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Tourist heterogeneity in carbon compensation: A two-stage framework for sustainable island tourism policy

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ABSTRACT

Small island tourism destinations face a paradox: prosperity depends on the natural assets that tourism threatens. Current compensation policies fail by treating tourists identically through single-stage frameworks that conflate participation barriers with contribution intensity. Using stated preference data from 70,930 Canary Islands tourists, hurdle models with bootstrap validation separate participation (Stage 1: complementary log-log) from contribution intensity (Stage 2: OLS) across four compensation levels (<5% to >20% of trip expenditure). Education increases participation yet reduces contribution intensity (€ − 0.23 to €-6.63); near-zero residual correlation ($\rho = 0.0004$, $p = 0.955$) confirms distinct mechanisms govern each stage. Progressive taxation aligned with spending capacity generates €770.4 M versus €267.9 M from flat rates—a 188% revenue increase—transforming compensation into a self-financing mechanism requiring expenditure proxies and machine learning for full implementation.

1. Introduction

Small island destinations depend heavily on tourism (20–80% of GDP) while confronting an intensifying paradox: economic prosperity depends on visitor flows that simultaneously threaten the environmental assets attracting those visitors. Climate change amplifies this challenge through extreme heat episodes, wildfires, water scarcity, and shifting tourist behaviour patterns that reshape destination competitiveness (Göss-ling & Scott, 2025; Scott, 2024). The Canary Islands exemplify these pressures. With 78% tourism dependence, geographic isolation, and limited economic diversification options (Trujillo et al., 2025), the archipelago mirrors structural conditions facing Caribbean, Pacific, and Mediterranean islands worldwide. These destinations face a fiscal paradox: growing needs for environmental financing amid severe budget constraints that prevent approaches dependent on external subsidies.

Carbon offset mechanisms, which encompass both voluntary programmes and mandatory environmental fees, offer potential avenues if designed as self-financing systems. Rather than considering offsetting as a budgetary cost requiring external funding, destinations can leverage tourism heterogeneity to create internally sustainable mechanisms. Tourists with low price sensitivity can generate substantial revenue through progressive environmental fees. Meanwhile, highly environmentally motivated tourists who face accessibility obstacles can benefit from barrier-reduction programmes. Mediterranean evidence demonstrates its feasibility: the Balearic Islands' both environmental tax and room-tax programmes have generated a substantial increase in tourism revenues over time (López Del Pino et al., 2021; Palmer & Riera, 2003).

However, there is still much concern about the public acceptability of eco-taxes in general, mainly because ex-post studies prevail and they are not useful for designing a tax to achieve the highest degree of acceptance (López Del Pino et al., 2021). Therefore, authors call for more ex-ante studies that can capture individuals' heterogeneity in terms of preferences and constraints (Blázquez V et al., 2024).

Addressing heterogeneity presents both challenges and opportunities. Designing effective compensation policies requires understanding whether observed variation reflects accessibility constraints (awareness, procedural barriers) or economic optimization (capacity-to-pay, budget allocation)—distinct mechanisms that demand different policy instruments. Yet research consistently adopts the same approach, treating carbon compensation as a unified phenomenon. Studies spanning Korean airlines (Park et al., 2024), Australian tourists (Mair, 2011), Italian air travellers (Rotaris et al., 2020), Alpine destinations (Raffaelli et al., 2022), and European contexts (Choi et al., 2010; Hares et al.,

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2010) universally employ single-stage decision models. This methodological gap obscures the behavioural distinctions necessary for effective targeting and differentiated policies: identifying where barrier reduction generates returns versus where revenue generation maintains fiscal viability.

This study develops a two-stage framework separating distinct behavioural processes: Stage 1 examines participation determinants (accessibility barriers, demographic facilitators), while Stage 2 analyses contribution intensity among tourists allocating budgets to higher compensation levels. Drawing on discrete choice literature (Cragg, 1971; Jones, 1989), hurdle models allow coefficients to vary across compensation levels and covariates.

Using stated preference data from 70,930 Canary Islands tourists (Instituto Canario de Estadística ISTAC, 2022) across four compensation levels (basic <5% to premium >20% of trip expenditure), we document substantial heterogeneity at demographic, economic, cultural, and trip-related levels with direct implications for self-financing policy design. The study extends López Del Pino et al., 2021, who found high average acceptance of environmental tourist taxes in the Canary Islands—with preferences varying by discount eligibility and higher willingness-to-pay among younger, international, and experienced tourists—but identified no clear patterns across socioeconomic or cultural dimensions.

Participation rates decline sharply from 30.4% (basic) to 4.5% (premium), with price sensitivity amplifying ten-fold across levels. Basic tourists combine high participation with low price elasticity (€12.9), offering revenue potential through modest progressive fees; premium tourists exhibit stronger environmental values and higher willingness to pay, justifying proportionally larger fees, though their small group size complicates equitable responsibility assignment.

Statistical validation—likelihood ratio tests rejecting pooled specifications and Wald tests confirming significant cross-stage coefficient differences—supports the two-stage structure. Education and cultural factors (national vs. international tourists) both show cross-stage sign reversals, confirming that fundamentally distinct mechanisms govern participation and intensity decisions—reversals that single-stage frameworks cannot capture.

Our contribution advances carbon compensation research through four innovations. First, we extend recent evidence on heterogeneous willingness-to-pay (Wu et al., 2025) by demonstrating that participation and intensity operate through statistically distinct processes. Second, we operationalize targeting using exclusively observable characteristics—demographics, economic indicators, trip patterns, nationality—directly addressing the implementation gap between research insights and policy requirements (Dolnicar & Greene, 2025; Wolf et al., 2024). Third, we provide empirical evidence that carbon compensation can evolve from budgetary cost to self-financing mechanism when policies align with underlying behavioural heterogeneity. Fourth, we demonstrate how sign reversals in key variables reveal distinct behavioural mechanisms that uniform policies systematically miss.

The paper is structured as follows. Following the introduction, section 2 reviews carbon compensation and island tourism policy literature. Section 3 presents the two-stage econometric specification using hurdle models with bootstrap validation. Section 4 reports empirical results. Section 5 develops policy targeting frameworks articulating the self-financing logic. Section 6 concludes with implications for small island destination management and validation directions.

2. Literature review

2.1. Carbon compensation policies: current approaches and fundamental limitations

Carbon compensation in tourism encompasses voluntary compensation programmes and mandatory environmental taxation, yet both approaches demonstrate systematic limitations constraining policy effectiveness and environmental outcomes. Voluntary carbon compensation research consistently documents low participation rates across contexts, despite evidence of increasing environmental sensitivity (Di Giusto et al., 2018). Korean evidence shows environmental knowledge moderates' personal norms–behaviour relationships (Park et al., 2024), while Australian research identifies distinct environmental orientation segments with different participation patterns (Mair, 2011).

Mandatory environmental taxation has gained prominence given voluntary approach limitations, though its effectiveness remains contested. High environmental taxes across EU countries can drive positive behavioural change while negatively affecting tourism receipts Usman and Alola (2023), whereas the Balearic Islands' eco and room taxes demonstrate that substantial revenue generation and competitiveness can coexist (Aguiló et al., 2005; Palmer & Riera, 2003). This persistent gap reflects a fundamental misalignment between program design and heterogeneous tourist behaviour.

Future research should disaggregate environmental taxes by demand segment and fund destination, as tax purpose clarity is critical for participation (López Del Pino et al., 2021). Experimental evidence further shows that embedding compensation options within core offerings outperforms voluntary add-on approaches (Warburg et al., 2021).

A critical methodological limitation pervades both voluntary and mandatory research streams: single-stage decision frameworks treat carbon compensation as a unified phenomenon, obscuring the behavioural distinction between participation decisions and contribution optimization—as illustrated by the methodological uniformity documented in Table 1. Compounding this, current research assumes uniform policy responsiveness across tourist populations, estimating average effects and applying near-identical recommendations despite systematic differences in tourist characteristics, capacity, and behavioural responsiveness.

In addition to methodological shortcomings, carbon compensation also raises normative concerns. Studies on environmental justice highlight that the legitimacy of climate policies depends not only on efficiency but also on distributive and procedural fairness (Rastegar & Becken, 2024). Uniform frameworks neglect these issues, overlooking who bears the costs and whether decision-making processes are transparent and participatory (Higgins-Desbiolles, 2018; Scott & Göss-ling, 2021).

2.2. Tourism self-financing: the sustainable path forward

Emerging literature increasingly supports a paradigmatic shift toward tourism self-financing its environmental impacts, moving beyond traditional subsidy-based approaches toward economically sustainable models that align economic incentives with environmental objectives. The theoretical foundation rests on the polluter pays principle, where sectors generating environmental externalities should internalize associated costs (Dwyer et al., 2010). Becken (2007) argue that sustainable tourism requires the sector to finance its own environmental impacts rather than relying on external subsidies that create moral hazard and undermine long-term behavioural change. This principal gains relevance in small island contexts, where tourism's environmental impacts are concentrated while fiscal resources for subsidies remain limited.

Empirical evidence supports Pigouvian-style environmental taxation effectiveness in tourism contexts. Palmer and Riera (2003) demonstrate that environmental taxes successfully generate funding while maintaining destination competitiveness. Aguiló et al. (2005) argue that environmental taxes represent the most economically efficient approach to sustainable tourism development. Font and McCabe (2017) demonstrate that economically self-sufficient sustainability models outperform subsidy-dependent approaches in both environmental effectiveness and long-term viability. Bramwell and Lane (2013) provide evidence that sustainable tourism systems must be economically self-sustaining to achieve lasting environmental improvements, as subsidy-dependent models create perverse incentives where environmental protection

Table 1
Carbon compensation research: methodological limitations and extension opportunities.

Study & Context	Decision Framework	Key Methodological Limitations
Park et al. (2024) Korean airlines	Single stage (participation only)	Uniform treatment; cannot distinguish participation vs. intensity drivers
Mair (2011) Australia/UK tourists	Single stage (willingness to compensate)	Homogeneous segments; treats €5 and €50 decisions identically
Warburg et al. (2021) Consumer products	Single stage (binary choice)	Uniform policy assumptions; ignores spending heterogeneity across participation levels
Rotaris et al. (2020) Italian air travellers	Single stage (WTP only)	Uniform WTP estimation; cannot distinguish participation barriers from amount optimization
Raffaelli et al. (2022) Dolomites tourists	Single stage (WTP discrete choice)	Low WTP findings; uniform treatment ignores heterogeneous compensation preferences
Hares et al. (2010) UK tourists	Single stage (compensation intentions)	Cannot distinguish awareness barriers from budget constraints in decision process
Choi et al. (2010) Korean tourists	Single stage (behavioural intentions)	Uniform structural equation modelling; treats all compensation levels identically
Becken (2007) New Zealand tourists	Single stage (willingness to pay)	Cannot separate accessibility concerns from economic optimization processes
Blázquez V et al. (2024) Meta-analysis	Single-stage frameworks predominant	Binary assumptions limit targeting precision across policy contexts
López Del Pino et al., 2021 Canary Islands	Single stage (behavioural intentions)	International versus Spanish tourists, discount preferences
Dolnicar et al. (2008) Australian tourists	Single stage (segment analysis)	Segments based on attitudes only; ignores behavioural differences in compensation amounts
This Study — Canary Islands	Two-stage (participation + intensity)	Heterogeneous segments; separates participation from intensity decisions for precise policy targeting

Notes: WTP = Willingness to Pay. Previous studies exhibit dual limitations: uniform tourist treatment and single-stage decision modelling that conflates distinct behavioural processes requiring different policy interventions.

becomes contingent on external funding.

Empirical validation supports self-financing mechanisms: Spanish hotels using tourist-generated revenue for environmental improvements outperformed those relying on external subsidies (Bonilla Priego et al., 2011), while voluntary environmental tools funded through tourist payments show higher adoption and better performance than subsidized alternatives (Ayuso, 2006). The Balearic Islands' ecotax and room-tax programmes further confirm sustained revenue generation over time (López Del Pino et al., 2021; Palmer & Riera, 2003).

These findings point toward a fundamental reorientation of tourism environmental policy: rather than treating environmental protection as an externally subsidized cost, destinations can leverage tourist payments to create self-sustaining funding mechanisms. Yet despite this growing evidence base, research still lacks frameworks sophisticated enough to operationalize differentiated tax structures that account for tourist behavioural heterogeneity—a gap rooted in insufficient understanding of the behavioural complexity underlying environmental decision-making (Román et al., 2020).

2.3. Behavioural heterogeneity and the need for sophisticated decision frameworks

Tourists perceive environmental taxes differently from service prices, treating them as contributions to public goods rather than private consumption (Thaler, 1985). This asymmetry reflects mental accounting processes where environmental expenses are categorized separately from core travel expenditures. Empirical evidence from choice experiments confirms these theoretical distinctions: tax parameters generate substantially larger utility effects than equivalent price changes, validating the behavioural separation between public and private good valuations (López Del Pino et al., 2021; Palmer & Riera, 2003).

Recent behavioural research integrates cognitive-affective-conative (CAC) dimensions with motivation-opportunity-ability (MOA) factors to explain tourist pro-environmental behaviour (Tang et al., 2022). The CAC-MOA framework demonstrates that compensation decisions reflect complex interactions between environmental knowledge (cognitive), emotional connection to sustainability (affective), behavioural intentions (conative), intrinsic motivation, situational opportunities, and practical ability—all of which vary systematically across tourist segments.

In this context, proving that the decision to participate in carbon compensation is a distinct behavioural process from determining the contribution amount is another step toward implementing effective self-financing systems and designing more sustainable carbon offsetting programmes. Current single-stage frameworks conflate these processes, limiting ability to optimize both participation rates and revenue generation simultaneously. The sustainable tourism field confronts a sobering implementation gap: three decades of problem identification have produced limited practical solutions generating measurable environmental improvements (Dolnicar & Greene, 2025).

2.4. Island tourism policy facing climate change

The burden of climate change is not equally distributed across regions and sectors. Islands and outermost regions are classified as highly vulnerable to climate change and will face severe impacts until 2050 even under low-emissions scenarios (Fauzel & Tandrayen-Ragoobur, 2023; Haldane et al., 2023; León et al., 2021). Some island countries—e.g. Tuvalu and Kiribati—have already started to disappear beneath the sea (Maucorps et al., 2025), while others —e.g. Vanuatu, Fiji, rank among the top 20 countries most strongly affected by climate-related extreme weather events in 1993–2022.

Their high vulnerability is exacerbated because most of them have no groundwater supplies and rely solely on rainfall and salinization —e.g. Canary Islands. Reduced rainfall on certain EU islands—e.g. Greek islands—is resulting in loss of agricultural land, but also in more forest fires affecting tourism (León et al., 2021). Islands also hinge largely on imported fossil fuels for their energy supply, air transport for their connection with mainland and tourism, and maritime transport for their supply of basic goods including the means of transports (Maucorps et al., 2025).

In addition, island economies rely heavily on tourism, and are mainly developed around sun, sea and sand model (Wolf et al., 2024). This has been for decades the segment more extremely sensitive and heavily dependent on weather and climate (Rosselló & Waqas, 2016). Besides, the limited freshwater supply put them under considerable risk as hotels and tourists consume a disproportionately higher amount than inhabitants. This is only the tip of the iceberg, as there are many other critical aspects that conjointly explain their high vulnerability.

In turn, islands must adopt an energy transition through renewables energy projects that protect the climate, mitigate harms in the future and ensure access to a more secure energy sector less dependent on imported fossil fuels. They also need protection and adaptation measures to face actual environmental threats (coastal erosion, droughts, floods, heat waves, etc.), and a more efficient use of energy and natural resources (water, fertile soil, vegetation cover).

All these programmes require investments, with the subsequent increase in taxes for residents and tourists. In this vein, Becken (2007) argues that gaining tourism sustainability do require self-sustaining its transition to a less pollutant and more climate-resilient activity, rather than relying on external subsidies that create moral hazard and undermine long-term behavioural change. This gains relevance in small island contexts, where tourism's environmental impacts are concentrated while fiscal resources are limited.

Self-financing climate action is particularly critical for islands, where three structural barriers persist: governments lack the local information needed for efficient policy implementation due to entrenched top-down design (Sarker et al., 2018); academics fail to provide sufficient granularity of climate-tourism data or distinguish behavioural processes across local contexts and market segments (Klöck & Fink, 2019; Wolf et al., 2024); and corruption alongside low trust in industry stakeholders to manage funds undermines confidence (Hess & Kelman, 2017; Rastegar & Becken, 2024). Together, these factors generate governmental hesitation about the cost-benefits of self-financing tourism policies.

Consequently, self-sufficient tourism climate initiatives remain scarce—limited to cases like Mauritius, Seychelles, and the Balearics—while the majority of islands depend on external funding sources such as the Caribbean Development Bank, which pools funds for SIDS lacking direct access (Wolf et al., 2024), or EU instruments including ERDF, Interreg, and LIFE programmes with special provisions for island territories. This dependency is compounded by island economies' heavy reliance on sun-sea-sand tourism, historically the segment most sensitive to weather and climate variability (Rosselló & Waqas, 2016; Wolf et al., 2024).

3. Data and methods

3.1. Data source and sample construction

Data derive from the Tourist Expenditure Survey (ISTAC), administered quarterly via stratified random sampling at Canary Islands airport departure gates throughout 2022–2023, with post-stratification weights ensuring representativeness across nationality, island, and season.

From 78,874 completed responses, a single expenditure-based filter excluded observations below the 5th percentile (€67) or above the 95th percentile (€4127), removing 7944 outliers (10.0%) likely reflecting measurement error or exceptional circumstances. The final analytical sample comprises 70,930 tourists. Fig. 1 illustrate this procedure.

3.2. Variables' measurement and descriptive patterns

Table 2 presents the summary statistics of the 70,930 tourists. The sample exhibits substantial heterogeneity across key dimensions: tourists range from 16 to 99 years old (mean = 45.4), with trip durations varying from single-night stays to extended visits (mean = 9.0 nights). Total trip expenditure demonstrates considerable variation (€841 mean, €1687 standard deviation after outlier removal), reflecting diverse tourist segments from budget to luxury travellers.

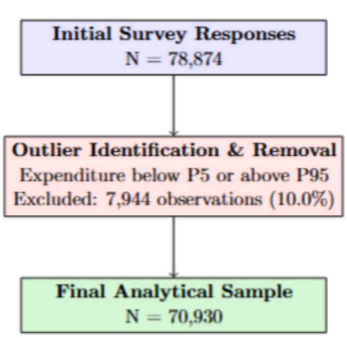

Fig. 1. Sample construction flowchart.
Notes Systematic filtering protocol applied to survey data (2022–2023). Outlier removal targets extreme expenditure values that may reflect data entry errors or atypical circumstances. Final analytical sample of 70,930 tourists is used for all subsequent analyses.

The survey instrument includes the question: “Would you be willing to spend more on your trip to reduce your carbon footprint?” Respondents select from five mutually exclusive categories: (i) no willingness to compensate, (ii) less than 5% of trip expenditure, (iii) between 5% and 10%, (iv) between 10% and 20%, and (v) more than 20%. 62.7% (44,516 tourists) express some willingness to compensate, while 37.3% (26,481 tourists) indicate no willingness. To validate that compensation categories reflect genuine environmental preferences rather than demographic sorting alone, Table 3 examines importance ratings for environmental factors across compensation levels.

Premium compensators systematically assign higher importance to environmental quality (+10.4%), natural landscapes (+10.4%), and hiking trail access (+21.1%) relative to non-compensators, demonstrating monotonic increases across compensation tiers. This pattern provides convergent validity that compensation intensity reflects underlying environmental values.

Total trip expenditure is elicited through structured recall questions covering accommodation, food and beverage, local transportation, recreational activities, and retail purchases within the destination; international airfare is excluded consistent with standard tourism expenditure accounting (Frechtling, 2006; UNWTO, 2010).

Table 4 reveals a monotonic increase in mean expenditure across compensation categories, from €1247 (no compensation) to €1823 (>20% compensation). This positive association between spending capacity and compensation willingness motivates the two-stage analytical framework: participation decisions may reflect accessibility barriers operating independently from the budget optimization processes governing contribution intensity among participants.

3.3. Conversion of categorical responses to monetary values and bootstrap validation

Categorical compensation ranges require conversion to monetary amounts for Stage 2 regression analysis. For tourist i selecting category j, stated compensation is operationalized as:

$$Compensation_{ij} = \frac{Midpoint_j \times GASTO\ TOTAL_i}{100} \tag{1}$$

where $Midpoint_j \in \{2.5, 7.5, 15, 25\}$ represents central tendency within each percentage range.

Midpoint assumptions introduce measurement uncertainty. We assess robustness through Monte Carlo bootstrap validation ($N = 2000$ iterations) across three distributional specifications: Conservative (Beta 2,5 toward lower boundaries), Midpoint (uniform, baseline), and Optimistic (Beta 5,2 toward upper boundaries). Parameter stability is assessed via coefficient of variation:

$$CV(\beta) = \frac{|\beta_{Conservative} - \beta_{Optimistic}|}{(\beta_{Conservative} + \beta_{Optimistic})/2} \tag{2}$$

Values below 0.10 indicate robustness to conversion specifications (Efron & Tibshirani, 1993). We validate theoretically critical parameters: accessibility factors in Stage 1 (education, demographics) and economic optimization factors in Stage 2 (spending capacity, price sensitivity). Stage 1 parameters should exhibit inherent stability since participation is binary and independent of monetary conversion. Stage 2 parameters may show moderate variation since intensity estimates depend directly on compensation amounts.

3.4. Econometric specification

Carbon compensation decisions involve sequential behavioural processes necessitating distinct analytical approaches. Following the discrete choice literature (Cragg, 1971; Hensher et al., 2015; Train, 2009), we employ hurdle models decomposing the decision into two

Table 2
Sample characteristics and trip patterns.

Variable	N	Mean	SD	Min	P25	Median	P75	Max
Age (years)	70,930	45.42	14.94	16	33	45	57	99
Trip Duration (nights)	70,930	9.03	7.99	1	7	7	10	181
Group Size (persons)	70,930	2.62	1.47	1	2	2	3	27
Total Spending (€)	70,930	840.78	1687.34	67	340	609	1000	4127
Daily Spending (€)	70,930	49.79	98.52	1.2	22	40	63	891

Notes: All monetary values in euros.

Table 3
Environmental motivation by compensation level.

Compensation Level	Environmental Quality	Natural Landscapes	Tranquillity	Hiking Trails	N
No compensation	2.97	2.97	3.30	1.85	26,421
Basic (<5%)	3.08	3.06	3.32	1.94	21,555
Med-Low (5–10%)	3.10	3.11	3.32	2.04	15,486
Med-High (10–20%)	3.15	3.19	3.36	2.18	4272
Premium (>20%)	3.28	3.28	3.42	2.24	3196
Difference (Premium − None)	**+0.31**	**+0.31**	**+0.12**	**+0.39**	**70,930**

Notes: Mean importance ratings on a 4-point scale (1 = not important, 4 = very important) for environmental factors influencing destination choice. Higher compensation groups systematically value environmental attributes more strongly, demonstrating monotonic increases across compensation tiers.

Table 4
Total trip expenditure by compensation level.

Compensation Level	N	Mean	SD	P25	Median	P75
No compensation	26,421	1247	892	634	1089	1642
<5%	21,555	1389	965	712	1203	1821
5–10%	15,486	1512	1041	798	1334	1987
10–20%	4272	1687	1156	923	1476	2198
>20%	3196	1823	1289	1012	1598	2387
Total	**70,930**	**1389**	**1098**	**689**	**1198**	**1843**

Notes: All monetary values in euros.

stages: whether to participate in compensation, and how much to contribute conditional on participation. Fig. 2 illustrates this two-stage process. Stage 1 examines participation based on accessibility factors and demographics. Stage 2 analyses intensity optimization through economic decision-making. Each stage responds to different drivers, requiring different policy approaches.

This separation proves critical because destinations must optimize both broad participation (political viability) and revenue generation (environmental funding). Stage 1 factors suggest targets for barrier reduction, while Stage 2 factors inform revenue optimization through progressive pricing.

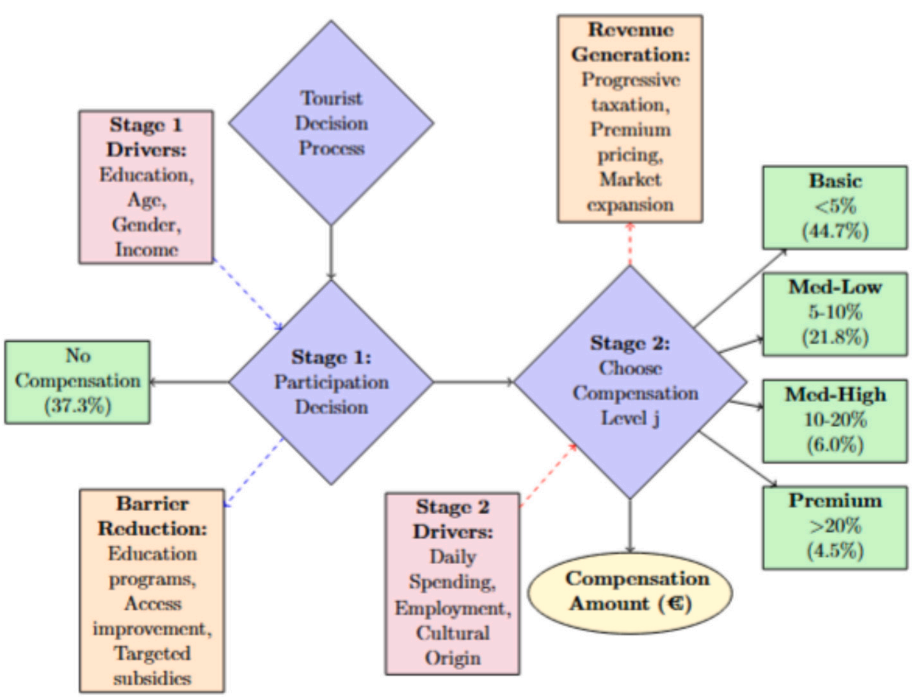

Fig. 2. Two-stage carbon compensation framework and policy targeting.
Notes: Framework separates carbon compensation into sequential decisions requiring different analytical approaches. Stage 1 examines participation drivers through binary analysis (complementary log-log models), while Stage 2 analyses contribution determinants via conditional regression. Policy instruments target different behavioural mechanisms identified in each stage.

For each compensation level $j \in \{<5\%, 5-10\%, 10-20\%, >20\%\}$, we estimate separate two-stage specifications comparing level *j* against non-participation using the full analytical sample of 70,930 observations.

Stage 1: Participation Decision. The probability that tourist i selects compensation level j (versus no compensation) is modelled as:

$$Pr\left(y_{ij} = 1 \mid X_i\right) = 1 - exp\left(-exp\left(X_i'\beta_j^{(1)}\right)\right) \tag{3}$$

where $y_{ij} \in \{0,1\}$ indicates selection of level j, X_i denotes predetermined tourist characteristics, and $\beta_j^{(1)}$ represents stage-specific coefficients. We employ the complementary log-log (cloglog) link function to accommodate rare event characteristics in higher compensation tiers, where participation rates decline to 4.5%. The cloglog specification handles asymmetric probability distributions more effectively than logit when baseline event rates are substantially below 0.5 (King & Zeng, 2001).

Stage 2: Intensity Decision. Conditional on selecting level j, compensation amount is modelled via ordinary least squares:

$$E\left[C_{ij} \mid y_{ij} = 1, X_i\right] = X_i'\beta_j^{(2)} \tag{4}$$

where C_{ij} represents stated compensation in euros calculated via Eq. (1). Estimation employs only the subsample of tourists selecting level j, excluding non-participants. Sample sizes for Stage 2 analyses are: Basic (<5%): $n = 21{,}587$; Med-Low (5–10%): $n = 15{,}398$; Med-High (10–20%): $n = 4335$; Premium (>20%): $n = 3196$. Both stages utilize exclusively predetermined characteristics observable through standard tourism data systems: demographics (age, gender, education, employment), economic factors (income, daily expenditure), trip characteristics (duration, group size, first-visit, package tour), and geographic controls (nationality). This focus on predetermined covariates eliminates endogeneity and simultaneity bias concerns.

4. Results

Three sections are presented. First, formal validation tests of the two-stage framework, followed by the examination of the determinants of each stage separately.

4.1. Validation of two-stage framework

Our central theoretical proposition—that participation and intensity decisions operate through distinct mechanisms—requires rigorous empirical validation before examining stage-specific determinants. Table 5 presents three complementary tests examining whether participation (Stage 1) and intensity (Stage 2) decisions can be adequately modelled as a single unified process or require separate analytical treatment.

Sign consistency analysis reveals three variables with opposing directional effects across stages—female, higher education, and employed status (all positive in Stage 1, negative in Stage 2). Higher education is significant in both, confirming the "education paradox": it increases participation likelihood by 17.7% (hazard ratio = 1.177, $p < 0.001$) while reducing contribution intensity by €0.23 ($p < 0.01$). Such reversals cannot be captured by single-stage frameworks and constitute substantive evidence of fundamentally distinct behavioural mechanisms governing each decision.

Residual correlation between stages is near-zero (ρ = 0.0004, $p = 0.955$), confirming statistical independence: participation drivers operate separately from intensity determinants. Correlated errors would be expected if both stages reflected the same underlying process. Bootstrap validation addresses measurement uncertainty from converting categorical compensation ranges to monetary values, using three Monte Carlo distributional specifications—Conservative (Beta(2,5)), Midpoint (uniform, baseline), and Optimistic (Beta(5,2))—with each iteration resampling with replacement and re-estimating both stages. Results are reported in Table 6.

Education effects demonstrate exceptional stability (CV < 0.001) because participation is binary and independent of monetary conversion assumptions. Daily spending semi-elasticity exhibits moderate variation (CV = 0.122, range €38.9), reflecting genuine sensitivity to conversion assumptions in Stage 2 where categorical ranges transform to monetary amounts. However, all specifications maintain consistent direction, statistical significance, and order of magnitude within conventional robustness thresholds (CV < 0.15; Efron, B. and Tibshirani, R. J. (1993)).

Table 6
Bootstrap validation results across conversion specifications.

Parameter	Conversion	Mean	Std. Dev	95% CI	CV
Stage 1: Education Effect on Participation (<5%)					
Education (HR)	Midpoint	1.177	0.022	[1.135–1.221]	< 0.001
Education (HR)	Conservative	1.177	0.022	[1.135–1.221]	< 0.001
Education (HR)	Optimistic	1.177	0.022	[1.135–1.221]	< 0.001
Stage 2: Daily Spending Semi-Elasticity on Intensity (>20%)					
Daily Spending (€)	Midpoint	128.4	2.4	[123.8–133.2]	–
Daily Spending (€)	Conservative	115.9	7.7	[102.5–128.9]	–
Daily Spending (€)	Optimistic	154.8	15.0	[129.1–179.7]	–
Robustness Assessment					
Education stability: Range = 0.000; CV < 0.001; Assessment: Exceptional stability					
Daily spending stability: Range = €38.9; CV = 0.122; Assessment: Moderate sensitivity					

Notes: Bootstrap validation with 2000 iterations per specification. Stage 1 education effect is invariant to conversion specifications because participation is binary. Stage 2 semi-elasticity varies moderately (CV = 0.122), reflecting genuine measurement uncertainty in categorical ranges but maintaining consistent direction and magnitude across specifications. Semi-elasticity represents absolute change in compensation (euros) associated with 1% change in daily spending.

Table 5
Statistical validation of two-stage separation.

Test	Null Hypothesis	Test Statistic	Result
Sign Consistency	Variables exhibit same directional effects across stages	1 variable with opposite signs (both statistically significant); 2 additional with opposite signs (at least one significant)	Evidence of distinct mechanisms
Residual Correlation	Prediction errors correlated across stages	ρ = 0.0004, $t = 0.056$, $p = 0.955$	Statistical independence confirmed
Bootstrap Validation	Key parameters sensitive to conversion assumptions	Education: CV < 0.001; Daily spending: CV = 0.122	Robust to measurement specifications

Notes: All tests conducted on basic compensation level (<5%) comparing Stage 1 (participation) versus Stage 2 (intensity) models. CV = coefficient of variation measuring parameter stability across alternative distributional assumptions for categorical range conversion.

Policy implications remain unchanged: premium compensation tourists demonstrate substantially higher spending-compensation relationships than basic tourists across all specifications, supporting differentiated targeting strategies.

Collectively, these validation approaches provide convergent evidence that carbon compensation involves sequential processes requiring differentiated analytical treatment. Sign reversals demonstrate opposite effects impossible in single-stage frameworks. Near-zero residual correlation confirms statistical independence. Bootstrap validation establishes robustness to measurement assumptions. These results validate our two-stage framework as an empirical necessity rather than methodological preference, justifying separate examination of each stage.

4.2. Stage 1: determinants of participation decisions

Participation rates decline hierarchically from 30.4% (basic compensation) to 4.5% (premium compensation), reflecting increasing accessibility barriers as commitment intensity rises. Table 7 reports hazard ratios from complementary log-log models comparing each compensation level against non-participation. Hazard ratios represent multiplicative effects on participation probability, with values above 1 indicating increased likelihood.

Three patterns emerge with direct policy implications. First, education operates as a universal participation facilitator (HR 1.177–1.274 across all levels), suggesting barrier reduction through educational awareness rather than economic incentives. Female tourists demonstrate particularly strong basic-level engagement (HR 1.303), indicating gender-responsive communication strategies could expand participation. Second, cultural segmentation proves complex: Spanish tourists avoid basic-medium levels yet show 28.5% higher premium participation, while UK/Ireland tourists systematically avoid higher tiers (21.4–34.0% lower participation).

This polarization requires culturally adapted outreach rather than uniform messaging. Third, package tour participation consistently reduces likelihood (5.4–25.9% reduction), revealing systematic structural barriers. However, this represents opportunity: integrating compensation into package offerings could dramatically expand participation by addressing accessibility constraints embedded in organized tourism structures.

4.3. Stage 2: determinants of contribution intensity

Conditional on participation, contribution amounts reflect economic optimization rather than accessibility considerations. Table 8 reports OLS regression coefficients for stated compensation amounts among participants at each level.

Daily spending dominates contribution decisions, with semi-elasticity amplifying ten-fold from €12.95 (basic) to €128.41 (premium). This dramatic escalation reveals sophisticated economic behaviour: premium segments demonstrate both high spending capacity and strong spending-compensation relationships, positioning them for progressive taxation calibrated to ability-to-pay rather than uniform structures ignoring capacity differences.

The education paradox manifests clearly: higher education reduces contribution intensity (€0.23–€6.63 reduction) despite facilitating participation (Stage 1). Educated tourists engage through deliberate economic optimization that constrains compensation intensity even with environmental commitment. This sign reversal—impossible in single-stage frameworks—demonstrates distinct behavioural mechanisms across decision stages. Employment status shows similar patterns (€0.81–€11.09 reduction), suggesting budget constraints limit intensity contributions despite minimal participation effects, indicating barriers operate through economic rather than engagement channels.

Spanish cultural patterns demonstrate pronounced cross-stage reversal: premium participation preference (Stage 1: HR 1.285) combines with substantially lower contributions when participating (€2.76–€28.76 reduction). This indicates Spanish engagement operates through different cultural mechanisms requiring adapted structures rather than uniform approaches. Mean compensation amounts (€28.65–€421.37) demonstrate substantial revenue concentration: premium participants contribute 15 times more than basic participants despite representing only 4.5% of sample, confirming that high-intensity targeting generates disproportionate revenue from small participant pools.

5. Discussion and policy implications

5.1. Reconciling progressive taxation with environmental commitment

Our framework suggests higher fees on segments expressing elevated concern (Table 3) and strong willingness to compensate. The key distinction is between stated environmental values and actual behaviour

Table 7
Determinants of compensation participation (Stage 1).

	Basic < 5%	Med-Low 5–10%	Med-High 10–20%	Premium > 20%
Panel A: Demographic Characteristics				
Highly Educated	1.177***	1.274***	1.244***	1.255***
Female	1.303***	1.125***	1.135***	0.943
Age (per year)	1.004***	1.010***	1.023***	1.025***
Panel B: Economic Factors				
Higher Income	1.053***	1.193***	1.076	0.842***
Higher Daily Spending	1.029**	1.071***	1.098***	1.040
Panel C: Trip Characteristics				
Long Trip (>7 nights)	0.972	1.016	1.132***	1.140***
Large Group (>2 people)	1.062***	1.018	0.955	1.016
First Visit	1.002	1.016	1.130***	1.219***
Panel D: Cultural Factors				
Spanish Origin	0.953**	0.889***	0.839***	1.285***
UK/Ireland Origin	0.996	0.786***	0.660***	0.865***
Package Tour	0.946***	0.846***	0.809***	0.741***
Participation Rate	**30.4%**	**21.8%**	**6.0%**	**4.5%**
Observations	**47,976**	**41,907**	**30,693**	**29,617**

Notes Hazard ratios from complementary log-log models comparing each compensation level versus non-participation. Values >1.000 indicate higher participation likelihood. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8
Determinants of compensation intensity (Stage 2).

	Basic < 5%	Med-Low 5–10%	Med-High 10–20%	Premium > 20%
Panel A: Demographic Characteristics				
Highly Educated	-0.23**	−0.65	0.03	−6.63**
	(0.11)	(0.35)	(0.73)	(2.64)
Female	0.12	0.06	0.57	2.56
	(0.12)	(0.38)	(0.79)	(1.56)
Age (per year)	0.03***	0.10***	0.17***	0.20**
	(0.01)	(0.02)	(0.04)	(0.08)
Panel B: Economic Factors				
Daily Spending (log)	12.95***	39.73***	80.83***	128.41***
	(1.23)	(3.87)	(8.12)	(15.92)
Higher Income	0.13	0.58	0.07	5.10
	(0.08)	(0.24)	(0.51)	(3.21)
Employed	−0.81***	−2.04***	−5.47***	−11.09***
	(0.15)	(0.47)	(0.98)	(1.94)
Panel C: Trip Characteristics				
First Visit	−0.57***	−2.24***	−4.64***	−2.56
	(0.13)	(0.41)	(0.86)	(1.69)
Package Tour	−0.31***	−1.19***	−4.78***	−8.07***
	(0.11)	(0.35)	(0.74)	(1.45)
Panel D: Cultural Factors				
Spanish Origin	−2.76***	−8.33***	−14.99***	−28.76***
	(0.26)	(0.82)	(1.71)	(3.36)
UK/Ireland Origin	−0.16	−1.17***	−2.92	−7.01**
	(0.15)	(0.47)	(0.99)	(3.44)
Mean Compensation (€)	28.65	89.18	198.45	421.37
Observations	21,555	15,486	4272	3196
R-squared	0.891	0.933	0.940	0.947

Notes: OLS regression coefficients for compensation amount in euros (conditional on participation). Daily spending coefficient represents semi-elasticity with respect to log-transformed daily expenditure. Bootstrap validation (N = 2000) confirms robustness. Observations represent participants at each level. Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * $p < 0.1$.

(Juvan & Dolnicar, 2014). Recent research shows that habits predict pro-environmental actions during holidays more accurately than attitudes and norms (MacInnes et al., 2025).

Tourists who express high environmental concern do not consistently recycle, conserve water, reduce energy use, or minimise food waste while on vacation. In this study, premium compensation tourists express elevated environmental concern. However, these attitudes do not guarantee a smaller individual carbon footprint. In turn, their higher compensation willingness may reflect awareness of higher impact, not successful impact reduction. One conclusion is that tourists who worry more for their emissions may be more willing to compensate precisely because of that acknowledgment.

The framework applies capacity-to-pay principles rather than environmental performance assessment. Daily spending strongly predicts contribution intensity (€12.95–€128.41 across compensation levels), supporting Pigouvian logic: greater spending capacity warrants greater contribution to internalize environmental damage, independent of stated values (Broadway & Tremblay, 2008; Pigou, 1920). European evidence confirms environmental taxes reduce greenhouse gas emissions when set above minimum thresholds, though effectiveness diminishes beyond maximum thresholds (Manta et al., 2023).

Progressive fees must therefore be calibrated to spending capacity—not uniformly maximised. The ten-fold coefficient increase from basic to premium segments reflects genuine capacity differences; progressive structures are warranted but must avoid levels that trigger participation collapse. This implements pollution internalisation through observable spending patterns without penalising environmental commitment. Premium tourists combine high environmental awareness with high spending capacity, making them natural candidates for progressive fees. Revenue generated can then fund barrier-reduction programmes for environmentally motivated tourists facing accessibility constraints—creating a self-financing system that enables broad participation without external subsidies or economically indifferent uniform burdens.

5.2. *Revenue generation and comparative policy performance*

All eco-tax studies document demand loss when implementing environmental fees (López Del Pino et al., 2021; Usman & Alola, 2023). Our no-compensation segment (37.3%, $N = 26{,}421$) represents this potential loss. However, Stage 1 results suggest this segment faces accessibility barriers, not fundamental opposition. Education, procedural familiarity, and demographic factors systematically determine their participation. These barriers can be reduced through targeted interventions while fundamental opposition requires demand substitution.

Reducing barriers requires long-term educational campaigns, simpler procedures, and cultural adaptation (López Del Pino et al., 2021; Palmer & Riera, 2003). These interventions take time. More immediately actionable is quantifying revenue from willing segments (62.8%, $N = 44{,}509$) and identifying which policy designs maximise environmental financing.

We compare three policy approaches using survey data ($N = 70{,}930$) expanded to annual visitors through survey weights. The Tourist Expenditure Survey uses post-stratification weights ensuring representativeness across nationality, island, and time. Each tourist receives a weight reflecting sampling probability. Total weights sum to 24,177,998 estimated annual visitors during 2022–2023. Population revenue equals $\sum_{i=1}^{N} w_i \times$ Compensation$_i$, where compensation varies by policy approach.

Scenario 1 — Flat Rate: Following López Del Pino et al., 2021, we apply a uniform €2/night fee for all participants. Sample revenue of €768,504 expands to €267.9 million annually, assuming 62.7% participation and 37.3% demand loss. This is the baseline for undifferentiated approaches.

Scenario 2 — Progressive by Daily Spending: Tourists are grouped into three tiers: Tier 1 (<€40/day) pays 1%, Tier 2 (€40–80/day) pays 2.5%, Tier 3 (>€80/day) pays 5%. These rates match implemented European tourism taxes (Palmer & Riera, 2003). Participation rates (55%, 65%, 70%) reflect Stage~1 findings: high-spending tourists face lower barriers (HR = 1.098 for Tier~3). A budget tourist spending 30€/day for 10 nights contributes 300€. A premium tourist spending 150€/day for 7 nights contributes 52.50€. This structure generates 487.0 million € annually (+81.8% versus flat rate) while reducing demand loss to 34.2%.

Scenario 3 — Two-Stage Behaviourally-Informed (Optimal Allocation): This approach calibrates fees to demonstrated willingness-to-pay using actual compensation willingness across four survey levels converted to amounts using midpoints. Aggregate revenue by tier: basic generates €127.3 million; medium-low generates €285.2 million; medium-high generates €158.9 million; premium generates €199.1 million. Total annual revenue reaches €770.4 million (+187.6% versus flat rate) at essentially identical demand loss (37.2%).

The revenue advantage reflects behavioural differentiation. Premium compensators (4.5% of participants) contribute 26% of total revenue, with average daily spending of €94.60 and average contribution of €421.37—a premium tourist with a €1400 budget selecting >20% generates €350, versus €14 under a flat rate (€2 × 7 nights). Meanwhile, basic compensators (30.4%) contribute €127.3 million in aggregate through broad participation at lower individual amounts (€28.65), demonstrating that minimising barriers generates substantial revenue even when individual contributions are modest.

Table 9
Revenue potential across policy approaches: Canary Islands evidence.

Policy Approach	Annual Revenue (€ Million)	Per Tourist (€)	Participation Rate (%)	Demand Loss (%)
Baseline: Uniform Treatment				
Flat rate (€2/night)	267.9	11.08	62.7	37.3
Progressive: Expenditure-Based Differentiation				
Tier 1: Low spenders (1%)	7.8	0.32	55.0	45.0
Tier 2: Medium spenders (2.5%)	64.3	2.66	65.0	35.0
Tier 3: High spenders (5%)	415.0	17.17	70.0	30.0
Progressive Total	**487.0**	**20.14**	**65.8**	**34.2**
Two-Stage Informed: Observed Willingness-to-Pay				
Basic (<5%)	127.3	5.27	30.4	–
Medium-Low (5–10%)	285.2	11.80	21.8	–
Medium-High (10–20%)	158.9	6.57	6.0	–
Premium (>20%)	199.1	8.23	4.5	–
Two-Stage Total	**770.4**	**31.86**	**62.8**	**37.2**
Revenue Advantage vs. Baseline				
Progressive approach	+€219.1 M (+81.8%)	+€9.06	+3.1 pp	−3.1 pp
Two-stage approach	+€502.5 M (+187.6%)	+€20.78	+0.1 pp	−0.1 pp

Notes: Notes: Revenue calculations expand sample (N = 70,930) to annual population (*N* = 24.2 M) using survey weights ensuring representativeness across nationality, island, and time. Flat rate applies €2/night uniformly. All values in 2022–2023 euros.

As Table 9 shows, the flat rate yields just €11.08 per tourist—insufficient for destination-scale challenges such as coastal erosion, biodiversity loss, and renewable energy transition.

Progressive structures raise this to €20.14 but impose an arbitrary 5% ceiling that forgoes additional revenue. The behaviourally informed approach achieves €31.86 per tourist by removing arbitrary constraints and aligning with actual stated preferences.

The €502.5 million annual advantage over the flat rate exceeds the Canary Islands' entire environmental protection budget. Critically, this gain comes with no sacrifice in participation: the two-stage approach maintains 62.8% participation versus 62.7% under the flat rate. The framework enables destinations to achieve equity (fees match capacity-to-pay), efficiency (maximum environmental financing), and inclusiveness (broad participation)—objectives that traditional eco-tax design treats as competing trade-offs.

5.3. Differentiated policy targeting and implementation

The previous sections established the theoretical rationale (Section 5.1) and revenue viability (Section 5.2). This section translates those insights into operational policy design.

Basic compensation tourists show 30.4% participation and a €12.95 spending-compensation semi-elasticity. They participate readily—30.4% is the highest rate across all levels. Their spending capacity is modest. Average contribution is €28.65 per trip. Total annual revenue from this group reaches €127.3 million through volume, not large individual amounts.

Policy approach: Keep compensation accessible. Implement gentle progressive fees (1–3% of trip expenditure). This group provides the political foundation of the system.

Premium compensation tourists show 4.5% participation and a €128.41 spending-compensation semi-elasticity. Low participation signals real barriers: complex procedures, awareness gaps, language barriers, or poor package tour integration. When they do participate, capacity is substantial. Average contribution is €421.37.

Policy approach: Combine barrier reduction with progressive taxation. First, expand participation through educational campaigns, simpler procedures, and better package tour integration. Second, implement progressive fees (10–25% of trip expenditure).

The disproportionate premium contribution (€199.1 M from 4.5% of participants; 26% of total) justifies targeted barrier-reduction investment. Basic and medium-low segments generate €412.5 M in combined base revenue alongside political legitimacy, while premium revenue funds the programmes that expand overall participation. In aggregate, the two-stage approach yields €770.4 M annually—€502.5 M more than uniform treatment.

Implementation is feasible with existing data: education consistently predicts participation across all levels (hazard ratios 1.177–1.274) and daily spending predicts contribution intensity (€12.95–€128.41), both routinely collected in tourism statistics. One practical challenge remains—total trip expenditure is unobservable at arrival—but accommodation expenditure provides a workable proxy ($\rho \approx 0.75$ with total daily spending), enabling system launch with progressive refinement through predictive models trained on accumulating transaction data.

5.4. Insights for islands' tourism policy worldwide

Although the market situation of this study is limited to an island tourism destination in the Atlantic, the results can serve as insights to other geographical contexts. This is possible as there are shared structural conditions between island destinations worldwide.

For many islands and outermost regions (also SIDS), tourism is the main economic driver, with climate change being positioned as an existential threat to tourism, and by extension, islands' development (Wolf et al., 2024). At the same time, their tourism sectors are vectors of climate change, so adaptation and transitioning to less emissions intensive investments should be at the top of priorities of island governments (Wolf et al., 2024). Islands also share intrinsic challenges that reinforce their high vulnerability nature. Fiscal constraints and dependence on external financing (Klöck & Fink, 2019), insufficient granularity and downscaled climate and tourism data, and the uncertainty about the cost and benefits of self-financing mechanisms (Hess & Kelman, 2017; Wolf et al., 2024). Finally, islands' road maps and strategies for adaptation and mitigation repetitively do not analyse alternative financial schemes (Haldane et al., 2023; Hess & Kelman, 2017). These conditions are common across Caribbean, Pacific, and Southeast Asian destinations.

In this vein, this study cannot translate into generalizable recommendations but represent a step forward designing a methodological guide that can be utilised to replicate the same study in all islands, relatively easy. This type of analysis is useful to complement broad cost-benefit analyses of their energy transition programmes. This study also opens an opportunity to explore the application of benefit transfer functions, from an island study site to an island policy site if no statistical data is available (Johnston & Rosenberger, 2010). This seems possible as the tourism market composition of Bali (Indonesia), for instance, mirrors our Canary Islands sample. The island shows clear profiles of high-spending long-haul visitors alongside shorter-haul regional tourists with different budget profiles (Australian and European tourists), while there is a growing Chinese tourism segment - high-spending with uneven environmental awareness (Widiani & Budhi, 2024; Wu et al., 2025).

In 2024, Bali introduced a flat-rate International Tourism Levy of IDR 150,000 (approximately USD 10) per international arrival. This uniform structure is analogous to our Scenario 1 baseline. It captures only a fraction of available revenue. Segmenting tourists into expenditure-based tiers calibrated to accommodation category could be layered onto this infrastructure without new data requirements. The 81.8% revenue advantage of progressive over flat structures in the Canary Islands provides a conservative benchmark for what Bali's levy could generate under differentiated design.

Another interesting case study is Fiji island. Tourism contributes approximately 40% of Fiji's GDP, and near 60% of tourist expenditure leaks abroad through imported goods and foreign-owned hospitality (Dean, 2022; Export Finance Australia, 2022; Reserve Bank of Fiji, 2023). This constrains the financing capacity available for environmental protection. Notably, Pratt (2015) estimates a relatively high tourism income multiplier for Fiji compared to other Small Island Developing States (Cheer et al., 2018), suggesting that retaining a larger share of tourism revenue through self-financing mechanisms could generate meaningful environmental dividends.

A more distant case study can be Okinawa (Japan). The destination has recently moved toward sustainable tourism financing, enacting an accommodation tax and formally adopting sustainability as a destination management goal (Johnson, 2025). But Okinawa's source market is dominated by domestic tourists, with international arrivals drawn primarily from East Asian markets. Environmental norm-behaviour relationships differ systematically across these markets (Di Giusto et al., 2018). Parameter transfer from the Canary Islands a priori do not seem appropriate.

Finally, there are three conditions that limit transferability. First, our revenue projections assume low price elasticity. Destinations with closer mainland alternatives face greater demand-loss risk from progressive structures. They should model demand explicitly before adopting Scenario 2 or Scenario 3 architectures. Second, administrative requirements increase with framework sophistication. Expenditure-based tiers need only accommodation data. Behaviourally optimised allocation requires stated-preference surveys and predictive modelling. Simpler tier structures are the right starting point. Third, destinations with strong tour operator market power may need participatory governance to ensure transparent revenue allocation. This is consistent with environmental justice principles (Rastegar & Becken, 2024).

5.5. *Limitations and future research directions*

Three categories of limitations warrant acknowledgment: demand-side responses, operational implementation challenges, and counter-intuitive behavioural patterns requiring further theoretical development.

Demand Elasticity and Transferability: The findings derive from stated preferences in a mature island destination. Transferability to other contexts, cultural settings, and tourism types requires further testing. Revenue calculations assume fixed demand. Our approach charges tourists at or below their stated willingness-to-pay, which minimises substitution risk. Island tourism has characteristically low-price elasticity and limited substitution possibilities.

The behaviourally informed approach faces two measurement challenges: total trip expenditure is unobservable at arrival (accommodation expenditure approximates it at $\rho \approx 0.75$ but introduces error) and predicting willingness-to-pay tier membership remains unsolved—a critical avenue for future research.

Machine learning offers a path forward, using observable characteristics (nationality, accommodation type, demographics, booking patterns) to predict optimal fee allocation. The dataset provides a training foundation, linking tourist profiles to stated compensation level selections. Future research should develop and validate such predictive models against revealed preferences in field settings, enabling destinations to begin with the progressive structure (Scenario 2) while building toward behaviourally optimised allocation over time.

The Education Paradox and Destination Perceptions. Education increases participation likelihood but reduces contribution intensity. This is counter-intuitive given established links between education and environmental concern. Recent evidence offers an explanation: highly educated populations in developed countries often express lower environmental concern despite greater awareness. The reason is confidence in institutional capacity to address challenges (Peñasco & Grossman, 2025). Educated tourists visiting the Canary Islands may assume EU-level resources are sufficient and calibrate their contributions downward.

This points to two research directions. First, comparative studies across destinations at different development levels could test whether the education-compensation relationship reverses where perceived institutional capacity is lower. Second, communication campaigns emphasising island-specific vulnerabilities—ecological fragility, resource constraints, geographic isolation—might raise contribution intensity among educated segments. This would transform the paradox into a policy opportunity.

Island destinations should begin with expenditure-based progressive structures (Scenario 2), building administrative capacity while allocating revenues transparently to environmental initiatives to establish political legitimacy. Monitoring systems should track behavioural patterns, enabling gradual evolution toward optimised allocation as data accumulate. Longitudinal studies on stated versus revealed preference alignment, cross-cultural validation beyond European island contexts, and field experiments on communication strategies would strengthen external validity prior to system-wide adoption.

Behavioural differentiation generates substantially more revenue than uniform treatment without sacrificing participation. The outlined research agenda—predictive allocation models, cross-contextual validation, communication interventions—converts current limitations into concrete pathways for advancing both theory and practice in self-financing environmental programmes for tourism destinations.

6. Conclusion

The central finding of this study is straightforward: participation decisions and contribution intensity represent different behavioural mechanisms. Ignoring this distinction prevents destinations from achieving two essential objectives simultaneously broad participation for political legitimacy and sufficient tourism revenue for environmental and climate change programmes.

In turn, a more sustainable tourism fiscal policy could consist in generating more revenue from high-capacity segments which fund barrier-reduction programmes for environmentally motivated tourists facing accessibility constraints. The result is a self-financing system supporting coastal protection, renewable energy, bio-diversity conservation, and sustainable transport—while maintaining broad political support through inclusive participation.

Several limitations require acknowledgment. The findings derive from stated preferences in a mature island destination. Transferability to other contexts, cultural settings, and tourism types remains to be tested. Revenue projections assume fixed demand. Our framework charges tourists at or below their stated willingness-to-pay, which minimises substitution risk. Nevertheless, destinations with closer alternatives or higher price sensitivity should conduct explicit demand modelling before adoption.

Implementation also faces measurement challenges. Destinations cannot directly observe total trip expenditure or willingness-to-pay at arrival. Accommodation expenditure provides a workable proxy for the former but introduces measurement error. Predicting willingness- to-pay tier membership from observable characteristics—nationality, accommodation type, demographics—is a critical research frontier. Machine learning approaches could translate the behavioural patterns observed here into implementable allocation algorithms as administrative systems mature.

We recommend a sequenced approach for island destinations. Start with expenditure-based progressive tiers. Ensure transparent allocation of revenues to environmental initiatives. Build monitoring systems to track behavioural patterns over time. Evolve toward behaviourally optimised allocation as data and administrative capacity grow. Cross-contextual validation is essential before claiming broad generalisability.

The framework also has wider methodological value. Many pro-environmental behaviours share the same two-stage structure—-whether to adopt versus how intensively to engage—yet are routinely anal-ysed through single-stage models. Recycling, energy conservation, sustainable consumption, and bio-diversity protection could all benefit from explicit two-stage modelling. The validation approach combining sign consistency analysis, residual correlation tests, and bootstrap procedures offers a replicable template for researchers assessing whether a phenomenon requires multi-stage treatment.

The practical question for island destinations is not whether to implement carbon compensation. It is how to design mechanisms that reduce accessibility barriers for willing participants while leveraging spending capacity among high-capacity segments. Getting this distinction right determines whether a destination achieves environmental effectiveness, fiscal sustainability, and political legitimacy.

Declaration of generative AI and AI-assisted technologies

During the preparation of this work the author(s) used Claude Sonnet 4.5 to check the correct use of English. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

CRediT authorship contribution statement

Aythami Santana-Padrón: Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation. **Yen E. Lam-González:** Writing – review & editing, Validation, Supervision, Investigation, Formal analysis, Conceptualization. **Javier de León:** Writing – review & editing, Supervision, Resources, Investigation, Conceptualization.

Ethical statement

Not applicable.

Declaration of competing interest

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

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Data availability

Data available under request.

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