

BAMBOO ARCHITECTURE IN BALI: A MULTIDISCIPLINARY PATHWAY TOWARD SUSTAINABLE TOURISM AND SDGs

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ABSTRACT

This research examines bamboo architecture in Bali as a multidisciplinary approach to sustainable tourism and SDG achievement. Through qualitative analysis of Green School Bali, Green Village, and Penglipuran Bamboo Forest, the study investigates how bamboo construction integrates traditional wisdom with modern sustainability principles. Findings demonstrate that bamboo architecture significantly contributes to SDG 8, 11, 12, and 13 through green job creation, carbon emission reduction, and community empowerment. Cross-disciplinary collaboration among architects, engineers, and local communities enables effective sustainable tourism development. This study provides a replicable model for community-based sustainable architecture that balances economic growth, environmental preservation, and cultural heritage conservation globally.

Keywords: bamboo architecture, multidisciplinary approach, SDGs, sustainable tourism

1. INTRODUCTION

Sustainable tourism has become a global priority in efforts to achieve the Sustainable Development Goals (SDGs), particularly in tourist destinations facing intensive environmental and social pressures such as Bali (UNWTO & UNDP, 2018). As an island with a high economic dependence on the tourism sector, Bali faces complex challenges in balancing economic growth with environmental and local cultural preservation (World Bank, 2022). Data shows that the tourism sector in Bali contributed 20.8% of Indonesia's total national tourism investment in the first semester of 2025. However, this growth also presents serious problems such as environmental degradation, social inequality, and cultural erosion (Antara News, 2025; Putra, 2020).

The growth of mass tourism in Bali has created various negative impacts that threaten long-term well-being. The tourism sector, which consumes up to 65% of Bali's total water supply, causes water shortages for local communities and drought during dry conditions (Cole, 2012). Waste production reached 4,281 tons per day in 2021, with 11% consisting of plastic waste causing serious environmental pollution (BPS Provinsi Bali, 2023). Furthermore, the conversion of agricultural land for tourism infrastructure development reaches 1,000 hectares per year, threatening food security and ecological balance (Suryawan, 2022). From a socio-cultural perspective, the commercialization of Balinese culture for tourism purposes has led to the dilution of traditional practices and the transformation of spiritual values into mere entertainment (Putra, 2020). Property price increases of up to 30% have made housing no longer affordable for local communities, while economic inequality

continues to widen as most tourism profits flow to large corporations and outside investors (Center for Sustainable Development, Udayana University, 2023).

Amid these challenges, bamboo architecture emerges as an innovative approach capable of integrating Balinese traditional values with sustainable development principles. Bamboo has superior characteristics as a sustainable construction material: extremely rapid growth (can reach one meter per day), higher tensile strength than wood, and a strength-to-weight ratio 3-4 times greater than steel (FAO, 2021). Moreover, bamboo can absorb up to 35% more CO₂ compared to other tree species with equivalent biomass, making it a strategic material for carbon sequestration (Iswanto, 2017). Traditionally, bamboo has been an integral part of Bali Aga architecture, such as in Tenganan and Pedawa villages, where traditional houses are built with Tri Mandala principles to support functionality, thermal comfort, and social continuity (Putra, 2020). The application of Tri Hita Karana philosophy in traditional architecture creates harmony between humans, nature, and God, aligning with sustainable development principles (Suryawan, 2022).

Modern bamboo processing technology developments have overcome the weaknesses of this traditional material. Green School Bali, founded by the Hardy family in 2006, became a pioneer of contemporary bamboo architecture with more than 50 structures demonstrating bamboo's potential as a sustainable construction material (Hardy, Hardy, & Hardy, 2013). Preservation technology using boron has increased bamboo's durability to a lifetime (FAO, 2021). The IBUKU architecture studio has also developed more than 60 bamboo structures in Bali, such as Green Village, Sharma Springs, and Bambu Indah Eco Resort, which have gained international recognition as models of sustainable development (IBUKU, 2024).

Although the potential of bamboo architecture has been proven, research integrating bamboo architecture with sustainability and SDG achievement remains limited. Most studies still focus on technical aspects of construction or the economic impacts of tourism separately, without examining the multidisciplinary synergy between architecture, culture, community, and economy (Gössling, Scott, & Hall, 2020). This limitation highlights the need for a cross-disciplinary approach to understand the complex interactions between sustainable architecture, cultural preservation, community empowerment, and inclusive economic development (Center for Sustainable Development, Udayana University, 2023).

Bamboo architecture has great potential in supporting the achievement of various SDGs. In the context of SDG 8 (Decent Work and Economic Growth), the bamboo industry creates quality jobs while preserving local communities' traditional skills. SDG 11 (Sustainable Cities and Communities) can be achieved through the development of community-based environmentally friendly tourism infrastructure. SDG 12 (Responsible Consumption and Production) is realized through the utilization of renewable materials and circular construction. Within the framework of SDG 13 (Climate Action), bamboo can significantly reduce carbon emissions compared to concrete or steel (FAO, 2021). In addition, SDG 14 (Life Below Water) and SDG 15 (Life on Land) are also supported through the reduction of natural resource exploitation and conservation of local ecosystems (UN, 2023).

The urgency of this research is reinforced by post-pandemic conditions that demand the transformation of the tourism sector toward a more resilient and regenerative model. Bali is now at a crossroads between economic and ecological needs, where bamboo architecture has the potential to be a catalyst for this change (Gössling et al., 2020). The Indonesian government has demonstrated commitment to achieving 61.4% of SDG indicators, with sustainable tourism becoming a priority in the national development strategy (Bappenas, 2024). This research is directed to explore how bamboo architecture can become a multidisciplinary pathway for sustainable tourism

in Bali, considering technical, social, economic, cultural, and environmental dimensions in an integrated manner.

2. RESEARCH METODOLOGY

This research employs a qualitative descriptive approach focusing on understanding the meanings, values, and processes occurring in the phenomenon of bamboo use in Balinese architecture and its relevance to sustainable tourism development. The research design emphasizes in-depth exploration of various forms of bamboo architecture applications—including educational buildings such as Green School, accommodations such as Green Village Bali, and ecological tourism areas such as Penglipuran Bamboo Forest—to illustrate the contribution and cross-disciplinary relationships among architectural, environmental, economic, and socio-cultural aspects.

The research is conducted in Bali, with primary focus on three representative areas, including:

1. Green School Bali (Badung) – representation of innovation in education and sustainable bamboo architecture.
2. Green Village Bali (Abiansemal) – example of commercial-organic bamboo architecture supporting ecotourism.
3. Penglipuran Bamboo Forest (Bangli) – example of bamboo preservation and local community empowerment in ecotourism.

Research subjects include bamboo architects and designers (IBUKU Studio, Bamboo U), bamboo-based tourism managers, local communities, and tourists visiting the research sites. The types and sources of data used in this research are primary data and secondary data. Primary data are obtained through field observations and in-depth interviews with various informants such as architects, craftsmen, tourism managers, and local community leaders. Meanwhile, secondary data are sourced from literature reviews, policy reports, tourism development plan documents, and journal articles relevant to the themes of bamboo architecture and sustainability.

Data collection techniques in this research include conducting direct observations of bamboo buildings to examine aspects of form, structure, function, and their relationship with environmental and social contexts. Additionally, conducting semi-structured interviews with architecture practitioners, managers of Green School or Penglipuran Bamboo Forest, and local communities to explore their perspectives regarding the function, meaning, and impact of bamboo architecture implementation on sustainable development. Furthermore, conducting visual documentation such as photographs, site maps, and architectural drawings that record design elements and their integration with the local landscape.

Analysis techniques are carried out through stages of reduction, data presentation, and conclusion drawing/verification, following the interactive analysis model of Miles and Huberman. Data reduction is performed by sorting information from observation and interview results to identify key variables such as ecological, social, and economic functions of bamboo architecture. Next, data presentation is conducted by organizing field findings in the form of narrative descriptions and tables showing relationships among architectural forms, sustainability principles, and their contributions to SDGs. Then, drawing conclusions by interpreting data meanings to explain the multidisciplinary linkages of bamboo architecture with sustainable tourism development in Bali. Subsequently, data validity is achieved through triangulation techniques—including source triangulation (different informants), method triangulation (observation, interviews, documentation), and time triangulation (data collection at multiple occasions). Furthermore, data are

strengthened through member checking with informants and comparison with academic literature related to bamboo architecture practices in Bali.

The expected outcomes through this approach can produce in-depth understanding of how bamboo architecture in Bali becomes a medium of integration among ecological design, local cultural values, creative economy, and environmental education. Thus, the research results provide a conceptual foundation for developing sustainable tourism models based on bamboo architecture that align with the SDGs agenda.

3. RELATED RESEARCH/LITERATUR REVIEW

The literature review of this research focuses on the relationship among bamboo architecture, environmental sustainability, and the achievement of Sustainable Development Goals (SDGs). Previous studies indicate that bamboo is a construction material with great potential to support sustainable development due to its renewable nature, rapid growth, and high strength compared to wood or steel (FAO, 2021; Iswanto, 2017). In the Bali context, bamboo architecture has evolved from local tradition toward contemporary practice applied through projects such as Green School Bali, Green Village, and Bambu Indah Eco Resort (Hardy et al., 2013; IBUKU, 2024).

Socially, bamboo architecture is capable of maintaining the philosophical values of Tri Hita Karana and Tri Mandala in Balinese architectural planning that emphasize harmony among humans, nature, and God (Putra, 2020; Suryawan, 2022). The study by Gössling, Scott, and Hall (2020) highlights the importance of a multidisciplinary approach in the tourism sector, particularly in the post-pandemic context, to create more resilient, regenerative, and environmentally friendly tourism models. On the other hand, UNWTO and UNDP (2018) affirm that sustainable tourism is key to achieving many SDG indicators, especially SDG 8 (decent work), SDG 11 (sustainable cities), and SDG 13 (climate action).

A number of studies also emphasize the need for integration among architectural, social, economic, and cultural aspects so that bamboo architecture functions not only as a physical material but also as an instrument for local community empowerment and environmental preservation (Center for Sustainable Development, Udayana University, 2023). This cross-sectoral approach forms the conceptual foundation of this research on bamboo architecture in Bali as a multidisciplinary pathway toward sustainable tourism and SDGs.

4. RESULTS AND DISCUSSION

This research finds that bamboo architecture in Bali has successfully become an integrative model among local values, modern technology, and sustainability principles. Projects such as Green School Bali utilize more than 50 bamboo structures with open designs that maximize natural lighting and air circulation, thereby saving energy consumption by up to 70%. The same approach is also applied at Green Village Bali, which combines residential functions and ecotourism with an environmentally friendly organic architecture approach.



Figure 1. Green School and Bamboo Village

From a socio-cultural perspective, bamboo architecture plays a role in maintaining the continuity of Tri Hita Karana values as a representation of harmony among humans, nature, and local spirituality. Interviews with the community at Penglipuran Bamboo Forest demonstrate that the use of bamboo not only presents a distinctive architectural identity but also encourages community participation in the preservation of bamboo ecosystems that serve as village tourism assets. Furthermore, the bamboo industry increases employment opportunities for local craftsmen and strengthens the creative economy sector in alignment with SDG 8 (Decent Work and Economic Growth).

From an environmental perspective, observation results show that bamboo structures in Bali have a low carbon footprint and are capable of functioning as natural carbon sinks. This aligns with FAO (2021) data indicating that bamboo can absorb up to 35% more carbon dioxide compared to ordinary trees. This ecological advantage makes bamboo architecture a solution in supporting SDG 13 (Climate Action) through greenhouse gas emission reduction and low-carbon development.

Cross-disciplinary collaboration among architects, engineers, craftsmen, and academics is clearly evident in every project. For instance, IBUKU Design Studio collaborates with modern technology and organic design to enhance the structural strength of bamboo using boron coating techniques. These results demonstrate that cross-sectoral work is key to the success of bamboo innovation in sustainable architecture.

Specifically, this research also affirms the contribution of bamboo architecture to community-based sustainable tourism development. This approach enables tourists not only to enjoy the aesthetic beauty of architecture but also to learn about sustainability, nature conservation, and Balinese cultural values. In other words, bamboo architecture in Bali serves as a medium for ecological and cultural education that supports sustainable tourism strategies based on local community participation.

Integration of Tradition, Innovation, and Sustainability

Bamboo architecture in Bali cannot be separated from the Tri Hita Karana philosophy that emphasizes harmony among humans, nature, and God. The research finds that every bamboo building is designed by considering the Tri Mandala principle that divides space into three zones: utama mandala (sacred), madya mandala (middle), and nista mandala (profane). The use of bamboo in architectural structures reflects functional sustainability, social acceptance, and thermal comfort aligned with Balinese local wisdom.

Research results show that bamboo architecture in Bali is capable of integrating Balinese local wisdom, technological innovation, and sustainability principles. The application of bamboo as the primary material is evident in various architectural projects such as Green School, Green Village, and various eco-resorts. These

buildings demonstrate high energy efficiency, carbon emission reduction, and responsible utilization of natural resources.

Bamboo as a construction material offers superior characteristics: rapid growth, high tensile and compressive strength, and carbon absorption capacity exceeding ordinary timber trees. Modern processing and preservation techniques, such as the use of boron, have increased bamboo's durability, enabling its use for high-standard permanent buildings.

A case study at Green School Bali reveals that the Heart of Green School (HGS) building uses two main bamboo species: *Dendrocalamus asper* (petung bamboo) for structural columns due to high compressive strength, and *Gigantochloa apus* (tali bamboo) for beams, floor frames, and roofs due to its balanced flexural, tensile, and compressive strength. The structural system applies bamboo bending techniques and split bamboo lamination binding to reinforce the vertical core structure.



Figure 2. Green School

The Arc project at Green School represents the technical achievement of bamboo architecture with a 19-meter span and 14-meter height built from a series of intersecting bamboo arches with an anticlastic gridshell. This structure required 8 months of research and development with collaboration among IBUKU, German bamboo specialist Jörg Stamm, and structural engineering firm Atelier One. Construction used low-tech yet ingenious techniques without the assistance of heavy equipment or cranes.



Figure 3. Green School

Analysis of the application of sustainable architecture principles at Green School Bali using GREENSHIP Region indicators shows comprehensive implementation across seven categories of sustainable development. Buildings at Green School prioritize:

1. Energy conservation: the campus generates 90% of its energy from renewable sources through a combination of solar panels, Ayung River micro-hydro systems, and pedal power. Biobus uses waste cooking oil from local restaurants and hotels as fuel, addressing waste problems while reducing emissions.
2. Natural lighting and ventilation: open design maximizes natural lighting and air circulation, saving energy consumption by up to 70%.
3. Water and waste management: waste management and composting programs have processed more than 15 tons of recycled materials, with a composting system supporting permaculture gardens and organic rice fields.

Contribution to Sustainable Tourism

Penglipuran Village in Bangli serves as a successful example of integrating bamboo forest conservation with ecotourism. This village has 13 types of bamboo that serve as the main tourist attraction, creating employment and increasing community income. SWOT analysis shows that the main strength is high community support (the highest value in the survey) for bamboo forest preservation, with opportunities from increasing demand for tourism destinations.

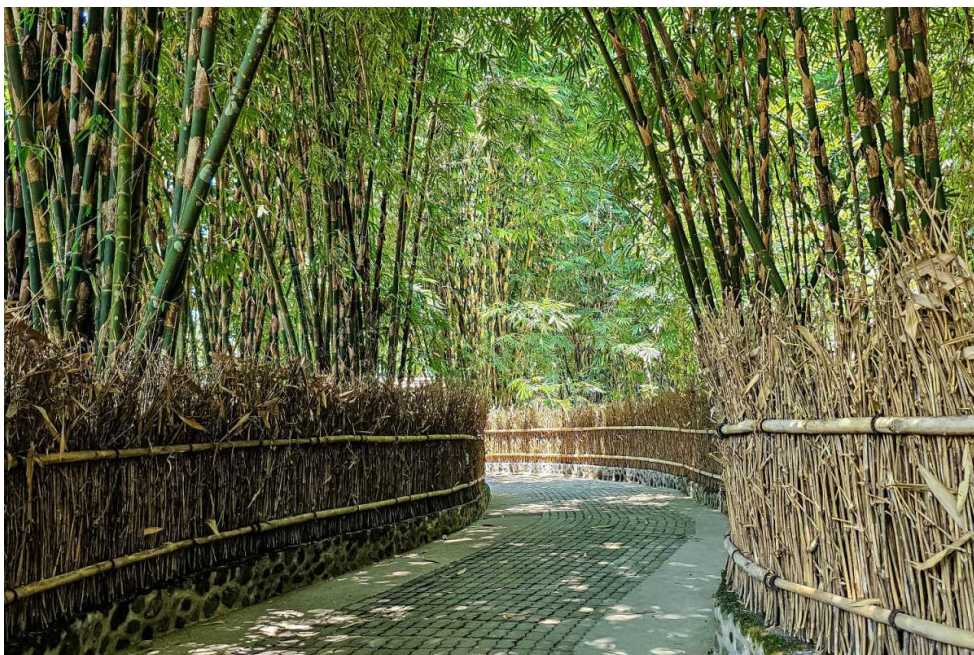


Figure 4. Penglipuran Village

Interview results with managers show that bamboo forest ecotourism development has:

1. Increased community income through entrance ticket sales, bamboo handicraft products, and tourism services
2. Opened new employment opportunities as tour guides, craftsmen, and homestay managers
3. Maintained awig-awig (customary rules) of the village in natural resource management
4. Encouraged the creative economy through bamboo woven product production for local and international markets

Green School Bali demonstrates a transformative educational tourism model. Before COVID-19, more than 300 local students participated in the Kul Kul Connection program that taught English and sustainability, "paying" using recycled materials they brought. This program integrates sustainability education with local community empowerment.

The "Seeds-to-Table" concept, where student food is produced organically on campus grounds, with plates made from banana leaves and straws from papaya stems, serves as a living laboratory for sustainability practices. The Innovation Hub (iHub) enables students to design sustainable products such as surfboard fins from plastic bottles or bicycles from bamboo.



Figure 5. Green School

Multidisciplinary and Socioeconomic Impacts

Results from in-depth interviews and observations with architecture practitioners, managers, and local communities show that the presence of bamboo buildings provides significant social and economic impacts. The bamboo industry in Bali creates new employment opportunities, enhances community skills, and strengthens the creative economy sector in tourism areas. Community empowerment, tradition preservation, and participation in ecotourism management are part of the multidisciplinary success of Balinese bamboo architecture.

Contribution to Sustainable Development Goals (SDGs)

This research confirms that bamboo architecture is highly relevant to achieving several SDG targets, including:

1. SDG 8 (Decent Work and Economic Growth): Opening new employment opportunities and improving the welfare of local bamboo craftsmen.
2. SDG 11 (Sustainable Cities and Communities): Development of environmentally friendly infrastructure based on community and local culture.
3. SDG 12 (Responsible Consumption and Production): Utilization of renewable materials and circular construction design.
4. SDG 13 (Climate Action): Carbon emission reduction and CO₂ absorption through bamboo growth.

Bali has successfully built a sustainable tourism model through integration among bamboo architecture, community involvement, and collaboration across various scientific disciplines. The synergy between local knowledge and modern innovation makes Bali a living laboratory for bamboo architecture implementation that can be adopted for sustainable tourism destination development in other regions.

Multidisciplinary Integration Model

This research identifies that the success of bamboo architecture as a pathway toward sustainable tourism and SDGs requires a multidisciplinary approach that integrates various dimensions:

1. Technical dimension: includes innovation in structural systems, material treatment, and construction standards that ensure safety and durability.
2. Environmental dimension: encompasses life cycle assessment, carbon sequestration, biodiversity conservation, and circular economy principles.
3. Socio-cultural dimension: integrates Balinese local wisdom such as Tri Hita Karana, preservation of traditional skills, and cultural immersion for tourists.
4. Economic dimension: creates a value chain from upstream to downstream that empowers local communities, generates green jobs, and supports the creative economy.
5. Educational dimension: uses bamboo architecture as a living laboratory for sustainability education, as demonstrated by Green School Bali.

This integration model shows that bamboo architecture is not merely a material choice but represents a holistic system that connects technical, environmental, social, economic, and educational aspects within the framework of sustainable tourism and SDG achievement. This multidisciplinary approach enables bamboo architecture to become a catalyst for transformation toward a more regenerative and inclusive development model in Bali

5. CONCLUSION

Bamboo architecture in Bali has proven to be an effective multidisciplinary solution in supporting sustainable tourism and achieving SDGs. The application of bamboo architecture integrates local values and technological innovation, strengthens community economy, preserves the environment, and supports Balinese culture. This model demonstrates that cross-disciplinary collaboration—architecture, environmental engineering, creative economy, and community empowerment—is the key to successfully developing tourism destinations that are greener, more inclusive, and globally competitive.

REFERENCE

- Badan Pusat Statistik (BPS) Provinsi Bali. (2023). *Laporan Statistik Lingkungan dan Sumber Daya Alam Provinsi Bali 2023*. Denpasar: BPS Provinsi Bali.
- Bank Dunia. (2022). *Indonesia: Menuju model pariwisata yang lebih berkelanjutan*. Washington, DC: Grup Bank Dunia.
- Bappenas. (2024). *Laporan Capaian Tujuan Pembangunan Berkelanjutan (TPB/SDGs) Indonesia 2024*. Jakarta: Kementerian PPN/Bappenas RI.

- Berita Antara. (2025, Juni). *Investasi Pariwisata Bali mencapai 20,8 persen dari total nasional semester I 2025*. Jakarta: LKBN Antara.
- Cole, S. (2012). Ekologi politik kesetaraan air dan pariwisata: Studi kasus dari Bali. *Annals of Tourism Research*, 39 (2), 1221–1241. <https://doi.org/10.1016/j.annals.2012.01.003>
- FAO. (2021). *Bambu sebagai material konstruksi berkelanjutan: Peluang untuk bangunan hijau dan pembangunan pedesaan di Asia-Pasifik*. Roma: Organisasi Pangan dan Pertanian Perserikatan Bangsa-Bangsa.
- Gosling, S., Scott, D., & Hall, CM (2020). Pandemi, pariwisata, dan perubahan global: Penilaian cepat COVID-19. *Jurnal Pariwisata Berkelanjutan*, 29 (1), 1–20. <https://doi.org/10.1080/09669582.2020.1758708>
- Hardy, J., Hardy, C., & Hardy, E. (2013). *Sekolah Hijau: Membangun masa depan berkelanjutan di Bali*. Bali: PT Bamboo Pure.
- IBUKU. (2024). *Inovasi dalam arsitektur bambu*. Bali: Publikasi IBUKU Studio.
- Iswanto, AH (2017). Potensi pemanfaatan bambu untuk pembangunan bangunan berkelanjutan di Indonesia. *Seri Konferensi IOP: Ilmu Bumi dan Lingkungan*, 60 (1), 1–8. <https://doi.org/10.1088/1755-1315/60/1/012016>
- Pusat Pembangunan Berkelanjutan Universitas Udayana. (2023). *Pariwisata berkelanjutan dan pemberdayaan masyarakat di Bali*. Denpasar: Udayana Pers.
- Putra, IND (2020). *Pariwisata, budaya, dan masyarakat di Bali: Transformasi dan tantangan*. Denpasar: Universitas Udayana Pers.
- Perserikatan Bangsa-Bangsa. (2023). *Laporan Tujuan Pembangunan Berkelanjutan 2023*. New York: Departemen Urusan Ekonomi dan Sosial Perserikatan Bangsa-Bangsa.
- Suryawan, A. (2022). Dampak sosial-ekonomi pariwisata Bali pascapandemi dan tantangan pembangunan berkelanjutan. *Jurnal Kajian Pariwisata dan Budaya*, 24 (3), 155–172.
- UNWTO & UNDP. (2018). *Pariwisata dan Tujuan Pembangunan Berkelanjutan – Perjalanan Menuju 2030*. Madrid: Organisasi Pariwisata Dunia (UNWTO).