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The Influence of Smart Infrastructure, Cultural Heritage Preservation, and Green Mobility on Urban Sustainable Tourism Development: The Mediating Role of Tourist Satisfaction

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KEYWORDS
SDG 11; SDG 12; Green Mobility; Smart Infrastructure; Cultural Heritage Preservation; Tourist Satisfaction; Urban Sustainable Tourism Development; Malaysia; China

ABSTRACT

This paper investigates the multidirectional nature of the relationship between smart infrastructure, preservation of cultural heritage, and green mobility in the context of sustainable tourism development in the city, with the mediating variable being the tourists' satisfaction. This paper draws on the Sustainable Development Theory and the Triple Bottom Line to examine the relationship between the elements and Sustainable Development Goals (SDGs) 11 and 12, and how they contribute to sustaining a sustainable and inclusive tourism ecosystem. This paper employed a quantitative research design, in which a structured questionnaire was administered online to 252 Chinese students studying in Malaysia who are all experienced urban tourists in both China and Malaysia. Adapted constructs were those based on a proven scale, with a five-point Likert scale, and PLS-SEM was the means of analysis. A measurement reliability and validity test, a structural relationship test, and a mediation effect test were measured by the results of the analysis through bootstrapping. As the results suggest, the slight or non-significant effect of smart infrastructure and cultural heritage preservation on tourist customer satisfaction and sustainable outcomes is noticed. Relative to this, green mobility is a highly strong driver in shaping tourist satisfaction, not to mention urban sustainable tourism planning, which is why it ought to be central in creating sustainable urban destinations. This study is relevant to the discussion of sustainable tourism, as it emphasizes the importance of considering the ecologically friendly movement and integrating IoT technologies into tourist-focused solutions, while also revitalizing cultural heritage through new forms of communication.

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1.0 INTRODUCTION

The concept of sustainable urban tourism has become a crucial component of tourism on a global scale, which facilitates economic growth, cultural exchange, and social liveliness on the urban scale [1][2]. Nevertheless, the increasing popularity of urban tourism has also sparked the debate of sustainability, with symptoms such as environmental degradation, diminished culture, and congestion of the city [3][4]. These challenges also lead to the regular development of sustainable urban tourism as a priority policy and research topic in response, which is shown in the United Nations Sustainable Development Goals (SDGs), i.e., SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production) [5][6][7]. Cities in every region of the world are being urged to work towards putting in place plans that would allow them to achieve economic benefits without losing sight of environmental values and cultural preservation, but on the need to ensure that tourism is being used as a tool for long-term urban sustainability [2][8].

Three areas that can be termed as essential agents of change in the context of sustainable urban tourism in the context of the current study include smart infrastructure [9], cultural heritage conservation, and green mobility [10][11][12]. A combination of these factors forms a whole idea of how sustainable city planning and tourism should be developed, not only based on the tangible and technological characteristics of the urban ecosystem but further into the cultural and ecological value upon which tourism can also be popular [9][13][14]. Interestingly, even though these strategies form a central part of the policymaking process, the mediating effect of tourist satisfaction has been the mitigating factor in determining whether visitors will revisit the destinations and promote the destinations in a sustainable manner [15][16][17][18].

Smart infrastructure has become an inevitable element of the contemporary urban environment as it welcomes digital technologies, intelligent transport facilities, and digital control to become effective and improve touristic experiences [19][20]. In terms of urban tourists, smart infrastructure implies that informational accessibility, access to comfortable mobility, access to security, and services without interruptions and disruptions are available [9][21]. Research in the tourism literature and, simultaneously, the literature on the topic of service quality reveal that the well-developed infrastructure services have a profound impact on the perception of convenience and trust that, in turn, positively influence the satisfaction [22][23][24]. Regarding the environmental perspective, smart infrastructure can not only enhance tourist experience better, but also reduce the waste resources, optimize flows in cities, and remove adverse social effects on the environment [25], hence, contributing to SDG 11 and SDG 12 [26][27].

Another sustainable urban tourism pillar is cultural heritage preservation [28]. Cultural heritage cities are also known to possess large quantities of cultural landmarks, traditions, and heritage properties that attract people from around the globe [29][30]. Not just by maintaining the authenticity and uniqueness of destinations, but also by strengthening the identity of the community and their social unity [31][32], preserving these cultural assets. Nevertheless, the commercialization and overuse of heritage sites usually jeopardize the integrity of these sites [33][34]. The inclusion of cultural preservation in the development of urban tourism will guarantee that tourism not only fails to erode cultural resources but will also make them available to the future generations [35][36]. To the tourists, the presence of intact heritage sites enhances their experience and boosts satisfaction as well as increases their tendencies of participating in sustainable practices, including buying local crafts and adhering to cultural expectations [2][15][24].

Green mobility, in the meantime, has become a revolutionary idea to lessen the environmental impact of city tourism [37]. Congestion, pollution, and carbon emissions are some of the problems that urban destinations encounter, and are compounded by large inflows of tourists [38][39]. Enhancing green mobility that includes environmentally friendly transport, cycling trails, walking areas as well as electric vehicles offers a long-term solution to the urban mobility requirements [40]. The green mobility not only decreases adverse environmental impacts, but it also creates added value to the tourist experience that offers healthier, safer, and live transportation [41]. Tourism, service,

and management literature have highlighted that tourists are attracted to destinations that offer convenient and sustainable access through clean transport, which is a positive effect on their satisfaction levels and revisit motivation [42]. Furthermore, green mobility policies fall under the broader urban agenda, which includes the accomplishment of the lower emissions levels, resource saving and resilient cities according to the SDG 11 [43].

This study has four objectives. First, it aims at investigating the direct impact of Smart Infrastructure (SI), Cultural Heritage Preservation (CHP), and Green Mobility (GM) on Urban Sustainable Tourism Development (SUTD). Second, it will evaluate the influence of SI, CHP, and GM on the (Tourist Satisfaction) as the core solutions to the long-term sustainability. Third, it will examine the mediation aspect of Tourist Satisfaction as regards to the relationships between SI, CHP, GM, and SUTD by testing whether the perceptions of the tourists are like the potential mediating variable in the linkages among tourism and sustainable outcomes. Lastly, the research is expected to assess the direct influence of Tourist Satisfaction on Urban Sustainable Tourism Development, which reveals the significance of positive visitor experiences in relation to sustainable tourism development in cities.

Most of the literature tends to analyse infrastructure, heritage, or mobility independently, and then neglects how sustainability is influenced, negatively or positively, by multiple factors [11]. Moreover, few studies have explored the underlying mechanism that explains how these policies and strategies translate into sustainable outcomes [44][45]. Thus, this study provides an innovative and comprehensive framework in which technological, cultural, and environmental dimensions are integrated into a cohesive model of sustainability with the ultimate goals framed by the SDGs. Thus, the present model covers this new construct that only a handful of models on smart tourism and sustainable destinations have previously discussed, with additional empirical results that clarify how the tourists' assessment of policy and infrastructure positively influences their sustainable conduct [46]. Therefore, the present study's model widely expands the existing framework, creating a link between technology and visitor-focused sustainability, and contributing theoretical originality and practical implications to the model [11].

2.0 LITERATURE REVIEW

2.1 Theoretical Model

The theoretical framework of this study is rooted in Sustainable Development Theory and the Triple Bottom Line, while being also supported by the Service Quality Theory. Overall, this approach forms a comprehensive solution-oriented paradigm of development of sustainable urban tourism. Sustainable Development Theory argues that economic growth should be balanced with environmental protection and sociocultural well-being, aligning closely with the United Nations Sustainable Development Goals (SDG 11 and SDG 12) [47][48]. According to this principle, sustainable urban tourism requires integrative strategies that harmonize economic benefits, cultural preservation, and ecological stewardship [49]. Moreover, the integrationist principle of the Triple Bottom Line framework should include measurement of three sustainability dimensions, including economic, social, and environmental: all three are crucial for the successful employment of tourism in a long-term perspective [50]. Collectively, these dimensions form the holistic foundation of sustainable tourism development. However, while Sustainable Development Theory and the Triple Bottom Line establish and provide strength to the model at its micro-level justification, there is little to no evidence of how these dimensions may impact each other or tourists' demand for urban tourism [50]. Such integration occurs at the micro-sociocultural and perceptual level, for which the Service Quality Theory should be taken into consideration [46]. According to the service quality theory, the determinant of service consists of the person's familiar way to anticipate the future [24]. When integrated, these theories offer a framework in which urban sustainability is a result not only of smart

infrastructure or cultural policies but also of tourists' satisfaction, which converts these into longer-lasting habits and beliefs [33]. Therefore, the model proposes sustainable urban tourism as a system in which smart infrastructure, cultural heritage preservation, and green mobility have an impact on urban sustainability, both directly and indirectly, mediated through tourism satisfaction. This system advances theoretical discussions by examining how objective measures of sustainability interact with subjective tourists' experiences, which have not been adequately published.

2.2 SDG 11 and SDG 12

The Sustainable Development Goals, established by the United Nations, provide the world with a platform to make the process of globalizing tourism in a sustainable manner a reality [51]. Sustainable Development Goal 11 (SDG 11) recommends that cities should be inclusive, resilient, safe, and sustainable [52]. At the tourism level, this involves commissioning infrastructure, protecting cultural resources, and making them available both to the locals and the tourists [53]. SDG 12 (Responsible Consumption and Production) acknowledges the efficient utilization and use of resources and reduction of wastage and sustainable living, all of which intersevere with tourism in terms of promotion of eco-friendliness, support of heritage and green mobility [54]. To achieve both these objectives, urban tourism is well-placed to play its part in designing, managing, and consuming destinations [55]. As example, waste and congestion are decreased with smart infrastructure, intergenerational equity is promoted by cultural preservation, and the environmental footprint is decreased with green mobility [26]. Positioning urban tourism activities according to SDGs 11 and 12 is, therefore, not only a normative intervention but also a practical model to assess sustainability results.

2.3 Sustainable Urban Tourism Development

The urban sustainable tourism development is a concept that involves philosophies and practices that facilitate the establishment of a balanced relationship between the economic, social, and environmental sides of urban tourism [56]. Unlike rural or natural tourism, urban tourism is being incessantly embroiled with the case of infrastructure, urban identity, and urban livability [57]. The effect of an increase in tourism in urban centers is often characterized by congestion, environmental degradation, cultural commodification, and tenant poverty [3]. The sustainable urban tourism objective is to ensure reduced negative externalities and the maximisation of benefits to both the local people and visitors [56][58]. Researchers highlight that urban tourism sustainability needs to be approached in an integrated manner that incorporates a new approach to infrastructure planning, heritage preservation, and an environmentally friendly mobility system [56]. It will provide the cities with the opportunities not only to secure the promotion of tourist experiences but also preserve the cultural authenticity and sufficiently high ecological quality [59]. Furthermore, sustainable urban tourism is also concerned with not only policy actions but also the perception of such actions and their appropriateness to tourists [49][60]. The future likelihood of visitors adopting sustainable behavior, which can be achieved through the use of green transport or adherence to cultural values, is highly dependent on their overall satisfaction with the experience [11][61]. As such, the evolution of sustainable urban tourism is an issue that requires both administrative and behavioral changes, according to city-scale approaches and tourist attitudes [3][58].

Despite that, while prior frameworks in smart tourism and sustainable destination studies have surrounded digital innovation or environmental management in isolation [55][56], thus largely leaving sustainability studies and practice in a silo formation. Indeed, this study implies an innovative model of a unique approach that the smart infrastructure, cultural heritage preservation, and green mobility are vital components in a circular paradigm for the sustainable urban tourism ecosystem. Similarly, however, earlier models have mainly disregarded the behavioral and emotional possibilities of sustainability theory [58][61]. They have not linked physical networks with human-centered results from which the designed structure was studied in previous research. This structure thus introduces dual-style innovation, where conceptually, it connects technology, culture, and

ecology to urban tourism sustainability theory in a satisfaction-based mechanism, while empirically, it operationalizes this model through measurable constructs aligned with SDG 11 and SDG 12 [51][52], offering a broader generalizability and practical framework for sustainable urban policy and destination management [60].

2.4 Smart Infrastructure

The concept of smart infrastructure along the line of sustainable urban tourism development involves a complicated combination of all three spheres involving digital infrastructure, intelligent solutions, and creative advancement of urban areas that facilitate sustainable urban tourism, particularly in the domains of cultural preservation and contemporary facilities [26][62]. When it comes to tourism, smart infrastructure would include such factors as smart transport systems, internet-based information systems, smart buildings, and smart waste management [63]. The innovations enhance the experience of the tourists by providing travelers with seamless services, real-time information, and better safety [64]. At the same time, smart infrastructure can be an element that contributes to sustainability, with a smaller number of resources, reduced congestion, and enhanced mobility in cities [19][64]. Studies have shown that sustainable urban tourism destinations with smart infrastructure have more opportunities to attract more tourists, especially repeat tourists, due to the cultural preservation and convenience in accessibility to the destinations [65][66]. Regarding its sustainability, smart infrastructure is closely connected with SDG 11 and SDG 12 as it promotes optimal resource management and a sustainable city. Its functionality, however, is highly reliant on how well such systems are perceived and benefited by the tourists, and therefore, satisfaction is a vital process to tie infrastructure investments to sustainable tourism outcomes. Hence, proposed hypotheses as below:

H1: Smart Infrastructure has a significant positive effect on Tourist Satisfaction.

H2: Smart Infrastructure has a significant positive effect on Urban Sustainable Tourism Development.

2.5 Cultural Heritage Preservation

The preservation of cultural heritage describes the protection, confection and marketing of historical places, traditions and cultural activities in the urban cities [67][68]. Cities usually gain uniqueness and tourism interest through the cultural facilities, and because of this, preservation is effectively a major aspect of sustainable urban tourism [55]. Conservation of heritage means that tourism development should not cross the continuity, by eliminating authenticity, but the cultural identity remains intact to be experienced by the future generations [31]. People travelling are seeking more authentic cultural experiences, and having a well-preserved heritage leads to greater satisfaction with a sense of attachment to the past and traditions [69]. Preservation also results in social benefits in the sense of building community pride and enhancing intercultural dialogue [70]. Cultural preservation will further enhance inclusivity and responsible consumption of tourism as provided in SDGs 11 and 12 [71]. Nevertheless, preservation programs will be determined by the perceptions of visitors in terms of authenticity and accessibility [71]. Tourist satisfaction, therefore, is a central issue that leads to heritage conservation results in sustainability (loyalty, advocacy, conservation support, etc.) [72]. Hence, proposed hypotheses as below:

H3: Cultural Heritage Preservation has a significant positive effect on Tourist Satisfaction.

H4: Cultural Heritage Preservation has a significant positive effect on Urban Sustainable Tourism Development.

2.6 Green Mobility

Green mobility is a concept based on sustainable transportation that is aimed at reducing environmental degradation while increasing the sustainability and livability of cities, such as electric

transport, walking areas, bicycle access, and shared mobility [40][73]. Green mobility offers tourists convenience, as well as cleaner, safer, and healthier travel experiences [11]. Empirical evidence also indicates that sustainable mobility systems increase tourist satisfaction, by alleviating stress, congestion, and pollution when traveling [3][11]. Green mobility has a direct positive impact on the sustainability of the environment, as it helps decrease carbon emissions, become a responsible consumer, and meet the goals of SDG 11 [74]. It also increases the competitiveness of destinations by keeping pace with the increasing demand by tourists for environmentally conscious methods [75]. However, green mobility should be convenient and secure to be efficient because customers are highly sensitive to the contentment with service quality, which can govern their readiness to use these systems [76]. This study highlights that satisfaction has a mediating role in the relationship between green mobility efforts and sustainable urban tourism growth. Hence, proposed hypotheses as below:

H5: Green Mobility has a significant positive effect on Tourist Satisfaction.

H6: Green Mobility has a significant positive effect on Urban Sustainable Tourism Development.

2.7 Tourist Satisfaction as a Mediator

Tourist satisfaction is the psychological assessment of the experiences, showing how well the destinations can satisfy them or even fail in the expected way [69]. Satisfaction has been employed as a key driver of behavioral response in tourism literature in terms of loyalty, positive word of mouth, and its application in sustainable practices [22]. The application of this construct to sustainable urban tourism satisfaction offers the missing balance between infrastructural/policy interventions and long-term results [77]. In contrast to previous sustainability frameworks that treat satisfaction merely as an outcome variable, this study conceptualizes it as a mediating mechanism that translates technological, cultural, and environmental inputs into sustainable behavioral outputs [77]. This conceptual place fills a significant theoretical vacuum identified in prior work, where the authors largely failed to explain how smart infrastructure and cultural protection and mobility policy transformed tourists' perceptions and feelings into actual sustainable outputs [78]. An example of how this might work is that people who like smart infrastructure will tend to use it responsibly, whereas people who like heritage experiences will tend to respect the conservation work [77]. Likewise, green mobility gives rise to a higher propensity to choose a friendly transport mode repeatedly due to the positive feelings felt about it [78]. Therefore, satisfaction is not only an embodiment of immediate evaluation of tourists, but also when it is transformed into sustainable behaviors that promote urban sustainability agendas [78]. Theoretically, this mediating function corresponds to service-quality theory, which defines satisfaction as the cognitive-emotional link between perceived service attributes and long-term behavioral intentions [69]. Accordingly, satisfaction is both a judgmental parameter and a transformative variable that links service encounters with sustainable behavior, shaping the psychological center of the conceptual model [76]. As a result, in the context of this study, satisfaction is set as the central mediator in the relationship between urban policies, smart technologies, and destinations' sustainability performance. Such an approach justifies the reason for its role as a mediator rather than a moderator in the model. Hence, proposed hypotheses as below:

H7: Tourist Satisfaction has a significant positive effect on Urban Sustainable Tourism Development.

H8: Tourist Satisfaction mediates the relationship between Smart Infrastructure and Urban Sustainable Tourism Development.

H9: Tourist Satisfaction mediates the relationship between Cultural Heritage Preservation and Urban Sustainable Tourism Development.

H10: Tourist Satisfaction mediates the relationship between Green Mobility and Urban Sustainable Tourism Development.

Conceptually, tourist satisfaction is shown as a mediator, mainly because it is an internalized evaluative reaction that results from tourists' exposure to "objective" attributes, which include smart infrastructure, heritage preservation, and green mobility. In other words, however, these attributes function as antecedent causes that stimulate perceptions and feel perceptions, or rather account for service-quality evaluation, while satisfaction converts views into behavioural intentions or rather returns visiting occasions, substantiates behaviors, and pro-environmental selections. This causality order is shown as appropriate with the assistance-quality model, such as with the customer behavior framework, and hence supports the mediating model instead of a moderating one.

2.8 Development of Framework

Building on the preceding subsections, this study constructs an integrated conceptual framework linking Smart Infrastructure (SI), Cultural Heritage Preservation (CHP), and Green Mobility (GM) to Urban Sustainable Tourism Development (SUTD) through Tourist Satisfaction (TS) as a mediating variable within a single, SDG-aligned framework. Crucially, by placing Tourist Satisfaction at the center as a mediating mechanism, the model explains how objective system changes translate into human-centred, pro-sustainability behaviours. This conceptual integration and its empirical operationalization (measured via Likert constructs) distinguish this study from prior models that rarely connect technology, culture, and behaviour in a single mediational framework. The theoretical model proposed here bridges between Sustainable Development Theory, the Triple Bottom Line, and Service Quality Theory, and may serve as a guide to connect macro-level sustainability goals with micro-level experiential evaluations. While several earlier models emphasized the infrastructural or environmental determinants of sustainability, this framework uniquely articulates technological innovation, cultural conservation, and ecological mobility into a single integrated system. The role of Tourist Satisfaction as the psychological mediator connecting the three dimensions allows the conversion of improvements in objective infrastructure, heritage, and mobility to subjective evaluation of value and responsibility, encouraging repeated visitation, advocacy, and environmentally valid behavior. In theory, thus, the model contributes to existing smart-tourism discourse by shifting the analytical aversion from technology-dependent efficiency to visitor-based sustainability. In practice, it allows this study to contribute to the literature by focusing on the mediating mechanism of satisfaction across sustainability dimensions, providing comprehensive evidence on how tourist experiences may perform SDG 11 and SDG 12 at the city level. The integrated model proposed here contrasts with earlier models in several essential ways. Figure 1 shows how infrastructural, cultural, and environmental dimensions are combined into the single shooting analysis, responding to the prior fragmentation of studies focused on any of the elements separately. Second, by including tourist satisfaction as the mechanism of mediation, the model provided a bridge between external interventions and internal psychological outcomes, answering the methodology gap. Thus, the twofold contribution, namely, the theoretical integration and the empirical validation, serve as theoretical and empirical novelty; whereas theoretically, this model develops sustainability theory, as satisfaction as a mediator translates service experience into pro-sustainability behavior; and empirically, the resulting constructs of this hypothesis become quantifiable categories to be measured by Likert-scale instruments and serve as the means of evaluation and basis for policy in urban tourism development. As a result, the proposed framework not only bridges theoretical gaps identified in prior research but also delivers a replicable model for policymakers seeking to balance urban modernization with cultural integrity and environmental stewardship. Figure 1. Conceptual Relationships and Hypothesized Relationships between SI, CHP, GM, TS, and SUTD.

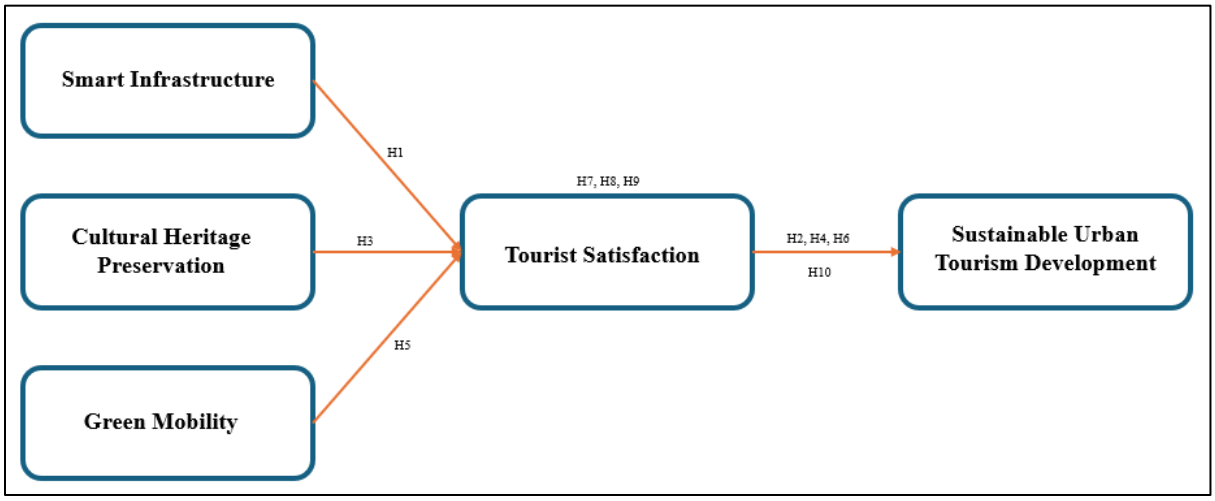

Figure 1: Theoretical Framework

3.0 METHODOLOGY

3.1 Research Design

This study uses a quantitative research design involving a questionnaire survey in the form of a structured questionnaire to identify the number of views on the development of urban sustainable tourism at the three elements, which are smart infrastructure, preservation of cultural heritage, and green mobility, and the analysis of tourist satisfaction as a mediator. Partial Least Squares Structural Equation Modeling (PLS-SEM) is the analytical technique employed to analyze and test tourism study models, complex relationships, mediation variables, and predictivism [79]. PLS-SEM can be especially beneficial where the main purpose is the development of the theory and prediction, instead of the confirmation of the theory.

3.2 Population and Sampling

The population targeted is Chinese students pursuing studies in Malaysia, which is a perfect sample of the target group in the study, since they have been exposed to city tourism in Malaysia and in their country of origin. This survey was also shared via the Internet on several Chinese student organizations in most major Malaysian universities, such as Universiti Sains Malaysia (USM), Universiti Malaya (UM), Universiti Teknologi Malaysia (UTM), Universiti Kebangsaan Malaysia (UKM), Universiti Putra Malaysia (UPM), and Universiti Utara Malaysia (UUM). An online technique was used for student groups because it provided ease of access to the sample. The respondents to be reached comprise 252, which corresponds to the recommendations made for PLS-SEM [80], which is a minimum of 10 times the number of paths pointing to a construct to its last finite variable. This will provide sufficient statistical power to provide an indication of direct, indirect, and mediation effects.

3.3 Instrumentation

The questionnaire is divided into two primary categories. Demographic and control variables, such as gender, education level, and frequency of visits to the urban destination, are included in the first section. These variables are descriptive ones and may enable possible subgroup analysis. The second section covers the core constructs of the study, all of which were adapted from validated scales in tourism and sustainable urban development research. Responses were measured on a 5-point Likert scale, where 1 (strongly disagree) to 5 (strongly agree), which is common in the literature of previous research to understand the degree of perceptions. Four measurement items represent each

construct. In line with the research by [81][82], the smart infrastructure membrane is in the implementation of digital tools, subsequent functions, and the incorporation of technology in urban settings. Cultural heritage preservation can be adapted from [83], and it observes preservation and genuineness of historical and cultural sites, and the establishment of heritage tourism subject to responsibility. As [84] and other sources of urban transport literature define it, green mobility can be called the supply of an environmentally friendly transport, spaces to walk and ride, and programs to encourage sustainable urban mobility. Given the conceptualization by [85], tourist satisfaction scales can be used to measure the happiness levels of individual tourists in their utilization of tourism services, the satisfaction levels of experiences in accordance with expectations, as well as their perceived quality of having chosen to tour with the management. Lastly, an adaptation of [86] and UNWTO indicators is urban sustainable tourism development, which encompasses environmental friendliness, financial gain, appreciation of culture, and benefits to both the visitor and the host. All in all, it consists of twenty items, which is not too long but sufficient for use in the PLS-SEM analysis.

3.4 Data Collection Procedure

The online questionnaire was administered with the help of the Google Forms platform and was distributed using the WeChat and WhatsApp chats, where Chinese student associations are actively involved. Respondents were free to participate and were guaranteed anonymity and confidentiality. The host university had been informed of the study, and informed consent was obtained from all the subjects before the data was collected. Data was collected in a one-month duration to ensure that the response rates were as high as possible.

3.5 Data Analysis Technique

The data was analyzed using the SmartPLS 4.0 program. Two stages are part of the analysis. The measurement model assessment is the initial step, which determines the reliability and validity of constructs. Internal consistency was tested with the help of Cronbach's alpha and composite reliability. Convergent validity was achieved by measuring the Average Variance Extracted (AVE), and discriminant validity will be evaluated by measuring the Fornell-Larker criterion and the numeric index of heterotrait-monotrait (HTMT). The second phase, structural model assessment, is the stage whereby the model is tested in accordance with the hypothesis made. The coefficient of determination (R2) and the predictive relevance (Q2) will be employed to test the model. Testing the mediating role of tourist satisfaction will involve testing the indirect effects, where bootstrapping will be used, according to the recommendations by [87]. This will enable the research to determine whether tourist satisfaction acts as a complete or incomplete mediator between smart infrastructure and the preservation of tourism cultural heritage, green mobility, and the creation of a sustainable city-tourism.

3.6 Ethical Considerations

The purpose of the study was explained to all participants, their confidentiality was assured, and the opportunity to leave at any point was provided. The information was gathered anonymously, and no contact details were recorded. The study was conducted in accordance with the new ethical standards for human subject survey research.

4.0 RESULTS AND DISCUSSION

4.1 Results

This study gathered the answers of 252 Chinese students studying in Malaysia, comprising 148 males and 104 females. Regarding their academic background, 97 were PhD students, 86 were master's students, and 69 were undergraduates. Based on prior experience visiting urban tourism destinations, 35 respondents had fewer than three visits, 89 had 3-5 visits, 75 had 6-8 visits, and 53 reported having more than 8 visits. This distribution represents a wide variety of exposure to urban

tourism. The sampling was done using Chinese students' associations on the Malaysian associations of top universities, such as USM, UM, UTM, UKM, UPM, and UUM.

Table 1: R-square & R-square adjusted

	R-square	R-square adjusted
SUTD	0.667	0.666
TS	0.401	0.394

As the model in Table 1 shows, it accounts for a considerable part of the variance in both Sustainable Urban Tourism Development (SUTD) and Tourist Satisfaction (TS). Smart infrastructure (SI), cultural heritage preservation (CHP), and green mobility (GM) explain the overall variation in the SUTD by 0.667, which is nearly 66.7 percent, which indicates a high predictive strength or power of the model. The stability of the model is ensured by the adjusted R-squared value of 0.666, indicating the lowest chances of overfitting. In the case of TS, R-squared is 0.401; hence, it can be concluded that the independent variables explain 40.1 percent of its variance, and the adjusted R-squared equals 0.394, implying that it presents a moderately strong explanatory power.

Table 2: Reliability and Validity

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
CHP	0.866	0.867	0.908	0.713
GM	0.877	0.878	0.915	0.730
SI	0.806	0.898	0.866	0.620
SUTD	0.826	0.826	0.884	0.657
TS	0.819	0.821	0.881	0.648

Table 2 indicates that the measurement quality of all constructs is high based on findings of the reliability and validity. The values of Cronbach's alpha lie within a range of 0.806 to 0.877, which is higher than 0.7, which depicts good internal consistency. Equally, rho_a and rho_c values are more than 0.80, which indicates composite reliability. All the AVE values were above 0.5, which range from 0.620 to 0.730, and the recommended value to ensure convergent validity was 0.50; therefore, it confirms convergent validity. These findings are indicative that the constructs, being Smart Infrastructure (SI), Cultural Heritage Preservation (CHP), Green Mobility (GM), Tourist Satisfaction (TS), and Urban Sustainable Tourism Development (SUTD), are reliably and validly measured, thus can be incorporated in the analysis of other structural models.

Table 3: Discriminant Validity

	CHP	GM	SI	SUTD	TS
CHP	0.844				
GM	0.882	0.854			
SI	0.128	0.107	0.787		
SUTD	0.585	0.607	0.175	0.810	
TS	0.555	0.624	0.171	0.817	0.805

Table 3 represents the discriminant construct validity of the constructs in the Fornell-Larcker criterion. The diagonal figures (highlighted in bold) are the square root of AVE, and all exceed the resulting correlations with other constructs, showing that there is good discriminant validity. For example, the value of Cultural Heritage Preservation (CHP) is significant, at 0.844, which is higher than that of SUTD (0.585) and TS (0.555), respectively. On the same note, the correlation of Green Mobility (0.854) with SUTD (0.607) and TS (0.624) is higher. Even though its correlations are less robust, Smart Infrastructure (0.787) still fits the requirement. In general, the findings reveal that all the constructs in the model are differentiated and separated.

Table 4: Model Fit

	Saturated model	Estimated model
SRMR	0.053	0.061
d_ULS	0.590	0.791
d_G	0.317	0.330
Chi-square	445.165	456.977
NFI	0.848	0.844

Table 5: BIC

	BIC (Bayesian information criterion)
SUTD	-267.322
TS	-107.948

According to the model fit indices in Table 4, the measurement model is acceptable. The Saturated (0.053) and the estimated model (0.061), which have lower values of the Standardized Root Mean Square Residual values (SRMR) below the 0.08 level, depict a good fit. The d_ULS and d_G values are small, and this indicates that there is minimal differentiated discrepancy between the observed and predicted covariance. The chi-square value significantly falls (from 445.165 to 456.977), but in large models, this is a fairly normal occurrence. The normed fit index (NFI) values (0.848 and 0.844) are similar to the 0.90 benchmark, which shows reasonable fit. Furthermore, Table 5 indicates that the negative values of BIC of the predictors of SUTD and TS confirm the good parsimony and predictive significance of the model.

Table 6: structural model

	Original sample	Mean (M)	STDEV	T statistics	P values
CHP -> TS	0.002	0.005	0.092	0.026	0.979
GM -> TS	0.611	0.609	0.087	7.056	0.000
SI -> TS	0.105	0.116	0.054	1.963	0.050
TS -> SUTD	0.817	0.818	0.022	37.523	0.000

Results contained in the structural model (Table 6) indicate the importance of relationships between the constructs. Cultural heritage preservation (CHP) → Tourist Satisfaction (TS) does not have a significant effect on it ($\beta = 0.002$, $p = 0.979$). Green Mobility (GM) → TS has considerable significance ($\beta = 0.611$, $t = 7.056$, $p < 0.001$), indicating that GM is a strong predictor of satisfaction. Smart Infrastructure (SI) → TS has a rather insignificant impact ($\beta = 0.105$, $t = 1.963$, $p = 0.050$), indicating a weak but not negligible contribution. Lastly, TS → Urban Sustainable Tourism Development (SUTD) shows the highest correlation ($\beta = 0.817$, $t = 37.523$, $p < 0.001$), which confirms the notion that tourist satisfaction has a major contribution to sustainable tourism development.

Table 7: Mediation Effects

	Original sample	Mean (M)	STDEV	T statistics	P values
SI -> TS -> SUTD	0.086	0.095	0.044	1.966	0.049
CHP -> TS -> SUTD	0.002	0.004	0.075	0.026	0.979
GM -> TS -> SUTD	0.499	0.498	0.073	6.874	0.000

Table 7 shows the mediation effects of Tourist Satisfaction (TS) on the relationships between Smart Infrastructure (SI), Cultural Heritage Preservation (CHP), Green Mobility (GM), and Urban Sustainable Tourism Development (SUTD). The indirect effect via SI → TS → SUTD is marginally significant ($\beta = 0.086$, $t = 1.966$, $p = 0.049$), which suggests that the indirect effect is weak but significant. CHP → TS → SUTD has the smallest mediation effect ($\beta = 0.002$, $p = 0.979$), indicating that CHP is not a game changer to SUTD via TS. Conversely, GM → TS → SUTD has a very high level of

significance (β = 0.499, t = 6.874, p < 0.001); therefore, Green Mobility is one of the two significant contributors to the facilitation of sustainable tourism development through tourist satisfaction.

Table 8: The structural model 2

	Original sample	Mean (M)	STDEV	T statistics	P values
CHP -> SUTD	0.002	0.004	0.075	0.026	0.979
CHP -> TS	0.002	0.005	0.092	0.026	0.979
GM -> SUTD	0.499	0.498	0.073	6.874	0.000
GM -> TS	0.611	0.609	0.087	7.056	0.000
SI -> SUTD	0.086	0.095	0.044	1.966	0.049
SI -> TS	0.105	0.116	0.054	1.963	0.050
TS -> SUTD	0.817	0.818	0.022	37.523	0.000

Table 8 results from the structural model give results derived on the direct effects of the constructs.Cultural Heritage Preservation (CHP) has no significant effect on both Tourist Satisfaction (TS) and Urban Sustainable Tourism Development (SUTD), as indicated by extremely low path coefficients (β = 0.002, p = 0.979). Contrary to that, Green Mobility (GM) has a significant impact in both SUTD (β = 0.499, p < 0.001) and TS (β = 0.611, p < 0.001), and therefore is a crucial driver. There is weak but slightly important impacts of Smart Infrastructure (SI) on SUTD (β = 0.086, p = 0.049) and TS (β = 0.105, p = 0.050). Lastly, TS is a strong predictor of SUTD (b = 0.817, p < 0.001), which certifies that it is indeed at the centre of mediation.

4.2 Discussions

H1: Smart Infrastructure → Tourist Satisfaction

According to the results, the positive impact of Smart Infrastructure (SI) on the Tourist Satisfaction (TS) is marginally significant (β = 0.105, t = 1.963, p = 0.050). Although the effect is not strong, it indicates that investments in digital connectivity, intelligent transport systems, and smart services can enhance the overall tourist experience. The Chinese cities Hangzhou and Shenzhen are known for implementing various smart features in various aspects: mobile payment, navigation using voice over artificial intelligence, and even batteries for booking tickets [88]. It is worth noting that these innovations have been positively received by most tourists as they simplify many routines [88]. Similarly, smart city tests have been conducted in both Kuala Lumpur and Penang in Malaysia, but to date, this element has not been sufficiently used in the hospitality industry [89]. The rather weak point of the factor may be that, although tourists are satisfied with such innovations, they perceive them more as the ease of infrastructure than as immediate factors of satisfaction.

H2: Smart Infrastructure → Urban Sustainable Tourism Development

Smart Infrastructure also shows a marginal but positive effect on Urban Sustainable Tourism Development (SUTD) (β = 0.086, t = 1.966, p = 0.049). One might suggest SI to be a vehicle to sustainability, rather than one of its wheels. That is, SI contributes to sustainability through its direct and indirect consequences, such as success and efficiency, as well as monitoring and environmental outcomes. Thus, smart infrastructure played a huge role in combating overcrowding and improving the assessment and monitoring of the environment in tourism cities in China, helping to reach the country's sustainability goals [90]. In this regard, Malaysia's development, in contrast, has seen the adoption in legislation, since the Putrajaya Smart City and Penang's digital start-up projects have not yet produced a significant impact on sustainable tourism planning. Thus, the success of the reforms is not a good part of a solution, but, if supported by cultural and environmental change, it will lead to increased sustainability.

H3: Cultural Heritage Preservation → Tourist Satisfaction

Cultural Heritage Preservation (CHP) was found to have no significant correlation with Tourist Satisfaction (β = 0.002, p = 0.979). This result is equally surprising and intriguing since urban tourism

is often heavily dependent upon heritage attractions. This finding may be reflective of the fact that the mere existence of heritage assets does not ensure tourists' satisfaction if they are not well-preserved, accessible, or interestingly incorporated into the overall experience for the contemporary visitor. For example, some of the Chinese cities, including Xi'an and Suzhou mentioned above, are facing the problems of overtourism due to a high heritage appeal, with multiple negative implications for visitor experience [92][93]. In Malaysia, complaints about overt commercialization and poor preservation from a large number of visitors were raised regarding George Town and Melaka, other UNESCO-listed heritage sites [94][95]. This sub-section of results therefore demonstrates that the authenticity of heritage is not enough, as it has to be professionally managed and maintained, interpreted, and offered for it to convert into a visitor's experience.

H4: Cultural Heritage Preservation → Urban Sustainable Tourism Development

Similarly, CHP does not significantly affect SUTD with a $\beta = 0.002$, $p = 0.979$. This outcome reflects the difficulty that both China and Malaysia have in developing while simultaneously preserving their heritage. Urbanization in China poses a threat to historic districts, while the leniency in Malaysia's enforcement of regulations permitted insensitive developments [96]. Thus, the preservation of heritage needs to be more than just protection from development, and it requires governance, participation of stakeholders, and incorporation into infrastructure and mobility planning to create a sustainable tourism effect.

H5: Green Mobility → Tourist Satisfaction

There is a strong and statistically significant positive relationship between Green Mobility (GM) and TS ($\beta = 0.611$, $t = 7.056$, $p < 0.001$). This confirms that eco-friendly transport systems directly contribute to higher visitor satisfaction. In China, investments in metro systems, bike-sharing programs, and electric buses have made urban mobility cleaner and more efficient [97]. These improvements allow tourists to travel safely and conveniently while reducing environmental impacts [98]. In Malaysia, efforts to enhance sustainable transport in destinations such as Langkawi and Kuala Lumpur are underway. However, the last-mile transport connecting these sites remains a significant hurdle [99]. In other words, tourists' predilection for environmentally friendly transportation modes to fulfil their needs is increasing.

H6: Green Mobility → Urban Sustainable Tourism Development

Green Mobility also exhibits a strong and positive effect on SUTD ($\beta = 0.499$, $p < 0.001$). This highlights that sustainable transport not only enhances the tourist experience but also reduces the environmental footprint of tourism activities. China's expansion of high-speed rail networks and electric vehicles has significantly reduced reliance on private cars, fostering long-term tourism sustainability [100][101]. Similarly, Malaysia's tourism master plans promoting bus rapid transit and pedestrianization show potential, though implementation challenges persist. Therefore, mobility infrastructure is one of the most critical levers for connecting tourism growth with urban sustainability.

H7: Tourist Satisfaction → Urban Sustainable Tourism Development

The most significant direct effect in the model is TS → SUTD ($\beta = 0.817$, $t = 37.523$, $p < 0.001$). This result emphasizes the pivotal role of satisfaction in promoting repeat visitation, destination loyalty, and sustainable practices. In China and Malaysia, ensuring high satisfaction through service quality, accessibility, and safety has been key to sustainable tourism growth [102]. This confirms that tourist satisfaction functions not merely as a psychological outcome but as a behavioral driver of sustainable tourism development.

H8: Smart Infrastructure → TS → SUTD

The mediation analysis reveals that TS plays a partial mediating role between SI and SUTD (β = 0.086, p = 0.049). This indicates that SI contributes to sustainability primarily through its influence on satisfaction rather than direct outcomes. For instance, the use of mobile apps, e-payment systems, and digital tour guides in China enhances convenience, which, in turn, promotes sustainability through repeated and responsible tourist behaviors [23]. Similarly, in Malaysia, using smart ticketing and navigation systems could indirectly lead to increased satisfaction and successful outcomes [103].

H9: Cultural Heritage Preservation → TS → SUTD

CHP does not exhibit a mediating effect through TS (β = 0.002, p = 0.979). This again suggests that heritage value alone does not guarantee either satisfaction or sustainability. In both China and Malaysia, issues such as overcrowding, commercialization, and weak integration of heritage with modern tourism experiences hinder positive outcomes [104]. Cultural heritage as a sustainable tourism resource goes underutilized without proper interpretation and management.

H10: Green Mobility → TS → SUTD

The relationship between GM and SUTD is highly mediated by TS (β = 0.499, p < 0.001). This indicates that green mobility not only directly boosts satisfaction but also passes the increased satisfaction through to sustainable tourism in other parts. Researchers found that the high mass transit in China was one of the biggest drivers of satisfactory urban tourism and sustainability [105]. Malaysia can leverage this by enhancing travel experience and linking up green transport networks in cities with a high tourism potential [106].

Mediation was tested using PLS-SEM conducted on 5,000 bootstrapped indirect effects to determine whether the influence of SI/CHP/GM on SUTD includes Tourist Satisfaction through a non-zero indirect effect rather than only through total or direct effects and interaction. Although moderation is theoretically feasible by several scholars, mediation was preferred, and subsequent studies can explore interaction.

4.3 Practical Impacts

From a more practical perspective, the insights offer concrete implications for policymakers and destination managers alike, irrespective of whether these are mature or emerging destinations. Firstly, investing in smart infrastructure does not mean implementing technology, but focusing on tourist-centered services, such as digital assistance, real-time updates, and intelligent navigation systems [23]. Secondly, cultural heritage is only relevant if it is brought alive with immersive experiences, interpretive strategies, and crowd control so that it is counted toward satisfaction and loyalty in the long term [104]. Thirdly, green mobility can only be viable if better last-mile connections, more walking-friendly places, and an improved bicycle infrastructure make tourists satisfied and destinations more sustainable [107]. All of those, if rigorously integrated into tourism and transport policymaking and enforcement in cities like Kuala Lumpur and Penang, can deliver significant sustainability dividends. Furthermore, tourist satisfaction also means tourists who come back, tourists who recommend the destination to others, and tourists who conserve and sustain it.

4.4 Global Impacts

In a global context, this analysis provides important conclusions about the role of smart infrastructure, cultural heritage, green mobility, and tourism satisfaction as combined influence factors of sustainable development through tourism. As can be seen, the existing smart tourism concepts are generally focused on the development of the infrastructure and the general context of its reliability. This model, on the contrary, defines the satisfaction-focused link of the behavioral mechanism granted with the modern infrastructure for immediate sustainability development, as well as enabling it [108]. In a way, it shows that smart infrastructure is a greater enabling factor than

direct beneficial or sustaining, being an intermediate form of enhancement in the form of background efficiency improvements rather than behavior [108]. And that cultural heritage is the underlying form of enabling insofar as it is empowered by interpretation and modernization [35]. Green mobility is the biggest overall and globally enforced factor, considering that it remains equally enforced due to the trends of development as an advanced factor by the world's development dimensions of eco-transport [11]. The similarly quantitative but mediation-central role for the other factor is the tourist satisfaction, showing that sustainability outcomes depend not only on the maintaining factor but on how they actively enhance the visitor experience from region to region. These data suggest that overall urban sustainable development worldwide should be on the people-driven satisfaction-based frameworks and enabled, connecting local and global horizontal values.

4.5 Limitations

Even though the empirical context of the study might be seen as a limitation to its generalizability. After all, urban governance, specific cultural norms, and patterns of technology adoption might differ from city to city and even country to country; thus, in the future, the model should be tested in a broader range of geographies and using longitudinal or experimental designs. After all, the satisfaction-driven behavior might develop differently over time, and the model may be faced with challenges outside of cross-sectional research designs. However, the integrated, SDG-aligned nature of the study provides a replicable template for evaluating urban tourism sustainability through policy, ensuring comparability of findings and their alignment with the concept of SDGs.

5.0 CONCLUSIONS

This study has considered smart infrastructure, cultural heritage preservation, and green mobility to present a more appropriate perspective of tourist satisfaction and sustainable urban tourism development**.** The findings show that direct effects of smart infrastructure and cultural heritage preservation on satisfaction and sustainability are **only substantial in a modest manner**, while green mobility features prominent and consistent impacts. Among the internal measures, tourist satisfaction assumes a central mediating role, and the sustainable outcomes are not determined by the external factors of infrastructure and heritage alone. It is the correlation between them that is the determining factor, given that this ultimately prescribes the impressions of the visitors. On a global scale, smart infrastructure, in other words, digital navigation, digital and contactless e-payment tools, smart transport, etc., all appear to be enablers of satisfaction and sustainability rather than shapers. The meaning is that this kind of technology investment ameliorates the touristic experience on the sidelines by boosting the efficiency and making the services, per se, more accessible. Whereas the cultural heritage remains a constituting bloc of global sustainability, one to be reinterpreted and re-integrated into the holistic framework of sustainable tourism in the future. In comparison, green mobility presents a salient and direct impact. For example, a balanced mix of, say, energy-efficient transport systems, coherent metro, and continuum-walking urban design, does reduce the footprint but enhances the fun people have when visiting. Many places worldwide, like Amsterdam or Singapore, use interconnected mobility to boost competitiveness and meet today's ambitious global climate and livability objectives**.** In practical terms, green mobility schemes should be the top priority for the advice-oriented experts of policymakers and destination managers**.** They should also prioritize the development of smart technologies that can enhance visitor satisfaction. In the meantime, designing client engagement strategies that interlink today's tourism experiences with traditional guiding principles is required. Ultimately, when tourists are pleased with their experiences, they are more willing to endorse eco-tourism policies, exhibit loyalty toward the destination, and ensure that sustainably strives to remain feasible.

Author Contribution

Ku Shanshan: Conceptualization, methodology, investigation, visualisation, writing, and editing.
Mohamad Shaharudin Samsurijan: Investigation, supervision, writing, and editing.
Ooi Zheng Yao: Methodology, investigation, Software, Analysis, writing, and editing.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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