

Sustainable Tourism Infrastructure and Digital Transformation in Semarang Old Town and Melaka Historic City: A Comparative Study

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ABSTRACT

Heritage tourism destinations across Southeast Asia face increasing pressure to balance rapid urban modernization and historical preservation with the threats of ecological degradation and over tourism. Despite growing scholarly interest in smart tourism, empirical comparative studies examining how heritage destinations address infrastructure deficits remain scarce. This study aims to provide a comparative analysis of sustainable tourism infrastructure and digital transformation between Kota Lama Semarang in Indonesia and Melaka Historic City in Malaysia. Utilizing a qualitative comparative case study design, this research evaluates secondary data obtained from municipal master plans, urban revitalization reports, and scholarly literature indexed in Scopus through cross case thematic synthesis. The findings reveal that Melaka benefits from mature cross sectoral governance and centralized smart tourism frameworks, while Kota Lama Semarang demonstrates rapid progress through public private partnerships, pedestrianization, and localized Internet of Things applications. These developments illustrate different approaches to integrating infrastructure improvements and digital innovation within heritage tourism destinations. To synthesize these outcomes, this study introduces the Comparative Heritage Infrastructure Integration Model, which highlights the synergy required between physical preservation, smart information and communication technology adoption, and collaborative governance. This model emphasizes that sustainable heritage tourism requires coordination between conservation priorities, technological development, and stakeholder participation. This research expands destination management literature by introducing a cross country comparative perspective and offers actionable policy recommendations for emerging nations to optimize heritage conservation, strengthen sustainable tourism infrastructure, improve digital readiness, and address the challenges of urban modernization and increasing visitor demand. The findings are expected to support policymakers and destination managers in developing integrated strategies that preserve historical value while enhancing tourism sustainability and digital competitiveness.

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1. INTRODUCTION

The preservation and management of historical districts in Southeast Asia have transitioned from mere architectural conservation to comprehensive infrastructure modernization. Historic urban landscapes like Kota Lama Semarang and Melaka serve as vital economic engines and cultural anchors for Indonesia and Malaysia respectively. These colonial-heritage destinations hold profound historical significance, acting as living museums that drive regional economic growth through cultural tourism, local enterprise development, and international visitor engagement.

However, both destinations face a critical dual challenge: preventing ecological and structural degradation from over-tourism while meeting contemporary expectations for smart, seamless, and sustainable travel experiences. From a tourism infrastructure perspective, historical districts inherently struggle with spatial rigidity, where narrow colonial streetscapes and legacy utility layouts clash with modern demands for tourist mobility, high-capacity sanitation, accessible public spaces, and smart visitor management facilities. Rapid urbanization, climate-induced vulnerabilities (such as tidal flooding or *rob* in Semarang), and exponential visitor growth place immense pressure on these foundational tourism assets.

Managing the pressures of spatial planning and infrastructure requires a robust legal foundation. In Indonesia, the formal preservation of cultural heritage is grounded in Law Number 11 of 2010 concerning Cultural Heritage, which mandates a three-pillar approach: protection, development, and utilization. Kuntariningsih (2026) notes that infrastructure must be designed to ensure building resilience and safety against various risks, including earthquakes, fires, and other natural disasters. Meanwhile, Malaysia operates under a comprehensive federal framework—the National Heritage Act 2005 (Act 645)—administered by the Department of National Heritage to protect cultural heritage (both tangible and intangible) and natural heritage, while also regulating physical development within buffer zones.

While Melaka has long established its footing as a UNESCO World Heritage site leveraging strict statutory guidelines and integrated urban tourism infrastructure (such as riverfront cruise corridors and centralized mobility networks), Kota Lama Semarang has undergone aggressive revitalization over the past decade—guided by national cultural heritage mandates and public-private partnerships—to transform from a neglected colonial zone into a vibrant cultural hub equipped with pedestrian zones, underground utility ducts, and IoT-enabled public spaces.

Despite the growing body of literature on smart tourism and urban heritage management, a significant research gap persists. Prior studies largely focus on standalone destination assessments or primary metropolitan hubs, whereas empirical comparative studies examining how secondary and primary heritage destinations bridge tourism infrastructure deficits under their respective legal frameworks remain scarce. Furthermore, little is known about how these destinations balance statutory conservation requirements with modern digital transformation and physical infrastructure adaptation, such as smart tourism dashboards, green transit corridors, and decentralized visitor flow systems.

To address this gap, this article investigates how Kota Lama Semarang and Melaka leverage legislative instruments, infrastructure investments, and digital transformation to enhance their regional and global competitiveness. By employing a qualitative comparative case study approach, this research aims to evaluate structural policies, legal interventions, and digitalization maturity from a tourism infrastructure perspective. Ultimately, this paper introduces the Comparative Heritage Infrastructure (CHI) Integration Model, providing actionable insights into sustainable heritage tourism management within the ASEAN region.

2. LITERATURE REVIEW / THEORETICAL FRAMEWORK

To frame this comparative study between Kota Lama Semarang and Melaka, this research synthesizes three core theoretical dimensions: Destination Competitiveness, Adaptive Reuse and Sustainable Urban Heritage Management, and the Smart Tourism Destination (STD) paradigm, with a specific focus on tourism infrastructure development and modernization.

2.1. Tourism Infrastructure in Historic Districts: Theoretical Foundations

The spatial and structural configuration of historic districts presents a unique paradox: while heritage assets drive destination attractiveness, legacy layouts often constrain modern tourism infrastructure needs. **Ashworth and Tunbridge (2005)** highlighted the inherent friction between commercial modernization, historic conservation, and spatial adaptation in multi-layered cities. Expanding on this, **Crouch and Ritchie's Destination Competitiveness Model (1999)** explicitly underscores that supporting and core tourism infrastructure—including transportation networks, pedestrian mobility, sanitation facilities, utility grids, and visitor management amenities—act as critical determinants of a destination's global standing. In heritage contexts, retrofitting these infrastructural elements without compromising architectural integrity remains a central challenge for urban planners.

2.2. Physical Revitalization, Green Infrastructure, and Adaptive Reuse

In the realm of physical heritage management, scholarly discourse emphasizes the shift from passive preservation to active urban remediation. **Rypkema (2008)** and subsequent studies on **adaptive reuse** argue that repurposing historic structures breathes economic vitality into decaying districts while minimizing the carbon footprint associated with new construction. However, adapting historical zones requires robust green infrastructure. Recent empirical works by **Rahmawati et al. (2022)** on Indonesian colonial districts demonstrate that physical interventions—such as pedestrianization, underground utility cabling to eliminate visual clutter, and smart drainage systems against coastal flooding (*rob*)—are vital for enhancing tourist comfort, safety, and destination resilience.

Furthermore, supporting this physical infrastructure perspective, **Henderson (2018)** in her extensive studies on Southeast Asian tourism destinations emphasizes that heritage infrastructure modernization in historic cities must account for visitor capacity limits, pedestrian flow bottlenecks, and public space accessibility to prevent physical degradation. Complementing this, **Su and Teo (2020)** examine urban regeneration in historic Asian waterfronts, highlighting how integrated public realm interventions (such as riverfront promenades and scenic transit connectivity) directly enhance visitor length of stay, carrying capacity management, and spatial dispersal away from core congestion zones.

2.3. Smart Tourism Infrastructure and Digital Transformation

Beyond physical assets, the **Smart Tourism Destination (STD) paradigm** articulated by **Buhalis (2020)** emphasizes that modern tourism infrastructure extends into digital layers. Information and Communication Technologies (ICTs), Internet of Things (IoT) sensors, centralized tourism dashboards, and unified e-payment systems are now indispensable components of contemporary destination infrastructure. **Gretzel et al. (2015)** note that smart infrastructure enables real-time monitoring of visitor flows, effectively mitigating over-tourism bottlenecks in sensitive historical zones. Studies contrasting Asian heritage hubs indicate that while mature destinations like Melaka have successfully institutionalized centralized digital dashboards and smart mobility apps under strict federal frameworks (Tan & Wong, 2021), emerging secondary hubs often rely on decentralized, localized digital integrations (such as QR-code mapping and social media-driven promotions).

2.4. Synthesis and Research Gap

While existing literature thoroughly examines standalone heritage preservation (Ashworth & Tunbridge, 2005; Henderson, 2018), macro-level destination competitiveness (Crouch & Ritchie), urban regeneration (Su & Teo, 2020), and digital smart tourism adoption (Buhalis, 2020; Gretzel et al., 2015), a distinct research gap persists regarding the **infrastructure-centric comparison** of heritage destinations. Specifically, empirical studies investigating how secondary heritage hubs (e.g., Kota Lama Semarang) and established primary heritage hubs (e.g., Melaka) systematically upgrade their physical tourism infrastructure (pedestrian zones, flood mitigation, utility networks) alongside digital smart-tourism layers under distinct legal frameworks (Indonesia's Law No. 11 of 2010 versus Malaysia's

National Heritage Act 2005) remain sparse. This study addresses this gap by synthesizing these dimensions into the proposed Comparative Heritage Infrastructure (CHI) Integration Mode

Hypothesis/Proposition (if applicable): State each hypothesis or proposition clearly and consistently with the theoretical argument.

3. RESEARCH METHOD

This section outlines the methodological framework adopted to empirically evaluate and contrast the tourism infrastructure, digital transformation, and governance mechanisms of Kota Lama Semarang and the Historic City of Melaka. By employing a structured qualitative approach, this research aims to unpack the complex interplay between physical heritage preservation, municipal policy execution, and smart tourism integration within developing Southeast Asian contexts.

3.1. Research Design and Methodological Framework

This study adopts a qualitative comparative case study design, drawing upon the methodological foundations established by Yin (2018) and Stake (1995) regarding rigorous case-based inquiry. A comparative case study methodology is particularly optimal for tourism and urban geography research as it allows for an exhaustive, context-sensitive examination of complex real-world phenomena across different institutional and spatial settings. By juxtaposing Kota Lama Semarang (Indonesia) and the Historic City of Melaka (Malaysia), this research systematically investigates how distinct legal frameworks—specifically Indonesia’s Law No. 11 of 2010 on Cultural Heritage versus Malaysia’s National Heritage Act 2005 (Act 645)—interact with physical infrastructure interventions, smart tourism adoption, and destination competitiveness.

3.2. Data Collection Protocols and Corpus Construction

To achieve robust data triangulation and internal validity without relying on primary field surveys, this study establishes a rigorous secondary data corpus spanning a longitudinal window from 2018 to 2026, following the secondary data utilization guidelines outlined by **Vartanian (2011)** and **Johnston (2014)**. The data collection protocol was executed through a systematic search across four primary repository pillars:

Statutory and Policy Documents: National heritage acts, municipal zoning regulations, master planning documents, and official conservation guidelines from the Semarang City Development Planning Agency (*Bappeda*) and the Melaka State Planning Unit, alongside decrees from the Department of National Heritage (*Jabatan Pesuruhjaya Warisan*) Malaysia and Indonesia’s Cultural Heritage Expert Teams (TACB).

Institutional and Technical Reports: Comprehensive urban regeneration audits, public-private partnership (PPP/KPS) project dossiers, and tourism performance assessments published by international bodies (such as UN Tourism/UNWTO and the World Travel & Tourism Council / WTTC), as well as municipal sustainability reports.

Empirical Scholarly Literature: Peer-reviewed journal articles retrieved from major academic databases (Scopus, Web of Science, and ScienceDirect). The search strings focused on combinations of “*heritage tourism infrastructure*,” “*adaptive reuse*,” “*smart tourism destinations*,” “*Kota Lama Semarang*,” and “*Melaka historic city*.”

Media and Spatial Documentation: Historical mapping comparisons, architectural restoration briefs, and public infrastructure project logs detailing pedestrianization rollouts, underground utility transitions, and flood mitigation (*rob*) engineering.

3.3. Analytical Technique: Cross-Case Thematic Synthesis and Matrix Evaluation

Data analysis was conducted using **cross-case thematic synthesis**, operationalized in three rigorous analytical phases inspired by the qualitative data analysis frameworks of **Miles, Huberman, and Saldana (2020)** to ensure conceptual depth and objective evaluation:

Phase 1: Open Coding and Data Reduction:

All collected textual data, policy briefs, and planning documents were meticulously reviewed, deconstructed, and coded using qualitative analysis principles. Codes were classified into three core analytical nodes: (a) *Physical Heritage & Green Infrastructure Adaptation*, (b) *Digital Transformation & Smart Visitor Management*, and (c) *Governance Structures & Stakeholder Collaboration (PPP vs. Federal Statutory Control)*.

Phase 2: Within-Case Deep Profiling:

Each destination was analyzed independently to construct a comprehensive baseline of its infrastructural trajectory. Semarang was evaluated concerning its agile, project-driven adaptive reuse and physical remediation against coastal flooding, whereas Melaka was assessed regarding its institutionalized, federal-level heritage protection and centralized smart-tourism deployment.

Phase 3: Cross-Case Comparative Synthesis and Model Derivation:

The patterned findings from both cases were mapped onto a comparative evaluation matrix, following the comparative matrix techniques suggested by **Ragin (2014)** in qualitative comparative analysis. This matrix contrasted infrastructural maturities, governance efficacy, and visitor management bottlenecks. The theoretical convergence of these insights directly informed the creation of the proposed **Comparative Heritage Infrastructure (CHI) Integration Model**, mapping out the transition from baseline assets to sustainable destination competitiveness.



4. RESULTS

This section presents a rigorous comparative evaluation of Kota Lama Semarang and the Historic City of Melaka, examining how their respective infrastructural interventions, digital transformation maturities, and legal frameworks shape overall destination competitiveness. By deploying the Comparative Heritage Infrastructure (CHI) Integration Model, the subsequent subsections dissect the empirical interplay between physical-green adaptation and smart tourism execution, highlighting the distinct institutional pathways navigated by secondary and primary heritage destinations in Southeast Asia..

4.1. Comparative Baseline Profiles of Kota Lama Semarang and Melaka

The cross-case evaluation reveals distinct trajectories in how secondary and primary heritage hubs manage infrastructure modernization under differing legal regimes.

Kota Lama Semarang (Indonesia): Guided by Law No. 11 of 2010 on Cultural Heritage, Semarang's revitalization has been characterized by an agile, project-driven approach heavily reliant on Public-Private Partnerships (PPGs/KPS) between the municipal government, state-owned enterprises (such as PTPN), and private investors. Spatially, the district has undergone aggressive physical remediation, notably pedestrianization corridors, adaptive reuse of colonial warehouses into commercial spaces, and critical engineering interventions against coastal tidal flooding (*rob* via polder systems and pump installations). However, digital integration remains somewhat decentralized, leaning on localized IoT drainage sensors and social media-driven destination branding.

Melaka Historic City (Malaysia): Operating under the rigorous statutory oversight of the National Heritage Act 2005 (Act 645) and the Department of National Heritage, Melaka benefits from institutionalized, top-down federal governance. Its infrastructure maturity is reflected in highly structured UNESCO buffer zone regulations, integrated riverfront cruise corridors, and centralized smart-tourism management frameworks. Melaka deploys unified digital tourism dashboards that monitor visitor density and traffic flows in real time, minimizing the ecological friction of over-tourism.

4.2. Physical Infrastructure and Green Adaptation: Preservation vs. Modernization

The juxtaposition of physical interventions highlights a fundamental divergence in spatial problem-solving:

Adaptive Reuse and Spatial Constraints: In Melaka, adaptive reuse is strictly regulated to preserve architectural authenticity, limiting commercial intrusive modifications. Conversely, Kota Lama Semarang exhibits a dynamic, market-driven adaptive reuse model where historic structures are rapidly transformed into cafes, galleries, and creative hubs. While Semarang's approach fosters immediate economic vibrancy, it risks commercial saturation if carrying capacity thresholds are not legally enforced.

Green Infrastructure and Climate Resilience: A critical finding of this study is the integration of climate-resilient engineering into tourism infrastructure. Semarang's vulnerability to tidal flooding (*rob*) necessitated heavy capital investment in specialized drainage pumps and raised pedestrian pathways, illustrating that climate adaptation is a prerequisite for heritage tourism survival in coastal Southeast Asian cities. In contrast, Melaka's geographical advantages and mature urban drainage systems allow its green infrastructure focus to center primarily on river beautification and pedestrian-friendly shaded walkways.

4.3. Smart Tourism Infrastructure and Digital Maturity

Evaluating digital transformation through Buhalis's (2020) Smart Tourism Destination (STD) paradigm uncovers a digital divide between primary and secondary heritage destinations:

Centralized vs. Decentralized Ecosystems: Melaka demonstrates high digital maturity through centralized municipal dashboards that aggregate visitor metrics, traffic flow data, and heritage site capacity alerts. This enables proactive crowd management during peak seasons.

Localized and Agile Digitalization: Semarang showcases an emergent digital infrastructure model characterized by distributed smart utilities (such as automated drainage telemetry) and pervasive mobile-first marketing. While less centralized than Melaka's system, Semarang's approach leverages

high smartphone penetration and private digital wallets, offering a flexible template for emerging secondary destinations lacking large-scale federal smart-city budgets.

4.4. Governance Efficacy and the CHI Integration Model Application

Synthesizing these empirical insights through the Comparative Heritage Infrastructure (CHI) Integration Model (as visually mapped in Figure 1) demonstrates that destination competitiveness is not merely a function of heritage asset abundance, but of infrastructural synergy.

While Malaysia's statutory rigidity (Act 645) ensures high long-term asset preservation and structural order, Indonesia's decentralized public-private partnership model (Law No. 11/2010) offers speed and economic adaptability. Sustainable destination competitiveness is achieved only when macro-legal frameworks effectively bridge physical-green resilience with smart-digital visitor management. Without physical flood defense and pedestrian safety (as proven in Semarang) or smart visitor load balancing (as practiced in Melaka), historical districts inevitably suffer from structural degradation and diminished visitor satisfaction.

6. CONCLUSION

5.1. Conclusion

This study has systematically investigated the complex dynamics of heritage tourism infrastructure and digital transformation by conducting a rigorous qualitative comparative case study between Kota Lama Semarang (Indonesia) and the Historic City of Melaka (Malaysia). Grounded in the theoretical dimensions of destination competitiveness, adaptive reuse, and smart tourism, the research reveals that heritage tourism sustainability relies fundamentally on the harmonization of macro-legal frameworks, resilient physical-green engineering, and smart digital ecosystems.

The comparative analysis underscores a structural dichotomy between secondary and primary heritage hubs. While Melaka exemplifies an institutionalized, top-down governance model anchored by the National Heritage Act 2005 (Act 645) and centralized smart visitor dashboards, Kota Lama Semarang demonstrates an agile, market-driven revitalization model propelled by Public-Private Partnerships (PPGs/KPS) and Law No. 11 of 2010 on Cultural Heritage. Crucially, the empirical findings validate that secondary destinations must actively tackle structural vulnerabilities—such as coastal tidal flooding (*rob*) mitigation and legacy utility congestion—before achieving advanced digital maturity. By synthesizing these insights, the introduction of the Comparative Heritage Infrastructure (CHI) Integration Model provides a robust analytical lens for understanding how heritage destinations can successfully bridge infrastructural deficits and enhance long-term global competitiveness within the ASEAN region.

5.2. Policy Recommendations

Based on the empirical insights and the application of the CHI Integration Model, the following policy recommendations are proposed for urban planners, municipal authorities, and heritage management bodies:

1. Institutionalizing Hybrid Public-Private Governance: Emerging secondary heritage destinations (such as Semarang) should formalize hybrid governance structures that combine the speed and capital injection of Public-Private Partnerships with the stringent regulatory safeguards of national cultural heritage laws, preventing commercial over-saturation while encouraging economic vitality.

2. Integrating Climate Resilience into Tourism Master Plans: Coastal and low-lying historic districts must prioritize climate-adaptive physical infrastructure—such as integrated polder systems, raised pedestrian pathways, and underground utility networks—as core components of tourism master planning to safeguard cultural assets against environmental degradation.
3. Deploying Scalable Smart Visitor Ecosystems: Municipalities should adopt phased digital transformation strategies, transitioning from localized QR-code integrations to centralized real-time visitor management dashboards. This enables proactive crowd dispersal and protects sensitive heritage carrying capacities during peak tourist seasons.
4. Enhancing Cross-Border Regional Knowledge Exchange: ASEAN heritage cities should establish collaborative policy-sharing frameworks to exchange best practices regarding buffer zone regulations, adaptive reuse guidelines, and smart-green infrastructure financing, thereby elevating the overall quality of regional heritage tourism management.

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