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CONCEPT OF MODERN RESIDENTIAL HOUSES OF BALI ARCHITECTURE IN SUPPORTING ENVIRONMENTAL SUSTAINABILITY

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ABSTRACT

The architecture of the archipelago is rich in cultural values that have been inherited from generation to generation. By adopting local architectural elements into modern designs, we help preserve and preserve Indonesia's cultural heritage. Respect for Local Wisdom: Traditional architecture is designed based on centuries of experience that takes into account the local environmental and cultural conditions. Proud of the Nation's Identity: Showing the architecture of the archipelago in the midst of the era of globalization is a form of appreciation for local wealth that is often forgotten. The typical architecture of the archipelago is rooted in the principle of respecting nature and contextualizing it with the surrounding environment. Traditional houses are often in harmony with the topography, vegetation, and surrounding natural conditions. In the modern context, this can mean maintaining environmental sustainability and creating harmony with nature. Conceptualizing a modern residential house with typical archipelago architecture is not only about beauty, but also about functionality, cultural preservation, and responsibility for the environment. This approach offers a blend of modern conveniences and local wisdom that has proven effective over the centuries. The concept of a modern residence with traditional Balinese architecture combines contemporary elements with local Balinese wisdom, creating a harmonious residential atmosphere between tradition and modernity. The research method used to examine the concept of traditional Balinese architecture requires a comprehensive approach, considering that this architecture is very rich in cultural, spiritual, social, and environmental values. The results of this study are: The concept of using guardrails and vegetation that is quite dense in terms of function to reduce the source of noise from outside the site and inside the site. The concept of building placement is in or away from the road. ; The use of vegetation can filter the air to cool so that it can affect the air conditioning in the building. ; Use of voids in Buildings. ; The Indonesian wind moves from the Southeast to the Northwest. ; Maximizing natural ventilation without compromising comfort in the building. ; The addition of a small canopy or tritisan as a barrier to sunlight that directly enters the building with later added curtains inside to reduce heat. ; The concept of circulation in this building is the main entrance which functions as an in-out vehicle. ; Drainage Creation in the house entrance area to accelerate the descent of rainwater. ; Rainwater reservoir by directing towards the front sewer. ; The concept of parking this building will be made one because it is considered for a private house.

Keywords: Architect, House, Concept, Tradition, Bali.

INTRODUCTION

Modern housing meets architectural heritage — that's the reality of what is happening in Bali today. On the one hand there is a strong pressure to meet the needs of modern occupancy, thermal comfort, and aesthetics; on the other hand there are traditional Balinese values (Tri Hita Karana), family-communal patterns, and passive climate solutions that have developed over the centuries. If not carefully managed, "modernization" efforts risk scrubbing away the functional elements that actually support environmental sustainability, leaving Balinese-style houses only as decorative displays with no real ecological benefits. Traditional Balinese architecture preserves a set of principles relevant to sustainability: spatial orientation and air circulation for cross ventilation, use of courtyard (anggah/ajeg), use of local materials with high permeability (stone, bamboo, reeds), natural surface drainage, and open land-space relationships that strengthen water infiltration. These concepts essentially offer passive strategies to reduce energy needs, improve rainwater management, and maintain the balance of micro-ecosystems. In modern practice, concrete opportunities—such as the integration of solar panels, rainwater harvesting systems, bio-septic, and long-lived materials—can strengthen sustainability without depriving Bali's architectural identity, provided they are translated technically and regulatively. (Santi & Syukur, 2010) (Yudantini & Wisnawa, 2013) (IRWAN, 2018) (PARWATA, 2011)

But the reality on the ground shows an inconsistency: many "Balinese architecture" housing imitates the shape of the roof or ornament without applying functional principles that reduce the environmental burden. Emerging problems include reduced Green Open Space (KDH), increased hard cover that reduces infiltration, inadequate drainage thus increasing the risk of inundation, and inefficient energy and water consumption. Market pressures, fragmentation of plots, and a lack of technical guidelines linking Balinese aesthetics with local sustainability standards exacerbate the situation. In other words: form is not necessarily a function — and it must be tested quantitatively. This research places the concept of modern residential houses with Balinese architecture as a measurable object of study. The main objectives are: (1) to map Balinese architectural principles that are relevant to environmental sustainability; (2) evaluate the extent to which such elements are implemented in the design and construction practices of modern homes; and (3) formulate technical guidelines and policy recommendations to integrate Balinese aesthetics with environmental targets (e.g. KDB/KDH, energy efficiency, water management, and waste management). The measurement indicators used will be quantitative and applicable so that the results can be directly used by architects, developers, and policymakers. (Primary, 2024) (Manoi, 2025) (Hafil, 2025) (PARWATA, 2011)

The expected contribution is practical and transformative: it does not simply suggest "more Bali", but shows how Balinese architectural principles can be translated into measurable environmental performance — for example, reduced energy consumption, increased water infiltration, and improved quality of open space. With this approach, the research seeks to close the gap between cultural preservation and the need for modern housing, as well as provide a blueprint for sustainable tropical housing models that maintain local identity. Conceptualizing a modern residential house with typical archipelago architecture has a number of important benefits, both in terms of culture, environment, and functionality. Here are the main reasons why incorporating traditional elements of the archipelago in modern home design is important: (PARWATA, 2011) (Kelvin Darma Putra, I Wayan Balika Ika, 2023)

1.1. Preservation of Local Culture and Identity and Harmony with Nature

The architecture of the archipelago is rich in cultural values that have been inherited from generation to generation. By adopting local architectural elements into modern design, we are helping to preserve and preserve Indonesia's cultural heritage. It also gives a strong identity to the house, reflecting the cultural diversity of the area. Respect for Local Wisdom: Traditional architecture is designed based on centuries of experience that takes into account the local environmental and cultural conditions. Proud of the Nation's Identity: Showing the architecture of the archipelago in the midst of the era of globalization is a form of appreciation for local wealth that is often forgotten. (Santi & Syukur, 2010)

The traditional architecture of the archipelago is generally designed with the local climatic and natural environment conditions in mind. For example, stilt houses in coastal or highland areas are designed to deal with extreme weather and flooding. Energy Efficiency: Traditional home designs of the archipelago usually utilize natural ventilation and good lighting, thereby reducing dependence on refrigeration or artificial lighting. Sustainable Life Cycle: The use of natural materials such as bamboo, wood, and natural stone in traditional architecture tends to be environmentally friendly and sustainable, thus supporting the concept of green building. (Yudantini & Wisnawa, 2013)

1.2. Adaptation to Tropical Climates with Unique Aesthetic Value

The archipelago has a humid tropical climate, so traditional houses are designed to handle hot temperatures and high humidity. Adapting this design in a modern context can improve the comfort of the occupants. Use of Weather-Resistant Local Materials: Materials such as bamboo and wood are resistant to heat and moisture, while the high roof design allows for better air circulation. Open Space and Natural Ventilation: Traditional Nusantara houses usually have a lot of open or semi-open space to maximize air circulation, which makes the house feel cooler and more comfortable without the need for a lot of air conditioning. (IRWAN, 2018)

Combining traditional elements with modern style results in a unique and attractive aesthetic look. The typical architecture of the archipelago, with carvings, natural material textures, and forms that are in harmony with nature, can provide a distinctive beauty as well as functionality. Blend of Modern and Traditional: Integrating modern minimalist design with typical carvings or architectural details of the archipelago, such as pillars, wall ornaments, and the use of traditional roofs, creating a balance between modern and traditional aesthetics. Stand out in the middle of Global Architecture: Homes with local architectural styles will stand out more in the midst of a homogeneous global architecture, adding value in terms of aesthetics and pride. (PARWATA, 2011)

1.3. Design Flexibility to Occupant Comfort and Health

The archipelago's architecture generally has a flexible structure and is easily adapted to modern needs. Traditional houses often use modular concepts, such as stilt houses that can be expanded or altered as needed. Dynamic Space: This modular design allows the home to be easily adapted, both for the addition of space and for interior rearrangements, according to the needs of today's families. Optimal Space Utilization: In modern homes, the concept of open and multifunctional spaces common in traditional architecture can be leveraged to create more efficient spaces. (Kelvin Darma Putra, I Wayan Balika Ika, 2023)

Traditional houses of the archipelago are designed with the comfort of their occupants in a humid and hot tropical climate. A design that pays attention to natural air circulation and good lighting supports the health of residents by improving the air quality inside the house. Good Natural Ventilation: The traditional design of the archipelago utilizes natural ventilation that prevents humid and hot air from being trapped inside the house, thereby reducing the risk of illness due to poor air quality. Natural Lighting: Traditional homes are usually designed to receive the maximum amount of natural light, which is also important for the physical and mental well-being of the occupants. (Hafil, 2025) (Cahyono et al., 2025)

1.4. Appreciation of the Environment and Local Context

The typical architecture of the archipelago is rooted in the principle of respecting nature and contextualizing it with the surrounding environment. Traditional houses are often in harmony with the topography, vegetation, and surrounding natural conditions. In the modern context, this could mean maintaining environmental sustainability and creating harmony with nature . Conceptualizing a modern residential house with typical archipelago architecture is not only about beauty, but also about functionality, cultural preservation, and responsibility for the environment. This approach offers a blend of modern conveniences and local wisdom that has proven effective over the centuries. (Manoi, 2025) (Cahyono et al., 2025)

LITERATURE REVIEW

The concept of a modern residence with traditional Balinese architecture combines contemporary elements with local Balinese wisdom, creating a harmonious residential atmosphere between tradition and modernity. Here are some of the main elements that can be used in designing a modern house with a touch of Balinese architecture: (Primary, 2024)

2.1. Spatial Planning

a. Open and Air Circulation: Balinese architecture pays great attention to the flow of air and natural light. Open spaces, such as pavilions or bales, allow good air circulation, which can also be applied in modern homes through the open-plan concept. (Primary, 2024)

b. Traditional Zoning: Balinese traditional houses are divided into three main zones: Main (sacred place), Madya (main room), and Nista (outer or service). In modern homes, this zoning can be applied by distinguishing private, semi-private, and public areas. (Primary, 2024)

2.2. Building Materials

a. Natural Materials: Such as natural stone, wood, bamboo, and reeds for roofs. Natural materials give a warm feeling and harmony with nature, while combining traditional beauty. (Hafil, 2025)

b. Red Brick and Stone Level: Used for wall decoration or exterior elements that reflect Balinese style. (Hafil, 2025)

2.3. Balinese Traditional Elements

a. Small Temple (Sanggah): As a spiritual symbol, a small temple is usually placed in the corner of the house. In modern design, the rebuttal can still be maintained in a minimalist form while still respecting tradition. (PARWATA, 2011)

b. Balinese Carvings and Ornaments: Carved motifs on doors, windows, or walls can be kept in the design, but with a simpler look to suit the modern style. (PARWATA, 2011)

2.4. Parks and Landscapes

a. Tropical Garden: A landscape that features tropical plants such as coconut trees, palms, and frangipani flowers. Small pools or water elements are also important in creating a calm and natural atmosphere. (Santi & Syukur, 2010)

b. Natural Fence and Gate: Using a hedge or low fence with carved gates to mark the entrance to the yard. (Santi & Syukur, 2010)

2.5. Roof and Bale Bengong

a. Multi-storey Roof (Meru): The roof of a traditional Balinese house is often in the shape of a meru, multi-storey and uses straw or reeds. In modern versions, the roof can still retain this shape but with more durable materials, such as tiles or metal roofs. (IRWAN, 2018)

b. Bale Bengong: A typical Balinese open relaxation area that can be placed in the garden or outside the house, giving a feeling of relaxation and connection with nature. (IRWAN, 2018)

2.6. Color and Lighting

a. Natural Colors: The color palette of traditional Balinese houses is usually inspired by earth colors, such as brown, beige, and green. It can still be applied in a modern home, giving it a cool and natural feel. (Kelvin Darma Putra, I Wayan Balika Ika, 2023)

b. Natural Lighting: Balinese houses pay great attention to natural lighting. Using large windows and skylights in a modern design can keep this concept alive, with a combination of warm artificial lighting at night. (Kelvin Darma Putra, I Wayan Balika Ika, 2023)

c. By combining these elements, modern dwellings can still maintain the uniqueness and values of Balinese culture without sacrificing the comfort and practicality of today's lifestyle. (Kelvin Darma Putra, I Wayan Balika Ika, 2023)

Color and Lighting for green green buildings in Indonesia — prepared based on SNI and relevant technical standards/assessments (intended for journal writing). I include a summary of key rules, metrics used, color-→thermal and color/surface→lighting relationship mechanisms, and practical design recommendations that can be applied right away. The main sources of SNI / Greenship are listed after the most important parts, namely:

1. SNI 03-2396 : Procedures for Designing Natural Lighting in Buildings
2. SNI 03-6575 : Procedures for Designing Artificial Lighting Systems in Buildings
3. GREENSHIP New Building & GREENSHIP Homes — Green Building Council Indonesia (Daylighting & Lighting Efficiency Criteria)

Figure 1. Aerial photo of the research location.
Source : Data Analysis.

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Dearsip, Vol. 05 No. 02 Tahun 2025

RESEARCH METHODS

The research methods used to examine the concept of traditional Balinese architecture require a thorough approach, considering that this architecture is very rich in cultural, spiritual, social, and environmental values. Here are some methods that can be applied in research on traditional Balinese architecture: (Wahyuni et al., 2024)

3.1. Research Approach

This study uses mixed structured methods: (1) quantitative surveys and technical field measurements, (2) analysis of documents and regulations (SNI/PKKPR/IKKPR/Greenship), (3) structured qualitative interviews with stakeholders, and (4) technical simulations (energy & daylighting) for performance verification. This approach was chosen to test the hypothesis that the concept of modern Balinese architecture can be measured and modified to meet practical sustainability criteria.

3.2. Technical Standards and References

All calculations and verifications refer to the following national/technical standards:

1. SNI 03-7065 : 2005 (Plumbing) — water needs, gutters, infiltration wells, septic.
2. SNI 03-6389 (OTTV/RTTV) — Conservation of building envelopes.
3. SNI 03-2396 (Daylighting) & SNI 03-6575 (Artificial Lighting).
4. SNI 6197 (Energy conservation of lighting systems).
5. IKKPR/PKKPR documents and Regional Regulations related to PSU/handover.

Each finding is verified against the relevant clauses in the respective document.

3.3. Calculation of Clean Water, Chamfers, and Infiltration Wells (SNI 03-7065)

1. Clean water: use explicit formula:

   Requirement = Number of Occupants × Number of Usage (turns/day) × Usage per turn (L). Verify PDAM availability (L/min discharge)

2. Gutter : count :

   Roof Runoff Discharge = Rainfall (L/min) × Roof Area (m²); Number of gutters = ceil(bulk / gutter capacity per unit)

3. Infiltration wells :

   Required volume = Catch area / 25 m² per 1 m³ (according to team reference/report)

3.4. Inspection of Septic Tank & Communal WWTP; Wastewater Sampling

Check the capacity of the septic tank (L) of each unit; Measure the level of mud, record the cleaning record.

3.5. Lighting & Color Measurement (Interior / Exterior)

1. Lux measurement at the working point (morning/noon/cloud) using a lux meter; Take an average of 5 points per space.
2. Measure the reflectance of ceiling/wall/roof surfaces (spectroradiometer or manufacturer's data); Note the color and type of finishing.
3. Simulated daylighting (DIALux/Radiance) for the before & after scenario of the recommendation (e.g. high reflectance ceiling, light shelf).

3.6. Case Studies

Case studies allow researchers to study one or more specific examples of traditional Balinese architecture in depth. (Wahyuni et al., 2024)

a. Purpose: To study traditional buildings that still exist, such as traditional houses, temples, or palaces (puri) in Bali.

b. Procedure: Visit important architectural sites in Bali and analyze the details of the building in terms of structure, materials, layout, and symbolism.

c. Data Collection Techniques: Documentation through photography, measurement, and analysis of building design and construction.

d. Output: An in-depth description and analysis of one or more traditional Balinese buildings as a representation of typical Balinese architecture.

3.7. Architectural Design Approach

This approach focuses on the technical and aesthetic aspects of traditional Balinese architecture. This method can combine field studies and design experiments. (Keristian et al., 1997)

a. Spatial Analysis

- Objective: Study the spatial patterns of traditional Balinese houses, including zoning between sacred areas, public areas, and private areas.

- Procedure: Analyze traditional Balinese house plans based on the Asta Kosala Kosali principle and how this principle can be applied or modified in the context of modern architecture.

- Output: Understanding of the interconnectedness of space, proportion, and function of buildings.

b. Design Experiment

- Purpose: Combining traditional Balinese elements with modern architecture.

- Procedure: Testing and designing new concepts that combine Balinese architecture with contemporary architectural principles, both in terms of aesthetics and functions.

Output: A harmonious new design concept between traditional and modern elements.

3.8. Environmental and Ecological Approach

Traditional Balinese architecture pays great attention to harmony with nature and the environment. This approach examines the ecological and sustainability aspects of Balinese architecture. (Keristian et al., 1997)

a. Sustainability Analysis

- Objective: To examine how the principles of traditional Balinese architecture can be applied to create sustainable and environmentally friendly buildings.

- Procedure: Examine the use of natural materials, passive designs that utilize ventilation and natural light, and other eco-friendly concepts.

- Output: Identify Balinese architectural elements that can be applied in modern sustainable architectural design.

- With the above methods, research on Balinese traditional architecture can provide a comprehensive understanding, not only from the technical aspects, but also from the social, cultural, spiritual, and environmental aspects.

In this study, several types of analysis were carried out based on the requirements and rules that apply in accordance with the location and designation of the planned building, including the calculation of the need for sanitary water, septic tanks, the number of toilets, and the number of rain gutters:

Table 1. Planned Concepts.

SHOP DRAWING
RENC. KONSEP KEBISINGAN
RENC. KONSEP PENGHAWAAN
RENC. KONSEP ARAH MATAHARI
DETAIL KONSEP ARAH MATAHARI
RENC. KONSEP SIRKULASI
RENC. KONSEP DRAINASE
RENC. KONSEP PARKIR
RENC. KONSEP TATA RUANG
RENC. AKSES MOBIL PEMADAM
RENC. JALUR EVAKUASI
RENC. KONSEP TITIK TEMPAT SAMPAH

Source : Data Analysis.

ANALYSIS AND DISCUSSION

1. Noise Concept Plan

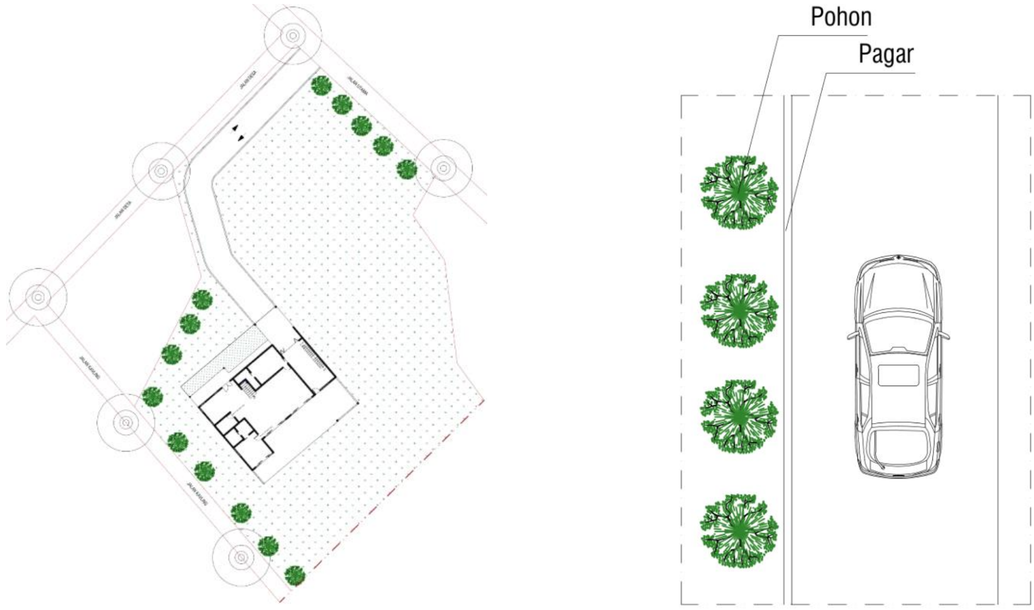

Figure 2. Noise Concept Plan.
Source : Data Analysis.

a. The concept of using guardrails and vegetation that is quite dense serves to reduce noise sources from outside the site and inside the site.

b. The concept of building placement is in or away from the road.

Core design: guardrails + dense vegetation; The placement of the building is set back from the road.

Support for environmental and social sustainability, namely vegetation as a sound absorber, reduce acoustic pollution, improve occupant comfort and health value. The placement of the building backwards reduces direct noise exposure.

Measurable indicators: noise level reduction (dB) at interior points (before–after), vegetation band width (m), vegetation type (sound absorption).

Technical recommendation: use a combination of dense vegetation (broadleaf trees + shrubs) with a depth of at least 3–5 m; choose local species with high sound absorption; Consider acoustic dampers (earth berm or vegetative panels) for the most vulnerable sides. Field verification with sound level meter (SPL) measurements during the day/night.

E-ISSN : 2808-0947

Dearsip, Vol. 05 No. 02 Tahun 2025

2. Air Conditioning Concept Plan

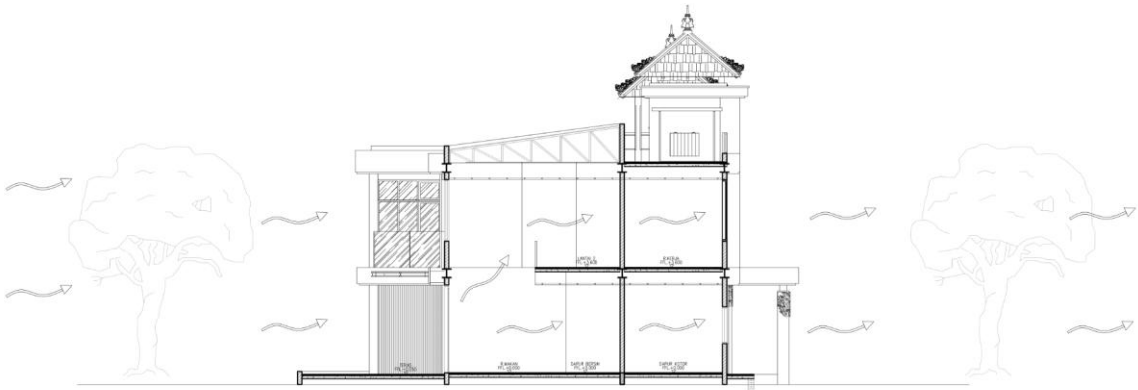

Figure 3. Air Conditioning Concept Plan.
Source : Data Analysis.

a. The use of vegetation can filter the air to cool so that it can affect the air conditioning in the building.

b. Use of voids in Buildings.

Core design: vegetation for microclimate cooling; use of internal void.

Support for sustainability, i.e. passive/void ventilation reduces the need for mechanical cooling; vegetation lowers the ambient temperature (urban heat island mitigation).

Measurable indicators: difference in interior operating temperature (°C), natural air exchange rate (ACH), percentage of space with cross ventilation.

Technical recommendations: orient openings for cross venting, high-height void design & openings that promote stack effect; Choose evapotranspirative vegetation near the opening for pre-cooling of incoming air. Simulate ventilation (simple CFD) and measure ACH in the field.

3. Concept Plan of the Direction of the Sun

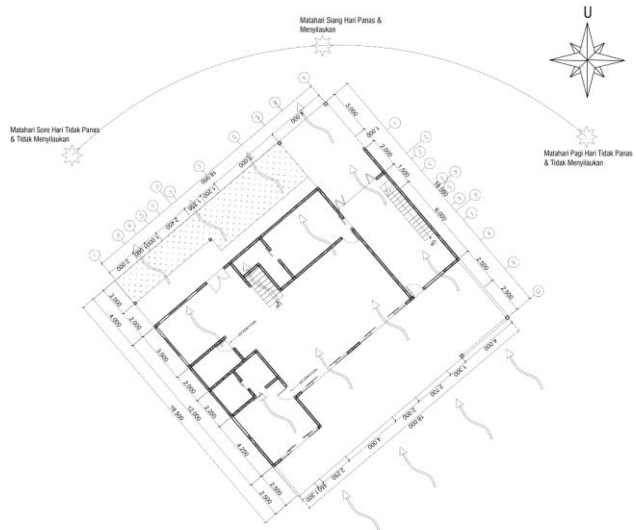

Figure 4. Concept Plan of the Sun's Direction.
Source : Data Analysis.

a. The Indonesian wind moves from the Southeast to the Northwest.

b. Maximizing natural ventilation without compromising comfort in the building.

Design core: understand the dominant wind direction (SE→NW) and maximize ventilation without compromising comfort.

Support for sustainability is the correct orientation and shadow setting lowering the cooling load and maximizing daylighting.

Measurable indicators: insolation value on the façade (W/m²), reduction in cooling demand (%), daylight factor in the workspace.

Technical recommendations: set the main orientation of the façade and openings based on sun/wind analysis; Combine overhang/vertical fins in the west/east orientation to reduce direct afternoon/morning radiation.

4. Details of the Concept of the Sun's Direction

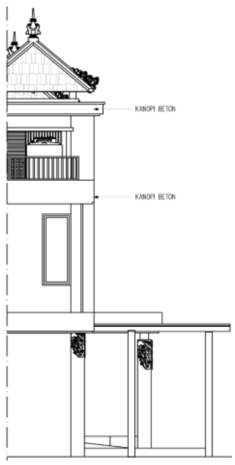

Figure 5. Details of the Concept of the Direction of the Sun.
Source : Data Analysis.

a. The addition of a small canopy or tritisan as a barrier to sunlight that directly enters the building with later added curtains inside to reduce heat.

The core of the design: addition of canopies/tritisan + indoor gordyn.

Support for sustainability, i.e. canopies reduce heat gain; Gordyn adds internal controls. However, passive solutions (overhang, shading devices) are more durable than gordyn which depends on user behavior.

Measurable indicators: reduction of incoming radiation (W/m²), effect on interior illuminance (lux).

Technical recommendation: calculate RBS (required overhang depth) based on the angle of elevation of the sun for each orientation; Use a high albedo or vegetative canopy material (green canopy) to add insulation. Choose a gordyn only as a complement—wear a low-emissivity thermal curtain if needed.

5. Circulation Concept Plan

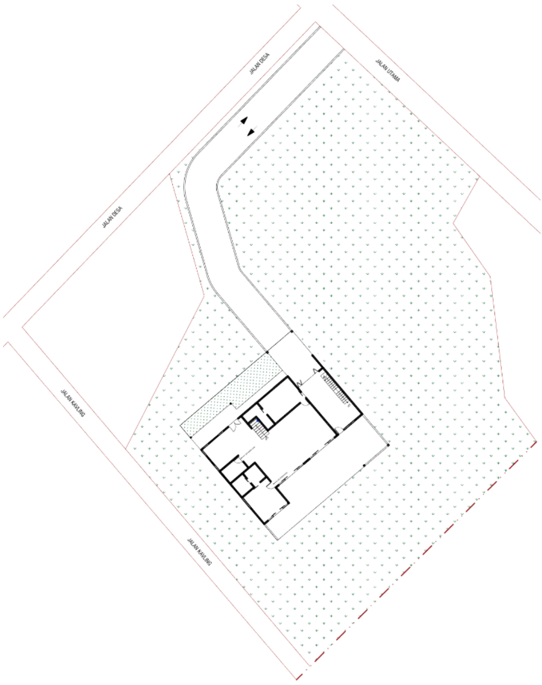

Figure 6. Circulation Concept Plan.
Source : Data Analysis.

a. The concept of circulation in this building is the main entrance which functions as an in-out vehicle.

The core of the design: the main entrance as a vehicle entry and exit route.

Support for social sustainability and safety, namely good circulation, reduce vehicle emissions during maneuvering, and accelerate emergency access. But from an environmental perspective, it needs to be associated with the permeability of the surface and parking area.

Measurable indicators: average vehicle maneuver time (seconds), impervious area (%) in access.

Technical recommendations: design of maneuvering spaces that reduce stop-and-go; use permeable pavement in the parking/circulation area to increase infiltration; Provide safe pedestrian paths to encourage non-motorized mobility.

6. Rainwater Drainage Concept Plan

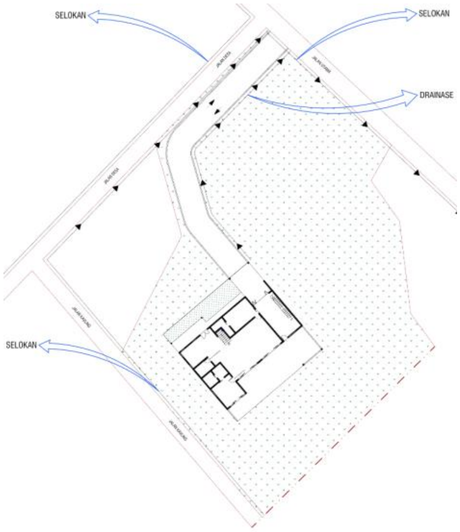

Figure 7. Rainwater Drainage Concept Plan.
Source : Data Analysis.

a. Drainage Creation in the entrance area of the house to accelerate the descent of rainwater.

b. Rainwater reservoir by directing towards the front sewer.

The core of the plan: the channel at the entrance to remove stagnation; point to the front ditch.

Support for sustainability: i.e. drainage accelerates runoff; Good for safety & prevent damage. However, sustainable solutions emphasize retention/infiltration (detention, bioswale, infiltration wells) rather than simply discharging into public sewers.

Measurable indicators: inundation time (hours), channel capacity (L/s), contained volume vs runoff volume (m³).

Technical recommendations: add retention elements (bioswale, infiltration trench) and integrated infiltration wells; make sure the outlet is filtered (sediment trap) before entering the public sewer; design according to SNI related to drainage and infiltration well planning.

7. Parking Concept Plan

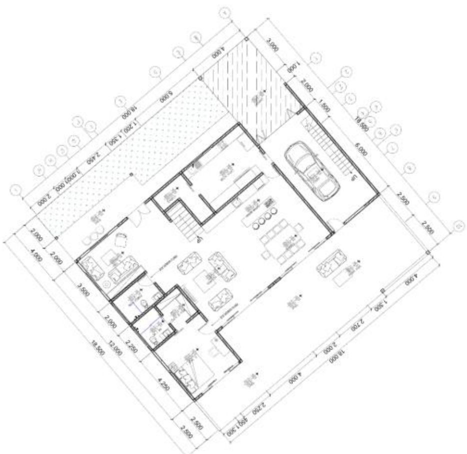

Figure 8. Parking Concept Plan.
Source : Data Analysis.

a. The concept of parking this building will be made one because it is considered for a private house.

The core of the design: private parking is combined per unit.

Support for sustainability i.e. private parking reduces the need for public infrastructure, but if the design encourages excessive use of private vehicles, it has a negative impact on carbon. The material and layout of the parking have an effect on surface infiltration and heat.

Measurable indicators: parking area per unit (m²), surface permeability ratio, green area lost (%).

Technical recommendations: use permeable paving, provide space for bicycles, future-proof charging stations, and shade trees to reduce the effects of heat.

8. 1st Floor Spatial Plan

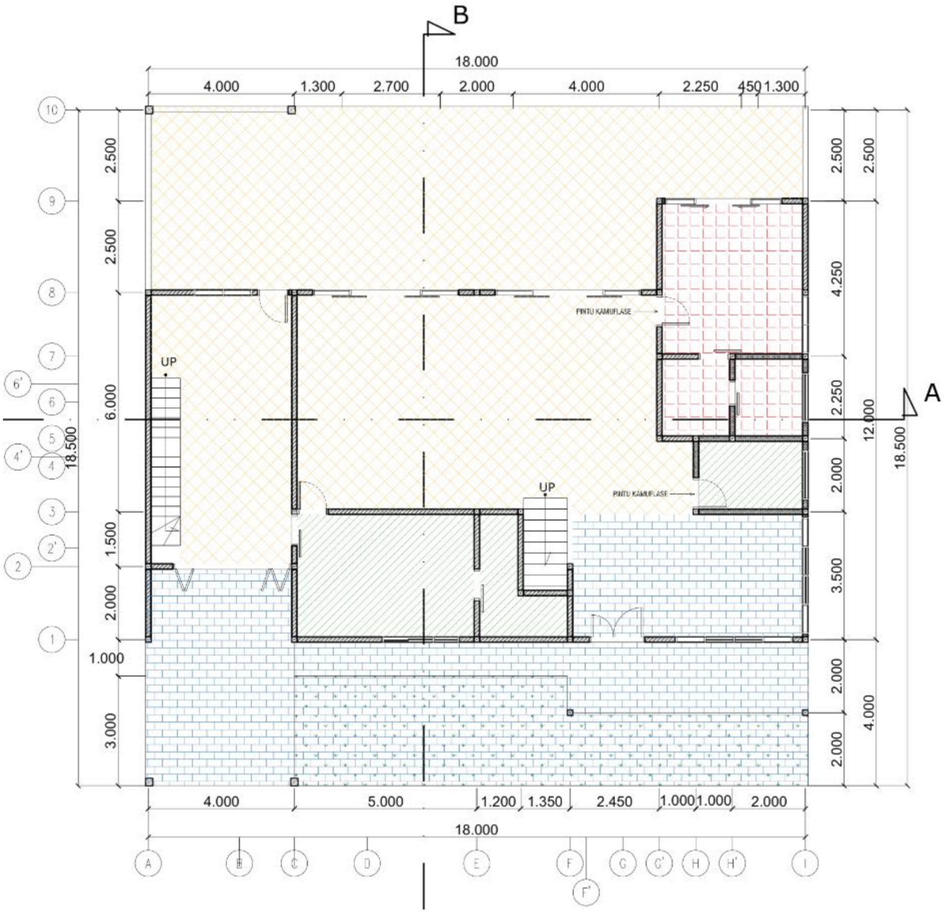

Figure 9. 1st Floor Spatial Plan.
Source : Data Analysis.

The core of the design: distribution of functional space, access, and utilization of the rooftop.
Support for sustainability is good spatial planning to improve daylighting, ventilation, potential rooftop use (park/solar PV) and rainwater management. Rooftops can be green areas for UHI mitigation and water retention.
Measurable indicator: percentage of roof area used for green/solar (%), average daylight factor, interior ACH.
Technical recommendation: allocate rooftop parts for parks and/or solar PV; ensure internal circulation supports cross-ventilation; Place the wet chamber closest to the plumbing shaft for piping system efficiency.

9. 2nd Floor Spatial Plan

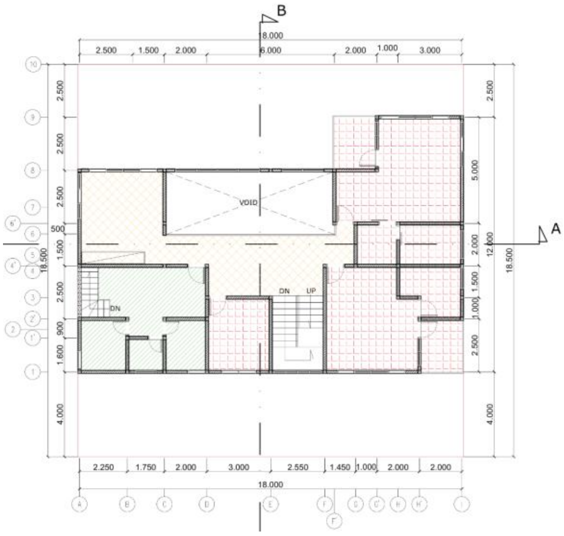

Figure 10. 2nd Floor Spatial Plan.
Source : Data Analysis.

The core of the design: distribution of functional space, access, and utilization of the rooftop. Support for sustainability: YES (design-dependent) — good spatial planning improves daylighting, ventilation, potential rooftop use (park/solar PV) and rainwater management. Rooftops can be green areas for UHI mitigation and water retention. Measurable indicator: percentage of roof area used for green/solar (%), average daylight factor, interior ACH. Technical recommendation: allocate rooftop parts for parks and/or solar PV; ensure internal circulation supports cross-ventilation; Place the wet chamber closest to the plumbing shaft for piping system efficiency.

10. Roof Top Spatial Plan

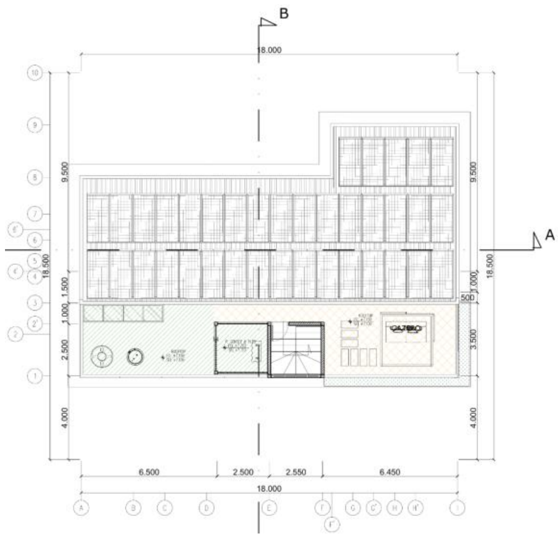

Figure 11. Roof Top Spatial Plan.
Source : Data Analysis.

11. Fire Engine Access Plan

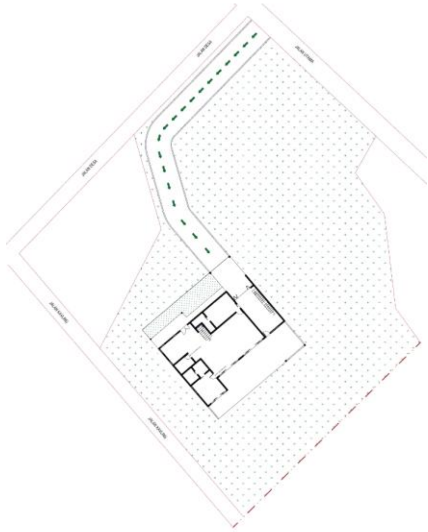

Figure 12. Fire Engine Access Plan.
Source : Data Analysis.

a. Circulation Access for fire engines, to make it easier for fire engines when there is a fire.

The core of the design: distribution of functional space, access, and utilization of the rooftop. Support for sustainability: YES (design-dependent) — good spatial planning improves daylighting, ventilation, potential rooftop use (park/solar PV) and rainwater management. Rooftops can be green areas for UHI mitigation and water retention. Measurable indicator: percentage of roof area used for green/solar (%), average daylight factor, interior ACH. Technical recommendation: allocate rooftop parts for parks and/or solar PV; ensure internal circulation supports cross-ventilation; Place the wet chamber closest to the plumbing shaft for piping system efficiency.

12. 1st Floor Evacuation Line Plan

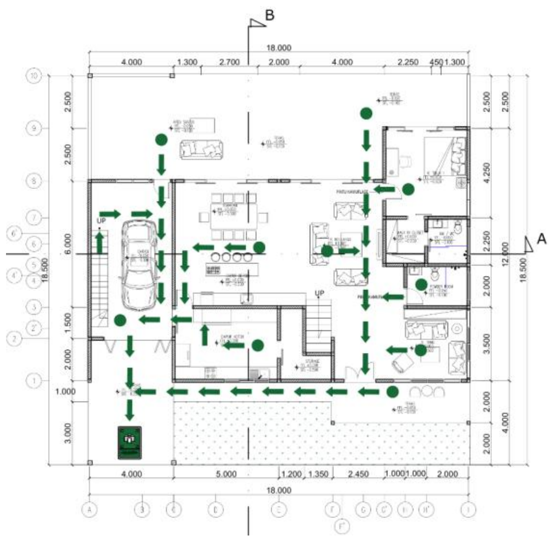

Figure 13. 1st Floor Evacuation Line Plan.
Source : Data Analysis.

Core design: vertical and horizontal evacuation paths.
Support for sustainability, resilience & safety, namely efficient evacuation, protecting lives and reducing environmental damage in times of emergency.
Measurable indicators: evacuation capacity (people/minute), estimated evacuation time, availability of access to safe points.
Technical recommendations: the path must be barrier-free, fire-resistant, implement energy-efficient emergency lighting (LED + battery/diesel), and clear evacuation signs.

13. 2nd Floor Evacuation Line Plan

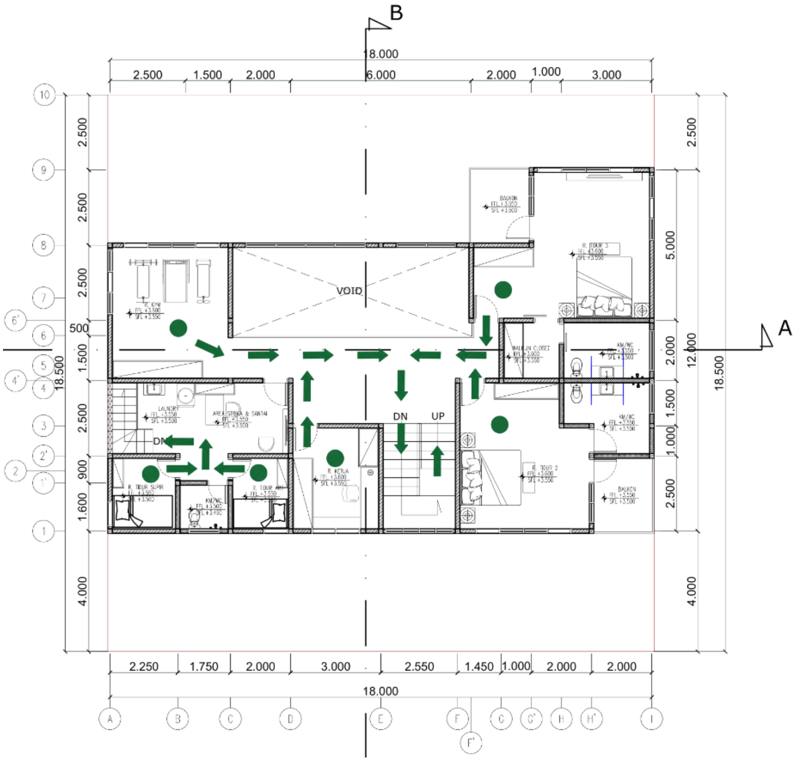

Figure 14. 2nd Floor Evacuation Line Plan.
Source : Data Analysis.

Core design: vertical and horizontal evacuation paths.
Support for sustainability, resilience & safety, namely efficient evacuation, protecting lives and reducing environmental damage in times of emergency.
Measurable indicators: evacuation capacity (people/minute), estimated evacuation time, availability of access to safe points.
Technical recommendations: the path must be barrier-free, fire-resistant, implement energy-efficient emergency lighting (LED + battery/diesel), and clear evacuation signs.

14. Roof Top Evacuation Route Plan

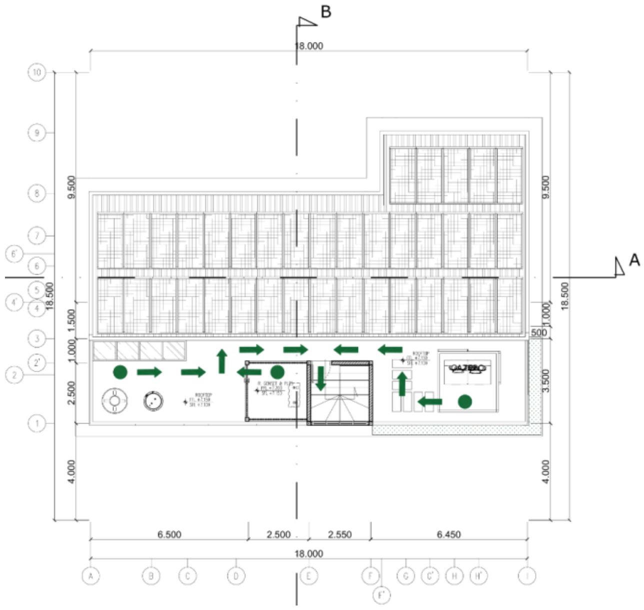

Figure 15. Roof Top Evacuation Route Plan.
Source : Data Analysis.

Core design: vertical and horizontal evacuation paths.
Support for sustainability, resilience & safety, namely efficient evacuation, protecting lives and reducing environmental damage in times of emergency.
Measurable indicators: evacuation capacity (people/minute), estimated evacuation time, availability of access to safe points.
Technical recommendations: the path must be barrier-free, fire-resistant, implement energy-efficient emergency lighting (LED + battery/diesel), and clear evacuation signs.

15. 1st Floor Garbage Point Plan

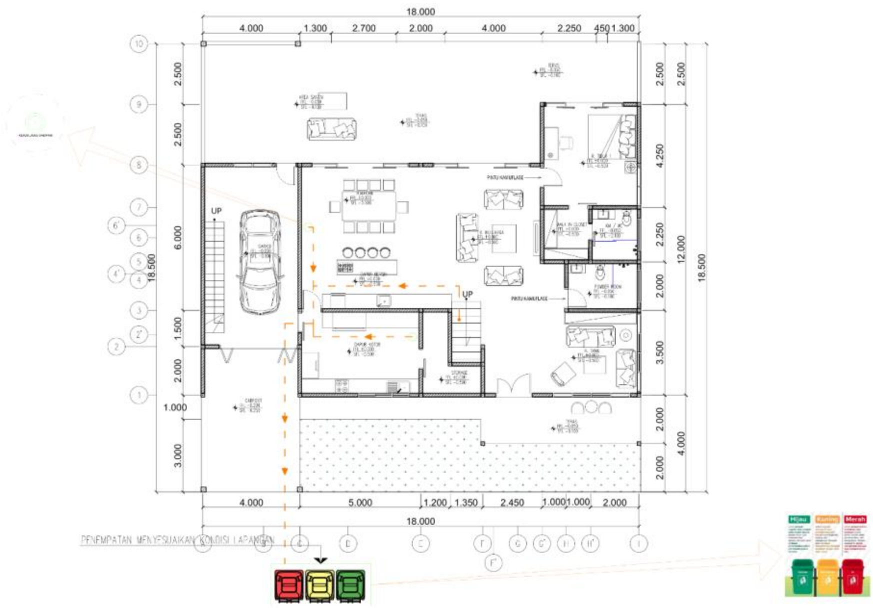

Figure 16. Plan of Evacuation Waste Point 1st Floor.
Source : Data Analysis.

The core of the design: garbage collection points on each floor.
Support for sustainability, namely integrated collection facilities, enables the implementation of 3Rs (reduce, reuse, recycle) and reduce waste to landfills. Without management, this point becomes a source of odor/disease vector.
Measurable indicators: ratio of sorted waste (%), transportation frequency, distance of point to main gathering area (m).
Technical recommendation: provide sorting facilities (organic/inorganic) with sealable compactors or separate containers; integrate composting programs for organic waste; arrange transportation schedules and education of residents; Place the garbage point away from public ventilation/spaces.

16. 2nd Floor Garbage Point Plan

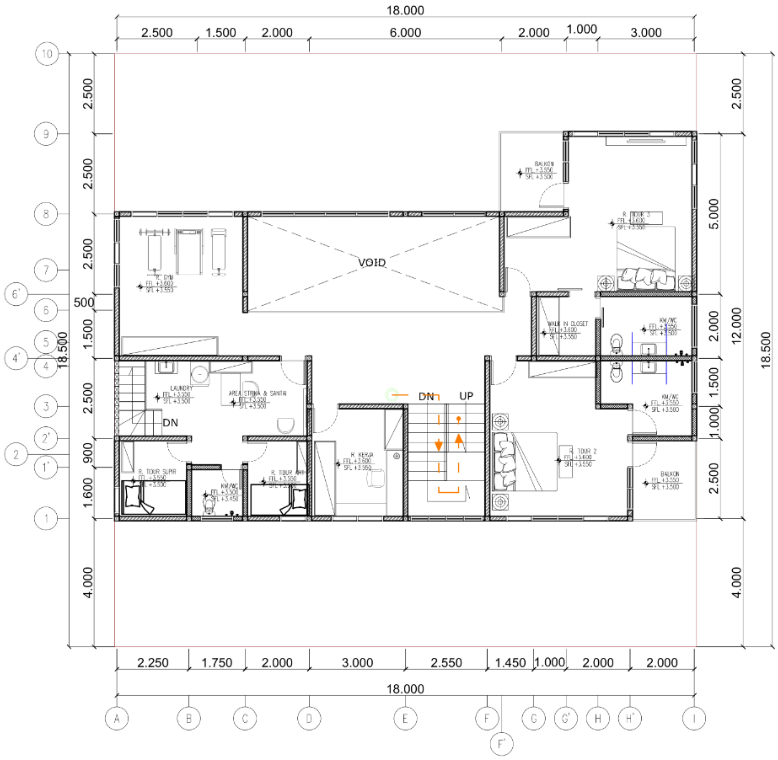

Figure 12. Plan of the 2nd Floor Evacuation Waste Point.
Source : Data Analysis.

The core of the design: garbage collection points on each floor.
Support for sustainability, namely integrated collection facilities, enables the implementation of 3Rs (reduce, reuse, recycle) and reduce waste to landfills. Without management, this point becomes a source of odor/disease vector.
Measurable indicators: ratio of sorted waste (%), transportation frequency, distance of point to main gathering area (m).
Technical recommendation: provide sorting facilities (organic/inorganic) with sealable compactors or separate containers; integrate composting programs for organic waste; arrange transportation schedules and education of residents; Place the garbage point away from public ventilation/spaces.

CONCLUSION

The conclusions of this study confirm that the application of a series of design strategies—which include the use of dense tree guardrails, mass placement of buildings back from the road, integration of evapotranspiratory vegetation, utilization of internal void space, orientation that is in harmony with the dominant Southeast–Northwest wind pattern, and the use of passive devices such as canopies/tritisans—are collectively able to form modern dwellings with Balinese architecture that are more sustainable both in terms of ecological, functional, and social. Ecologically, a fairly wide band of vegetation at the edge of the plot and around the fence not only serves as an effective noise reducer but also lowers the micro-environmental temperature through evaporation and shading, thereby reducing the need for mechanical cooling and lowering the energy footprint of the building; but its effectiveness depends on the selection of local species that are climate-hardy, the depth of vegetation is minimal (e.g. 3–5 m on the main façade), and the planting pattern that favors habitat continuity.

From a spatial perspective, placing the mass of the house further away from the traffic corridor reduces exposure to noise and direct pollution, improves indoor air quality, and makes room for surface permeability—a step that should be complemented by technical provisions on boundary spacing and compensation mechanisms when future road widening is required. The use of voids and orientations that take into account the dominant air circulation reinforces the passive ventilation strategy: voids designed to create the effect of chimneys and openings that accommodate cross ventilation can lower indoor temperatures and improve indoor air quality without sacrificing thermal comfort, provided that the dimensions and opening ratios are calculated based on a simple CFD analysis and the functional needs of the room.

Regarding the control of solar radiation, the addition of a canopy or tritisan calculated according to the sun's trajectory is effective in reducing the direct heat acquisition of the façade and at the same time maintaining natural lighting — the use of gordyns or thermal curtains is only recommended as a complementary solution that depends on the behavior of the occupants; The best solution is to remain passive shading that does not require user intervention. On the infrastructure front, drainage planning that relies solely on rapid discharge into public sewers needs to be revised towards a hybrid approach that prioritizes retention and infiltration — infiltration wells, bioswales, and permeable paving in access areas will reduce peak runoff volumes and increase groundwater replenishment, rather than simply draining water into sewers without treatment.

For mobility and parking lot management, an integrated private parking design should be combined with the use of permeable paving, bicycle parking facilities, and the readiness of its infrastructure for electric vehicles to reduce long-term emissions; At the same time, efficient vehicle circulation will reduce emissions from maneuvers and facilitate emergency access. The emphasis on fire engine access and evacuation routes emphasizes the dimensions of resilience and safety in sustainability: a design that provides a wide path, hydrants, and unobstructed access points that not only meet safety requirements but also maintain the continuity of environmental functions in the event of an incident.

However, it is important to note that many of these recommendations are still at the conceptual level and require technical specifications—e.g. canopy depth, reflectance values of roofing materials, infiltration well capacity (m^3), vegetation size and planting distance, and drainage capacity (L/s)—which must be defined, modeled, and tested at the detailed design stage in order for sustainability impacts to be measured and optimized. Thus, a commitment to the integration of these principles—along with measurable monitoring mechanisms (dB measurements, interior temperature, ACH, runoff discharge, percentage of permeable area, and segregated waste ratio)—will transform the design concept into a standardized practice that is able to preserve Bali's architectural heritage while meeting the environmental, social, and economic goals of truly sustainable modern housing.

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