Evaluation of Green Building Implementation in the Construction Project of UPI Tasikmalaya Campus Building

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Abstract

This study aims to evaluate the implementation of green building concepts in the development project of the Universitas Pendidikan Indonesia (UPI) campus building in Tasikmalaya. The research is motivated by the urgency of adopting environmentally friendly construction practices to address issues such as climate change, resource efficiency, and environmental sustainability. A descriptive method with an evaluative approach is employed, using the Greenship for New Building v1.2 standard issued by the Green Building Council Indonesia (GBCI). The evaluation covers six main categories: Appropriate Site Development, Energy Efficiency and Conservation, Water Conservation, Material Resources and Cycle, Indoor Health and Comfort, and Building Environmental Management. The findings reveal that the building scored 68 out of a possible 106 points, earning a Gold rating. Improvements made include the installation of solar panels, infiltration wells, and rainwater harvesting systems. These results demonstrate that a systematic approach to green construction can significantly enhance building performance while offering ecological and long-term operational benefits. The campus building is positioned to serve as a model for sustainable educational infrastructure development across Indonesia.
Keywords: Green Building, Environmental Evaluation, Greenship, Sustainable Campus, Energy Efficiency

1. INTRODUCTION

Infrastructure development, particularly the construction of campus buildings, plays an important role in supporting higher education activities. However, the construction and operational processes of buildings often cause negative impacts on the environment, such as increased carbon emissions, excessive energy consumption, and ecosystem degradation. In addressing global challenges such as climate change and environmental degradation, the concept of green building has become increasingly relevant as a sustainable development approach. Green building refers to buildings that are designed and operated with resource efficiency principles while considering environmental, social, and economic sustainability (Green Building Council Indonesia, 2010; Propertek.id).One approach applied in green building is green construction, which involves managing the construction process in an environmentally friendly manner by utilizing energy- saving technologies, sustainable building materials, and efficient waste management systems (Sun Energy, 2025; Fandeli & Muhamad, 2020).

As an educational institution committed to sustainability, Universitas Pendidikan Indonesia (UPI) has taken strategic steps by applying green construction principles in the development of its campus building in Tasikmalaya. This project not only aims to meet academic space needs but also to serve as an example of the implementation of environmentally friendly building practices in the education sector. The evaluation of green building implementation in this project uses the Greenship for New Building v1.2 standard issued by the Green Building Council Indonesia, which includes six main categories: land use and resources, energy efficiency and conservation, water conservation, materials and resource cycles, indoor health and comfort, and building environmental management (Green Building Council Indonesia, 2010; Fandeli & Muhamad, 2020).

Although the green building concept has been widely recognized, its implementation in Indonesia still faces various challenges. These include the lack of trained experts, relatively high initial costs, and uneven distribution of regulations and supporting policies (Propertek.id; Sun Energy, 2025). In this context, the evaluation of the construction of the UPI Tasikmalaya Campus Building is important to measure the extent to which sustainability principles have been implemented and what obstacles have been encountered. In addition, this study also aims to identify aspects that are not yet optimal and provide improvement solutions that allow for enhancing building performance toward higher green building standards.

Based on this background, this study was conducted to evaluate the implementation of the green building concept in the construction of the UPI Tasikmalaya Campus Building. This evaluation will not only provide an overview of the conformity of construction with Greenship standards but also offer strategic recommendations for improving sustainability in the future. Thus, the results of this study are expected to provide a tangible contribution in supporting sustainable campus development and serve as a model for other educational institutions in Indonesia.

2. RESEARCH METHODS

This study employs a descriptive-evaluative approach aimed at providing a comprehensive overview of the implementation of the green building concept in the construction of the Universitas Pendidikan Indonesia (UPI) campus building in Tasikmalaya. The descriptive approach is used to identify the extent to which green building principles have been applied in the construction project. Meanwhile, the evaluative approach is used to assess the environmental performance of the building by comparing it against the assessment standards established by the Green Building Council Indonesia (GBCI), specifically the Greenship for New Building v1.2. This evaluation provides an objective basis for determining the level of success in applying green building principles to the construction project under study.

The population in this research consists of all buildings included within the scope of the UPI Tasikmalaya campus development. However, for a more focused study, this research applies purposive sampling, where only one main building is selected as the object of evaluation. The selection of this building is based on its relevance to the six assessment categories in Greenship for New Building v1.2, namely: Appropriate Site Development (ASD), Energy Efficiency and Conservation (EEC), Water Conservation (WAC), Material Resources and Cycle (MRC), Indoor Health and Comfort (IHC), and Building Environmental Management (BEM).

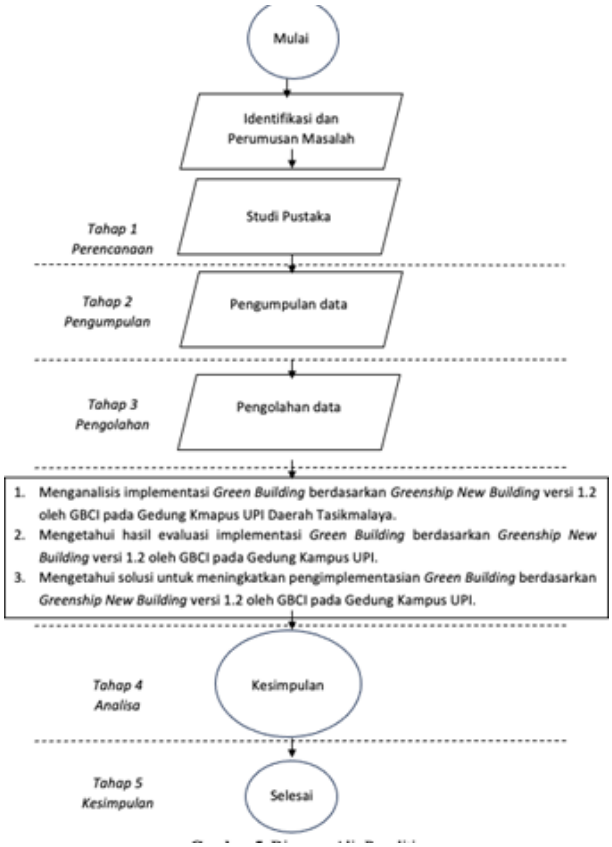

Figure 1. Research Flow Diagram

3. RESULTS AND DISCUSSION

Evaluation in construction projects plays an important role in assessing time and cost performance as well as the overall effectiveness of project implementation, thus serving as a basis for improving the quality of development. Implementation is understood as the process of applying an idea or policy into activities that bring about positive changes in attitudes, skills, and knowledge, which are crucial to the successful application of projects such as building construction. A building itself, according to Law No. 28 of 2002, is the result of construction that serves as a place for human activities, either for residential or other functional purposes.

Green building refers to a construction approach that emphasizes energy, water, and material efficiency while considering environmental, social, and economic sustainability. The objectives of green building include creating an environmentally friendly, resource-efficient, and cost-effective construction process. Its benefits cover environmental aspects (emission and waste reduction), economic aspects (energy savings and increased property value), and social aspects (comfort and health of occupants). To support its implementation, the government has issued various regulations such as Ministry of Public Works and Housing (PUPR) Regulation No. 2 of 2015 and No. 21 of 2021, as well as technical standards such as SNI and ASHRAE, which regulate energy conservation,

ventilation, and the management of green open spaces as essential elements in the development of green buildings.The evaluation instrument used in this study directly refers to **Greenship New Building v1.2** from the **Green Building Council Indonesia (GBCI)**, which is the national assessment standard for green buildings. The assessment was conducted through direct field observations, documentation, and technical analysis of building elements related to the evaluation criteria. The evaluation results were then analyzed to determine the extent to which the campus building meets the green building criteria and how it contributes to environmental sustainability. In addition, the implementation cost of improvements was also calculated as part of the project's efficiency and effectiveness analysis.

Figure 2. UPI Tasikmalaya Campus Building

Based on the evaluation results using the Greenship New Building v1.2 instrument from the Green Building Council Indonesia (GBCI), the Universitas Pendidikan Indonesia campus building in Tasikmalaya obtained a total of 68 points out of a maximum of 102 points, thereby achieving the Gold rating. The score was derived from six assessment categories, namely Appropriate Site Development (ASD), Energy Efficiency and Conservation (EEC), Water Conservation (WAC), Material Resources and Cycle (MRC), Indoor Health and Comfort (IHC), and Building and Environmental Management (BEM).Several solutions successfully implemented include the installation of solar panels, infiltration wells, CO_2 sensors, rainwater harvesting, and roof repainting, with a total implementation cost of IDR 341,113,500.

This evaluation demonstrates that the implementation of the green building concept can significantly improve building efficiency and environmental performance. This systematic approach can also serve as a model for other educational institutions in developing sustainable campuses. For further improvement, it is recommended that the building conduct regular energy and water audits and optimize underperforming categories through more accurate measurement methods. The replication of eco-friendly strategies such as rainwater management, landscape vegetation, and the use of renewable energy should also be applied to other buildings to support climate change mitigation efforts.

3.1. Evaluation of Green Building Implementation at the UPI Campus Building

The minimum required building area is 2,500 m². Based on the calculation results, the UPI Tasikmalaya campus building meets the requirement with a total building area of 3,850 m², which is greater than 2,500 m². The following table presents the floor area of the UPI Tasikmalaya campus building.

Table 1. Floor Area of UPI Tasikmalaya Campus Building

Floor	Area (m²)
1	770
2	770
3	770
4	770
5	770
Total	**3,850**

Source: Analysis Results (2025)

Based on the Regional Regulation of Tasikmalaya City regarding the Spatial Planning (RTRW) of Tasikmalaya City for the years 2011–2031, as well as the Detailed Spatial Plan (RDTR) document applicable in the Tamansari District, the construction site of the UPI Tasikmalaya Campus building is located within the designated zone for education and government.This indicates that the construction site of the campus building is in accordance with the designated land use and meets the spatial planning requirements for the provision of public facilities and higher education services. Therefore, from a spatial planning perspective, the development of the UPI Tasikmalaya Campus does not violate the land-use regulations established by the local government.

The Universitas Pendidikan Indonesia (UPI) campus building in Tasikmalaya successfully obtained 68 points out of a total of 102 points based on the Greenship New Building v1.2 assessment issued by the Green Building Council Indonesia (GBCI). With this achievement, the building was classified at the Gold level, which demonstrates compliance across six key assessment categories: Appropriate Site Development (ASD), Energy Efficiency and Conservation (EEC), Water Conservation (WAC), Material Resources and Cycle (MRC), Indoor Health and Comfort (IHC), and Building Environmental Management (BEM).

The score in each category was achieved through the implementation of various technical and managerial strategies. These include the installation of solar panels as a renewable energy source, the use of infiltration wells and rainwater harvesting for water conservation, and the application of CO_2 sensors to maintain indoor air quality. In addition, roof repainting was carried out as part of temperature control and energy efficiency efforts.

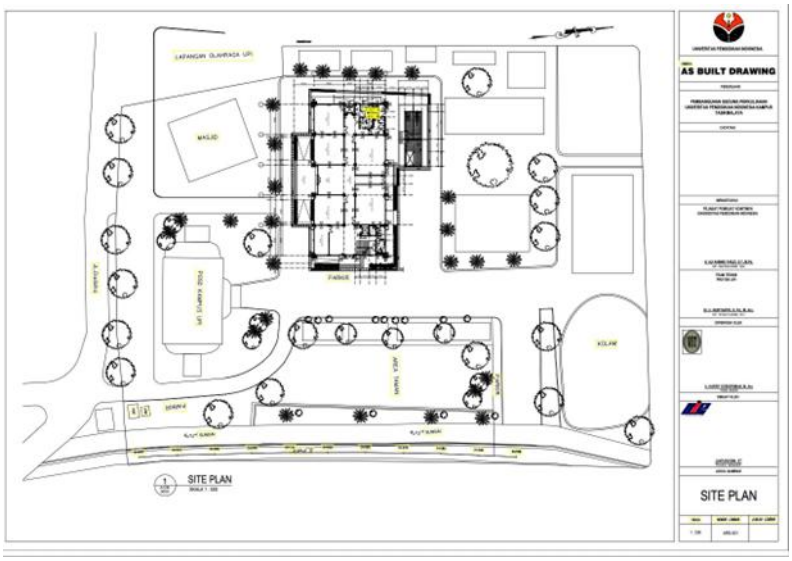

Figure 3. UPI Tasikmalaya Site Plan

Although the Gold rating has been achieved, there is still room for performance improvement in several categories that have not yet reached the maximum score. Activities such as regular energy and water audits, enhancing measurement accuracy, and strengthening environmental management practices have the potential to drive higher point attainment. Approaches such as landscape vegetation, stormwater management, and the optimization of renewable energy utilization can also be further developed to improve the building's environmental performance and ensure consistency with green building principles.

3.2. Evaluation results of green building implementation at the UPI campus building

The Appropriate Site Development (ASD) category achieved 9 out of 17 points, with the highest scores obtained in the subcategories of landscaping on site (3 points), bicycle facilities (2 points), and community accessibility (2 points). However, there were shortcomings in the aspects of public transportation and stormwater management, which did not receive any points. This indicates that although the use of green space and user-friendly facilities has been implemented, transport connectivity and rainwater management remain suboptimal.Meanwhile, the Energy Efficiency and Conservation (EEC) category only earned 12 out of 31 points, with the largest contribution coming from the energy efficiency subcategory (10 points). This reflects the application of energy-efficient technology, but the low scores in natural lighting and renewable energy highlight the potential for further development.

The Water Conservation (WAC) category achieved 11 out of 21 points, with maximum achievement in the subcategories of water use reduction and water features. However, several important aspects such as water recycling, rainwater harvesting, and landscape efficiency have not been fully utilized.On the other hand, the Material Resources and Cycle (MRC) category obtained only 5 out of 14 points, indicating that the use of environmentally friendly materials, recycling, and prefabrication is still limited. The highest points in this category came from regional materials and the use of certified wood. This suggests that material procurement strategies can still be enhanced to better support sustainable development principles.

Table 2. Evaluation of Appropriate Site Development

Category and Criteria	Evaluation Maximum Points GBCI v1.2	Maximum Points
Appropriate Site Development (ASD)		
ASD P – Basic Green Area	P	P
ASD 1 – Site Selection	1	2
ASD 2 – Community Accessibility	2	2
ASD 3 – Public Transportation	0	2
ASD 4 – Bicycle Facility	2	2
ASD 5 – Site Landscaping	3	3
ASD 6 – Micro Climate	1	3
ASD 7 – Stormwater Management	0	3
Total ASD Category Score	**9**	**17**

In the Indoor Health and Comfort (IHC) category, a total of 7 out of 10 points was achieved, with the highest scores obtained from chemical pollutant control, visual comfort, and thermal comfort. A score of zero in CO_2 monitoring and noise level indicates the absence of adequate air quality and acoustic monitoring systems.Meanwhile, in the Building Environmental Management (BEM) category, 6 out of 13 points was achieved. The highest scores came from waste management and the submission of green building data, while the absence of points in commissioning systems and fit-out management reflects a lack of post- construction control.Overall, these findings indicate that the implementation of green building concepts has been carried out; however, there remains room for improvement in nearly all categories to achieve higher efficiency and sustainability.

3.3. Improvement Solutions to Enhance the Implementation of Green Building at the UPI Tasikmalaya Campus Building

To enhance the implementation of green building at the UPI Tasikmalaya campus building, improvements can begin with the Appropriate Site Development (ASD) category. Several aspects that did not receive points, such as public transportation and stormwater management, can be addressed by providing better access to bus stops or public transport routes, as well as constructing environmentally friendly drainage systems such as biopores, rain gardens, or infiltration channels. Strengthening connectivity and managing rainwater are crucial to support the ecological and social functions of the site, especially in response to the high rainfall intensity in the Tasikmalaya region.

In the Energy Efficiency and Conservation (EEC) category, optimization of natural lighting and the application of renewable energy are necessary. The building can increase window openings or add skylights to maximize natural light, thereby reducing dependence on artificial lighting. In addition, the use of solar panels can be enhanced in terms of both capacity and coverage area. Regular energy audits can also be conducted to identify potential savings and to improve inefficient electrical systems.

For the Water Conservation (WAC) category, solutions can focus on the development of water reuse systems. The building can integrate technologies such as greywater recycling to filter and reuse water from sinks or showers for garden irrigation or toilet flushing. Furthermore, the installation of rainwater harvesting systems can help reduce the demand for clean water while simultaneously addressing stormwater runoff. The selection of water-efficient landscape plants can also be applied to improve the efficiency of outdoor water use.

Table 3. Cost of Implementing Improvements for the Gold Rating

Rating	Improvement Solutions	Cost
Gold (67 points)	Installation of 40 units of Solterra 550WP solar panels	Rp 145,530,000
	Rental of dB meter for 3 days to measure noise levels	Rp 150,000.00
	Provision of 2 roof tanks with 30 m² capacity	Rp 40,000,000
	Construction of 3 infiltration wells (1.1 m diameter, 4 m depth)	Rp 9,000,000
	Rental of lux meter for 3 days to measure indoor lighting	Rp 150,000.00
	Replacement of 8,981 roof tiles with red ceramic tiles	Rp 115,000,000
	Installation of 50 CO_2 sensors	Rp 31,433,500
	Total Cost	**Rp 341,263,500**

For the Material Resources and Environmental Management categories, improvements can be achieved by increasing the use of recycled, prefabricated, and eco-friendly materials in every renovation or new construction project. Coordination with local building material suppliers can also be strengthened to ensure the availability of certified and sustainable materials. On the other hand, a commissioning system needs to be implemented to ensure that all building systems operate according to the design plan, while regular user satisfaction surveys should be conducted. This approach will strengthen operational management and create spatial comfort that fully aligns with green building standards.

4. CONCLUSIONS

Based on the evaluation using the Greenship New Building v1.2 instrument from the Green Building Council Indonesia (GBCI), the construction of the Universitas Pendidikan Indonesia campus building in Tasikmalaya obtained a total of 68 points out of a maximum of 102 points, which falls under the Gold rating. The assessment covered six categories, with the highest contributions coming from Building Environmental Management (BEM) and Water Conservation (WAC). This achievement was supported by the implementation of various improvement solutions such as the installation of solar panels, infiltration wells, rainwater harvesting, CO_2 sensors, roof repainting, as well as measurements of light intensity and noise levels. The total cost of implementing all technical solutions amounted to Rp 341,113,500.

The application of the green building concept has been proven to deliver positive impacts on energy efficiency, resource management, and occupant comfort, while also serving as a model for sustainable campus development. To further enhance performance, it is recommended to conduct regular energy and water audits, ensure more accurate measurements with devices such as the OTTV meter and lux meter, and replicate sustainability systems across other buildings within UPI. Such systematic evaluation demonstrates that green design and management strategies can make tangible contributions to climate change mitigation and the improvement of the built environment quality.

REFERENCES

[1] Adeswastoto, H., Setiawan, B., Desrimon, A., Febryanto, F., Putra, A. A., & Islah, M. (2023). nalisis Penerapan Green Building Pada Bangunan Gedung Klinik Universitas Pahlawan. Journal of Engineering Science and Technology Management (JES-TM),, 3(1), 37-43.

[2] Aisyah, A., Rizky, F. K., Lksamana, B., & Fajar, M. D. (2022). Diseminasi Hukum Penanganan Perubahan Iklim dan Pemanasan Global Ditinjau Berdasarkan Perspektif Hukum Lingkungan Internasional di Kelurahan Padang Bulan Selayang I Kecamatan Medan Selayang. Community Development Journal: Jurnal Pengabdian Masyarakat, 3(3), 1401-1411.

[3] Arlisyah, F. N., Sukmawati, S., & Triasiana, A. (2020). Penilaian Green Building Berdasarkan Perangkat Greenship Untuk Bangunan Baru Versi 1.2 Menggunakan Logika Fuzzy (Studi Kasus: Gedung Pascasarjana Fakultas Hukum Universitas Jember). Journal of Applied CIvil Engineering And Infrastructure Technology (JACEIT), 1(1), 43-49.

[4] Atmanto, A. E., Koesdaryanto, A. D., Gupita, G., Sindyartha, M., Iswati, T. Y., & Setyaningsih, W. (2020). Penilaian Kategori Green Building Pada Desain Bangunan Co- Working Space dan Serviced Office di Jakarta Selatan. SENTHONG, 3(2), 519-528.

[5] Burhan, B., Hanny, J., Dena, H., Henry, N., & Gembong, B. (2021). Green Building Analysis of PT United Tractors on Existing Building Based on the Latest Rating Tools Green Building Council Indonesia. Conference on Management and Engineering in Industry, 170(1), 1-11.

[6] Cantika, C., & Yudith, V. (2022). Implementation of Green Building Aspects Based on the Green Building Council Indonesia: A Case Study in the Regional Library Building of East Java Province. Journal of Architectural Research and Education, 4(1).

[7] Fatmala, H. (2019). Pengaruh Penggunaan Material Kaca Terhadap Beban Panas Pada Bangunan National Hospital Surabaya. Malang: Universitas Brawijaya.

[8] Fatmayati, D., Anita, T., & Luthfi, A. (2021). Green Building Achievement Level Analysis Based on Greenship for New Buildings Version 1.2 (Case Study: Kokoon Banyuwangi Hotel). Journal of Applied Civil Engineering and Infrastructure Technology, 2(1), 27- 34.

[9] Febrina, F., Buraida, & Febriyanti, M. (2020). Assessment of Green Building Criteria at the Faculty of Economics and Islamic Business Building, Ar-Raniry State Islamic University Banda Aceh Using Assessment Ratings Greenship Rating Tools for New Building Version 1.2. Journal of the Civil Engineering Student, 2(1), 78-84.

[10] GBCI. (2016). Greenship for New Building v1.2. Jakarta: Green Building Council Indonesia: Divisi Rating dan Teknologi.

[11] Iqbal, M. (2015). Overall Thermal Transfer Value (Studi Kasus: Ruang Kuliah III Pada Program Studi Arsitektur Universitas Malikussaleh). Jurnal Arsitekno, 5(5), 32-41.

[12] Kurniawan, B., Moctar, K., & Simanjuntak, M. R. (2020). Analisis Komponen Konstruksi Pada Penerapan Persyaratan Green Building Menurut Konsil Green Bulding Indonesia (GBCI). Prosiding Seminar Nasional Teknil Sipil 2020 (pp. 308-315). Surakarta: Fakultas Teknik Universitas Muhammadiyah Surakarta.

[13] Lerebulan, A. A., Sangadji, F. A., & Buyang, C. G. (2023). Identifikasi Kriteria Prasyarat Green Building Pada Geudng OJK Provinsi Maluku. Seminar Nasional " ARCHIPELAGO ENGINEERING" 2023.

[14] Massie, F. Y., Dundu, A. K., & Tjakra, J. (2018). Penerapan Konsep Green Building Pada Industri Jasa Konstruksi di Manado. Jurnal Sipil Statik, 6(8), 553- 558.

[15] Mongan, Aditya, I., Jermias, T., Tisano, T., & Arsjad. (2019). Evaluasi Konsep Green Building Pada Gedung Baru Fakultas Hukum Universitas Sam Ratulangi Manado. Jurnal Sipil Statik, 7(12), 1661-1668.

[16] Putra, A. A. (2022). OPTIMALISASI GREENSHIP: PENDINGINAN PASIF MENGGUNAKAN BUILDING INFORMATION MODELING (BIM). Jurnal Ilmiah Desain Sains Arsitektur (DeSciArs), 1, 1-11.

[17] Qiao, R., & Liu, T. (2019). Impact of Building Greening on Building Energy Consumption. Journal of Cleaner Production, 246, 1-13.

[18] Reztrie, N. D., Lubis, i. H., Kusuma, H. E., Koerniawan, M. D., & Budiarto, R. (2018). Wijayaningtyas, M., & Lukiyanto, K. (2021). Home occupants awareness toward Green building : Greenship rating index application. AIP Conference Proceedings 2447, 030010(October), 1–6. https://doi.org/https://doi.org/10.1063/5.007259_5\Wijay. In 2018 2nd International Conference on Green Energy and Applications (ICGEA) (pp. 166- 170). IEEE.

[19] Rohmat, A. (2020). Analisis Kerusakan Struktur Dan Arsitektur Pada Bangunan Gedung (Studi Kasus: Gedung F Universitas Muhammadiyah Sukabumi). Jurnal Student Teknik Sipil, 2(2), 134-140.

[20] Sulistiawan, A. P., Maryanto, D. A., Aprizal, M. I., & Rachman, F. F. (2022). Penilaian Sumber Dan Siklus Material Arsitektural Dalam GBCI Pada Gedung Kuliah Bersama Institut Pertanian Bogor (IPB). Jurnal Arsitektur TERRACOTTA,, 3(2).

[21] Warlina, L. (2017). Manajemen Pembangunan dan Lingkungan. Tangerang Selatan: Universitas Terbuka.

[22] Wijayanigtyas, M., & Lukiyanto, K. (2021). Home occupants awareness toward Green building : Greenship rating index application. AIP Conference Proceedings , (pp. 1- 6).

[23] Wijayaningtyas, Redjo, R. E., Handoko, F., Lukiyanto, K., & Jiram, W. R. (2021). The Millennials' Energy Efficiency Behaviour towards Eco-friendly Home. Civil Engineering and Architecture, 9(2), 394-403.

[24] V

[25]

[26] Erizal, Yudi, C., & Iriani, M. (2019). Evaluasi Aspek Green Building pada Gedung Andi Hakim Nasoetion Rektorat IPB. Jurnal Manajemen Aset Infrastruktur & Fasilitias, 3(2), 131-152.

[27] Fatmala, H. (2019). Pengaruh Penggunaan Material Kaca Terhadap Beban Panas Pada Bangunan National Hospital Surabaya. Malang: Universitas Brawijaya.

[28] Pareek, R. (2022). Green Building: A Step Towards Sustainable Future. Just Agriculture, 2(11), 1-4.

[29] Pei, G., Rim, D., Schiavon, S., & Vannucci, M. (2019). Effect of Sensor Position on the Performance of Co2- Based Demand Controlled Ventilation. Energy And Buildings, 202, 2-27.

[30] Qiao, R., & Liu, T. (2019). Impact of Building Greening on Building Energy Consumption. Journal of Cleaner Production, 246, 1-13.

[31] Sujatmiko, W., Yusniewati, Fefen, S., Fanny, K., Yulia, R., & Ramadan, P. (2020). Sistem Rating Bangunan Gedung Hijau. Bandung: Kementerian Pekerjaan Umum Dan Perumahan Rakyat.

[32] Xie, B. (2020). Assessment of Energy and Emission Performance of a Green Scientific Research Building in Beijing, China. Energy And Buildings, 224, 1-13.

[33] Badan Standardisasi Nasional. (2005). SNI 03-7065-2005: Tata Cara Perencanaan dan Pemasangan Alat Plambing Pada Bangunan Gedung*. Jakarta: BSN.

[34] Badan Standardisasi Nasional. (2017). SNI 8456:2017 – Sumur Resapan Untuk Air Hujan*. Jakarta: BSN.

[35] Direktorat Jenderal Cipta Karya. (2020). *Panduan Teknis Sistem Penampungan dan Pemanfaatan Air Hujan Di Gedung*. Jakarta: Kementerian PUPR.

[36] Green Building Council Indonesia. (2016). *Greenship New Building Version 1.2*. Jakarta: Gbci.

[37] Kementerian Lingkungan Hidup dan Kehutanan. (2019). Peraturan Menteri LHK No. P.102/Menlhk/Setjen/Kum.1/11/2019 Tentang Pedoman Teknis Penerapan Bangunan Gedung Hijau*. Jakarta: KLHK.

[38] Kementerian Pekerjaan Umum dan Perumahan Rakyat. (2021). *Peraturan Menteri PUPR No. 21 Tahun 2021 Tentang Penilaian Kinerja Bangunan Gedung Hijau*. Jakarta: Kementerian PUPR.

[39] PT. Solterra Energy. (2024). *Spesifikasi Panel Surya Solterra 550 Wp*. Jakarta: Solterra Energy Indonesia.

[40] Pvgis – Photovoltaic Geographical Information System. (2024). *Solar Panel Performance Data*. Retrieved From Https://Re.Jrc.Ec.Europa.Eu/Pvg_Tools/

[41] Google Earth. (2024). *Citra Satelit Kota Tasikmalaya*. Diakses Melalui Https://Earth.Google.Com/

[42] Qgis Development Team. (2023). *Qgis Geographic Information System*. Open Source Geospatial Foundation Project. Retrieved From Https://Qgis.Org

[43] Esri. (2024). *Arcgis Online Basemap Imagery*. Retrieved From Https://Www.Arcgis.Com/

[44] Openstreetmap Contributors. (2024). *Openstreetmap Base Data*. Retrieved From Https://Www.Openstreetmap.Org/

[45] International Energy Agency. (2022). *World Energy Outlook 2022*. Paris: IEA.

[46] Putri, A. D., & Nugroho, A. B. (2021). Analisis Efektivitas Panel Surya Pada Bangunan Komersial di Indonesia. *Jurnal Energi Terbarukan Indonesia*, 10(2), 55–64.

[47] Yulianti, R. D. (2020). Evaluasi Penerapan Greenship Pada Gedung Pemerintahan. *Jurnal Teknik Lingkungan*, 19(1), 21–29.

[48] Siregar, H. T., & Pratama, G. R. (2021). Penerapan Sumur Resapan Untuk Penanganan Limpasan Air Hujan di Perkotaan. *Jurnal Infrastruktur Hijau*, 5(1), 11–20.