SMART DESTINATION MANAGEMENT: AI INTEGRATION FOR TOURIST MOBILITY AND HOTEL ENERGY EFFICIENCY

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Abstract: This paper explores the integration of artificial intelligence in urban tourism, linking mobility optimization with hotel energy management. It proposes the AI-SFUT framework, highlighting how AI-driven systems enhance sustainability, reduce energy consumption, and improve tourist experience, contributing to more competitive and resilient smart tourism destinations.
Keywords: Artificial Intelligence; Smart Tourism; Urban Mobility; Hotel Energy Management; Sustainability

1. Introduction

The global tourism industry is entering a new growth phase. According to the UN Tourism World Tourism Barometer [1], international tourist arrivals reached 1.4 billion in 2024, an increase of 11% over 2023, marking the full recovery of international tourism from the pandemic crisis (99% of pre-pandemic levels). In 2025, arrivals reached a new post-pandemic record of 1.52 billion, a further 4% increase over 2024, with international tourism receipts estimated at USD 1.9 trillion globally [2]. Despite sustained growth, the accommodation sector faces mounting obligations under the European Green Deal, with HVAC systems accounting for 40–60% of total hotel energy consumption [3], [4].

Smart cities are increasingly recognized as the natural environment for next-generation tourism. The integration of AI, IoT sensors, digital twins, and large language models creates unprecedented opportunities for destination managers and accommodation operators. Vujko et al. [5], surveying 1,239 tourists across Amsterdam, Barcelona, and Vienna, identify three dimensions of smart city tourism performance: smart efficiency (mobility and trip planning), smart travel (experiential quality), and digital enhancement (personalized services). Their SEM analysis confirms that smart efficiency positively influences smart travel quality with a path coefficient of 1.602.

Generative AI (GenAI) is restructuring how visitors interact with destinations. Florido-Benítez and Coca-Stefaniak [6] propose aerotainment, a holistic model linking airports, theme parks, regional attractions, and urban destinations into a single GenAI-augmented ecosystem. Their Urban Tourism Destination Pyramid classifies cities from those with deficient transport to those deploying fully personalized, phygital visitor journeys.

The systematic review by Aghili et al. [4], covering 249 peer-reviewed publications, confirms that AI-driven control strategies reduce energy consumption by up to 40%, primarily through deep reinforcement learning (DRL), artificial neural networks (ANN), and LSTM models applied to HVAC management. Takuli et al. (2025) report a 25% reduction in average daily energy consumption following AI implementation, together with a 43.75% improvement in Energy Efficiency Ratio (EER) and 28% reduction in CO_2 emissions.

Despite accumulating evidence, tourist mobility and hotel energy management are treated as distinct academic domains. This fragmentation motivates the present study's integrative approach, which proposes an AI Sustainability Framework for Urban Tourism (AI-SFUT) treating smart mobility and hotel energy efficiency as co-dependent dimensions of a single urban tourism sustainability system.

2. Literature Review

Contemporary smart tourism or 'Smart Tourism 2.0' [7], encompasses AI assistants, autonomous vehicles, digital twins, and extended reality applications. Florido-Benítez and Coca-Stefaniak [6] reconceptualize destinations as nodes within a GenAI-enabled ecosystem, with their Urban Tourism Destination Pyramid classifying cities from low-accessibility to fully AI-enhanced destinations. Empirical support from Hu et al. [8] (2024), covering 297 Chinese cities over 2000 - 2021, confirms that smart city designation increases tourism revenue by 24.3% and arrivals by 17.2%, with effects strengthening as infrastructure matures. In the European context, Vujko et al. [5] (2025) find that interactive experience ($\beta = 0.977$) and instant information access ($\beta = 0.941$) are the highest-impact dimensions of smart travel satisfaction.

Regarding hotel energy management, HVAC systems account for 40-60% of total hotel energy use [3]. AI-powered predictive EMS integrate IoT sensor data, weather APIs, and booking systems to anticipate rather than react to energy demands. Deep reinforcement learning (DRL) achieves 30-40% energy savings in controlled studies, while LSTM networks excel at multivariate time-series demand forecasting [9]. Despite progress, the two domains, urban mobility and hotel energy, have developed in relative isolation, leaving city-level visitor flow data as an underutilized asset for hotel EMS optimization. This integration gap motivates the AI-SFUT framework proposed herein.

3. Methodology

This study adopts a secondary data analysis design integrated within a systematic conceptual synthesis. Secondary analysis is appropriate when the objective is identifying patterns and building theoretical frameworks from existing evidence [10]. The research proceeds through three stages: (1) systematic review of empirical literature on AI in tourism mobility and hotel energy management; (2) comparative secondary data analysis; and (3) inductive framework construction.

Primary empirical anchors are Florido-Benítez and Coca-Stefaniak (2025), Vujko et al. (2025), Aghili et al. (2025), and Takuli et al. (2025). These are complemented by Eurostat 2023 energy consumption data for the accommodation sector, UN Tourism World Tourism Barometers (January 2025 and January 2026), Fortune Business Insights (2025) market intelligence.

Data from these sources were synthesized using a structured comparison matrix organized around three analytical dimensions: (a) AI application type, (b) documented performance outcomes, and (c) sustainability implications. The AI-SFUT framework was constructed by mapping relationships between AI applications, mobility outcomes, energy outcomes, and sustainability performance indicators.

4. Results

The smart tourism market was valued at USD 813.7 million in 2025 and is projected to reach USD 2,848 million by 2034 (CAGR: 15.0%), with transportation and mobility services holding the largest market revenue share [11]. International tourist arrivals reached a new record of 1.52 billion in 2025 (+4% over 2024), with tourism receipts estimated at USD 1.9 trillion globally [2]. Europe alone welcomed 793 million international tourists in 2025, a 4% increase over 2024. Extrapolated to the European accommodation sector, which consumed 253 PJ in 2023 [12], AI-driven efficiency gains of 25-40% could yield annual savings of 63–101 PJ, equivalent to the total energy consumption of a mid-sized European country.

The SEM analysis of Vujko et al. [5], conducted across Amsterdam, Barcelona, and Vienna, reveals smart efficiency as the dominant influence on smart travel perception ($\beta = 1.602$), confirming that operational AI infrastructure is foundational to tourist satisfaction. Interactive experience ($\beta = 0.977$) and instant access to information ($\beta = 0.941$) emerge as the highest-impact dimensions, while the digital enhancement paradox ($\beta = -1.266$) indicates that technological complexity without integration reduces rather than enhances satisfaction.

HVAC AI performance metrics are presented in (Tab. 1), based on Takuli et al. [3] and Aghili et al. [4].

Tab. 1

Performance Metric	Before AI	After AI	Change
Daily Energy Consumption	1,200 kWh	900 kWh	**-25%**
Peak Energy Demand	250 kW	180 kW	**-28%**
Energy Efficiency Ratio (EER)	8.0	11.5	**+43.75%**
HVAC Runtime (hours/day)	12 hrs	8 hrs	**-33%**
Guest Comfort Score	7.0 / 10	9.0 / 10	**+28.6%**
CO_2 Emissions (kg/day)	250 kg	180 kg	**-28%**
Response Time to Changes	60 min	15 min	**-75%**
Forecast Accuracy	70%	90%	**+28.6%**

A critical finding concerns the direct relationship between tourist mobility patterns and hotel energy demand. Takuli et al. [3] demonstrate that 90% occupancy produces 1,500 kWh daily consumption versus 800 kWh at 50% occupancy, while festival events at 95% occupancy reach 1,600 kWh. This occupancy-energy nexus confirms that hotel EMS systems integrating city-level mobility data outperform those relying solely on in-property sensors.

5. The AI-SFUT Framework

Building on the empirical patterns in Section 4, we propose the AI Sustainability Framework for Urban Tourism (AI-SFUT), organized around three interconnected layers and three feedback loops (Fig. 1). Layer 1 - Urban AI Infrastructure - comprises IoT sensor networks, data integration platforms, GenAI/LLM applications, digital twins, and smart grid infrastructure.

Layer 2 - Operational Optimization - translates infrastructure capability into improvements across tourist mobility management (predictive demand forecasting, real-time rerouting, GenAI itinerary personalization, DMO capacity management) and hotel energy efficiency (HVAC predictive control via DRL, occupancy data integration from city platforms, LSTM consumption forecasting, FDD predictive maintenance). Layer 3 - Sustainability Outcomes - captures the measurable results: environmental (energy savings 25–40%, CO_2 reduction 28%), economic (+24.3% tourism revenue, +17.2% arrivals, EER +43.75%), and socio-experiential (guest comfort 7.0→9.0/10, interactive experience β = 0.977).

Three dynamic feedback mechanisms connect the layers. The Mobility-to-Energy Loop uses real-time visitor flow data from urban AI platforms to inform hotel occupancy predictions, enabling proactive HVAC management; aggregated hotel energy data then feeds back into urban smart grid optimization. The Experience-to-Adoption Loop captures how positive tourist experiences generate demand for further digital investment (path coefficient 0.504, [5], sustaining a virtuous investment cycle. The Data-Quality-to-Performance Loop explains why smart city effects strengthen over time [8]: as platforms mature and data quality improves, model accuracy improves, producing better operational outcomes and richer training data for next-generation systems.

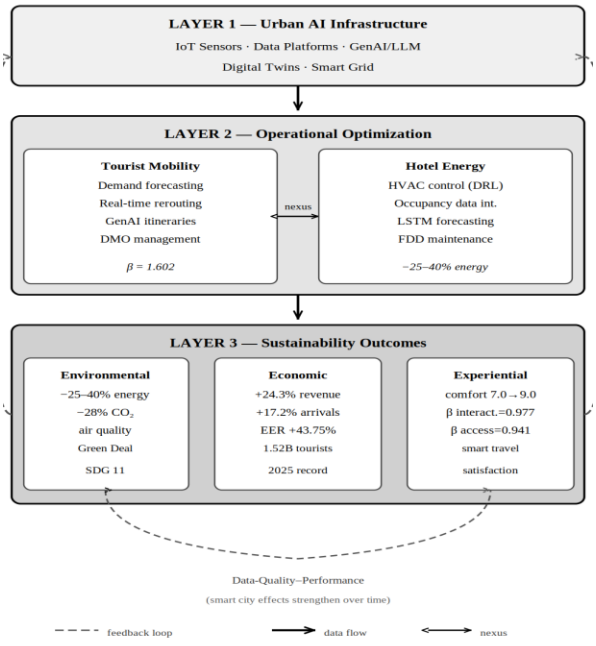


Fig. 1. AI-SFUT Framework: three layers and three feedback loops.

6. Discussion

The AI-SFUT framework has direct practical implications across three actor groups. For DMOs, the priority should be reconceptualizing their role as data governors: establishing data-sharing agreements with accommodation operators, enabling hotel EMS systems to access real-time visitor flow predictions, is a high-leverage, low-cost intervention currently unsupported by most urban governance arrangements. Investments should prioritize interactive experience and instant access dimensions, identified as highest-impact by Vujko et al. [5]. The digital enhancement paradox cautions against technological complexity: integration and simplicity outperform multiplication of digital touchpoints.

For hotel operators, the 43.75% EER improvement [3] provides a compelling financial case for AI HVAC investment independent of sustainability motivation. Priority should go to EMS systems capable of integrating external data sources, particularly in high-seasonality destinations where occupancy volatility is greatest. For policymakers, mandating interoperability between hotel BMS systems and city-level smart platforms would reduce data silos preventing the mobility-to-energy feedback loop. Explainable AI (XAI) frameworks should be incorporated from the design stage to build public trust in AI-driven urban management systems, addressing the black-box limitation noted by Aghili et al. [4].

7. Conclusions

This paper has established five principal conclusions. First, AI-driven mobility optimization delivers measurable tourist satisfaction improvements, with interactive experience (β = 0.977) and instant information access (β = 0.941) as highest-impact dimensions. Smart city designation correlates with +17.2% tourist arrivals and +24.3% revenue.

Second, AI-powered HVAC management achieves 25-40% energy savings, simultaneously improving guest comfort from 7.0 to 9.0/10 and reducing CO_2 by 28%. The Energy Efficiency Ratio improved by 43.75%.

Third, the occupancy-energy nexus is a critical and underexplored link: hotel EMS integrating city-level mobility data theoretically outperform property-only systems. Fourth, the AI-SFUT framework provides an integrated structure for managing these interdependencies through three layers and three reinforcing feedback loops. Fifth, the digital enhancement paradox cautions that technological complexity without integration reduces rather than enhances tourist satisfaction.

These findings support alignment with EU Green Deal targets and SDG 11. Future research should pursue longitudinal validation of the AI-SFUT framework, experimental tests of the mobility-to-energy integration hypothesis, and equity implications of AI-driven smart tourism for digitally excluded visitor segments.

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