

Rethinking the Technology Acceptance Model: A Structural Analysis of Sustainable Technology Adoption in Malaysian Tourism

Haslinda Musa^{1*}, Abdul Rahim Abdullah², Mohd Nasar Othman³, Nurulizwa Rashid¹, Fadhlur Rahim Azmi⁴

^{1,2}Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 75350 Taman Tasik Utama, Melaka, Malaysia.

³NMS Legacy Sdn Bhd Lot 2890 E, Losong Panglima Perang, 21000 Kuala Terengganu, Malaysia.

⁴UiTM Cawangan Melaka Kampus Bandaraya Melaka Jalan Hang Tuah, Melaka 75300, Malaysia.

*Corresponding author

DOI: <https://dx.doi.org/10.47772/IJRISS.2025.909000500>

Received: 10 September 2025; Accepted: 15 September 2025; Published: 16 October 2025

ABSTRACT

This study explores the behavioral factors influencing the adoption of ePenambang, a solar-powered boat system introduced in Kuala Terengganu, Malaysia, as a sustainable tourism innovation. Utilizing an extended Technology Acceptance Model (TAM), the research examines the roles of socioeconomic status (SES), environmental awareness (EA), and technological proficiency (TP), with perceived usefulness (PU) and perceived ease of use (PEOU) as mediators, and subjective norms (SN) as a moderator. Data from 304 respondents were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). Results reveal that SES and EA significantly influence PU and PEOU, while TP only affects PEOU. Crucially, PU and PEOU did not significantly predict adoption intention challenging key TAM assumptions. Framed through posthumanist theory, the study reconceptualizes technology as an entangled agent within socio-ecological systems. It offers theoretical advancement and practical insights for sustainable tourism design and policy.

Keywords— Posthumanism, Sustainable Tourism, Technology Adoption, Technology Acceptance Model (TAM), Eco-transport, PLS-SEM, Relational Agency

INTRODUCTION

In recent years, the global tourism industry has been placed under intensifying scrutiny as scholars and practitioners recognize its dual role in contributing to environmental degradation and serving as a potential site for sustainable innovation [5]. Transportation within tourism, in particular, has been identified as a significant contributor to carbon emissions, prompting calls for low-impact mobility solutions that align with ecological ethics and climate goals [1]. To meet escalating calls for sustainability, new technologies for sustainable mobility, like solar boats, electric buses, and intelligent energy systems, have become very popular as alternative options for conventional tourist infrastructure. A prime example is ePenambang, a boat system run on solar power unveiled at Kuala Terengganu, Malaysia, as part of a larger effort to promote ecofriendly travel and reduce the environmental footprint of river-based tourism.

Despite advances in technologies for sustainable tourism at a rapid pace, there is an immediate need to understand users' motivation for adopting such technologies. Technical viability is also supported by human factors such as environmental concern, societal norms, and digital literacy, which act as key building blocks for implementing sustainable innovation [10]. In the past, the Technology Acceptance Model (TAM) has been the model under examination when considering adopting technologies, with perceived usefulness (PU) and perceived ease of use (PEOU) as key predictors for behavioral intention [4]. The development of empirical inconsistencies and conceptual rigidity has, however, led researchers to reconsider the applicability of the model in environments as complicated as sustainable tourism [8].

This research fills the gap by theoretically broadening Technology Acceptance Model (TAM) to include environmental concerns, socioeconomic level, and technological competence, while also critiquing TAM's untested assumptions on human-technology relations from a posthumanist stance. Current posthumanist theory focuses on human subjects not being able to be thought of independently from technologies they use or ecologies they engage with, instead being mutually enacted through changing entanglements [3]. Tools like ePenambang cannot themselves then be thought of as passive tools to test solely on usability or efficiency levels, rather as having an active role in shaping behaviors, perceptions, and ethical sensitivities due to their context-specific embedding in socio-material assemblages. Indeed, posthumanist scholarship in tourism is beginning to gain traction, challenging the anthropocentric logics that underpin traditional behavioral models. In their study of technological innovation in the tourism ecosystem, [11] emphasizes that digital infrastructures (e.g., AI and VR) must be conceptualized not as external tools but as active participants in co-producing tourist experience, value, and environmental interaction. Similarly, [2] argues that posthumanist orientations allow for a more inclusive and ecologically attuned understanding of tourism, one that accommodates the agencies of non-human actors including technologies, landscapes, and animals within the travel encounter. These insights are especially salient in contexts like ePenambang, where sustainable transport exists not just as a vehicle but as an ethico-material interface linking tourists, environment, and machine.

Despite the theoretical promise of posthumanist perspectives, there is a conspicuous absence of empirical integration between posthumanism and mainstream technology adoption frameworks in tourism. While posthumanism deconstructs the human-centered logic of models like TAM, few studies have attempted to test this tension empirically using real-world behavioral data. Moreover, most adoption studies in tourism remain overly reliant on functionalist paradigms, such as TAM or UTAUT, and fail to address the deeper ontological assumptions about human technology nature relations [9].

This study, therefore, contributes to the emerging intersection of posthumanism, sustainable tourism, and behavioral adoption research. Using a Partial Least Squares Structural Equation Modeling (PLS-SEM) approach, we assess how travelers in Malaysia evaluate and adopt the ePenambang system, focusing on both traditional TAM constructs and broader ecological-social factors. Importantly, the study explores the empirical breakdown of TAM's core mediators (PU and PEOU), showing that their explanatory power is diminished in the presence of more relational, affective, and situated variables. Such a finding supports the argument that adoption is no longer about utility or usability, but about how humans experience and align with technologies as entangled parts of an ecological system.

Research Questions

1. What factors influence the adoption of sustainable transportation technology (e.g., ePenambang) in tourism?
2. Do TAM's core mediators perceived usefulness and ease of use retain their significance in eco-technological contexts?
3. How can posthumanist theory provide a deeper understanding of human–technology–environment relations in sustainable tourism?

In answering these questions, the study provides both theoretical advancement and practical insight into designing and promoting sustainable technologies that align not just with user expectations, but with emerging ethics of more-than-human coexistence.

LITERATURE REVIEW

Sustainable Tourism and Eco-Transport

The imperative to align tourism practices with environmental sustainability has intensified in recent years, driven by growing awareness of the industry's contribution to carbon emissions, biodiversity loss, and environmental degradation [5]. As tourism continues to expand globally, the need for low-impact alternatives, particularly in

transport infrastructure, has become critical. Eco-transport innovations, such as electric shuttles, solar-powered boats, and shared mobility systems, have emerged as viable interventions to mitigate these impacts.

In Southeast Asia, several initiatives demonstrate the rising integration of green mobility solutions into tourism ecosystems. One such innovation is ePenambang, a solar-powered boat introduced in Kuala Terengganu, Malaysia, designed to replace fossil-fueled transport along riverine heritage routes. These systems reduce not only emissions but also represent a commitment to sustainable tourism. According to [11], integration with Tourism 4.0 technologies, such as artificial intelligence, automation, and smart mobility, is key to building sustainable futures for tourism, especially where such technologies are balanced with natural and cultural environments. However, with all this great technological potential in these innovations, success with their integration is largely contingent on acceptance by users, an area where behavioral insights are currently not adequately advanced within sustainability debate.

Technology Adoption Models: TAM, UTAUT, and Extensions

Among all areas of technology, the Technology Acceptance Model (TAM) has become the most used theory to explain adoption by users. First proposed by [4], TAM states that two major beliefs Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) are predictors of users' intentions and adoption actions. TAM is now used in a wide range of fields, e.g., e-business and medicine, and more recently, in tourism technologies like booking apps, automatic kiosks, and payment systems, as noted by [8].

Extensions to TAM, such as the Unified Theory of Acceptance and Use of Technology (UTAUT), have added variables like facilitating conditions and social influence [12]. Even though UTAUT is a more extensive explanation, its underlying presumptions remain built on a rational-actor model, where people make decision-making behaviors driven by perceived usefulness and effort.

For tourism, the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) have been utilized to explain adoption of contactless payment systems [10], smart tourism platforms [9], and eco-friendly accommodation options. These models often overlook, though, contextual, affective, and relational dynamics affecting how users perceive and use technologies, when such technologies meet with environmental values and local cultural meanings.

Limitations of TAM in Eco-Contexts

Despite its wide popularity, Technology Acceptance Model (TAM) has faced growing criticism for its ontological and contextual limitations, especially when conducting research on sustainability-based or ethical technologies. According to critics, unlike the perceived usefulness (PU) and perceived ease of use (PEOU), environmentally conscious actions are often driven by values, identity, or a sense of ecological ethics and not by purely functional usefulness [13]. For example, a consumer will choose to buy a boat with an in-built solar panel not just because it is efficient, but because it reflects their environmental worldview. Such actions are value-laden and, as such, cannot be reduced to descriptive cognitive assessments of usefulness.

More recent empirical research corroborates this criticism. A PLS-SEM investigation into sustainable transport in Malaysia found that indirect effects by way of perceived usefulness (PU) and perceived ease of use (PEOU) were not statistically supported, suggesting that other variables, like environmental consciousness and societal norms, will have more explanatory power. This is also supported by research by [9], who argue that embedding affective and environmental perspectives in adoption models is vital to capturing real-world realities of sustainable conduct.

In addition, TAM does not fully take into consideration relational ontology in human–technology relations. It treats technology as a passive entity whose value is judged by a rational actor, ignoring ways technologies engage with users actively to shape, guide, or become enmeshed with them within larger systems of meaning and practice. This ontological neglect is particularly troubling in ecological contexts, where technologies are embedded in environmental stories, ethical conversations, and conceptions of a particular place.

Posthumanism as Theoretical Lens

Posthumanism critiques anthropocentrism by questioning the notion that humans are independent agents interacting with passive environments and technologies. The focus is on entanglement, relationality, and distributed agency, positing that humans, technologies, and ecosystems collaboratively shape experiences and actions [3]. This framework is well-suited for sustainability studies, where ethical and material entanglements play a central role.

Posthumanist scholars in tourism have initiated investigations into the role of non-human actors such as technologies, landscapes, and animals in influencing travel experiences. [11] examines the impact of Tourism 4.0 technologies in Tunisia, highlighting the emergence of new configurations of human tech interaction that alter both tourist experiences and ethical relationships to place. These technologies function as co-agents in environmental storytelling and behavior modification.

[2] critiques the homogenizing tendencies of tech-driven tourism, proposing that posthumanist frameworks enable a rethinking of technology as a participant in complex socio-material systems rather than merely as an enabler or disruptor. This has direct relevance for eco-transport solutions like ePenambang, where technology is embedded within environmental, historical, and cultural narratives, making the adoption decision one of alignment and resonance, not merely evaluation.

Posthumanist theory thus provides a compelling alternative to TAM by shifting the analytical focus from individual intention to relational systems. Rather than asking how users perceive technology, posthumanism asks how technology and users co-constitute each other within evolving ecosystems of ethics, embodiment, and experience [7].

Yet, despite its relevance, empirical integration of posthumanism into adoption research remains rare. While theoretical work abounds, few studies test posthumanist claims with behavioral data. This study addresses that gap by using empirical modeling to interrogate the assumptions of TAM, demonstrating that when sustainable technology is deeply entangled in ecological meaning, traditional mediators like PU and PEOU lose explanatory power. What emerges instead is a relational ethics of adoption, guided by ecological awareness, social norms, and techno-material alignment.

Conceptual Framework & Hypotheses

This study develops an extended Technology Acceptance Model (TAM) to examine the behavioral dynamics behind the adoption of ePenambang, a solar-powered transport system in Malaysian tourism. The proposed framework incorporates traditional TAM mediators Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) and extends it with three key antecedents: Socioeconomic Status (SES), Environmental Awareness (EA), and Technological Proficiency (TP). Additionally, Subjective Norms (SN) are introduced as a moderating factor influencing the relationship between mediators and the Adoption Intention (AI) of sustainable technology.

From a posthumanist standpoint, this model departs from conventional adoption logic by decentering the user as a rational evaluator, instead positioning adoption as a relational outcome that emerges through entanglements between humans, technologies, environments, and socio-material systems ([3]; [7]). Technologies like ePenambang are not merely tools to be evaluated for ease or usefulness; they are embedded agents that shape ethical choices, community norms, and ecological alignments (Nagara, 2025).

Construct Descriptions

1. Socioeconomic Status (SES): Captures education, income, and financial willingness to support eco-technologies.
2. Environmental Awareness (EA): Measures concern for sustainability and ethical responsibility in travel behavior.
3. Technological Proficiency (TP): Reflects comfort and familiarity with using digital or automated systems.

4. Perceived Usefulness (PU): Degree to which a person believes ePenambang enhances travel.
5. Perceived Ease of Use (PEOU): Extent to which ePenambang is perceived as effortless to operate.
6. Subjective Norms (SN): Perceived social pressures and community values around eco-technology use.
7. Adoption Intention (AI): Likelihood that the user will adopt or support ePenambang.

Hypotheses Development

1. H1a: SES positively influences PU. Educated and financially stable individuals often recognize environmental co-benefits and value efficiency [9].
2. H1b: SES positively influences PEOU. Technological comfort is often higher among users with stronger socioeconomic backgrounds.
3. H2a: EA positively influences PU. Environmentally aware individuals may view ePenambang as functionally superior due to its ethical design [13].
4. H2b: EA positively influences PEOU. Affective alignment with sustainability may reduce perceived complexity of technology [2].
5. H3a: TP positively influences PU. Familiarity with smart systems enhances recognition of their benefits though this hypothesis is empirically debated.
6. H3b: TP positively influences PEOU. More proficient users are likely to find technology intuitive and manageable [10].
7. H4: PU positively influences AI. Classic TAM logic users adopt technology they find beneficial.
8. H5: PEOU positively influences AI. Technologies perceived as easy to use are more likely to be adopted.
9. H6–H8: PU and PEOU mediate the relationships between SES, EA, TP and AI. TAM posits indirect effects through cognitive appraisals, though our results challenge this assumption.
10. H9a–H9b: SN moderates the relationships between PU, PEOU and AI. Social influence can amplify or suppress personal perceptions of utility and effort [11].

Posthumanist Positioning

This model not only critiques the assumption of linear cognition in TAM but repositions adoption as a relational construct, where non-human agents (e.g., boats, solar systems, social norms) co-produce behavioral outcomes (Figure 1). Such a framework is aligned with posthumanist tourism studies, which call for ecologically embedded, multi-agent models of technology adoption (Nagara, 2025;[2]).

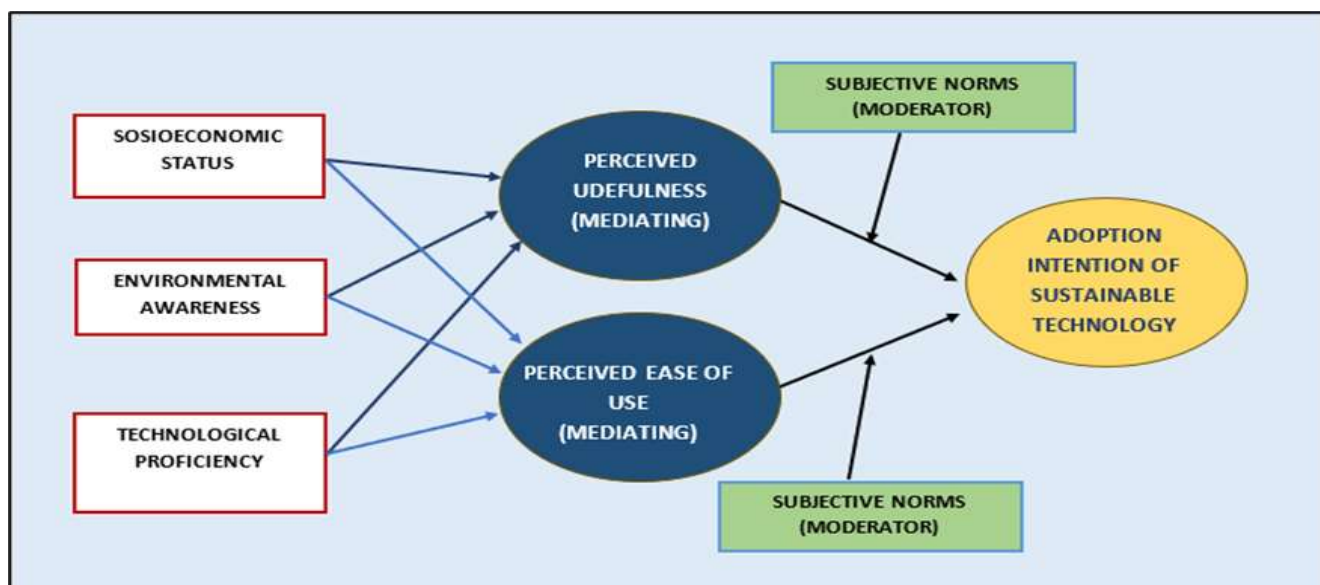


Fig 1. Conceptual Framework for Sustainable Technology Adoption

METHODOLOGY

Research Design and Philosophical Rationale

This study adopted a quantitative research design employing Partial Least Squares Structural Equation Modeling (PLS-SEM) to explore the behavioral and perceptual determinants of adopting sustainable transport technologies, specifically the solar-powered ePenambang system in Malaysian tourism. While posthumanist research often privileges qualitative inquiry due to its relational and affective complexity [3], this study positions PLS-SEM as a strategic complement providing empirical testing of how non-human agency, socio-material influence, and behavioral intentions co-evolve in real-world technological contexts [11].

This entangled epistemology resonates with emerging posthumanist approaches in tourism that aim to break binary distinctions between human cognition and technological materiality [2]. By using quantitative tools to track behavioral proxies for relational ethics, this study adds methodological diversity to posthumanism-informed research while challenging reductionist models of user intention.

Sampling and Data Collection

Data were collected via a structured questionnaire distributed online and in-person across major urban and tourist-centric areas in Kuala Terengganu, Malaysia. A total of 304 valid responses were collected through purposive sampling, focusing on individuals knowledgeable about riverine tourism or sustainable transport technologies. The sample size surpasses the minimum requirement for PLS-SEM models of moderate complexity, as indicated by [6], facilitating a strong estimation of path coefficients and construct reliability.

Measurement Instrument

The survey instrument was developed to encompass both traditional TAM characteristics and additional variables derived from the posthumanist expansion of the paradigm. Each construct was assessed using five items, formulated based on verified literature and tailored to the eco-transport context. All responses utilized a 5-point Likert scale, with 1 representing "Strongly Disagree" and 5 denoting "Strongly Agree."

Constructs and Sample Items

- 1) Socioeconomic Status (SES): "I am prepared to incur additional costs for eco-friendly transportation."
- 2) Environmental Awareness (EA): "I perceive a personal obligation to diminish my carbon footprint."
- 3) Technological Proficiency (TP): "I am adept at utilizing advanced travel technologies."
- 4) Perceived Usefulness (PU): "Utilizing ePenambang will enhance my travel experience."

Perceived Ease of Use (PEOU): "Utilizing ePenambang would be uncomplicated for me."

Subjective Norms (SN): "Individuals in my vicinity advocate for the utilization of sustainable transportation."

Adoption Intention (AI): "I plan to utilize sustainable transportation technologies such as ePenambang."

Items underwent pre-testing for clarity via a pilot research involving 30 respondents, subsequent to which minor language modifications were implemented for cultural and contextual appropriateness.

RESULTS

Demographic Profile of Respondents

The demographic details for respondents are shown in Table 1 below:

Table I Profile Of Respondents

Variable	Category	Frequency (n)	Valid Percentage (%)
Gender	Male	139	45.7
	Female	165	54.3
Age Group	Under 20 years old	28	9.2
	20–29 years old	142	46.7
	30–39 years old	32	10.5
	40–49 years old	37	12.2
	50 years and above	65	21.4
Nationality	Malaysian	304	100.0
Education Level	Primary / Secondary School	7	2.3
	Diploma	62	20.4
	Bachelor's Degree	82	27.0
	Master's Degree	131	43.1
	Ph.D or higher	19	6.3
	<i>Unspecified (Code 6)</i>	3	1.0

There are 304 respondents with a slightly greater number of females (54.3%) than males (45.7%). The age distribution demonstrates that a little over the half (46.7%) of the partakers are aged 20–29 and 21.4% are above 50 years. All respondents are Malaysian nationals. The sample security is also well educated, having 43.1%, 27.0%, and 6.3% of the sample having Master's, Bachelor's, and Ph.D. degrees, respectively. Among respondents, only 2.3% of them have primary or secondary school education. The demographic profile of the overall sample is that of a highly educated and, on average, relatively young adult sample, which makes important difference when interpreting the sustainable technology adoption results.

Table II Descriptive Statistics For Main Constructs (N = 304)

Construct	Min	Max	M	SD
Socioeconomic Status	1.20	5.00	4.47	0.61
Environmental Awareness	1.20	5.00	4.75	0.52
Technological Proficiency	1.20	5.00	4.69	0.53
Perceived Usefulness	1.20	5.00	4.77	0.52
Perceived Ease of Use	1.20	5.00	4.76	0.51
Subjective Norms	1.20	5.00	4.75	0.52
Adoption Intention	1.00	5.00	4.68	0.52

Note: M = Mean; SD = Standard Deviation; N = 304 (listwise).

The descriptive statistics reveal consistently high mean scores across all constructs, ranging from 4.47 to 4.77 on a 5-point scale. Perceived Usefulness has the highest mean (4.77), closely followed by Perceived Ease of Use (4.76) and both Environmental Awareness and Subjective Norms (4.75). Socioeconomic Status shows the lowest mean (4.47) but still indicates strong positive perceptions. Standard deviations are relatively low (0.51-0.61),

suggesting homogeneity in responses. The minimum values of 1.00-1.20 across constructs indicate that while most respondents rated items highly, there were some who disagreed with certain statements. These high mean scores suggest that respondents generally have positive attitudes toward sustainable technology adoption in tourism, particularly regarding its usefulness and ease of use.

Measurement Model Assessment

A thorough evaluation of the measurement model, prior to testing the structural relationships in the proposed model, was conducted by ensuring reliability and validity of the constructs. Several psychometric properties of the measures were examined including: indicator reliability using factor loadings, internal consistency using Cronbach's alpha and composite reliability, convergent validity using average variance extracted (AVE) and discriminant validity using Fornell-Larcker criterion. They were necessary to verify that the measuring instrument is robust before hypothesis testing.

Table III Factor Loadings, Construct Reliability, And Convergent Validity

Constructs	Items	Outer Loadings	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
1. Adoption Intention	AI1	0.835	0.867	0.904	0.654
	AI2	0.846			
	AI3	0.826			
	AI4	0.785			
	AI5	0.747			
2. Environmental Awareness	EA1	0.869	0.892	0.922	0.704
	EA2	0.924			
	EA3	0.920			
	EA4	0.772			
	EA5	0.687			
3. Perceived Ease of Use	PEOU1	0.786	0.906	0.930	0.729
	PEOU2	0.808			
	PEOU3	0.840			
	PEOU4	0.924			
	PEOU5	0.902			
4. Perceived Usefulness	PU1	0.909	0.908	0.932	0.734
	PU2	0.863			
	PU3	0.829			
	PU4	0.902			
	PU5	0.773			
5. Subjective Norms	SN1	0.819	0.892	0.922	0.703
	SN2	0.702			
	SN3	0.893			
	SN4	0.935			

	SN5	0.826			
6. Socioeconomic Status	SES1	0.723	0.817	0.872	0.576
	SES2	0.754			
	SES3	0.724			
	SES4	0.823			
	SES5	0.767			
7. Technological Proficiency	TP1	0.820	0.869	0.905	0.655
	TP2	0.775			
	TP3	0.838			
	TP4	0.808			
	TP5	0.804			

Table 3 shows the measurement model analysis, which proves reliability and validity of the research constructs. Each factor loadings are well above the suggested regime of 0.7 with the where the majority of the items load between 0.7 and 0.9 indicating excellent indicator reliability. Cronbach's Alpha values for Internal Consistency Reliability were found to be excellent (between 0.817 and 0.908), as were Composite Reliability values (between 0.872 and 0.932) which surpassed the 0.70 threshold. All the constructs have their Average Variance Extracted (AVE) values greater than 0.5 (0.576 to .734) fulfilling the convergent validity. This means that, the items of measurement have well represented the latent constructs and also the instrument demonstrates that it has powerful psychometric properties.

Table IV Discriminant Validity (Htmt) Ratio

Constructs	AI	EA	PEOU	PU	SN	SES	TP
Adoption Intention (AI)	–						
Environmental Awareness (EA)	1.016	–					
Perceived Ease of Use (PEOU)	0.981	1.009	–				
Perceived Usefulness (PU)	0.986	1.004	1.030	–			
Subjective Norms (SN)	1.034	1.049	0.993	0.990	–		
Socioeconomic Status (SES)	0.789	0.747	0.797	0.808	0.819	–	
Technological Proficiency (TP)	0.971	1.007	0.964	0.917	0.993	0.767	–

Note: HTMT values below 0.90 indicate good discriminant validity; values between 0.90 and 1.0 suggest potential issues; values above 1.0 indicate lack of discriminant validity.

HTMT results shown in Table 4 indicates possible discriminant validity issues among a few of the constructs. The majority of the HTMT values involving Environmental Awareness, Perceived Usefulness, Perceived Ease of use, Subjective Norms and Technological Proficiency are greater than the conservative threshold of 0.90 and exceed 1.0. Such a finding suggests that the respondents have conceptual overlap of these constructs in their mind. For instance, Subjective Norms and Environmental Awareness have the highest ratio of (1.049) hence the two constructs have been perceived similar. Apart from Socioeconomic Status, all other constructs have good discriminant validity with other constructs, indicated by values of less than 0.90. These results indicate that the variance shared across most constructs is accounted for by the items that load in a quality fashion on their assigned constructs, but that some constructs do share a lot of variance.

Table V Fornell-Larcker Criterion

Constructs	AI	EA	PEOU	PU	SN	SES	TP	SN×PEOU	SN×PU
AI	0.809								
EA	0.747	0.839							
PEOU	0.745	0.785	0.854						
PU	0.749	0.823	0.836	0.857					
SN	0.795	0.872	0.817	0.820	0.838				
SES	0.680	0.658	0.691	0.712	0.720	0.759			
TP	0.764	0.803	0.751	0.760	0.781	0.696	0.809		
SN×PEOU	0.803	0.832	0.805	0.806	0.843	0.692	0.789	1.000	
SN×PU	0.791	0.821	0.796	0.794	0.837	0.690	0.785	0.998	1.000

Note: Diagonal values (bold) should be greater than corresponding rows/columns for discriminant validity.

Table 5 is the Fornell-Larcker analysis of square roots of AVE values (diagonal, bold) versus inter-construct correlations. To achieve an ideal solution, diagonal values should be greater than off diagonal entries that sit in the same row and the same column, which means that constructs contribute more than the other constructs to their own indicators. The findings indicate acceptable discriminant validity for most of the relationship with diagonal values, in general, greater than corresponding off-diagonal values. In particular, it is Socioeconomic Status which had shown the sharpest distinctions from other constructs. On the other hand, the results in the HTMT method also reveal high correlations among some constructs (mostly between Environmental Awareness, Perceived Usefulness, Perceived Ease of Use, and Subjective Norms), concurring with the correlations observed in the PCA. This is a common pattern in TAM-based studies in which perceptions about technology typically match highly.

Structural Model Assessment

The measurement model was then validated, and the structural model was then evaluated in order to test the hypothesized relationships between constructs. The assessment included direct effects between exogenous and mediating variables, effects of the mediators on the dependent variable, mediating relationships and mediating effects of the moderating influence of subjective norms. The analysis of path coefficients, significance levels, coefficient of determination (R^2), the predictive relevance (Q^2), and the effect sizes (f^2) used PLS-SEM. The structural model with path coefficients is shown in Figure 2 and Table 6 and 7 present detailed assessment results with associated statistical significance.

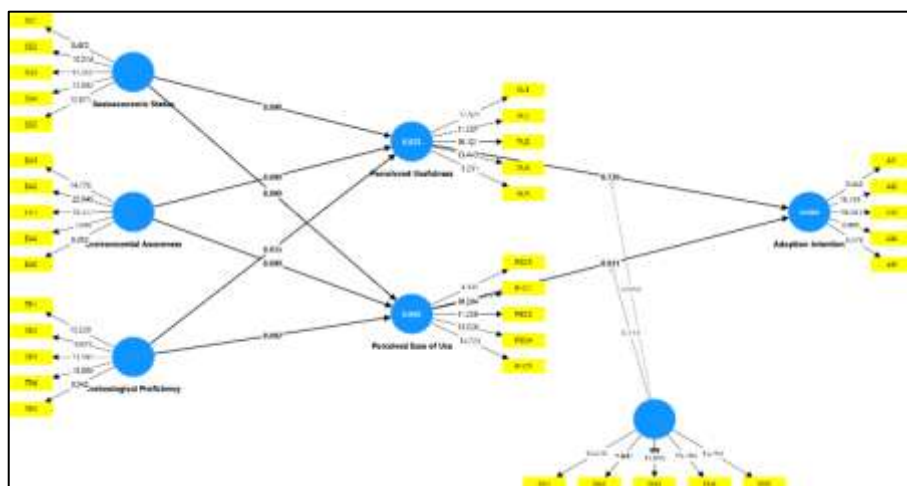


Fig 2. Partial Least Square Structural Equation Model

Table VI Hypotheses Testing Results

Hypotheses	Path	Path Coef.	t-Value	p-Value	Supported
H1a	SES → PU	0.180	5.037	0.000	Yes
H1b	SES → PEOU	0.132	4.009	0.000	Yes
H2a	EA → PU	0.787	8.413	0.000	Yes
H2b	EA → PEOU	0.661	9.910	0.000	Yes
H3a	TP → PU	0.006	0.081	0.935	No
H3b	TP → PEOU	0.192	3.086	0.002	Yes
H4	PU → AI	0.029	0.333	0.739	No
H5	PEOU → AI	-0.006	0.087	0.931	No
H6a	SES → PU → AI	0.005	0.324	0.746	No
H6b	SES → PEOU → AI	-0.001	0.084	0.933	No
H7a	EA → PU → AI	0.023	0.336	0.737	No
H7b	EA → PEOU → AI	-0.004	0.087	0.931	No
H8a	TP → PU → AI	0.000	0.025	0.980	No
H8b	TP → PEOU → AI	-0.001	0.083	0.934	No
H9a	SN × PU → AI	-0.022	0.179	0.858	No
H9b	SN × PEOU → AI	-0.085	0.653	0.514	No

Figure 2 shows the PLSSEM results that present the path coefficient with its accordance between constructs. The structural model assessment in Table 6 supports the hypothesized relationships in a mixed manner. Thus five hypotheses are supported: Socio economic Status positively effects on both Perceived Usefulness ($\beta=0.180$, $p<0.001$) and Perceived Ease of Use ($\beta=0.132$, $p<0.001$); Environmental Awareness is significantly impacting on both Perceived Usefulness ($\beta=0.787$, $p<0.001$) and Perceived Ease of Use ($\beta=0.661$, $p<0.001$); and Technological proficiency effect on Perceived Ease of Use ($\beta=0.192$, $p=0.002$).

Interestingly, eleven hypotheses are not supported, namely, the relationships between Technological Proficiency and Perceived Usefulness as well as between these two mediators both to Perceived Ease of Use and Adoption Intention. This unexpected result would indicate that the mediators are not important in affecting the adoption intention and the classic Technology Acceptance Model assumptions are not applicable here, despite the fact that the exogenous variables do impact the mediators.

Table VII Values Of R-Square, Q-Square, And F-Square

Evaluation Type	Variable / Path	Value
R²	Adoption Intention (AI)	0.860
	Perceived Usefulness (PU)	0.852
	Perceived Ease of Use (PEOU)	0.866
Q²	Adoption Intention (AI)	0.541
	Perceived Usefulness (PU)	0.608
	Perceived Ease of Use (PEOU)	0.611
F²	EA → PU	0.844

EA → PEOU	0.657
SES → PU	0.115
SES → PEOU	0.068
TP → PU	0.000
TP → PEOU	0.056
PU → AI	0.000
PEOU → AI	0.000
SN → AI	0.021
SN × PU → AI	0.000
SN × PEOU → AI	0.004

The results of Table 7 show that 86.0% of the variance in Adoption Intention model, 85.2% of Perceived Usefulness and 86.6% of Perceived Ease of Use is explained by the model with high R^2 values. The strong predictive relevance of the model is confirmed by the Q^2 values (all above 0.5). Environmental awareness has the largest effect on both mediators as determined by effect size (f^2) values of 0.844 (PU) and 0.657 (PEOU), indicating that they represent a large effect size as suggested by Cohen (1988). Small to medium effects are found for the other significant relationships.

DISCUSSION

The findings of this study reveal several compelling insights into the behavioral dynamics of sustainable technology adoption in tourism, particularly as they relate to the posthumanist re-evaluation of the Technology Acceptance Model (TAM). While traditional TAM constructs Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) are expected to play central mediating roles in adoption behavior [4], our results challenge this assumption. Both PU and PEOU were found to be statistically insignificant in predicting the adoption of ePenambang, a solar-powered boat technology used in Malaysian river tourism. This divergence from conventional TAM logic requires a thorough theoretical reevaluation.

Reassessing TAM: From Rational Evaluation to Entangled Relationally

The lack of significance of PU and PEOU indicates that users do not solely assess technology based on its practical utility or cognitive ease. The adoption of sustainable transport may be influenced by affective, ethical, and ecological considerations that cannot be solely defined by concepts of utility or convenience. This critiques TAM's cognitivist and anthropocentric foundations, which view the user as an isolated decision-maker evaluating a neutral object [13].

Conversely, posthumanist theory provides a broader framework. Rather than seeing technology as an object acted upon by humans, posthumanism conceptualizes adoption as a relational outcome emerging through the mutual entanglement of humans, technologies, environments, and discourses ([3]; [7]). From this perspective, ePenambang is not simply a vehicle; it is an agent of ethical alignment, a material-semiotic node that reconfigures how travelers relate to riverine ecologies, community values, and sustainable futures.

[11] writing in the Journal of Posthumanism, emphasizes this shift in the Tunisian context: smart tourism technologies do not merely optimize efficiency but participate in the co-production of ethical subjectivities and socio-technical ecosystems. Our study supports this view empirically, showing that the classic pathways of TAM collapse when users interact with technologies that are ethically and ecologically encoded.

The Rise of Socio-Environmental Variables: SES and EA

What remains significant in our model are the direct effects of Socioeconomic Status (SES) and Environmental

Awareness (EA) on adoption intention. These results reinforce the claim that value-driven and socially contextual factors are far more influential than technical perceptions in the adoption of sustainable innovation. Individuals with higher SES may possess greater access to education and resources, but perhaps more importantly, they may have greater agency to act ethically in line with sustainability goals. Similarly, individuals with heightened EA are ethically predisposed to support technologies like ePenambang, independent of how easy or useful the system appears to be.

This aligns with posthumanist assertions that ethical behavior is embedded and relational, not abstract or individualistic. As [2] suggests, technology adoption is not just a utilitarian decision it is a situated enactment of ecological belonging, involving both human intention and non-human affordances. In this context, ePenambang functions not just as a mode of transport, but as an artifact of shared environmental ethics.

Posthumanist Implications: Tech as Co-Agent

Theoretically, these findings open space for reconceptualizing TAM within a posthumanist ontology. They invite scholars to move beyond the assumption that adoption is mediated solely by human cognition. Instead, adoption emerges as a relational process, in which technology and user are mutually constitutive ([3]; [7]). The failure of PU and PEOU to mediate adoption in this study is not a statistical anomaly it is a signal that technology's agency is no longer peripheral.

Technologies like ePenambang are ethico-material assemblages they carry meanings, ethics, and affect that shape how they are encountered, embraced, or rejected. Their adoption is not about simplification or utility, but about resonance with a broader ecological identity.

Toward a Posthuman Adoption Model

Based on our results, we propose that future adoption models particularly in eco-technology and tourism should:

1. Integrate contextual ethical values (e.g., environmental concern, social equity).
2. Recognize technology as a co-agent, not a passive object.
3. Replace mediation via PU and PEOU with relational constructs, such as techno-ethical alignment, place attachment, and ecological attunement

In doing so, adoption research can transition from a predictive behavioral model to an ontologically aware framework, aligning with posthumanist ethics of care, relationality, and multispecies justice.

IMPLICATIONS

Theoretical Implications

This study challenges the long-held dominance of the Technology Acceptance Model (TAM) by demonstrating the empirical insignificance of its mediators, perceived usefulness (PU) and perceived ease of use (PEOU), in the context of eco-technological adoption. Theoretically, this calls for a posthumanist extension of TAM one that decentralizes the user and recognizes the co-agency of technologies, social values, and environments. By integrating relational ethics and non-anthropocentric assumptions into adoption models, future research can better reflect how technologies like ePenambang operate within socio-material assemblages rather than isolated user evaluations ([2]; [3]).

Practical Implications

From a design perspective, eco-technologies must be more than functionally efficient; they must be ethically resonant. This means embedding ecological values, local cultural identity, and community symbolism into the materiality and communication of technologies. For instance, ePenambang could be better promoted not as a

“smart solution” but as a living symbol of heritage sustainability, reinforcing relational trust with users.

Moreover, education campaigns and community dialogue are essential. The strong influence of Environmental Awareness and Socioeconomic Status in this study suggests that values and capabilities, not interface usability, drive sustainable adoption. Public engagement strategies must therefore shift from instructing how to use technology toward cultivating why it matters through storytelling, local narratives, and participatory inclusion.

Policy Implications

Policymakers must recognize that sustainable transitions are not purely technical or behavioral they are relational and posthuman. Policies should encourage shared agency between humans and technologies, supporting infrastructures of interaction where citizens and tools co-shape ethical landscapes. Investment should go toward inclusive design labs, local innovation hubs, and cross-sector partnerships that align ecological, technological, and cultural intelligences.

CONCLUSION

This study examined the behavioral and social dynamics behind the adoption of sustainable tourism technology, using the solar-powered ePenambang as a case in Malaysia. While conventional models such as TAM predict adoption through perceived usefulness and ease of use, our findings show these variables were not significant. Instead, Environmental Awareness and Socioeconomic Status emerged as key drivers, suggesting that value-based alignment and social context are more predictive than utility or simplicity.

By integrating posthumanist theory, this study contributes a conceptual reimagining of TAM. It proposes a model where technologies are entangled co-agents, and adoption is understood as a relational outcome rather than a rational choice. This opens space for more ecologically attuned, ethically grounded, and culturally embedded theories of adoption.

In terms of practical relevance, the study calls for a design shift toward symbolic, participatory, and heritage-integrated eco-technologies. It also underscores the need for community-centered educational strategies that move beyond “how to use” and instead cultivate “why it matters.”

However, the study is not without limitations. Its geographic focus on Malaysia limits generalizability, and the use of self-reported surveys may introduce response bias. Future studies could adopt qualitative or ethnographic approaches to capture embodied, emotional, and symbolic dimensions of technology adoption. Cross-cultural comparisons would also be valuable in understanding how different ecologies and ontologies shape adoption patterns.

Finally, we encourage scholars to continue bridging quantitative behavioral models with critical posthumanist theory to evolve a more nuanced, ethical, and relational science of sustainability and innovation.

ACKNOWLEDGMENTS

This publication was supported by University Technical Malaysia Melaka (UTeM) under the Journal Publication Fee Initiative 2025. The authors would also like to acknowledge the support from the Faculty of Technology Management and Technopreneurship.

REFERENCES

1. Becken, S. (2017). Sustainable tourism and its use of technology: A review. *Journal of Sustainable Tourism*, 25(5), 567–576.
2. Bozzato, S. (2024). Technologies: Comparing Experiences. In *Institutions and Enterprises Towards Post-Humanism* (pp. 387–402). Springer.
3. Braidotti, R. (2019). *Posthuman knowledge*. Polity Press.

4. Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340.
5. Gössling, S., & Higham, J. (2021). The low-carbon imperative: Destination management under urgent climate change. *Journal of Travel Research*, 60(3), 495–511.
6. Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2020). *A primer on partial least squares structural equation modeling (PLS-SEM)* (3rd ed.). Sage Publications.
7. Hayles, N. K. (1999). *How we became posthuman: Virtual bodies in cybernetics, literature, and informatics*. University of Chicago Press.
8. Khanra, S., Dhir, A., Parida, V., & Rana, N. P. (2021). A systematic literature review of the technology acceptance model in e-health contexts. *Journal of Business Research*, 124, 552–571.
9. Lu, Y., Papagiannidis, S., & Alamanos, E. (2023). What drives tourist use of sustainable mobility? Extending TAM with affective and ecological dimensions. *Annals of Tourism Research*, 96, 103530.
10. Mhlana, D. (2022). Emerging technologies and sustainable tourism: A review. *Technology in Society*, 68, 101911.
11. Nagara, Z. A. H. (2025). Technological Innovation in Tourism 4.0: Exploratory Study of Technological Innovation in Tunisia's Tourism Ecosystem. *Journal of Posthumanism*, 3(1), 22–38. <http://posthumanism.co.uk/jp/article/view/630>
12. Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425–478.
13. Verbeek, P. P. (2011). *Moralizing technology: Understanding and designing the morality of things*. University of Chicago Press.

