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Automation of Cost Estimation Considering Sustainable Construction Materials: Long-Term Economic Efficiency

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Abstract: Sustainable construction materials are becoming increasingly important in modern construction projects, as their use contributes to reducing environmental impact and improving energy efficiency in buildings. However, their integration into cost estimation processes faces challenges due to high initial costs and the lack of tools to assess long-term economic efficiency. This study examines the development of an automated cost estimation system that includes the assessment of operational costs, energy consumption, and maintenance expenses throughout the building's lifecycle. Calculation formulas and comparative analysis examples between traditional and sustainable materials are provided. The results show significant potential for savings when using sustainable solutions, particularly in the long term, due to reduced operational costs and fewer repairs. The development of such a tool could be an important step towards broader implementation of sustainable construction technologies, providing designers and construction companies with clear information for decision-making. The calculations presented confirm the need for the digital transformation of cost estimation systems, taking into account environmental and economic factors, especially in the long term.

Keywords: sustainable construction materials; cost estimation; environmental efficiency; energy efficiency; long-term savings; automation of construction processes; construction technologies; building lifecycle; eco-friendly materials; construction profitability

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1. Introduction

Sustainable construction materials are those that are developed in accordance with the principles of sustainable development, aimed at minimizing environmental impact and maximizing benefits for people and the planet [1,2]. These materials are often renewable, recyclable, energy-efficient, and non-toxic, contributing to more efficient use of natural resources and reducing harmful emissions during production and use [3–6]. Examples of sustainable materials include recycled materials, natural resources (such as clay and stone), energy-efficient insulation materials, and materials with a low carbon footprint. Energy-saving sustainable materials are those that help reduce energy consumption in buildings or other structures, improving their energy efficiency. Energy conservation is a key aspect of sustainable construction, as buildings consume significant amounts of energy for heating, cooling, and lighting. The use of such materials helps reduce energy consumption, decrease carbon emissions, and lower operating costs [7,8].

Despite the obvious environmental and economic benefits, the integration of sustainable construction materials into cost estimation remains a complex challenge for construction companies [9,10]. One of the main reasons for this is the high initial cost of procuring such materials, which, in turn, increases the overall project cost during its early stages. Additionally, construction companies often lack sufficient information about the durability and long-term benefits of using sustainable materials [11]. It is also important to note the absence of clear methods for calculating the cost of environmentally friendly materials in estimates, considering the profitability of projects in the long run.

At present, automated cost estimation systems lack dedicated modules for evaluating design solutions involving sustainable materials, hindering the accurate assessment of their economic viability [12]. This article discusses the main issues and challenges related to the integration of sustainable construction materials into cost estimation, as well as proposing a potential solution in the form of developing an automated system that accounts for the long-term economic and environmental benefits of such materials.

2. Materials and Methods

This study employs an analytical-applied research method aimed at identifying the problems and opportunities for integrating sustainable construction materials into automated cost estimation systems. The research is based on practical experience in design and cost estimation activities in the construction and energy sectors, as well as an analysis of current software solutions used in the cost calculations of construction projects.

An increase in property value represents a key economic advantage. The use of such materials ultimately raises the market value of the built structure. Reducing building operating costs, in terms of expenses for heating, cooling, repairs, and maintenance of the building [13–16]. Additionally, economic benefits can include tax incentives or subsidies from the government, as many countries offer such grants to construction companies using these technologies [17–19]. Additionally, properties built with sustainable materials often command higher rental rates, offering further economic benefits. Environmental benefits also exist as a consequence of using sustainable construction materials in the building process.

Since many countries have long been implementing methodologies for the use of "sustainable materials" in construction, there is a problem faced by construction companies, namely: contractors often do not see the potential of such construction due to the fact that, in most cases, cost estimation methodologies are focused on initial costs rather than long-term benefits from the use of such materials [20–22].

It is essential to comprehensively assess the advantages and disadvantages of adopting sustainable materials and technologies during the planning and cost estimation phases, particularly from a long-term perspective. In this regard, the development and implementation of an automated calculation system is necessary to visualize the long-term perspective and profitability of projects. The proposed system would comprise automated modules, incorporating sections with regularly updated price catalogs for material and labor resources, with its primary innovation being the integration of a calculation block dedicated to long-term operational analysis. For example, how much energy (in kWh) will be saved per year, month, or day for heating on the total area of the project that used energy-saving insulation panels made with eco-friendly materials and methods:

$$E = (\text{Cost before} - \text{Cost after}) \times \text{Electricity price} \times \text{Years}; \quad (1)$$

Where:
E – savings;
Cost before – electricity cost before using sustainable building materials;
Cost after – electricity cost after using sustainable building materials;
Electricity price – the price of electricity, in $;
Years – years of operation.

$$E = (100{,}000 - 70{,}000) \times 0.16 \times 10; \quad (2)$$

This represents the savings in electricity cost over 10 years, where:
100,000 is the cost of electricity before using sustainable materials,
70,000 is the cost after using sustainable materials,
0.16 is the price of electricity per unit,

10 is the number of years of operation.

Consequently, this would generate savings of $48,000 over a 10-year operational period, equating to $4,000 annually.

The proposed model should incorporate both direct economic benefits and indirect factors, including enhanced property value, potential tax incentives, and mitigation of operational risks. To visualize the comparative data, a table is proposed that demonstrates the differences in repair frequency and cost levels depending on the materials used.

Alternatively, the savings on maintenance costs can be shown, as some natural materials do not require maintenance costs, such as natural stone, or they require maintenance less frequently than conventional materials. All this should ultimately contribute to a specific sum, a table, or a chart for clarity. Additionally, the program should include standardized construction materials commonly used in building projects, so that at any moment, a "standard" material can be substituted for a "sustainable" material, allowing a comparison of the project's cost difference at both the initial stage and during operation.

This is exemplified in the repair frequency chart. When comparing two different methods using sustainable materials, the maintenance will occur half as often as with conventional materials, as shown in our example with natural stone, thus resulting in savings on repairs:

Table 1. Repair frequency for sustainable vs. conventional materials.

Construction	Years of operation											
	1	2	3	4	5	6	7	8	9	10	11	12
Using sustainable materials				R				R				R
Using conventional materials		R		R		R		R		R		R

R - Repair 5,000 $;

Over 12 years of operation, a building constructed with sustainable materials will require 3 current repairs (3 x $5,000), with a total cost of $15,000. In contrast, if the building is constructed without using sustainable materials, 6 current repairs (6 x $5,000) will be needed, amounting to a total of $30,000.

Additionally, the need for creating a specialized calculation block in cost estimation systems has been justified. This block would include up-to-date price databases for sustainable materials, as well as labor cost information, to assess the long-term efficiency of decisions.

The proposed methodology is applied in nature and can serve as the basis for developing a technical assignment for the implementation of an automated tool to assess the profitability of sustainable design solutions in construction.

3. Results

During the research, several analyses were conducted to assess the economic efficiency of using sustainable building materials in construction projects. Special attention was given to a comparative analysis between traditional and sustainable materials in terms of cost, durability, and operational characteristics over several years.

1. Economic Benefits of Sustainable Materials: In the conducted calculations, the savings resulting from the use of sustainable materials, such as energy-efficient insulating panels, were assessed. For instance, considering the durability of materials and their ability to reduce energy consumption, it was found that over the building's operational period, the use of sustainable insulating panels can lead to a 15-30% reduction in heating and cooling costs, depending on the region. Recognizing the long-term benefits at the project's inception is crucial for sustainable and economically efficient decision-making.

Famous Examples of Sustainable Construction.

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1.1. Bullitt Center, Seattle, USA

The Bullitt Center is a six-story office building certified under the Living Building Challenge, making it one of the eco-friendliest commercial buildings in the world. The building is equipped with 575 solar panels on its roof, which provide energy for its operations. Additionally, it collects and purifies rainwater for use in household activities. As a result, the building produces more energy than it consumes, significantly reducing its carbon footprint [23].

1.2. Bahnstadt, Heidelberg, Germany

Bahnstadt is a 116-hectare district designed with sustainable development principles in mind. The buildings in this district use 80% less energy for heating compared to traditional buildings. The district's infrastructure includes over 3,000 smart meters, green roofs, and extensive cycling paths, all contributing to reduced carbon emissions and an improved quality of life [24].

1.3. Wood City, Stockholm, Sweden

Wood City is the world's largest project using glued and cross-laminated timber (CLT), developed by Atrium Ljungberg in the Sickla district. The project includes residential and commercial buildings, being constructed at a rate of 1,000 square meters per week—twice as fast as with concrete. The use of timber reduces carbon emissions by 40% and contributes to creating a healthier and more comfortable urban environment [25].

1.4. Keppel Bay Tower, Singapore

Keppel Bay Tower is a 22-story building that, after renovation, became the first commercial building in Singapore to achieve net-zero carbon emissions. The renovation included the installation of solar panels, a smart lighting system, and efficient water management. These measures helped reduce energy consumption by 30% and achieve carbon neutrality.

2. Reduction of Maintenance and Repair Costs:

The analysis of maintenance costs also yielded positive results. For instance, using natural stone materials instead of traditional materials, which require more frequent repairs, led to a reduction in maintenance costs by half. While using conventional materials requires 6 repairs over 12 years, with sustainable materials, this number was reduced to 3 repairs. This results in substantial cost savings over the building's operational lifespan **[26–28]**. The importance of including a block for cost estimation systems lies in the visualization of long-term benefits through clear and illustrative charts and tables.

3. Impact on Real Estate Market Value:

Another crucial aspect is the impact of sustainable materials on the market value of real estate. Buildings constructed with sustainable materials can increase their market value, depending on the region and property type. This is due to the growing interest from buyers and tenants in eco-friendly and energy-efficient buildings **[29–31]**. If the cost estimation block for construction with sustainable materials includes a tool powered by artificial intelligence that identifies relevant government programs offering benefits and grants, it will significantly ease the understanding of the advantages for the client.

4. Challenges in Integrating Sustainable Materials into Cost Estimations:

The main issue identified during the study was the difficulty in integrating sustainable materials into traditional cost estimation processes. Construction companies often face a lack of information regarding the durability and economic benefits of these materials, which makes it challenging to make decisions in favor of their use. The absence of a clear methodology for calculating the cost of these materials in estimates, considering the long-term profitability of the project, is also a significant barrier to the widespread adoption of sustainable solutions.

Therefore, despite the obvious advantages of using sustainable construction materials, the implementation of such solutions requires the development of new approaches and methods for cost

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estimation in the long term, as well as the further dissemination of information about the long-term economic and environmental benefits.

4. Discussion

The study provided an overview of the integration of sustainable construction materials into cost estimation processes and evaluated the economic and environmental benefits these materials can offer at various stages of construction. The results demonstrated significant advantages for the long-term operation of buildings, particularly in terms of reducing operating costs such as heating, cooling, and ongoing maintenance. Several suggestions were also explored to improve the understanding of the benefits of using sustainable materials in construction.

Construction companies often prioritize short-term costs, posing challenges in recognizing the long-term economic and environmental advantages of implementing eco-friendly solutions. It is important to note that while sustainable materials may require higher initial investments, they provide substantial economic benefits during operation, including reduced energy costs and lower maintenance and repair expenses.

Currently, most cost estimation software lacks modules for calculating long-term savings associated with the use of sustainable materials, which hinders their integration into the real construction process. This is further evidenced by the absence of clear examples of savings that could demonstrate the potential economic advantages to construction companies.

Integration of Sustainable Construction Materials into Cost Estimations, particularly in the United States, demonstrates significant steps towards incorporating environmental solutions into construction practices. For example, tools like RSMeans and BuildingGreen provide extensive databases on the cost of sustainable materials, including green roofs, photovoltaic panels, and energy-efficient systems. However, these tools are generally focused on initial capital costs and rarely include an assessment of long-term economic effectiveness. Modern BIM systems, such as Edificius and RIB CostX, allow for project modeling with cost considerations but require additional modules and data for building life cycle analysis. Additionally, despite the existence of sustainable building standards such as LEED and Living Building Challenge, their criteria are not always integrated into cost estimations, limiting the ability to comprehensively assess profitability. Support programs like Property Assessed Clean Energy (PACE) help reduce initial costs through tax incentives and subsidies, but these are not directly reflected in traditional cost estimation systems **[32–34]**. All of this highlights the need for the development of new tools and modules in cost estimation software that consider not only material costs but also their operational and environmental characteristics in the long term. Tools like RSMeans, BuildingGreen, BIM systems, and PACE are important, but they often require additional customization to account for long-term benefits and life cycle assessments. The development of new tools for cost estimations that integrate environmental and operational characteristics is essential for advancing sustainable construction.

The long-term advantages of utilizing sustainable materials encompass decreased operational expenditures, enhanced property valuations, and increased tenant demand for energy-efficient buildings commanding premium rental rates. These benefits, along with the possibility of receiving tax incentives and subsidies, confirm the importance of using environmentally friendly materials. However, current cost estimation systems still cannot accurately account for these factors in their calculations.

An important limitation is that many construction companies currently lack the tools to fully evaluate the long-term economic benefits of using such materials. To overcome this problem, specialized automated systems need to be developed that can integrate data on the cost of sustainable materials and their long-term operational performance into standard cost estimations. These systems should consider not only the initial material costs but also the savings from reduced energy and maintenance costs over the long term.

Long-term benefits of using sustainable materials, such as reduced operational costs, increased property value, and improved environmental reputation, can significantly outweigh the initial

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expenses. This underscores the need for new approaches in cost estimation and design that can account for all aspects of sustainable construction.

For future research, it is important to continue developing and testing automated systems for calculating the profitability of sustainable construction materials. These systems could become valuable tools for designers and construction companies, helping them consider not only initial costs but also the long-term benefits associated with the use of environmentally friendly materials.

Limitations and Future Work.

While this study proposes a conceptual framework for integrating sustainable construction materials into automated cost estimation systems, it has not yet been validated through large-scale practical implementations. The presented model is currently based on theoretical calculations and literature analysis. Future research should focus on conducting pilot implementations in real construction projects to assess the practical applicability and performance of the proposed system. Additionally, integrating the developed model into existing Building Information Modeling (BIM) platforms could enhance the accuracy and usability of cost estimations, providing a comprehensive tool for lifecycle cost management in sustainable construction.

5. Conclusions

The research identified key issues and opportunities associated with integrating sustainable building materials into cost estimation processes. The data reviewed and analysis conducted led to the following conclusions:

1. Gaps in Existing Cost Estimation Systems: Currently, automated cost estimation systems lack a specialized module for calculating the cost and long-term economic benefits of using sustainable building materials. This represents a significant barrier for construction companies aiming to integrate eco-friendly materials into their projects.
2. Need for Automation of Calculations: For the effective implementation of sustainable materials, it is essential to develop automated systems that can account for not only initial costs but also long-term operational benefits. The introduction of such systems would enable designers and cost estimators to accurately forecast savings in building operation, including reductions in heating, cooling, maintenance, and current repair costs.
3. Development of Technical Specifications for the IT Sector: A crucial step for implementing automation is the creation of clear technical specifications for IT engineers who will develop such software solutions. These systems should include functionality for calculating both initial expenses and long-term savings, as well as visualizing this data in the form of tables and diagrams, making the decision-making process easier for construction companies.
4. Practical Application and Benefits for Construction Companies: The development and implementation of software tools for cost estimations that consider long-term benefits of sustainable materials will become an essential tool for construction companies and designers. These tools will help not only reduce ongoing operating costs but also increase property values, due to their environmental sustainability and energy efficiency.
5. Support from Government and Industry Initiatives: To accelerate the transition to sustainable building solutions, it is crucial to provide government and industry support, including subsidies, tax incentives, and other forms of encouragement for construction companies using eco-friendly technologies. This will reduce initial construction costs and stimulate the use of sustainable solutions.

For an effective assessment of the long-term economic benefits of using sustainable building materials, it is necessary to develop a specialized module within cost estimation programs that will account for not only initial expenses but also the entire spectrum of operational costs over the building's lifecycle. This module should include functionality for automated life cycle costing calculations, as well as integration with up-to-date databases on the cost of eco-friendly materials, their durability, energy efficiency, and repair frequency. Additionally, it should provide real-time

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information on government incentives and programs in a particular region using artificial intelligence.

A key element of this tool will be the ability to visually present data—through graphs, charts, and comparison tables—allowing users to dynamically see how resources are saved, maintenance costs decrease, and overall project profitability increases over time. This visualization is critical for decision-making, especially when convincing investors, clients, and regulatory bodies of the feasibility of choosing sustainable solutions. Implementing such visual tools also contributes to the development of a more transparent and reasoned justification system for project decisions, thus expanding the practice of sustainable construction in both the private and public sectors.

Ethical approval was not required in accordance with current legislation, as the research did not involve human or animal participation, nor did it use personal data.

References

1. Suhamad, D. A.; Martana, S. P. Sustainable Building Materials. IOP Conf. Ser.: Mater. Sci. Eng. 2020, 879, 012146. https://doi.org/10.1088/1757-899X/879/1/012146.
2. Firoozi, A.A.; Firoozi, A.A.; Oyejobi, D.O.; Avudaiyappan, S.; Saavedra Flores, E. Emerging Trends in Sustainable Building Materials: Technological Innovations, Enhanced Performance, and Future Directions. Results Eng.: 2024, 24, 103521. https://doi.org/10.1016/j.rineng.2024.103521.
3. An, B.; Wang, Y.; Huang, Y.; Xinyu, W.; Liu, Y.; Xun, D.; Church, G.M.; Dai, Z.; Yi, X.; Tang, T.-C.; Zhong, C. Engineered Living Materials For Sustainability. Chem. Rev. 2022, 123(5), 2349–2419. https://doi.org/10.1021/acs.chemrev.2c00512.
4. Tazmeen, T.; Mir, F.Q. Sustainability through materials: A review of green options in construction. Results in Surfaces and Interfaces 2024, 14(1), 100206. https://doi.org/10.1016/j.rsurfi.2024.100206.
5. Chen, L.; Yang, M.; Chen, Z.; Xie, Z.; Huang, L.; Osman, A. I.; Farghali, M.; Sandanayake, M.; Liu, E.; Ahn, Y.; Al-Muhtaseb, A. H.; Rooney, D. W.; Yap, P. Conversion of waste into sustainable construction materials: A review of recent developments and prospects. Materials Today Sustainability 2024, 27, 100930. https://doi.org/10.1016/j.mtsust.2024.100930.
6. Yahia, A. K. M.; Rahman, M. M.; Shahjalal, M.; Morshed, A. Sustainable Materials Selection in Building Design and Construction. Int. J. Sci. Eng. 2024, 1(4), 106–119. https://doi.org/10.62304/ijse.v1i04.199.
7. Hussain, A.; Kamal, M. A. Energy Efficient Sustainable Building Materials: An Overview. Key Engineering Materials 2015, 650, 38–50. https://doi.org/10.4028/www.scientific.net/KEM.650.38.
8. Khan, Z.; Khan, D.; Zahoor, M. H. Empowering Sustainable Construction through Advanced Strategies for Energy-Efficient Green Building Materials. Archaeology & Anthropology Open Access 2024, 5(3). https://doi.org/10.31031/AAOA.2024.05.000631.
9. Ekung, S.; Odesola, I. A.; Oladokun, M. Dimensions of Cost Misperceptions Obstructing the Adoption of Sustainable Buildings. Smart and Sustainable Built Environment 2021, ahead-of-print(ahead-of-print). https://doi.org/10.1108/SASBE-10-2020-0160.
10. Eze, E. C.; Sofolahan, O.; Omoboye, O. G. Assessment of Barriers to the Adoption of Sustainable Building Materials (SBM) in the Construction Industry of a Developing Country. Front. Eng. Built Environ. 2023, 3(3). https://doi.org/10.1108/FEBE-07-2022-0029.
11. Gounder, S.; Hasan, A.; Shrestha, A.; Elmualim, A. Barriers to the Use of Sustainable Materials in Australian Building Projects. Eng. Constr. Archit. Manag. 2021, ahead-of-print(ahead-of-print). https://doi.org/10.1108/ECAM-10-2020-0854.
12. Hammadi, A.; Ellk, D. S. Identifying Barriers to the Use of Sustainable Building Materials in Building Construction. J. Eng. Sustain. Dev. 2018, 22(02), 107–115. https://doi.org/10.31272/jeasd.2018.2.87.

13. Ries, R.; Bilec, M.M.; Gokhan, N.M.; Needy, K. The Economic Benefits of Green Buildings: A Comprehensive Case Study. Eng. Economist 2006, 51(3), 259–295. https://doi.org/10.1080/00137910600865469.
14. Azazga, I. Economic Benefits of Sustainable Construction. 2019. https://doi.org/10.37170/1986-000-009-022.
15. Reddy, S. Sustainable Construction: Analysis of Its Costs and Financial Benefits. Int. J. Innov. Res. Eng. Manag. 2016, 3(6), 522–525. https://doi.org/10.21276/ijirem.2016.3.6.12.
16. Weerainghe, A. S.; Ramachandra, T. Economic Sustainability of Green Buildings: A Comparative Analysis of Green vs Non-Green. Built Environ. Proj. Asset Manag. 2018. https://doi.org/10.1108/BEPAM-10-2017-0089.
17. Yeganeh, A.; McCoy, A. P.; Reichard, G.; Schenk, T.; Hankey, S. Green Building and Policy Innovation in the US Low-Income Housing Tax Credit Programme. Int. J. Housing Policy 2020, 543–560. https://doi.org/10.1080/09613218.2020.1842165.
18. Dahlan, A. S. Governmental Incentives for Sustainable Building Development – Saudi Arabia. J. Umm Al-Qura Univ. Eng. Archit. 2025, 16(4). https://doi.org/10.1007/s43995-025-00097-1.
19. Zhang, F.; Liu, B.; An, G. Do Government Subsidies Induce Green Transition of Construction Industry? Evidence from Listed Firms in China. Buildings 2024, 14(5), 1261. https://doi.org/10.3390/buildings14051261.
20. Osuizugbo, I. C.; Oyeyipo, O.; Lahanmi, M. Barriers to the Adoption of Sustainable Construction. 2020. https://www.researchgate.net/publication/341814520_Barriers_to_the_Adoption_of_Sustainable_Construction.
21. Mogaji, I.; Mewomo, M.; Bondinuba, F. K. Assessment of Barriers to the Adoption of Innovative Building Materials (IBM) for Sustainable Construction in the Nigerian Construction Industry. Eng. Constr. Archit. Manag. 2024, 32(13), 1–26. https://doi.org/10.1108/ECAM-04-2024-0430.
22. Nikyema, G. A.; Blouin, V. Y. Barriers to the Adoption of Green Building Materials and Technologies in Developing Countries: The Case of Burkina Faso. IOP Conf. Ser.: Earth Environ. Sci. 2020, 410(1), 012079. https://doi.org/10.1088/1755-1315/410/1/012079.
23. Crowe, J. H. Architectural Advocacy: The Bullitt Center and Environmental Design. Environ. Commun. 2019, 14(2), 1–19. https://doi.org/10.1080/17524032.2019.1646667.
24. Graczyk, A. M. Implementation of Sustainable Development in the City of Heidelberg. Acta Univ. Lodziensis, Folia Oeconomica 2015, 2(313), 193–206. https://doi.org/10.18778/0208-6018.313.14.
25. Nagy, E.; Jussila, J.; Häyrinen, L.; Lähtinen, K.; Mark-Herbert, C.; Toivonen, R.; Toppinen, A.; Roos, A. Unlocking success: key elements of sustainable business models in the wooden multistory building sector. Front. Sustain. 2024, 5, Article 1364444. https://doi.org/10.3389/frsus.2024.1364444.
26. Klemm, A.; Wiggins, D. Sustainability of Natural Stone as a Construction Material. In Sustainability of Construction Materials; Woodhead Publishing, 2016; pp. 283–308. https://doi.org/10.1016/B978-0-08-100370-1.00012-3.
27. Abushanab, A.; Alnahhal, W. Life Cycle Cost Analysis of Sustainable Reinforced Concrete Buildings with Treated Wastewater, Recycled Concrete Aggregates, and Fly Ash. Results in Engineering 2023, 20, 101565. https://doi.org/10.1016/j.rineng.2023.101565.
28. Sun, C.-Y.; Chen, Y.-G.; Wang, R.-J.; Lo, S.-C.; Yau, J.-T.; Wu, Y.-W. Construction Cost of Green Building Certified Residence: A Case Study in Taiwan. Sustainability 2019, 11(8), 2195. https://doi.org/10.3390/su11082195.

29. Hughes, L. C.; Moore, E. W.; Mario, C. The Impact of Green Building Certifications on Real Estate Value and Environmental Performance. Sustainability 2024. Available at: https://www.researchgate.net/publication/385659415_The_Impact_of_Green_Building_Certifications_on_Real_Estate_Value_and_Environmental_Performance.
30. Alagöz, M. Comparison of Certified „Green Buildings" in the Context of LEED Certification Criteria. AEA Journal 2021. Available at: https://doi.org/10.24427/aea-2019-vol11-no3-01.
31. Mariani, M.; Amoruso, P.; Caragnano, A.; Zito, M. Green Real Estate: Does It Create Value? Financial and Sustainability Analysis on European Green REITs. International Journal of Business and Management, 2018, 13(7), 80-80. https://doi.org/10.5539/ijbm.v13n7p80.
32. Jalaei, F.; Jrade, A. Integrating BIM with Green Building Certification System, Energy Analysis, and Cost Estimating Tools to Conceptually Design Sustainable Buildings. Electronic Journal of Information Technology in Construction 2014, 19, 140–149. https://doi.org/10.1061/9780784413517.015.
33. Nwodo, M.; Anumba, C. J.; Asadi, S. BIM-Based Life Cycle Assessment and Costing of Buildings: Current Trends and Opportunities. In Proceedings of the ASCE International Workshop on Computing in Civil Engineering 2017. https://doi.org/10.1061/9780784480847.007.
34. Figueiredo, K.; Pierott, R.; Hammad, A. W. A.; Haddad, A. N. Sustainable material choice for construction projects: A Life Cycle Sustainability Assessment framework based on BIM and Fuzzy-AHP. Building and Environment 2021, 196, 107805. https://doi.org/10.1016/j.buildenv.2021.107805.