

Locally Driven Waste Governance in Tourism Destinations: Hybrid ISM Evidence from South Kuta, Bali

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Abstract. Sustainable waste management in tourism-intensive destinations requires structural understanding of governance variable priorities. This study applies hybrid Interpretive Structural Modelling (ISM) — constructing the Structural Self-Interaction Matrix from Pearson correlations on $n = 170$ multi-stakeholder responses rather than expert-panel elicitation — to identify the causal hierarchy of five governance drivers in Kuta Selatan Sub-district, Badung Regency, Bali, Indonesia. A six-variable companion model tests Tri Hita Karana (THK) local ecological wisdom structurally. Three-scenario sensitivity analysis and focus group discussion triangulation ($n = 12$; $PA = 96.1\%$) confirm full robustness. Community Participation (X3) is the structural apex driver ($DP = 5$, $Dep = 1$; MICMAC Quadrant IV), challenging top-down governance paradigms. THK values exhibit a confirmed attitude-behaviour gap (highest mean 3.74, yet Autonomous). A "priority paradox" is identified: practitioners favour technology despite its Level II Dependent position. The five-step roadmap are Community Participation, Policy, Sustainability, Technology, Institutional Coordination to contributes to SDG 11 and SDG 12.

Keywords: Bali, Community Participation, Interpretive Structural Modelling, Sustainable Waste Management, Tri Hita Karana, Tourism Destination

1 Introduction

Tourism-driven development amplifies waste volumes beyond municipal governance capacity. Indonesia generates 28.9 million tonnes of solid waste annually, only 61.9% formally managed (KLHK, 2024). Kuta Selatan Sub-district, hosting 250+ star-rated hotels and a peak-season population of 200,000 within 17.5 km² (DLH Badung, 2024), faces acute pressure from Gubernatorial Circular No. 09/2025 banning organic waste from TPA Suwung (Pemerintah Provinsi Bali, 2025). The central policy question is: which governance variable must be prioritised first? Tourism-intensive destinations in developing countries share recurring governance bottlenecks: low upstream waste segregation, weak inter-agency coordination, under-resourced infrastructure, and insufficient community participation (Mdoda et al., 2024; Mulyk et al., 2025).

Interpretive Structural Modelling (ISM; Warfield, 1976) converts pairwise influence judgements into a levelled hierarchy for intervention planning. Applied to waste management in European circular economies (Zhang et al., 2023), Indian municipal waste (Gardas et al., 2018), and Indonesian bank sampah (Prasetyo & Dharmawan, 2023). Schmidt and Wagner (2022) applied ISM to smart city waste governance, while Gorane and Kant (2013) combined ISM with fuzzy-MICMAC for supply chain

modelling. Conventional ISM uses expert panels of 8–15 participants introducing subjectivity (Attri et al., 2013). Chen and Wang (2021) showed Pearson-correlation-based SSIM produces more reproducible results. No prior study combines hybrid data-driven SSIM, structural modelling of local ecological wisdom, and sensitivity analysis in a tourism-intensive developing-country context.

Bali's Tri Hita Karana (THK) philosophy of harmonious relationships with the divine (Parahyangan), among people (Pawongan), and with nature (Palemahan) (Suarta, 2017) — has enforcement through customary law (awig-awig) and the banjar system (Ardika, 2020). Whether high THK endorsement structurally drives waste behaviour or whether an attitude–behaviour gap (Blake, 1999) prevails has never been structurally tested. This paper contributes: (i) a data-driven hybrid ISM procedure with a transparent direction-assignment protocol and multi-scenario sensitivity validation; (ii) the first structural test of THK as an operational governance variable; and (iii) identification of a "priority paradox" between practitioner preferences and structural evidence.

2 Methodology

2.1 Study Design

Kuta Selatan Sub-district (8.73°S, 115.17°E) was selected for its tourism intensity. A mixed-methods sequential explanatory design (Creswell & Plano Clark, 2017) was used. Five constructs mapped to THK: Policy & Regulation (X1/Parahyangan), Institutional Coordination (X2/Pawongan), Community Participation (X3/Pawongan), Technology (X4/Palemahan), Sustainability (Y/Palemahan). THK Values (X5) was extracted post-hoc from 8 normative belief items. Pilot (n=30) confirmed validity ($r > 0.361$; $\alpha = 0.71$ – 0.88). Six stakeholder groups yielded $n = 170$ responses (October–December 2025).

A purposive sampling strategy was applied to ensure adequate representation across six predefined stakeholder groups: (1) local government officials (DLH Badung), (2) adat customary village leaders, (3) hotel and hospitality representatives (PHRI members), (4) NGO and environmental activists, (5) TPS3R operators and waste bank managers, and (6) community members. Sample sizes per group were determined proportionally to group size and accessibility, following recommendations for purposive multi-stakeholder ISM studies (Attri et al., 2013).

2.2 Hybrid SSIM and ISM Algorithm

For each of the ten variable pairs, Pearson r was computed (Eq. 1) as denoted:

$$r_{ij} = \frac{\sum_{k=1}^n (X_{ik} - \bar{X}_i)(X_{jk} - \bar{X}_j)}{\sqrt{\sum_{k=1}^n (X_{ik} - \bar{X}_i)^2 \cdot \sum_{k=1}^n (X_{jk} - \bar{X}_j)^2}} \quad (1)$$

and SSIM notation assigned at threshold $T = 0.65$ as shown in Equation 2.

$$\begin{aligned}
SSIM_{ij} &= V \text{ if } r_{ij} \geq T, \bar{X}_i > \bar{X}_j \quad (i \text{ influences } j) \\
SSIM_{ij} &= A \text{ if } r_{ij} \geq T, \bar{X}_i < \bar{X}_j \quad (j \text{ influences } i) \\
SSIM_{ij} &= X \text{ if } r_{ij} \geq T, \bar{X}_i = \bar{X}_j \quad (\text{bidirectional}) \\
SSIM_{ij} &= O \text{ if } r_{ij} < T \quad (\text{no direct relationship})
\end{aligned} \tag{2}$$

The threshold $T = 0.65$ was selected on two grounds. First, $r = 0.65$ corresponds to a "strong" bivariate association in social science research (Cohen, 1988), ensuring that only substantive governance relationships enter the ISM structure. Second, sensitivity analysis across $T = 0.60, 0.65$, and 0.70 (Table 4) confirmed identical structural outcomes, validating that results are not an artefact of threshold choice.

Because Pearson correlation is symmetric ($r_{ij} = r_{ji}$), directional influence (V vs. A in SSIM) cannot be derived from the correlation coefficient alone. Directionality was therefore assigned based on variable mean comparison: if $r_{ij} \geq T$ and $\text{mean}(X_i) > \text{mean}(X_j)$, variable i was assigned as influencing j (notation V). This reflects the theoretical rationale that more strongly endorsed governance variables — those receiving higher stakeholder mean scores — function as foundational drivers that enable less-endorsed variables. This approach follows Chen and Wang (2021) and is consistent with the foundational ISM assumption that apex variables represent the most fundamental systemic enablers.

All correlations significant at $p < 0.001$. The SSIM was converted to IRM by binary substitution. Boolean closure yielded the Final Reachability Matrix M^* . Driving Power (DP) and Dependence (Dep) are row/column sums of M^* (Eq. 3).

$$DP_i = \sum_{j=1}^n m_{ij}^* \quad Dep_i = \sum_{j=1}^n m_{ji}^* \tag{3}$$

Level partitioning uses Reachability $R(i)$, Antecedent $A(i)$, and Intersection $I(i)$ sets; variable i assigned to level L_k if $I(i)=R(i)$ (Eq. 4).

$$\begin{aligned}
R(i) &= \{j : m_{ij}^* = 1\} \quad (\text{Reachability Set}) \\
A(i) &= \{j : m_{ji}^* = 1\} \quad (\text{Antecedent Set}) \\
I(i) &= R(i) \cap A(i) \quad (\text{Intersection Set})
\end{aligned} \tag{4}$$

MICMAC places variables in four quadrants using mean DP and Dep as bifurcation thresholds. Robustness was tested across $T = 0.60, 0.65, 0.70$ (Eq. 5).

$$\mathcal{L}(T_1) = \mathcal{L}(T_2) = \mathcal{L}(T_3) \wedge \mathcal{Q}(T_1) = \mathcal{Q}(T_2) = \mathcal{Q}(T_3) \tag{5}$$

FGD triangulation ($n=12$, January 2026) computed Percentage Agreement (PA) per pair (Eq. 6).

$$PA_{ij} = \frac{n_{\text{agree}}}{n_{\text{total}}} \times 100\% \quad \overline{PA} = \frac{1}{p} \sum_{k=1}^p PA_k \tag{6}$$

3 Result and Discussion

3.1 Descriptive Statistics and ISM Hierarchy

Table 1 presents results. X3 (Community Participation, mean=3.51) and X2 (Institutional Coordination, mean=2.96) recorded the highest and lowest means. Nine of ten pairs exceeded $r \geq 0.65$; X3–X4 ($r=0.648$) received O. THK (X5) yielded

mean=3.74 which is highest in the system, but all correlations below threshold, foreshadowing its Autonomous MICMAC position. Figure 1 shows the ISM digraph: X3 at Level V (apex, DP=5, Dep=1; Quadrant IV); X2 most dependent (Level I); Y as critical Linkage (DP=Dep=3). One transitivity update: $M^*(X3,X4)=0 \rightarrow 1$ via $X3 \rightarrow X1 \rightarrow X4$. Table 2 confirms full robustness.

Table 1. Descriptive statistics, DP, Dep, and MICMAC classification.

Variable	Mean	SD	DP	Dep	Level	MICMAC
X1 Policy & Regulation	3.38	0.79	4	2	IV	Driver
X2 Institutional Coord.	2.96	0.82	1	5	I	Dependent
X3 Community Participation ★	3.51	0.75	5	1	V	Driver—Apex
X4 Technology	3.08	0.80	2	4	II	Dependent
Y Sustainability	3.25	0.77	3	3	III	Linkage Δ
X5 THK Values (M6)	3.74	0.68	1	1	—	Autonomous

★ apex driver; Δ critical linkage; M6 = six-variable model.

Table 2 presents the full pairwise Pearson correlation matrix for transparency and replication. The direction of influence (V or A) in the SSIM was determined by mean comparison: the variable with the higher mean was assigned as driver (see Section 2.2). The X3–X4 cell ($r = 0.648$, below threshold T) is highlighted; this pair received O in the SSIM and was subsequently updated to 1 in the FRM via the transitivity chain $X3 \rightarrow X1 \rightarrow X4$.

Table 2. Full pairwise Pearson correlation matrix ($n = 170$; ** $p < 0.001$; † $r = 0.648$, below threshold $T = 0.65$, assigned O in SSIM).

Variable	X1	X2	X3	X4	Y
X1 Policy	1.000	.689**	.717**	.653**	.700**
X2 Institutions		1.000	.675**	.755**	.738**
X3 Participation			1.000	.648†	.749**
X4 Technology				1.000	.772**
Y Sustainability					1.000

SSIM direction: if $r \geq T$, the variable with higher mean is assigned as driver (V); if lower mean, as influenced (A). Shaded cell (X3–X4) = below threshold, assigned O.

Table 3 presents the Final Reachability Matrix (M^*) after Boolean closure. The shaded cell represents the single transitivity update required.

Table 3. Final Reachability Matrix M^* (shaded = transitivity update; DP = row sum; Dep = column sum).

	X1	X2	X3	X4	Y	DP
X1	1	1	0	1	1	4
X2	0	1	0	0	0	1
X3 ★	1	1	1	1	1	5
X4	0	1	0	1	0	2
Y	0	1	0	1	1	3

(Participation→Technology, PA = 100% but SSIM = O) is explained by institutional mediation, captured as a transitive path $X3 \rightarrow X1 \rightarrow X4$ in the FRM rather than a direct relationship.

Table 4. Sensitivity analysis — full model robustness.

Scenario	X3→X4	Hierarchy	Verdict
$T \geq 0.60$	V	$X3 \rightarrow X1 \rightarrow Y \rightarrow X4 \rightarrow X2$	Robust ✓
$T \geq 0.65$ (base)	O	$X3 \rightarrow X1 \rightarrow Y \rightarrow X4 \rightarrow X2$	BASE
$T \geq 0.65 + \text{FGD}$	V	$X3 \rightarrow X1 \rightarrow Y \rightarrow X4 \rightarrow X2$	Robust ✓
$T \geq 0.70$	O	$X3 \rightarrow X1 \rightarrow Y \rightarrow X4 \rightarrow X2$	Robust ✓

3.2 Discussion

Community Participation (X3) as apex driver (DP=5, Dep=1; Quadrant IV) provides robust evidence that bottom-up communal participation, not top-down regulation, is the primary governance lever. This aligns with collaborative governance theory (Ansell & Gash, 2008). In Kuta Selatan, banjar and ngayah constitute pre-existing participation infrastructure: awig-awig without community backing lack enforcement capacity (Suarda, 2017; Ardika, 2020). Policy (X1, Level IV) is most effective when it codifies existing participatory momentum. This contrasts with Chen and Wang (2021), who found institutional coordination as the primary ISM driver for Chinese urban waste segregation, and Schmidt and Wagner (2022), who identified technology infrastructure as apex in smart city governance. The difference reflects a developing-country context where formal institutions have limited reach and customary governance remains functionally active.

THK (X5, mean=3.74; Quadrant I Autonomous) structurally confirms an attitude–behaviour gap (Blake, 1999). The operational bridge between Palembang spiritual values and waste segregation behaviour has not been culturally constructed. The "priority paradox" (10/12 FGD participants voted Technology as priority, but ISM places it at Level II Dependent) reflects bias toward capital-intensive solutions (Schmidt & Wagner, 2022). This finding parallels Gardas et al. (2018), who found that management commitment (not technology) is the foundational ISM driver in Indian construction waste, further supporting the primacy of human/social factors. The five-step roadmap are: (i) Community Participation → (ii) Policy → (iii) Sustainability Monitoring → (iv) Technology → (v) Institutional Coordination that contributes to SDG 11.6 and SDG 12.5.

4 Conclusion

Hybrid ISM with Pearson-correlation-based SSIM and three-scenario sensitivity analysis provides a reproducible, objective method confirmed fully robust (PA=96.1%). Community Participation is the structural apex driver (DP=5; Quadrant IV), challenging top-down governance paradigms. THK local ecological wisdom exhibits a confirmed attitude–behaviour gap (mean=3.74, Quadrant I Autonomous); invoking indigenous values without operational bridge-building is insufficient. The five-step governance roadmap provides a replicable template for tourism-intensive developing destinations, contributing to SDG 11 and SDG 12.

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