific landfills for bulkier, inert materials and Municipal Solid Waste (MSW) landfills for mixed non-hazardous waste. Under the Resource Conservation and Recovery Act (RCRA), specialized landfills are laden with stringent double-liner systems and leachate collection, which are designated for reactive or toxic construction by-products like asbestos, lead paint, and PCBs (EPA, 2025a, 2025b; Britannica, 2025; Superfund Arizona, 2025).

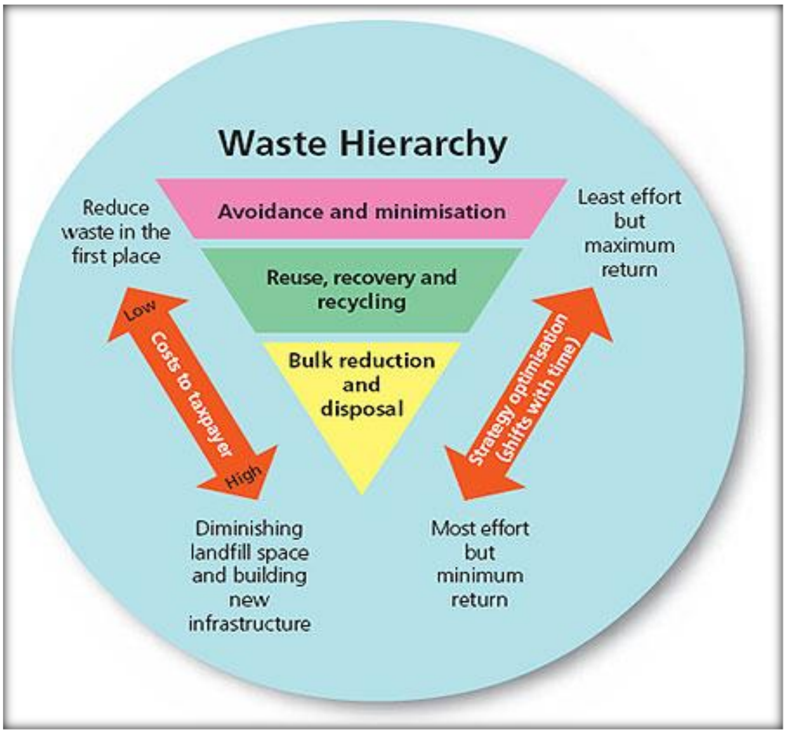
ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

In spite of the exceptional designs, C&D landfills are still a threat to the environment owing to the possible methane emissions from decaying organic matter, leachate release that has the potential to contaminate groundwater and land volatility (Hossain et al., 2020; EPA, 2023). In addition, the declining functional space and long-term maintenance liability of landfills highlight the need to shift towards more sustainable approaches. These issues including the respiratory complications and vector-borne diseases for the surrounding communities illustrate the critical need to divert waste from land disposal towards more beneficial resource recovery pathways.

Cross-sectional illustration of a C&D landfill showing potential environmental risks



Source: Adapted from Wijekoon et al. (2022), as cited in Almeida et al. (2023)



Source: European Parliament & Council (2008)

Such diversions fit within established waste management hierarchies, which prioritize avoidance, minimization, reuse, and recycling over reduction and disposal, providing the greatest return and lower long-term costs. This structured methodology not only alleviates waste but also offers economic benefits due to the recovery of materials and lowered disposal costs.

Leading institutions such as Stanford University have proven that over 80% waste diversion is achievable with Comprehensive Zero Waste Construction Plans, which include mandatory waste audits, contractor training, and material reuse programs (Stanford, 2019). Other real-time digital tracking tools using QR codes and mobile apps as well as LCC that assesses the overall financial impact beyond immediate disposal costs are essential for moving away from simplistic short-term cost measures to comprehensive campus-wide environmental sustainability initiatives (Liu et al., 2019; WRAP, 2021). These innovations transform construction waste management by enabling real-time transparent reporting, streamlined logistics, and optimized data-driven decision-making in construction waste management.

However, construction efforts currently ongoing at Morgan State University (MSU) encounter a major problem. Even though the university supports green campus initiatives, there is an insufficient systematic data-driven framework for waste management and evaluation of operational efficiency biased towards landfilling disposal due to its low upfront costs. This approach, which is not sustainable, not only compromises MSU's environmental goals but also misses possible economic opportunities. It also shows a critical gap in localized data and integrated sustainable infrastructure in the university's construction framework. Also, to the best knowledge of the researcher there is no prior LCA-based assessment of construction waste that has been conducted at MSU.

Therefore, to address these gaps, this study focused on the following research questions:

What are the current waste generation and disposal practices in MSU's construction projects?

What are the environmental and economic implications of these methods when evaluated with a life cycle perspective?

What life cycle–oriented strategies can be developed to improve sustainable construction waste management across the MSU campus?

By addressing these questions, the study aims to provide significant insights about the ecological impact of waste management practices on construction sites at MSU with regard to the vision of the university as a border marker in sustainable urban development and green campus initiatives in university-based construction projects.

METHODS

This study conducted a mixed methods descriptive analysis in order to achieve the objective of evaluating the waste management practices on construction sites at Morgan State University (MSU). The methods integrated primary data collected through the surveys with secondary data from literature to examine both environmental and economic cost implications of waste practices. In this research, a qualitative LCA was done due to time constraints, focusing on broad environmental impacts. Primary data collection involved a structured questionnaire distributed to MSU construction professionals (project directors, managers, waste contractors) via a purposive sampling approach. The survey gathered information on waste types, quantities, management techniques (landfilling, recycling, reuse), disposal costs, and sustainable waste management knowledge. For quantitative data, descriptive analyses were used while on open-ended responses thematic content analysis was carried out.

To validate the primary data, the survey instrument underwent expert review by three academic and industry professionals in construction and environmental management. Their feedback necessitated modification, which helped strengthen the instrument clarity, relevance, and alignment with the study objectives.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

To facilitate comparative analysis with local and international best practices, secondary data review included U.S. Environmental Protection Agency (EPA) (2023) C&D waste reports, Ecoinvent and GaBi environmental datasets, and university-based waste diversion case studies (Stanford University, 2019). The documents were chosen based on the credibility of the information offered and their relevant insights into construction waste practices and the availability of comparable metrics.

The Life Cycle Environmental Impact Assessment used one ton of mixed construction waste as its functional unit. Emission factors for C&D materials under landfilling, such as 0.7 tons of CO_2 per ton of drywall, were sourced from various studies (Hossain et al., 2020; EPA, 2023) Carbon emissions, the use of energy, and consumption of space in landfills were evaluated qualitatively. Cost estimation involved average disposal costs from survey data ($50–$100 per ton) and literature-based savings from material reuse and recycling. Financial findings compared traditional and sustainable practices for long-term feasibility, guided by Life Cycle Costing (LCC) principles (Liu et al., 2019b).

The section below presents the results from both primary and secondary data to examine the current waste practices and inform sustainable interventions.

RESULTS

This section describes the results based on the mixed-methods analysis, incorporating survey data provided by the construction industry experts at Morgan State University (MSU) construction sites, with relevant secondary data and life cycle environmental assessments. The results mainly focus on waste composition, management practices, costs constraints, environmental impacts, and stakeholder attitudes.

Waste Types and Volumes

The data from the survey revealed the most common types and approximate percentages of construction waste produced at MSU sites. As indicated in Table 1 below, concrete constitutes around 35% of the total waste volume. Wood waste accounts for approximately 25% of the total waste arising from formwork, scaffolding, pallets, and frames. These objects even though there is potential possibility for reusing are often removed and not reused. Drywall as well as asphalt materials that are commonly used for interior finishing and paving activities, respectively, each add up to 15% of the total waste volumes. Scrap metal waste, which includes steel rebar and pipes, accounted for 10% of the remaining generated waste. The revealed percentages are in support with the U.S. EPA's statistical data at the national level, where concrete and asphalt were revealed as the main sources of waste of this nature.

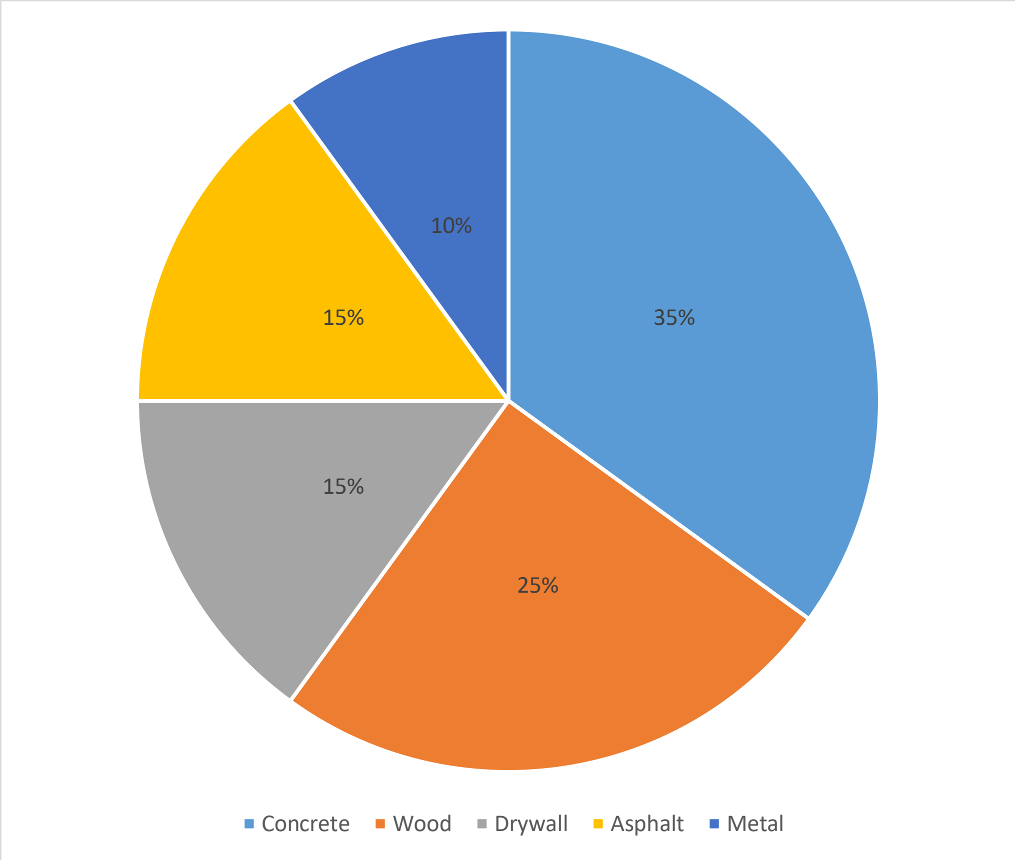
Table 1: Estimated Proportion of the Total Waste at MSU Construction Sites

Material Type	Estimated Proportion of Total Waste (%)	Common Sources
Concrete	35	Demolition, structural components
Wood	25	Formwork, scaffolding, pallets, frames
Drywall	15	Interior finishing
Asphalt Materials	15	Paving and roofing
Scrap Metal	10	Steel rebar, pipes

The table above provides a basic understanding of the waste streams that require university management intervention. Based on the proportions derived from the survey data provided by the MSU construction professionals, it shows that they are in consistent with general C&D waste classification. Wood and concrete are the two most important waste materials by volume, as shown in the data, emphasizing their significance in any targeted waste reduction and recycling initiatives.

The Figure 1 below shows how these types of materials are distributed within the MSU total construction waste stream. It gives a clear picture of the proportions based on Table 1.

Figure 1: Composition of Waste Generated at MSU



The figure makes it clear that concrete and wood make up most of the waste, which supports the idea that these materials should be given priority in sustainable management plans.

Current Waste Management Practices

The responses from the survey demonstrated the waste management strategies common at MSU's construction sites, as depicted in Table 2. It is evident that landfilling is the most widely used form of disposal method. This option seems to be more convenient, aligns with the contractor's work practices, it is relatively less expensive in the short run and operational convenience. Recycling and reuse practices are minimal, if not entirely absent, and only take place after client contracts necessitate them or when disposal cost rises sharply.

Respondents also mentioned some informal recycling methods, such as the collection of scrap metal and leftover wood, which could be made into construction aids to be used during the construction process. These methods, however, are often times random and not part of a solid plan or strategy. Additionally, respondents did not report the use of centralized digital systems for monitoring waste. Due to the absence of tracking system, project managers are unable to estimate, detect, or devise measures to mitigate waste in the project. The lack of systematic waste audits impedes responsible construction practices in the university.

Table 2: Current Waste Management Practices at MSU Construction Sites

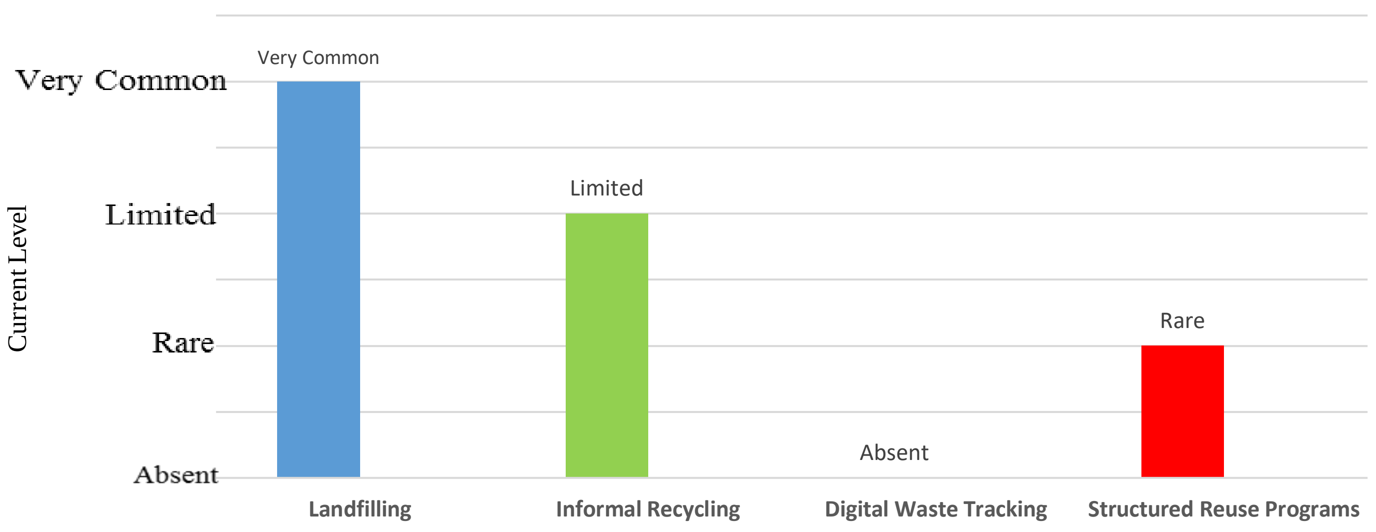
Practice	Prevalence	Description
Landfilling	Very Common	Main method due to low upfront costs, contractor familiarity, and it's environmentally harmful
Informal Recycling	Limited	Unplanned, sporadic reuse of some materials such as, metal and wood
Digital Waste Tracking	Absent	No centralized system framework for real-time waste monitoring
Structured Reuse Programs	Rare	Low implementation due to absence of specific policy or dedicated infrastructure

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

Prevalence is based on a qualitative assessment derived from survey responses. The above table illustrates the prevailing operational reality where economic convenience is place over environmental considerations in daily waste management. These results unequivocally indicate that the majority of waste is not managed with comprehensive environmental or long-term economic objectives in focus. The notable lack of centralized digital tracking system and organized reuse initiatives particularly impedes opportunities for policy and infrastructure enhancement.

Figure 2 below depicts landfilling as the most widely used form of disposal method as compared to other waste management techniques.

Figure 2: Current Waste Management Practices at MSU Construction Sites



The bar chart graphically illustrates how MSU construction sites primarily rely on landfilling and have adopted minimal systematic recycling, reuse, or digital tracking initiatives. It provides a visual representation of the qualitative dominance information found in Table 2.

Cost Constraints

One of the barriers emerging from the survey is the impact of financial cost on waste management assessments. Table 3 presents the key aspects of these cost constraints. The average reported waste disposal cost ranged from $50 to $100 per ton. While the unit cost of landfilling may seem manageable, the overall expense becomes burdensome when considering high volumes of waste during extended projects. Several contractors admitted that recycling or reusing materials often comes at an upfront expense (encompassing labor, specialized equipment, and time investment), which were not incorporated into the budget. For this reason, even when sustainable alternatives are available, many contractors default to landfilling due to its perceived affordability. Furthermore, data revealed that institutional financial incentives were largely factor that determined if sustainable measures could be practiced, and, in particular, without institutional mandates or subsidies set in place, cost problems will always drive the right progression in environmentally favorable waste strategies.

Table 3: Cost Constraints in MSU Waste Disposal Practices

Aspect	Reported Estimate
Average waste disposal cost	$50–$100 per ton
Cost perception for large projects	Burdensome due to high volumes
Upfront cost of recycling/reuse	High (labor, equipment, time)
Institutional financial incentives	Lacking

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

This table illustrates data obtained from survey instrument responses that were both quantitative (such as cost estimates) and qualitative (such as cost perceptions and lack of incentives). This highlights the short-term focus while illuminating the financial justifications for current waste management decisions.

Environmental Impact (Life Cycle Estimates)

Table 4 demonstrates the estimated environmental trade-offs between current landfilling practices and potential waste management options using a qualitative Life Cycle Assessment (LCA) and emission factors benchmarks from Hossain et al. (2020) and EPA (2023). For example, comparing the different waste management options currently under consideration in terms of environmental impact, it shows that converting landfilling to other waste management options is more beneficial. As illustrates in table 4 below, landfilling of 10 tons of drywall is estimated to result in 7.0 tons of CO_2 equivalents (CO_2e) due to emissions from gypsum decomposition causes by sulfate compounds breakdown. On the other hand, it is estimated that recycling one ton of steel and reusing one ton of concrete will result in significant environmental benefits, equal to a reduction of 5.18 tons CO_2e and 2.0 tons CO_2e, respectively. These benefits are primarily due to energy savings and avoided emissions from the extraction and transportation of virgin materials. Overall, these results demonstrate the potential substantial environmental benefit from diverting waste from landfills.

Table 4: Environmental Impact Estimates Based on LCA

Material	**Estimated Waste (tons)**	**CO_2 Factor (tons CO_2e/ton)**	**Total Impact (tons CO_2e)**	**Description**
Drywall (Landfilled)	10	+0.7	+7.0	Emissions from gypsum decomposition
Steel (Recycled)	1	−5.18	−5.18	Energy savings and avoided emissions
Concrete (Reused)	1	−2.0	−2.0	Reduced quarrying and transport emissions

Stakeholder Attitudes and Opportunities for Improvement

Table 5 indicates a strong enthusiasm among the surveyed construction professionals at MSU expressed a notable interest in embracing sustainable practices, but only when accompanied by institutional support. The table below depicts a summary of these attitudes. High proportions (78%) of stakeholders were in support of incorporating the Life Cycle Environmental Impact Assessment (LCEIA) tools in construction planning at MSU. Awareness of sustainable practices was relatively (~60%), and institutional capacity to implement change was observed as limited (~30%). While, interest in training and policy reform was very high (~85%), significantly indicating a keen readiness for guidance and organizational support from the university.

Figure 3 Stakeholder Attitudes Towards Sustainable Waste Practices

Aspect	**Survey Result**	**Estimated Percentage (%)**
Support for incorporating LCA tools	78% supportive	78%
Awareness of sustainable practices	Moderate	~60%
Institutional capacity to implement change	Limited	~30%
Interest in training and policy reform	High	~85%

This table illustrates data obtained from survey responses. Showing, approximate the estimated percentages, including both quantitative ratings and thematic analysis of open-ended questions. These findings indicate a positive attitudinal landscape, suggesting that institutional action could effectively leverage existing goodwill for sustainable change.

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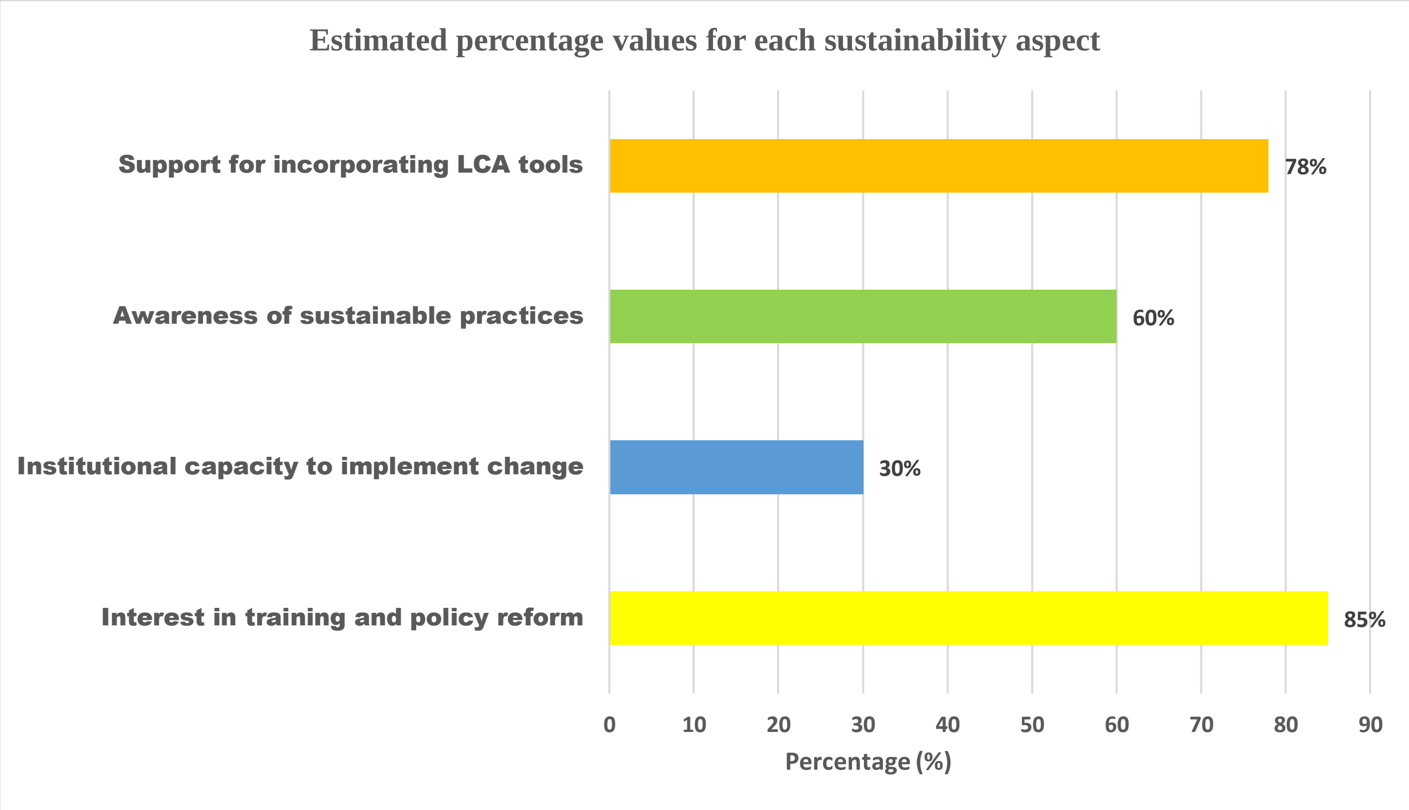
Figure 5 visually represents the estimated percentage values for each sustainability aspect from the survey.



It shows the strong support among stakeholders for training and policy reform, underscoring a key area where institutional intervention can significantly drive the adoption of sustainable waste practices at MSU. It illustrates the visual representation of the percentages outlined in Table 5.

DISCUSSION

This study's results verify that MSU construction sites are consistent with other U.S. institutions concerning the types and handling of waste streams. There is a considerable production of concrete and wood waste, as well as, predominately, dispositional landfilling; recycling and reuse efforts are minimal. These findings correspond with EPA (2023) data from the United States, noting more than 600 million tons of C&D waste is produced nationally, with concrete representing around 68 per cent of that value.

A number of factors explain the lack of sustainable waste management practices at MSU. Cost constraints, lack of institutional support, deficient incentives, and inadequate waste management systems pose some barriers for contractors; this is in line with results postulated in other studies (Liu et al., 2019a; Hossain et al., 2020). On the other hand, some leading institutions such as Stanford University have been able to exceed an 80 per cent diversion rate by enforcing Zero Waste Construction Plans with auditing requirements, training for contractors, and reusing materials (Stanford, 2019). This narrative serves as a realizable goal for MSU.

The LCA results underscore the possible environmental impacts associated with changing the disposition of waste from landfilling to material recovery. Even the slight increase in recycling and reuse of materials such as steel and concrete induces a great impact on the reduction of greenhouse emissions and resource consumption. The result buttress WRAP's (2021) recommendations, which highlight life cycle costing as a critical component in the assessment of the economic feasibility of sustainable construction practices.

Regarding stakeholder feedback, there is a high degree of willingness to adopt sustainable waste management at MSU although institutional leadership and support are also required. The single greatest opportunity for enhancement is within MSU's ability to create and execute a comprehensive policy for sustainable construction at the institutional level rather than for technological or awareness issues.

CONCLUSION AND RECOMMENDATION

This research assessed the relevant environmental and cost impacts of the waste management practices in place on selected construction sites at Morgan State University (MSU). Through the survey conducted among construction-related professionals, supported by the academic literature and industry principle, the study was able to trace critical aspects of the waste management processes, including generation and disposal, as well as the prevailing sustainable development policies at MSU.

The results indicate that MSU projects predominantly practice landfilling because it is the most convenient and cheapest option in the short term. However, this practice inflicts considerable long-term damage to the environment. The C&D waste stream particularly concrete, wood and drywall are predominantly disposed of as waste rather than being dismantled for the considerable reuse or recycling, in spite of their significant environmental and economic recovery.

The survey responses shown that stakeholders wish to adopt more sustainable approaches like recycling and material reuse as long as there is institutional backing in the form of policies, incentives, training, and adequate facilities. The life cycle assessment approach applied in this research shown that even slight changes in the usage and recycling of materials can drastically reduce greenhouse gas emission, energy consumption, and expenses over a period.

This study did not perform a complete Life Cycle Assessment (LCA) or Costing (LCC) analysis due to the time constricted for this research, but was able to use qualitative benchmarks with reference to emission factors to implement life cycle thinking. This serves as an ideal starting point for MSU towards adopting more efficient construction practices in line with the green campus initiatives.

Based on these findings, it is recommended that MSU institute a campus wide policy requiring waste audits for all construction projects. Life Cycle Environmental Impact Assessment (LCEIA) tools should be used as part of the decision making process in planning and procurement at design level. Create and enhance on-site recycling facilities and train contractors to ensure implementation. Furthermore, MSU should encourage sustainable sourcing and reuse of materials through institutional schemes that promote sustainable construction practices. This report not only addresses the local knowledge void but also serves as a precursor for developing streamlined, time-focused sustainability evaluations in academic infrastructure development.

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