Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 8, No.3, July 2026, pp. 02603020-01 ~ 02603020-010
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v8i3.2436

Hospital Building Value Engineering Strategy in Accordance with Building Technical Standards

Joko Riyanto*, **Slamet Imam Wahyudi, Kartono Wibowo**

Doctoral Program in Civil Engineering, Sultan Agung Islamic University, Semarang City, Central Java, 50112. Indonesia

*joko_riyant@yahoo.com

Abstract. This study developed a Value Engineering strategy for hospital buildings in accordance with Indonesian technical standards, namely Government Regulation No. 16, Minister of Health Regulation No. 40, and Minister of Public Works and Public Housing Regulation No. 21 concerning Green Building Performance Assessment. The purpose of this study was to determine design-appropriate variable criteria and formulate improvement strategies for variables that did not meet the requirements. A quantitative methodology was applied using the Likert strategy, validity and reliability tests (Guttman Split-Half), and mean value analysis. The results showed 16 variables valid, reliable, and feasible indicators (mean 0.92–0.99). Improvement strategies were applied to 16 variables, including additional innovations of 9 variables. The developed Value Engineering strategy is statistically significant and can be used as a reference for hospital planning decision-making, contributing to improved efficiency, sustainability, and quality of hospital buildings in Indonesia.

Keywords: Value engineering, hospital design, building standards, quantitative assessment, indonesia.

(Received 2025-07-25, Revised 2025-09-10, Accepted 2025-10-09, Available Online by 2026-06-09)

1. Introduction

Hospital buildings are strategic public facilities that play an important role in providing health services to the community [Grimaz, Kalalo] [1], [2]. The quality, efficiency, and sustainability of hospitals are highly dependent on proper planning and design, including the fulfillment of safety, health, comfort, and ease of access aspects for users [3], [4]. National technical standards, as reflected in Government Regulation No. 16 of 2021 and Minister of Health Regulation No. 40 of 2022, provide guidelines to ensure that every hospital building meets design and performance criteria [5]. Hospitals management transformative initiatives; towards energy efficiency and environmental sustainability in healthcare facilities [6].

In practice, even though regulations are clear, the implementation of these standards often faces challenges, including resource limitations, design complexity, and the need to integrate sustainability principles [7]. One effective approach to addressing these challenges is Value Engineering, which enables economical design development while still meeting optimal function and quality [8]. Value Engineering is a systematic method for balancing the cost, performance, and aesthetics of a project, with a focus on reducing unnecessary costs while maintaining functional value and quality [9], [10]. Value Engineering workshops on building construction projects, particularly those with a minimum area of 12,000 m² or 8 floors, can improve decision-making in the planning phase in accordance with Regulation of the Minister of Public Works and Public Housing Number 22/PRT/M.

Previous studies have demonstrated the effectiveness of Value Engineering in analyzing functions, risks, and life cycle costs, including purchase, maintenance, operational, financing, depreciation, and end-of-life costs [11], [12]. The integration of Value Engineering with Building Information Modeling (BIM) and value-based strategies (EVVE) has shown improvements in construction project management performance [13], [14],[26]

However, the existing literature is still limited to general coverage related to Value Engineering in construction projects, while specific research on hospital buildings that includes detailed variables and indicators to support planning decision-making is still rare. This gap indicates the need for studies that integrate Value Engineering principles with national technical standards and sustainability practices, thereby producing more applicable and relevant guidelines for hospital development [15].

This study aims to fill this gap by developing a Value Engineering strategy specifically for hospital buildings in Indonesia, determining design-appropriate variable criteria, and formulating improvement strategies for variables that do not meet the requirements. The uniqueness of this study lies in the addition of research variables and innovative indicators, as well as the provision of measurable and systematic improvement strategies, which have not been widely discussed in previous literature.

The results of this study are expected to make a significant contribution to hospital planning practices, including: improving cost efficiency and design performance, strengthening the sustainability and quality of buildings, and serving as a guide for decision makers in health infrastructure projects. Scientifically, this study also broadens the understanding of the application of Value Engineering in the context of hospitals, which can be a reference for similar studies at the national and international levels.

2. **Methods**

This study uses a quantitative approach with a descriptive-analytical design. This approach aims to analyze the criteria of variables that meet the requirements for hospital design based on the principles of Value Engineering and technical standards for buildings in Indonesia.

2.1 Research Location

The research location is in the Republic of Indonesia, based on the distribution of data on the procurement of goods and services by the Ministry of Health's LSPE and the LPSE of the Capital Region of Nusantara (East Kalimantan Province, Balikpapan City, North Penajam Paser Regency) in the Detailed Engineering Design (DET) planning package for hospitals.

2.2 Research population and sample

The determination of the research population and sample was adjusted to the research objectives, namely to obtain data from planners, architects, and related parties directly involved in hospital building planning. The population includes all relevant characteristics or properties of the subjects [16], with the sampling method using purposive sampling. The population consists of Activity Managers and Experts involved in various hospital planning projects, including construction management, detailed engineering design (DED), master plan planning, and construction supervision in several cities and provinces. The total population was 84 people, which was less than 100 people, so the study used a saturated sample, in which all individuals in the population were respondents [17], [18]. Respondents were selected based on demographic characteristics such as age, gender, education level, and experience and direct involvement in the project.

2.3 Data Collection

Research data was collected using several methods, namely questionnaires as the main technique for obtaining information from respondents, interviews to explore critical information related to the application of technical criteria, and documentation as supporting data covering hospital planning documents and national technical standards such as SNI, Minister of Public Works and Public Housing Regulations (PMPR), and other related regulations. This study has considered ethical aspects, including respondent consent and data confidentiality.

2.4 Research Variables

Research variables are defined as characteristics that can have various values and have been adjusted to the research objectives, namely to obtain variable criteria that meet design feasibility requirements and solution strategies to improve variables that do not meet the requirements.

Table 1. Research Variables

Criteria	**Variabel**
A. Building Design Eligibility Criteria (Government Regulation No. 16/2021)	A1. Determination of Building Location and Intensity
	A2. Architectural Requirements
	A3. Building Structure
	A4. Building Aspects
B. Hospital Design Eligibility Criteria (Minister of Health Regulation No. 40/2022)	B1. Land and Building Access
	B2. Building Layout
	B3. Space Requirements
	B4. Accessibility Facilities
	B5. Hospital Rooms
	B6. Inter-Room Relationship Patterns
	B7. Evacuation Facilities
	B8. Hospital Building Structure
	B9. Electrical Requirements
	B10. Mechanical Requirements
C. Green Building Criteria (Ministry of Public Works and Public Housing Regulation No. 21/2021)	C1. Green Building Implementation
	C2. Technical Planning Stage
D. Variable Improvement Solutions (Improvement Strategy)	D1. Compliance with Location & Intensity Requirements
	D2. Compliance with Architectural Requirements
	D3. Compliance with Building Structure Requirements
	D4. Compliance with Building Aspects Requirements
	D5. Compliance with Land and Building Access Requirements (E1)
	D6. Compliance with Land Use Requirements (E2)
	D7. Compliance with Minimum Hospital Building Area Requirements (E3)
	D8. Compliance with Special Facilities for Persons with Disabilities (E4)
	D9. Compliance with Hospital Room Standards and Inter-Room Relationship Patterns (E5–E6)
	D10. Compliance with Evacuation Facilities, Structure, Electricity, Mechanics & Green Building (E7–E10, F1–F2)

2.5 Data Analysis

Data analysis in this study was conducted through two main stages, namely validity testing and reliability testing, as well as descriptive statistical analysis to assess the variable criteria indicators. The validity test was conducted using product-moment correlation with a threshold of $r > 0.220$ at $N = 84$ with a significance level of $\alpha = 5\%$, so that indicators that met these criteria were declared valid. The reliability test used the Guttman Split-Half method with a minimum coefficient of > 0.213, which showed internal consistency between indicators. Furthermore, descriptive analysis was used to evaluate the average value of each indicator, where an average value ≥ 0.5 was considered to meet the design feasibility requirements. The results of this analysis then became the basis for comparing variable criteria that met and did not meet the design feasibility requirements, while also providing an initial overview of the effectiveness of implementing variable improvement strategies.

3. Results and Discussion

3.1 Demographic and Professional Characteristics of Respondents

This section describes the demographic and professional characteristics of the respondents involved in this study, including gender, age, education, professional position, work experience, and experience in planning or developing at least type C hospitals. This presentation is intended to provide an understanding of the profile of the respondents who are the source of the research data so that it can reflect the competence, experience, and background relevant to the research topic.

Table 2. Demographic and Professional Characteristics of Respondents

Criterion	Sub Criteria	Respondents (people)
Gender	1. Male Male	67
	2. Woman	17
	Total	84
Age	1. < 30 Years	2
	2. 31 – 40 Years	28
	3. > 40 years old	54
	Total	84
Education	1. Bachelor's degree	4
	2. Engineer Professional	10
	3. Master of Engineering	65
	4. Doctoral	5
	Total	84
Professional Positions	1. Commitment Making Officials	19
	2. Structural Expert	19
	3. Architect Expert	19
	4. MEP Expert	19
	5. Master of Hospital Administration	5
	6. Construction Management Expert	5
	Total	84
Work Experience	1. < 5 Years	2
	2. 6 – 10 Years	24
	3. > 10 Years	58
	Total	84
Experience in Hospital Building Planning or Construction at least type C	1. < 4 Projects	8
	2. 4 – 8 Projects	61
	3. > 8 Years	15
	Total	84

Based on Table 2, it can be seen that there were 84 respondents in this study, with the majority being male (67 people) and female (17 people). In terms of age, most respondents were in the over-40 age group (54 people), followed by those aged 31–40 (28 people), and only 2 people were under 30 years old.

The educational level was dominated by Master of Engineering graduates, with 65 people, followed by Doctoral graduates, with 5 people, Professional Engineers, with 10 people, and Bachelor's degree holders, with 4 people. The professional positions involved were relatively balanced, with 19 people each for Commitment Making Officials, Structural Experts, Architectural Experts, and MEP Experts, while Hospital Administration Masters and Construction Management Experts numbered 5 people each.

In terms of work experience, the majority of respondents had more than 10 years of experience (58 people), 24 people had 6–10 years of experience, and only 2 people had less than 5 years of experience.

Meanwhile, in terms of experience in hospital construction projects of at least type C, most respondents had been involved in 4–8 projects (61 people), 15 people had been involved in more than 8 projects, and 8 people had less than 4 projects under their belt.

3.2 Analysis of Instruments

The validity test of the variable criteria indicators used in the study shows that the indicators are valid if the correlation value (calculated r) is greater than the value in the product-moment table. With a sample size (N) of 84 respondents, the degree of freedom (N-2) is 82. Based on the table for N=80 at a significance level of 5%, the table r value is 0.220. The test results show that of the 16 variables analyzed, there are 16 variables with validity values ranging from 0.236 to 0.576 that are declared valid.

Furthermore, the reliability test was conducted using the Guttman Split-Half coefficient, where the instrument is declared reliable if the coefficient value is higher than the table r at the product moment. With N=84, the table r at a significance level of 5% is 0.213. The test results show that the lowest Guttman Split-Half coefficient value is 0.222, which is still greater than 0.213. Thus, all 16 Variabel can be declared reliable. The questionnaire return rate was also very good, with all 84 copies distributed being returned (84), resulting in a return rate of 100%3.

3.3 Analysis to obtain Variable Criteria that meet design feasibility criteria

Analysis of indicators that do not meet hospital design feasibility criteria shows that most indicators are valid and reliable, although there is one indicator, namely compliance with lightning rod installation requirements (E.9.4), whose item correlation value -total (0.198) is lower than the r table value (0.220), making it invalid and excluded from the analysis.

Overall, the reliability test showed the lowest Guttman Split-Half coefficient value of 0.610, well above the minimum limit of 0.213, indicating that the research instrument was consistent. The questionnaire return rate reached 100%, which is categorized as “Very Good,” so that the data obtained can be used as a basis for analyzing strategies to improve variables with high reliability.

Next, an analysis of improvement strategies was conducted using the average value of indicators on a Likert scale, where all indicators analyzed had an average value >3.5, indicating that respondents' perceptions of this variable were in the medium to high category. The indicators analyzed covered various important aspects ranging from location and building intensity in accordance with regulations, functional and user-friendly facade and interior design, the ability of building structures to meet SNI standards, fulfillment of safety, health, comfort, and accessibility aspects, to the application of green building including energy efficiency, water management, air quality, use of environmentally friendly materials, and waste management.

These results indicate that the solution strategy to improve the variables that are lacking in quality can be focused on the application of validated technical and operational principles, as well as strengthening the aspects of sustainability and accessibility in the planning of type C hospitals.

3.4 Variable Criteria Innovation and Improvement Strategies in Hospital Design

In this study, innovations were made to obtain variable criteria that meet the feasibility requirements for type C hospital design, as well as to develop solution strategies to improve variables that previously did not meet the design criteria. This study added 10 variables to the existing design feasibility criteria, as well as adding 9 variables to the improvement strategy. This aims to ensure that hospital designs not only meet technical and architectural standards, but also functional, safety, accessibility, and sustainability aspects.

A review of various prior studies reveals a significant development in the scope of variables used to assess the quality of hospital buildings. Overall, the variables examined can be grouped into three main aspects: general building requirements; technical and functional aspects of hospital buildings; and green building aspects.

Regarding general building requirements, provisions related to building aspects in general represent the most consistently used variable across all researchers, from Rachwan (2016) through the 2025 researcher [11]. This indicates that such aspects are regarded as fundamental and cannot be overlooked when assessing hospital building quality. Architectural provisions and the structural load-bearing capacity of buildings also received attention from nearly all researchers, except Thneibat (2022), whose scope of variables was the most limited among all researchers, covering only one variable and four indicators [19]. Meanwhile, provisions for building designation and classification only began to receive attention from Chen (2022) and several subsequent researchers, suggesting a gradual shift toward more formal standardization in the assessment of hospital buildings [20].

Regarding the technical and functional aspects of hospital buildings, electrical and mechanical requirements consistently emerged as two variables examined by nearly all researchers since 2016, reflecting that both aspects have long been recognized as essential components in hospital building operations. On the other hand, variables such as land and building access, building layout, space requirements, accessibility facilities, indoor spaces, spatial relationship patterns, evacuation facilities, and building exterior structures were exclusively examined by the 2025 researcher. The presence of these new variables marks a substantially broader perspective in understanding hospital building quality in a more comprehensive and user-oriented manner.

Regarding the green building aspect, the application of green building concepts and their technical planning provisions only emerged as study variables in Chen (2022) and were subsequently revisited by the 2025 researcher [20]. The absence of these variables in most earlier studies indicates that awareness of the importance of environmental sustainability in hospital building design remains relatively new and continues to evolve.

Overall, there is a clear trend toward increasingly comprehensive approaches over time. Researchers in the 2016 to 2017 period generally employed five variables with eleven indicators, while studies in subsequent years demonstrated a gradual increase in both the number of variables and indicators used. This culminated in the 2025 researcher, who covered sixteen variables and forty-seven indicators, far surpassing all previous studies. This reflects the growing complexity of hospital building quality assessment standards in line with the evolving demands of healthcare services and the increasing expectations for built environments that are safer, more functional, and more sustainable.

The results of the innovation research to obtain solution strategies for improving variables that do not meet design requirements include the addition of 9 variables, as follows:

Table 3. Comparison Getting a strategy for the solution of less qualified

No	Variables	Heiza, (2016)	Badawy, (2022)	Jadidoleslami & Azizi, (2022)	Researchers, (2025)
D1	Fulfillment of Provisions for Location and Building Intensity Designation in accordance with regulations	-	-	-	√
D2	Fulfillment in accordance with the architectural Provisions	√	√	√	√
D3	Ensuring the ability of the building to load load (structure)	√	√	√	√
D4	Fulfillment of all building aspect requirements	√	√	√	√
E1	Make sure the location in accordance with the land and building access requirement	√	√	-	√
E2	Make sure the location in accordance with land use	-	-	-	√
E3	Fulfillment of the minimum requirement of the floor area of the hospital building	-	-	-	√
E4	Fulfilled special facilities in the hospital for patients or visitors with disabilities	-	-	-	

E5	Fufillment of hospital space standards according to the type of service class	-	-	-	√
E6	Fulfillment according to hospital standards pattern of relationships between spaces according to zoning	-	-	-	√
E7	Evacuation routes are not hampered and evacuation facilities are safe	-	-	-	√
E8	Ensuring the requirement of the hospital building structure according to the SNI Hospital Buildings	√	√	√	√
E9	Ensuring electrometric design according to standards for SNI Hospital Buildings	√	√	√	√
E10	Ensuring mechanical design as per the standard for SNI Hospital Buildings	√	√	√	√
C1	Fulfillment of criteria for the implementation of the guilding building	-	-	-	√
C2	Fulfillment of the provisions of the technical planning stage of the building (BGH)	-	-	-	√
Number of Variables		5	5	7	16
Number of Indicators		22	13	18	46

This table shows the solution strategies adopted to improve variables that did not meet the design criteria. This study added new variables that focus on access, space, special facilities for people with disabilities, and green building aspects. With this strategy, variables that were previously inadequate can be improved, so that the overall hospital design is more in line with standards, functional, safe, comfortable, and sustainable.

3.5 Discussion

The results of the study indicate that the criteria for variables that meet hospital design feasibility requirements are valid and can be used as a reference in design. 16 main variables meet technical, architectural, and functional standards. The addition of 10 variables and 34 innovative indicators broadens the scope of the criteria, so that the resulting design not only complies with regulations but also covers aspects of safety, comfort, accessibility, and space efficiency. These results are in line with the findings of Li et al. [21] and Ludușanu et al. [22], which emphasize the importance of integrating technical and environmental aspects in the design of health facilities. However, this study adds more comprehensive innovative elements than previous studies.

In addition, this study developed improvement strategies for variables that previously did not meet the design criteria, covering 16 variables, with an additional 9 innovative variables. This strategy enables systematic design improvements, so that variables with deficiencies can be identified and optimized. This approach emphasizes the integration of functional, technical, and sustainability aspects, similar to research by Soliman-Junior [23], which emphasizes compliance with building standards as the basis for improving hospital design quality.

From a practical implementation perspective, the results of this study provide clear guidelines for hospital designers, developers, and managers. With valid variable criteria and a structured improvement strategy, the hospital planning and construction process can be more efficient, minimize the risk of errors, and meet user needs. This also supports the achievement of optimal building quality in terms of structure, safety, and comfort for patients and hospital staff. This finding reinforces the findings of Qiu [24] and Rahadianto et al. [25], which emphasize the importance of accessibility and spatial standards in improving the quality of health facilities.

Overall, this study emphasizes the importance of integrating innovation into design feasibility criteria and improvement strategies. The addition of new variables and indicators enriches the design framework and provides practical solutions for improving the overall quality of hospital design. Thus, these findings are not only useful for the development of hospital design theory, but also contribute significantly to the practice of designing and managing better and more sustainable healthcare facilities. This study expands on the understanding gained from previous studies by adding innovations that have not been discussed before.

4. Conclusion

This study shows that the application of Value Engineering in hospital buildings can improve efficiency, design quality, and sustainability in accordance with national technical standards. The criteria for variables suitable for design are declared valid and usable, consisting of 16 variables, with an additional 10 variables for innovation. Improvement strategies for variables that do not meet the criteria are also feasible to implement, covering 16 variables, with an additional 9 variables for innovation, which serve as practical guidelines for design improvement. These findings make a significant scientific contribution by providing a measurable framework for improving the quality of hospital buildings. The developed Value Engineering strategy can serve as a practical reference for planners and developers and strengthen the literature on evidence-based decision-making in healthcare facility planning. However, this study is limited to quantitative analysis based on technical standards and literature, without direct testing on actual hospital projects. For further research, it is recommended to apply the Value Engineering strategy to actual hospital construction projects, evaluate the impact on cost, time, and quality, and integrate a more comprehensive sustainability assessment. Further studies could also explore adapting the strategy to different hospital classes and regional areas to improve the generalization and effectiveness of improvement strategies.

Declaration of AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used ChatGPT in order to assist in language refinement, grammar checking, sentence restructuring, and improving the clarity of academic writing. After using this tool/service, the author(s) carefully reviewed and edited the content as needed and take full responsibility for the publication's content.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] S. Grimaz, E. Ruzzene, and F. Zorzini, "Situational assessment of hospital facilities for modernization purposes and resilience improvement," *International Journal of Disaster Risk Reduction*, vol. 66, p. 102594, 2021. https://doi.org/10.1016/j.ijdrr.2021.102594

[2] R. R. Kalalo, S. Simatupang, M. M. M. Simatupang, M. Muktar, and M. Arif, "The urgency of providing health infrastructure in improving the quality of life and creating a golden generation in 2045 in villages," *Journal Of Human And Education (JAHE)*, vol. 4, no. 3, pp. 198–205, 2024. https://doi.org/10.31004/jh.v4i3.911

[3] A. Vasileiou, E. Sfakianaki, and G. Tsekouropoulos, "Exploring sustainability and efficiency improvements in healthcare: A qualitative study," *Sustainability*, vol. 16, no. 19, p. 8306, 2024. https://doi.org/10.3390/su16198306

[4] Z. Ullah, A. R. Nasir, F. K. Alqahtani, F. Ullah, M. J. Thaheem, and A. Maqsoom, "Life cycle sustainability assessment of healthcare buildings: a policy framework," *Buildings*, vol. 13, no. 9, p. 2143, 2023. https://doi.org/10.3390/buildings13092143

[5] S. Uda, M. A. Wibowo, and J. U. D. Hatmoko, "Life cycle energy (LCE) on project life cycle (PLC): a literature review," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 2021, p. 012057. 10.1088/1755-1315/724/1/012057

[6] R. D. Alsaeed, H. Aljaddou, D. Shehab, B. Alaji, and D. Salloum, "Predictive Modeling of NaOCl Dosage for Iron Removal in a Combined Aeration–Oxidation System Using Gene Expression Programming," *International Journal of Environment, Engineering and Education*, vol. 8, no. 1, pp. 1–18. 10.55151/ijeedu.v8i1.235

[7] H. Dion, M. Evans, and P. Farrell, "Hospitals management transformative initiatives; towards energy efficiency and environmental sustainability in healthcare facilities," *Journal of Engineering, Design and Technology*, vol. 21, no. 2, pp. 552–584, 2023. https://doi.org/10.1108/JEDT-04-2022-0200

[8] H. Elhegazy, "State-of-the-art review on benefits of applying value engineering for multi-story buildings," *Intelligent Buildings International*, vol. 14, no. 5, pp. 544–563, 2022. https://doi.org/10.1080/17508975.2020.1806019

[9] E. Pramono, B. Witjaksana, and J. Purnama, "Cost and Time Efficiency Through The Application of Value Engineering In The Construction of an ASN Flat Building In Seram Bagian Barat Regency," *Devotion: Journal of Research and Community Service*, vol. 6, no. 3, pp. 251–261, 2025. https://doi.org/10.59188/devotion.v6i3.25434

[10] A. Gouda Mohamed, F. K. Alqahtani, E. R. Ismail, and M. Nabawy, "Synergizing BIM and value engineering in the construction of residential projects: a novel integration framework," *Buildings*, vol. 14, no. 8, p. 2515, 2024. https://doi.org/10.3390/buildings14082515

[11] R. Rachwan, I. Abotaleb, and M. Elgazouli, "The influence of value engineering and sustainability considerations on the project value," *Procedia Environ. Sci.*, vol. 34, pp. 431–438, 2016. https://doi.org/10.1016/j.proenv.2016.04.038

[12] V. Aramali, G. E. Gibson, H. Sanboskani, and M. El Asmar, "Enhancing project success: the impact of sociotechnical integration on project and program management using earned value management systems," *International Journal of Managing Projects in Business*, vol. 17, no. 8, pp. 1–21, 2024. https://doi.org/10.1108/IJMPB-07-2023-0160

[13] M. Badawy, F. Alqahtani, and H. Hafez, "Identifying the risk factors affecting the overall cost risk in residential projects at the early stage," *Ain Shams Engineering Journal*, vol. 13, no. 2, p. 101586, 2022. https://doi.org/10.1016/j.asej.2021.09.013

[14] S. Uda, M. A. Wibowo, and J. U. D. Hatmoko, "Life cycle energy (LCE) on project life cycle (PLC): a literature review," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 2021, p. 012057. 10.1088/1755-1315/724/1/012057

[15] R. Chandra *et al.*, "ENHANCING THE EFFECTIVENESS OF THE YOLO MODEL THROUGH CALADIUM LEAF IMAGES GENERATED BY GENERATIVE ADVERSARIAL NETWORKS," *Journal of Applied Engineering and Technological Science*, vol. 7, no. 1, pp. 180–196, 2025.

[16] F.-Y. Lo, A. Rey-Martí, and D. Botella-Carrubi, "Research methods in business: Quantitative and qualitative comparative analysis," 2020, *Elsevier*. 10.1016/j.jbusres.2020.05.003

[17] L. J. Duckett, "Quantitative research excellence: Study design and reliable and valid measurement of variables," *Journal of Human Lactation*, vol. 37, no. 3, pp. 456–463, 2021. https://doi.org/10.1177/08903344211019285

[18] U. Sekaran, "Research methods for business: A skill building approach," 2016, *John Wiley & Sons*.

[19] M. Thneibat, M. Thneibat, B. Al-Shattarat, and H. Al-kroom, "Development of an agent-based model to understand the diffusion of value management in construction projects as a sustainability tool," *Alexandria Engineering Journal*, vol. 61, no. 1, pp. 747–761, 2022. https://doi.org/10.1016/j.aej.2021.05.005

[20] W. T. Chen, H. C. Merrett, S.-S. Liu, N. Fauzia, and F. N. Liem, "A decade of value engineering in construction projects," *Advances in Civil Engineering*, vol. 2022, no. 1, p. 2324277, 2022. https://doi.org/10.1155/2022/2324277

[21] Y. Li, H. Zhang, X. Shen, B. Sun, and K. Qu, "Evaluating building performance and patient well-being in healthcare facilities: A literature review of environmental quality and design strategies," *Journal of Building Engineering*, vol. 98, p. 111031, 2024. 10.1016/j.jobe.2024.111031

[22] D.-G. Simion Ludușanu, D.-I. Fertu, G. Tinică, and M. Gavrilescu, "Integrated quality and environmental management in healthcare: impacts, implementation, and future directions toward

sustainability," *Sustainability*, vol. 17, no. 11, p. 5156, 2025. https://doi.org/10.3390/su17115156

[23] J. Soliman-Junior, P. Tzortzopoulos, and M. Kagioglou, "Automated regulatory compliance towards quality assurance in healthcare building projects," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 2022, p. 082012. 10.1088/1755-1315/1101/8/082012

[24] N. Qiu, T. Zhang, and J. Cheng, "Examining the impact of spatial accessibility to rehabilitation facilities on the degree of disability: A heterogeneity perspective," *SSM-Population Health*, vol. 23, p. 101489, 2023. https://doi.org/10.1016/j.ssmph.2023.101489

[25] M. A. E. Rahadianto, M. Nurhayati, A. W. Nugraha, and O. Anggara, "Evaluation of health facilities location to support accessibility to essential health services in Bandar Lampung city, Lampung province, Indonesia," *Journal of Science and Applicative Technology*, vol. 8, no. 1, pp. 1–10, 2024.

[26] S. Sutikno, S. Hardjomuljadi, H. Sulistio, M. A. Wibowo, and S. Dikun, "Exploring the financial dynamics of green building adoption: Insights from Indonesia," Journal of Applied Engineering and Technological Science, vol. 5, no. 2, pp. 1102–1122, 2024. https://doi.org/10.37385/jaets.v5i2.4773