Available online at
http://journal.uitm.edu.my/ojs/index.php/BEJ

e-ISSN: 2637-0395

Built Environment Journal 22(Special Issue) 2025, 199 – 213.

Built Environment Journal

Environmental Issues Affecting Sustainable Development in the Construction Industry

Nurul Huda Muhamad[1], Ani Saifuza Abd Shukor[2*], Mohammad Fadhil Mohammad[2]

[1]*Department of Built Environment Studies & Technology, College of Built Environment, Universiti Teknologi MARA, Cawangan Perak, Kampus Seri Iskandar, 32610 Seri Iskandar, Perak*
[2]*Department of Quantity Surveying, College of Built Environment, Universiti Teknologi MARA, 40450 Shah Alam, Selangor*

ARTICLE INFO

Article history:
Received 01 November 2024
Revised 05 June 2025
Accepted 12 June 2025
Online first
Published 31 July 2025

Keywords:
Environmental Issues
Sustainable Development
Construction Industry

DOI:
10.24191/bej.v22iSI.6957

ABSTRACT

The construction industry plays a vital role in the economic development of any country. However, this industry is also known for its significant environmental issues, including carbon emissions, the consumption of natural resources, and landfill waste. The mitigation of these issues lays the foundation for sustainable development. Despite the increasing number of publications on sustainable development in the construction industry, there is an absence of research that discusses environmental issues affecting sustainable development and the future direction of this strategy. Therefore, this article will review the current literature on the environmental issues affecting sustainable development in the construction industry. A list of keywords (environmental issue, carbon emission, landfill waste, waste of natural resources and sustainable development) related to the scope of this research was identified. In the second step, the keywords for studies in Scopus and Web of Science (WoS) were searched, and a total of 32 papers were reviewed. A themed review was performed, where four final themes were identified: assessment, building materials, technology, and framework. The results suggest a new framework for research trends in environmental issues affecting sustainable development in the construction industry. Accordingly, this study will benefit future researchers focusing on environmental issues affecting sustainable development.

INTRODUCTION

The construction industry plays a vital role in the economic development of any country (Sandaruwan et al., 2024; Herrera et al., 2024) and population welfare, providing infrastructure, buildings, and facilities essential for modern society (Golafshani et al., 2024). However, this industry is also known for its

[2*] Corresponding author. *E-mail address*: anisa278@uitm.edu.my

significant environmental issues, including carbon emissions, the consumption of natural resources, and the generation of landfill waste (Zubair et al., 2024; Golafshani et al., 2024; Gonzalez et al., 2024; Bellini et al., 2024).

The high use of natural resources, the high energy consumption (Gutai et al., 2024; Kanagaraj et al., 2024; Oumaima et al., 2024) and the consequent emission of Greenhouse Gases (GHGs) have led to a worrying environmental deterioration (Magalhaes et al., 2024). In recent decades, global warming has emerged as a significant challenge, and the primary driver of this phenomenon is GHGs (Myint and Shafique, 2024). In addition, GHG emissions are also a significant contributor towards climate change (Zubair et al., 2024). Subsequently, the construction industry is one of the world's most significant contributors to GHG emissions (Sandaruwan et al., 2024) and is responsible for around 39% of global GHG emissions, with building envelopes playing a significant role in this carbon footprint (Gutai et al., 2024). As a result, the reduction in GHG emissions throughout the construction industry has become a fundamental goal; this is especially true for carbon emissions, which is the most critical component of anthropogenic GHGs (Du et al., 2019). Among these gases, Carbon Dioxide (CO2), primarily emitted through the combustion of fossil fuels like coal, oil, and natural gas, is crucial in driving climate change (Myint and Shafique, 2024). Undoubtedly, the phenomenon of global warming and climate change arises from the emission of GHGs, among which CO2 plays a significant role (Monahan & Powell, 2011; Yong et al., 2024).

Therefore, reduction in carbon emissions, protecting natural resources and minimizing waste lays the foundation for sustainable development (Gehlot & Shrivastava, 2024). As environmental concerns become increasingly important worldwide, there is a growing imperative to adopt sustainable and eco-friendly practices in construction aiming to mitigate environmental issues (Golafshani et al., 2024; Chik et al., 2024; Myint & Shafique, 2024; Olsson, Miller & Kneifel, 2024). Despite such increasing interest, attention is lacking to reviewing and analysing the research studies conducted. Hence, this article will highlight selected literature, mostly from 2024, on the discussions that relate to environmental issues of the construction industry and answer the following questions: 1) what are the current trends on environmental issues affecting sustainable development in the construction industry? and 2) how to formulate a new framework on environmental issues affecting sustainable development for the future direction of this study?.

LITERATURE REVIEW

The following are the environmental issues established from selected publications: carbon emissions; landfill waste; and waste of natural resources.

Carbon Emissions

In recent years, several authors reported that the construction industry significantly contributes to global carbon emissions. This can be observed from Zubair et al. (2024) and Sutkwoska et al. (2024), who mentioned that over 39% of annual worldwide carbon emissions are caused by the construction industry. Meanwhile, Zhu et al. (2024) indicated that the construction industry, as a major consumer of resources and energy, accounts for about 40% of global carbon emissions. At the same time, Mulya et al. (2024) highlighted that the construction industry contributes a substantial amount of carbon emissions, accounting for 38% of energy-related GHG emissions, making it the largest contributor (Tiwari et al., 2024). The building construction industry stands as a significant player in energy consumption and carbon emissions on a global scale (Myint & Shafique, 2024). In addition, the construction sector contributes a considerable share of global carbon emissions, with high-rise buildings having high emission density (Mulya et al.,

https://doi.org/10.24191/bej.v22iSI.6957

2024). This is attributable to the fact that façades are among the highest contributors to embodied carbon emissions in commercial buildings. After all, curtain walls rely on the use of high-carbon materials such as glass, aluminium and silicon (Cheong et al., 2024).

Subsequently, the production of building materials emits the largest proportion of CO2, followed by the operational phase, while construction (including demolition) has the smallest proportion (Zhu et al., 2024). For instance, cement production is one of the significant contributors to the emission of CO2 in the building sector due to its energy intensity (Tiwari et al., 2024; Chik et al., 2024). In this regard, energy-intensive building materials are responsible for 80% of the carbon emissions of the construction industry in the world (Sandaruwan et al., 2024). The cement industry accounts for roughly 7% of global carbon emissions (Tiwari et al., 2024). Similarly, the cement manufacturing industry alone contributes up to 8% of the global anthropogenic CO2 emissions worldwide (Gonzalez et al., 2024). Every ton of ordinary Portland cement (OPC) produced emits 0.6 to 1.4 amount of CO2 depending on the specific country and production process (Kanagaraj et al., 2024). Moreover, cement production is responsible for global warming (Kanagaraj et al., 2024). Therefore, reducing carbon emissions from the construction sector is the most critical factor in the struggle against climate change (Tiwari et al., 2024), and reducing GHG emissions throughout the construction industry has become a crucial goal (Du et al., 2019).

Cheong et al. (2024) mentioned Australia's building and construction sector are the next frontier to significantly reduce carbon emissions because the construction sector is responsible for one-fifth of the total carbon emissions, including up to 50 million tonnes of carbon dioxide equivalent per year for domestic production of building materials. The carbon emission of a building material on its degree of influence is ranked as cement, steel, concrete and wire (Li et al., 2021). Another study by Zubair et al. (2024) & Sandaruwan et al. (2024) identified a number of materials, including steel, concrete, cement, bricks, and ceramic tiles, were the most critical materials influencing carbon emissions and were barriers to sustainable buildings. Consequently, these issues have become the subject of policies and programs at the national and international levels, and in many cases, they are also being proactively addressed by the construction industry itself (Gonzalez et al., 2024).

Landfill Waste

Another significant environmental issue is landfill waste. Several authors indicated that the construction industry has faced significant challenges due to waste management issues. Karaca and Tleuken (2024) highlighted that proper Construction and Demolition (C&D) waste management remains challenging, with waste often ending up in landfills. This is due to the fact that buildings are often disposed of at the end of their useful life, and the potential for material reuse is sometimes impossible (Akanbi et al., 2018). The global population is continually generating vast amounts of waste materials across various sectors, leading to environmental challenges associated with landfill disposal (Adhikary et al., 2024). Further, the high C&D waste generation rates are critical aspects of the construction industry and present a significant challenge to modern waste management (Khan, Balunaini and Costa, 2024). Moreover, Oumaima et al. (2024) mentioned that vast amounts of C&D waste are abandoned in the streets or accumulated in landfills each year. This can negatively impact the environment if it is not managed correctly. The production of GHGs, namely methane, is one primary environmental concern during the breakdown of organic waste in landfills (Poyyamozhi et al., 2024). According to Khan, Balunaini and Costa (2024), due to rapid population growth and urbanization, construction activities have increased worldwide, resulting in the generation of an enormous volume of C&D waste. For instance, the growing demand for dimensional stone generates a large amount of waste from mining and processing, which is typically landfilled in open areas, causing air pollution, water pollution, and health problems (Gehlot & Shrivastava, 2024; Modi et al., 2024). The waste produced by the sandstone mining sector ends up in landfills and is a serious environmental concern (Modi et al., 2024). The amount of construction and demolition waste

https://doi.org/10.24191/bej.v22iSI.6957

generated has been rising significantly in recent decades as many infrastructures and buildings have approached the end of their useful life, and/or damaged by conflicts and natural disasters (Khan et al., 2024). Construction and demolition waste accounts for a significant part of solid waste generated by humans (Khan et al. 2024). The waste generated from construction and demolition activities in construction sector leads to degraded air quality with large amount of particulate matter (PM) and fine aerosols suspended in the atmosphere leading to respiratory problems in the vicinity areas (Singh et al., 2024).

Several authors discussed the expanding waste stream accelerates, posing severe risks to human health and ecosystems (Poyyamozhi et al., 2024) and improper disposal of waste materials in an open environment can potentially lead to contamination by heavy metals and harmful bacteria, which can pose a significant health risk during handling (Adhikary et al., 2024). The absence of biodegradability exhibited by plastics is a matter of significant concern among environmentalists and scientists on a global scale (Hilal et al., 2024). The production of greenhouse gasses, namely methane is one primary environmental concern during the breakdown of organic waste in landfills (Poyyamozhi et al., 2024). Thus, to meet the human needs and sustain life in various countries, the industry sector produces large amounts of waste materials or by products, the collection, maintenance and disposal of which impose great costs and create many health and environmental problems that need sustainable solutions (Mousavi et al., 2024). Subsequently, construction firms are currently dealing with challenges, emphasizing a lack of comprehensive regulations concerning the management of construction demolition waste, giving rise to concerns related to the storage and disposal of such waste materials (Karaca & Tleuken, 2024). Therefore, the ultimate goal is to achieve net zero landfill and net zero waste worldwide (Khan et al., 2024).

Waste of Natural Resources

In recent years, several authors highlighted the high natural resource consumption in the construction industry (Cavalliere et al., 2019). Moreover, the processes and products of the dominant site-based construction techniques deplete a significant amount of virgin materials (Wuni & Shen, 2022; Cao et al., 2015; Monahan & Powell, 2011). Therefore, the conscientious utilization of natural resources and efficient waste management have become a matter of great concern in recent years due to the harmful environmental impacts (Magalhaes et al., 2024). The construction sector presents itself as one of the sectors that most contribute to raw materials consumption and waste generation, demanding the investigation of more sustainable and eco-friendly building materials, where the valorisation of wastes originating from other industries can be promising (Magalhaes et al., 2024). According to Kanagaraj et al. (2024), cement production is responsible for global warming and creates a risk of raw material deficiency. In addition, there has been extensive extraction and use of sand, which is the most extracted solid material globally, second only to water (Rohit et al., 2024). On the other hand, natural aggregate can no longer satisfy the needs of the construction industry in most countries, both in terms of quantity and quality, considering the tremendous growth in aggregate consumption (Mondem & Balunaini, 2024). The high use of natural resources, the high energy consumption and the consequent emission of GHGs have led to a worrying environmental deterioration (Magalhaes et al., 2024).

The construction industry consumes high volumes of concrete that need large amounts of natural aggregates and, hence, causes irreparable damage to the nature (Mousavi et al., 2024). Like concrete, plastering and masonry work also consumes a huge quantity of fine aggregates, resulting in scarcity and uncontrolled exploitations of its natural sources (Gehlot & Shrivastava, 2024). As the environmental policies and protection guidelines of natural resources are among the great challenges in the concrete production or construction industry, they can be properly addressed if effort is made to produce green, nature-friendly concretes by different waste materials (Mousavi et al., 2024). In recent decades, the surge in concrete consumption within the construction sector and the constrictions imposed by finite natural resources have compelled researchers to explore alternative materials for replacing cement and aggregates

https://doi.org/10.24191/bej.v22iSI.6957

in concrete and mortar blends (Pournoori et al., 2024). On the other front, there has been extensive extraction and use of sand, which is the most extracted solid material globally, second only to water (Rohit et al., 2024). Therefore, to achieve sustainable development, it is imperative that we find ways to manage natural resources wisely (Rohit et al., 2024; Gehlot & Shrivastava, 2024).

METHODOLOGY

This research method applies a manual thematic analysis procedure in the literature review. Thematic analysis can be defined as a process of identifying patterns and constructing themes by reading about the subject (Clarke & Braun, 2013; Zairul, 2021). The next step is to identify the pattern and construct themes to understand the trend of environmental issues affecting sustainable development in the construction industry. The research's principles are to analyse and interpret the findings to recommend future research in related domains. The literature review was selected according to several selection criteria: 1) publication in 2024; and 2) have at least the keyword(s) environmental issue, carbon emission, landfill waste, waste of natural resources and sustainable development. The literature sources were the research databases, mainly from Scopus of Elsevier and Web of Science (WoS), as it has the most extensive collection of peer-reviewed publications. The results of this paper are divided into two parts, first part will report the data that was obtained from the numerical points of view, while second part will establish themes that were established from the selected articles and formulate a conceptual framework for environmental issues affecting sustainable development. Figure 1 shows the literature review process. An in-depth and critical literature review was conducted in this study. Manual move analysis is then conducted to remove the duplicate article. As such, thirty-five duplicated articles were removed, and the remaining 1,429 were undergone for title and abstract screening. Accordingly, a total of 32 articles were selected for further assessment.

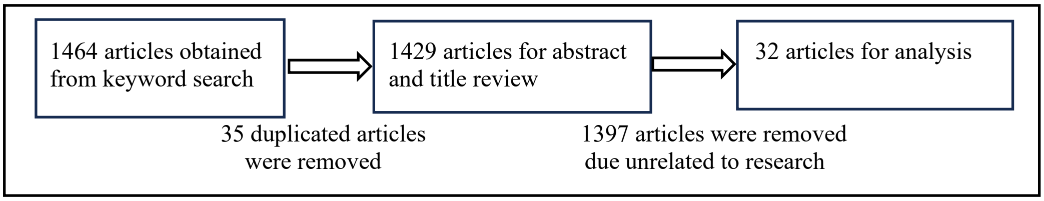

Fig. 1. Literature Review Process

Source: Authors (2025)

RESULTS AND DISCUSSION

This paper will discuss the themes derived to answer the research question. Four themes were established based on the directions and subject of the articles. Table 1 shows the themes established from the selected publications: Assessment (5), Building materials (18), Framework (4), and Technology (5).

Table 1. Authors According to Themes

An example of a column heading	Assessment	Building Materials	Framework	Technology
Cheong et al. (2024)	√			
Sandaruwan, Manoharan and Kulatunga (2024)	√			
Mulya et al. (2024)	√			
Zubair et al. (2024)	√			
Myint and Shafique (2024)	√			
Kashem et al. (2024)		√		
Zhu et al. (2024)		√		
Tiwari et al. (2024)		√		
Rohit, Rao and Chandrasekhar (2024)		√		
Modi, Gajjar and Sharma (2024)		√		
Gehlot and Shrivastava (2024)		√		
Magalhaes et al. (2024)		√		
Poyyamozhi et al. (2024)		√		
Gonzalez et al. (2024)		√		
Alkhrissat (2024)		√		
Hilal et al. (2024)		√		
Chik et al. (2024)		√		
Kanagaraj et al. (2024)		√		
Pournoori et al. (2024)		√		
Karaca and Tleuken (2024)		√		
Khan, Balunaini and Costa(2024)		√		
Subramaniam, Davis and Thomas (2024)		√		
Adhikary et al. (2024)		√		
Adewumi, Opoku and Dangana (2024)			√	
Yin and Zhao (2024)			√	
Zairul (2021)			√	
Elsamni et al. (2024)			√	
Sutkwoska et al. (2024)				√
Du et al. (2019)				√
Li et al. (2021)				√
Waqar (2024)				√
Hassan et al. (2024)				√

Source: Authors (2025)

Assessment

Building Performance

Several authors proposed carbon emission reduction through a life-cycle assessment approach. For instance, Cheong et al. (2024) explored the life cycle assessment of three façade systems from the cradle to the grave, analysing the trade-off between the impacts of the service life and end-of-life stages to identify the associated environmental benefits. A total of 27 scenarios based on different façade service lives of 20, 40 and 100 years and different end-of-life scenarios, including landfill, recycling and reuse, are examined (Cheong et al., 2024). Results from this study revealed that reuse provides more net benefits to global warming potential and the total use of renewable primary energy resources and non-renewable primary energy resources than recycling. This is attributable to the fact that materials reuse requires minimal energy usage compared to the energy needed for material recycling (Akanbi et al., 2018). Another pertinent study by Sandaruwan et al. (2024) focused on cradle-to-gate embodied carbon assessment of green office buildings using life cycle analysis. The findings revealed that the use of low-carbon materials, materials minimising design, utilisation of reusable or recycled materials, utilisation of local or regional materials, and utilisation of eco-labelling materials are potential measures to reduce cradle-to-gate embodied carbon in the building construction industry. Similarly, Mulya et al. (2024) quantified the embodied and operational carbon reduction of GreenRE (local) and LEED (international) certifications on a high-rise office building using a life cycle assessment in a tropical country.

Mathematical Equation

On the other hand, Zubair et al. (2024) developed a Building Information Modelling (BIM)- and Geographic Information System (GIS)-based life cycle assessment (LCA) framework for enhancing eco-efficiency and sustainability in the construction sector. This study developed an integration of the BIM, LCA, GIS, and mathematical calculation of the embodied disposal-process GHG emissions to optimise the construction design, material selection, operations, maintenance, and waste-management processes. Results from this study indicated that 29.35% of the materialization stage, 16.04% of the operational stage, and 21.14% of the end-of-life-phase GHG emissions can be effectively reduced. From this theme, it can thus be concluded that there are many developments in the application to create a mathematical estimation of building efficiency based on the environmental impact in the construction sector. Meanwhile, Myint and Shafique (2024) explored integrating BIM with eco-resilient principles to create a framework for designing and constructing sustainable buildings. The BIM approach assesses the carbon footprints associated with distinct stages of the construction process, including raw material production and transportation. Further, this study highlighted the potential for BIM-driven eco-resilient practices in mitigating carbon emissions and the need for continued innovation and collaboration in sustainable building design and construction. In addition, Hao et al. (2020) developed a BIM-based approach to measuring carbon emission reduction during the materialization stage of a prefabricated building project. Findings from this study indicated that BIM is an efficient and effective method for measuring carbon emissions from the construction of new buildings. Therefore, it can be concluded that many developments in the application can create a mathematical estimation of building efficiency based on the environmental impact in the construction sector.

Green Building Materials

Construction Materials

The building materials industry ranks first in terms of carbon emissions and energy consumption within the industrial sector (Yin & Zhao, 2024). The growing demand for sustainable building materials has prompted exploring alternative materials to traditional cement and fine aggregate in construction (Chik et al., 2024). The construction industry is trying to reduce the environmental impact of cement production in concrete by incorporating alternative and supplementary cementitious materials and lowering carbon emissions (Kashem et al., 2024). This can be observed by Chik et al. (2024), who indicated that ultrafine coal bottom ash and spent garnet hold great potential as replacements for cement and fine aggregate in concrete. This provides a means to mitigate the environmental impact of construction. Another material that has gained popularity in this context is Rice Husk Ash (RHA) due to its pozzolanic reactions (Kashem et al., 2024).

Subramaniam et al., (2024) investigated the feasibility of using Basic Oxygen Furnace (BOF) slag and fly ash as primary precursors in the development of steel fibre-reinforced Engineered Geopolymer Composites with Iron Ore Tailings (IoT), replacing manufactured sand as fine aggregate. Meanwhile, Kanagaraj et al. (2024) revealed that limestone calcined clay cement possesses superior performance in terms of energy requirement and GHG emission than Ordinary Portland Cement (OPC). At the same time, Hilal et al. (2024) investigated the influence of nano sunflower ash and nano wheat shell ash as partial replacements for cement on sustainable, lightweight, self-compacting concrete properties. This is conducted with a fixed amount of recycled waste ceramic powder as cement replacement and a fixed

https://doi.org/10.24191/bej.v22iSI.6957

amount of plastic waste as a partial replacement of normal coarse aggregate for all mixes. In addition, Pournoori et al. (2024) investigated tempered glass as waste glass coarse aggregate was substituted for natural coarse aggregate in the formulation of eco-friendly self-compacting concrete. Therefore, increasing aggregate demand worldwide has encouraged recycling waste materials to produce sustainable recycled materials and reduce environmental pollution (Khan et al., 2024).

Circular Economy Strategy

Green building material meets the core elements of sustainable development based on the principles of the circular economy (Zhu et al., 2024) that allow utilising various reliable materials as substitutes, like C&D waste (Tiwari et al., 2024; Zairul, 2021). According to Bellini et al. (2024), adopting a circular economy in the built environment contributes to lowering the consumption of natural resources, limiting waste generation, and reducing GHG emissions. Several studies have suggested the utilisation of C&D waste to reduce negative impacts on the environment. For instance, Rohit et al. (2024) investigated the strength and fracture properties of slag-based geopolymer mortar while varying the molarities of sodium hydroxide and altering the proportions of recycled fine aggregate sourced from C&D waste (Rohit et al., 2024). The research by Lin et al. (2024) investigated the feasibility of using Recycled Concrete Aggregate (RCA) stabilised by one-part geopolymers to produce an innovative semi-rigid inclusion column system for ground improvement of soft soils. The author indicated that RCA is a voluminous solid waste material derived from the construction sector and is typically stockpiled in landfills. The strategy of waste-to-resources was extended by Modi et al., (2024) through their experiment on the potential of dimensional sandstone waste used as a 50% replacement to sand in mortar for masonry. The idea of using dimensional sandstone mining waste in construction is to reduce dependence on natural resources like clay, natural river sand and topsoil (Modi et al., 2024). Another research by Gehlot and Shrivastava (2024) identified the optimum utilization of granite-cutting waste in sustainable rendering mortar development.

Subsequently, the valorisation of wastes originating from other industries can be promising (Magalhaes et al., 2024). The research conducted by Magalhaes et al. (2024) investigated the potential use of textile waste in cement-based lightweight construction material, evaluating the fire reaction of the material using cone calorimeter equipment. Meanwhile, Poyyamozhi et al. (2024) suggested sustainable utilization of municipal solid waste incinerated fly ash as a substitute for manufactured sand for eco-friendly concrete roof tiles. This research emphasises the potential of waste-to-resource strategies in achieving sustainable development goals and reducing the ecological footprint of construction materials. Moreover, Gonzalez et al. (2024) explored the use of waste material from the chemical industry to produce low-strength concrete hollow blocks. This study aims to technically support the reduction of Portland cement consumption in manufacturing nonstructural masonry units, generally known as hollow concrete blocks, by replacing cement with waste products from the chemical industry. Results from the study by Alkhrissat (2024) indicated that plastic aggregates may substitute natural fine aggregates to create an environmentally friendly mortar with similar strength characteristics. Furthermore, the use of recycled plastic in concrete addresses the issue of its proper disposal and contributes to the preservation of natural aggregate resources (Hilal et al., 2024).

Technology

Prefabrication

Innovation and technological solutions have also been discussed by several authors as contributors to significant environmental benefits, especially in reducing carbon emissions. For instance, Sutkwoska et al. (2024) indicated that integrating renewable materials and technology is pivotal for sustainability, with natural material prefabrication offering promising solutions by reducing carbon footprint. Therefore, this

https://doi.org/10.24191/bej.v22iSI.6957

study explored existing natural material prefabrication technologies, delving into their capabilities and assessing their suitability for application in single-family housing. Similarly, Du et al. (2019) investigated the differences in CO2 emissions between the prefabricated and conventional construction methods and the effect of the prefabrication rate on building carbon emissions. This study concluded that adopting prefabrication technology contributes to significant environmental benefits for reducing CO2 emissions; the optimal prefabrication rate can be chosen according to the demand.

BIM Related Activities

On the other hand, several studies used BIM to research carbon footprint and incorporated BIM as the study design. This can be observed by Li et al. (2021), who employed BIM technology to establish a carbon footprint calculation model for the materialization phase of precast concrete buildings. Akanbi et al. (2018) developed a BIM-based Whole-life Performance Estimator for appraising the salvage performance of structural components of buildings right from the design stage. Driven by the rapid evolution of 3D printing technology, the construction industry is on the verge of a momentous revolutionary shift (Hassan et al., 2024). Therefore, Hassan et al. (2024) proposed a comprehensive review of 3D printing in construction towards innovative and sustainable buildings.

New Technology (3D printing, etc.)

Driven by the rapid evolution of 3D printing technology, the construction industry is on the verge of a momentous revolutionary shift (Hassan et al., 2024). Therefore, Hassan et al. (2024) proposed a comprehensive review of 3D printing in construction towards innovative and sustainable buildings. Moreover, Intelligent Decision Support Systems (DSS) have gained considerable interest within the field of construction engineering through the utilization of Artificial Intelligence (AI) and Machine Learning (ML) methodologies to augment the process of decision-making, optimise the results of projects, and foster the adoption of sustainable practices (Waqar, 2024).

Framework and Model

Policy and Site Management

Several authors have proposed frameworks that could help deliver environmental targets such as reducing carbon emissions, using renewable energy in new buildings, reducing landfill waste, protecting natural resources and minimizing waste. For instance, Zairul (2021) proposed a circular economic framework for prefabricated construction to analyse the environmental benefits of prefabrication in terms of its components and ensure that circular economy principles are adhered to. Circular construction practices are essential to reduce the profound impact of the construction sector on the widening global circularity gap (Wuni & Shen, 2022). In some countries, prefabricated have often been described as potential solutions in the sustainable construction process, moreover with the integration with a circular economy (Zairul, 2021). One of the Malaysian government's initiatives is to promote prefabricated components and off-site construction methods for efficiency and sustainability. On the other hand, Adewumi, Opaku and Dangana (2024) explored the extent to which sustainability assessment frameworks can help UK construction companies demonstrate their commitment to Environmental, Social, and Governance (ESG) targets. ESG compliance has become increasingly important in the face of increasing climate risks as it deals with a company's impact on the environment and society. Further, Elsamni et al. (2024) developed a conceptual framework for sustainability by achieving three sustainability pillars: social, environmental, and economic and applied the framework to a sustainable project. Therefore, a sustainable and ecologically sound framework should be adopted to utilise and integrate innovative construction

https://doi.org/10.24191/bej.v22iSI.6957

materials, advanced methods, modern designs, and digital technologies that will revamp the environment (Zubair et al., 2024).

Supply Chain

An agent-based evolutionary system model of the transformation from the building material industry to Green Intelligent Building Materials (GIBMs) under supply chain management has been proposed by Yin and Zhao (2024), which could help achieve the goal of reducing carbon emissions. This study emphasises the importance of government regulations and support in promoting the growth of the GIBM industry. By implementing appropriate control measures, providing financial assistance, imposing punishments for pollution, and investing in infrastructure, the government can effectively encourage the development of the GIBM industry (Yin & Zhao, 2024). These measures contribute to achieving the double carbon goals and fostering a more sustainable built environment (Yin & Zhao, 2024).

A PROPOSED CONCEPTUAL FRAMEWORK FOR ENVIRONMENTAL ISSUES AFFECTING SUSTAINABLE DEVELOPEMENT

The thematic review led to the proposal of new studies to extend the development of information in the related field. According to the conceptual framework in Figure 2, future studies can be clustered into Assessment (to assess the building performance based on the environmental impact in the construction sector), Green Building Materials (more studies on construction materials that are sustainable and to utilise the waste); Technology (focus on alternative, low carbon, BIM-related activities to implement technology enablers to mitigate environmental issues); and Framework and Model (a new framework and model on government policy, site management and supply chain).

Assessment	Green Building Materials	Technology	Framework & Model
• Building performance • Mathematical equation	• Construction materials • Circular economy strategy	• Prefabrication • BIM related activities • New technology (3D, etc)	• Policy & site management • Supply chain

Fig. 2. A Conceptual Framework on the Existing Discussion on Environmental Issues Affecting Sustainable Development.

Source: Authors (2025)

CONCLUSION

The key contribution of this article has been to examine the literature about environmental issues affecting sustainable development in the construction industry. The practical contribution is to speed up the government transformation move for a sustainable construction industry. This article highlights existing sustainable and eco-friendly practices in construction that are important to mitigate environmental issues. It is thus necessary to adopt Environmental, Social and Governance (ESG) practices in the construction industry. Accordingly, the conceptual framework developed will be analysed and validated through focus group discussions and questionnaires in the next stage.

https://doi.org/10.24191/bej.v22iSI.6957

ACKNOWLEDGEMENTS/FUNDING

The authors would like to acknowledge the support of Universiti Teknologi Mara (UiTM), Cawangan Perak, Kampus Seri Iskandar and College of Built Environment, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia for providing the facilities and financial support on this research.

CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

All authors participated in conducting the research, drafting and revising the article, conceptualizing the central research idea, providing the conceptual framework, reviewing and approving the article for submission.

REFERENCES

Adewumi, A.S., Opoku, A. and Dangana, Z. (2024). Sustainability assessment frameworks for delivering Environmental, Social, and Governance (ESG) targets: A case of Building Research Establishment Environmental Assessment Method (BREEAM) UK New Construction. *Corporate Social Responsibility and Environmental Management*, 1-13.https://doi.org/10.1002/csr.2768

Adhikary, S.K., D' Angelo, A., Viola, V., Catauro, M. and Perumal, P. (2024). Alternative construction materials from industrial side streams: Are they safe?. *Energy, Ecology and Environment*, 9(2), 206-214. https://doi.org/10.1007/s40974-023-00298-1

Akanbi, L.A., Oyedele, L.O., Akinade, O.O., Ajayi, A.O., Delgado, M.D., Bilal, M. and Bello, S.A. (2018). Salvaging building materials in a circular economy: A BIM-based whole-life performance estimator. *Resources, Conservation & Recycling*, 129, 175-186. https://doi.org/10.1016/j.resconrec.2017.10.026

Alkhrissat, T. (2024). Impact of adding waste polyethylene (PE) and silica fume (SF) on the engineering properties of cement mortar. *Case Studies in Chemical and Environmental Engineering*, 9, 100731. https://doi.org/10.1016/j.cscee.2024.100731

Bellini, A., Tadayon, A., Andersen, B. and Klungseth, N.J. (2024). The role of data when implementing circular strategies in the built environment: A literature review. *Cleaner Environmental Systems*, 13, 100183. https://doi.org/10.1016/j.cesys.2024.100183

Cao, X., Li, X., Zhu, Y. and Zhang, Z. (2015). A comparative study of environmental performance between prefabricated and traditional residential buildings in China. *Journal of Cleaner Production*, 109, 131-143. https://doi.org/10.1016/j.jclepro.2015.04.120

Cavalliere, C., Dell'Osso, G.R., Favia, F. and Lovicario, M. (2019). BIM-based assessment metrics for the functional flexibility of building designs. *Automation in Construction*, 107, 102925.

https://doi.org/10.1016/j.autcon.2019.102925

Cheong, C.Y., Brambilla, A., Gasparri, E., Kuru, A. and Sangiorgio, Z. (2024). Life cycle assessment of curtain wall facades: A screening study on end-of-life scenarios. *Journal of Building Engineering*, 84, 108600. https://doi.org/10.1016/j.jobe.2024.108600

Chik, W.M.E.K.W., Mokhatar, S.N., Othman, N.H., Budiea, A.M.A. and Muthusamy, K. (2024). The exploration of the characteristics of concrete incorporating ultrafine coal bottom ash and spent garnet. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, 36(2), 164-175. https://doi.org/10.37934/araset.36.2.164175

Clarke, V. and Braun, V. (2013). *Teaching thematic analysis : Overcoming challenges and developing strategies for effective learning*. Associate Professor in Sexuality Studies, vol. 26. Department of Psychology Faculty of Health and Life Sciences University of the West of England Coldharbour Lane Br. University of the West of England, pp. 120–123

Du, Q., Bao, T., Li, Y., Huang, Y. and Shao, L. (2019). Impact of prefabrication technology on the cradle to site CO2 emissions of residential buildings. *Clean Technologies and Environmental Policy*, 21, 1499-1514. https://doi.org/10.1007/s10098-019-01723-y

Elsamni, J., Elhegazy, H., Abdulrasheed, I. and Kohail, Mohamed. (2024). A conceptual framework for sustainable construction in the Arab region. *Innovative Infrastructure Solutions*, 9(6). https://doi.org/10.1007/s41062-024-01501-w

Gehlot, M.R. and Shrivastava, S. (2024). An AHP based sustainability assessment of cement mortar with synergistic utilization of granite cutting waste. *Journal of Building Engineering*, 86, 108794. https://doi.org/10.1016/j.jobe.2024.108794

Golafshani, E., Khodadadi, N., Ngo, T., Nanni, A. and Behnood, A. (2024). Modelling the comprehensive strength of geopolymer recycled aggregate concrete using ensemble machine learning. *Advances in Engineering Software*, 191, 103611. https://doi.org/10.1016/j.advengsoft.2024.103611

Gonzalez, J.H., Rabell, G.O., Dominguez, J.X., Farias, O.O., Vivian, I.F., Leal, F.V. and Miguel, G.F.S. (2024). Use of waste material from the chemical industry for the production of low-strength concrete hollow blocks. *Sustainable Materials and Technologies*, 40, e00870. https://doi.org/10.1016/j.susmat.2024.e00870

Gutai, M., Mok, B., Cavana, G. and Kheybari, A.G. (2024). Global carbon viability of glass technologies: Life-cycle assessment of standard, advanced and water-filled glass (WFG) building envelopes. *Applied Energy*, 367, 123281. https://doi.org/10.1016/j.apenergy.2024.123281

Hassan, H., Ubinas, E.R., Al Tamimi, A., Trepci, E., Mansouri, A. and Almerhairbi, K. (2024). Towards innovative and sustainable buildings: A comprehensive review of 3D printing in construction. *Automation in Construction*, 163, 105417. https://doi.org/10.1016/j.autcon.2024.105417

Herrera, C.R., Soto, A.M., Vera, C.A. and Cardenas-R, J.P. (2024). Characterization and utilization of sawdust waste generated from advanced manufacture for its application as a thermal insulation in sustainable buildings using the blowing technique. *Journal of Building Engineering*, 88, 109217. https://doi.org/10.1016/j.jobe.2024.109217

Hao, J.L., Cheng, B., Lu, W., Xu, J., Wang, J., Bu, W. and Guo, Z. (2020). Carbon emission reduction in prfabrication construction during materialization stage: A BIM-based life-cycle assessment approach. *Science of The Total Environment*, 723, 137870. https://doi.org/10.1016/j.scitotenv.2020.137870

Hilal, N., Sor, N.A.H., Nyarko, M.H., Radu, D. and Tawfik, T.A. (2024). The influence of nanosunflower ash and nanowalnut shell ash on sustainable lightweight self compacting concrete characteristics. *Scientific Reports*, 14, 9450. https://doi.org/10.1038/s41598-024-60096-5

Kanagaraj, B., Anand, N., Alengaram, U. J., Raj, R.S. and Khartick, S. (2024). Limestone calcined clay cement (LC3): a sustainable solution for mitigating environmental impact in the construction sector. *Resources, Conservation & Recycling Advances*, 21, 200197. https://doi.org/10.1016/j.rcradv.2023.200197

Kashem, A., Karim, R., Das, P., Datta, S.D. and Alharthai, M. (2015). Compressive strength prediction of sustainable concrete incorporating rice husk ash (RHA) using hybrid machine learning algorithms and paramater analyses. *Case Studies in Construction Materials*, 20, e03030. https://doi.org/10.1016/j.cscm.2024.e03030

Karaca, F. and Tleuken, A. (2024). Reforming construction waste management for circular economy in Kazakhstan: A cost-benefit analysis of upgrading construction and demolition waste recycling centres. *Recycling,* 9(2), e03030. https://doi.org/10.3390/recycling9010002

Khan, Z. A., Balunaini, U. and Costa, S. (2024). Environmental feasibility and implications in using recycled construction and demolition waste aggregates in road construction based on leaching and life cycle assessment. *Cleaner Materials*, 12. https://doi.org/10.1016/j.clema.2024.100239

Li, X. J., Lai, J.Y., Ma, C.Y., & Wang, C. (2021). Using BIM to research carbon footprint during the materialization phase of prefabricated concrete buildings: A China study. *Journal of Cleaner Production*, 279, 123454. https://doi.org/10.1016/j.clepro.2020.123454

Lin, B. and Teng, Y. (2024). Synergistic disparities of pollution reduction and carbon mitigation in the industrial chain: Evidence from China's industrial sector. *Environmental Research*, 248, 118286. https://doi.org/10.1016/j.envres.2024.118286

Magalhaes, L., Conde, O., Mesquita, L., Briga-sa, A. and Ferreira, D.M. (2024). Evaluating the fire behaviour of cement-based lightweight materials with textile waste incorporation using a cone calorimeter. *Case Studies in Construction Materials*, 20, e02798. https://doi.org/10.1016/j.cscm.2023.e02798

Modi, P.I., Gajjar, R.K. and Sharma, A. K. (2024). Investigating the potential of dimensional sandstone waste used as a 50% replacement to sand in mortar for masonry. I*nnovative Infrastructure Solutions,* 9(5), 135. https://doi.org/10.1007.s41062-024-01438

Monahan, J. and Powell, J. C. (2011). An embodied carbon and energy analysis of modern methods of construction in housing: A case study using a lifecycle assessment framework. *Energy and Buildings*, 43, 179-188. https://doi.org/10.1016/j.enbuild.2010.09.005

Mondem, N. and Balunaini, U. (2024). Manufacturing artificial aggregates from overburden coal mine waste and their properties for pavement applications. *Journal of Material Civil Engineering,* 36(7), 04024147. https://doi.org/10.1061/JMCEE7.MTENG-17138

Mousavi, S. R., Bahrpeyma, A., Afshoon, I. and Chakkoshi, M. (2024). Protecting the environment and natural resources using green Roller Compcted Concrete (RCC) containing fine and coarse recycled copper slag aggregates. *Process Safety and Environmental Protection, 186,* 04024147. https://doi.org/10.1016/j.psep.2024.04.048

Mulya, K.S., Ng, W.L., Biro, K., Ho, W.S., Wong, K.Y. and Woon, K. S. (2024). Decarbonizing the high-rise office building: A life cycle carbon assessment to green building rating systems in a tropical country. *Building and Environment*, 255, 111437. https://doi.org/10.1016/j.buildenv.2024.111437

Myint, N.N. and Shafique, M. (2024). Embodied carbon emissions of buildings: taking a step towards net zero buildings. *Case Studies in Construction Materials*, 20, e03024. https://doi.org/10.1016/j.cscm.2024.e03024

Olsson, J.A., Miller, S.A. and Kneifel, J.D. (2024). A review of current practice for life cycle assessment of cement and concrete. *Resources, Conservation & Recycling*, 206, 107619. https://doi.org/10.1006/j.resconrec.2024.107619

Oumaima, A., Latifa, E., Naoual, B., Mustapha, J. and Abdellah, Z. (2024). Green recycling of red brick waste into aerogel panels for thermal insulation in buildings. *Journal of Sol-Gel Science and Technology,* 110(1), 62-73. https://doi.org/10.1007/s.10971-024-06321-z

Pounoori, P., Murugesan, B., Perumal, S., Chidambaranathan, V. and Senthil, R. (2024). Experimental exploration of fracture behavior (pure mode III) in eco friendly steel fiber reinforced self compacting concrete with waste tempered glass as coarse aggregates. *Scientific Reports*, 14, 9043. https://doi.org/10.1038/s41598-024-58912-z

Poyyamozhi, M., Davaparnah, T.Q.A., Rajaee, A., Ghodratnama, M., Abrishami, S. and Masoodi, A.R. (2024). Elevating thermal comfort with eco-friendly concrete roof tiles crafted from municipal solid waste. *Journal of Building Engineering*, 88, 109222. https://doi.org/10.101016/j.jobe.2024.109222

Rohit, P., Rao, T.D.G. and Chandrasekhar, M. (2024). Effect of construction demolition waste as fine aggregate and NaOH molarity on strength and fracture parameters of slag based geopolymer mortars. *Journal of Engineering and Applied Science*, 71, 37. https://doi.org/10.1186/s44147-024-00373-2

Sandaruwan, I.P.T., Manoharan, K. and Kulatunga, U. (2024). Cradle-to-gate embodied carbon assessment of green office building using life cycle analysis: A case study from Sri Lanka. *Journal of Building Engineering,* 88, 109155. https://doi.org/10.1016/j.jobe.2024.109155

Singh, S., Maiti, S., Bisht, R.S., Panigrahi, S.K. and Yadav, S. (2024). Large CO2 reduction and enhanced thermal performance of agro-foresty, construction and demolition waste based fly ash bricks for sustainable construction. *Scientific Reports,* 14, 8368. https://doi.org/10.1038/s41598-024-59012-8

Subramaniam, S., Davis P, R. and Thomas, B.S. (2024). Sustainable engineered geopolymer composites: A study on the potential of fly ash, BOF slag, and iron ore tailings. *Environmental Engineering Research,* 29(5), 230450. https://doi.org/10.4491/eer.2023.540

Sutkwoska, M., Stefanska, A., Vaverkova, M.D., Dixit, S. and Thakur, A. (2024). Recent advances in prefabrication techniques for biobased materials towards a low-carbon future: from modules to sustainability. *Journal of Building Engineering*, 91, 109558. https://doi.org/10.1006/j.jobe.2024.109558

Tiwari, S. K., Kim, K., Singh, R.S., Lee, J., Kim, T., Mahlknecht, J., Giri, B.S. and Kumar, M. (2024). A critical review on CO2 sequestration using construction waste and demolition: future scope and perspective. *Environmental Engineering Research,* 29(3), 230256. https://doi.org/10.4491/eer.2023.256

Waqar, A. (2024). Intelligent decision support systems in construction engineering: An artificial intelligence and machine learning approaches. *Expert Systems With Applications*, 249, 123503. https://doi.org/10.1016/j.eswa.2024.123503

Wuni, I.Y. and Shen, G. Q. (2022). Developing critical success factors for integrating circular economy into modular construction projects in Hong Kong. *Sustainable Production and Consumption,* 11, 574-587. https://doi.org/10.1016/j.spc.2021.11.010

Yin, S. and Zhao, Y. (2022). An agent-based evolutionary system model of the transformation from building material industry (BMI) to green intelligent BMI under supply chain management. *Humanities and Social Sciences Communications*, 11, 468. https://doi.org/10.1057/s.41599-024-02988-5

Yong, Z.C., Yew, M.K., Yew, M.C., Beh, J.H., Lee, F.W., Lim, S.K. and Saw, L.H. (2024). Utilizing bio-based and industrial waste aggregates to improve mechanical properties and thermal insulation in lightweight foamed macro polypropylene fibre-reinforced concrete. *Journal of Building Engineering*, 91, 109588. https://doi.org/10.1016/j.jobe.2024.109588

Zairul, M. (2021). The recent trends on prefabricated buildings with circular economy (CE) approach. *Cleaner Engineering and Technology*, 4, 100239. https://doi.org/10.1016/j.clet.2021.100239

Zhu, H., Liou, S., Chen, P., He, X. and Sui, M. (2024). Carbon emissions reduction of a circular architectural practice: A study on a reversible design pavillion using recycled materials. *Sustainability*, 16, 1729. https://doi.org/10.3390/su16051729

Zubair, M.U., Ali, M., Khan, M.A., Khan, A., Hassan, M.U. and Tanoli, W. A. (2024). BIM- and GIS-based life-cycle-assessment framework for enhancing eco efficiency and sustainability in the construction sector. *Buildings*, 14, 360. https://doi.org/10.3390/buildings14020360