Environmental Synergy: Green Building Design for the Al-Amin Industrial Park Main Building

Patricia Yosefina Bakhita, Eliyana Nasiroh Br Bangun, Sri Wahyuningsih, Peranita Sagala

Abstract

The development of industrial areas often exerts pressure on the environment through high energy consumption and ecological degradation. This study aims to design the Main Building of Al-Amin Industrial Park, located in Sampe Cita Village, Deli Serdang Regency, by integrating the Eco-Synergy concept and the Green Building (BGH) approach in accordance with the Minister of Public Works and Public Housing Regulation No. 21 of 2021. The method employed is a descriptive qualitative approach with a green architectural design framework, transitioning through site analysis, space programming, to concept synthesis. The result yields a 6-story mixed-use building design that integrates educational, research, informational, and commercial functions. The green principles are implemented through building mass zoning around a central inner courtyard, a passive facade featuring a secondary skin for energy efficiency, a circular water system (greywater recycling and rainwater harvesting), and integrated on-site solid waste and wastewater management. This study concludes that the Eco-Synergy approach effectively creates a space that is adaptive to the tropical climate while minimizing adverse environmental impacts. The implication of this design serves as a benchmark for future sustainable Techno Park developments

Keywords: *Eco-Synergy, Green Building, Mixed-Use, Industrial Park, Energy Efficiency.*

Patricia Yosefina Bakhita[1]
[1]Architecture, Universitas Pembangunan Panca Budi, Indonesia
e-mail: patriciayosefina80@gmail.com[1]

Peranita Sagala[2], Eliyana Nasiroh[3], Sri Wahyuningsih[4]
[2,3,4]Architecture, Universitas Pembangunan Panca Budi, Indonesia
e-mail: peranita@dosen.pancabudi.ac.id[2], eliyananasiroh@gmail.com[3], yuniie0912@gmail.com[4]

Introduction

The development of industrial areas in recent decades has shown significant growth as a result of economic growth and production needs. However, industrial development often places pressure on the environment, such as high energy consumption, increased carbon emissions, and a decline in environmental quality. The building and industrial sectors are even considered major contributors to global energy consumption and greenhouse gas emissions, necessitating a more sustainable design approach. (Fadillah & Febrita, 2024)

In response to these issues, the concept of sustainable building has begun to be widely applied in area design, including Techno Parks. This concept focuses not only on energy efficiency but also encompasses comprehensive resource management and considers the long-term impact on the environment and society. (Chertow, 2000). The application of sustainability principles in industrial areas has been proven to increase operational efficiency and significantly reduce environmental impacts.

Along with these developments, the Eco-synergy approach emerged, integrating the relationship between industrial activities and ecological systems. This concept emphasizes the interconnectedness of buildings, the environment, and users as a mutually supportive system. In practice, this approach can be realized through the use of renewable energy, integrated waste management, and the provision of green open spaces as part of the area's ecological system.

According to Marie Davidova, the Eco-synergy concept, or eco-systemic synergy, is a synergistic relationship between architecture, the natural environment, humans, and social systems that are integrated to create a sustainable built environment. This concept emphasizes that buildings do not stand alone but are part of a living, interacting ecosystem.

Eco-synergy is a design approach that integrates the reciprocal relationship between buildings, humans, and the ecological environment in a harmonious manner to create a spatial system that is sustainable, adaptive, and responsive to the surrounding ecosystem..(Davidova, 2020). The Al-Amin area has the potential to be developed as a sustainability-based industrial park. Its strategic location in Sampu Cita Village, Kutalimbaru District, Deli Serdang Regency, and the availability of land are supporting factors in the development of the area. However, without careful planning, the development of the TechnoPark area has the potential to have a negative impact on the surrounding environment, especially in terms of changes in land use and environmental degradation. The AL-Amin Industrial Park area already has a Main Building Plan based on Green Buildings.

Based on this, this study aims to design Al-Amin Industrial Park, which is the Main Building, with a green building approach in addition to the eco-synergy concept, so that it can produce an efficient, environmentally friendly, and sustainable industrial area. The focus of the research is directed at identifying site potential, implementing sustainability principles, and developing a building design concept that is adaptive to environmental conditions. sustainable, adaptive, and responsive space to the surrounding ecosystem.

The concept of the Glugur Rimbun mixed-use area is designed with a Green Building (GGH) approach that refers to seven main assessment aspects, namely sustainable site development, energy efficiency, water conservation, building cycles and materials, health and comfort of space, building environmental management, and green innovation and design. The application of this concept is realized through the processing of building mass, space systems, and the appearance of a modern horizontal facade as in the design that aims to create a building that is adaptive to tropical climates and environmentally friendly.

A. SITE MANAGEMENT (Appropriate Site Development / ASD)

Evaluation Weight: 9 Criteria | Maximum Score: 38 Points

The site layout for this mixed-use area centers around an inner courtyard, which serves as the hub for communal activities. By clustering the building masses around this central core, we create a multi-functional gathering area and outdoor event space that naturally fosters social interaction while improving the local microclimate.

Separating the buildings based on their specific functions helps streamline traffic, keeping vehicular logistics clearly divided from pedestrian walkways to ensure safety and ease of movement. Additionally, maximizing green open spaces and natural retention areas significantly cuts down rainwater runoff, prevents local flooding, and restores the site's ecological balance.

B. ENERGY EFFICIENCY (Energy Efficiency and Conservation / EEC)

Evaluation Weight: 7 Criteria | Maximum Score: 46 Points

Since energy efficiency carries the highest point weight, the project adopts a bioclimatic design tailored to the humid tropical climate to drastically cut down electricity consumption.

- Passive Facade Design: The building envelopes utilize a secondary skin featuring horizontal louvers and elongated openings. This setup is specifically engineered to block harsh solar radiation without sacrificing indoor daylighting.
- Natural Daylighting: The building floor plans are kept relatively slim rather than massive. This structural depth ensures that natural light penetrates deep into classrooms and offices, reducing the need for artificial lighting during operating hours.
- Cross Ventilation: We leverage natural breeze patterns by placing strategic openings across the building facades and the central courtyard. This continuous airflow keeps indoor spaces cool and significantly lowers the reliance on energy-heavy air conditioning (AC) systems.

C. WATER EFFICIENCY (Water Conservation / WAC)

Evaluation Weight: 3 Criteria | Maximum Score: 22 Points

Water management in this development focuses on smart consumption, groundwater preservation, and recycling systems to reduce reliance on the municipal water supply.

- Rainwater Harvesting: Given the high tropical rainfall, the rooftops double as catchment surfaces. Collected rainwater is channeled through a filtration system into storage tanks to supply non-potable needs, such as landscape irrigation and toilet flushing.
- Low-Water Landscaping: The inner courtyard landscape uses native plant species that are highly resilient and require minimal watering, lowering long-term maintenance needs.
- Natural Infiltration: Permeable paving and natural grass are used throughout the courtyard, ensuring surface water absorbs back into the ground to maintain the local water table.
-

D. INDOOR AIR QUALITY (Indoor Health and Comfort / IHC)

Evaluation Weight: 3 Criteria | Maximum Score: 19 Points

Indoor environmental quality is prioritized to boost productivity, psychological well-being, and thermal comfort for students, staff, and visitors alike.

- Fresh Air Supply: The open courtyard acts as the lungs of the development, continuously feeding fresh air into the surrounding corridors and rooms. Manually operable windows allow for high air exchange rates, preventing sick building syndrome.
- Visual and Thermal Connection: Major zones like classrooms, meeting rooms, the marketplace, and the café feature large windows facing the central greenery. This design element reduces eye strain, lowers stress, and maintains a fresh, open indoor environment.

E. USE OF ECO-FRIENDLY MATERIALS (Material Resources and Cycle / MRC)

Evaluation Weight: 2 Criteria | Maximum Score: 21 Points

Material selection focuses on low carbon footprints, high construction efficiency, and long structural lifespans.

- Modular Construction: The architectural design relies on a clean, modular geometric framework. This minimizes raw material cutting and significantly reduces construction waste on-site.
- Local & Green Certified Materials: Sourcing prioritizes local manufacturers within a close radius to cut down transport emissions. Materials used also favor Green Label certifications, including low-VOC paints and sustainably sourced timber.
- Tropical Durability: The horizontal facade elements are built from robust, weather-resistant materials that withstand extreme humidity and mold, reducing the need for frequent repainting or premature replacements.

F. SOLID WASTE MANAGEMENT

Evaluation Weight: 3 Criteria | Maximum Score: 7 Points

The development implements a structured waste management plan to ensure that the volume of waste sent to city landfills is kept to an absolute minimum.

- Sorting at the Source: Every floor across all buildings—the 4-story administrative building, 6-story educational wing, 2-story marketplace, and 3-story café—features clearly labeled, segregated bins for organic, recyclable, and residual waste.
- Internal Waste Logistics: Waste collection routes are designed through dedicated service corridors to keep the public areas clean and hygienic. Sorted waste is periodically moved to an on-site waste storage facility equipped for sorting and compacting, fully supporting 3R (Reduce, Reuse, Recycle) initiatives.

G. WASTEWATER MANAGEMENT

Evaluation Weight: 2 Criteria | Maximum Score: 12 Points

To complete the project's eco-synergy concept, all liquid waste generated within the development is treated on-site rather than being dumped directly into the municipal drainage system.

- On-Site Sewage Treatment Plant (STP): The site features an eco-efficient, aerobic STP. Plumbing networks split domestic wastewater at the source into greywater (from sinks, washbasins, and café operations) and blackwater (from toilets).
- Recycling for Reuse: Treated wastewater is filtered to meet strict environmental safety standards. This reclaimed water is then cycled back into the loop to handle secondary needs, such as building flush systems and landscape irrigation, cutting overall daily freshwater demands.

BUILDING FUNCTION ZONING

4-Story Building

- 1st Floor: Information Centre
- 2nd Floor: Management Office
- 3rd–4th Floor: Meeting Rooms
- *This building serves as the central operational and information hub for the entire development, positioned for easy public access.*

6-Story Building

- 1st Floor: Student Lobby
- 2nd–6th Floor: Classrooms and Mini Laboratories
- *This educational building is designed vertically to support learning and training activities while maximizing ground-level green space.*

2-Story Building

- 1st–2nd Floor: Marketplace
- *Dedicated to local MSMEs and community trade to boost the local economic ecosystem.*

3-Story Building

- 1st–3rd Floor: Café and Lounge Area

- *A recreational and social space that opens directly onto the central courtyard.*

INNOVATION AND FUTURE DEVELOPMENT

The Eco-synergy concept is brought to life by blending education, commerce, management, and recreation into a single integrated district. The inner courtyard anchors the development as both a social hotspot and an ecological engine that elevates the environmental performance of the entire site. The modern building masses and clean, horizontal facades establish a contemporary visual identity while maximizing green building performance. This approach ensures that the Glugur Rimbun mixed-use development functions not just as a workplace or educational center, but as a sustainable, climate-responsive environment built for the future.

Literature Review

The development of the industrial sector in the contemporary era has positioned buildings and production areas as one of the main contributors to the global environmental crisis. The urgency of implementing the green building concept emerged in response to the high levels of energy consumption and greenhouse gas emissions generated by massive industrial activities. As explained in recent literature, the building and industrial sectors have a crucial role in future research agendas due to their significant potential in mitigating climate change through significant carbon footprint reduction. Therefore, the design of industrial areas today is no longer solely focused on production functions, but must adopt a more sustainable design approach to maintain long-term ecosystem balance.(Musa & Mahmud, 2026)

Sustainable construction is a key pillar in designing ideal green buildings. This approach goes beyond mere energy efficiency to encompass holistic resource management, from planning through construction to building operations. In this context, the use of environmental assessment tools is crucial to ensure that every design element meets objective sustainability standards. Implementing sustainable construction principles has been proven not only to drastically reduce environmental impacts but also to positively contribute to long-term operational cost efficiency through optimized natural resource consumption.(Rostamnezhad & Thaheem, 2022)

In line with these developments, the Eco-synergy approach has emerged, integrating the reciprocal relationship between industrial activities and the surrounding ecological system. This concept views buildings, the environment, and users as a unified system that supports and synergizes each other. This approach is closely related to the theory of industrial symbiosis, which emphasizes the efficient exchange of energy and materials within the area. Practically, the Eco-synergy strategy in an industrial park can be realized through the integration of green infrastructure, such as the use of independent renewable energy systems, integrated waste management that minimizes pollution, and the provision of green open spaces that function as an ecological buffer system for the area. Through the application of these concepts, industrial areas can be transformed into entities that are adaptive, efficient, and environmentally friendly.(Dutt et al., 2025)

The concept of green building is an architectural approach that emphasizes energy efficiency, resource conservation, and the creation of a healthy and environmentally friendly built environment. The application of green building principles is not only oriented towards reducing negative impacts on the environment, but also considers the quality of life of building users by improving thermal comfort, air quality, and water efficiency. In the context of industrial areas, the application of this concept can be realized through the use of environmentally friendly materials, optimization of natural lighting and ventilation, the implementation of energy-saving systems, and the use of renewable energy such as solar panels. Furthermore, the presence of green open spaces and water absorption systems also play an important part in creating industrial areas that are more adaptive to climate change and ecologically sustainable.(Suharyadi & Effendie, 2023)

Research Methodology

The method used in this research is a qualitative descriptive method with a green building architectural design approach. This approach was chosen to produce a more environmentally friendly industrial area design by considering energy efficiency, resource management, and the area's environmental quality.Data collection was conducted through several methods, including literature review, field observation, and documentation. The literature study was conducted by reviewing journals, books, and references related to the concept of green buildings and industrial area design. Field observations were conducted directly in the Al-Amin area to understand the existing site conditions, such as orientation, accessibility, and environmental conditions. (Greenship et al., 2013) surrounding areas, as well as potential development opportunities. Documentation in the form of photos, maps, and other supporting data is used to hijau, seperti efisiensi energi, pengelolaan air, pemanfaatan complete the analysis process.

The collected data was then analyzed in stages. The analysis began with a site analysis, which covered the physical conditions of the area, such as climate, sun direction, circulation, and land use. A space requirements analysis was then conducted to determine the planned functions within the area. Furthermore, the analysis focused on the application of building principles for natural lighting and ventilation, as well as the provision of green open space. The design phase involved problem identification, analysis, concept synthesis, and design development. During the identification phase, key issues related to industrial area development that could potentially impact the environment were identified. The analysis phase processed the collected data, followed by concept synthesis leading to the application of green building principles within the area. The final stage, design development, resulted in a more efficient, comfortable, and environmentally responsive design for the Al-Amin Techno Park area.During the design process, software tools such as AutoCAD and SketchUp were used to visualize the design. Furthermore, green building assessment benchmarks were used as guidelines in formulating design strategies that align with environmentally friendly principles.

Results

1. Analysis

The design of the Main Building in the Al-Amin Industrial Park area developed by Panca Budi Development University is located in Sampe Cita Village, Kutalimbaru District, Deli Serdang Regency, North Sumatra. By implementing the Mixed-Use Building concept with a Green Building (BGH) approach. This building will be designed as high as 6 floors by providing various functions, such as Education, research, information, and commercial in one integrated building. The functions of the space in this building include student classrooms, laboratories, a mini auditorium, an information center, a library, a meeting room, a cafeteria, and a marketplace.

Based on the classification stipulated in PUPR Ministerial Regulation No. 21 of 2021 concerning Green Building Performance Assessment, which refers to Government Regulation No. 16 of 2021 concerning the Implementation of Law No. 28 of 2002 concerning Building Construction, this building is included in the category of buildings that are required (mandatory) to meet BGH requirements. This building is included in class 4 buildings for educational buildings such as classrooms, libraries, and laboratories, class 6 for commercial buildings such as cafeterias and marketplaces. With a medium height of 6 floors or around 18-21 meters, so it is mandatory to have BGH certification as a requirement for Building Approval (PBG).

The green building assessment system uses the benchmarks set out in PUPR Ministerial Regulation No. 21 of 2021, which contains assessment aspects and categories, each with a value. The assessment system is divided into seven main aspects:

PARAMETER	KRITERIA YANG DINILAI	POIN MAKS
A. PENGELOLAAN TAPAK	9 KRITERIA	38 POIN
B. EFISIENSI PENGGUNAAN ENERGI	7 KRITERIA	46 POIN
C. EFISIENSI PENGGUNAAN AIR	3 KRITERIA	22 POIN
D. KUALITAS UDARA DALAM RUANG	3 KRITERIA	19 POIN
E. PENGGUNAAN MATERIAL RAMAH LINGKUNGAN	2 KRITERIA	21 POIN
F. PENGELOLAAN SAMPAH	3 KRITERIA	7 POIN
G. PENGELOLAAN AIR LIMBAH	2 KRITERIA	12 POIN
TOTAL TAHAPAN		165 POIN

165 POIN

Figure 1. Seven Aspects Form The Basis For Implementing The Green Building Concept

These seven aspects form the basis for implementing the Green Building concept in the design of the Main Building at Al-Amin Industrial Park. The application of the Green Building principles aims not only to comply with government regulations but also to create a building that is energy-efficient, environmentally friendly, comfortable for users, and able to sustainably support educational, research, and commercial activities. Therefore, each assessment aspect is analyzed and applied to the building design in accordance with the characteristics of the planned mixed-use building.

In terms of site management, the building design takes into account the surrounding environmental conditions by maximizing green open space, water catchment areas, and good circulation. Vegetation is arranged to help reduce heat around the building and improve thermal comfort in the area. Furthermore, the provision of pedestrian paths, well-organized parking areas, and accessibility for all building users are crucial in supporting the green building concept, which emphasizes comfort and environmental sustainability.

In terms of energy efficiency, the building is designed to maximize natural lighting and ventilation through the placement of openings, windows, and cross-ventilation. Glass is also used in some parts of the building, while still considering solar heat control through shading or a secondary skin to reduce the cooling load. Furthermore, the use of energy-efficient lighting and efficient utility systems are strategies to reduce the building's electricity consumption.

Water efficiency is implemented through the design of a water-efficient plumbing system and the use of rainwater as an alternative water source for watering vegetation and certain utility needs. The area's drainage system is also designed to increase water infiltration into the soil, thereby helping to reduce rainwater runoff in the area.

In terms of indoor air quality, the building design prioritizes good air circulation through natural ventilation and a ventilation system that supports the comfort of building occupants. The use of low-emission interior materials and humidity control are also considered to ensure healthy and comfortable indoor air quality for learning, working, and commercial activities.Aspek material ramah lingkungan diterapkan dengan mempertimbangkan penggunaan material lokal, material yang dapat didaur ulang, serta material yang memiliki daya tahan tinggi sehingga dapat mengurangi dampak lingkungan dalam jangka panjang. Pemilihan material juga memperhatikan efisiensi konstruksi dan kemudahan perawatan bangunan agar lebih berkelanjutan.

In terms of waste management, the building is designed with a separation area for organic and inorganic waste to support better waste management. Furthermore, the concept of reduce, reuse, and recycle (3R) is implemented throughout the building to reduce the volume of waste generated from educational and commercial activities within the building.

Regarding wastewater management, the building is planned to have a wastewater treatment system that meets standards so that the resulting liquid waste does not pollute the surrounding environment. Domestic wastewater from toilets, pantries, and cafeterias will be treated before being discharged into the final sewer. This treatment system ensures that the area's environmental quality is maintained and aligns with the principles of sustainable development.

Based on the implementation of these seven aspects, the design of the Al-Amin Industrial Park Main Building is expected to be a mixed-use building that is not only functional and modern but also meets the principles of Green Buildings as stipulated in PUPR Ministerial Regulation No. 21 of 2021. This approach is expected to create an efficient, comfortable, healthy, and sustainable building environment for all building users.

2. Concept

The development of the Sampe Cita Village area is directed as a sustainable tourism area that integrates environmental, social, and economic aspects through a Green Building (BGH) approach and eco-friendly area principles. This concept aims to create a built environment that is efficient in resource use, minimizes environmental impact, and maintains the village's local character.

The mixed-use building functions include: Information Center, Student Lobby, Classrooms, Laboratory, Meeting Room, Library, Auditorium, Cafeteria, and Marketplace.

The mixed-use space program provided within this area includes:

1. Information and Public Facilities: The Information Center serves as the main gateway for providing information in the area, and the Student Lobby serves as an open communal space for interaction.
2. Academic and Research Facilities: Classrooms, Laboratories as a forum for student research and practice, Meeting Rooms for collaboration, and the Library as a literacy center for those seeking tranquility.
3. Mass Facilities: The Auditorium to accommodate academic activities, seminars, and large-scale cultural gatherings.
4. Commercial and Economic Facilities: Cafeteria and Marketplace as a place for economic circulation, providing daily student needs, as well as a place to market products resulting from innovation or entrepreneurship of UNPAB students.

The Green Building approach refers to Minister of Public Works and Public Housing Regulation No. 21 of 2021, which emphasizes energy efficiency, water efficiency, the use of environmentally friendly materials, and improving health and comfort within buildings. In its implementation, buildings in the area are designed to maximize natural lighting and ventilation through optimal openings, thereby reducing artificial energy consumption.

Assessment aspects have categories, each with its own value.

1. Site Management

   Maintaining large local vegetation to control the effects of heat and maintain the outdoor thermal comfort index based on a study of the North Sumatra microclimate (Siregar & Nasution, 2020). Accessibility within the site separates the logistics route (Cafeteria/Marketplace) from the student pedestrian path to ensure safety and walking comfort.

2. Energy Efficiency

   Given the high volume of lectures and commercial activities, the building wasdesigned using passive cooling (cross-ventilation) to achieve natural thermal comfort without air conditioning, in accordance with SNI 6389:2020 standards. Meeting rooms and classrooms are equipped with occupancy sensors to automatically turn off lights when empty. The electrical panel system uses separate sub-metering between the UNPAB academic zone and the commercial zone to fulfill the absolute requirements of BGH.

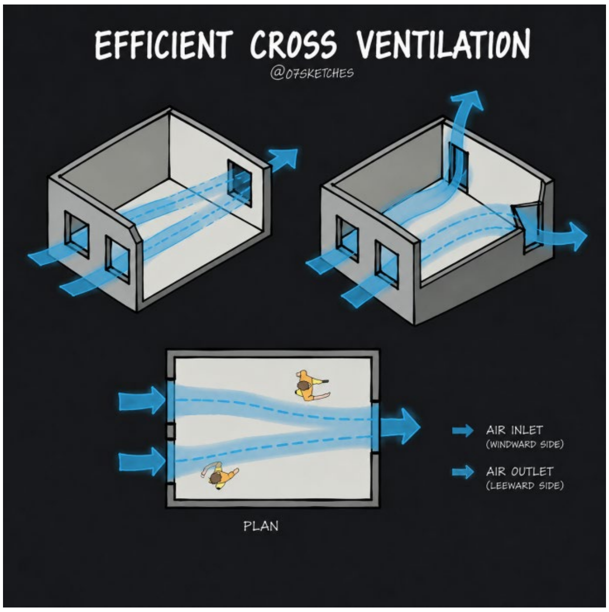

Figure 2.(Passive Cooling)**.**

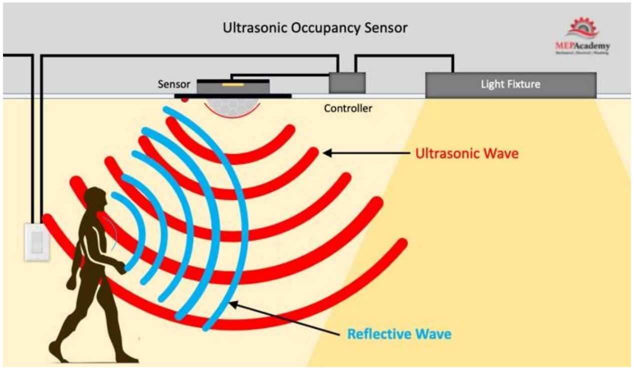

Figure 3. (Occupation sensor)

3. Water Efficiency

The surge in water usage in public restrooms (Lobby, Auditorium, and Marketplace) is addressed by the use of water-efficient (low-flow) fixtures certified according to SNI 8153:2015 standards. This area also implements a circular system: greywater and air conditioning wastewater from all classrooms are reprocessed through a filter system and then channeled specifically to flush toilets in the commercial area. The Auditorium's expansive roof is utilized for rainwater harvesting in accordance with SNI 8456:2017.

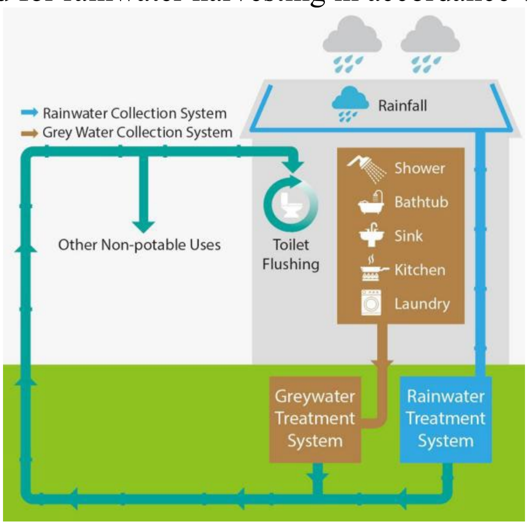

Figure 4. (Low-flow)

4. Indoor Air Quality

Specifically for the Laboratory, the mechanical ventilation system is designed with negative air pressure and special carbon filters to prevent air pollutants from leaking into the Classroom or Library areas. All interior materials (such as Auditorium carpet and wall paint) are required to be labeled Low-VOC (low chemical emissions) to maintain indoor air quality in accordance with ASHRAE 62.1 standards.

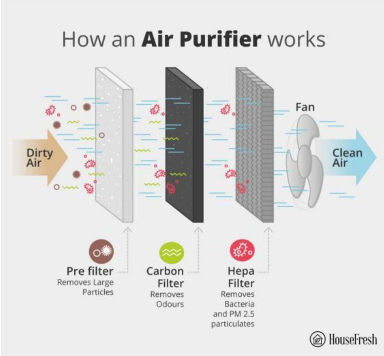

Figure 5. (Low-VOC)

5. Material Cycle, Waste & Waste Management

Building construction prioritizes the use of local materials from North Sumatra to reduce the carbon footprint of transportation (Tarigan, 2019). In the service area, a 3R waste disposal facility is provided to separate organic waste from the cafeteria, paper waste from the library, and a special hazardous waste storage facility from the laboratory. The domestic wastewater treatment system is filtered using a natural installation before being discharged back into water bodies in accordance with Ministerial Regulation No. P.68/2016.

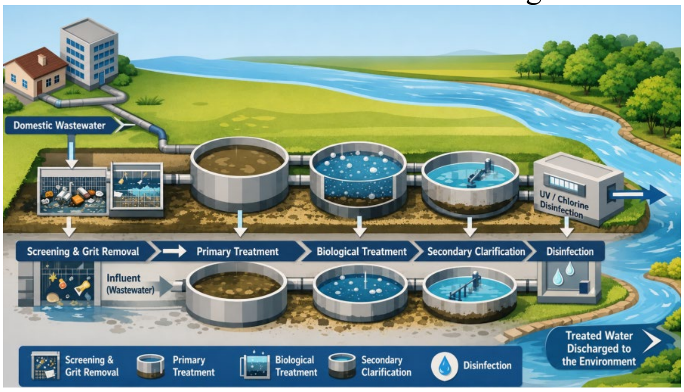

Figure 6. Waste treatment

The development of environmentally friendly village areas is directed at a sustainability concept that integrates environmental, social, and economic aspects.in the journal Regional Development, villages must be developed based on local potential while maintaining environmental sustainability to improve long-term community welfare.(Rachmawati, 2018)

An environmentally friendly approach at a regional scale can be implemented through efficient and conservative natural resource management.in the Journal of Regions and Environment, sustainable regional development must consider ecological systems such as water management, green open spaces, and the balance between built-up land and the natural environment.(Kusumawati et al., 2026)

In the context of tourism villages, area development must also consider local community involvement. in the Indonesian Tourism Journal states that environmentally based tourism villages can improve the local economy without damaging natural resources if managed in a participatory manner.(Rika Sukmadewi, 2019)

Furthermore, the application of environmentally friendly concepts is also related to rainwater management and infiltration systems. (in the Civil Engineering Journal, sustainable drainage systems such as infiltration wells and permeable pavements are effective in reducing water runoff and increasing soil absorption in residential areas.(Safriani et al., 2024)

Village development must also consider the balance between physical development and environmental conservation. in the Journal of Regional Planning states that sustainable areas are characterized by the integration of green open spaces, economic activity, and environmental comfort for the community.(Zainuri, 2018)

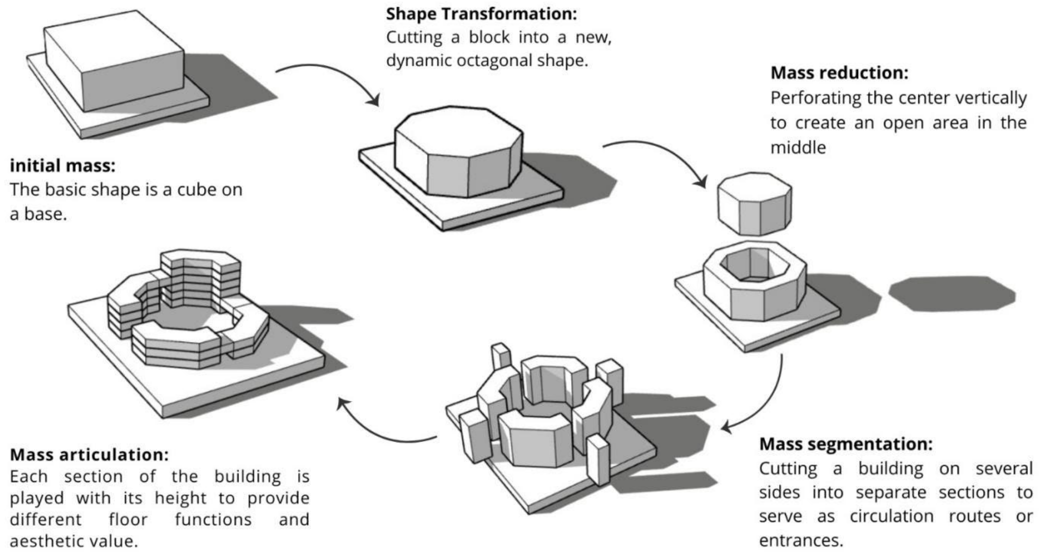

Figure 7. Rainwater Management and Infiltration Systems

1. Initial Mass

• Form Description: The design process begins with the establishment of a basic building envelope in the form of a pure, massive cube (single geometric block). This mass stands upright on a base (podium).

• Function & Basic Principles: This stage represents the maximum allowable volume of the building, adjusted to the initial building coefficient (KDB) on the site. Its nature is still rigid, static, and does not respond to environmental aspects or spatial functions.

2. Shape Transformation

• Intervention Description: Symmetrical corner-cutting is performed at the four main corners of the basic cube.

• Geometric Analysis Results: This cutting projects a new, dynamic octagonal shape.

• Design Objective: Visually, the octagonal shape reduces the rigid (monotonous) impression of the cubic form. From a microclimatic perspective, the angled corners of the octagonal configuration serve to break down wind loads around the site and provide flexibility in the building's orientation relative to the direction of incoming sunlight.

3. Mass Reduction (Mass Reduction / Subtractive Method)

• Intervention Description: The subtractive method was applied by performing a vertical perforation at the center axis of the octagonal mass. The geometric core was extruded downward, leaving an octagonal ring-shaped mass.

• Spatial & Architectural Impact: This intervention created an open space in the center (open courtyard/void).

• Design Goal: This central void breaks up the building's thickness, creating cross-ventilation and ensuring that sunlight can evenly penetrate the deepest interior areas. This central courtyard also functions as a communal open green space (micro-greenery) isolated from outside noise.

4. Mass Segmentation

• Intervention Description: The octagonal ring mass is cut radially at several points along the outer perimeter, dividing it into several separate solid masses that encircle the court.

• Spatial & Architectural Impact: New openings are created between the building segments, breaking up the massive outer boundary walls.

• Design Goal: The resulting gaps serve a crucial dual function:

o Entrance/Accessibility Circulation: Serves as a main entrance (porch) that leads users from various corners of the site into the building or to the central courtyard.

o Wind and Visual Corridors: Serves as a passageway for air from the outside into the courtyard, while creating a continuous visual link between the exterior landscape and the interior areas.

5. Mass Articulation

• Intervention Description: The final stage involves vertical scaling and stacking of the masses. The height of each segment is varied and not uniform.

• Final Design Result: The building configuration is stepped, hierarchical, and has an aesthetic visual rhythm.

• Design Objectives:

o Programmatic Zoning: Differences in floor heights directly represent the different interior functions within. Lower/sloping floors can accommodate public/commercial functions, while higher segments are allocated for private functions, administrative offices, or upper utility spaces.

o Aesthetic Value: The shadow play resulting from the differences in building heights creates a facade rich in depth, expressive proportions, and a non-monotonous appearance when viewed from various human perspectives.

1. Appropriate Site Development (ASD)
Score : Excellent (8/12)
Advantages
• Clear main access to the area.
• Organized vehicle circulation through the roundabout reduces traffic conflicts.
• Ample open space remains around the main building.
• Supporting facilities such as sports fields and centralized parking areas are available.
Recommendations
• Add shade-giving vegetation to the parking area.
• Provide connecting pedestrian paths between buildings.
• Add infiltration areas and bioswales along internal roads.

2. Energy Efficiency and Conservation (EEC)
Score : Good (7/12)
Advantages
• The main building mass is located in an open area, thus potentially receiving good natural lighting.
• The distance between buildings is sufficiently loose so that they do not obstruct air flow.
Recommendations
• Determine the building orientation to minimize exposure to western sunlight.
• Use shading devices and a secondary skin on the facade.
• Install solar panels on the roof of the main building.

3. Water Conservation (WAC)
Nilai: Enough (5/10)
Advantages
• There is still open space available that can be used as an infiltration area.
Recommendations
•Adding an infiltration well.
• Utilizing rainwater for landscape irrigation.
• Using porous paving in the parking area.

4. Material Resource and Cycle (MRC)

Score: Good (4/6)

Potential

• Local materials can be used to reduce the carbon footprint of transportation.
• Use recycled materials in landscape elements.

Recommendations

• Develop a construction waste management plan.
• Use certified environmentally friendly materials.

5. Indoor Health and Comfort (IHC)

Score: Excellent (8/10)

Advantages

• Sufficient spacing between buildings supports natural ventilation.
• High potential for natural lighting because the buildings are not too dense.

Recommendations

• Maximize cross-ventilation.
• Provide green areas as a thermal buffer.

6. Building Environment Management (BEM)

Score : Enough (3/5)

Potential

• Area management is relatively easy because building zoning is clear.
• Service and parking areas can be centrally managed.

Recommendations

• Provide a waste sorting system.
• Develop operational SOPs for green buildings.

7. Innovation and Future Development (IFD)

Score : Excellent (4/5)

Innovation Potential

• Smart lighting in the area.
• Rainwater harvesting.
• Solar panel deployment.
• Productive and educational landscapes.

Kriteria	**Skor**
Appropriate Site Development *(ASD)*	8/12
Energy Efficiency and Conservation *(EEC)*	7/12
Water Conservation *(WAC)*	5/10
Material Resource and Cycle *(MRC)*	4/6
Indoor Health and Comfort *(IHC)*	8/10
Building Environment Management *(BEM)*	3/5
Innovation and Future Development *(IFD)*	4/5
Total	**39/60**

Percentage

$$\frac{39}{60} \times 100\% = 65\%$$

This site plan already demonstrates the basic principles of green building, featuring extensive open space, good circulation, and high potential for natural ventilation. However, to achieve a higher BGH value, active green space, a rainwater conservation system, shaded parking vegetation, comfortable pedestrian paths, and the use of renewable energy would be necessary.

Conclusion

The design of the Main Building at Al-Amin Industrial Park successfully integrates the Eco-Synergy concept with a Green Building approach, directly referencing the Minister of Public Works and Public Housing Regulation No. 21 of 2021. The implementation of this concept is realized through the optimization of seven core aspects: appropriate site management, energy efficiency via passive design, water conservation utilizing circular systems, the use of durable local materials, enhanced indoor air quality, and integrated solid waste and domestic wastewater management. The functional design of this 6-story mixed-use building effectively accommodates educational, research, informational, and commercial activities in a sustainable manner that is responsive to the tropical climate.

Implications and Future Development: The implications of this study demonstrate that applying green building standards to industrial sectors can significantly mitigate the negative impacts of environmental degradation caused by land-use changes. Future development of these findings should focus on quantitative measurements of periodic carbon emission reductions and the macro-level integration of renewable energy systems, such as solar panels, across the entire Techno Park

References

[1] Chertow, M. R. (2000). Industrial symbiosis: Literature and taxonomy. *Annual Review of Energy and the Environment*, *25*, 313–337. https://doi.org/10.1146/annurev.energy.25.1.313

[2] Davidova, M. (2020). Synergy in the systemic approach to architectural performance. *FormAkademisk - Forskningstidsskrift for Design Og Designdidaktikk*, *13*(2), 1–30. https://doi.org/10.7577/formakademisk.3387

[3] Dutt, S., Purwanto, P., & Sudarno, S. (2025). Synergizing Circular Economy and Eco-Industrial Park Concepts: A Literature-Based Exploration for Advancing Inclusive and Sustainable Industrial Development in Indonesia. *E3S Web of Conferences*, *650*, 1–16. https://doi.org/10.1051/e3sconf/202565002013

[4] Fadillah, A., & Febrita, J. (2024). Implementasi Aspek Green Building Berdasarkan Kenyamanan Ruang di Gedung Pusat Penelitian Kelapa Sawit Medan. *Jurnal Teknik Sipil Dan Lingkungan*, *9*(1), 41–50. https://doi.org/10.29244/jsil.9.1.41-50

[5] Greenship, P. P., Kriteria, R., & Tolok, D. A. N. (2013). *GREENSHIP RATING TOOLS GREENSHIP untuk BANGUNAN BARU*. *April*.

[6] Kusumawati, Y., Farhaty, M., Ramadhan, R. D., & Muhaimin, Y. (2026). *Program Penghijauan Berbasis Partisipasi Masyarakat sebagai Strategi Meningkatkan Kesadaran dan Pelestarian Lingkungan di Desa Tolouwi Kecamatan Monta J urnal Penelitian , Pengabdian dan Pemberdayaan Masyarakat*. *3*, 53–66.

[7] Musa, W. J. A., & Mahmud, M. (2026). *Industrial Symbiosis and Eco-Industrial Parks in the Era of ESG and Decarbonization : Assessment Methods , Regional Scaling , and Sectoral Evidence from 2000-2026*. *13*(April), 678–696.

[8] Rachmawati, R. (2018). Pengem Bangan Sm Art Villag E Untuk. *Jurnal Sistem Cerdas 2018*, *01*(02), 12–18.

[9] Rika Sukmadewi, N. P. I. N. D. P. (2019). Pendahuluan. *Jurnal Jumpa*, *05*, 424–442.

[10] Rostamnezhad, M., & Thaheem, M. J. (2022). Social Sustainability in Construction Projects—A Systematic Review of Assessment Indicators and Taxonomy. *Sustainability (Switzerland)*, *14*(9). https://doi.org/10.3390/su14095279

[11] Safriani, M., Rafshanjani, M. A., Hasdanita, F., & Yulianur, A. (2024). Evaluasi Kapasitas Tampang Drainase Kawasan Perumahan Desa Leuhan Kabupaten Aceh Barat. *Teras Jurnal : Jurnal Teknik Sipil*, *14*(1), 11–25. https://doi.org/10.29103/tj.v14i1.999

[12] Suharyadi, T. A., & Effendie, M. I. N. (2023). Implementasi Konsep Green Building Berdasarkan Peraturan Menteri Pekerjaan Umum Dan Perumahan Rakyat Republik Indonesia Nomor 21 Tahun 2021 Tentang Penilaian Kinerja Bangunan Gedung Hijau Pada Perumahan Cianjur Asri Residence Cianjur Asri. *Jurnal Momen*, *06*(01), 59–73.

[13] Zainuri, Z. (2018). Urgensi Kebijakan Hukum Penataan Ruang Provinsi Kepulauan Dalam Sistem Penataan Ruang Nasional. *DiH: Jurnal Ilmu Hukum*, *14*, 43–60. https://doi.org/10.30996/dih.v0i0.1790