

Sustainable Tourism Infrastructure and Digital Transformation in ASEAN: Borobudur and Destination Competitiveness

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ABSTRACT

Tourism infrastructure across ASEAN is expanding quickly, yet its quality, integration, and distribution of benefits remain uneven. This extended abstract compares how infrastructure is managed in selected ASEAN destinations, using Indonesia's Super-Priority Destinations, especially Borobudur, as anchor cases and Singapore as the regional benchmark. A qualitative comparative case design is applied to secondary data policy documents, regional strategic plans, academic studies, and teaching materials across five paired cases, which are analysed through three strategic dimensions: sustainable tourism, digital transformation, and destination competitiveness. The findings show that regional leaders excel in intermodal connectivity, data integration, and consistent service standards, whereas Indonesia's main strengths are its cultural and natural capital and its scale. Indonesia, however, still faces fragmented last-mile connectivity, uneven basic services, limited real-time data, and weak lifecycle financing. Borobudur illustrates both the promise and the risks of rapid investment: new gateways, a relocated trading area, and a single destination management model coexist with social resistance, concentrated benefits, and multi-authority complexity. The study proposes the Integrated Sustainable Tourism Infrastructure or ISTI Model, which links the three dimensions through collaborative governance, lifecycle financing, and an integrated data platform, with periodic evaluation as a feedback loop. Theoretical and policy implications for ASEAN are discussed.

Keywords: Tourism Infrastructure Management; ASEAN; Sustainable Tourism; Digital Transformation; Borobudur

1. INTRODUCTION

Tourism infrastructure encompasses transportation, accommodation, utilities, communications, sanitation, environmental management, and—increasingly important today—digital systems. Infrastructure is pivotal to such development and organization, covering aspects such as accessibility, waste management, and other supporting facilities (Kuntariningsih 2026:31). This infrastructure determines accessibility, comfort, and safety, while directly influencing visitor satisfaction and the destination's image (Inskeep, 1991). In the ASEAN region, tourism is a strategic sector for job creation, foreign exchange earnings, and regional integration; the region is currently striving to establish a more robust and interconnected tourism system through the ASEAN Tourism Strategic Plan.

Three pressures make the transformation of ASEAN tourism infrastructure urgent. **First**, visitor flows are concentrated in popular places and seasons, which creates overcrowding, environmental load, and risks to heritage. **Second**, data and services are still fragmented, so destinations cannot manage visitors or maintain assets using real-time evidence. **Third**, countries compete on integrated experience rather than on attractions alone. Singapore and Malaysia lead in transport connectivity and technology readiness, Indonesia and Thailand lead in accommodation capacity because of their visitor volumes, and the CLMV countries (Cambodia, Laos, Myanmar, Vietnam) are improving fast on sustainability indicators while still struggling with basic infrastructure.

Borobudur makes these pressures visible. It is a UNESCO World Heritage Site and one of Indonesia's five Super-Priority Destinations, and its infrastructure has been upgraded through new gateways, water and waste systems, homestay improvement, and the Kampung Seni trading area. At the same time,

authority is divided by zone and asset ownership under Presidential Regulation 101/2024, vendors have been relocated with considerable friction, and economic benefits remain concentrated near the temple. These conditions raise the study's central question: *how can ASEAN destinations manage infrastructure so that it is simultaneously sustainable, digitally integrated, and competitive?*

The study addresses three research questions: (RQ1) How do ASEAN destinations differ in infrastructure management across the three strategic dimensions? (RQ2) What does the Borobudur case reveal about their interaction? (RQ3) What integrated model can guide policy and management? The contribution is a comparative, governance-sensitive framework that treats the three dimensions as one system rather than as separate agendas.

2. LITERATURE REVIEW / THEORETICAL FRAMEWORK

Grand theories. The study rests on four complementary theories. (1) *Sustainable tourism and the triple bottom line* (Elkington, 1997) require infrastructure to balance environmental, social, and economic outcomes; the Tourism Area Life Cycle (Butler, 1980) and the carrying-capacity concept explain why unmanaged growth erodes a destination's quality. (2) *Destination competitiveness theory* (Ritchie & Crouch, 2003; Dwyer & Kim, 2003) treats infrastructure as a supporting factor that enables attractions to be experienced and sold. (3) *Smart tourism* (Gretzel et al., 2015) highlights the role of data, connectivity, and interoperable services in co-creating visitor experience and supporting management decisions. (4) *Stakeholder theory and collaborative governance* (Freeman, 1984; Jamal & Getz, 1995) explain why multi-actor destinations need shared rules, forums, and participation.

Previous research. Classic planning studies define infrastructure components and planning stages (Inskip, 1991). Heritage-tourism research focuses on conservation and visitor management. Smart-tourism studies concentrate mainly on cities. Borobudur-specific studies discuss vendor relocation, community participation, and the uneven distribution of tourism benefits among surrounding villages. **Research gap:** these streams rarely meet. Few studies compare ASEAN destinations across sustainability, digitalisation, and competitiveness at once, and fewer still add governance and lifecycle financing as binding conditions. This study fills that gap.

3. RESEARCH METHOD

The study uses a **qualitative comparative multiple-case design**. Five Indonesian destinations are paired with Singapore benchmarks: Borobudur–Singapore heritage districts (Chinatown, Little India, Kampong Gelam); Bali–Singapore integrated resorts (Marina Bay, Sentosa); Labuan Bajo–Singapore cruise hub; Mandalika–Singapore Sports Hub; and Lake Toba–Singapore smart tourism. A regional overview of ten ASEAN countries provides context. Pairing was chosen because each pair shares a tourism product type, which allows differences in infrastructure management to be interpreted.

Data sources are secondary: official regulations and agency publications, the ASEAN Tourism Strategic Plan, UNESCO and UNWTO materials, national statistics, academic studies, and advanced tourism infrastructure management course materials. **Analysis** proceeds in three steps: (a) cross-case comparison on nine indicators (access, transport, visitor flow, conservation or environment, amenities, community involvement, data and digital services, coordination, and financing); (b) a simple gap analysis, *Infrastructure Gap* = *Peak Demand* – *Existing Capacity*, applied to parking, toilets, water, waste, shuttles, and health and security services; and (c) thematic synthesis that groups findings under the three strategic dimensions and builds the conceptual model. Triangulation across official, academic, and media sources supports validity.

Limitations of design. No primary survey was conducted, Singapore is a city-state and not a like-for-like comparator, and capacity values are indicative until verified in the field.

4. RESULTS

1.1 ASEAN overview

The regional comparison shows three broad profiles. **Connectivity and technology leaders** (Singapore, Malaysia) integrate transport, information, and service standards. **Volume and capacity leaders** (Indonesia, Thailand) have large accommodation stock and visitor numbers but face distribution and quality gaps. **Fast-improving CLMV countries** are advancing on sustainability but still need basic infrastructure. Indonesia is therefore often described as having the greatest potential rather than the greatest readiness: its challenge is turning scale and diversity into integrated, well-maintained systems.

1.2 Paired-case comparison

Table 1. Paired comparison of Indonesian destinations and Singapore benchmarks

Pair (dimension)	Indonesian destination	Singapore benchmark	Key lesson
Borobudur vs heritage districts (Sustainability)	Road-based access; last-mile and public transport need strengthening; one-way routes and restricted temple access; reservation system still developing; amenities and signage need upgrading.	Integrated with MRT and bus; clear wayfinding; routine heritage maintenance under strict standards; multilingual signage and information.	Apply visitor zoning and quotas for peak season; build low-emission last-mile transport; share benefits clearly with local communities.
Bali vs integrated resorts (Competitiveness)	Dispersed attractions; congestion, water stress, waste, land conversion, and coastal erosion; fragmented coordination across local governments.	Compact, walkable integrated resorts; water recycling (NEWater); centralised waste treatment; single coordination between government and operators.	Strict zoning in vulnerable areas; minimum standards for water, waste, and energy; integrated public transport from airport to destinations.
Labuan Bajo vs cruise hub (Sustainability)	Growing airport and marina, but limited for large vessels; ecosystem pressure from overtourism; economic leakage to outside players.	Global air-sea-land integration; standardised operators; strong enforcement and monitoring.	Carrying-capacity quotas, operator standards, integrated digital ticketing, and stronger local MSME supply chains.
Mandalika vs Sports Hub (Competitiveness)	Large circuit venue, but last-mile access and shuttle integration are weak; congestion at peak events; under-used facilities off-season.	Multi-venue hub linked to MRT; international crowd-safety protocols; year-round event calendar.	Event-mobility plan (shuttles, integrated parking), diversified calendar, local workforce training, and benefit indicators.
Lake Toba vs smart tourism (Digital)	Uneven network quality; scattered information with little real-time data; limited online reservation and digital payment; analytics limited.	5G/fibre coverage; official real-time platforms; widespread cashless payment; sensors and data-driven decisions.	Cross-district data platform, real-time digital maps, water-quality indicators, inclusive payment, and digital literacy for local businesses.

Source: author's synthesis of the *Advanced Tourism Infrastructure Management* teaching materials (Kuntariningsih, n.d.) and the Borobudur paper.

1.3 Three strategic dimensions

Dimension 1: Sustainable tourism. Across the pairs, sustainability depends on managing demand and not only on building supply. Singapore uses strict spatial limits, water recycling, and

routine maintenance; Indonesian destinations face pressure on water, waste, and land at popular sites. The consistent lesson is to combine carrying-capacity monitoring, zoning, reservation or quota systems, and minimum national standards for water, sanitation, safety, and accessibility.

Dimension 2: Digital transformation. Digital readiness differs more sharply than physical capacity. Benchmarks provide real-time information, integrated ticketing, and cashless payment, which support both visitor experience and management analytics. Indonesian destinations hold data in separate systems and have uneven networks, particularly in villages. The lesson is not to copy Singapore's

technology but to adapt it: a shared data platform, simple real-time information, and inclusive payment options (including QR and e-wallets), combined with digital-literacy training for local businesses.

Dimension 3: Destination competitiveness. Competitiveness comes from integration: airport–port–road links, last-mile access, standardised service quality, and an event and product calendar that uses facilities all year. Weak last-mile links and uneven service standards reduce the value of Indonesia’s strong attractions. Local supply chains and MSME partnerships determine whether competitiveness also generates local benefit.

1.4 Borobudur in depth

Borobudur combines all three dimensions in one place. Presidential Regulation 101/2024 divides the temple complex into Zones 1–5 and applies single destination management through PT TWC, while asset ownership and local government authority remain distributed. Infrastructure already delivered includes four regional gateways, a drinking-water system serving 12 buffer villages, waste facilities (TPS3R) in 12 villages, the improvement of 821 homestay units, and Kampung Seni Borobudur with 1,943 kiosks. A further trading area, Kampung Seni Kujon (10.74 ha, 2,061 planned kiosks), is intended to move kiosks and parking out of Zone 2 to protect the heritage buffer.

Table 2. Borobudur evidence by strategic dimension

Dimension	Evidence	Remaining gap
Sustainability	Relocation of kiosks and parking from Zone 2 (8.4 ha) to Zone 3 to lower building coverage in the buffer zone; water and TPS3R systems in 12 villages.	Vendor resistance and limited information; benefits concentrated near the temple; need for peak-day carrying-capacity control.
Digital transformation	Digital ticketing and Pasar Digital Menoreh as an MSME platform; Kampung Seni used as the main entrance with EV or pedestrian access during Waisak 2025.	Health, education, and security data are not yet integrated; no public real-time dashboard or complete GIS database; field verification needed.
Competitiveness	Four gateways, link to Yogyakarta International Airport (about 45 minutes), strong event demand; a 14.71% rise in aircraft movements at the airport during the 2025 Waisak holiday.	Last-mile and public transport; peak and event mobility; uneven benefits among villages; integration of the customer journey from gateway to Zone 1.

Source: Borobudur group paper (Kelompok 7, 2026), based on official documents and media reports.

The Borobudur experience yields a key insight: the same investment can be positive or negative depending on how the three dimensions interact. Relocation supports conservation but needs transparent communication and participation to avoid social conflict. A new entrance makes the customer journey smoother only if parking, ticketing, shuttles, toilets, and emergency routes are planned together. Infrastructure should therefore be assessed with the demand–capacity gap under three operating conditions: normal day, peak day, and special event, and gate or facility functions should be mapped separately for each scenario.

1.5 Cross-cutting findings

- **Fragmented last-mile and intermodal links** appear in Borobudur, Bali, Mandalika, and Labuan Bajo.
- **Fragmented data and weak real-time monitoring** limit quota enforcement, event management, and maintenance planning.



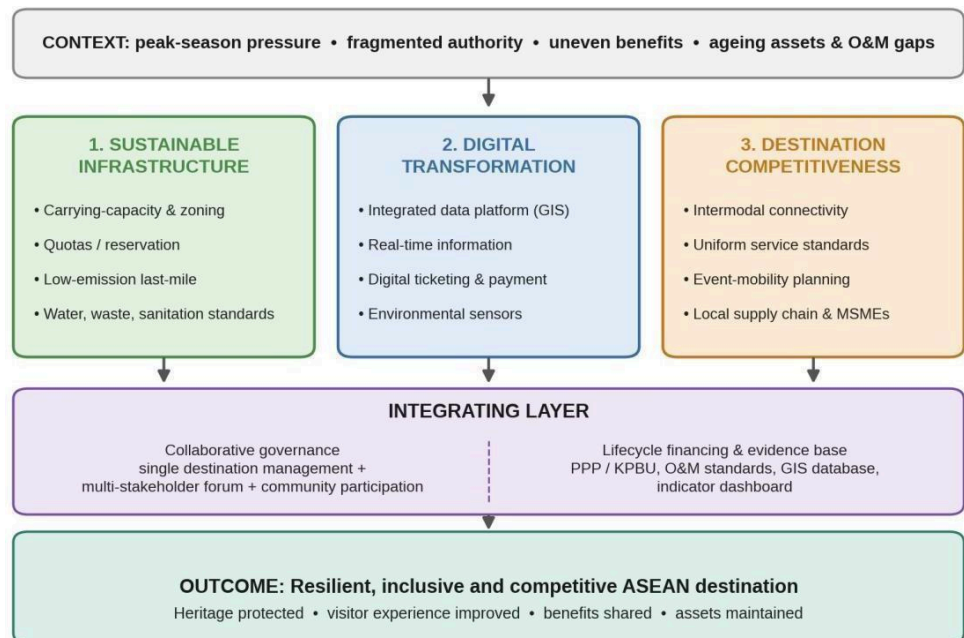
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- **Governance and financing gaps** (multiple authorities, unclear participation, and weak operation and maintenance funding) undermine the value of physical assets.
- **Local benefit is not automatic.** Without supply-chain partnerships and fair benefit sharing, infrastructure investment can concentrate gains and create conflict.



2. Proposed Conceptual Model

Based on these findings, the study proposes the **Integrated Sustainable Tourism Infrastructure (ISTI) Model** (Figure 1). The model starts from contextual pressures (peak-season demand, fragmented authority, uneven benefits, and ageing assets). Three strategic pillars respond: sustainable infrastructure, digital transformation, and destination competitiveness. They are bound together by an **integrating layer**: collaborative governance (single destination management plus a multi-stakeholder forum and community participation) and lifecycle financing supported by an evidence base (PPP schemes, operation and maintenance standards, a GIS database, and indicator dashboards). The intended outcome is a resilient, inclusive, and competitive destination. Periodic evaluation (quarterly for operational readiness, annual for physical and budget progress, five-yearly for the overall map) feeds back into the gap analysis.



Feedback loop: quarterly / annual / five-year evaluation updates the gap analysis (Demand – Capacity) and the infrastructure map

Figure 1. Integrated Sustainable Tourism Infrastructure (ISTI) Model

The model generates four propositions for future testing:

- **P1.** Demand-management tools (zoning, quotas, reservation) strengthen the effect of physical infrastructure on conservation outcomes.
- **P2.** An integrated real-time data platform improves visitor management and maintenance decisions.
- **P3.** Intermodal and last-mile integration raises competitiveness more than additional attraction capacity alone.
- **P4.** Collaborative governance and lifecycle financing moderate the relationship between the three pillars and local benefit.

5. DISCUSSION

Theoretical implications. The study extends destination competitiveness and smart-tourism theory by showing that infrastructure value depends on governance and financing conditions, and

it links sustainability, digitalisation, and competitiveness in one framework applicable to heritage destinations in emerging economies. It also suggests that benchmarking against advanced systems should lead to *contextual adaptation*, not imitation

Policy and managerial implications.

- **National governments:** set minimum service standards (water, sanitation, safety, accessibility) for all priority destinations, and build a national tourism data platform.
- **Destination managers:** apply quota, zoning, and time-slot systems; prepare scenario plans for normal, peak, and event days; and adopt lifecycle budgeting that funds operation and maintenance.
- **Local governments and communities:** institutionalise multi-stakeholder forums, transparent information on relocation or development, and local procurement and training programmes.
- **ASEAN level:** harmonise basic infrastructure standards, share tourism data and good practice, and support cross-border connectivity, particularly for CLMV countries.

6. CONCLUSION

ASEAN destinations are converging on the need for infrastructure that is sustainable, digitally integrated, and competitive, but the capacity to deliver differs widely. Singapore's strengths lie in integration, standards, and data, while Indonesia's lie in cultural and natural capital and scale. Borobudur shows that physical upgrades alone are not enough: conservation, social acceptance, mobility, and benefit sharing must be planned together. The ISTI Model offers a practical structure for doing so, with collaborative governance, lifecycle financing, and continuous evaluation as the glue.

Limitations and future research. The study relies on secondary data and a single regional benchmark. Future work should (a) include Thailand, Malaysia, Vietnam, and other ASEAN destinations; (b) collect primary data through field observation, stakeholder interviews, and visitor surveys; (c) build a spatial (GIS) database to quantify demand–capacity gaps; and (d) test propositions P1–P4 using mixed methods.

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