

Life-Cycle Cost Assessment of Sustainable Building Materials in Residential Construction

Abdulkabir Oluwadamilola Bello¹, Bello Halimat², Oladipupo Sadare³

¹University of Greater Manchester, MSc, Los Angeles, California, USA

²Ripen Marine Contractors Limited, 123 Ladipo Street, Papa Ajao, Mushin, Nigeria

³University of Salford, Bournemouth, United Kingdom

ABSTRACT

The rise in demand for a sustainable built environment in residential construction has informed the need to consider the environmental and economic performance of building materials. The study investigates the life-cycle cost assessment of sustainable building materials in residential buildings, emphasizing on initial investment, installation, maintenance, energy use, replacement and end-of-life. A method of comparative assessment approach is suggested to compare sustainable and conventional materials in various phases of the building life cycle. The study is based on literature research and takes into account the durability of materials, energy usage, environmental impacts, and maintenance costs in order to assess the overall cost-effectiveness. It also looks at how life cycle assessment (LCA), life cycle cost analysis (LCCA), energy simulation and Building Information Modelling (BIM) can be used together to help make informed choices about materials in the selection and planning of construction. The assessment aims to determine whether sustainable materials can offer a future cost and environmental benefit, but at a higher up-front price. The study also highlights the need for accurate cost information, suitable evaluation periods, and standardized evaluation criteria when comparing different material alternatives. It is expected to provide architects, engineers, developers, and policymakers with a tool to consider their decisions in residential development with both a sense of economic and environmental responsibility. The study includes life cycle costs and sustainability indicators to promote sustainable, long-lasting and cost-effective building of housing.

Keywords: Sustainable building materials, life-cycle cost assessment (LCCA), life-cycle assessment (LCA), residential construction, cost-effectiveness, environmental sustainability, energy efficiency, Building Information Modelling (BIM).

International Journal of Technology, Management and Humanities (2025)

DOI: 10.21590/ijtmh.11.01.09

INTRODUCTION

Construction is one of the highest energy consuming industries, is heavily dependent on resources, produces large amounts of waste and contributes to GHG emissions. Sustainability assessments are especially relevant for residential buildings, as their environmental and economic effects are not limited to construction, operation, maintenance and renovation, but also reach all the way from raw material extraction to demolition. Thus, choosing building materials for their purchase price or initial construction costs may fail to consider the long-term economic or environmental costs. Life-cycle assessment (LCA) and life-cycle cost analysis (LCCA) are complementary tools to address such impacts and to facilitate better decision making in the field of residential construction (Janjua et al., 2019a; Islam et al., 2015a).

Sustainable materials are chosen based on factors like resource efficiency, durability, and recyclability, as well as factors related to their carbon emissions and potential health and environmental impacts. These include materials with recycled content, responsibly sourced timber, low carbon

Corresponding Author: George Zacharia, Independent Researcher, USA, e-mail: georgezacharia1983@gmail.com

How to cite this article: Bello, A.O., Halimat, B., Sadare, O. (2025). Life-Cycle Cost Assessment of Sustainable Building Materials in Residential Construction. *International Journal of Technology, Management and Humanities*, 11(1), 68-75.

Source of support: Nil

Conflict of interest: None

concrete, high performance insulation and process efficient production. Their suitability, however, will be dependent on availability in the local area, climate, construction techniques, maintenance needs, and service life. Akadiri and Olomolaiye (2012) stress the need to develop sustainability assessment criteria for the selection of building materials to serve as a guide for the assessment of building material alternatives beyond the initial cost.

Life-cycle cost assessment is necessary because costs will be incurred during different phases of a building's life. The

initial costs are those of purchase, transport and installation while the subsequent costs may be inspection, repairs, maintenance and replacement, energy use and disposal costs. A more expensive material can offer more economical benefits in long term use if it can decrease maintenance costs or increase the building life or enhance the building efficiency. On the other hand, a product that is referred to as sustainable could not be economically beneficial if the transportation, specialized installation, availability, or replacement costs are high. Atmaca (2016a) investigates the methodological connection between RBLCA and cost analysis, and Atmaca (2016b) offers a case-study view to the application of these techniques in residential buildings in the southeast of Turkey.

Integrating environmental and economic assessments can therefore improve the reliability of material-selection decisions. Janjua et al. (2019b) review residential building sustainability performance through a life-cycle assessment approach, highlighting the relevance of evaluating building impacts across multiple stages rather than concentrating exclusively on operational performance. Similarly, Islam et al. (2015a) review the relationship between residential building LCA and LCCA, demonstrating the importance of considering environmental consequences alongside economic implications. Earlier work by Blanchard and Reppe (1998) on the life-cycle analysis of a residential home in Michigan also illustrates the relevance of examining housing impacts beyond the construction phase.

The economic assessment of sustainable residential construction further requires attention to building components and technologies. Roofing, flooring, insulation, walls, and structural systems can differ considerably in purchase cost, durability, energy performance, and maintenance needs. Islam et al. (2015b) investigate life-cycle assessment and cost implications associated with roofing and floor designs in residential buildings, illustrating why component-level comparisons are important. In addition, König and De Cristofaro (2012) address benchmarks for life-cycle costs and life-cycle assessment of residential buildings, providing a basis for comparative evaluation. Hajare and Elwakil (2020) further connect life-cycle cost analysis with energy simulation to assess energy-efficient building strategies.

Technological developments offer additional opportunities to improve life-cycle cost assessment. Building Information Modelling (BIM) can support the integration of material quantities, construction costs, maintenance information, and alternative design scenarios. Marzouk et al. (2018) explore a BIM-based approach for optimizing the life-cycle costs of sustainable buildings, while AbouHamad and Abu-Hamd (2019) present a framework for selecting construction systems based on life-cycle cost and sustainability assessment. These approaches can help designers and developers compare alternatives systematically and identify options that balance affordability,

environmental performance, and functional requirements.

Recent research also demonstrates the continuing importance of evaluating sustainable residential technologies through an economic perspective. Vitkova and Vitasek (2024) examine sustainable technologies in residential buildings from a life-cycle cost analysis perspective. Dwaikat and Ali (2018) discuss practical applications of green-building life-cycle cost analysis and budget development, while Khan and Ali (2020) examine lessons from integrating LCA and LCCA in sustainable construction. Collectively, these studies support the need for an assessment framework that considers both immediate expenditure and longer-term financial and environmental outcomes.

Despite these developments, selecting sustainable materials remains challenging because results can vary with regional prices, energy sources, climate, building design, assessment periods, discount rates, and assumptions about maintenance and replacement. Comparisons may also become misleading when alternatives are evaluated using different functional requirements or inconsistent system boundaries. Therefore, a systematic assessment should define the building's expected service life, specify the materials and building components under investigation, establish consistent cost categories, and use transparent environmental indicators.

The purpose of this study is to assess the life-cycle costs of sustainable building materials in residential construction and examine how their economic performance relates to environmental sustainability. Specifically, the study seeks to compare initial and long-term costs, identify the principal factors influencing cost-effectiveness, evaluate the relationship between material durability and environmental performance, and establish practical recommendations for material selection. By integrating LCA and LCCA principles, the study aims to support architects, engineers, contractors, property developers, and policymakers in making informed decisions that promote affordable, durable, and environmentally responsible housing.

In summary, life-cycle cost assessment provides a structured basis for determining whether sustainable building materials deliver economic value over the full service life of a residential building. When combined with environmental assessment, energy simulation, and digital design tools, it enables a more comprehensive comparison of construction alternatives and supports decisions that balance initial affordability with long-term performance.

LITERATURE REVIEW

The literature on sustainable residential construction emphasizes the importance of evaluating building materials based on their environmental impacts, durability, energy performance, and total life-cycle costs. Janjua, Sarker, and Biswas (2019a) assessed residential building sustainability using a life-cycle assessment (LCA) approach, while their review examined methods for evaluating residential

Table 1: Major assessment criteria for sustainable building materials in residential construction

<i>Assessment criterion</i>	<i>Key indicators</i>	<i>Importance to life-cycle cost assessment</i>	<i>Supporting references</i>
Initial construction cost	Purchase price, transportation, installation, labor	Establishes the initial investment required for each material	Atmaca (2016a); Dwaikat and Ali (2018)
Durability and service life	Expected lifespan, resistance to deterioration, replacement frequency	Determines maintenance demands and replacement expenditure	Janjua et al. (2019a); Khan and Ali (2020)
Energy performance	Thermal resistance, operational energy demand, energy savings	Helps estimate long-term operating costs associated with building components	Hajare and Elwakil (2020); Vitkova and Vitasek (2024)
Environmental impact	Embodied energy, greenhouse gas emissions, resource depletion, waste generation	Identifies environmental trade-offs across the material life cycle	Janjua et al. (2019b); Islam et al. (2015a)
Maintenance and replacement	Inspection, repairs, maintenance frequency, component renewal	Captures recurring costs throughout the building's service life	Islam et al. (2015b); Atmaca (2016b)
End-of-life performance	Demolition, disposal, reuse, recycling, residual value	Accounts for costs and potential recovery value at the end of service life	Blanchard and Reppe (1998); Khan and Ali (2020)
Material selection and design optimization	Sustainability criteria, life-cycle benchmarks, BIM-based cost comparisons	Supports consistent comparisons and identifies cost-effective alternatives	Akadiri and Olomolaiye (2012); König and De Cristofaro (2012); Marzouk et al. (2018); AbouHamad and Abu-Hamd (2019)

Source: Compiled from the cited literature.

buildings' sustainability performance (Janjua et al., 2019b). Atmaca (2016a) discussed the methodology for integrating life-cycle assessment and cost analysis, highlighting the importance of considering environmental and economic factors throughout a building's service life. Similarly, Blanchard and Reppe (1998) demonstrated the relevance of life-cycle analysis in evaluating the resource and environmental implications of residential housing.

Life-cycle cost analysis (LCCA) provides a framework for comparing initial construction expenses with future maintenance, energy consumption, replacement, and disposal costs. Islam, Jollands, and Setunge (2015a) reviewed the relationship between LCA and life-cycle costs in residential buildings, while Islam et al. (2015b) examined the cost and environmental implications of roofing and flooring designs. König and De Cristofaro (2012) contributed benchmarks for comparing residential building life-cycle costs and environmental performance. Furthermore, AbouHamad and Abu-Hamd (2019) proposed a framework for selecting construction systems based on life-cycle cost and sustainability considerations, supporting more informed material and system selection.

Recent studies also emphasize the role of technological integration in improving cost efficiency. Hajare and Elwakil (2020) explored the integration of energy simulation and LCCA for assessing energy-efficient building strategies, while Marzouk, Azab, and Metawie (2018) investigated the use of Building Information Modelling (BIM) to optimize sustainable building life-cycle costs. Dwaikat and Ali (2018) examined practical applications of life-cycle cost analysis and budget development for green buildings. Additionally, Akadiri and Olomolaiye (2012) established sustainability assessment criteria for building material selection, and Khan and Ali (2020) discussed lessons from integrating LCA and LCCA in sustainable construction. Vitkova and Vitasek (2024) further examined sustainable residential building technologies from a life-cycle cost perspective, while Atmaca (2016b) presented a case study of residential building life-cycle assessment and cost analysis in southeastern Turkey.

Overall, the literature establishes that sustainable material selection requires an integrated assessment of economic performance and environmental impacts rather than a focus on initial purchase costs alone. However, differences in building designs, geographical conditions, energy prices,



Table 2: Research Methodology Framework for Life-Cycle Cost Assessment

<i>Methodological component</i>	<i>Assessment approach</i>	<i>Key indicators</i>
Research design	Comparative literature review and residential building case studies	Material performance and cost differences
Data collection	Published studies, building records, material prices, and energy data	Acquisition, installation, maintenance, and replacement costs
Life-cycle boundaries	Construction, operation, maintenance, and end-of-life stages	Total life-cycle expenditure and environmental impacts
Economic assessment	Life-cycle cost analysis using a consistent assessment period and discount rate	Initial cost, operating cost, replacement cost, and present value
Environmental assessment	Life-cycle assessment of selected building materials	Embodied energy, carbon emissions, and resource consumption
Comparative analysis	Evaluation of sustainable and conventional materials	Cost-effectiveness, durability, and environmental performance
Decision support	Integration of energy simulation and BIM where applicable	Energy savings, budget optimization, and material-selection suitability

Source: Developed from Janjua et al. (2019b), Atmaca (2016a), Islam et al. (2015a), Dwaikat and Ali (2018), and Vitkova and Vitasek (2024).

material availability, and assessment periods can affect the comparability of results. This study therefore focuses on evaluating sustainable residential building materials through a combined life-cycle cost and sustainability perspective to support informed, long-term construction decisions.

RESEARCH METHODOLOGY

This study adopts a comparative life-cycle assessment (LCA) and life-cycle cost analysis (LCCA) approach to evaluate sustainable building materials used in residential construction. A systematic review of existing literature and residential building case studies provides data on material acquisition, transportation, installation, maintenance, energy consumption, replacement, and end-of-life disposal (Janjua et al., 2019a; Atmaca, 2016a). Sustainable and conventional materials are compared using consistent assessment boundaries, service-life assumptions, and cost indicators. Environmental performance is evaluated through indicators such as embodied energy, carbon emissions, and resource consumption, while economic performance considers initial investment and long-term ownership costs (Islam et al., 2015a; Akadiri & Olomolaiye, 2012).

The methodology also incorporates energy simulation and Building Information Modelling (BIM), where relevant, to assess energy-related savings and support cost optimization (Hajare & Elwakil, 2020; Marzouk et al., 2018). Findings from residential building case studies and published benchmarks are used to evaluate the reliability and applicability of the comparisons (Blanchard & Reppe, 1998; König & De Cristofaro, 2012). The assessment framework supports evidence-based material selection by balancing economic feasibility with environmental sustainability (AbouHamad & Abu-Hamd, 2019; Khan & Ali, 2020).

Overall, the methodology provides a structured basis for determining whether sustainable building materials offer long-term economic and environmental advantages. It also recognizes that results depend on local material prices, climatic conditions, building design, service life, and maintenance requirements (Atmaca, 2016b; Islam et al., 2015b).

Life-Cycle Cost Assessment of Sustainable Building Materials

Life-cycle cost assessment evaluates the total costs of building materials throughout their service life, including acquisition, transportation, installation, maintenance, energy consumption, replacement, and disposal. Sustainable materials may require higher initial investment but can provide long-term savings through improved durability, reduced energy consumption, and lower maintenance requirements (Janjua et al., 2019a; Islam et al., 2015a). A systematic comparison of conventional and sustainable materials helps identify options that balance economic performance with environmental sustainability (Atmaca, 2016a; Akadiri & Olomolaiye, 2012).

Material selection should consider the building's expected service life, local climate, material availability, and maintenance requirements. Roofing and flooring alternatives, for example, can produce different life-cycle costs depending on their durability, energy performance, and replacement frequency (Islam et al., 2015b). Residential building case studies also demonstrate the importance of evaluating environmental impacts alongside financial costs (Blanchard & Reppe, 1998; Janjua et al., 2019b; Atmaca, 2016b).

Integrating energy simulation and Building Information Modelling (BIM) can improve cost forecasting and support

comparisons of alternative construction systems (Hajare & Elwakil, 2020; Marzouk et al., 2018). In addition, life-cycle budgeting and sustainability-based selection frameworks help decision-makers evaluate long-term affordability and resource efficiency (Dwaikat & Ali, 2018; AbouHamad & Abu-Hamd, 2019). Recent research on sustainable residential technologies further highlights the value of assessing long-term costs when selecting energy-efficient building solutions (Vitkova & Vitasek, 2024). Overall, life-cycle cost assessment supports more informed material selection by considering both initial expenditure and long-term economic and environmental performance (König & De Cristofaro, 2012; Khan & Ali, 2020).

RESULTS, DISCUSSION, AND RECOMMENDATIONS

Results of Life-Cycle Cost Assessment

The life-cycle cost assessment of sustainable building materials in residential construction evaluates the economic and environmental performance of materials throughout their service life. The assessment considers initial purchase and installation costs, maintenance, energy consumption, replacement, and end-of-life management. The findings should establish whether sustainable materials that require higher initial investment can deliver lower cumulative costs and improved environmental performance over time. Janjua, Sarker, and Biswas (2019a) demonstrate the relevance of a life-cycle assessment approach to evaluating residential building sustainability, while Islam, Jollands, and Setunge (2015a) highlight the relationship between life-cycle environmental impacts and economic considerations.

The comparison should cover major building components, including structural materials, wall systems, roofing, flooring, and insulation. Materials with greater durability and improved thermal performance may reduce repair frequency and operational energy requirements. However, their overall cost-effectiveness depends on local prices, installation requirements, service life, maintenance schedules, and climatic conditions. Atmaca (2016b) provides a residential case-study perspective for examining the relationship between life-cycle costs and environmental impacts.

Discussion of Economic and Environmental Performance

The findings should be interpreted by comparing the initial expenditure with the total discounted cost of ownership. Conventional materials may offer lower upfront costs, whereas sustainable alternatives may provide savings through reduced energy consumption, fewer repairs, and longer replacement intervals. Vitkova and Vitasek (2024) examine sustainable residential building technologies from a life-cycle cost perspective, supporting the importance of evaluating long-term financial implications rather than purchase prices alone.

Environmental performance is another important consideration. Material extraction, manufacturing, transportation, installation, operational energy consumption, and disposal can contribute to the environmental footprint of residential buildings. Janjua, Sarker, and Biswas (2019b) review residential building sustainability performance through a life-cycle assessment approach, emphasizing the importance of considering multiple life-cycle stages. Blanchard and Reppe (1998) also provide an early residential home life-cycle analysis that can inform discussions of whole-building environmental impacts.

The selection of sustainable materials should therefore balance cost, durability, energy efficiency, resource consumption, and environmental impact. Akadiri and Olomolaiye (2012) provide a basis for incorporating sustainability criteria into building material selection, while Khan and Ali (2020) discuss lessons from integrating life-cycle assessment and life-cycle cost analysis in sustainable construction.

Comparison of Building Components and Cost-Optimization Strategies

Roofing and flooring systems deserve particular attention because their material composition, thermal properties, maintenance requirements, and replacement cycles can influence both operating expenses and environmental performance. Islam, Jollands, Setunge, Haque, and Bhuiyan (2015b) examine life-cycle assessment and cost implications associated with roofing and floor designs in residential buildings. Their work supports comparing alternative designs using consistent cost and environmental assessment boundaries.

Energy simulation can strengthen this comparison by estimating how alternative materials and building strategies affect energy consumption under specified operating conditions. Hajare and Elwakil (2020) address the integration of life-cycle cost analysis with energy simulation to assess energy-efficient building strategies. In addition, Building Information Modelling (BIM) can support cost estimation, design comparisons, and the identification of cost-saving opportunities throughout the building life cycle (Marzouk et al., 2018).

Construction-system selection should consequently consider the combined effects of economic and sustainability indicators. AbouHamad and Abu-Hamd (2019) propose a framework for construction-system selection based on life-cycle cost and sustainability assessment. Similarly, Dwaikat and Ali (2018) address practical applications of life-cycle cost analysis and budget development for green buildings.

The graph makes it possible to identify which cost categories account for the largest differences between alternatives. König and De Cristofaro (2012) provide a basis for considering residential building life-cycle cost and assessment benchmarks, while Atmaca (2016a) offers relevant methodological foundations for residential building life-cycle assessment and cost analysis.



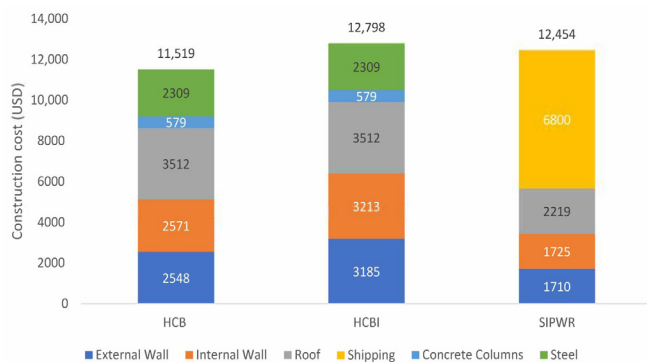


Figure 1: Comparative Life-Cycle Cost of Sustainable and Conventional Residential Building Materials

RECOMMENDATIONS

The following recommendations emerge from the proposed assessment:

1. Adopt whole-life costing. Residential developers should evaluate purchase, installation, maintenance, energy, replacement, and disposal costs rather than relying solely on initial material prices (Islam et al., 2015a; Dwaikat & Ali, 2018).
2. Prioritize durable and resource-efficient materials. Material selection should incorporate service life, thermal performance, maintenance requirements, recyclability, and environmental impacts (Akadiri & Olomolaiye, 2012).
3. Integrate cost and energy modelling. Energy simulation and life-cycle cost analysis should be used together to evaluate the financial implications of energy-efficient design alternatives (Hajare & Elwakil, 2020).
4. Use BIM for early-stage optimization. BIM-based cost modelling can help compare material options, assess design alternatives, and identify opportunities to reduce long-term expenditure (Marzouk et al., 2018).
5. Establish consistent assessment assumptions. Researchers and practitioners should document the study period, discount rate, service-life assumptions, maintenance schedules, energy prices, and end-of-life scenarios to support meaningful comparisons (Atmaca, 2016a; König & De Cristofaro, 2012).
6. Account for local conditions. Climate, material availability, transportation distance, construction practices, and local energy prices should inform material selection because they influence both economic and environmental outcomes (Atmaca, 2016b; Janjua et al., 2019a).

Overall, the assessment should determine whether sustainable building materials offer measurable long-term economic and environmental advantages over conventional alternatives. The expected value of the approach lies in combining life-cycle cost analysis with environmental assessment, energy simulation, and design optimization. The literature provides methodological and practical foundations for this integrated approach (AbouHamad & Abu-Hamd, 2019; Khan & Ali, 2020; Vitkova & Vitasek, 2024).

The conclusions should ultimately be based on comparable data and transparent assumptions. Where empirical results are not yet available, findings should be presented as expected outcomes or research propositions rather than confirmed savings. This approach supports evidence-based material selection and more sustainable, cost-effective residential construction.

CONCLUSION AND RECOMMENDATIONS

Life-cycle cost assessment provides an effective approach for evaluating the long-term economic and environmental performance of sustainable building materials in residential construction. By considering initial investment, maintenance, energy consumption, replacement, and end-of-life costs, developers can make more informed decisions than by comparing purchase prices alone. Janjua, Sarker, and Biswas (2019a) emphasize the value of life-cycle assessment in evaluating residential building sustainability, while Islam, Jollands, and Setunge (2015a) highlight the relationship between environmental performance and life-cycle costs.

The study highlights the importance of selecting durable, energy-efficient, and resource-efficient materials that balance affordability with long-term performance. Integrating life-cycle cost analysis with energy simulation and Building Information Modelling can further improve material selection, cost forecasting, and sustainable design decisions (Hajare & Elwakil, 2020; Marzouk et al., 2018). Furthermore, construction-system selection should incorporate both financial and sustainability criteria to support more comprehensive decision-making (AbouHamad & Abu-Hamd, 2019).

It is recommended that residential developers, architects, and policymakers adopt standardized life-cycle assessment procedures, use reliable local cost data, and account for climate, material availability, durability, and maintenance requirements. Future research should validate cost comparisons using real-world residential building data and consistent assessment assumptions. Ultimately, integrating life-cycle cost assessment into residential construction planning can support economically viable housing, reduced environmental impacts, and more sustainable use of building resources (Khan & Ali, 2020; Akadiri & Olomolaiye, 2012).

REFERENCES

- [1] Janjua, S. Y., Sarker, P. K., & Biswas, W. K. (2019). Sustainability Assessment of a Residential Building using a Life Cycle Assessment Approach. *CET Journal-Chemical Engineering Transactions*, 72, 19.
- [2] Janjua, S. Y., Sarker, P. K., & Biswas, W. K. (2019). A review of residential buildings' sustainability performance using a life cycle assessment approach. *Journal of Sustainability Research*, 1(1).
- [3] Atmaca, A. (2016). Life cycle assessment and cost analysis of residential buildings in south east of Turkey: part 1—review and methodology. *The international journal of life cycle assessment*, 21(6), 831-846.

- [4] AbouHamad, M., & Abu-Hamd, M. (2019). Framework for construction system selection based on life cycle cost and sustainability assessment. *Journal of Cleaner Production*, 241, 118397.
- [5] Blanchard, S., & Reppe, P. (1998). Life cycle analysis of a residential home in Michigan.
- [6] Vitkova, A., & Vitasek, S. (2024). A Case Study on Sustainable Technologies in Residential Buildings from a Life Cycle Cost Analysis (LCC) Perspective. *Sustainability*, 16(24), 10892.
- [7] König, H., & De Cristofaro, M. L. (2012). Benchmarks for life cycle costs and life cycle assessment of residential buildings. *Building Research & Information*, 40(5), 558-580.
- [8] Hajare, A., & Elwakil, E. (2020). Integration of life cycle cost analysis and energy simulation for building energy-efficient strategies assessment. *Sustainable Cities and Society*, 61, 102293.
- [9] Atmaca, A. (2016). Life-cycle assessment and cost analysis of residential buildings in South East of Turkey: part 2—a case study. *The International Journal of Life Cycle Assessment*, 21(7), 925-942.
- [10] Marzouk, M., Azab, S., & Metawie, M. (2018). BIM-based approach for optimizing life cycle costs of sustainable buildings. *Journal of cleaner production*, 188, 217-226.
- [11] Islam, H., Jollands, M., & Setunge, S. (2015). Life cycle assessment and life cycle cost implication of residential buildings—A review. *Renewable and sustainable energy reviews*, 42, 129-140.
- [12] Islam, H., Jollands, M., Setunge, S., Haque, N., & Bhuiyan, M. A. (2015). Life cycle assessment and life cycle cost implications for roofing and floor designs in residential buildings. *Energy and Buildings*, 104, 250-263.
- [13] Khan, M. W., & Ali, Y. (2020). Sustainable construction: Lessons learned from life cycle assessment (LCA) and life cycle cost analysis (LCCA). *Construction Innovation*, 20(2), 191-207.
- [14] Adepoju, S. A., & Adepoju, M. A. (2024). From Portals to Case Graphs: A Reference Architecture and Benchmark for Safety Investigation Operations with Agentic Orchestration.
- [15] Awodire, M. (2024). Zero-trust and least-privilege IAM design in federal/regulated cloud deployments. *ADHYAYAN: A JOURNAL OF MANAGEMENT SCIENCES*, 14(02), 84-93.
- [16] Khan, H. A. (2024). Data-Driven Epidemiological Modeling Using Machine Learning For Disease Spread Forecasting And Public Health Decision Support In The United States. *International Journal of Applied Mathematics*, 37(6s), 178-192.
- [17] Udeze, C. T., Falebita, O., & Fasasi, S. T. (2024). AI-Based Cybersecurity Risk Prediction and Management. *SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology*, 16(04), 216-225.
- [18] Sanusi, B. O. (2024). The role of data-driven decision-making in reducing project delays and cost overruns in civil engineering projects. *SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology*, 16(04), 182-192.
- [19] Areghan, E., & Ndibe, O. S. (2024). Explainable AI for autonomous threat detection in critical infrastructure systems. *Journal of Computational Analysis and Applications*, 33(8), 6841-6857.
- [20] Ojuri, M. A. (2024). Cybersecurity Vulnerability Testing as a Core Component of Quality Assurance. *Pioneer Research Journal of Computing Science*, 1(3), 122-138.
- [21] Begum, S. (2025). AI at scale: Predictive analytics as a strategic engine for national competitiveness in US startup and small business financing. *International Journal of Progressive Research in Engineering Management and Science Development*, 2582, 7421.
- [22] Kola, J. N. (2024). Longitudinal Cohort Intelligence for Self-Insured Employer Groups: A Predictive Framework for Healthcare Cost Trajectory Modeling and Proactive Risk Intervention. *Journal of Information Systems Engineering & Management*, 10.
- [23] Ojuri, M. A. (2024). Integrating Cybersecurity Standards into Software Quality Assurance Frameworks: A Holistic Approach. *Journal of Computer Science and Technology Studies*, 6(1), 258-271.
- [24] Sanusi, B. O. (2024). Integration of nature-based solutions in urban planning: policy, governance, and institutional frameworks. *Journal of Mechanical, Civil and Industrial Engineering*, 5(2), 10-25.
- [25] Areghan, E., & Onwuegbuchi, O. (2024). Predictive Cyber Threat Analysis in Cloud Platforms Using Artificial Intelligence and Machine Learning Algorithms. *Applied Science, Computing, and Energy*, 1(1), 197-205.
- [26] Ojuri, M. A. (2023). Risk-Driven QA Frameworks for Cybersecurity in IoT-Enabled Smart Cities. *Journal of Computer Science and Technology Studies*, 5(1), 90-100.
- [27] Areghan, E. (2023). From Data Breaches to Deepfakes: A Comprehensive Review of Evolving Cyber Threats and Online Risk Management. *Communication in Physical Sciences*, 9(4), 538-553.
- [28] Awodire, M. (2023). Cost optimization strategies (tagging, rightsizing, capacity planning) in enterprise cloud operations. *International Journal of Technology, Management and Humanities*, 9(04), 307-317.
- [29] Kola, J. N. (2023). Measuring the Business Value of Analytics-Driven Decisions: A Decision Impact Attribution Framework for Enterprise Environments. *Journal of Information Systems Engineering & Management*, 1-9.
- [30] SANUSI, B. O. (2023). Performance monitoring and adaptive management of as-built green infrastructure systems. *Well Testing Journal*, 32(2), 224-237.
- [31] Ojuri, M. A. (2023). AI-Driven Quality Assurance for Secure Software Development Lifecycles. *International Journal of Technology, Management and Humanities*, 9(01), 25-35.
- [32] Ojuri, M. A. (2021). Measuring Software Resilience: A QA Approach to Cybersecurity Incident Response Readiness. *Multidisciplinary Innovations & Research Analysis*, 2(4), 1-24.
- [33] Awodire, M. (2022). Trend Analysis in Recurring IT Security Findings: What Repeated Vulnerabilities Reveal About Systemic Control Weaknesses. *International Journal of Technology, Management and Humanities*, 8(04), 119-145.
- [34] Akinyemi, A. (2021). Cybersecurity Risks and Threats in the Era of Pandemic-Induced Digital Transformation. *International Journal of Technology, Management and Humanities*, 7(04), 51-62.
- [35] Audu, K., Adebimpe, S., Adejare, Q., Abdulquadri, A. R., Hamid-Mosaku, I., & Oladokun, D. (2022). Water Quality Assessment in part of Lagos Lagoon Using Sentinel-2A and Landsat-8 Multispectral Imagery. *Int J Sci Res Sci Technol*, 9(6), 852-871.
- [36] Ojuri, M. A. (2022). The Role of QA in Strengthening Cybersecurity for Nigeria's Digital Banking Transformation. *Well Testing Journal*, 31(1), 214-223.
- [37] Akinyemi, A. (2022). Zero Trust Security Architecture: Principles and Early Adoption. *International Journal of Technology, Management and Humanities*, 8(02), 11-22.
- [38] Ojuri, M. A. (2022). Cybersecurity Maturity Models as a QA Tool for African Telecommunication Networks. *SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology*, 14(04), 155-161.



- [39] SANUSI, B. O. (2022). Sustainable Stormwater Management: Evaluating the Effectiveness of Green Infrastructure in Midwestern Cities. *Well Testing Journal*, 31(2), 74-96.
- [40] Nwaneto, C., Nwaneto, C. P., & Fasasi, S. T. (2024). The Hidden Cost of Scope Ambiguity: Why OFCI vs. CFCI Delineation Breaks Data Center Budgets. *SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology*, 16(04), 214-222.
- [41] Begum, S. (2022). Optimizing capital deployment in post-pandemic America: AI-powered predictive analytics for startup resilience and growth. *International Journal of Computer Applications Technology and Research*, 11(12), 700-710.
- [42] Nwaneto, C., Jimoh, A., & Nwaneto, C. P. (2024). Energy Audit Comparison between Residential and Commercial Buildings in Denver and Other Climate Zones. *SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology*, 16(04), 223-235.
- [43] Ojuri, M. A. (2021). Evaluating Cybersecurity Patch Management through QA Performance Indicators. *International Journal of Technology, Management and Humanities*, 7(04), 30-40.
- [44] Naidu, K. J. (2014). Secure OLAP Reporting Architectures: Integrating Role-based Access Control and Query Execution Plan Optimization for Enterprise Analytical Environments. *SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology*, 5(02), 155-159.
- [45] Kazmi, S. Chemical Upcycling of Polyethylene Terephthalate (PET) Waste into High-Value Functional Polymers.
- [46] Naidu, K. J. (2013). Performance Optimization Of ETL Pipelines In Distributed Data Warehouse Environments: A Network-Aware Scheduling Approach. *International Journal of Advance Industrial Engineering*, 1(03), 63-67.
- [47] Kola, J. N. (2011). An Integrated Framework for Data Mining and Distributed Database Optimization in Resource-Constrained Network Environments. *SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology*, 2(02), 82-86.
- [48] Nwaneto, C., Jimoh, A., & Nwaneto, C. P. (2024). Energy Audit Comparison between Residential and Commercial Buildings in Denver and Other Climate Zones. *SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology*, 16(04), 223-235.
- [49] Dwaikat, L. N., & Ali, K. N. (2018). Green buildings life cycle cost analysis and life cycle budget development: Practical applications. *Journal of Building Engineering*, 18, 303-311.
- [50] Akadiri, P. O., & Olomolaiye, P. O. (2012). Development of sustainable assessment criteria for building materials selection. *Engineering, Construction and Architectural Management*, 19(6), 666-687.