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How vivid memories connect sustainable tourism attributes to tourist loyalty

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Abstract

The concept of tourism experience has evolved to emphasize memorability, focusing not only on satisfaction but also on creating unforgettable experience. In the digital era, technologies have had a substantial impact on the retention of biological memory. However, limited research has focused on how sustainable tourism attributes foster memorable experiences and how technology aids tourist memory. Therefore, this research examines how sustainable tourism attributes can foster tourist loyalty through internal and external vivid memory. Sustainable tourism is measured through three dimensions: environmental, socio-cultural, and economic attributes. Internal vivid memory refers to the clarity and quality of biologically stored travel memories, while external vivid memory is associated with technologically enhanced memory recollections. A quantitative approach was adopted using a structured questionnaire administered to 432 international tourists across four Indonesian cities (Yogyakarta, Manado, Badung–Bali, and Surabaya). The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The findings indicate that each sustainable attribute contributes significantly to the external vivid memory. However, environmental attributes do not significantly affect internal vivid memory. Furthermore, the results reveal that neither internal nor external vivid memory serves as a mediating variable between environmental attributes and tourist loyalty. In contrast, vivid memory partially mediates the effect of socio-cultural attributes on loyalty and fully mediates the effect of economic attributes. Moreover, the result shows that remembering through digital technology is more impactful on loyalty than biological memory. This study provides new perspectives on the role of technology and biological memory in enhancing tourist loyalty.

Keywords Sustainable tourism, Tourism experience, Vivid memory, Tourist loyalty

1 Introduction

Tourism has evolved to focus on memorable experiences, which can increase the value of tourism services [1–3]. This shift has occurred due to changes in tourist behaviour, as they are no longer satisfied with ordinary tourist attractions; instead, they are looking for destinations that will offer a unique and authentic experience [1, 4–6]. Positive tourist experiences significantly influence their perceptions and memories of tourist visits [7–10]. According to the concept of Memorable Tourism Experience (MTE),



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only experiences that are perceived as exceptional and personally meaningful are vividly remembered [11–13]. Moreover, the more detailed the memory, the less probable that the experience will be erased from memory [12]. Therefore, vivid memory is considered a key component in the memory recall process [47, 65]

The term vivid memory describes autobiographical memories linked to sensory experiences from previous events [14]. The value of such experiences strengthens tourists' vivid memories, which subsequently promote loyalty through recommendations and revisit intentions [11–13]. However, most existing studies conceptualize vivid memory solely as biological memory—memories naturally encoded and stored in the human brain [11–13, 15]. In contrast, the increasing use of digital technologies such as smartphones and social media allows tourists to externally store and retrieve memories, a process referred to as cognitive augmentation [16–18]. Despite its growing relevance, this digitally supported memory has received limited attention in tourism research.

In addition, there is increasing recognition of sustainability as a core principle in tourism development [19–21]. The concept of sustainability in the tourism industry highlights the significance of implementing responsible tourism practices with the dual objective of preserving natural and cultural resources while simultaneously generating economic benefits [22, 23]. It is argued that a tourism industry that is able to prioritize environmentally friendly programs, economic growth, and the preservation of the culture of its local population will be able to provide tourists with a positive experience [24]. Previous studies have generally employed a three-dimensional conceptualization of sustainability, including environmental, socio-cultural, and economic dimensions [24–26]. The environmental aspect of sustainable development encompasses conserving renewable and non-renewable natural resources. The socio-cultural dimension pertains to the protection of socio-cultural resources. The economic dimension prioritizes the fulfillment of society's economic needs and the enhancement of its living standards. Yet, existing literature tends to examine sustainability either from the perspective of local communities [27, 28] or tourism businesses [21, 29, 30], and rarely from the perspective of tourists themselves [26]. In addition, research on sustainable tourism that examines tourist behaviour is mostly concerned with the assessment of pre-visit attitudes or behaviours [31, 32]. Moreover, tourist-focused studies on sustainability often emphasize only environmental aspects [33–36], neglecting the socio-cultural and economic dimensions [37].

This study addresses two critical gaps in the literature. First, it extends the concept of vivid memory by incorporating both internal (biological) and external (technology-enhanced) dimensions. Second, it evaluates how sustainable tourism attributes—across all three dimensions—affect these memory types and, in turn, influence tourist loyalty. By integrating sustainability and memory augmentation in one framework, this study provides a novel perspective on how destination attributes contribute to lasting tourist experiences and behaviors.

2 Literature review

One of the fundamental concepts underpinning this study is the notion of Memorable Tourism Experience (MTE), which emphasises the psychological, emotional and cognitive impressions that render tourism encounters unforgettable [38, 39]. MTE provides a valuable lens through which to understand how long-lasting travel experiences are

formed, and how these experiences ultimately influence future tourist behaviour [40]. The present study is grounded in two key theoretical foundations to further develop this concept, which are Cognitive Augmentation Theory and Sustainable Tourism. While prior research has predominantly conceptualised vivid memory as a biological process, the advent of digital technology has introduced technology-enhanced memory as a complementary dimension. Meanwhile, sustainable tourism has gained increased attention for its potential to enhance tourist experience. This study integrates these two perspectives to propose a novel framework linking internal and external vivid memories with sustainable tourism attributes to explain the formation of tourist loyalty.

2.1 Cognitive augmenting theory

Digital technologies can significantly enhance human memory by providing tools that help reconstruct past events with greater clarity and detail [16, 17, 41]. External storage of personal memories, e.g. photos, videos, and diaries, falls under the concept of cognitive augmenting, where external media are a means of expanding biological memory capabilities rather than replacing them [16]. This is because human memories are prone to bias, distortion, and fading over time. In contrast, external media that digitally store memory traces are reliable due to their accuracy, completeness/detail, and objectivity [17]. As such, one of the important benefits of using digital memory aids is reducing the cognitive load [16]. This may reduce the concern of forgetting important information where the data has been stored externally. This externalization of memory allows a person to focus on other cognitive activities, thus increasing overall cognitive efficiency and potentially improving quality of life in work, health, and education [17].

2.2 Sustainable tourism

The main idea of sustainable tourism is to promote the integration of economic, social, and environmental considerations into the management of tourism-related activities. The underlying premise was that such an approach could ensure the fulfilment of these diverse needs of stakeholders by incorporating cultural elements, ecological processes, and biodiversity, thereby facilitating the advancement of society [42]. From the tourists' perspective, sustainable tourism is viewed as a continuous process that considers their current needs and future generations [43]

Recognizing its complexity, sustainable tourism is inherently multidimensional and cannot be accurately evaluated through a single lens. While some studies have focused primarily on environmental aspects [33, 34, 44, 45], such an approach is insufficient to capture the full scope of sustainability in tourism. Therefore, it is necessary to employ multidimensional measurements to gain a more comprehensive understanding [25, 26]. A previous study delineated the four dimensions of sustainable tourism, namely, environmental, social, cultural, and economic [46]. However, most prior studies have classified the dimensions of sustainable tourism into three primary categories, integrating social and cultural aspects into a unified framework. This approach aligns with the triple bottom-line theory [24, 26, 42, 47]. In other studies, social and economic factors are examined in conjunction with other elements, such as culture and the environment. [48].

2.3 Economic attributes, vivid memory, and tourist loyalty

The economic growth of a destination can be observed in several ways, including an increase in business and employment opportunities, the development of local facilities and infrastructure, an improvement in the living standards of the population, and an expansion in the number of local products and services [48]. Prior research indicates that elements of a city's economy, such as public infrastructure, accessibility, tourism facilities, and the cost of goods and services, can also impact tourists' travel experiences [26, 31]. The condition of a tourist destination concerning this aspect can subsequently impact a person's travel experience, whereby tourists will have a positive experience if the destination has well-maintained infrastructure and a wide range of appealing facilities [24]. Nevertheless, should tourists perceive the area as lacking adequate facilities and infrastructure, they may experience a sense of disappointment [26]. Extending this perspective, the quality of accommodation was demonstrated as a pivotal economic attribute that significantly shapes travelers' overall satisfaction [8].

Building on the crucial role of economic attributes, prior research indicates that maintaining public facilities can positively lead to more positive travel memories and an increased likelihood of revisiting or recommending the destination [49]. Such positive experiences can result in vivid memories, which are critical to a traveler's intention to revisit or recommend the destination to others [2, 7]. Moreover, local souvenirs that possess the tourist destination's distinctive attributes can facilitate a more detailed recollection of the tourist experience [50, 51]. Additionally, shopping malls represent another significant factor influencing tourists' memories. The diversity and distinctiveness of souvenirs, the ambiance of the shopping environment, and the quality of service in these shopping centers can collectively create memorable shopping experiences [52].

Considering these aspects, economic attributes play a significant role not only in shaping memorable experiences but also in fostering long-term loyalty. Empirical evidence demonstrates that tourists' evaluations of infrastructure adequacy, availability of affordable tour packages, quality of cuisine and accommodation, and efficient transportation services substantially influence their intention to revisit the destination [53]. Moreover, repeat tourists desire the availability of well-maintained infrastructure that facilitates convenient access during their journeys [54]. Additionally, the availability of shopping facilities, such as malls and entertainment venues, enriches the overall tourist experience and impacts future tourist behavior [55, 56]. On the other hand, purchasing souvenirs or other items associated with a destination is serving as a defining aspect of many travelers' journeys. Consequently, the authenticity of local souvenirs and the allure of tourist attractions in a given destination play a significant role in influencing subsequent visits and recommendations for other tourist attractions [54]. Based on the previously stated evidence, the following hypotheses are developed:

H1 Economic attributes of a destination positively influence tourist loyalty.

H4a Economic attributes of a destination positively influence internal vivid memory.

H4b Economic attributes of a destination positively influence external vivid memory.

2.4 Environmental attributes, vivid memory, and tourist loyalty

In examining the environmental attributes, scholars have focused their attention on the environment, atmosphere, and natural attractions. [48]. Pollution and congestion are examples of environmental issues identified as causes of concern for tourists, with the potential to impact their experiences negatively [31, 57]. Furthermore, preserving a natural environment can be a competitive advantage for a tourist destination. Due to its authenticity and inherent natural potential, a destination can also offer a distinctive experience for tourists, particularly those with an affinity for nature [26, 57]. The preservation and beneficial nature of a locale can also foster local support for the tourism industry, which may subsequently enhance the environmental reputation of a city [24]. Accordingly, tourists are more likely to have a favorable experience while traveling and leave the destination with positive sentiments if the natural environment is perceived as well-maintained [24, 58, 59].

It has been demonstrated that the environmental attributes of a tourist destination are also a significant factor influencing tourists' behavioral intentions. Tourists' perceptions of sustainable management practices in a destination are a significant predictor of their intention to revisit and recommend the destination to others [25]. Engaging with a stunning and genuine natural setting has the potential to stimulate the five senses, thus enhancing the depth and meaningfulness of the tourist experience [57]. Tourism destinations that demonstrate effective maintenance and cleanliness of their natural environment are more likely to elicit a positive response from tourists, including a greater propensity to revisit and recommend the destination [24, 26, 48] and even willing to pay more [31].

The natural resources and environments that tourists encounter, including wildlife, weather conditions, and natural scenery, are elements that are inherently difficult to control and not created by humans. Consequently, tourists' positive judgments about these elements can directly affect their memory [60]. Travellers who appreciate the inherent natural authenticity of tourist attractions may feel that they seem to leave their daily routines and enter a different world temporarily. This experience can lead to a profound appreciation of the beauty and satisfaction that it offers. As a result, these experiences can be genuinely memorable [61]. Furthermore, natural stimuli that engage the senses, including the sound of the sea, the scent of nature, and visual details of natural beauty, leave a lasting impression on memories and are vital for the formation of future recollections [62]. Additionally, tourists who participate in nature conservation initiatives, such as observing turtle nesting and other conservation activities, may develop a unique and profound connection to the destination [63]. In conclusion, the following hypotheses are formulated:

H2 Environmental attributes of a destination positively influence tourist loyalty.

H5a Environmental attributes of a destination positively influence internal vivid memory.

H5b Environmental attributes of a destination positively influence external vivid memory.

2.5 Socio-cultural attributes, vivid memory, and tourist loyalty

The cultural assets of a destination, including ancestral and historical heritage, can be presented in various formats, such as tourist attractions, festivals, arts, and traditions. These assets can create a distinctive impression for tourists, shaping their perceptions and experiences within a destination [44]. In addition to the favorable consequences, tourism can also result in unfavorable outcomes, such as the erosion of community identity [48]. Consequently, it is essential to safeguard a destination's cultural heritage to preserve the local community's identity while attracting tourists. Tourists are more likely to have a memorable experience if they are allowed to learn about and participate in the local culture when they visit a tourist destination [24]. Conversely, social issues such as elevated crime rates, vandalism, substance abuse, and communities with high rates of alcohol dependency can harm tourists, potentially influencing their overall impression of the destination [31]. Consequently, the tourist experience may also be affected by the social conditions of the tourist destination. A positive travel experience is enhanced when tourists perceive the area as safe and the locals as friendly and helpful [24]. Conversely, if tourists perceive the area to be unsafe or incompatible with the local society, their experience is likely to be negative.

This interplay between cultural offerings and the social environment is vital to the formation of travel memories. The local culture allows tourists to gain a unique and authentic experience that is unlikely to be encountered elsewhere [10]. Such experiences encompass local traditions, culinary practices, festivals, and interactions with the local population. Collectively, they enhance the traveler experience and foster the formation of unforgettable memories [48]. Cultural symbols and attractions experienced while traveling serve as a catalyst for the formation of profound cultural insights and comprehension, which are then stored in tourist memories.[64]. The distinctive and genuine aspects of local culture can serve as the defining characteristics of a region and can be utilized as a promotional instrument for its traditional culture, thereby fostering positive memories among tourists [51, 65]. Moreover, interactions with tourism service providers, such as tour guides, service staff, or local communities, have been shown to create more memorable experiences [60].

These socio-cultural attributes often translate into future behavioral responses. Prior research indicates that local culture directly influences tourists' intentions to revisit a destination by providing authentic local experiences [30, 66]. Travelers who strongly recollect the cultural festival memory are more likely to consider returning to the destination to relive the experience or to recommend it to others [63]. Furthermore, social aspects, such as interaction and communication with local residents, can facilitate an understanding of tourists' needs, thereby increasing the likelihood of tourists intending to revisit, sharing their experiences, and recommending the tourist destination [30, 66]. Accordingly, the following hypotheses are formulated:

H3 Socio-cultural attributes of a destination positively influence tourist loyalty.

H6a Socio-cultural attributes of a destination positively influence internal vivid memory.

H6b Socio-cultural attributes of a destination positively influence external vivid memory.

2.6 Vivid memory and loyalty

Vivid memory is a component of autobiographical memory, encompassing recollections of past personal experiences [14]. Vivid memory demonstrates the richness and complexity of the human memory process. The degree of visual imagery and emotional reaction is a significant predictor of memory recall [14, 67]. Individuals who experience high levels of visual imagery and emotional reaction are more likely to remember the details of an event, access the memory, and have a vivid recollection of it. This vivid memory is considered an important factor in the recall process [50, 68], indicating that memories stored with high visual imagery and emotional intensity can be long-lasting and accurate [12]. Additionally, vivid memories are an essential cognitive process, stored in long-term memory and reappearing when recalling memorable personal events [40, 67, 69].

Thus, vivid memory has been identified as a strong predictor of future repeat behavior [67], as the locations and environments that elicit these memories will be strongly associated with feelings such as happiness, excitement, positive meaning, participation, and refreshment [69]. Vividness is an important construct in the pre-purchase evaluation of products [15] and determines post-experience behaviour [12, 13, 69]. Travelers who recall a greater number of sensory experiences from previous travel encounters are more likely to return to the destination and engage in similar activities [62].

In the context of the digital era, vivid memory is no longer confined to internal cognitive processes. Tourists increasingly rely on external memory, such as photographs, digital videos, and social media posts, to record their experiences [16, 18, 70]. These external representations act as visual and emotional cues that reinforce internal memories and can trigger emotional responses upon recall [70]. The accessibility and shareability of these digital memories further influence tourists' intention to revisit and recommend destinations, especially when such content is validated or shared within their social networks [71]. As such, external memory plays a complementary and amplifying role in the formation of vivid memory [16, 17], and by extension, tourist loyalty [62, 72]. Therefore, the following hypotheses are formulated:

H7. Internal vivid memory positively influences tourist loyalty.

H8. External vivid memory positively influences tourist loyalty.

2.7 Mediating role of vivid memory

Vivid memory serves as a mediator in the relationship between economic attributes and tourists' loyalty. Fair pricing and the availability of high-quality local products have contributed significantly to creating memorable experiences that enhance tourists' intentions to revisit and recommend a destination [12]. Positive experiences with local products, particularly in terms of price and quality, also increase the clarity of recalled memories and strengthen tourists' desire to return and share their experiences with others [52, 67].

In addition to economic aspects, environmental attributes such as natural beauty also contribute to vivid memory formation. The natural beauty of a tourism destination creates memorable experiences [60, 63, 73]. The uniqueness appeal of an environment improves a tourist's ability to recall that place, which can shape their future decisions and actions [12, 57].

Moreover, previous studies revealed that memories related to the social aspect exert the strongest influence on tourist loyalty [12]. Social interactions and a sense of

togetherness often generate more intense emotional responses and lead to deeper memory encoding [74]. Social experiences, such as engaging with local residents or participating in cultural events, enhance the vividness of recalled memories, thereby fostering tourist loyalty [50, 65, 75].

Therefore, the following hypotheses are formulated:

H9a-H9b Internal vivid memory (H9a) and external vivid memory (H9b) mediate the relationship between economic attributes and tourist loyalty.

H10a-H10b Internal vivid memory (H10a) and external vivid memory (H10b) mediate the relationship between environmental attributes and tourist loyalty.

H11a-H11b Internal vivid memory (H11a) and external vivid memory (H11b) mediate the relationship between socio-cultural attributes and tourist loyalty.

Figure 1 below illustrates this study's research model and hypothesis.

3 Methodology

This study employs a field study through a survey, which utilises a questionnaire as a data collection method. The questionnaires were distributed to foreign tourists visiting four areas that serve as tourist destinations: Likupang/Manado, Badung Bali, Magelang/Jogjakarta, and Surabaya. The convenience sampling method was implemented, and data were collected during September 2024. The survey was conducted through both online and offline channels. For the online distribution, screening questions ensured that only international tourists who had visited one of the targeted destinations within the past 12 months could participate. For the offline distribution, respondents were approached directly and qualified if they had spent at least one full day visiting the destination. The questionnaire was available in both English and Chinese. Each variable indicator is measured using a 7-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree".

In terms of research ethics, the respondent was first asked about their willingness to participate in the study, with explicit written consent obtained. The subsequent questions

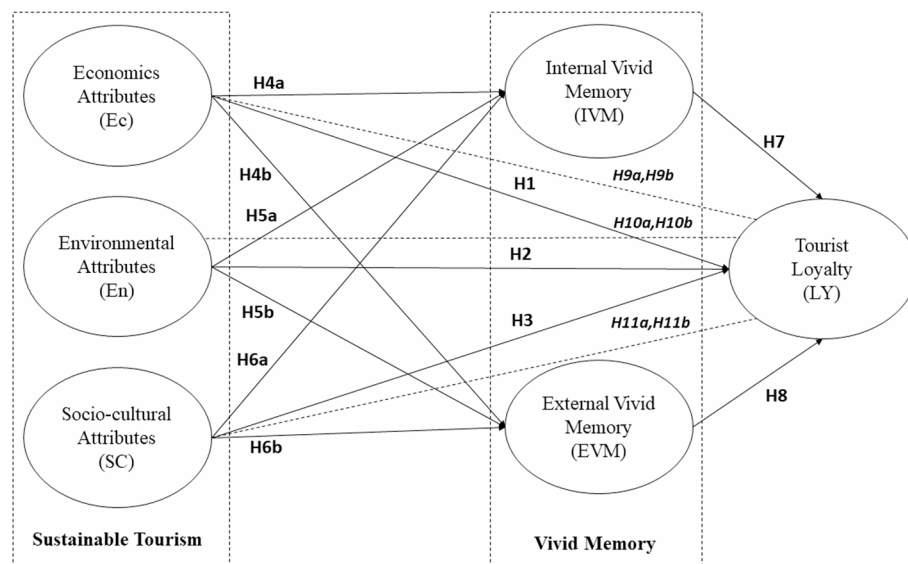


Fig. 1 Research Model

in the questionnaire were designed to correspond with the variables being investigated. Additionally, respondents were asked to consent to the release of their contact information should they wish to participate further in the study. The consent statement included a direct query regarding their agreement to participate. The study protocol was approved by the Institute of Research and Community Outreach at Petra Christian University. All respondents voluntarily agreed to participate and were informed of their right to withdraw at any point without facing any consequences.

This study defines sustainable tourism as tourists' positive perception of a destination's natural, cultural, and economic aspects. Environmental attributes are described through eight indicators that have been adapted from previous research [24, 26, 31, 48]. The socio-cultural attributes are translated into six indicators, which have been adapted from previous research [24, 31, 48, 75]. The economic attributes are reflected in eight indicators adapted from previous research [24, 31, 48]. Vivid memory can be divided into internal and external, which is defined as the clarity and detail of memories that are particularly vivid and closely match the tourist experience. Internal vivid memory indicators are derived from previous research to measure this construct [11, 12, 15, 68]. External vivid memory is measured by four indicators developed from studies on how digital technology enhances memory retention [17, 18, 41, 70, 76]. Moreover, five indicators used to measure loyalty are adapted from previous research [24, 48, 62]. Table 1 presents a detailed overview of the measurement items along with their respective sources of adaptation.

Prior to the distribution of the questionnaire, a pilot test was conducted to validate the measurement items. In the initial phase, the questionnaire was reviewed by several academics with expertise in tourism marketing to evaluate the clarity, relevance, and intent of each item. In the second stage, feedback was gathered from a sample of 30 respondents. The focus of this feedback pertained to the wording and length of the questions. Furthermore, a concluding evaluation of construct validity was conducted employing the Pearson Correlation Coefficient, whilst Cronbach's Alpha was utilised to appraise reliability.

A total of 600 questionnaires were distributed across four cities, with 150 questionnaires allocated to each location. Furthermore, 432 foreign tourists completed and returned the survey, resulting in a satisfactory response rate (72%) for analysis. The collected data were then processed and analyzed using partial least squares structural equation modeling (PLS-SEM). An overview of the respondents' demographic characteristics is provided in Table 2.

As illustrated in Table 2, the respondents in this study exhibit a balanced gender distribution, with nearly equal proportions of males and females. Moreover, the majority of respondents were between the ages of 22 and 40, primarily originated from Europe, and were employees.

4 Results and analysis

4.1 Measurement model

The research model has been evaluated with reflective measurement through external model testing. At this stage, the internal consistency of the constructs is assessed through Cronbach's alpha test, with a minimum acceptable limit of 0.6, and composite reliability, which ideally ranges from 0.6 to 0.9. In addition, convergent validity is

Table 1 Sources of measurement items for all constructs

Construct	Authors
<i>Economics Attributes</i>	
Good public transportation system	[24, 48]
Good public physical infrastructure	
Diverse locally-owned business	[24, 31, 48]
Various places to go out and have fun	[24, 48]
Modern and convenient shopping choices*	
Widely available facilities	[24, 31, 48]
Adequate pricing*	
High-quality of local souvenirs and crafts	[48]
<i>Environmental Attributes</i>	
Interesting natural attractions	[48]
Clean environment*	[26, 31, 48]
Low traffic congestion issue*	[24, 48]
The level of pollution is acceptable	[24, 31]
	[26, 48]
Concerned preservation of natural areas	[26, 31, 48]
Pleasant weather and climate	[48]
Restful and relaxing atmosphere	[24, 48]
Not too crowded with people*	[31, 48]
<i>Socio-cultural Attributes</i>	
Fascinating cultural attractions	[24, 48]
Aesthetic local arts and crafts	
Appealing local cuisine*	[48]
Authentic cultural heritage and traditions	[24, 48]
Effort to safeguard valuable cultural heritage*	[24, 31, 48]
Interaction between residents and visitors	[31, 48, 75]
<i>Internal Vivid Memory</i>	
Clearly recall what he/she saw	[11, 15, 68]
Clearly recall what he/she heard	[11, 12, 68]
Clearly remember his/her emotions	[11, 12, 15, 68]
Clearly recall the layout*	[11, 12, 68]
Clearly remember the ambience	[11, 15]
<i>External Vivid Memory</i>	
Clearly remember his/her trip by looking back at the photos stored in cell phone	[18, 41, 76]
Clearly visualize his/her trip by reading travel notes on my gadgets	[17]
Clearly describe his/her travel trip by looking at social media posts of others	[70, 76]
Vividly describe his/her trips by reading his/her social media posts	
<i>Loyalty</i>	
Come back to this tourist destination	[24, 48, 62]
Visit other tourist destinations in Indonesia*	
Recommend this tourist destination to others	
Say positive things to other people	
Share positive experience on social media	[24, 48, 62]

*Item was excluded due to low factor loading

examined through the average variance extracted (AVE), which should be greater than 0.50, as suggested by [78]. At this stage, the AVE value still did not meet the requirements, so eight indicators had to be discarded, as shown in Table 1. The removal items are likely to be influenced by contextual variations across regions (e.g., cleanliness, crowding, and traffic), tourists' limited information (e.g., traditional food and cultural preservation effort), and ambiguous item interpretation (e.g., recall on layout). After

Table 2 Respondent Profile

	Frequency (N = 432)	Percent
<i>Gender</i>		
Female	218	50,34
Male	211	48,96
Prefer not to mention	3	0,70
<i>Age</i>		
17–21 years old	65	15,08
22–30 years old	214	49,42
31–40 years old	106	24,59
41–50 years old	38	8,82
More than 50 years old	9	2,09
<i>Country of Origin</i>		
Africa	5	1,16
America	24	5,57
Asia	148	34,11
Australia	21	4,87
Europe	232	53,83
Others	2	0,46
<i>Occupation</i>		
Employee	177	40,84
Entrepreneur	64	14,85
Housewife	30	6,96
Not working/Retired	14	3,25
Self-employed	54	12,53
Student	91	21,11
Others	2	0,46

removing these indicators, the convergent validity requirement was met. The results of the tests for each construct are presented in Table 3 below.

In addition, discriminant validity was evaluated using the Fornell-Larcker test and the HTMT ratio, where the HTMT value must be less than 0.90. [78]. The test results in Table 4 show that the research model meets the requirements of discriminant validity.

According to Table 4, the Fornell-Larcker value for each variable is higher with its own indicators compared to other variables, indicating adequate discriminant validity. Additionally, all HTMT values are below the threshold of 0.90, confirming that each construct is sufficiently distinct from the others [78]. Thus, the results indicate that all constructs have successfully met the criteria for discriminant validity.

4.2 Structural model

The results of the structural model test on international tourists demonstrate that not all the proposed hypotheses are accepted. The results are presented in Table 5 below.

Table 5 demonstrates that two hypotheses are rejected: economic attributes do not affect loyalty (H1), and environmental attributes do not affect internal vivid memory (H5a). However, the results indicate that environmental and socio-cultural attributes directly affect loyalty (H1 and H2), while economic attributes influence vivid memory (H4a and H4b). Socio-cultural attributes affect vivid memory (H6a and H6b), while environmental attributes only impact external vivid memory (H5b). In addition, both internal and external vivid memory influences tourists' loyalty (H7 and H8). However, external vivid memory has a higher impact on loyalty compared to internal vivid memory. The results of this path analysis are presented more clearly in Fig. 2 below.

Table 3 Reliability and Validity

Item	Loading Factor	Cronbach Alpha	Composite Reliability	AVE
Economic Attributes (Ec)		0.799	0.857	0.501
Ec1. Good public transportation system	0.798			
Ec2. Good public physical infrastructure	0.701			
Ec3. Diverse locally-owned businesses	0.654			
Ec4. Various places to go out and have fun	0.640			
Ec6. Widely available public facilities	0.719			
Ec8. High-quality local souvenirs and crafts	0.723			
Environmental Attributes (En)	0.742			
En1. Interesting natural attractions	0.629			
En4. The level of pollution is acceptable	0.687			
En5. Concerned preservation of natural areas	0.708			
En6. Pleasant weather and climate	0.793			
En7. Restful and relaxing atmosphere	0.769			
Socio-cultural Attributes (SC)		0.763	0.838	0.510
SC1. Fascinating cultural attractions	0.725			
SC2. Aesthetic local arts and crafts	0.687			
SC4. Authentic cultural heritage and traditions	0.734			
SC6. Interaction between residents and visitors		0.708	0.819	0.532
Internal Vivid Memory (IVM)		0.686	0.809	0.514
IVM1. Clearly recall what I saw	0.711			
IVM2. Clearly recall what I heard	0.718			
IVM3. Clearly remember my emotions	0.690			
IVM5. Clearly remember the ambiance	0.749			
External Vivid Memory (EVM)		0.700	0.817	0.529
EVM1. Remembered through photos on the phone	0.638			
EVM2. Visualized through travel notes on gadgets	0.695			
EVM3. Described through social media of others	0.741			
EVM4. Described through my social media posts	0.823			
Loyalty (LY)		0.679	0.803	0.511
LY1. Revisit the destination	0.535			
LY2. Recommend to others	0.812			
LY3. Say positive things	0.763			
LY4. Share a positive experience on social media	0.718			

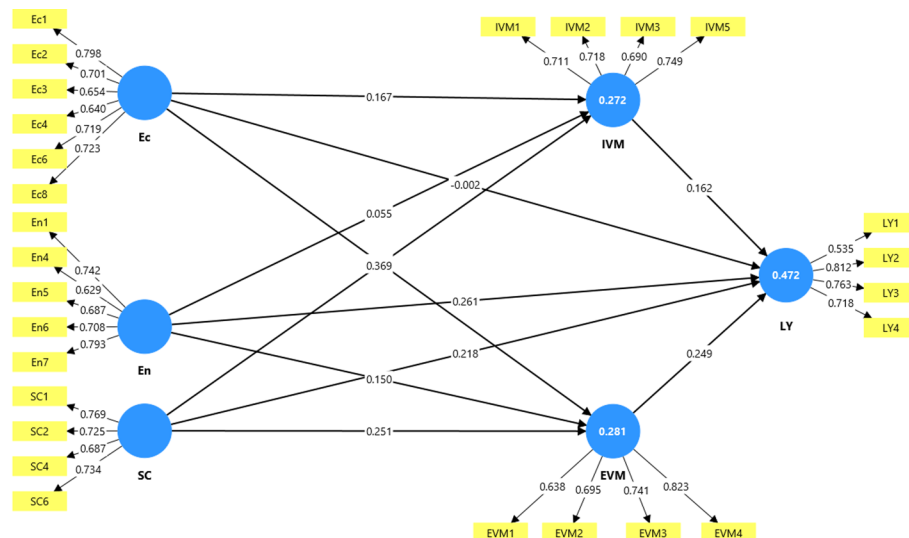
Table 4 Discriminant validity

Constructs	Ec	En	LY	SC	VME	VMI
<i>Fornell-Larcker Criterion</i>						
Economic Attributes (Ec)	0.708					
Environment Attributes (En)	0.508	0.714				
Loyalty (LY)	0.442	0.526	0.715			
Socio-cultural Attributes (SC)	0.603	0.523	0.550	0.729		
External Vivid Memory (EVM)	0.456	0.397	0.544	0.467	0.727	
Internal Vivid Memory (IVM)	0.417	0.333	0.496	0.499	0.558	0.717
<i>Heterotrait-Monotrait Ratio (HTMT)</i>						
<i>Economic Attributes (Ec)</i>						
Environment Attributes (En)	0.663					
Loyalty (LY)	0.589	0.736				
Socio-cultural Attributes (SC)	0.801	0.682	0.757			
External Vivid Memory (EVM)	0.603	0.521	0.768	0.650		
Internal Vivid Memory (IVM)	0.554	0.429	0.689	0.703	0.805	

Table 5 Path Analysis Result

	Path	Original Sample	Sample mean	Standard deviation	T statistics	P values	Hypotheses Result
H1	Ec—> LY	−0.002	−0.005	0.071	0.035	0.486	Rejected
H2	En—> LY	0.261	0.263	0.056	4.646	0.000	Accepted
H3	SC—> LY	0.218	0.215	0.066	3.322	0.001	Accepted
H4a	Ec—> IVM	0.167	0.172	0.076	2.191	0.014	Accepted
H4b	Ec—> EVM	0.229	0.235	0.082	2.776	0.003	Accepted
H5a	En—> IVM	0.055	0.055	0.071	0.780	0.218	Rejected
H5b	En—> EVM	0.150	0.151	0.064	2.345	0.010	Accepted
H6a	SC—> IVM	0.369	0.368	0.073	5.088	0.000	Accepted
H6b	SC—> EVM	0.251	0.247	0.100	2.513	0.006	Accepted
H7	IVM—> LY	0.162	0.166	0.052	3.113	0.001	Accepted
H8	EVM—> LY	0.249	0.247	0.063	3.956	0.000	Accepted

t-statistic value at 5%

**Fig. 2** Path coefficients

4.3 Mediation analysis

A mediation analysis was conducted to examine the mediating roles of internal vivid memory (IVM) and external vivid memory (EVM) in the relationship between destination attributes and tourist loyalty (LY). The destination attributes included economic attributes (Ec), environmental attributes (En), and sociocultural attributes (Sc). Table 6 summarizes the mediation results.

The results show that internal vivid memory (H9a) and external vivid memory (H9b) fully mediated the relationship between economic attributes and tourist loyalty, indicating that tourists' memories effectively transmit the influence of economic aspects into loyalty. In the case of environmental attributes, no significant mediation was found through either internal vivid memory (H10a) or external vivid memory (H10b), suggesting that environmental attributes do not influence tourist loyalty through memory-based mechanisms. Meanwhile, sociocultural attributes showed partial mediation through both internal vivid memory (H11a) and external vivid memory (H11b), indicating that sociocultural attributes influence tourist loyalty both directly and indirectly (Table 7).

Table 6 Mediation Test

	Path	Original Sample	T statistics	P values		Conclusion	Hypotheses Result
				Indirect	Direct		
H9a	Ec—>IVM—>LY	0.027	1.717	0.043	0.486	Full Mediation	Accepted
H9b	Ec—>EVM—>LY	0.057	2.188	0.014	0.486	Full Mediation	Accepted
H10a	En—>IVM—>LY	0.009	0.675	0.250	0.000	No Mediation	Rejected
H10b	En—>EVM—>LY	0.037	1.900	0.029	0.000	Partial Mediation	Accepted
H11a	SC—>IVM—>LY	0.060	2.750	0.003	0.001	Partial Mediation	Accepted
H11b	SC—>EVM—>LY	0.062	2.176	0.015	0.001	Partial Mediation	Accepted

t-statistic value at 5%

Table 7 Model Fit

Items	R ²	Q ² predict	PLS-SEM		LM	
			RMSE	MAE	RMSE	MAE
Internal Vivid Memory (IVM)	0.272	0.245	0.877	0.677		
IVM1		0.109	0.881	0.729	0.883	0.692
IVM2		0.165	0.962	0.745	0.960	0.740
IVM3		0.071	0.923	0.730	0.916	0.696
IVM5		0.144	0.911	0.730	0.927	0.727
External Vivid Memory (EVM)	0.281	0.250	0.876	0.609		
EVM1		0.077	0.830	0.705	0.804	0.668
EVM2		0.091	1.131	0.884	1.099	0.840
EVM3		0.159	1.080	0.824	1.098	0.793
EVM4		0.192	1.025	0.770	1.045	0.779
Loyalty (LY)	0.472	0.362	0.813	0.591		
LY1		0.099	1.537	1.165	1.363	1.026
LY3		0.263	0.924	0.711	0.938	0.712
LY4		0.177	0.914	0.749	0.905	0.717
LY5		0.178	1.174	0.859	1.176	0.834

The Standardized Root Mean Square Residual (SRMR) is an index used to assess the goodness of fit in structural equation modeling by measuring the difference between observed and predicted correlations. The SRMR value obtained was 0.095, which, although slightly above the threshold of 0.08, is still considered acceptable [79], indicating that the model has an adequate overall fit.

The results presented in the table above indicate that the Q² predict values are greater than zero [78], which implies that the model captures positive predictive relevance. Moreover, the PLS-SEM model demonstrates medium predictive power, as 6 out of 12 indicators show lower prediction errors (RMSE or MAE) compared to the linear benchmark model. Both results indicate that the PLS-SEM model has moderate predictive relevance.

5 Discussion

The findings of this study suggest that the attributes associated with sustainable tourism enhance tourist loyalty, particularly those related to environmental and socio-cultural aspects. While economic attributes do not directly impact loyalty, they appear to enhance the vividness of tourists' internal and external memories. This implies that the perception of infrastructure, public facilities, and transportation is seen as a fundamental aspect of travel, which may not strongly motivate foreign tourists to revisit, recommend, and share their experiences. This aligns with Herzberg's two-factor theory, which

classifies such elements as hygiene factors, which are necessary to prevent dissatisfaction but insufficient to create satisfaction or loyalty on their own [80]. In tourism, hygiene factors include infrastructure, public facilities, and safety [81, 82]. In accordance with the concept of memorable experiences, tourists are more likely to revisit, recommend, and share information about destinations that offer novel and extraordinary features [39, 83]. For instance, the mega shopping mall of Qatar and Villaggio offer modern facilities, social spaces, and technology-enabled services that create enjoyable experiences. These features enhance revisit intentions by leaving vivid and memorable impressions on both local and international tourists [55].

Environmental attributes have been shown to significantly influence tourist loyalty. This is aligned with Attention Restoration Theory, which suggests that natural environments help restore depleted cognitive resources, reduce mental fatigue, promote psychological well-being, and increase the likelihood of tourists recommending and revisiting [77]. Additionally, the evidence suggests that a stunning and authentic natural environment has the ability to stimulate the senses, thereby enriching the travel experience [54]. On the other hand, Environmental attributes do not significantly impact the clarity of biological memories, but they influence memories requiring technological assistance. This might be explained by the complexity and richness of sensory elements inherent in natural attributes through multi-sensory experiences, such as the smells of whale blow, sounds of birdsong, and the visual beauty of wildlife movements [61]. These sensory elements are inherently unconstructed, providing tourists with authentic and immersive encounters that are difficult to replicate artificially [84]. The theoretical concept of externalising memory is employed to illustrate the role of digital technology as a cognitive extension. These technologies facilitate the offloading of processing elements, such as encoding and retrieval, to external devices, thereby reducing the cognitive burden on human memory [16, 17, 41]. Consequently, the sensory details of such experiences are more effectively encoded and retained with the assistance of photos, videos, digital records, or social media platforms.

The sociocultural attributes of sustainability tourism have been identified as the most influential factors in creating vivid internal and external memories. Interestingly, this attribute only influences biological memory more strongly than technology-assisted memory. This finding is consistent with the results of previous studies, that culture has the potential to enhance tourists' memories of destinations through new cultural learning [64], as well as nostalgic experiences and authenticity [51]. In this context, memorable tourism is synonymous with elements perceived as novel and high levels of interaction [60]. For instance, participating in Melukat purification ceremonies in Bali [85] or engaging in cultural activities at the Sultan Palace in Yogyakarta [86] allows tourists to directly interact with local traditions, thereby reinforcing unforgettable memories.

According to the mediation analysis results, vivid memory plays a key role in mediating the relationship between destination attributes and tourist loyalty, particularly for economic attributes like infrastructure, public facilities, and shopping centers. These economic factors need to be vividly remembered in order to create lasting impressions that influence loyalty. To be memorable, transportation systems, infrastructure, and public facilities must offer more than basic functionality; they should feature unique and authentic characteristics that enhance the overall travel experience and leave a lasting impression on tourists [2, 7, 52, 68]. On the other hand, sociocultural attributes also

mediate loyalty through memory, but they also have a direct effect, showing that cultural experiences impact loyalty both through vivid recollections and immediate engagement. This finding highlights the importance of cultural authenticity, as deeply rooted and unique cultural elements leave a distinct impression on tourists [10, 58]. Such authentic cultural experiences not only enrich their visit but also create meaningful memories that contribute to a stronger attachment, which triggers loyalty to the destination [30, 87, 88]. Environmental attributes, however, showed only a direct effect on loyalty, without needing to be vividly remembered. This finding may be explained by the notion that natural landscapes or ecological features have the capacity to elicit spiritual and emotional outcomes [89, 90], rather than memory. Natural and aesthetically pleasing environments often develop feelings of excitement, relaxation, and joy, which enhance loyalty [91]. Moreover, the experience of escaping to restful environments has been demonstrated to facilitate a psychological shift that is expressed through feelings of well-being and the subsequent desire to repeat the experience [92, 93]. Therefore, these affective mechanisms suggest that loyalty may emerge not only from remembered experiences but also from the emotional intensity of the moment.

Moreover, the findings indicate that memory facilitated by technology has a greater impact on loyalty than natural memory. This suggests that the perception of destination attributes in a tourist destination is not retained in tourists' biological memory but rather facilitated by social media, photographs, and other forms of technology. Several studies have previously emphasized the importance of technology, proposing directions for future research to consider technology in tourism studies and practice [94, 95].

5.1 Theoretical implications

This study represents further development of the concept of memorable tourism experience in the digital era. Vivid memory can be considered an essential cognitive process, as these memories are stored in long-term memory and reappear when recalling memorable personal events [40, 67, 69]. A comprehensive grasp of the concept of vivid memory can prove invaluable in creating models for memorable experiences [40, 68]. The degree of vividness, therefore, represents a crucial element in assessing traveller loyalty. Hence, this research expands the concept of memorable experiences by examining the externalization of memory, which is a potential solution to enhance tourists' recollections of their experiences. Finally, it provides tourists with remarkable experiences that lead to their intention to revisit, recommend, and share them with others [57].

Furthermore, the study makes a significant contribution to the field of sustainability research by integrating the three core dimensions of sustainable tourism into the framework of memory-based experience. The study explores the differential impact of these attributes on both internal and external memory, and consequently, on tourist loyalty. This integration offers a more holistic theoretical framework that bridges sustainability practice and cognitive perspectives in tourism research.

5.2 Managerial implications

The results of this study indicate that the attractiveness of tourism in the eyes of international tourists lies primarily in the social and cultural aspects of a destination. Therefore, it is important to properly maintain the authenticity of local culture and behaviour. This includes efforts to preserve traditions, local values, and social interactions that are

unique to the destination. In addition, destination managers and governments should proactively incorporate socio-cultural content into promotion strategies by developing immersive cultural workshops, organizing local festivals, and collaborating with community members to offer authentic experiences. They can also leverage user-generated content on social media platforms to showcase tourists' personal cultural experiences.

The findings of this study indicate that destination attributes related to a beautiful and well-maintained natural environment will increase tourists' desire to recommend and share their experiences. This underscores the importance of providing internet and digital infrastructure to facilitate information sharing. Destination managers must also prioritize the maintenance of the natural environment through the development of regulations and educational initiatives at tourist attractions.

In addition, destination managers and tourism business providers should consider enhancing the availability of technology that allows tourists to capture photos and videos and access social media. This approach facilitates the multisensory integration of natural elements, thereby enhancing tourist loyalty. Additionally, destination managers can create experiences that are not only memorable during the visit but also encourage tourists to share and recommend them, which can help promote the destination organically.

6 Conclusion and recommendations

In conclusion, the findings provide valuable insights regarding the relationships between sustainability tourism attributes, vivid memory, and tourist loyalty. Economic attributes were found to have no direct impact on loyalty or internal vivid memory. However, environmental and socio-cultural attributes play significant roles in shaping both loyalty and internal memory clarity. Moreover, environmental attributes influence external memory but not internal memory. Specifically, socio-cultural attributes have the highest impact on vivid memory, while environmental attributes influence loyalty most. Furthermore, the mediation analysis underscores the pivotal role of vivid memory in shaping tourist loyalty, particularly concerning economic and sociocultural destination attributes. Infrastructure, public facilities, and shopping centers must be offered beyond their functionality to be vividly remembered and influence long-term loyalty. In addition, sociocultural attributes rely on memory and exert a direct influence, highlighting the effect of culturally rich encounters on tourists' emotional connections to a destination. In contrast, environmental attributes directly affect loyalty without requiring vivid memory, suggesting that their impact lies more in the emotional states they induce rather than in strong cognitive impressions. Furthermore, the findings reveal that technology-enhanced memory (through photographs, social media, and digital notes) has a greater influence on loyalty than natural memory alone. This emphasizes the growing importance of digital tools in complementing tourist experiences and the need for further exploration of technology's role in tourist behavior and destination branding.

7 Limitation and future direction

In addition to offering novel insights into the role of technology in vivid memory and its impact on enhancing international visitor loyalty, this study has several limitations that must be acknowledged. The present study is limited to four cities in Indonesia; it is acknowledged that other regions or countries may exhibit different characteristics and economic dynamics. Consequently, it is recommended that future research be conducted

in other locations to facilitate a more comprehensive comparison. Furthermore, based on the findings of this study, it is recommended that subsequent research endeavours explore the potential of alternative mediating variables or mechanisms for environmental factors, such as perceived authenticity, escapism, or emotional well-being. It is also recommended that exploring specific economic attributes that are considered extraordinary and have a stronger influence on fostering tourist loyalty be examined. Moreover, qualitative research focusing on the process of memory formation could provide deeper insights into how tourists develop their travel memories and impact their behaviour.

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Author contributions

R.J., H.S., and S.W. conceptualised the study and contributed to its methodology. R.J. conducted the data analysis and drafted the paper. H.S. and S.W. reviewed and approved the final manuscript. Additionally, H.S. and S.W. secured the project's funding. All authors have read and agreed to the published version of the manuscript.

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Data availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to containing information that could compromise the privacy of research participants.

Declarations

Ethics approval

The protocol of this study was reviewed, and formal ethical approval was waived by the Institute of Research and Community Outreach at Petra Christian University, as the research involved non-sensitive survey data and posed no risk to participants. The study was conducted in accordance with the ethical standards of the committee and the principles outlined in the Declaration of Helsinki.

Consent to participate

All participants were informed about the objectives and procedures of this study and voluntarily provided their informed consent prior to participation. Participation was optional, and confidentiality and anonymity of responses were maintained.

Consent for publication

All participants provided consent for the publication of data derived from their responses in anonymized form, without the disclosure of personal identifying information.

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