



PLANNING MALAYSIA:

Journal of the Malaysian Institute of Planners

VOLUME 24 ISSUE 5 (2026), Page 116 – 129

PRACTICES, CHALLENGES AND STRATEGIES FOR INTEGRATING GREEN BUILDING ELEMENTS INTO HERITAGE CONSERVATION: EVIDENCE FROM THE GEORGE TOWN WORLD HERITAGE SITE

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Abstract

Heritage buildings hold significant architectural, historical and cultural values, yet their conservation increasingly demands alignment with sustainability goals. This study explores the integration of green building elements within heritage conservation, focusing on George Town, Penang, a UNESCO World Heritage Site. Using a qualitative research design, data were collected through semi-structured interviews with five purposively selected experts with relevant professional experience in heritage conservation and green building practices. Interview data were examined using narrative analysis supporting by thematic coding. The findings identified thirteen distinct green building elements currently incorporated into conservation efforts, ten major challenges hindering their integration and nine key strategies supporting successful implementation. By providing evidence-based insights, this study contributes to policy development and industry best practices, guiding practitioners toward more environmentally responsible heritage conservation. It also highlights the need to align green interventions with conservation requirements, sustainability criteria and relevant heritage approval processes while safeguarding heritage authenticity.

Keywords: green building element, heritage conservation, challenges, strategies, George Town, Malaysia

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INTRODUCTION

George Town, Penang, was designated a UNESCO World Heritage Site in 2008 and is a home to nearly 5000 heritage buildings. Beyond its historical significance, the city has embraced sustainability initiatives that align with global trends in heritage conservation and environmental stewardship (Alauddin et al., 2022; Bagheri et al., 2022). This aligns with the Penang 2030 vision, which emphasises environmental sustainability in heritage conservation. Heritage buildings in George Town, are important legacies of the past, embodying architectural, historical and cultural values that are vital to community identity and should be persevered for future generation (Abdullah et al., 2024; Husa & Harun, 2023). Numerous studies highlight the importance of maintaining the authenticity of heritage sites to retain their historical, cultural and architectural characteristics (Mohd Rahil et. al, 2020; Abdul Aziz, 2021; Al-Sakkaf et al., 2020; Husa & Harun, 2023; Mat Hasan et al., 2022).

In striving for a balanced approach to heritage site management, emphasis has also been placed on ensuring that heritage conservation activities comply with sustainable and environmentally responsible practices (Teoh, 2021; Adib et. al, 2025). However, while the integration of sustainable principles has gained traction in new development projects, their adoption in heritage conservation remains comparatively limited. This is evident from the small number of heritage buildings formally certified under Malaysia's Green Building Index (GBI). Yet there are cases where green features have been incorporated without receiving formal environmental rating recognition (Green Building Index, 2025). The lack of acknowledgment and promotion of sustainable efforts in heritage conservation raises concerns about missed opportunities for environmental benefits (Alauddin et al., 2022; Pedersen et al., 2024). Globally, researchers have highlighted similar challenges in balancing heritage preservation with sustainability. Pedersen et. al (2024) highlight the development and evaluation of advanced energy-efficient technologies to improve building performance, while also identifying challenges and solutions associated with energy upgrading and preservation. Similarly, Panakaduwa et. al (2024), examine advanced energy-efficient technologies for retrofitting buildings, addressing challenges and proposing solutions to balance sustainability and architectural integrity. These studies provide important insight into balancing sustainability and cultural heritage, offering perspectives that are highly relevant to the Malaysian context. Without a clear understanding of how green elements can be integrated into heritage conservation and what challenges hinder the process, achieving a balance between heritage preservation and sustainability remains difficult (Abdul Aziz, 2021; Alauddin et al., 2022; Lidelöw et al., 2019).

Against this backdrop, this study seeks to investigate heritage conservation with the George Town World Heritage Site as the focal area.

Specifically, this study pursues three objectives: to identify green building elements, challenges and important strategies for integrating green building elements into heritage building conservation.

LITERATURE REVIEW

Conservation of Heritage buildings

Heritage buildings encompass structures, artifacts and areas of historical and architectural significance. They serve as tangible links to the past and reflect community cultural identity (Al-Sakkaf et al., 2020). Norazman et al. (2023) define heritage in terms of its architectural, aesthetic, historical and cultural significance and emphasise the importance of preserving local identity and history. Therefore, many scholars agree that heritage buildings require delicate conservation strategies to preserve their historical, cultural and architectural characteristics (Alauddin et al., 2022; Husa & Harun, 2023; Norazman et al., 2023). Conservation strategies can be divided into four types: restoration and repair, adaptive reuse, maintenance, and retrofitting or rehabilitation. Heritage conservation today is seen not just as protecting old buildings but as a process of balancing historical authenticity with modern social, economic and environmental needs (Alauddin et al., 2022; Husa & Harun, 2023; Vafaie et al., 2023). It also involves adapting heritage assets to contemporary urban life while retaining their meaning and functionality.

George Town World Heritage Site and Green Heritage Conservation

George Town World Heritage Site (GTWHS), is a thriving living heritage site that combines modern urban life with historical and cultural preservation. Conservation measures include stringent rules, adaptive reuse of heritage structures, and community involvement. George Town World Heritage Incorporated (GTWHI) has been actively involved in conservation projects, community engagement, and educational programs to address challenges such as urbanisation and development. Scholars agree that sustaining the vitality of George Town requires not only protective regulations but also collaborative governance involving communities, stakeholders and international organisation. Green buildings are defined as those that use eco-friendly technologies, such as renewable energy and low-carbon systems, to reduce their adverse environmental impacts while remaining safe, functional and reliable (Yin et al., 2024). While maintaining historical and cultural features, green heritage conservation seeks to promote ecosystem protection, reduce carbon footprints and encourage sustainable practices (Shehata et al., 2024). In Malaysia, policy frameworks have been introduced to align heritage conservation with sustainability. The Green Technology Master Plan (2017-2030) sets out a roadmap towards a resource-efficient, low carbon economy including the construction sector (Ministry of

Energy, Green Technology and Water (KeTTHA), 2017). Complementing this, the Green Building Index (GBI) serves as a national benchmark for sustainable building practices and has been extended to cover heritage projects. However, while these frameworks demonstrate Malaysia's commitment, their application in the heritage context remain selective and uneven, revealing a gap between policy and implementation. The integration of green building elements into heritage conservation can promote environmental sustainability and reduce carbon emission, contributing to a more sustainable built environment (Shehata et al., 2024). However, such integration must balance modernisation with authenticity to preserve heritage value.

Principles of Green Building Element Heritage Conservation

Green building elements are commonly structured around the following interrelated principles; energy efficiency, indoor environmental quality, sustainable site planning and management and material and resources. *Energy efficiency* emphasises on reducing energy consumption through resources optimization while maintaining comfortable indoor conditions (Gupta & Chakraborty, 2021; Lidelöw et al., 2019; Min et al., 2022). *Indoor environmental quality* encompasses factors such as air quality, lighting, thermal comfort, and ergonomics, which affect occupants' health, comfort and well-being (Kang et al., 2024). It can be improved through natural ventilation, appropriate mechanical ventilation, indoor temperature control and humidity and moisture management. *Sustainable site planning and management* aims to minimise the environmental impact of development while maximising social and economic benefits. This idea can be implemented through facility evaluations (such as examining roofs, windows, HVAC systems, and plumbing), energy and erosion management, and the use of renewable energy sources for heating and cooling (Alauddin et al., 2022). *Material and resources*, focusses on materials with appropriate performance, durability, low maintenance requirements and low embodied energy (Tazmeen & Mir, 2024). Green Heritage conservation also depends on sustainable materials that minimise environmental impacts while providing long term durability effect (Tam & Hao, 2019).

Challenge in Maintaining Authenticity and Green Value in Heritage Conservation

Scholars acknowledge that integrating green building elements into heritage conservation is a complex process primarily due to regulatory, technical and structural limitations. Heritage conservation is governed by national and international regulations, which often priorities the protection of the original form and character (Azizan et al., 2020; Conejos et al., 2019). Adherence to heritage protection requirements is important but impede the implementation of energy-

efficient renovations because alterations to original features can affect heritage value. The lack of explicit guidelines for integrating green building elements within conservation constraints can discourage their adoption in heritage buildings (Conejos et al., 2019). Another key barrier is the lack of professionals with expertise in both heritage conservation and green building approaches (Azizan et al., 2020; Harun, 2011), making implementation more difficult. The structural condition of heritage building presents additional challenge to green integration.

Strategies for incorporating green element in heritage conservation

Researchers have identified several strategies to address the challenges of incorporating green building elements into heritage conservation. One of the key approaches is stakeholder involvement and awareness. Awareness programs are used to inform stakeholders of the benefits of integrating green technologies in conservation efforts. Such initiatives can also mitigate concerns about regulatory implications and promote wider acceptance of sustainable practices (Harun, 2011). Another recurring strategy is the establishment of adaptable regulatory frameworks that enable energy-efficient improvement without undermining conservation principles. Conejos et. al (2019) argue that updating existing guidelines to provide clearer pathways for green technologies is essential for ensuring compliance and heritage integrity. In addition, scholars emphasise training and education to equip architects, engineers and artisans with the skills required to integrate sustainability into historic structures. Leijonhufvud et al (2024) highlight that such capability-building effort are critical for developing practical solutions that respect cultural heritage. Adaptive reuse is also widely recognised as a means of introducing contemporary sustainable technologies into existing buildings. Shehata et al (2024) show that adaptive reuse not only preserves the historical significance of structures but also improves their functionality and environmental performance. Finally, collaboration with conservation experts (Hassan & Abdul Nasir, 2017) during planning and implementation stages is considered vital to ensure that modification align with conservation principles. Involving specialist helps to identify potential conflict between modern technologies and historical features, enabling better-informed decision making. Overall, these strategies demonstrate that green integration requires a multidimensional approach that combines technical solutions with the governance mechanism while balancing sustainability and authenticity.

RESEARCH METHODOLOGY

This research employed a qualitative research design using purposive sampling. Participants were selected due to their professional roles and project experience to heritage conservation and integration of green building elements. George

Town was selected as the case study due to its significance as a UNESCO World Heritage Site. Between February and April 2025, five (5) eligible experts, including conservation architects, heritage managers and related professionals were interviewed to gain in-depth insight into green heritage elements, implementation challenges and effective strategies. As shown in Table 1, all participants had approximately five to ten years professional experience, while the majority had been involved in several green building projects, with two reporting extensive experience in heritage building conservation, indicating sufficient relevant expertise to provide credible insights for the study. Data were analysed using narrative analysis supported by systematic coding to identify recurring patterns and categories across respondents. Similar statements were coded and grouped into related domains and patterns were compared across respondents and with the literature. This method helped develop a clearer understanding of the complex issues involved in green heritage conservation (Creswell & Poth, 2024).

Table 1: Demographic Information

	Position	Experience in Construction Industry	Green project involvement	Heritage conservation project involvement
R1	Director	> 5 years	< 5 projects	< 5 projects
R2	Conservation Architect	> 5 years	< 5 projects	>10 projects
R3	Heritage Operation Manager	> 5 years	>10 projects	>10 projects
R4	Assistance Curator for Building Conservation	> 5 years	< 5 projects	< 5 projects
R5	Assistance Manager Architect	> 5 years	< 5 projects	< 5 projects

ANALYSIS AND DISCUSSION

The interview findings were organised into three thematic domains corresponding to the research objectives (i) green building elements, (ii) challenges to integration and (iii) implementation strategies. Table 1 shows all respondents had relevant experience in both green building and heritage project making them suitable for this study.

Table 2: Green Building Elements in GTWHS

Category		Green Building Element
Energy Efficiency (EE)	i	Installation of Solar Panel
	ii	Installation of Low-Carbon Air Conditioning
	iii	Reduce the number of Air-Conditional
	iv	Installation LED Lighting
	v	Passive Design
Indoor Environment Quality (IEQ)	i	Natural Ventilation
	ii	Natural Lighting
Sustainable Site Planning and Management (SM)	i	Vegetation
	ii	Restore Drainage System
	iii	Rainwater Harvesting System
Materials and Resources (MR)	i	Original Material
	ii	Low-Carbon Material
Water Efficiency (WE)	i	Rainwater Harvesting System
	ii	Low-Flush Toilet System

As shown in Table 2, the findings identified thirteen green building elements integrated in the GTWHS across five categories: energy efficiency (EE), indoor environmental quality (IEQ), sustainable site planning and management (SM) and materials and resources (MR) and water efficiency (WE). These elements also correspond to relevant GBI criteria. Rainwater harvesting contributes to both SM and WE but is counted once. For EE, most respondents generally (R1, R2, R3 and R4) acknowledged that solar panels can be integrated, provided that installation remain visually unobtrusive and comply with relevant regulations. This reflects conditional acceptance of renewable technologies within the heritage context, particularly due to concerns regarding safety and regulatory compliance. The findings reflect previous research which argues that renewable energy technologies can contribute meaningfully to conservation areas if interventions are unobtrusive and their application remains sensitive to regulatory and structural limitations (Conejos et al., 2019). In the George Town heritage context, such external services require careful assessment against the UNESCO-related authenticity considerations. This is consistent with Abdullah et. al (2024) who emphasise the importance of maintaining external appearance without compromising authenticity. IEQ findings emphasised natural ventilation and lighting through features such as air wells, timber shutters and high ceilings. This confirms earlier studies that highlight these features as both functional and environmentally responsive (Alauddin et al., 2022; Bay et al., 2022). SM measures, including vegetation, drainage restoration and rainwater harvesting were viewed as relatively non-intrusive ways to improve environmental performance. More importantly, these measures are generally less intrusive and can be incorporated with limited disturbance to the heritage fabric. These findings align with Amaka-Anolue et al. (2024) and Hoyle and Sant’Anna (2023), who

emphasise the role of site interventions in reducing environmental risks. For MR, all respondents prioritised the original materials such as lime plaster and timber, while low-carbon alternatives were considered acceptable only when compatible with the original materials. The findings reflect the ongoing debate in the literature which point out both the advantages and risks of replacing traditional materials with modern ecological ones (Abd Elgawad et al.,2025; Alauddin et al., 2022; Tazmeen & Mir, 2024). Finally, WE measures revealed both opportunities and constraints. Rainwater harvesting was widely accepted (R1-R5) as practical and non-intrusive, complementing the broader site management strategies. However, the use of low-flush toilets was less accepted due to higher costs. Hence, these findings illustrate how economic considerations strongly influence the adoption of sustainable practices, consistent with earlier research by Amaka-Anolue et al., (2024).

Table 3 Challenges of Green Building Integration in Heritage Conservation

Challenges	Representative interview evidence
Regulatory Constraint	R2: “The first point is regulation, as you know regulation for heritage building is very tight. So, anything that we want to develop, installation and repair, we need to refer to the guideline, ‘special area plan for George Town’.”
Lack of Skilled Worker	R4: “In Malaysia, our worker involved in the heritage conservation is less, they are more like to join the other type building which is fast finish and easy job.”
Structural and Appearance Restrictions	R2: “We need to maintain the exterior look, if we integrate more of green features, then we need to install something to maintain the exterior look.”
Cost Constraints	R3: “Many heritage building owners are individuals or small businesses that may not have the budget to invest in green technology that also meets heritage standards.”
Material Availability and Authenticity	R5: “Because the heritage building material is already old... maybe in Malaysia didn’t have this kind of original material, but in heritage conservation, we want to try to maintain the original material.”
Stakeholder Awareness and Understanding	R4: “I think is the awareness of the public. This is because not so many people interesting involved in heritage conservation.”
Enforcement and Expertise Gaps	R1: Some conservation work is “renovated in a hurry” without following the heritage conservation guideline, while there are too few green-heritage specialists to evaluate the integration accurately.
Conflicting Requirements	R1: “They want us to maintain the wood thing... But the Bomba say cannot... so want to accept both requirements, we do RC and cover with wood.”

Challenges	Representative interview evidence
Balancing Aesthetics and Functionality	R5: “It’s required careful planning in-order to balance modern technologies with historical aesthetics, energy efficiency vs functionality and cost constraints.”
Time and Process Constraints	R4: “The heritage conservation building takes a lot time to done the project... they like to do fast project and get fast money, so this is a challenge.”

Based on Table 3, the interview findings revealed ten (10) key challenges in integrating green building elements into heritage conservation. The most recurrent concerns were regulatory constraints, shortages of skilled workers, cost, material availability and the need to protect structural and visual authenticity. The policy gap creates uncertainty among practitioners regarding the appropriate application of green standards in conservation projects. This is supported by Conejos et al., (2019) who underscore that misaligned regulatory frameworks can hinder would hinder effective implementation. In addition, all respondents emphasised the shortage of skilled workers emerged as key constraint, as heritage conservation requires specialized expertise that remains limited within the current industry. This is also highlighted by Abdullah et. al (2024). Economic barriers were another recurring theme, with all respondents indicating that many clients were unwilling to invest beyond minimum requirements. Abdullah et. al (2024) further noted that sourcing materials can be challenging, thereby increasing overall project costs. Limited material availability compounds this problem as the difficulty of sourcing authentic materials raises both procurement challenges and project expenditure. Similar to Halim and Tambi (2021), several respondents also indicated that limited stakeholder awareness further complicates progress, as contractors often prioritise cost efficiency over sustainability goals. All respondents also highlighted the difficulty of balancing aesthetic integrity with modern functionality, noting that such decisions require careful negotiation to avoid undermining heritage values. Collectively, these challenges illustrate the complex trade-offs that must be managed in aligning environmental objectives with heritage preservation priorities.

Table 4: Strategies for integrating green building elements

Strategies	Representative interview evidence
Stakeholder Education and Awareness	R3: “When building owners and local people understand the environmental value of traditional design, they are more likely to support green conservation practices.”
Financial Incentives	R4: “Government can give some incentive to the contractor if they interested in green heritage conservation.”

Strategies	Representative interview evidence
Expert Knowledge	R1: “This is good, this activity should be more practice. But the experts from outside country need look careful because the habit is different.”
Integrated Guideline	R1: “Since we didn’t have specific guideline on how green building element can integrate into the heritage conservation, so have a specific guideline as reference is good.”
Material Sourcing and Innovation	R4: “If say the wood didn’t have, then one way we practice is replace to more quality wood or high grad material.”
Skilled Workforce Development	R4: “But I think most important is training, like we train ourselves worker have this knowledge, which increase their awareness.”
Adaptive Reuse Strategies	R3: “Heritage buildings are given new functions while keeping their original form.”
Research and Documentation	R2: It is essential to understand the history of a heritage building before intervention; this can include speaking with an elderly person or owner to learn the building’s history, purpose and ownership.
Leveraging Traditional Design	R3: “Many traditional structures in Penang, such as old shophouses, already include green features like air wells, high ceilings, and timber windows that support natural ventilation and cooling.”

Findings in Table 4 revealed nine (9) key strategies that can support the integration of green building elements into heritage conservation. Most respondents emphasised stakeholder education and awareness as the foundation for progress with respondents noting that training programs and stakeholder engagement can enhance understanding and foster long-term commitment to sustainable heritage practices (Harun, 2011; Leijonhufvud et al., 2024). This aligns with earlier literature that stresses the role of knowledge as the driver for behavioural change and informed decision-making in conservation. In addition, several respondents (R1, R2) highlighted expert collaboration and knowledge sharing were also viewed as essential for ensuring technical quality and consistency, as they promote interdisciplinary cooperation that enhances both energy efficiency and the preservation of heritage value (Shehata et al., 2024). The development of updated and comprehensive guidelines also emerges as major priority. Majority respondents (R1, R2, R3, R4) emphasized that Malaysia requires a regulatory framework specifically tailored to harmonies heritage conservation and sustainability goals, supporting Conejos et al., (2019), who argue that clear policy direction is critical for effective implementation. Adaptive reuse was further identified by several respondents (R2, R3, R5) as a practical strategy, demonstrating how existing buildings can be repurposed while maintaining authenticity, as exemplified by the Penang Hill Gallery @ Edgecliff

(Shehata et al., 2024). Meanwhile most respondents (R1, R2, R4) highlighted financial incentives and funding mechanism, including grant and tax reduction as key enablers to encourage client participation and offset the higher cost associated with sustainable materials and technologies. Developing a skilled workforce through continuous professional was considered equally important to ensure that conservation practitioners are equipped to manage both heritage requirement and sustainability standards. All respondents (R1-R5) also highlighted the importance of research and documentation in understanding a building's history, materials and condition before any intervention. Such preparation helps reduce risks and improve conservation outcomes. Finally, leveraging traditional methods such as passive design and the use of local materials was seen as one of the most authentic and sustainable approaches. These methods not only retain cultural identity but also provide environmental benefits without major alterations to the building structure. Collectively, these strategies suggest that achieving sustainable heritage requires an integrated approach, combining education, collaboration, financial support and traditional wisdom to balance the authenticity with environmental responsibility.

CONCLUSION

In an effort to understand the integration of green building elements into heritage conservation, this study focuses on George Town Penang, a UNESCO World Heritage Site and highlights the importance of aligning conservation efforts with environmental responsibility. The study also identifies significant challenges that emerge when integrating modern sustainability practices with heritage conservation. These findings underscore the need to reconcile environmental responsibility with heritage conservation, ensuring that sustainability improvements are introduced without compromising the authenticity and significant fabric of heritage building in line with Penang 2030 goals. These insights provide practical references for policymakers and practitioners toward environmentally responsible heritage preservation. Future research should further explore scalable solutions and policy frameworks to accelerate the integration of green building principles within heritage conservation practices.

ACKNOWLEDGEMENT

This study is supported by Fundamental Research Grant Scheme (FRGS) (FRGS/1/2023/SSI02/USM/02/1) awarded by Ministry of Higher Education Malaysia.

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Received: 15th May 2026. Accepted: 6th June 2026