International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 21s, 2025
https://theaspd.com/index.php

Assessing The Environmental Impact Of The Construction Industry: Insights For Environmental Science And Sustainable Development

B Ravinder[1]
[1]Nicmar University of Construction studies, Hyderabad , Telangana , https://orcid.org/0000-0002-7871-3081

Abstract
The construction industry plays a vital role in economic development but is also a significant contributor to global environmental degradation. This study assesses the environmental impact of construction activities and key drivers for the adoption with a focus on their implications for environmental science and sustainable development. Key environmental concerns associated with the industry include high energy consumption, greenhouse gas emissions, land use changes, water and air pollution, and extensive waste generation. Using a combination of literature review and case-based analysis, this research identifies major sources of environmental harm across the construction lifecycle—from material extraction and manufacturing to building operations and demolition. The study employs Life Cycle Assessment (LCA) methodologies to quantify impacts and highlights the role of sustainable construction materials and green building technologies in mitigating environmental damage. Findings suggest that early design decisions, material choices, and regulatory frameworks significantly influence a project's ecological footprint. Furthermore, the research aligns its analysis with relevant Sustainable Development Goals (SDGs), particularly those addressing climate action, sustainable cities, and responsible resource use. The study concludes with policy recommendations aimed at promoting environmentally responsible construction practices and supporting the transition to a more sustainable built environment. This work contributes to the broader discourse on integrating sustainability principles into construction and urban development planning.
Keywords: *Environmental impact, Construction industry, Sustainable development, Life Cycle Assessment (LCA), Green building, Sustainable construction materials*

INTRODUCTION

The construction industry plays a critical role in driving global economic development. It contributes significantly to national Gross Domestic Product (GDPs), creates employment opportunities, and supports the development of essential infrastructure such as roads, housing, schools, hospitals, and commercial spaces. As urbanization and population growth continue to rise, particularly in developing countries, the demand for new construction is expected to increase substantially over the coming decades. This expansion, while necessary for societal progress, poses serious environmental challenges that must be urgently addressed.

Despite its economic and social importance, the construction industry is one of the most resource-intensive and environmentally damaging sectors globally. Construction activities consume immense quantities of natural resources including timber, minerals, fossil fuels, and freshwater. According to global estimates, the industry is responsible for approximately 36% of global final energy use and nearly 40% of energy-related carbon dioxide (CO_2) emissions. These figures include both the operational phase of buildings and the embodied energy used in producing construction materials like cement, steel, and glass. Cement production alone accounts for around 8% of global CO_2 emissions.

In addition to energy consumption and greenhouse gas emissions, the construction industry contributes significantly to land degradation and biodiversity loss. Large-scale infrastructure projects often require clearing of vegetation, excavation, and alteration of natural landscapes, leading to habitat destruction and fragmentation. Urban sprawl associated with construction also intensifies pressure on surrounding ecosystems. Furthermore, construction activities generate high levels of dust, noise, and other pollutants, which negatively impact air and water quality and pose risks to both human and environmental health.

Waste generation is another pressing issue. Construction and demolition activities produce vast quantities of solid waste, including concrete, bricks, wood, metals, and plastics. In many regions, the majority of this waste ends up in landfills, adding to the strain on waste management systems. Poorly managed construction sites may also lead to soil erosion, sedimentation of water bodies, and the release of hazardous materials such as asbestos or lead-based paints.

The cumulative impact of these environmental challenges necessitates a comprehensive understanding of the construction industry's ecological footprint. As the world moves toward more sustainable development pathways, guided by frameworks such as the United Nations Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action), the construction sector must play a proactive role in reducing its environmental burden.

There is a growing body of research and policy interest in promoting sustainable construction practices, including the use of eco-friendly materials, energy-efficient building designs, recycling and reuse of materials, and adoption of green certification systems such as LEED and BREEAM. However, significant gaps remain in understanding the full environmental impacts across the lifecycle of construction activities—from raw material extraction to demolition.

This study seeks to address these gaps by systematically assessing the environmental impact of construction activities and exploring insights that can inform both environmental science and sustainable development policies. By identifying key drivers of environmental harm and proposing practical, evidence-based solutions, the research aims to support a transition toward a more sustainable built environment.

B. Research Problem

The construction industry, while essential to economic growth and infrastructure development, poses significant and complex environmental challenges that are often inadequately addressed. Its operations-from raw material extraction to on-site activities and eventual demolition have far-reaching ecological consequences. These include high energy consumption, carbon emissions, resource depletion, habitat destruction, and substantial waste generation. However, despite the scale of these impacts, there remains a notable gap in how comprehensively they are assessed, understood, and managed.

One key issue is the lack of consistent, standardized methods for evaluating the environmental footprint of construction activities across different contexts and regions. Many existing studies focus narrowly on individual components—such as energy use or emissions—without considering the full lifecycle impact of buildings and infrastructure. As a result, critical interdependencies between materials, design choices, and environmental consequences are overlooked. This fragmented approach limits the ability of governments, developers, and policymakers to implement effective, evidence-based mitigation strategies.

Moreover, rapid urbanization and rising construction demands in emerging economies often outpace the development and enforcement of environmental regulations. In many cases, environmental assessments are either not conducted at all, or are treated as formalities rather than essential planning tools. This lack of robust assessment and enforcement allows unsustainable practices to persist, exacerbating environmental degradation and undermining long-term development goals.

Understanding and addressing the environmental impact of the construction industry is therefore not only an academic exercise but a critical necessity for sustainable development. Without accurate data and comprehensive impact assessments, the industry will continue to contribute disproportionately to global environmental problems, including climate change and resource scarcity.

This research seeks to bridge that gap by assessing the full environmental implications of construction activities, identifying high-impact areas, and proposing practical strategies for sustainable building practices. Through this approach, the study aims to support more informed decision-making and promote a balance between economic development and environmental protection.

LITERATURE REVIEW

Environmental economic practices, outlined by Nascimento et al. (2019) and Uduji et al. (2019), are the implementation of sustainable construction methods that minimize adverse environmental effects, such as cutting down on waste and emissions and optimizing the use of resources, like water and energy. In a similar vein, **[12]** assert that environmental economic practices entail integrating environmental factors into the construction project decision-making process, such as taking into account the environmental impacts of materials over their lifecycle and designing buildings for energy efficiency. Adopting circular economy concepts, such as material reuse and recycling and waste reduction via prefabrication and modular construction techniques, is another aspect of environmental economic practices **[14].** Although there are different definitions, the paradigm suggests that environmental economic practices in building entail using sustainable methods to reduce adverse environmental effects, maximize resource efficiency, and foster social and economic advantages. Green economy, sustainable development, ecological economics, green growth, environmental management, low-carbon economy, circular economy, sustainable resource management, green infrastructure, environmental stewardship, and a number of other terms have recently been used interchangeably with environmental economic practices. (Fitriani & Ajayi, 2022; Mistri et al., 2020; Oke et al., 2019; Tokbolat et al., 2020; Khan, Ali, et al., 2021; Khan, Razzaq, et al., 2021).

Numerous factors influence the shift toward the adoption of environmental economic practices **[34].** Nonetheless, the term "drivers" is interpreted differently by many academics. According to **[44],** from the standpoint of green building, drivers are factors that influence people to embrace particular green building practices. These factors could be decisions, actions, or possible advantages that motivate people to take part in the adoption of sustainable building practices. Additionally, **[33]**contend that drivers have enabling and beneficial impacts that advance a certain field or environment. These drivers can be any number of things that promote and support a specific result or behavior, including laws, technological advancements, and societal trends. Accordingly, the government is one of the most important forces behind the implementation of environmental economic practices **[45].** Through the implementation of policies that create a regulatory framework, including standard legislation rules and assessment systems, the government can promote and incentivise the adoption of sustainable practices. This helps create a more sustainable economy and lessens the influence on the environment (Khan et al., 2020; Khan et al., 2022; Oke et al., 2019; Thangamani et al., 2022; Tokbolat et al., 2020). Furthermore, by offering financial incentives, the government may significantly aid in the adoption of sustainable practices and technologies. These incentives, which can assist defray the costs of adopting sustainable practices or investing in new sustainable technologies, might come in the form of tax breaks, grants, low-interest loans, and subsidies **[21].**

According to reports, very few private developers and contractors make an effort to think about the environment and develop the idea of recycling building materials **[42]** because the majority of them prioritize completion time and give the environment little thought**[30].** According to **[61],** project managers in particular need to raise their level of expertise and awareness about the environmental effects of construction operations. At this point, **[53]**concurred with **[61]**and asserted that improving the identification of the primary environmental consequences of construction processes will contribute to the enhancement of environmental management systems' efficacy. Regretfully, developing nations suffer from a lack of scientific information regarding the environmental effects of building materials and technology, making it challenging to make well-informed decisions intended to lessen those effects. (Kotak and Pittet, 2009). **Table - 1** summarizes some of the drivers for the adoption of environmental economic practices based on existing studies.

TABLE 1. Drivers for the adoption of environmental economic practices.

Code	Drivers	Literature sources
D1.	Access to financing	Li et al. (2019); Oke et al. (2019); Fathalizadeh et al. (2022)
D2.	Advancements in green building technologies	Li et al. (2019); Oke et al. (2019); Fathalizadeh et al. (2022)
D3.	Carbon pricing and taxes	Li et al. (2019); Oke et al. (2019); Fathalizadeh et al. (2022)
D4.	Collaboration and partnerships for sustainability	Akinshipe et al. (2019); Oke et al. (2019); Fathalizadeh et al. (2022)
D5.	Community engagement and participation	Akinshipe et al. (2019); Oke et al. (2019); Fathalizadeh et al. (2022)
D6.	Corporate sustainability reporting	Li et al. (2019); Oke et al. (2019); Tokbolat et al. (2020)

D7.	Cost savings from energy efficiency	Aghimien, Aigbavboa, et al. (2018); Aghimien, Aghimien, et al. (2018); Akinshipe et al. (2019); Li et al. (2019)
D8.	Creation of certification programs	Tunji-Olayeni et al., (2018); Akinshipe et al. (2019); Li et al. (2019)
D9.	Digitalization and data-driven decision-making	Tunji-Olayeni et al., (2018); Akinshipe et al. (2019); Li et al. (2019)

Source: Ayodeji Emmanuel Oke (2023)

Objectives of the Study

The main purpose of this study is to investigate and assess the environmental impact of the construction industry, with a particular focus on the lifecycle of construction processes and their contribution to environmental degradation.

Research Designs

This study will adopt a **mixed-methods research approach**, combining both qualitative and quantitative methods to provide a comprehensive understanding of the environmental impacts of construction. The quantitative component will focus on data analysis using Life Cycle Assessment (LCA), carbon footprint calculations, and waste estimates, while the qualitative component will explore stakeholder perspectives, policy gaps, and case studies through interviews and document analysis.

The Statistical Package for the Social Sciences (SPSS) was used to analyze the respondents' demographic data using frequency and percentage. To do this, the data had to be entered into the SPSS software, which processed it and produced output tables and charts that displayed the frequency and percentage distribution of the demographic characteristics. These statistical tools offer crucial background information for evaluating the study's findings and drawing perceptive inferences by making it simpler to identify trends, patterns, and significant characteristics in the sample population. Given the wide range of occupations of the respondents, the differences in ratings of the variables in section two were analyzed using statistical tests like the chi-square ($\chi 2$), Kendall's coefficient of concordance (W), and the Kruskal–Wallis H test (K–W). Exploratory factor analysis (EFA) was used to break down the variables into smaller, easier-to-manage subscales. This stage was essential since dividing the variables into smaller subscales allows for a more concise analysis, and some of the components might have similar loading patterns. The study's validity was ensured by carefully examining the Kaiser-Meyer-Olkin (KMO) value, Bartlett test of sphericity (BTS), p-values, communality values, and sample size prior to conducting the EFA.

Life Cycle Assessment (LCA) and the Role of Sustainable Construction in Reducing Environmental Impacts

A well-known technique for assessing the environmental effects of a product's life cycle, including extraction and processing of raw materials, manufacture, distribution, use, and recycling or disposal at the end of its useful life, is life cycle assessment, or LCA. LCA offers a thorough framework for calculating the environmental impact of infrastructure, buildings, and building materials in the context of the construction sector. LCA assists in finding ways to lessen resource depletion, greenhouse gas emissions, energy use, and other environmental costs by examining every stage of a building's life cycle.

One of the biggest users of natural resources, the construction industry also plays a major role in global environmental problems such waste production, pollution, and climate change. Nearly 40% of the world's energy consumption and a significant portion of carbon dioxide (CO_2) emissions come from buildings alone. As a result, there is now more interest in environmentally friendly building techniques that preserve economic feasibility, functionality, and safety.

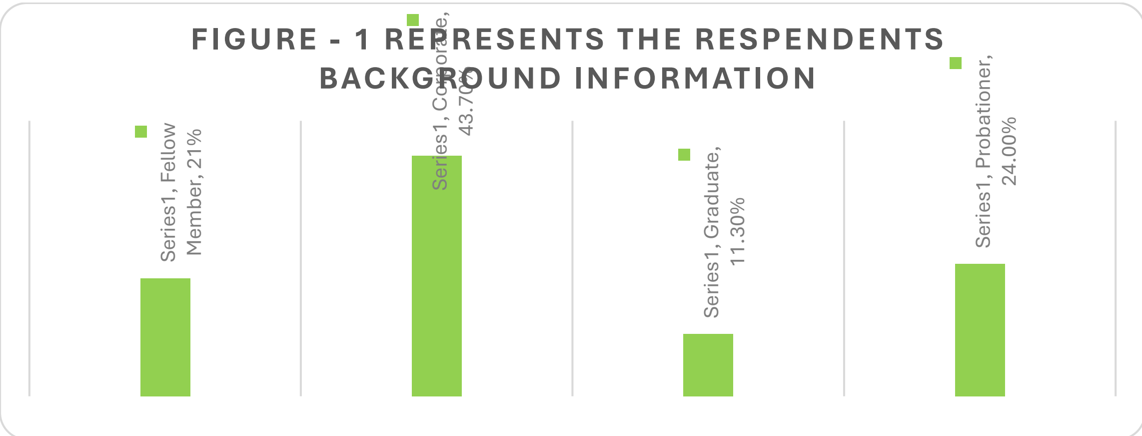
Using eco-friendly materials is a crucial part of sustainable construction. These consist of low-embodied carbon items, recovered or recycled materials, and renewable resources like bamboo or wood from forests that are managed responsibly. These materials frequently lead to decreased emissions during manufacture and transportation, which in turn lessens the demand for virgin resources. Architects, engineers, and developers can make well-informed decisions by using life cycle assessment (LCA) technologies to objectively compare the environmental profiles of various materials.

Green building technologies are essential for lowering a building's environmental impact, in addition to material choices. Green roofs, rainwater harvesting systems, solar panels, energy-efficient Heating, ventilation, and air conditioning (HVAC) ~~HVAC~~ systems, and smart building automation are some

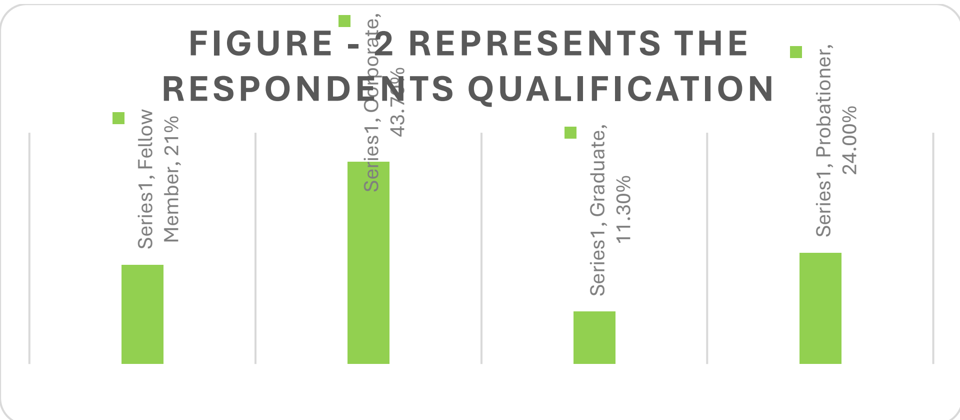
examples of these technologies. Such technologies can drastically minimize operating energy consumption and water usage when integrated early in the design phase, hence minimizing the building's life cycle impacts. By simulating and evaluating these systems' long-term environmental performance benefits, life cycle assessment (LCA) facilitates this integration.
Additionally, the application of LCA-based metrics to assess building performance is frequently a part of the adoption of certification systems such as Leadership in Energy and Environmental Design (LEED) LEED (Leadership in Energy and Environmental Design), Building Research Establishment Environmental Assessment Method (BREEAM) BREEAM (Building Research Establishment Environmental Assessment Method), and other green building standards. These systems promote the use of design techniques that lower carbon emissions, enhance resource efficiency, and improve indoor environmental quality.

In summary, the use of Life Cycle Assessment techniques in the building industry offers important new perspectives on how design, material choices, and building technologies affect the environment. By focusing on sustainability over the course of a building's existence, life cycle assessment (LCA) promotes more responsible and knowledgeable decision-making. Combining life cycle assessment (LCA) with green building technology and sustainable building materials provides a workable solution to lessen the built environment's ecological impact as resource shortages and climate change become more pressing issues.

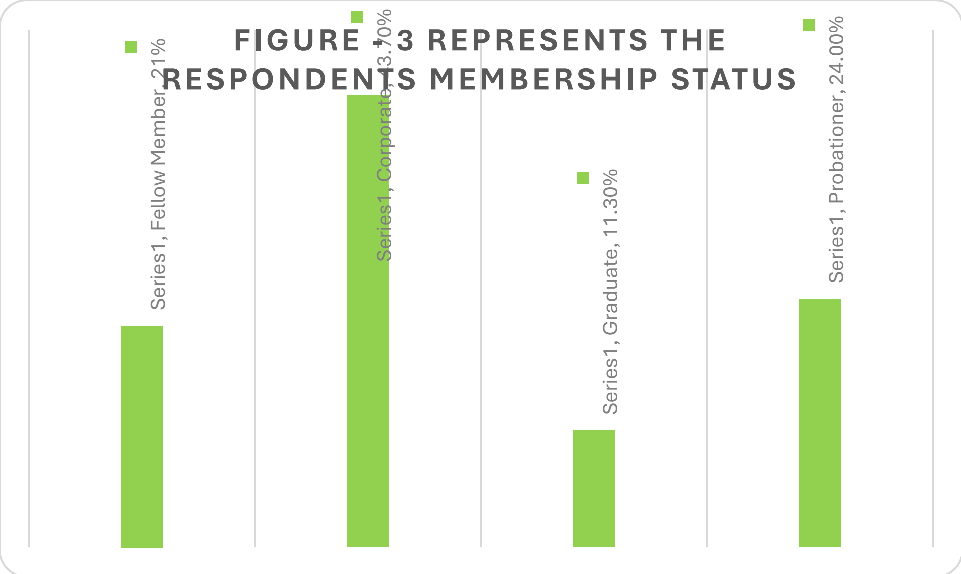
RESULTS AND DISCUSSION



According to the respondents' background information, engineers made up the majority (36%), followed by architects (28.8%), quantity surveyors (19.2%), and builders (16.5%). This indicates that experts with backgrounds in engineering, architecture, quantity surveying, and construction make up the majority of the survey sample; as a result, their opinions and feedback may offer insightful information about the drivers.



The respondents' educational backgrounds varied, with the majority having a master's degree (37.7%), followed by a bachelor's degree (21.5%), a doctorate (9.2%), and an Diploma (31 %). This variety of credentials indicates that the poll participants were highly qualified individuals from a range of backgrounds, and their opinions may also provide insightful information.



According to the survey's findings, 30.7% of participants were corporate members of their respective professional associations, followed by colleague members (19.3%), probationers (26.7%), and graduates (23.3%). According to the study's findings, the participants had sufficient professional and academic background as well as a wealth of work experience to add to the conversation regarding the factors that influence environmentally friendly business practices in the construction sector. Respondents reported varying levels of work experience: 29.1% with 1-5 years, 35.8% with 6-10 years, 14.6% with 11-15 years, 11.9% with 16-20 years, and 8.6% with over 20 years.

Key Drivers for Environmental Economic Practices Adoption for Sustainable Development

In this table, we can see the averages, ranges, and rankings of the many factors that have an impact on the spread of green economic policies. Based on their evaluations, respondents ranked the drivers' relevance using the mean scores; higher means indicated a larger perceived influence.

Top Driven Key Factors:

With a mean score of 4.01 and a relatively low standard deviation (0.654), cost savings from energy efficiency (D7) ranks top. This suggests that individuals strongly believe that cutting costs through energy efficiency is the most important factor for adopting environmental economic practices.

As a result of rounding or presentation order, "Collaboration and Partnerships for Sustainability" (D4) ranked second with a mean of 4.05, marginally higher than "D7," but still placed second. This exemplifies the importance of group initiatives in promoting long-term fiscal policies.

The significance of regulatory frameworks in promoting environmental economic actions is highlighted by the fact that Green building codes and standards (D14) and Energy and resource efficiency (D11) both rank third with means of 3.91 and 4.02, respectively.

Mid Ranked Drivers:

Ranking fifth, sixth, and seventh, respectively, are drivers such as Sustainable materials and products (D20), Innovation and adoption of renewable energy sources (D18), and Improved risk management and long-term value (D16). It appears that these aspects are not as important as direct cost and efficiency improvements, although they are nonetheless crucial.

Also scoring in the middle of the pack are environmental policies and regulations (D9) and availability to financing (D12), suggesting that regulatory backing and financial accessibility are significant but not the primary determinants.

Lower Ranked Drivers:

With mean scores below 3.0, factors including Sustainable supply chain management practices (D21), Carbon pricing and taxes (D3), Advancements in green construction technology (D2), and Government incentives and subsidies (D13) are ranked toward the bottom. This suggests that the respondents do not consider these drivers to be very important or influential.

With a mean score of 2.57 and a standard deviation of only 0.412, Sustainable supply chain management practices (D21) stands out as a topic on which there is widespread agreement but little perceived impact on adoption choices.

TABLE 2. Mean rankings of drivers for the adoption of environmental economic practices.

Code	Drivers	Mean ()	Std. deviation (SD)	Rank
D7	Cost savings from energy efficiency	4.01	0.654	1
D4	Collaboration and partnerships for sustainability	4.05	0.888	2
D11	Energy and resource efficiency	4.02	0.761	3
D14	Green building codes and standards	3.91	0.925	3
D16	Improved risk management and long-term value	3.84	1.067	5
D18	Innovation and adoption of renewable energy sources	3.81	0.812	6
D20	Sustainable materials and products	3.77	0.704	7
D9	Environmental regulations and policies	3.75	0.879	8
D12	Accessing to finance	3.71	0.887	9
D1	Digitalization and data-driven decision-making	3.7	0.768	10
D5	Community engagement and participation	3.68	0.933	11
D6	Corporate sustainability reporting	3.64	0.815	12
D23	Water management and conservation	3.62	0.914	13
D10	Efficient transportation and logistics	3.58	0.849	14
D22	Waste reduction and recycling practices	3.51	0.855	14
D15	Growing demand for sustainable buildings	3.58	0.969	16
D19	Stakeholder pressures	3.22	0.851	17
D8	Creation of certification programs	3.13	0.878	18
D17	Increased social and environmental awareness	3.05	0.921	19
D13	Government incentives and subsidies	3	0.904	20
D2	Advancements in green building technologies	2.73	0.993	21
D3	Carbon pricing and taxes	2.71	1.032	22
D21	Sustainable supply chain management practices	2.57	0.412	23

Variability in Respondents:

The standard deviations, which reveal the level of agreement among respondents, ranged from 0.412 to 1.067. A lack of agreement on the significance of these drivers is shown by larger standard deviations, such as Improved risk management and long-term value (1.067).
For drivers with smaller standard deviations, such Sustainable supply chain management techniques (0.412), it appears that most respondents believed that the driver was not very important.

Summary

In general, the findings highlight that the primary motivations for implementing environmental economic practices stem from the monetary gains associated with cooperative sustainability initiatives, resource efficiency, and energy efficiency. Direct savings and partnerships take precedence over regulatory frameworks and innovation, which both play important but secondary roles. Financial incentives, new technology, and supply chain methods are viewed as having less influence, while they are nevertheless acknowledged.

By putting an emphasis on cost-cutting measures, collaboration, and efficiency improvements, these insights can assist policymakers and industry stakeholders in effectively prioritizing policies to promote sustainable economic practices.

TABLE 3. Kruskal–Wallis H test and the Kendall W test.

K–W test	Results
$\chi 2$	7.476
p-value	0.052
Kendall's W	
N	75
Kendall's Wa	0.073
$\chi 2$ calculated value	352.571
$\chi 2$ critical value obtained from Table	51.871
Df	36
Asymp. Sig	0

Source: SPSS

Kruskal–Wallis H test:

The Kruskal–Wallis H test statistic (χ^2) is **7.476** with an associated **p-value of 0.052**.Since the p-value (0.052) is slightly above the common significance threshold of 0.05, the test indicates that there is **no statistically significant difference** among the groups compared at the 5% significance level. In other words, the null hypothesis that the different groups have the same median ranking cannot be rejected. This suggests that respondents' rankings of the drivers (or whatever groups were compared) do not differ significantly.

Kendall's W test:

N = 75 indicates the number of respondents or judges participating in the ranking. **Kendall's W (coefficient of concordance)** is **0.073**, which is quite low. Kendall's W measures the degree of agreement among raters. A value of 1 means perfect agreement, while 0 means no agreement beyond chance. Therefore, 0.073 indicates **very weak agreement among respondents** in their rankings. The **calculated χ^2 value (352.571)** is much larger than the **critical χ^2 value (51.871)** at degrees of freedom (df) = 36.The **asymptotic significance (Asymp. sig) is 0**, indicating that the observed agreement (though low) is statistically significant — the rankings are not completely random but still show minimal consensus.

Summary:

The Kruskal–Wallis test suggests no significant difference in median rankings among groups. Kendall's W shows low but statistically significant agreement among respondents on the ranking order. This implies that while respondents differ somewhat in their specific rankings of drivers, there is a statistically meaningful pattern, albeit weak, in how these drivers are perceived overall.

Principal component analysis (PCA) with varimax rotation was employed in this study's exploratory factor analysis (EFA). This method is widely used and maximizes the variance of the squared loadings of each variable on each factor, leading to simpler and more interpretable components. A total cumulative variance (TCV) of 73.46% was reached, which is higher than the 50% threshold suggested in prior research (Pallant, 2007). This means that the factors that were extracted explain a significant amount of the data variance and can be trusted for future analysis. These five critical elements account for about 72% of the drivers for the adoption of environmental economic practices, according to the derived TCV. An analysis of the variables contained in each cluster reveals a strong component structure, as demonstrated in Table 4, where factor loadings of 0.50 or higher are observed. The names of the groupings were changed to more accurately represent the main factors that influence the adoption of environmental economic practices, taking into account the hidden commonalities among the variables in each cluster.

Table 4 Results of Factor Analysis

Cluster naming	Items loaded	Factor loadings	Eigen values	% of variance	Cumulative % of the variance	Number of extracted factors
1. Operational drivers	Energy and resource efficiency	0.951	13.265	52.011	52.011	5
	Waste reduction and recycling practices	0.872				
	Efficient transportation and logistics	0.76				
	Water management and conservation	0.702				
	Sustainable supply chain management practices	0.622				
2: Stakeholder drivers	Increased social and environmental awareness	0.821	5.441	11.044	64.026	5
	Stakeholder pressures	0.882				
	Collaboration and partnerships for sustainability	0.733				
	Corporate sustainability reporting	0.729				
	Community engagement and participation	0.791				
3: Market and financial drivers	Growing demand for sustainable buildings	0.801	3.2161	9.037	71.295	5
	Cost savings from energy efficiency	0.895				
	Access to financing	0.744				
	Improved risk management and long-term value	0.701				
	Creation of certification programs	0.751				
Cluster 4: Regulatory and policy drivers	Environmental regulations and policies	0.733	3.711	5.014	77.261	4
	Government incentives and subsidies	0.714				
	Green building codes and standards	0.691				
	Carbon pricing and taxes	0.628				
5: Technological drivers	Advancements in green building technologies	0.727	1.046	3.011	80.46	4
	Innovation and adoption of renewable energy sources	0.711				
	Sustainable materials and products	0.691				
	Digitalization and data-driven decision-making	0.648				

Source: Principal component analysis (PCA) using SPSS

This table presents the results of a **factor analysis** used to group related drivers of environmental economic practices into **five distinct clusters**. Each cluster consists of variables (or "items loaded") that load heavily onto a common underlying factor, suggesting they are conceptually related. Key metrics include **factor loadings**, **eigenvalues**, **percent variance explained**, and **cumulative variance**.

Cluster 1: Operational Drivers

This is the **most significant cluster**, explaining over half of the total variance in the data. These drivers focus on operational improvements that reduce resource consumption and enhance logistical efficiency. High factor loadings indicate a strong association with the operational performance of environmentally sustainable practices.

Cluster 2: Stakeholder Drivers

This cluster represents drivers related to **external influences and social expectations**, including engagement from communities, pressure from stakeholders, and transparency. The moderately high loadings suggest these social and relational factors are also key motivators for adopting sustainable practices.

Cluster 3: Market and Financial Drivers

These are **economic and market-based incentives** that influence environmental adoption, such as cost reduction, access to funds, and increased demand. High factor loadings reinforce that financial viability remains a strong motivator.

Cluster 4: Regulatory and Policy Drivers

This cluster includes **external policy mechanisms and governmental regulations**. While they are influential, the lower variance suggests these are less dominant compared to operational or market drivers, though still relevant.

Cluster 5: Technological Drivers

Technological innovations are grouped here. Despite being important for long-term transformation, they contribute the least variance among the clusters, suggesting they are **less immediate drivers** compared to financial or operational factors.

Overall Insights:

The five clusters together explain **80.46% of the total variance**, indicating a strong model for understanding the underlying structure of drivers.The **Operational drivers (Cluster 1)** are the most influential, followed by **Stakeholder** and **Market/Financial drivers.Technological and Regulatory drivers**, while important, appear to play **secondary roles** in motivating environmental economic practices, possibly due to longer implementation times or indirect effects.

CONCLUSION AND RECOMMENDATIONS

This study assessed the environmental impact of the construction industry using Life Cycle Assessment (LCA) methodologies and explored the key drivers influencing the adoption of environmental economic practices. The findings underscore the construction sector's significant contribution to environmental degradation, including high energy consumption, carbon emissions, and material waste. However, the analysis also reveals promising opportunities for mitigation through operational improvements, stakeholder engagement, financial incentives, regulatory measures, and technological advancements.

Factor analysis identified five major clusters of drivers—**Operational**, **Stakeholder**, **Market and Financial**, **Regulatory and Policy**, and **Technological**—with operational drivers such as energy efficiency and waste reduction emerging as the most influential. The Kruskal–Wallis and Kendall's W tests suggest limited but statistically significant agreement among respondents regarding the relative importance of these drivers. This indicates a shared, though not unanimous, understanding of the key levers for sustainable transformation in construction practices.

Recommendations

1. **Prioritize Energy and Resource Efficiency -** Policymakers and construction stakeholders should place greater emphasis on operational efficiency—especially energy and resource optimization—as these offer immediate environmental and financial benefits. Incentivizing best practices in energy management and circular construction methods can drive widespread adoption.
2. **Strengthen Multi-Stakeholder Collaboration -** Encouraging partnerships between government bodies, private developers, communities, and NGOs can enhance the social acceptance and effectiveness

of sustainability initiatives. Stakeholder involvement also supports knowledge sharing and community-led innovation.

3. **Leverage Market-Based Incentives** - Cost savings and market demand for green buildings are powerful motivators. Expanding access to green financing, sustainable building certifications, and risk reduction programs can make environmentally responsible practices more attractive and feasible for developers.

4. **Enhance Regulatory Frameworks** - Governments should reinforce existing policies and introduce clear, enforceable green building codes, environmental standards, and tax incentives. Regulatory consistency is critical for guiding industry-wide change and ensuring accountability.

5. **Accelerate Technological Integration** - Investments in green technologies—such as smart building systems, renewable energy integration, and digital design tools—should be supported through research funding and pilot programs. Despite currently being underutilized, these innovations have the potential to significantly reduce life cycle impacts in the long term.

6. **Promote LCA in Decision-Making** - Embedding Life Cycle Assessment into project planning, design, and procurement processes ensures that environmental considerations are integrated from the outset. Training professionals in LCA use and interpretation can improve its application across the industry.

To move toward a sustainable construction future, a balanced approach that integrates economic, environmental, and technological strategies is essential. By aligning policy, practice, and innovation, the construction industry can play a pivotal role in achieving global sustainability and climate goals.

REFERENCE

1.Adekunle, S. A., Ejohwomu, O., & Aigbavboa, C. O. (2021). Building information modelling diffusion research in developing countries: A user meta-model approach. Buildings, **11**(7), 264.

2.Aghimien, D., Aigbavboa, C., Meno, T., & Ikuabe, M. (2021). Unravelling the risks of construction digitalization in developing countries. Construction Innovation, **21**(3), 456–475.

3.Aghimien, D. O., Aghimien, E. I., Fadiyimu, A. O., & Adegbembo, T. F. (2018). Survival strategies of built environment organisations in a challenging economy. Engineering, Construction and Architectural Management, **25**(7), 861–876. **https://doi.org/10.1108/ECAM-06-2017-0106**

4.Aghimien, D. O. C., Aigbavboa, O., Oke, A. E., & Musenga, C. (2018). Barriers to sustainable construction practices in the Zambian construction industry. Proceedings of the international conference on industrial engineering and operations management, 2383–2392.

5.Aigbavboa, C., Ohiomah, I., & Zwane, T. (2017). Sustainable construction practices: "A lazy view" of construction professionals in the South Africa construction industry. Energy Procedia, **105**, 3003–3010.

6.Akinradewo, O., Aigbavboa, C., Aghimien, D., Oke, A., & Ogunbayo, B. (2021). Modular method of construction in developing countries: The underlying challenges. International Journal of Construction Management, **23**(8), 1344–1354. **https://doi.org/10.1080/15623599.2021.1970300**

7.Akinshipe, O., Oluleye, I. B., & Aigbavboa, C. (2019). Adopting sustainable construction in Nigeria: Major constraints. In IOP conference series: Materials science and engineering (Vol. **640**, 012020). IOP Publishing.

8.Ali, A. H., Kineber, A. F., Elyamany, A., Ibrahim, A. H., & Daoud, A. O. (2023). Identifying andassessing modular construction implementation barriers indeveloping nations for sustainable building development. Sustainable Development, 1–19. **https://doi.org/10.1002/sd.2589**

9.Ametepey, O., Aigbavboa, C., & Ansah, K. (2015). Barriers to successful implementation of sustainable construction in the Ghanaian construction industry. Procedia Manufacturing, **3**, 1682–1689.

10. Ayarkwa, J., Acheampong, A., Wiafe, F., & Boateng, B. E. (2017). Factors affecting the implementation of sustainable construction in Ghana: The architects perspective.

11. Cook, L. M., & Larsen, T. A. (2021). Towards a performance-based approach for multifunctional green roofs: An interdisciplinary review. Building and Environment, **188**, 107489.

12. Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approach. Sage Publications.

13. Dano, U. L., Balogun, A. L., Abubakar, I. R., & Aina, Y. A. (2020). Transformative urban governance: Confronting urbanization challenges with geospatial technologies in Lagos, Nigeria. GeoJournal, **85**, 1039–1056.

14. Darko, A., Zhang, C., & Chan, A. P. (2017). Drivers for green building: A review of empirical studies. Habitat International, **60**, 34–49.

15. David, V. E., John, Y., & Hussain, S. (2020). Rethinking sustainability: A review of Liberia's municipal solid waste management systems, status, and challenges. Journal of Material Cycles and Waste Management, **22**, 1299–1317.

16. Ebekozien, A., Aigbavboa, C., & Samsurijan, M. S. (2023). An appraisal of blockchain technology relevance in the 21st century Nigerian construction industry: Perspective from the built environment professionals. Journal of Global Operations and Strategic Sourcing, **16**(1), 142–160.

17. Eze, E. C., Awodele, I. A., & Egwunatum, S. I. (2021). Labour–specific factors influencing the volume of construction waste generation in the construction industry. Journal of Project Management Practice, **1**(2), 1–16.

18. Fareed, Z., Abbas, S., Madureira, L., & Wang, Z. (2022). Green stocks, crypto asset, crude oil and COVID19 pandemic: Application of rolling window multiple correlation. Resources Policy, **79**, 102965.
19. Fathalizadeh, A., Hosseini, M. R., Vaezzadeh, S. S., Edwards, D. J., Martek, I., & Shooshtarian, S. (2022). Barriers to sustainable construction project management: The case of Iran. Smart and Sustainable Built Environment, **11**(3), 717–739.
20. Fayomi, O. S. I., Esse, U. C., Fakehinde, O. B., Onakwai, A. O., Oluwasegun, K. M., & Jen, T. C. (2022). Productivity index of the Nigeria power sector. In AIP conference proceedings (Vol. **2437**, 020178). AIP Publishing LLC.
21. Fellows, R. R., & Liu, A. (2008). Research methods for construction (3rd ed.). Wiley- Blackwell Science.
22. Field, A. (2005). Discovering statistics using SPSS (introducing statistical methods) (Vol. 3). SAGE Publications.
23. Fitriani, H., & Ajayi, S. (2022). Barriers to sustainable practices in the Indonesian construction industry. Journal of Environmental Planning and Management, 1–23. **https://doi.org/10.1080/09640568.2022.2057281**
24. Iqbal, M., Ma, J., Ahmad, N., Hussain, K., Usmani, M. S., & Ahmad, M. (2021). Sustainable construction through energy management practices in developing economies: An analysis of barriers in the construction sector. Environmental Science and Pollution Research, **28**, 34793–34823.
25. Ifije, O., & Aigbavboa, C. (2020). Identifying barriers of sustainable construction: A Nigerian case study. In MATEC web of conferences (Vol. 312, p. 04004). EDP Sciences.
26. Joensuu, T., Edelman, H., & Saari, A. (2020). Circular economy practices in the built environment. Journal of Cleaner Production, **276**, 124215.
27. Khan, S. A. R., Razzaq, A., Yu, Z., & Miller, S. (2021). Industry 4.0 and circular economy practices: A new era business strategies for environmental sustainability. Business Strategy and the Environment, **30**(8), 4001–4014.
28. Khan, Z., Ali, S., Dong, K., & Li, R. Y. M. (2021). How does fiscal decentralization affect CO2 emissions? The roles of institutions and human capital. Energy Economics, **94**, 105060.
29. Khan, Z., Badeeb, R. A., & Nawaz, K. (2022). Natural resources and economic performance: Evaluating the role of political risk and renewable energy consumption. Resources Policy, **78**, 102890.
30. Khan, Z., Hossain, M. R., Badeeb, R. A., & Zhang, C. (2023). Aggregate and disaggregate impact of natural resources on economic performance: Role of green growth and human capital. Resources Policy, **80**, 103103.
31. Khan, Z., Hussain, M., Shahbaz, M., Yang, S., & Jiao, Z. (2020). Natural resource abundance, technological innovation, and human capital nexus with financial development: A case study of China. Resources Policy, **65**, 101585.
32. Li, Y., Ding, R., & Sun, T. (2019). The drivers and performance of environmental practices in the Chinese construction industry. Sustainability, **11**(3), 614.
33. Loosemore, M., & Lim, B. T. H. (2017). Linking corporate social responsibility and organizational performance in the construction industry. Construction Management and Economics, **35**(3), 90–105.
34. Luo, F., Guo, Y., Yao, M., Cai, W., Wang, M., & Wei, W. (2020). Carbon emissions and driving forces of China's power sector: Input-output model based on the disaggregated power sector. Journal of Cleaner Production, **268**, 121925.
35. Ma, W., Hao, J. L., Zhang, C., Di Sarno, L., & Mannis, A. (2023). Evaluating carbon emissions of China's waste management strategies for building refurbishment projects: Contributing to a circular economy. Environmental Science and Pollution Research, **30**(4), 8657–8671.
36. Mistri, A., Bhattacharyya, S. K., Dhami, N., Mukherjee, A., & Barai, S. V. (2020). A review on different treatment methods for enhancing the properties of recycled aggregates for sustainable construction materials. Construction and Building Materials, **233**, 117894.
37. Moser, C. A., & Kalton, G. (1999). Survey methods in social investigation (2nd ed.). Gower Publishing Company.
38. Nascimento, D. L. M., Alencastro, V., Quelhas, O. L. G., Caiado, R. G. G., Garza-Reyes, J. A., Rocha-Lona, L., & Tortorella, G. (2019). Exploring industry 4.0 technologies to enable circular economy practices in a manufacturing context: A business model proposal. Journal of Manufacturing Technology Management, **30**(3), 607–627.
39. National Bureau of Statistics (NBS). (2021). Annual abstract on statistics, summary of survey findings, 87–94.
40. Oke, A., Aghimien, D., Aigbavboa, C., & Musenga, C. (2019). Drivers of sustainable construction practices in the Zambian construction industry. Energy Procedia, **158**, 3246–3252.
41. Oke, A. E., Aliu, J., Fadamiro, P. O., Akanni, P. O., & Stephen, S. S. (2023). Attaining digital transformation in construction: An appraisal of the awareness and usage of automation techniques. Journal of Building Engineering, **67**, 105968.
42. Oke, A. E., & Arowoiya, V. A. (2021). Evaluation of internet of things (IoT) application areas for sustainable construction. Smart and Sustainable Built Environment, **10**(3), 387–402.
43. Pallant, J. (2007). SPSS survival manual: A step-by-step guide to data analysis using SPSS version 15 (3rd ed.). Open University Press.
44. Pim-Wusu, M., Aigbavboa, C., & Thwala, W. D. (2023). Adaptability capacity framework for sustainable practices in the Ghanaian construction industry. Built Environment Project and Asset Management, **13**(1), 89–104.
45. Pirouz, B., Palermo, S. A., & Turco, M. (2021). Improving the efficiency of green roofs using atmospheric water harvesting systems (an innovative design). Water, **13**(4), 546.
46. Porwal, A., Parsamehr, M., Szostopal, D., Ruparathna, R., & Hewage, K. (2023). The integration of building information modeling (BIM) and system dynamic modeling to minimize construction waste generation from change orders. International Journal of Construction Management, **23**(1), 156–166.
47. Sari, A., Iswahyuni, D., Rejeki, S., & Sutanto, S. (2020). Google forms as an EFL assessment tool: Positive features and limitations.
48. Seedat-Khan, M., Ogunsola, V. I., Okocha, R. O., Owoyomi, A. V., & Ramnund-Mansingh, A. (2023). Sustainable wastewater management: An imperative for urban development in Lagos, Nigeria. Sustainable Development.
49. Suzer, O. (2019). Analyzing the compliance and correlation of LEED and BREEAM by conducting a criteria-based comparative analysis and evaluating dual-certified projects. Building and Environment, **147**, 158–170.
50. Tabachnick, B. G., & Fidell, L. S. S. (2007). Using multivariate statistics (5th ed.). Allyn & Bacon.

51. Thangamani, A., Ganesh, L. S., Tanikella, A., & Prasad, A. M. (2022). Issues concerning IoT adoption for energy and comfort management in intelligent buildings in India. Intelligent Buildings International, **14**(1), 74–94.
52. Tokbolat, S., Karaca, F., Durdyev, S., & Calay, R. K. (2020). Construction professionals' perspectives on drivers and barriers of sustainable construction. Environment, Development and Sustainability, **22**, 4361–4378.
53. Toriola-Coker, L. O., Alaka, H., Bello, W. A., Ajayi, S., Adeniyi, A., & Olopade, S. O. (2021). Sustainability barriers in Nigeria construction practice. IOP Conference Series: Materials Science and Engineering, **1036**, 012023.
54. Tunji-Olayeni, P. F., Mosaku, T. O., Oyeyipo, O. O., & Afolabi, A. O. (2018). Sustainability strategies in the construction industry: Implications on green growth in Nigeria. In IOP conference series: Earth and environmental science (Vol. 146, No. 1, p. 012004). IOP Publishing.
55. Tulebayeva, N., Yergobek, D., Pestunova, G., Mottaeva, A., & Sapakova, Z. (2020). Green economy: Waste management and recycling methods. In E3S web of conferences (Vol. **159**, 01012). EDP Sciences.
56. Uduji, J. I., Okolo-Obasi, E. N., & Asongu, S. A. (2019). Corporate social responsibility and the role of rural women in sustainable agricultural development in sub-Saharan Africa: Evidence from The Niger Delta in Nigeria. Sustainable Development, **27**(4), 692–703.
57. Ukenna, S., Nkamnebe, A., & Idoko, E. (2019). Inhibitors of sustainable consumption: Insights from university academic staff in southern Nigeria. Sustainable Development, **27**(1), 96–108.
58. Wang, N. (2014). The role of the construction industry in China's sustainable urban development. Habitat International, **44**, 442–450.
59. Wassie, S. B. (2020). Natural resource degradation tendencies in Ethiopia: A review. Environmental Systems Research, **9**, 1–29.
60. Yamane, T. (1967). Statistics, an introductory analysis (2nd ed., p. 886). Harper and Row.