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Spatial Efficiency and Site Optimization Analysis of a Vertical Educational Facility in Pekanbaru

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Abstract

This study examines the spatial efficiency and sustainable site development of the Poltekkes Riau Tower, a vertical educational facility, using the Greenship New Building Version 1.2 framework established by the Green Building Council Indonesia (GBCI). It focuses on the Appropriate Site Development (ASD) category and assesses green area ratio, site selection, accessibility, transportation, landscape quality, microclimate control, and stormwater management. The building scored 5 out of 17 points (29.4%), indicating shortcomings in bicycle access, landscaping, and runoff mitigation. The evaluation process involves four key steps: (1) Scoring Analysis, which quantifies compliance with the Greenship criteria; (2) Spatial Mapping of green cover, access, and hydrology based on site plans and field data; (3) Gap Identification, which compares actual conditions with benchmarks; and (4) Recommendation Formulation to enhance sustainability through passive design, landscape optimization, and integrated stormwater systems. The findings provide insights for improving site sustainability in future vertical educational buildings located in tropical urban settings.

Keywords: *green architecture; greenship assessment; land optimization*; *site development; vertical campus*

Introduction

Urbanization and land scarcity in dense city centers such as Pekanbaru, Indonesia, have prompted the emergence of vertical typologies in institutional and educational building development. These vertical campuses are envisioned as spatial solutions to limited land availability and as catalysts for sustainable urban transformation. However, many educational buildings in tropical cities fail to fully optimize land use through sustainable site planning, resulting in excessive hardscape areas, insufficient public transport linkage, and limited climate-responsive open space.

Figure 1. Location of the building in Pekanbaru
Source: Author, 2025

In response to growing concerns about sustainable development, assessment frameworks such as the Greenship Rating Tool-developed by the Green Building Council Indonesia (GBCI), have established measurable criteria to evaluate land suitability and spatial performance in architectural projects. Specifically, the Appropriate Site Development (ASD) category in the Greenship New Building Version 1.2 outlines essential parameters for optimizing land use, including green area ratio, community connectivity, alternative mobility infrastructure, and microclimate responsiveness. This research focuses on the ASD category because it represents the earliest and most fundamental stage in the green building planning cycle, particularly for new constructions. If land use is not optimized from the outset, achieving other categories such as energy efficiency and water conservation becomes significantly more challenging. Furthermore, based on my preliminary study, the ASD category is the most frequently unmet in educational building projects in Indonesia. Therefore, this research aims to address the root issues of land use and provide in-depth, context-specific insights that can contribute to refining GBCI's standards, making them more applicable and effective for educational facilities.

This study focuses on Poltekkes Riau Tower, a vertical academic building constructed in 2022, to evaluate the extent to which its site planning aligns with sustainable spatial development standards. While previous studies have emphasized total sustainability ratings, this research highlights the spatial configuration and land-use implications as a standalone factor in shaping sustainable educational environments. The outcome is expected to contribute to a deeper understanding of sustainable site strategies for high-rise campus buildings in tropical urban settings.

Literature Review

Sustainable Land Development in Educational Facilities

Sustainable site development is a critical component in the broader discourse of green architecture. In dense urban settings, the demand for vertical expansion has reshaped the spatial dynamics of educational campuses, which traditionally rely on expansive horizontal layouts. According to Chansomsak and Vale (Chansomsak & Vale, 2009)The compact campus typology must integrate environmental, social, and spatial responsiveness to remain functional and sustainable. This involves the effective use of open spaces, stormwater absorption zones, non-motorized circulation, and integration with public transport.

Research by (Harputlugil & Bedir, 2016) Emphasizes that the urban footprint of institutional buildings significantly affects microclimate regulation, energy use, and walkability, especially in tropical and equatorial contexts. The application of green infrastructure and landscape-based solutions such as vegetated buffers, softscape zoning, and multi-functional public spaces becomes essential in these conditions.

Rating Frameworks for Site Sustainability

Green building certification systems offer a structured method for assessing site development. Among the most recognized are:

- LEED (Leadership in Energy and Environmental Design) - developed by the US Green Building Council (USGBC),

United States

- BREEAM (Building Research Establishment Environmental Assessment Method) - United Kingdom
- CASBEE (Comprehensive Assessment System for Built Environment Efficiency) - Japan
- Greenship - Indonesia, managed by the Green Building Council Indonesia (GBCI)

While LEED and BREEAM provide broad guidelines for land use efficiency, they often require regional adaptation, especially in tropical zones. (Liu et al., 2017). Greenship by GBCI addresses such contextual adaptation with specific categories under its New Building v1.2 framework, notably the Appropriate Site Development (ASD) category.

The ASD category is composed of eight sub-criteria including green base area (ASD-P), site selection (ASD-1), community access (ASD-2), public transit facilities (ASD-3), bicycle infrastructure (ASD-4), landscape management (ASD-5), microclimate control (ASD-6), and stormwater management (ASD-7). Each criterion assigns weight based on environmental contribution and urban contextual relevance. (GBCI, 2018).

Table 1. GBCI Greenship Categories and Points

Cetegory	Category Name	Maximum Points	Percentage Contribution
ASD	Appropriate Site Development	17	16.8%
EEC	Energy Efficiency and Conservation	26	25.7%
WAC	Water Conservation	21	10.8%
MRC	Material Resources Comfort	12	11.9%
IHC	Building Environmental	17	16.8%
BEM	Management	8	7.9%
Total		**101**	**100%**

Source: GBCI, 2018

Relevance of Greenship ASD to Urban Vertical Buildings

Vertical educational buildings present a unique opportunity and challenge in implementing sustainable land-use strategies. Their small footprint must compensate through high-density vertical programming while still fulfilling green space requirements and connectivity standards. Studies by (Li et al., 2016) Stress that improper site handling in tall buildings may lead to urban heat island intensification, stormwater flooding, and loss of biodiversity.

In the Indonesian context, Greenship's ASD category has been used in several public sector buildings, including universities (Maryati, 2013), yet literature on high-rise academic buildings remains limited. Evaluating Poltekkes Riau Tower with this lens offers insights into how spatial sustainability performance manifests in a vertical campus prototype.

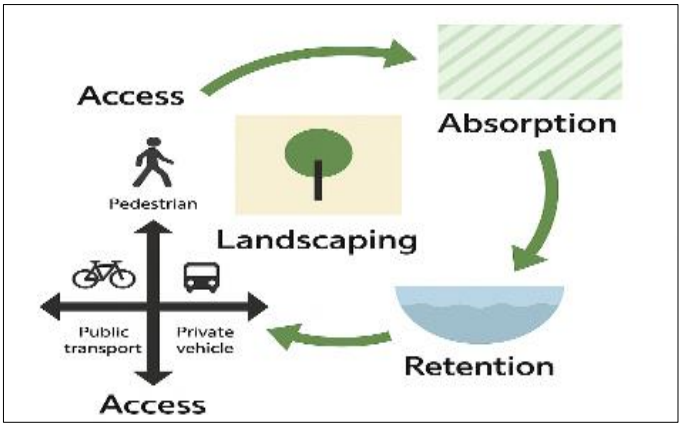


Figure 2. Greenship Site Strategy Concept
Source: Author, 2025

Methodology

1. Research Design

This research adopts a mixed-methods approach, combining quantitative scoring using the Greenship New Building v1.2 rating system with qualitative spatial evaluation through document analysis and on-site verification. The primary focus is the Appropriate Site Development (ASD) category, which consists of eight specific indicators assessing land efficiency, connectivity, green area provision, and climate responsiveness.

2. Object and Site Description

The object of this research is the Poltekkes Riau Tower, a ten-story educational facility located in Pekanbaru, Indonesia. Built in 2022 on a land area of 3,292.56 m², with a total floor area of 12,841.70 m², the tower accommodates academic functions, including classrooms, computer-based testing centers, and an auditorium. Its vertical typology makes it an ideal model for evaluating spatial efficiency in urban campuses.

Figure 3. Documentation of the Facade of the Riau Polytechnic of Health Tower
Source: Author, 2025

Table 2. Site and Building Technical Specifications

Parameter	Description
Project Name	Poltekkes Riau Tower
Location	Jl. Melur No. 103, Sukajadi, Pekanbaru, Riau
Function	Academic: Lecture Rooms, CBT Rooms, Auditorium
Building Classification	New Vertical Educational Building
Land Area	3,292.56 M²
Building Area (Total GFA)	12, 841.70 M²
Number of Floors	10 floors (including rooftop technical zone)
Floor Area Ratio (FAR)	3.9
Building Coverage Ratio (BCR)	49,5%
Building Height	±37 Meters
Construction Period	Completed in late 2022

Source: Author, 2025

3. Data Collection

Data were collected through the following methods:

- Field observation: Verifying the presence of softscape, pedestrian access, shading devices, and water management elements on-site
- Document analysis: Review of *as-built drawings*, master plans, and urban planning policies (RTRW Pekanbaru

2030).

- Photographic documentation: Supporting the evaluation of spatial configurations and design elements.
- Greenship scoring tool: Assessment conducted using ASD criteria from Greenship NB v1.2 (GBCI, 2018)

4. Variables and Indicators

The study refers to the following eight ASD indicators, treated as evaluation variables:

Table 3. Site and Building Technical Specifications

Code	Indicator	Weight
ASD-P	Basic Green Area (Prerequisite)	Mandatory
ASD-1	Site Selection	2 points
ASD-2	Community Accessibility	2 points
ASD-3	Public Transport Access	2 points
ASD-4	Bicycle Facilities	2 points
ASD-5	Landscape Performance	3 points
ASD-6	Microclimate Management	3 points
ASD-7	Stormwater Runoff Management	3 points

Source: GBCI, 2018

5. Analytical Framework

The evaluation process in this study adopts a systematic and evidence-based approach to assess the sustainability performance of the Appropriate Site Development (ASD) category based on the Greenship New Building Version 1.2 framework. It comprises four key stages:

- **Scoring Analysis**
  Serves as the initial step, where each ASD indicator is evaluated based on its compliance level with the Greenship criteria. Scores are assigned on a scale from 0 to the maximum possible value for each indicator, which is then interpreted as a percentage reflecting the building's sustainability performance.
- In the **Spatial Mapping** phase,
  Physical attributes such as green area distribution, vehicular and pedestrian access routes, and zones related to stormwater management are visualized using data extracted from architectural site plans and verified through field observations.
- **Gap Identification** follows,
  Involving a detailed comparison between actual site conditions and the ideal benchmarks set by the Greenship system. This phase reveals critical gaps, shortcomings, and missed opportunities in the current implementation.
- Lastly, **Recommendation Formulation**
  Translates the analytical findings into actionable strategies. These include spatial reconfiguration, passive design integration, landscape enhancement, and stormwater system improvements aimed at increasing the site's environmental performance in future development projects, especially within dense, tropical urban contexts.

Result and Discussion

A. Scoring Overview

Based on the comprehensive assessment of the eight indicators outlined in the Appropriate Site Development (ASD) category of the Greenship rating system, the Poltekkes Riau Tower obtained a total score of 5 points out of a possible 17, which is equivalent to 29.4%. This result indicates a relatively low level of achievement in implementing sustainable site development practices. The detailed scoring results for each indicator are presented in Table 4 below:

Table 4. Scoring Summary of ASD Indicators

Code	Indicator	Max Point	Score Achieved
ASD-P	Basic Green Area (Prerequisite)	Mandatory	√ ((Partial)
ASD-1	Site Selection	2 points	1
ASD-2	Community Accessibility	2 points	1
ASD-3	Public Transport Access	2 points	1
ASD-4	Bicycle Facilities	2 points	0
ASD-5	Landscape Performance	3 points	0
ASD-6	Microclimate Management	3 points	2
ASD-7	Stormwater Runoff Management	3 points	0
	Total	**17**	**5**

Source: Adapted from GBCI Assessment Sheet (2025)

B. Indicator-Based Analysis

1. ASD-P – Basic Green Area

- Softscape coverage on the site reached approximately 11% of the total land area, successfully fulfilling the minimum requirement outlined in Criterion 1A of the Greenship ASD category.
- However, the project did not meet the requirement of Criterion 2, which mandates that at least 50% of the vegetation must consist of native or adaptive plant species.
- Supporting visual data are presented in Figure 4 and Table 5

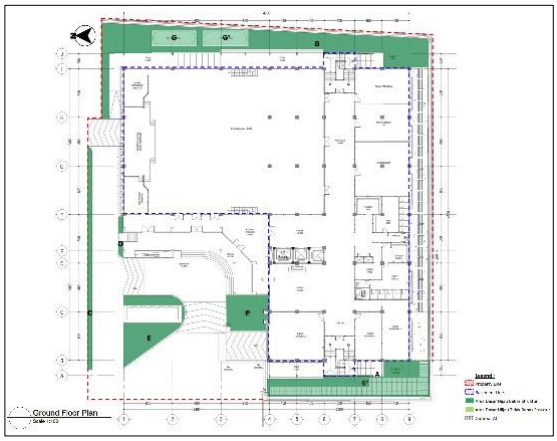


Figure 4. Green base area calculation zone
Source: Author, 2025

Table 5. Recapitulation of green base area calculations

Green Basic Area Calculation (Benchmark 1A)				
Land Area			3,292 M²	
Site Selection			464.6 M²	
Community Accessibility			364.4 M²	
Public Transport Access			11%	
Bicycle Facilities			118.24 M²	
Landscape Performance			4%	
A = 99.7 M²	C = 21.8 M²	E = 54.4 M²	G = 19.5 M²	G² = 99.7 M²
B = 179.19 M²	D = 3.7 M²	F = 40.8 M²	G¹ = 19.5 M²	

Source: Author, 2025

Table 6. ASD-P Basic Green Area Criteria Assessment Results

	Basic Green Area				
	Objective:				
	To preserve or expand urban greenery to improve microclimate quality, reduce CO_2 and other pollutants, prevent soil erosion, lessen the burden on the drainage system, and maintain the balance of the clean water cycle and groundwater system.				
	Benchmark:		**Point**	**Max Point**	**Actual Point**
ASD-P	**1**	Landscaped zones featuring vegetation (softscape) without any building constructions or minimal garden elements (hardscape), whether located at ground level or beneath the surface. **a.** For newly developed buildings, a minimum of 10% of the entire site area must be designated for this purpose. **b.** In cases of major renovations, at least half of the open area on the site, excluding spaces above basement structures, must be maintained.	**P**		
	2	This site features vegetation that aligns with the provisions outlined in Article 13 (2a) of the Ministry of Home Affairs Regulation No. 1 of 2017. The land is composed of 50% mature plant coverage, incorporating a variety of vegetation types such as small to large trees, semi-arboreal shrubs, general shrubs, and underbrush. Additionally, the selection of plant species takes into account the vegetation guidelines specified in Article 2.3.1 of the Ministry of Public Works Regulation No. 5/PRT/M/2008 concerning Green Open Space (GOS), particularly those related to vegetation standards for residential yards.	**P**	**P**	**P**

Source: Author, 2025

2. ASD-1 – Site Selection

- The site is located in a developed urban zone with 9 of 12 urban facilities present.
- Scored 1 out of 2 due to missing technical documents for complete verification.
- Referensi visual: Figure 5 – 10 & Tabel 7

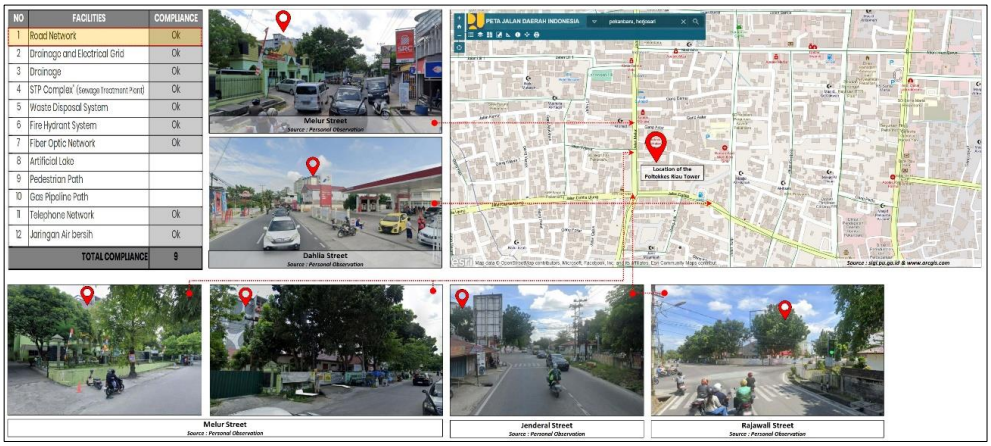


Figure 5. Data verification via a map against the road network
Source: Author, 2025

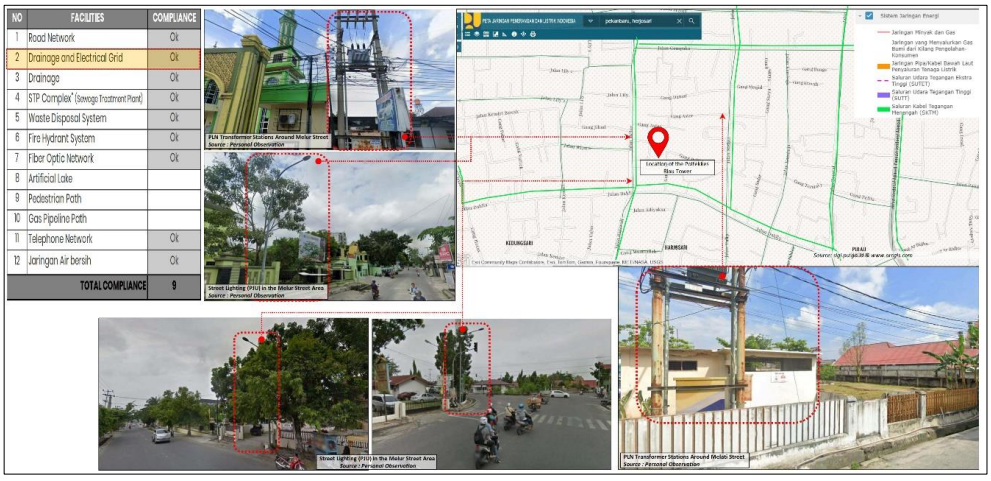


Figure 6. Data verification via maps against lighting and electricity networks
Source: Author, 2025

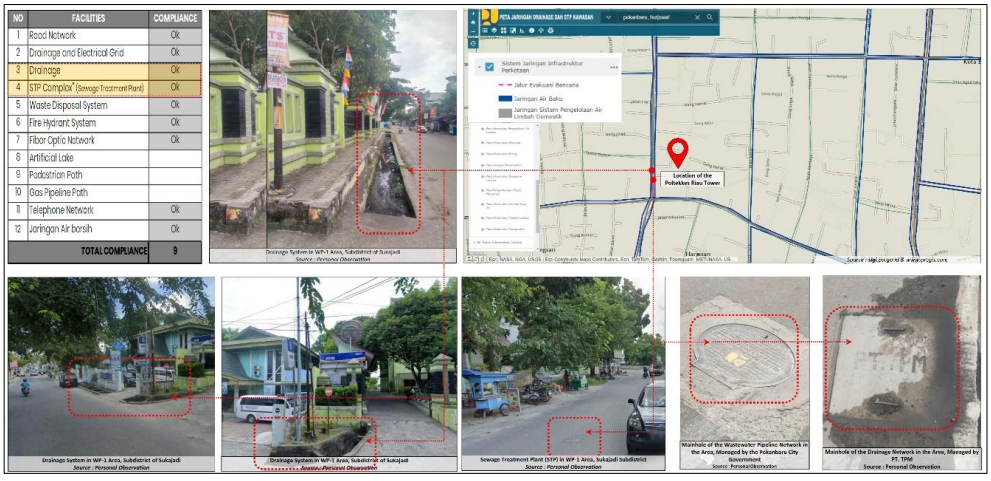
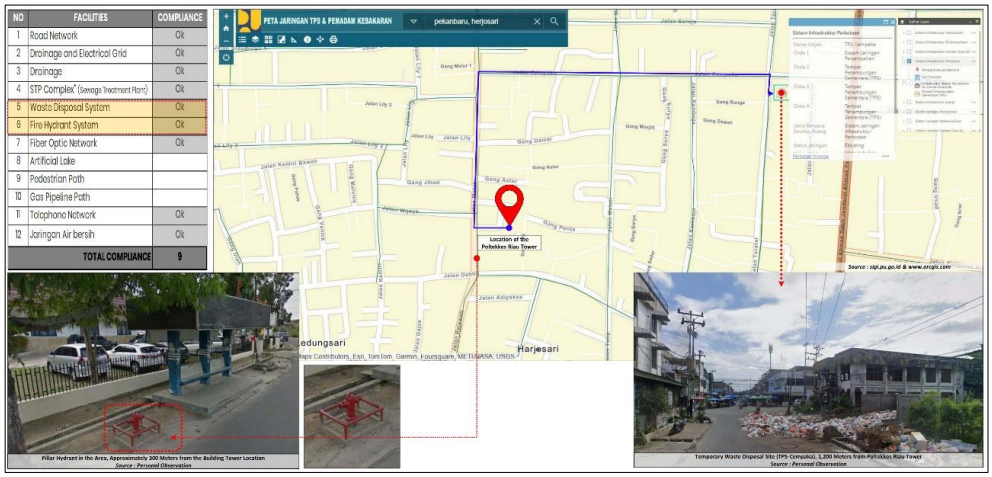
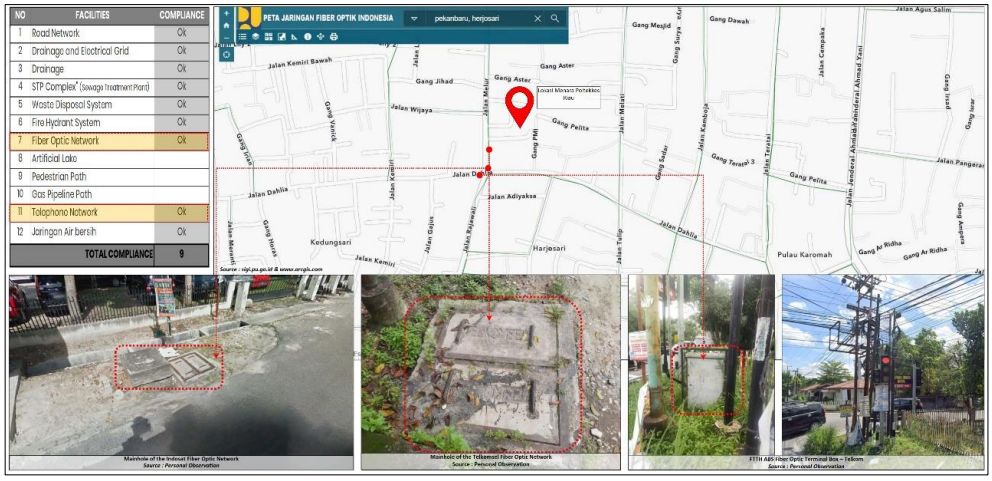


Figure 7. Data verification via maps against drainage networks & STP Areas
Source: Author, 2025



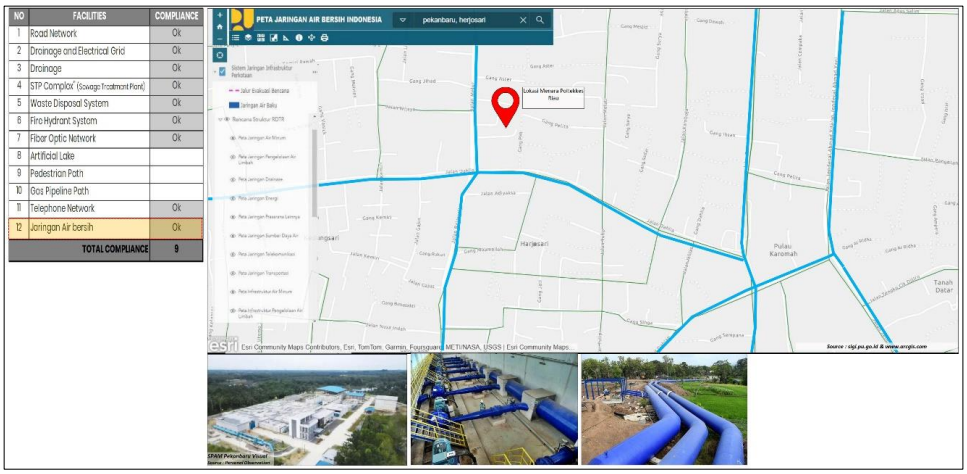
NO	FACILITIES	COMPLIANCE
1	Road Network	Ok
2	Drainage and Electrical Grid	Ok
3	Drainage	Ok
4	STP Complex* (Sewage Treatment Plant)	Ok
5	Waste Disposal System	Ok
6	Fire Hydrant System	Ok
7	Fiber Optic Network	Ok
8	Artificial Lake	
9	Pedestrian Path	
10	Gas Pipeline Path	
11	Telephono Network	Ok
12	Jaringan Air bersih	Ok
TOTAL COMPLIANCE		9

Figure 8. Data verification via maps against waste disposal and fire extinguishing systems
Source: Author, 2025



NO	FACILITIES	COMPLIANCE
1	Road Network	Ok
2	Drainage and Electrical Grid	Ok
3	Drainage	Ok
4	STP Complex* (Sewage Treatment Plant)	Ok
5	Waste Disposal System	Ok
6	Fire Hydrant System	Ok
7	Fiber Optic Network	Ok
8	Artificial Lake	
9	Pedestrian Path	
10	Gas Pipeline Path	
11	Telephono Network	Ok
12	Jaringan Air bersih	Ok
TOTAL COMPLIANCE		9

Figure 9. Data verification via maps against fiber optic networks and telephone networks
Source: Author, 2025



NO	FACILITIES	COMPLIANCE
1	Road Network	Ok
2	Drainage and Electrical Grid	Ok
3	Drainage	Ok
4	STP Complex* (Sewage Treatment Plant)	Ok
5	Waste Disposal System	Ok
6	Fire Hydrant System	Ok
7	Fiber Optic Network	Ok
8	Artificial Lake	
9	Pedestrian Path	
10	Gas Pipeline Path	
11	Telephone Network	Ok
12	Jaringan Air bersih	Ok
TOTAL COMPLIANCE		9

Figure 10. Data verification via maps against clean water networks
Source: Author, 2025

Table 7. ASD-1 Site Selection Criteria Assessment Results

	Site Selection				
	Objective: To avoid development in greenfield areas and prevent the clearing of new land				
	Benchmark:		**Point**	**Max Point**	**Actual Point**
ASD-1	1A	Select a development zone that includes no fewer than eight of the twelve available categories of urban infrastructure and amenities: 1. Transportation Infrastructure 2. Electrical and Illumination System 3. Stormwater Management Network 4. Centralized Wastewater Treatment Facility 5. Solid Waste Management System 6. Fire Safety and Prevention Infrastructure 7. Integrated Fiber Optic Infrastructure 8. Constructed Water Body Covering at Least 1% of the Site Area 9. On-Site Pedestrian Circulation Routes 10. Centralized Gas Distribution System 11. Landline Communication Network 12. Potable Water Distribution System	**1**	**2**	**1**
		or			
	1B	Choosing a site for development that features a Floor Area Ratio (FAR) exceeding 3			
	2	Revitalizing and developing land with negative value and unused potential due to previous construction or the adverse impacts of past development	**1**		**0**

Source: Author, 2025

3. ASD-2 – Community Accessibility

- The site is within 1,500 meters of more than 7 public facilities, including clinics, schools, and a mosque.
- Lacks a dedicated pedestrian linkage to three key facilities within 300 meters.
- Referensi visual: Table 8, Figure 11 – 21, dan Table 8.

Table 8. Distance from the site to public facilities

Site Menara Poltekkes Riau Terdapat Minimal 11 dari 19 Fasilitas Umum				
No	**Public Facility**	**Facility Name**	**Address**	**Distance (m)**
1	Bank	BRI KCP. Ahmad Yani	Jl. Ahmad Yani	1,200
2	Public Park			0
3	Public Parking (Off-Site)	Parkir Mobil/Motor RS. Ibnu Sina	Jl. Melati	850
4	Stall / Convenience Store	Warung Rizky	Jl. Melur	180
5	Multipurpose Hall			0
6	Security Post / Police Station	Pos Polisi Gurindam-7	Jl. Riau	1,400
7	Place of Worship	Mesjid Al-Jihad	Jl. Melur	230
8	Sports Field			0
9	Childcare Center			0
10	Pharmacy	Apotek Dyandri	Jl. Melur	350
11	Restaurant / Canteen	Bofet Kurai Taji	Jl. Dahlia	350
12	Public Photocopying Service	Iqbal Print & Foto Kopi	Jl. Melur	160
13	Healthcare Facility	Puskesmas Melur	Jl. Melur	130
14	Post Office			0
15	Fire Station	Kantor Pemadam Kebakaran	Jl. Cempaka	1,200
16	Public Transport Terminal / Station			0
17	Library			0

18	Government Office			0
19	Market	Pasar Kodim		1,200
			Total Facilities	**11**

Source: Author, 2025

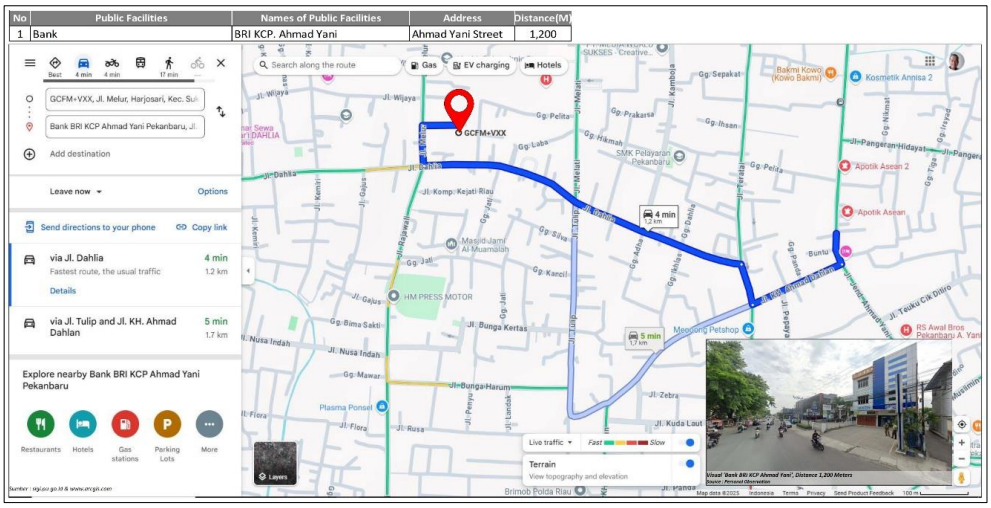


Figure 11. Data verification via a map against the BANK public facilities
Source: Author, 2025

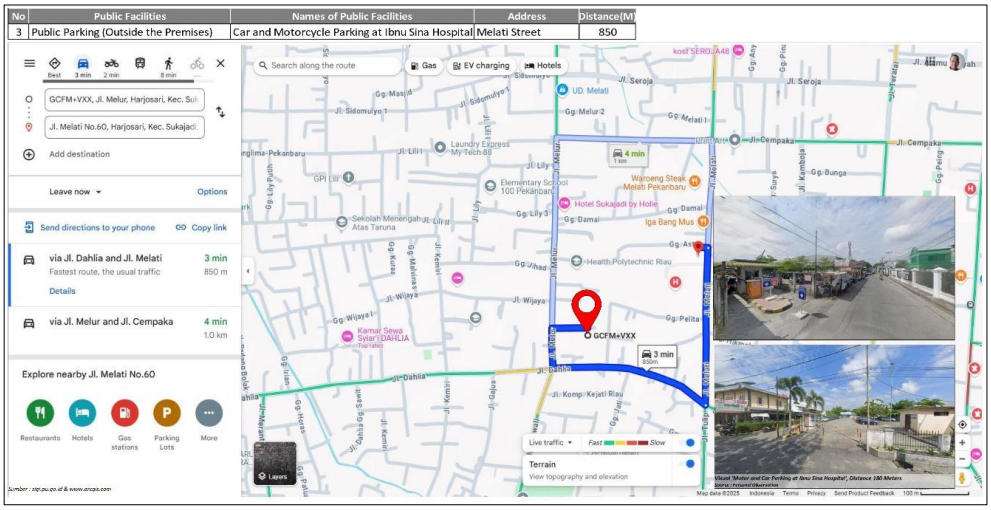


Figure 12. Verify data via map against public facilities, Public Parking
Source: Author, 2025

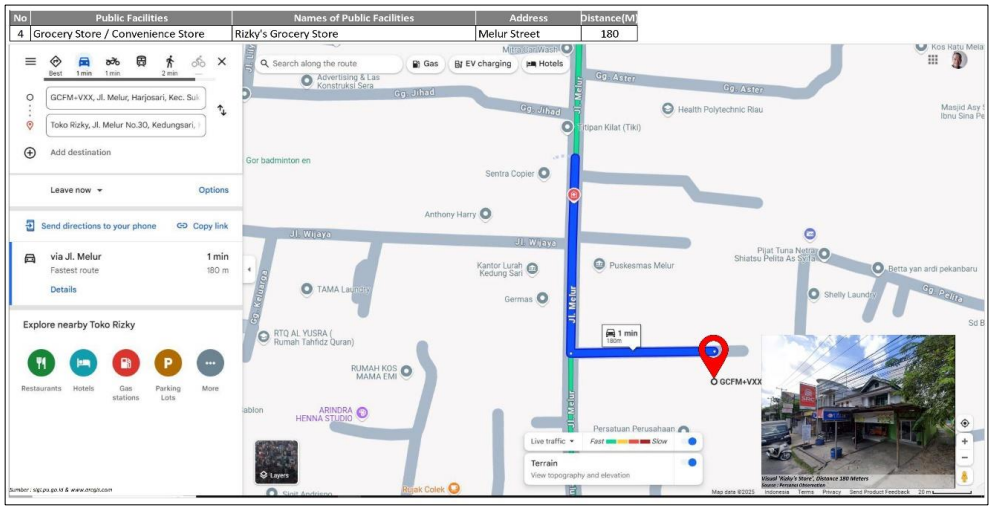


Figure 13. Verify data via maps against public facilities such as shops/grocery stores.
Source: Author, 2025

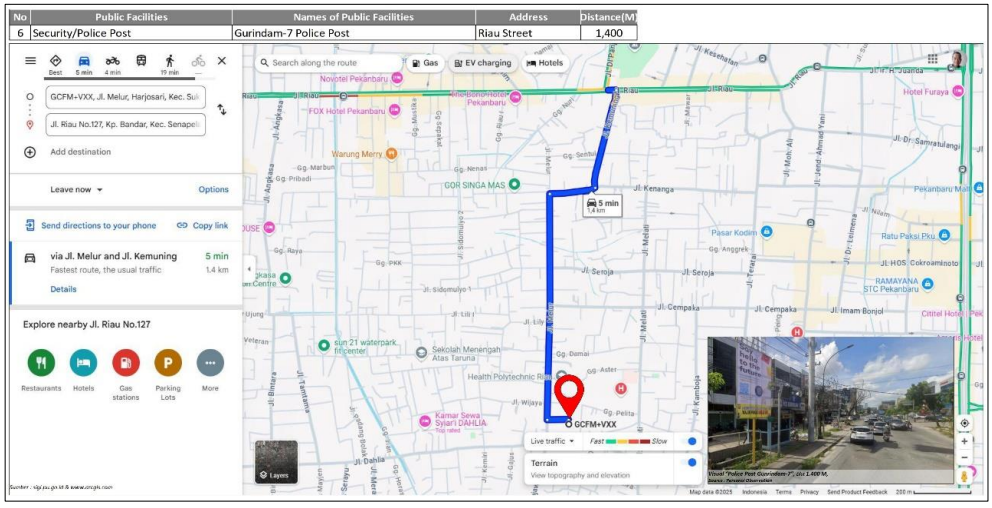


Figure 14. Verify data via map against public facilities, Security/Police Posts
Source: Author, 2025

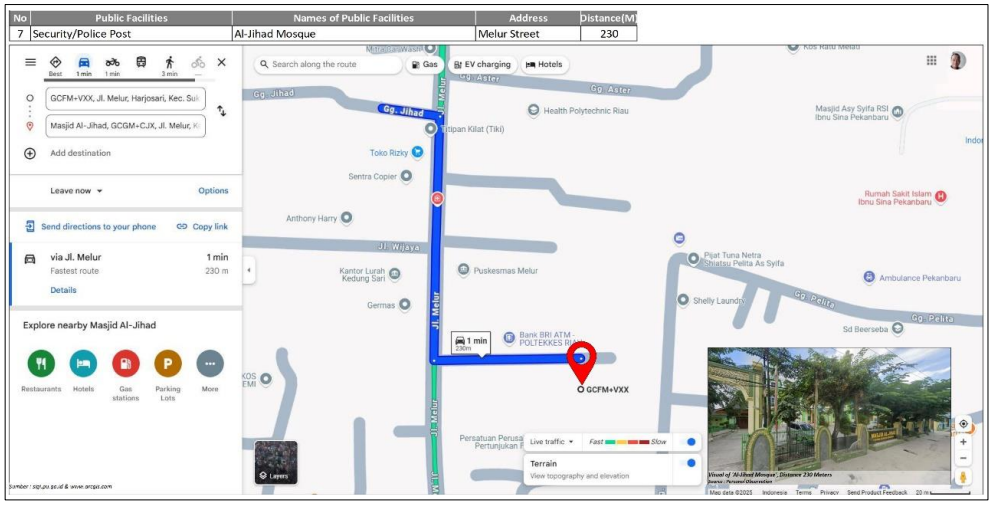


Figure 15. Data verification via maps of public facilities, Places of Worship
Source: Author, 2025

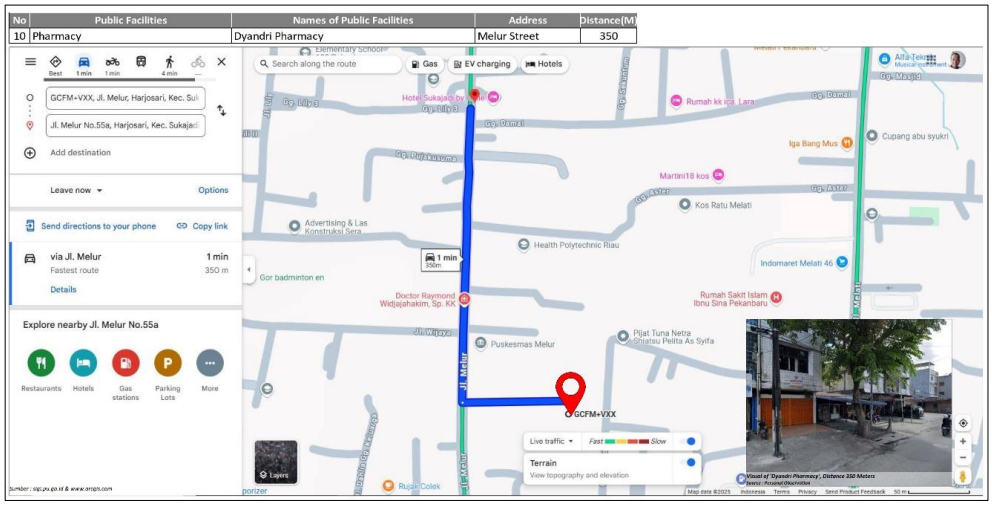


Figure 16. Data verification via a map against public pharmacy facilities
Source: Author, 2025

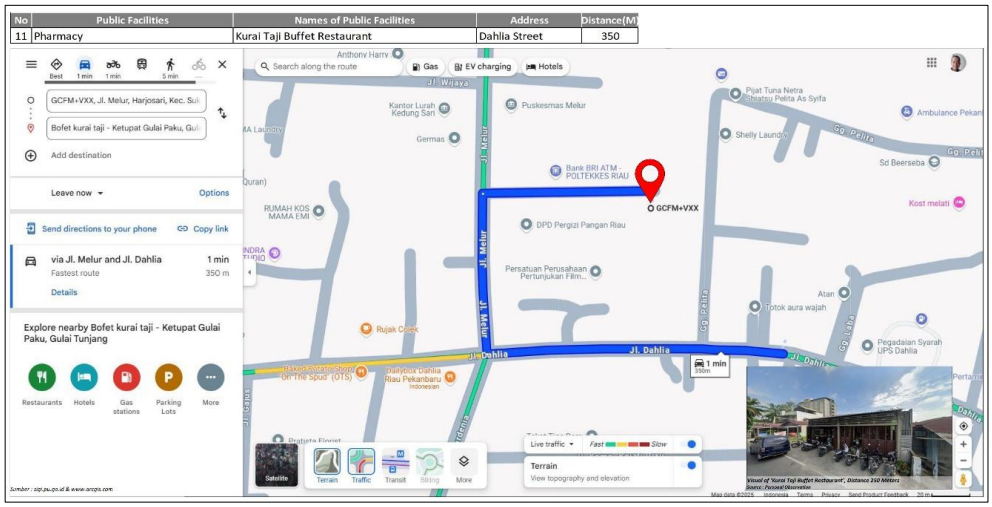


Figure 17. Data verification via a map of public facilities of Restaurants/Canteens
Source: Author, 2025

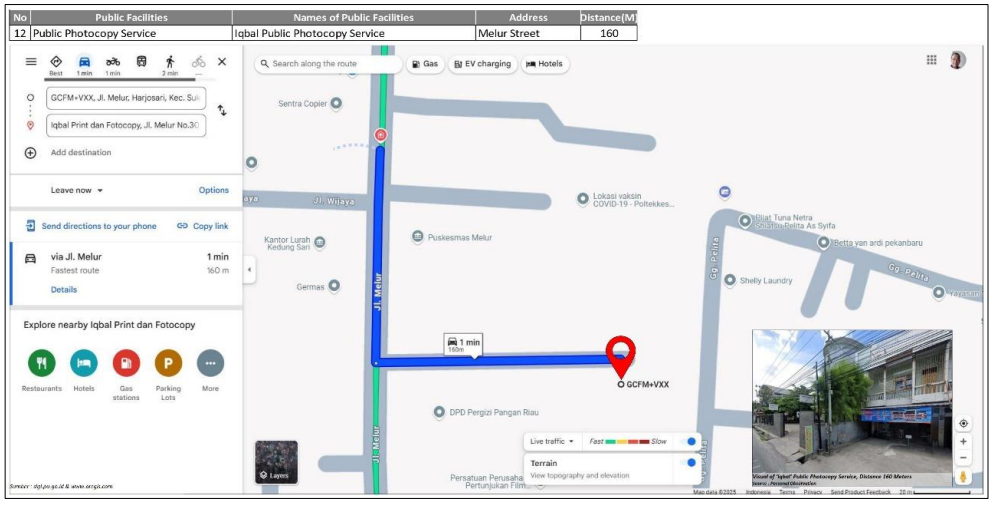


Figure 18. Verification of data via maps against public facilities, General Photocopy
Source: Author, 2025

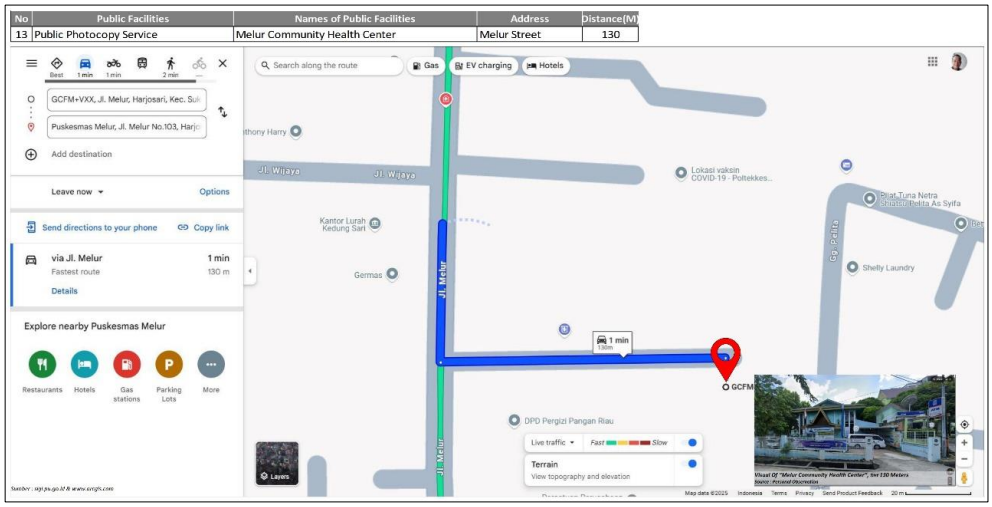


Figure 19. Data verification via maps against public facilities, Health Facilities
Source: Author, 2025

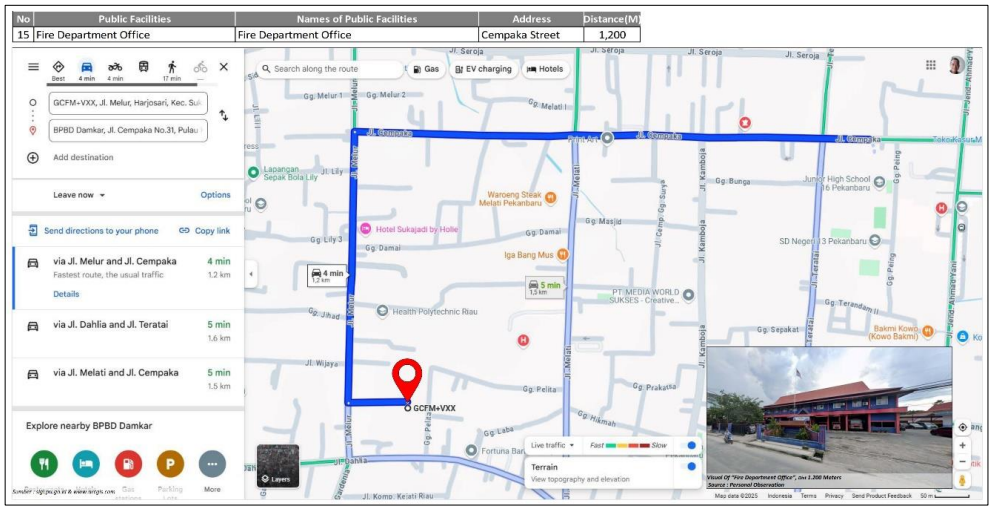


Figure 20. Data verification via a map against the public facilities of the Fire Department Office
Source: Author, 2025

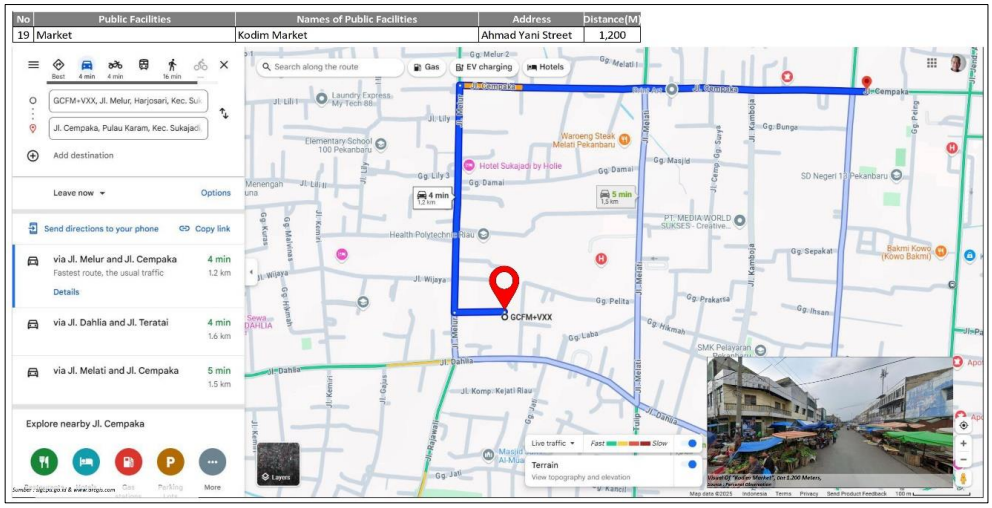


Figure 21. Data verification via a map against the public facilities of the Market
Source: Author, 2025

Table 9. ASD-2 Community Accessibility Criteria Assessment Results

	Community Accessibility				
	Objective: To encourage development in areas that already have established connectivity networks and to enhance building utilization, thereby facilitating daily activities for the community and reducing the reliance on motorized vehicles.				
	Benchmark:		**Point**	**Max Point**	**Actual Point**
ASD-2	1	There are at least seven types of public facilities within a reachable distance of 1,500 meters from the main road to the site. 1. Bank 2. Public Park 3. Public Parking (Off-Site) 4. Stall / Convenience Store 5. Multipurpose Hall 6. Security Post / Police Station 7. Place of Worship 8. Sports Field 9. Childcare Center 10. Pharmacy 11. Restaurant / Canteen 12. Public Photocopying Service 13. Healthcare Facility 14. Post Office 15. Fire Station 16. Public Transport Terminal / Station 17. Library 18. Government Office 19. Market	**1**	**2**	**1**
	2	Providing pedestrian access not only to the main road outside the site but also to secondary roads and/or neighboring properties, ensuring access to at least three public facilities within a 300-meter walking distance.	**1**		**0**
	3	Ensure the provision of secure, convenient, and unobstructed access routes—distinct from motor vehicle lanes—that offer direct connections between the building and surrounding structures. These pathways must lead to a minimum of three public amenities and/or a nearby mass transit stop.	**2**		
	4	Ensuring that the building's ground level is open to offer a secure and pleasant pedestrian passage for at least 10 hours daily.	**2**		

Source: Author, 2025

4. ASD-3 – Public Transport Access

- The halt bus is located within 280 meters of the site.
- Pedestrian access is unpaved and lacks shading or signage.
- Referensi visual: Figure 22 – 23 dan Table 10.

Figure 22. Verify data via the map regarding the existence of Bus Stops
Source: Author, 2025

Figure 23. Visual Exit of Riau Polytechnic Area
Source: Author, 2025

Table 10. ASD-3 Criteria Assessment Results for Public Transportation

	Public Transportation				
	Objective: To encourage building users to utilize mass public transportation and reduce the use of private vehicles.				
	Benchmark:		**Point**	**Max Point**	**Actual Point**
ASD-3	**1A**	The presence of a public transportation Stop or station within a 300-meter walking distance from the building site's entrance, excluding the length of pedestrian bridges and ramps.	**1**	**2**	**1**
		or			
	1B	Providing a shuttle bus service for regular building occupants, with a minimum number of units sufficient for 10% of the regular users.			
	2	Providing pedestrian pathway facilities within the building area to ensure safe and comfortable access to the nearest public transportation station, by the Minister of Public Works Regulation No. 30/PRT/M/2006 concerning Technical Guidelines for Facilities and Accessibility in Buildings and the Surrounding Environment, Appendix 2 B.	**1**		**0**

Source: Author, 2025

5. ASD-4 – Bicycle Facilities

- There were no designated parking spaces or shower amenities available for cyclists.
- This suggests an oversight in promoting alternative transport and carbon reduction.
- Referensi visual: Figure 24 – 25 & Table 11.

Figure 24. Visual Parking Area Outside the Car/Motorcycle Area of Riau Polytechnic of Health
Source: Author, 2025

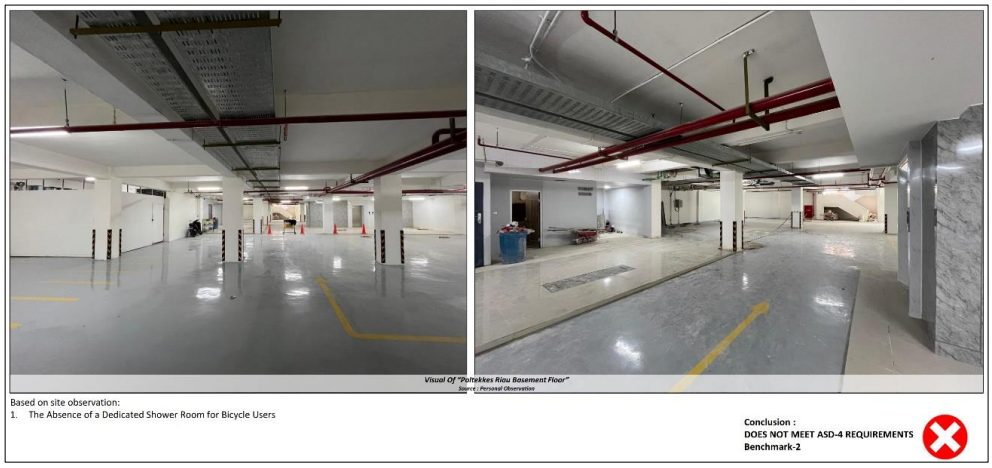


Figure 25. Visual of the Basement Parking Area of the Riau Polytechnic Tower
Source: Author, 2025

Table 11. ASD-4 Criteria Assessment Results for Bicycle Facilities

ASD-4	**Bicycle Facility**				
	Objective: Encouraging building users to use bicycles by providing adequate facilities, thereby reducing the use of motor vehicles.				
		Benchmark:	**Point**	**Max Point**	**Actual Point**
	1	The provision of secure bicycle parking at a ratio of one parking space per 20 building users, up to a maximum of 100 bicycle parking units.	**1**	**2**	**0**
	2	If Benchmark 1 above is fulfilled, one shower unit must be provided for every 10 bicycle parking spaces.	**1**		**0**

Source: Author, 2025

6. ASD-5 – Landscape

- The softscape area was less than the required 40% of the total site area.
- Only a limited number of native plant species were identified, far below the 60% threshold.
- Referensi visual: Table 12 & Figure 26 – 27

Figure 26. Green Landscape Area Limitations of Riau Polytechnic Tower
Source: Author, 2025

Figure 27. Green Landscape Area Limitations of Riau Polytechnic Tower
Source: Author, 2025

Table 12. ASD-5 Criteria Assessment Results for Landscape

	Site Landscaping				
	Objective: Maintaining or expanding urban greenery to improve microclimate quality, reduce CO_2 and pollutants, prevent erosion, reduce the burden on the drainage system, and preserve the balance of the clean water cycle and groundwater system.				
	Benchmark:		**Point**	**Max Point**	**Actual Point**
ASD-5	1A	The presence of landscaped areas consisting of vegetation (softscape) that are free from built structures, as well as open hardscape, must cover at least 40% of the total land area. The calculated area includes those stated in Prerequisite 1, such as gardens above basements, roof gardens, terrace gardens, and wall gardens. These considerations refer to the Minister of Public Works Regulation No. 5/PRT/M/2008 concerning Green Open Space (RTH), Article 2.3.1, which outlines the criteria for vegetation in residential yards.	**1**	**3**	**0**
	1B	If Benchmark 1 is fulfilled, each additional 5% of landscape area from the total land area will earn 1 point.	**1**		**0**
	2	The use of plants that have been locally cultivated at the provincial scale accounts for 60% of the total area. Mature tree canopy coverage relative to the landscape area in ASD-5 Benchmark 1	**1**		**0**

Source: Author, 2025

7. ASD-6 – Microclimate Strategy

- The roof material has an albedo of 0.61, surpassing the required minimum of 0.3.
- The reflectance standards are also met by non-roof surfaces.
- There is a lack of vegetative shading for sidewalks and pedestrian zones.
- Visual references: Table 13 - 14 & Figure 28 - 29.

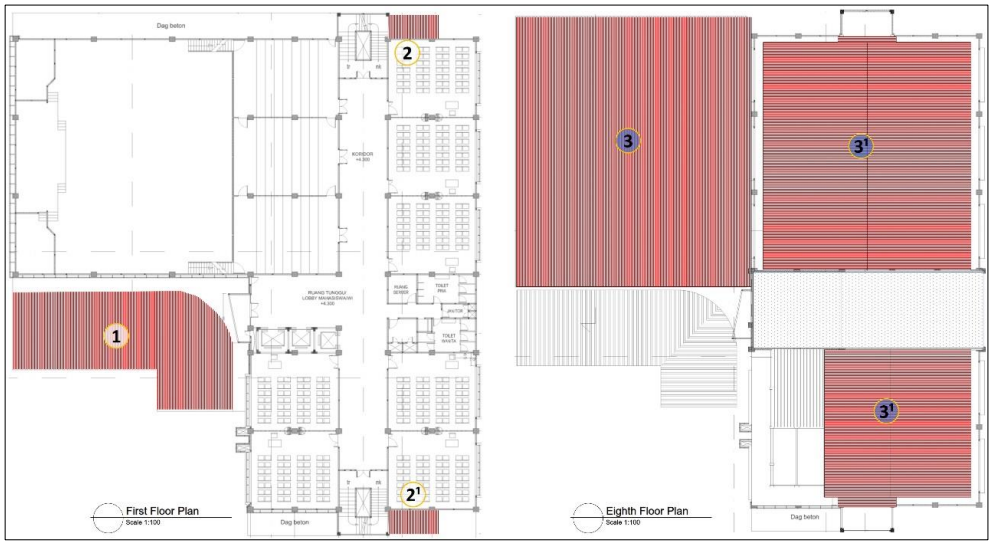


Figure 28. The area calculation for albedo on the rooftop of the Riau Polytechnic Tower
Source: Author, 2025

Table 13. The calculation zone for albedo

No	Area	Kode	Jenis Material	Nilai Albedo (An)	Luas (Ln)	(An x Ln)	Albedo Typical
1	Atap Lobby Utama Gedung	**1**	Spandek Alumunium Zinc Coating	0.61	159.05	97.02	0.61
2	Atap Teras Barat	**2**	Spandek Alumunium Zinc Coating	0.61	11.23	6.85	0.61
3	Atap Teras Timur	**2¹**	Spandek Alumunium Zinc Coating	0.61	11.23	6.85	0.61
4	Atap Teras Auditorium	**3**	Spandek Alumunium Zinc Coating	0.61	355.65	216.95	0.61
5	Atap Lantai Delapan	**3**	Spandek Alumunium Zinc Coating	0.61	521.59	318.17	0.61
				Sub Total	**1,058.75**	**645.84**	
				Nilai Albedo Min. 0.3		**0.61**	

Source: Author, 2025

Table 14. Typical albedo of the material

Surface Material	Typical albedo	Source	Surface Material	Typical albedo	Source
New asphalt	0.05	(a)	White cement concrete pavement (aged)	0.4 – 0.6	(b)
Aged asphalt	0.1	(a)	Granite	0.35	(c)
New concrete (ordinary)	0.35 to 0.45	(a)	Brick	0.2 – 0.5	(d)
Aged concrete	0.2 to 0.3	(a)	Stone	0.2 – 0.35	(d)
New white Portland cement concrete	0.7 to 0.8	(a)	Andesit	0.1 – 0.65	(e)
Paving	0.05 – 0.4	(b)	Black acrylic paint	0.05	(a)
Gray-cement concrete pavement (new)	0.35 – 0.4	(b)	White acrylic paint	0.8	(a)
Gray-cement concrete pavement (aged)	0.2 – 0.3	(b)	Red, brown, and green paint	0.2 – 0.35	(a)
White cement concrete pavement (new)	0.7 – 0.8	(b)	Alumunium coating	0.61	(f)

Source: Technical Guidelines for the Green Building Assessment Tools for New Buildings Version 1.2

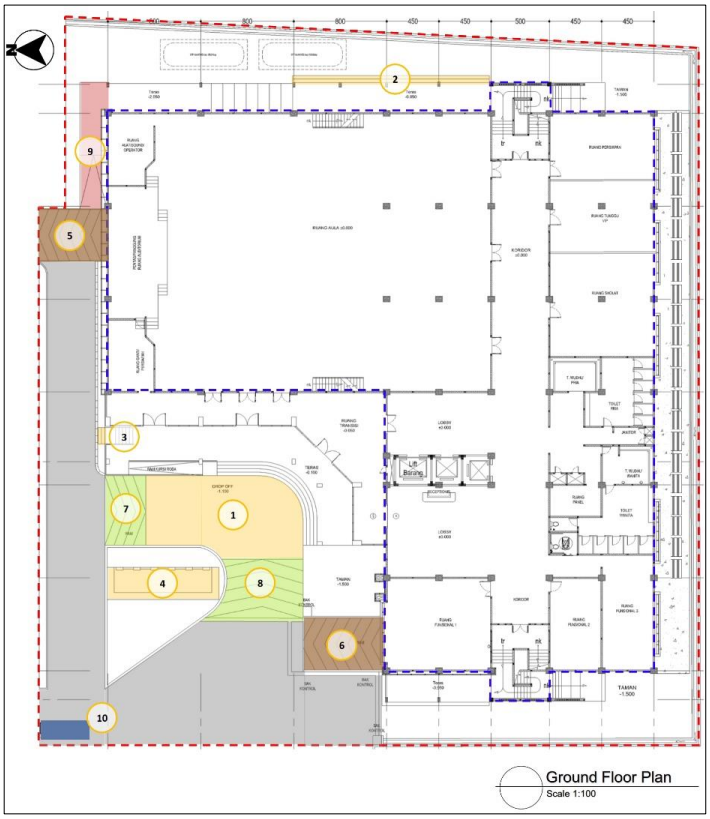


Figure 29. The calculation zone for albedo on the building's non-roof area of Riau Polytechnic Tower
Source: Author, 2025

Table 15. ASD-5 Criteria Assessment Results for microlimate

	Micro Climate				
	Objective: Improving the microclimate quality around the building, including human comfort and the surrounding habitat				
	Benchmark:		**Point**	**Max Point**	**Actual Point**
ASD-6	1A	Utilizing diverse materials to mitigate the heat island effect on the roof of the building, ensuring that the solar reflectance (albedo) value is at least 0.3, in line with the specified calculations	1	3	1
		Or			
	1B	Install a green roof that covers 50% of the roof area, excluding space used for mechanical and electrical (ME) equipment, with the coverage area calculated based on the canopy size.			
	2	Employing different materials to reduce the heat island effect on non-roof paved surfaces by achieving a minimum solar reflectance (albedo) value of 0.3, in line with the specified calculations	1		1
	3A	The inclusion of plant life (softscape) in the landscape design along the primary pedestrian pathways offers shielding against heat generated by solar exposure	1		0
		Or			
	3B	The inclusion of vegetation along the primary pedestrian pathway serves as a shield against intense wind exposure.			

Source: Author, 2025

8. ASD-7 – Stormwater Runoff

- No visible bioretention features, rain garden, or infiltration wells were found on-site.
- The drainage system is conventional and directly connected to the public drainage line.
- Referensi visual: Table 16.

Table 16. The Assessment Results of the ASD-7 Criteria for Stormwater Management

	Stormwater Management				
	Objective: Reducing the burden on the environmental drainage system by managing stormwater runoff through an integrated water management system.				
	Benchmark:		**Point**	**Max Point**	**Actual Point**
ASD-7	1A	A reduction of up to 50% in the stormwater runoff volume entering the city's drainage system from the building site, determined by calculating rainfall intensity values *	**1**	**3**	**0**
		or			
	1B	The volume of stormwater runoff directed to the city's drainage system can be reduced by as much as 85%, as determined by calculating the rainfall intensity values *	**2**		**0**
	2	Showcasing initiatives to reduce the impact of external environmental flooding from beyond the building site	**1**		**0**
	3	Utilizing technologies that can minimize the volume of rainwater runoff	**1**		**0**
	* In the DKI Jakarta area, apply a daily rainfall of 50mm/day as specified in the Governor's Regulation No. 38 of 2021 regarding Green Buildings * For other regions, use the maximum local daily rainfall (10-year return period), supported by calculation documentation				

Source: Author, 2025

Table 17. Tabulation of Land Use Appropriate Category Assessment

	Basic Green Area				
	Objective: To preserve or expand urban greenery to improve microclimate quality, reduce CO_2 and other pollutants, prevent soil erosion, lessen the burden on the drainage system, and maintain the balance of the clean water cycle and groundwater system.				
	Benchmark:		**Point**	**Max Point**	**Actual Point**
ASD-P	**1**	The area designated for landscaping, consisting of vegetation (softscape), must be free from any building structures or minor garden constructions (hardscape), whether located above ground or below the surface. **a.** For newly constructed projects, this area should cover at least 10% of the total land area. **b.** For major renovations, the area should encompass at least 50% of the open space that is not occupied by basement structures on the site.	**P**	**P**	**P**
	2	This designated area must include vegetation in line with the Ministry of Home Affairs Regulation No. 1 of 2017, Article 13 (2a), with a composition where at least 50% of the land is covered by mature vegetation, including small, medium, and large trees, semi-tree shrubs, bushes, and other plant varieties. The selection of plant species must also comply with the standards outlined in the Ministry of Public Works Regulation No. 5/PRT/M/2008 on Green Open Space (GOS), Article 2.3.1, which specifies the vegetation criteria for residential yards.	**P**		
	Site Selection				
	Objective: To prevent development in greenfield sites and avoid the clearance of new land				
	Benchmark:		**Point**	**Max Point**	**Actual Point**
ASD-1	1A	Select a development area that is already equipped with at least eight out of twelve types of urban infrastructure and facilities: 1. Transportation Infrastructure 2. Electrical and Illumination System 3. Stormwater Management Network 4. Centralized Wastewater Treatment Facility 7. Integrated Fiber Optic Infrastructure 8. Constructed Water Body Covering at Least 1% of the Site Area 9. On-Site Pedestrian Circulation Routes 10. Centralized Gas Distribution System	**1**	**2**	**1**

		5. Solid Waste Management System 6. Fire Safety and Prevention Infrastructure	11. Landline Communication Network 12. Potable Water Distribution System		
		Or			
	1B	Choosing a site for development that features a Floor Area Ratio (FAR) exceeding 3			
	2	Revitalizing and developing land with negative value and unused potential due to previous construction or the adverse impacts of past development	**1**		**0**
ASD-2	**Community Accessibility**				
	Objective: To encourage development in areas that already have established connectivity networks and to enhance building utilization, thereby facilitating daily activities for the community and reducing the reliance on motorized vehicles.				
	Benchmark:		**Point**	**Max Point**	**Actual Point**
	1.	There are at least seven types of public facilities within a reachable distance of 1,500 meters from the main road to the site. 1. Bank 2. Public Park 3. Public Parking (Off-Site) 4. Stall / Convenience Store 5. Multipurpose Hall 6. Security Post / Police Station 7. Place of Worship 8. Sports Field 9. Childcare Center 10. Pharmacy 11. Restaurant / Canteen 12. Public Photocopying Service 13. Healthcare Facility 14. Post Office 15. Fire Station 16. Public Transport Terminal / Station 17. Library 18. Government Office 19. Market	**1**	**2**	**1**
	2	Providing pedestrian access not only to the main road outside the site but also to secondary roads and/or neighboring properties, ensuring access to at least three public facilities within a 300-meter walking distance.	**1**		**0**
	3	Ensure the provision of secure, convenient, and unobstructed access routes—distinct from motor vehicle lanes—that offer direct connections between the building and surrounding structures. These pathways must lead to a minimum of three public amenities and/or a nearby mass transit stop.	**2**		
	4	Ensuring that the building's ground level is open to offer a secure and pleasant pedestrian passage for at least 10 hours daily.	**2**		
ASD-3	**Mass Transit Accessibility**				
	Objective: To promote the use of public mass transit among building occupants and minimize reliance on personal vehicles.				
	Benchmark:		**Point**	**Max Point**	**Actual Point**
	1A	A public transport stop or station is available within a 300-meter walk from the main entrance of the building site, with the exception of the distance covered by pedestrian bridges and ramps.	**1**	**2**	**1**
		Or			
	1B	Offering transportation via shuttle buses for daily users of the building, ensuring the fleet size can accommodate at least 10% of the total regular occupants.			
	2	Facilities for pedestrian pathways are made available within the site to guarantee secure and convenient movement toward the closest public transportation stop. This implementation aligns with Appendix 2B of the Regulation of the Minister of Public Works No. 30/PRT/M/2006, which provides technical guidelines for accessibility and facility standards in buildings and their surrounding areas.	**1**		**0**
ASD-4	**Bicycle Facility**				
	Objective: Encouraging building users to use bicycles by providing adequate facilities, thereby reducing the use of motor vehicles.				
	Benchmark:		**Point**	**Max Point**	**Actual Point**
	1	The provision of secure bicycle parking at a ratio of one parking space per 20 building users, up to a maximum of 100 bicycle parking units.	**1**	**2**	**0**

	2	If the first benchmark is achieved, a minimum of one shower facility should be available for every ten designated bicycle parking spots.	**1**		**0**

ASD-5

Landscaping of the Site

Objective:
Enhancing or preserving green open spaces in urban areas contributes to better microclimate regulation, lowers carbon dioxide levels and air pollutants, minimizes erosion, eases the load on drainage infrastructure, and supports the sustainability of clean water cycles and groundwater systems.

Benchmark:		**Point**	**Max Point**	**Actual Point**
1A	The presence of landscaped areas consisting of vegetation (softscape) that are free from built structures, as well as open hardscape, must cover at least 40% of the total land area. The calculated area includes those stated in Prerequisite 1, such as gardens above basements, roof gardens, terrace gardens, and wall gardens. These considerations refer to the Minister of Public Works Regulation No. 5/PRT/M/2008 concerning Green Open Space (RTH), Article 2.3.1, which outlines the criteria for vegetation in residential yards.	**1**	**3**	**0**
1B	If Benchmark 1 is fulfilled, each additional 5% of landscape area from the total land area will earn 1 point.	**1**		**0**
2	The use of plants that have been locally cultivated at the provincial scale accounts for 60% of the total area. Mature tree canopy coverage relative to the landscape area in ASD-5 Benchmark 1	**1**		**0**

ASD-6

Micro Climate

Objective: Enhancing the quality of the microclimate around the building, which encompasses both human comfort and the surrounding ecosystem

Benchmark:		**Point**	**Max Point**	**Actual Point**
1A	Employing a range of materials to mitigate the heat island effect on the building's rooftop, ensuring that the albedo (solar reflectance) value meets or exceeds 0.3, as per the calculations	1	3	1
	Or			
1B	Implement a green roof that covers 50% of the roof space, excluding areas designated for mechanical and electrical (ME) systems, with the coverage measured based on the canopy area.			
2	Utilizing different materials to reduce the heat island effect on paved surfaces other than roofs by achieving a minimum solar reflectance (albedo) of 0.3, as per the calculated values	1		1
3A	The landscape design, incorporating plants (softscape) along the primary pedestrian pathways, offers shelter from the heat generated by sunlight	1		0
	Or			
3B	The inclusion of vegetation in the landscape design, particularly along the primary pedestrian pathways, offers a shield against the impact of strong winds.			

ASD-7

Stormwater Management

Objective: Alleviating the pressure on the environmental drainage infrastructure by controlling stormwater runoff through a comprehensive water management approach.

Benchmark:		**Point**	**Max Point**	**Actual Point**
1A	The volume of stormwater runoff directed to the city's drainage system from the building site can be reduced by as much as 50%, determined based on rainfall intensity values *	**1**	**3**	**0**
	Or			
1B	A reduction of stormwater runoff volume directed to the urban drainage system by as much as 85%, determined through rainfall intensity values *	**2**		**0**
2	Showcasing initiatives to reduce the impact of external floodwaters from surrounding areas on the building site	**1**		**0**
3	Utilizing technologies that help minimize the volume of rainwater runoff	**1**		**0**

* For the DKI Jakarta region, apply a daily rainfall of 50mm/day as stipulated in the Governor Regulation No. 38 of 2021 regarding Green Buildings

* For other regions, use the local maximum daily rainfall corresponding to a 10-year return period, along with the supporting calculation evidence

Source: Author, 2025

C. Spatial Reflection and Design Gaps

The results suggest that key performance gaps in spatial planning lie in:

- Lack of non-motorized access and multimodal transport integration
- Underutilization of landscape zones for stormwater management
- Missed opportunities for vertical greenery or rooftop garden integration

The building's vertical typology offers substantial opportunity for landscape layering, yet this potential remains untapped. Moreover, several site decisions appear driven by structural constraints rather than green compliance, which is a common issue in post-construction assessments of buildings not originally intended to meet Green Ship criteria.

D. Strategic Recommendations (to be expanded in Conclusion)

- Incorporate multi-layered landscape design to meet both ASD-5 and ASD-P standards.
- Add bioretention and infiltration areas to mitigate stormwater discharge.
- Designate bike facilities and shaded walkways to strengthen mobility indicators.

Integrate reflective and vegetated surfaces within the overall master plan.

Conclusion and Suggestions

A. Conclusion

This study assessed the spatial sustainability performance of the Poltekkes Riau Tower, a vertical educational building in Pekanbaru, using the Appropriate Site Development (ASD) category of the Greenship New Building v1.2 framework. Based on the evaluation of eight indicators, the building achieved 5 out of 17 points (29.4%), which reflects a suboptimal implementation of sustainable land-use principles.

Key findings include:

1. Partial fulfillment of green base area (ASD-P) and moderate success in site selection (ASD-1), community accessibility (ASD-2), public transportation access (ASD-3), and microclimate strategy (ASD-6).
2. Complete non-compliance in bicycle facilities (ASD-4), landscape integration (ASD-5), and stormwater management (ASD-7), which significantly reduced the total score.
3. The vertical typology, while beneficial for compact land usage, showed limitations in accommodating spatially dependent sustainability strategies such as extensive softscape and decentralized runoff handling.

These results indicate a disconnect between vertical spatial configuration and horizontal ecological performance, particularly in the areas of mobility infrastructure and water-sensitive urban design.

B. Suggestions

To enhance site sustainability performance in vertical educational buildings, the following design and planning strategies are recommended:

1. Integrate Multi-Layered Landscaping.

Employ vertical greenery, rooftop gardens, and intermediate green decks to increase softscape coverage and

biodiversity without consuming horizontal land.

2. **Implement Water Retention Features.**

   Design site zones for rainwater harvesting, bioretention cells, or infiltration trenches to reduce direct discharge and improve stormwater absorption.

3. **Promote Active Transport.**

   Provide bicycle parking, shower facilities, and marked bike lanes within and around the site to support low-emission commuting.

4. **Enhance Pedestrian Infrastructure.**

   Install shaded pedestrian corridors, green pavements, and wayfinding systems to encourage walkability and reduce urban heat stress.

5. **Adopt Passive Cooling Strategies.**

   Leverage building orientation, shading devices, and reflective materials to optimize microclimatic conditions and reduce cooling loads.

6. **Policy and Pre-design Alignment.**

   Future projects should incorporate Greenship-based site assessment tools during the planning phase, ensuring early-stage compliance with sustainability benchmarks.

Recommendations

Based on the conclusions above, the criteria and benchmarks that have been achieved should be continuously maintained, while for those that have not yet been met, several design concept recommendations are proposed as an initial step in implementing green building principles within the Appropriate Site Development (ASD) category at Vertical Educational Facility in Pekanbaru:

1. **Enhancement of Green Base Area**: Optimize open space by increasing vegetation coverage to at least 50% of the total site area to improve the microclimate and reduce the urban heat island effect.
2. **Community Accessibility Optimization**: Improve pedestrian connectivity by expanding sidewalks, providing disability-friendly pedestrian pathways, and integrating the site with public transportation networks to support sustainable mobility.
3. **Bicycle Facility Management**: Redesign bicycle parking areas to provide adequate, safe, and secure spaces equipped with support facilities such as showers and lockers to enhance user comfort and promote cycling.
4. **Stormwater Runoff Management**: Implement bio-retention systems and rain gardens to support more efficient and environmentally friendly stormwater management.
5. **Environmental Monitoring System**: Install monitoring systems for air quality and temperature to evaluate the effectiveness of implemented green design strategies.

These recommendations are expected to serve as a practical guideline for realizing Vertical Educational Facility in Pekanbaru as a sustainable green building aligned with the directives of the Indonesian Minister of Health Decree No. HK.01.07/MENKES/550/2024, dated April 29, 2024. Future research is encouraged to explore the other five categories in the Greenship GBCI assessment system—Energy Efficiency and Conservation (EEC), Water Conservation (WAC), Material Resources and Cycle (MRC), Indoor Health and Comfort (IHC), and Building Environmental Management (BEM)—which collectively influence the overall success of sustainable green building implementation.

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References

Adi, A. R., & Ernawati, E. (2020). Kajian Penilaian Greenship GBCI Dalam Menunjang Pembelajaran Arsitektur Hijau. *Jurnal Teknologi Dan Desain*. https://doi.org/10.51170/jtd.v2i1.41

Amalia, A. A., Amal, C. A., & Amin, S. F. A. (2018). *Evaluasi Aspek Tepat Guna Lahan Pada Mall Nipah Makassar Dengan Menggunakan Greenship Rating Tools*. *December*, C007-C014. https://doi.org/10.32315/sem.3.c007

Andrian, F. (2024). Analisis Kinerja Bangunan Hijau dalam Konteks Kebutuhan Energi. *Tugas Mahasiswa Program Studi Arsitek*, 1–11. https://coursework.uma.ac.id/index.php/arsitek/article/view/635%0Ahttps://coursework.uma.ac.id/index.php/arsitek/article/download/635/482

Ardhiansyah, I., & Azizah, R. (2020). *Pengukuran Greenship New Building Ver. 1.2 pada Bangunan Baru Rumah Atsiri Indonesia (Final Assessment)* (Vol. 15, hal. 79–86). https://doi.org/10.23917/sinektika.v15i2.9864

Ayuthia, G. T., Dewi, O. C., & Panjaitan, T. H. (2020). The Role of Green Buildings in Supporting Green Buyer Behaviour Towards Green Users. *E3s Web of Conferences*. https://doi.org/10.1051/e3sconf/202021101003

Basten, V., Crévits, I., Latief, Y., & Berawi, M. A. (2019). Conceptual Development of Cost-Benefit Analysis Based on Regional, Knowledge, and Economic Aspects of Green Building. *International Journal of Technology*. https://doi.org/10.14716/ijtech.v10i1.1791

Berawi, M. A., Miraj, P., Windrayani, R., & Berawi, A. R. B. (2019). Stakeholders' perspectives on green building rating: A case study in Indonesia. *Heliyon*, *5*(3). https://doi.org/10.1016/j.heliyon.2019.e01328

Chansomsak, S., & Vale, B. (2009). *The Roles of Architects in Sustainable Community Development The Roles of Architects in Sustainable Community Development บทบาทของสถาปนิ กในการพั ฒนาชุ มชนอย่ างยั ่ งยื น*. http://www.tds.tu.ac.th/jars/download/jars/v6-3/06_The Roles of Architects in S Community Development_Sant.pdf

Erizal, Chadirin, Y., & Furi, I. M. (2019). Evaluasi Aspek Green Building Pada Gedung Andi Hakim Nasoetion Rektorat IPB. *Jurnal Manejemen Aset Infrastruktur \& Fasilitas*. https://doi.org/10.12962/j26151847.v3i2.5888

GBCI. (2018). Greenship Panduan Teknis Rating Tools For New Building V 1.2.pdf. In *Technical Manual Green Building Rating Tool For New Building* (hal. 620). 2018. https://www.gbcindonesia.org/training/21818174790c4d09aaeeacaeeb5a252bwx2eeD6Hz7w

Harputlugil, G. U., & Bedir, M. (2016). Effects of occupant behavior on the energy performance of dwellings: A sensitivity analysis. *Journal of Architectural and Planning Research*, *33*(2), 159–178.

Kandita, K., Akmalah, E., & Irawati, I. (2018). KAJIAN KATEGORI TEPAT GUNA LAHAN DALAM PENERAPAN KONSEP GREEN BUILDING DI ITENAS. *Potensi : Jurnal Sipil Politeknik*, *20*(1). https://doi.org/10.35313/potensi.v20i1.999

Karimi, H., Adibhesami, M. A., & Bazazzadeh, H. (2023). Green Buildings: Human-Centered and Energy Efficiency Optimization Strategies. *Energies*. https://doi.org/10.3390/en16093681

Li, D., Zheng, Y., Liu, C., Qi, H., & Liu, X. (2016). Numerical analysis on thermal performance of naturally ventilated roofs with different influencing parameters. *Sustainable Cities and Society*, *22*, 86–93. https://doi.org/10.1016/j.scs.2016.02.004

Li, Y., Huan-bin, S., Sang, P., Chen, P., & Liu, X. (2019). Review of Critical Success Factors (CSFs) for Green Building Projects. *Building and Environment*. https://doi.org/10.1016/j.buildenv.2019.05.020

Linggasari, D. (2020). Optimasi Biaya Pencapaian Predikat Bangunan Hijau Pada Bangunan Terbangun. *Jurnal Muara Sains Teknologi Kedokteran Dan Ilmu Kesehatan*. https://doi.org/10.24912/jmstkik.v3i2.5941

Liu, G., Xiao, M., Zhang, X., Gal, C., Chen, X., Liu, L., Pan, S., Wu, J., Tang, L., & Clements-Croome, D. (2017). A review of air filtration technologies for sustainable and healthy building ventilation. *Sustainable Cities and Society*, *32*(April), 375–396. https://doi.org/10.1016/j.scs.2017.04.011

Maryati, S. (2013). Challenge in Integrating Clean Water Infrastructure Provision in the Jabodetabek Metropolitan Area. *Procedia Environmental Sciences*, *17*, 666–674. https://doi.org/10.1016/j.proenv.2013.02.083

Mauludi, A. F., Anisa, A., & Satwikasari, A. F. (2020). Kajian Prinsip Arsitektur Hijau pada Bangunan Perkantoran (Studi Kasus United Tractor Head Office dan Menara BCA). *Sinektika: Jurnal Arsitektur*, *17*(2), 155–161. https://doi.org/10.23917/sinektika.v17i2.11629

Ohueri, C. C., Enegbuma, W. I., & Habil, H. (2019). MyCREST Embedded Framework for Enhancing the Adoption of Green Office Building Development in Sarawak. *Built Environment Project and Asset Management*. https://doi.org/10.1108/bepam-10-2018-0127

Prabowo Sulistiawan, A., Arif Maryanto, D., Ilham Aprizal, M., & Fathur Rachman, F. (2022). Penilaian Sumber dan Siklus Material Arsitektural dalam GBCI pada Gedung Kuliah Bersama Institut Pertanian Bogor (IPB). *Jurnal Arsitektur TERRACOTTA* |, *3*(2), 47–57.

Pragati, S., Priya, R. S., Pradeepa, C., & Senthil, R. (2023). Simulation of the Energy Performance of a Building With Green Roofs and Green Walls in a Tropical Climate. *Sustainability*. https://doi.org/10.3390/su15032

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