RESILIENT AND BIOCLIMATIC DESIGN STRATEGIES IN BALINESE ARCHITECTURE FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT

Balinese architecture reflects a harmonious integration between local wisdom, ecological adaptation, and cultural resilience. This paper explores how traditional and contemporary Balinese architectural approaches utilize bioclimatic design strategies to address challenges of sustainable development in the context of Bali. Key principles such as building orientation, natural ventilation, material selection, and spatial zoning—rooted in Tri Hita Karana and Asta Kosala-Kosali philosophies—not only ensure thermal comfort and energy efficiency but also strengthen the local identity and resilience of Balinese communities. Through multidisciplinary analysis, the study highlights the adaptation of vernacular techniques with modern innovations, demonstrating how resilient and bioclimatic architecture contributes significantly to several Sustainable Development Goals (SDGs), including climate action, sustainable cities, and cultural preservation. This approach offers a valuable model for regions facing rapid urbanization and environmental changes, affirming that sustainable architecture must embrace both tradition and innovation to achieve long-term resilience and ecological harmony.

Keywords: *balinese architecture, bioclimatic design, local wisdom, resilience, sustainable development*

1. INTRODUCTION

Balinese architecture represents a unique intersection of culture, ecology, and spirituality—an enduring manifestation of environmental adaptation and cultural continuity that has evolved over centuries. Rooted deeply in local wisdom, particularly the Tri Hita Karana and Asta Kosala-Kosali philosophies, Balinese architecture emphasizes harmony between humans, nature, and the divine. These philosophical foundations inform spatial organization, material selection, and climatic responsiveness, leading to architecture that not only meets human needs but also sustains ecological balance and spiritual meaning. (Aryani and Tanuwidjaja, 2013; Senjaya and Sudarwani, 2025)

In the context of architectural theory, Balinese design can be understood as a vernacular response to its tropical environment. Scholars such as Oliver (1997) argue that vernacular architecture emerges as an adaptive system to local ecological and cultural contexts, shaping design features such as orientation, openness, and material use to enhance thermal comfort, energy efficiency, and spatial harmony. For instance, traditional Balinese structures like the *bale* are

typically designed with open layouts, elevated floors, and steeply sloped roofs, which optimize natural ventilation and shading—key bioclimatic principles for maintaining indoor comfort in humid climates. These strategies not only respond to climatic demands but also embody a symbolic expression of social hierarchy and spiritual balance, aligning architecture with cosmological beliefs intrinsic to Balinese identity (Aryani and Tanuwidjaja, 2013; Senjaya and Sudarwani, 2025).

Recent academic literature underscores the growing relevance of traditional Balinese architectural methods within the sustainability discourse. In modern development contexts, the integration of traditional design wisdom with contemporary innovations—such as passive cooling systems, green materials, and digital design tools—has emerged as a model for resilient and sustainable architecture. This reflects the principles of bioclimatic design identified by Victor Olgyay, which advocate for building forms that adapt to their immediate environmental context, using natural airflow, sunlight, and thermal mass to minimize reliance on mechanical systems. Applying these principles in Balinese architectural design has proven to create thermally comfortable and energy-efficient spaces while preserving cultural identity and environmental ethics. (Aryani and Tanuwidjaja, 2013; Dewi et al., 2025; Dwijendra et al., 2025; Senjaya and Sudarwani, 2025)

Moreover, the rapid urbanization of Bali and the pressures of global tourism have amplified the necessity for sustainable architectural practices that balance modernization with cultural preservation. Studies demonstrate that adopting climate-responsive design and local materials, such as bamboo, timber, and natural stone, significantly reduces environmental impact while promoting cultural resilience. These findings align with the broader goals of the United Nations Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 15 (Life on Land), as they emphasize sustainable resource management, heritage conservation, and adaptive resilience in architectural development. (Aryani and Tanuwidjaja, 2013; Dewi et al., 2025; Dwijendra et al., 2025)

Thus, exploring resilient and bioclimatic design strategies in Balinese architecture provides valuable insight into how indigenous knowledge systems can inform contemporary sustainable design practices. The adaptive principles embedded in Balinese architecture—through its holistic integration of ecology, spirituality, and technology—offer a replicable framework for sustainable design not only in tropical regions but also within global efforts to mitigate climate change while preserving cultural uniqueness.(Aryani and Tanuwidjaja, 2013; Dewi et al., 2025; Dwijendra et al., 2025)

2. RESEARCH METODOLOGY

This study employs a qualitative phenomenological approach to identify resilient and bioclimatic design strategies embedded within traditional Balinese architecture as exemplified in the Bayung Gede Traditional Village, Kintamani, Bangli. The overarching aim of this methodology is to systematically interpret traditional ecological wisdom and spatial resilience found in Bayung Gede’s built environment, and to extract architectural principles applicable to contemporary sustainable design.

The methodological framework is grounded in Edmund Husserl’s phenomenology, as applied in existing local theory development from prior Bayung Gede research. This paradigm emphasizes understanding architectural phenomena through the lived experiences and consciousness of the local community. The analysis follows three sequential processes—empirical reduction, eidetic reduction, and

transcendental reduction—to uncover deep structural meaning and conceptual essence within Bayung Gede's spatial organization.

This framework allows interpretation of tangible (sekala) and intangible (niskala) elements of the built environment, integrating spiritual, ecological, and social dimensions of resilience. The combination of these levels enables a holistic understanding of how architectural practices sustain equilibrium between tradition and environmental adaptation.

Historical and cultural documentation, such as the Bayung Gede monograph and academic architectural texts, were analyzed to identify traditional site planning, cosmology (Kaja–Kelod and Kangin–Kauh axes), and building typologies. This includes the analysis of layout systems based on *Tri Mandala*, *Sanga Mandala*, *Tri Angga*, and the syncretic local concept *Dwitya A Tunggil*—representing dual yet unified spatial harmony.

Field research examined spatial orientation, material use, and thermal behavior of traditional buildings (e.g., *Paon*, *Bale Pegaman*, *Jineng*, *Sanggah*). Documentation involved mapping airflow patterns, humidity levels, and solar exposure to infer the bioclimatic functions embedded in vernacular design, especially for humidity control and passive cooling in a tropical highland climate.

The analytical framework synthesizes traditional ecological and spatial knowledge using a multi-layered thematic analysis:

- Spatial-Ecological Analysis: Understanding climate-responsive strategies within dwellings and communal layouts—such as airflow orientation, vegetative shading, and positioning of sacred and profane zones.
- Cultural-Phenomenological Analysis: Interpreting how symbolic dualities (e.g., *Hulu–Teben*, *Sekala–Niskala*, *Sunia–Patala*) correspond to spatial and environmental order.
- Resilience and Adaptation Analysis: Identifying architectural features that enhance durability, renewability, and adaptability to climatic shifts—evaluating structures that balance protection from rainfall, optimal ventilation, and communal flexibility.

Thematic coding of spatial data isolates core principles forming the theoretical base of resilient bioclimatic design, such as:

(1) Dwitya A Tunggil — dual harmony of ecological and spiritual balance;
(2) Jaga Baya Sekala lan Niskala — resilience through tangible and intangible protection;
(3) Nemu Gelang Paumahan lan Wewengkon — circular ecological continuity across settlement and territory;
(4) Hulu lan Teben Karang Umah — elevation-based hydrological adaptation.

By interpreting the Bayung Gede traditional layout through both phenomenological and ecological lenses, the research identifies transferable strategies for modern architectural contexts. Cultural balancing mechanisms, climatic zoning, and local resource utilization serve as prototypes for sustainable, context-driven contemporary architecture. The resilient logic found in Bayung Gede—where water flow, ventilation, and community interaction construct a living environmental system—provides valuable guidance for integrating vernacular intelligence with technological innovation to meet current sustainability goals.

3. LITERATUR REVIEW

The conceptualization of resilience and bioclimatic design in traditional Balinese architecture derives from a convergence of indigenous spatial order, ecological intelligence, and cosmological worldview. The literature demonstrates that Balinese architecture—particularly in traditional villages such as Bayung Gede, Tenganan, and Kedonganan—constitutes an integrated environmental system combining climate-responsive construction, material conservation, and social sustainability. This section critically synthesizes relevant theories, field-based studies, and heritage frameworks to establish a multidisciplinary foundation for understanding adaptive and sustainable design strategies.

a. Traditional Architecture as a Model of Resilience

Balinese vernacular architecture serves as a microcosm of resilience, where spatial composition expresses interdependence between human, ecological, and spiritual dimensions. Dwijendra (2020) and Muliawan (2017) underscore the resilience of the Undagi tradition, wherein master builders sustain continuity in knowledge transfer and construction practices despite modernization pressures. Similarly, Aryani (2013) explains that the Tri Mandala zoning system promotes environmental adaptation by ensuring cross ventilation, natural lighting, and spatial separation that minimizes health risks while maintaining ritual order (Aryani and Tanuwidjaja, 2013).

In Bayung Gede, as discussed in Vianthi & Putra (2021), the settlement pattern follows the Tri Angga (head–body–legs) logic, symbolizing hierarchical harmony between sacred, communal, and profane spaces. The village structure configures climate-sensitive architecture where the upper zone (*Hulu*) receives spiritual functions, the middle zone houses residences, and the lower zone serves as agricultural and waterflow space—indicating a spatial metabolism parallel to natural biophysical cycles (Suastika et al., 2019; Vianthi and Putra, 2022).

Moreover, resilience manifests socially and ecologically through ritualized land management and adaptability to changing socio-environmental contexts. Mahastuti (2019) described the Hulu–Teben system in Bayung Gede as a spatial order dictating both environmental flow and cultural hierarchy, providing equilibrium between sacred orientation and practical hydrological management. This dual logic—cosmic and ecological—is what makes Balinese villages living laboratories of environmental adaptation within cultural frameworks (Mahastuti et al., 2019).

b. Bioclimatic Design Principles and Local Wisdom

Bioclimatic design theory, as developed by Victor Olgyay (1963), emphasizes designing buildings in harmony with natural climate forces—utilizing sun orientation, airflow, thermal mass, and vegetation to reduce reliance on artificial energy sources. In the Balinese context, this principle naturally aligns with traditional design practices. Rahmadiah (2019) integrates bioclimatic architecture and local wisdom, showing how elements such as open pavilions, thatched roofing, and spatial zoning enhance thermal comfort and microclimatic balance (Rahmadiah, 2019; Senjaya and Sudarwani, 2025).

The bioclimatic dimension of Balinese houses extends beyond comfort to embody ethical environmental interaction. In Kedonganan, the *Tri Hita Karana* philosophy—emphasizing harmony among humans, nature, and God—continues to shape spatial practices, material use, and community cooperation in environmental management. The same principle guides contemporary sustainability frameworks, such as the *Tri Hita Karana Sustainable Development Forum (2025)*, which aligns Balinese heritage with the UN Sustainable Development Goals (SDGs),

demonstrating how cultural ecology can formalize sustainable design policies (Mildawani et al., 2024).

In Bayung Gede, the combination of open courtyard systems (natah), cross-ventilation, and vegetation layers functions as a passive cooling mechanism consistent with bioclimatic parameters. The village's highland topography enhances airflow orientation, contributing to its natural microclimate regulation. Vianthi (2022) identifies these features as physical components distinguishing Bayung Gede's architecture from coastal villages, marking it as a unique example of resonant spatial ecology (Vianthi and Putra, 2022).

c. Cultural Resilience and Architectural Continuity

Resilience in Balinese architecture is not limited to material form but sustained through the cultural code of Undagi craftsmanship. Traditional builders serve as cultural mediators, embodying an epistemology of environmental ethics and ritual order. The study of Undagi's role reveals challenges in intergenerational knowledge transfer, yet also underscores its continued contribution to sustainable architecture through syncretic modernization processes(Dwijendra and Adhika, 2022).

Moreover, the integration of biophilic principles—as introduced by Artha (2022)—further expands the dialogue between traditional and modern contexts. Biophilic design reinforces human–nature connection, enhancing health and well-being while preserving traditional spatial syntax. This approach situates traditional Balinese architecture within the global discourse of eco-humanistic design, promoting continuity between heritage and emergent ecological science (Artha et al., 2022)

The *Bayung Gede research corpus* reaffirm that the village's design encapsulates a "living resilience," where ancestral cosmology becomes an ecological algorithm that informs layout, material choice, and symbolic hierarchy. The continued presence of rituals such as placenta burial ceremonies, bamboo forest conservation, and the spatial practice of *Tri Angga–Tri Hita Karana* reflects the dynamic equilibrium of socio-spiritual and climatic adaptation (Suastika et al., 2019; Vianthi and Putra, 2022).

d. Integrating Vernacular Knowledge into Contemporary Practice

Contemporary architectural discourse increasingly recognizes the value of vernacular strategies as adaptive models for urban resilience. Vianthi & Putra (2021) proposed that Bayung Gede's morphological order—a tri-layered zoning model and communal governance—provides structural metaphors for sustainable tourism and eco-architecture (Vianthi and Putra, 2022). Mamou-Mani's *Tri Hita Karana Tower* (2024), an AI-assisted bamboo-rattan structure, exemplifies such translation of local philosophical principles into modern technological expression, signifying the global relevance of Balinese design ethics (Sunil, 2024)

Integrating these vernacular systems into modern architecture aligns with the circular economy paradigm, emphasizing renewable materials and low-energy design. Collaboration between traditional communities and architects, as seen in several eco-projects in Bali and Java, fosters a **hybrid architectural model**—one that honors cultural heritage while addressing pressing sustainability issues such as climate change mitigation and carbon neutrality (Salain et al., 2025).

e. Summary of Theoretical Insights

The literature collectively outlines three fundamental intersections relevant to this study:

1) Resilience – Defined by continuous adaptation of spatial and social structures through cosmological order (*Tri Mandala*, *Hulu–Teben*, *Dwitya A Tunggil*) and social cohesion rooted in customs and rituals.
2) Bioclimatic Responsiveness – Achieved through passive environmental design, thermal regulation, and material efficiency embedded within traditional practices.
3) Translatability to Contemporary Architecture – The integration of traditional ecologies and modern technological innovation offers a replicable framework for resilient tropical design.

Together, these frameworks illuminate that traditional Balinese architecture—particularly in Bayung Gede—is not a fossilized heritage but a dynamic environmental system. Its embedded knowledge provides valuable parameters for designing context-driven, culturally aligned, and climate-resilient

4. RESULTS AND DISCUSSION

A. Identification of Resilient Strategies in Bayung Gede Traditional Architecture

Bayung Gede represents one of Bali's most distinctive traditional villages where resilience is deeply embedded in its architecture, spatial logic, and cultural practices. The identification of resilient strategies in this context requires analyzing several core dimensions: spatial organization, material choice, environmental adaptation, and socio-cultural norms.

1) Spatial and Organizational Resilience

Bayung Gede implements a zoning system consisting of macro (village territory), meso (settlement cluster), and micro (compound/home) scales. At the macro level, the village is characterized by the Tri Angga concept—mirroring the hierarchical division of head, body, and foot, where the central temple zone (*utama mandala*) is surrounded by residential layers (*madya mandala*) and bordered by agricultural and cemetery zones (*nista mandala*). This spatial composition is not only symbolic but provides practical resilience against environmental threats and external pressures (Suastika et al., 2019; Vianthi and Putra, 2022).

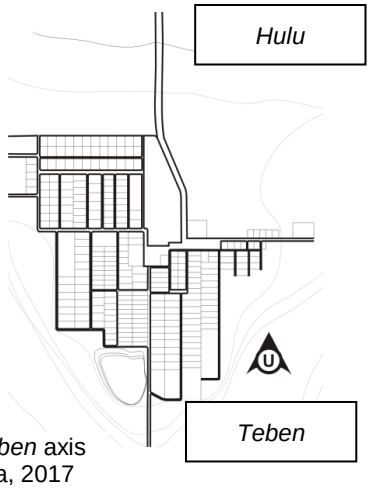

Figure 1 *Hulu-Teben* axis
Source: Adiputra, 2017

The unique application of the Hulu–Teben axis (center–periphery), which prioritizes the center as the most sacred and gradually transitions to profane and functional spaces outward, further strengthens spatial resilience by structuring security, access, and climate responsiveness, and minimizing vulnerability (Adiputra et al., 2019; Suastika et al., 2019)

2) Material and Structural Adaptation

Bayung Gede's architecture relies on locally sourced, renewable materials such as bamboo, timber, and stone. The use of bamboo is especially prominent in kitchens (*paon*) and ceremonial buildings due to local beliefs about its spiritual and protective qualities, as well as its bioclimatic advantages for airflow, humidity mitigation, and thermal performance. Bamboo forests are conserved as a communal resource, insuring a sustainable supply, supporting erosion control, and strengthening community rituals tied to both ecological and spiritual cycles.
Structural layouts integrate open plans, courtyards (*natah*), and vegetative buffers, which maximize passive cooling and natural lighting, providing both environmental comfort and energy efficiency. The building orientation and placement are optimized for prevailing wind flow and solar path, reflecting a vernacular understanding of site-specific bioclimatic adaptation.

Figure 2 Passive cooling and natural lighting through natah
Source: Adiputra, 2017

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3) Ritual, Social, and Governance Mechanisms

The role of *Undagi* (traditional master builders) and communal governance are critical for maintaining architectural resilience and perpetuating local wisdom. Regulations around building techniques, gate and wall design, and community-wide rituals—such as the unique placenta burial practice—reinforce hygiene, social control, and symbolic protection, fostering a sense of collective ownership and stewardship of the built environment. Social cohesion is deepened through mutual cooperation (gotong royong), regulation of material use, and preservation of the

custom house and communal forest, all of which contribute to ongoing resilience and identity maintenance (Dwijendra and Adhika, 2022; Pratiwi and Wikantiyoso, 2022).

4) Hydrological and Environmental Management

Hydrological resilience is evident in the orientation of pathways and building zones to optimize water drainage and safeguard against erosion. The bamboo forest, besides cultural and material significance, functions as a landscape buffer, while the layout of agricultural zones connects ecological cycles directly to the built environment. Conservation practices and ritual regulation of forest use help stabilize microclimates, reinforce water management strategies, and conserve biodiversity in the village territory.

B. Bioclimatic Design Principles in Bayung Gede

Bayung Gede Village provides a rich example of how bioclimatic strategies are inherently woven into traditional Balinese architecture and settlement design. These principles address climatic adaptation, resource efficiency, comfort, and sustainability using vernacular wisdom and locally available materials.

1) Settlement Orientation and Zoning

The settlement layout in Bayung Gede is governed by cosmological and environmental logic, notably the Hulu–Teben (mountain–sea) axis and Tri Mandala or zonal hierarchy. Houses are oriented to maximize cross-ventilation, take advantage of prevailing wind, and avoid direct sun exposure during peak hours, promoting passive cooling and reducing heat gain in interior spaces. Spatial zoning divides areas into sacred, communal, and profane, aligning environmental control with ritual functions and microclimate creation.

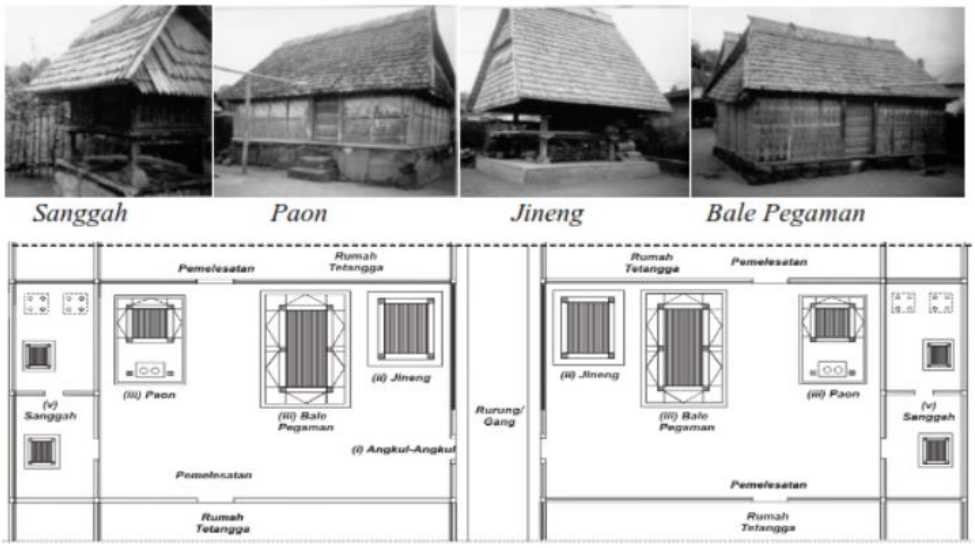

Figure 3 Settlement orientation and zoning
Source: Adiputra, 2017

2) Passive Cooling and Ventilation Systems

Traditional houses utilize features such as *natah* (courtyards) and open-sided pavilions (bale), enhancing airflow and facilitating thermal dissipation. Ventilation

gaps, elevated flooring, and minimal internal partitions allow air movement through living spaces, preventing humidity buildup and maintaining comfort without mechanical intervention. Large roof overhangs and vegetation buffers help shade walls and windows, further reducing solar heat gain.

3) Material Selection and Thermal Performance

Construction in Bayung Gede prioritizes locally sourced, renewable materials—bamboo, timber, and volcanic stone. Bamboo is frequently used for its ability to facilitate airflow, as well as its rapid renewability and carbon sequestration properties. Thatch or palm-leaf roofing provides excellent insulation and breathability, with steep pitches to shed rainwater efficiently and minimize overheating. Walls constructed of wood and permeable panels enable further climatic adaptation by balancing insulation and air flow.

4) Vegetation and Landscape Integration

The use of landscape elements such as communal bamboo forests, shading trees, and layered planting integrates architecture with natural surroundings. Vegetative buffers around house compounds reduce reflected heat, store moisture, and enhance microclimate comfort. Courtyards may include water features or ground cover, aiding evaporative cooling and further regulating temperature.

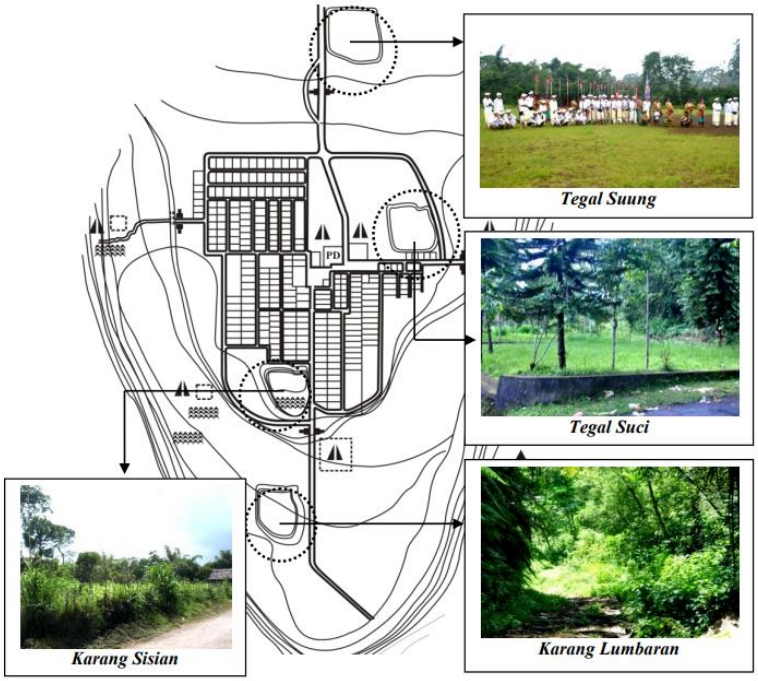

Figure 4 Vegetation and landscape surrounding the village
Source: Adiputra, 2017

5) Water Management and Adaptation

Bayung Gede's hydrological logic aligns settlement and building placement with drainage and water conservation patterns. Roofs channel rainwater away from compounds, village pathways follow natural contours to minimize erosion, and home gardens utilize runoff or stored water for irrigation—demonstrating resource-sensitive design embedded in daily practice.

C. Comparative Adaptation: Traditional vs Contemporary Contexts

The evolution of Balinese architecture from its traditional roots toward contemporary adaptation is marked by a dynamic interplay between preservation of essential cultural values and the integration of new technologies, materials, and spatial needs.

1) Preservation and Transformation of Core Principles

Traditional architecture in Bayung Gede features distinct zoning, orientation (Tri Angga, Tri Mandala, Hulu–Teben), use of natural materials, passive cooling, and strong ritual components. Contemporary Balinese architecture retains many of these principles but often adapts them through open floor plans, integration of minimalist styles, and flexible zoning to meet modern lifestyles, while still preserving spiritual and ecological values.

2) Hybrid Architectural Approaches

Modern villas, resorts, and public buildings in Bali increasingly adopt a hybrid style that fuses local identity and craftsmanship—from carved gateways and bamboo details to the use of indigenous spatial concepts—with global design trends and technologies. Materials such as bamboo, timber, and stone remain central but are now combined with reinforced concrete, glass, and metal for durability, seismic safety, and design innovation. Zoning logic inspired by traditional hierarchy (head–body–foot, sacred–profane–functional) is modernized in villa compounds for privacy, comfort, and aesthetic appeal.

3) Bioclimatic Strategies: Past and Present

Contemporary buildings continue deploying bioclimatic strategies inherent in Bayung Gede architecture: maximizing cross-ventilation, shading through overhangs and landscape, use of courtyards, and orientation strategies. Passive cooling, natural lighting, rainwater harvesting, and renewable energy technologies such as solar panels reflect both continuity and advancement in sustainable design. However, increased commercial development and density pose challenges for microclimate management and preservation of communal green buffers.

4) Ritual Adaptation and Cultural Integrity

While traditional rituals and social regulations remain foundational for local communities, contemporary spaces often reframe ritual zones for hospitality, wellness, and cultural tourism programs. The adaptation or commercial reinterpretation of sacred spaces requires careful balancing to avoid loss of cultural authenticity and dilution of social resilience. Some developers and architects collaborate with local Undagi to fuse ritual and contemporary needs in new settings, preserving essential spiritual values within modern developments.

D. Synthesis and Implications for Sustainable Design

The cumulative findings from the Bayung Gede case study indicate that resilient and bioclimatic principles in traditional Balinese architecture hold significant implications for contemporary sustainable design, policy, and community development.

1) Adaptive Strategies for Climate and Culture

Traditional spatial logic (Tri Angga, Tri Mandala, Hulu–Teben) and building orientation in Bayung Gede maximize passive cooling, natural lighting, and

resource efficiency, providing context-driven frameworks for modern energy-conscious design. The integration of open courtyards, strategic zoning, and landscape elements demonstrates how climate-responsive adaptation is harmonized with ritual, social, and ecological needs.

The use of local materials (bamboo, timber, stone) maintains low embodied energy, supports circular resource cycles, and anchors contemporary projects in place-based aesthetics and sustainability. Neo-vernacular approaches—melding modern technologies and building standards with indigenous design principles—enabled ongoing experimentation and innovation without sacrificing heritage values.

2) Heritage Preservation, Tourism, and Community-Based Development

The preservation of vernacular architecture, especially under social and economic pressures from modernization and tourism, requires adaptive regulation, incentives, and education. Bayung Gede's transformation into a tourism village leverages its unique settlement layout, special interest tourism (ritual, culture, agro-tourism), and community-managed branding as drivers for sustainable local development.

Special interest tourism, which values novelty, cultural learning, and experiential rewards, can promote sustainable revenue streams while raising awareness for traditional architectural preservation. However, strong local governance (customary law, awig-awig) and collaborative partnerships are essential for ensuring authenticity and mitigating negative commodification of heritage.

3) Sustainability Policy and Education

For lasting resilience, policy frameworks must support mixed material strategies, encourage the use of local resources, and provide incentives for conservation and community engagement. Education and capacity building—both among villagers and the broader public—are vital for transferring traditional knowledge, fostering creative adaptation, and upholding socio-cultural resilience in changing contexts.

The lessons from Bayung Gede illustrate that sustainable design is best achieved through dialogical processes—merging past wisdom with present needs and future visions—where local, cultural, and ecological logics are given equivalent priority.

4) Transferability and Future Research

Bayung Gede’s adaptive strategies, zoning logic, material utilization, and communal management offer transferable models for other tropical vernacular and modern settings. Further research is recommended in areas such as optimizing hybrid construction methods, monitoring long-term environmental performance, and evaluating the socio-economic impacts of tourism on tradition and design.

Efforts to brand, document, and regulate sustainable architecture must continually involve local stakeholders to maintain core values and responsiveness to local change.

5. CONCLUSION

The findings from the case study of Bayung Gede, supported by broader literature on traditional Balinese architecture, underscore that resilience and bioclimatic adaptation are deeply integrated within indigenous spatial, material, and socio-cultural practices. Spatial organization based on cosmological axes (Tri Angga, Tri

Mandala, Hulu–Teben) and ritual zoning ensures optimal orientation, climate responsiveness, and environmental harmony, while communal regulatory frameworks and mutual cooperation (gotong royong) strengthen both social and ecological resilience.

Traditional material choices—bamboo, timber, stone—and passive cooling strategies such as natah courtyards and open pavilion layouts further illustrate the adaptive intelligence of vernacular construction, supporting thermal comfort and energy efficiency. The role of undagi (master builder) and transmission of ritual knowledge maintain the integrity, adaptability, and renewal of local design traditions.

Comparatively, contemporary applications of Bayung Gede's principles in modern Bali demonstrate that these strategies can be hybridized with new technologies and materials, as long as core ethical, cultural, and environmental logics are respected. The critical implication for sustainable design is that context-specific and culturally-rooted approaches—those that valorize local wisdom, environmental ethics, and community engagement—are most effective for realizing resilient architecture in the face of climate and social change.

Ultimately, the study confirms that traditional Balinese architecture embodies a dynamic and living heritage of resilience, providing replicable models for sustainable architecture and policy, both within Bali and in other tropical settings. Continued research, policy support, and educational efforts are essential to safeguard and creatively adapt these principles for future generations.

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