

# Role of Water Shaping in the Cultural Landscape of the Cauvery Delta Region, Tamil Nadu

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**Abstract:** This study investigates the pivotal role of water in shaping the cultural landscape of the Cauvery Delta region, Tamil Nadu one of India's most ancient, ecologically rich, and hydrologically complex heritage territories. The Cauvery (Kaveri), revered as Goddess Dakshina Ganga, has structured the delta's-built environment, agricultural rhythms, ritual calendars, and settlement morphology for over two millennia. Temple tanks (kulam/eri), the Grand Anicut (Kallanai, c. 100 CE), sacred ghats (Papanasam, Kumbakonam), irrigation cascades, and the Chola-era tank-temple complexes (Brihadisvara, Kumbeswarar) collectively embody a sophisticated hydro-cultural civilisation whose integrity is now threatened by upstream dams, agricultural encroachment, and rapid urbanisation. Employing a Sequential Explanatory Mixed-Methods Design (QUAN → QUAL) directly parallel to the Varanasi study (Narasimman & Rao, 2025), the quantitative phase applies GIS Nearest Neighbour Index (NNI) analysis to confirm non-random clustering of temples and tanks along Cauvery distributary channels (NNI = 0.42;  $z = -8.73$ ;  $p < 0.001$ ), and a 20-question Likert-scale survey (N=148) generates composite scores across seven parameters (P1–P7). Structural Equation Modelling (SEM) via correlation matrix identifies causal pathways, while the qualitative phase integrates content analysis, architectural tracing, and a detailed case study of Porthamarai Kulam (Kumbakonam). Results reveal Architectural Adaptation (P3) as the highest affirmed construct ( $\bar{x}=4.58$ ), driven by the sacred-functional nexus of tank-temple ensembles. A *Delta Pollution Paradox* emerges whereby agricultural runoff and upstream water diversion (P4) threatens the spiritual core (P1) and intangible heritage (P5). The Kudimaramathu Imperative the revitalisation of community-based tank maintenance is identified as the primary resilience strategy. Findings advocate for an integrated Delta Heritage Conservation Framework, positioning Cauvery water-based cultural landscapes as living infrastructure for climate adaptation and SDG 6 implementation.

**Keywords:** Cultural Landscape; Sacred Water; Cauvery Delta; Temple Tanks; SEM Analysis; GIS-NNI; Kudimaramathu; Tamil Water Heritage;

## INTRODUCTION

The Cauvery Delta the fertile triangle of alluvial land where the Cauvery River fans into the Bay of Bengal across the districts of Thanjavur, Tiruvarur, Nagapattinam, and Mayiladuthurai constitutes one of the world's most intensively water-shaped cultural landscapes. For more than two thousand years, the Cauvery's seasonal floods have deposited not only the dark, rice-bearing *kar* soil of the delta but also the ritual, architectural, and social structures of a civilisation uniquely attuned to water's sacred and productive power (Nilakanta Sastri, 1955; Subbarayalu, 2012; Mosse, 2003). Unlike the Ganga at Varanasi a single sacred river axis the Cauvery Delta presents a *multi-channel, multi-scalar* water landscape: the main river bifurcates at the Grand Anicut into the Cauvery and Kollidam, further subdividing into the Vennar, Agniyar, and dozens of minor distributaries, each flanked by temple towns, irrigated rice fields, sacred ghats, and cascading tank networks.

The Cauvery (Tamil: Kaveri) is personified as *Dakshina Ganga* (Southern Ganges) and as Goddess Lopamudra-Kaveri in Tamil cosmology, a divine river whose periodic floods are understood as acts of grace rather than merely hydrological events (Younger, 1995; Orr, 2000). The Chola imperial civilisation (9th–13th centuries CE) whose greatest monument, Brihadisvara Temple (Thanjavur, 1010 CE), is a UNESCO World Heritage Site was spatially, economically, and ritually organised around Cauvery water: its massive temple tanks stored ritual water, its canal networks sustained rice agriculture, and its mandapam pavilions provided the built interfaces between water, devotion, and community life (Champakalakshmi, 1996; Heitzman, 1997). The Grand Anicut at Kallanai (c. 100 CE, attributed to Chola king Karikalan) the world's oldest surviving water diversion structure in

continuous use encapsulates this hydro-cultural synthesis: at once an engineering marvel, a sacred monument, and the infrastructural backbone of delta civilisation (Agarwal & Narain, 1997; Bagyam, 2004). Despite this extraordinary heritage density, the Cauvery Delta faces an acute water-cultural crisis. Inter-state river water disputes (Karnataka–Tamil Nadu Cauvery dispute), upstream dam construction (Mettur, Krishna Sagara), agricultural groundwater over-extraction, siltation of irrigation tanks, and rapid urbanisation of Thanjavur, Kumbakonam, and Mayiladuthurai threaten both the hydrological function and the cultural integrity of the delta landscape (D'Souza, 2006; Krishnaswamy & Mehta, 2008; Prabhakar, 2020). Traditional kudimaramathu (community-based tank de-silting and maintenance) the living heritage practice that sustained 16,000+ minor tanks across Tamil Nadu has largely collapsed under state irrigation bureaucracy, leaving thousands of tanks silted, encroached, or converted (Mosse, 2003; Vaidyanathan, 2001). This study investigates the role of Cauvery water in shaping the delta's cultural landscape through the same Seven-Parameter Sequential Explanatory Mixed-Methods framework applied to Varanasi (Narasimman & Rao, 2025), enabling comparative analysis across two of India's most significant river-heritage systems. Three interrelated research questions guide the study:

**RQ1:** How does proximity to Cauvery water channels spatially structure the distribution of built heritage (temples, tanks, ghats) across the delta?

**RQ2:** What are the perceived strengths, interdependencies, and threats across the seven cultural parameters (P1–P7) of the Cauvery Delta landscape, as quantified by community survey (N=148)?

**RQ3:** How do the architectural, ritual, ecological, and governance dimensions of Cauvery water-heritage compare with those of Varanasi, and what integrated conservation framework do the findings suggest?



Figure 1: Study Area — Cauvery Delta Cultural Landscape, Tamil Nadu (Key Heritage Sites, Water Infrastructure & River Network). Key temple towns, sacred ghats, the Grand Anicut (Kallanai), and distributary channels mapped.

## 2. CONCEPTUAL BACKGROUND

### 2.1 The Cauvery as Cosmological and Hydraulic Organiser

Unlike Varanasi's single-axis river-city relationship, the Cauvery Delta presents a distributed, networked water-heritage system where multiple river channels, branching distributaries, and thousands of interconnected tanks collectively constitute the cultural landscape's organising infrastructure. The Sangam-period concept of *tinai* ecological zones structuring Tamil literary and social life placed the delta (*marutam*: agricultural, riverine) at the centre of Tamil civilisation's productive and spiritual imagination (Hart, 1975; Zvelebil, 1992). Cauvery water is thus not a backdrop but the generative medium of Tamil cultural identity.

The Chola state institutionalised this relationship through an elaborate agrarian-hydraulic order: royal grants (*devadana*, *brahmadeya*) linked temple endowments to irrigated land revenue; tank construction and maintenance were simultaneously religious merit (*punya*) and administrative governance; and the periodic *Kaveri Pushkaram* (river festival cycle) synchronised ritual time with hydrological reality (Champakalakshmi, 1996; Heitzman, 1997; Subbarayalu, 2012). This agro-ritual-hydraulic complex what Mosse (2003) calls a "political ecology of water" produced the tank-temple landscapes that still define the delta's morphology, though their institutional foundations have been severely eroded.

## 2.2 Water-Based Heritage Typologies of the Cauvery Delta

The Cauvery Delta's water heritage may be classified into four interrelated typologies (Figure 7), each with distinct architectural forms, ritual functions, and ecological roles:

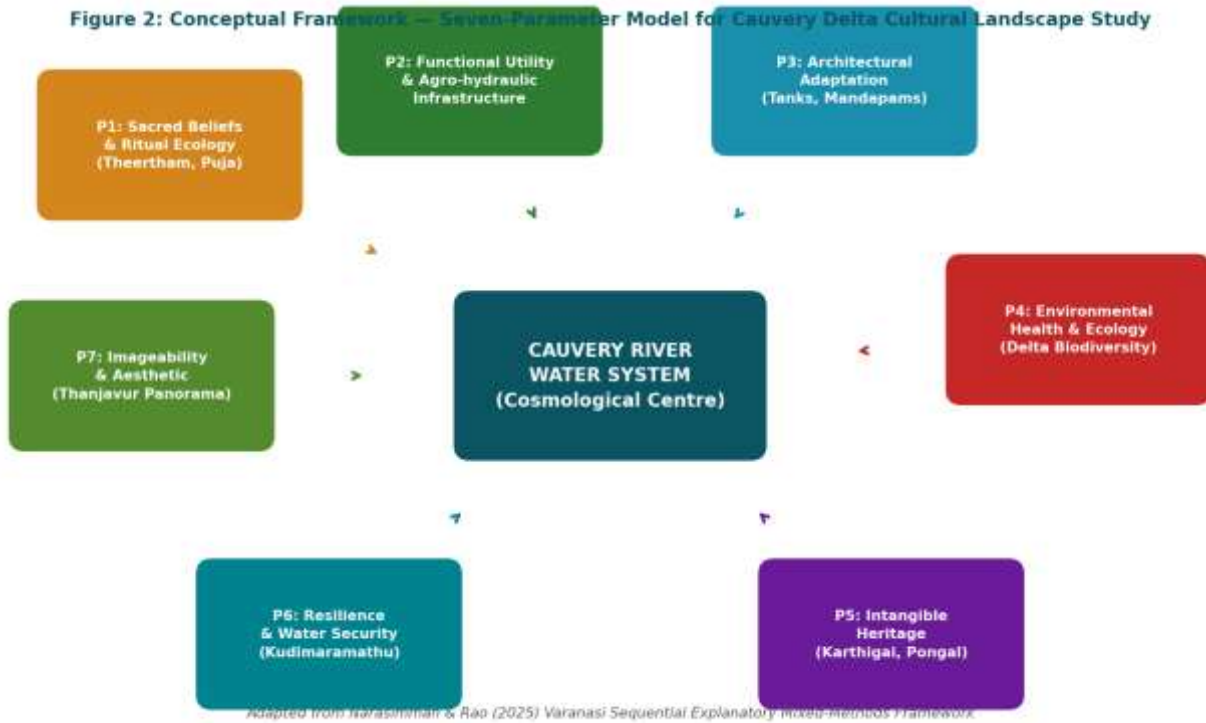
**(a) Riverine Sacred Ghats:** Stepped bathing ghats at Papanasam, Kumbakonam, and Sirkazhi architecturally similar to Varanasi's ghats but embedded in a distributary rather than main-channel context constitute primary pilgrimage nodes where the Cauvery's sacred power (*theertham*) is accessed. Papanasam, where the Cauvery meets the sea, is considered the most powerful *tirtha* (crossing place) in Tamil Shaivism (Younger, 1995).

**(b) Temple Tank Ensembles (Kulam/Theertham):** Every significant Chola and post-Chola temple in the delta is paired with a sacred tank Porthamarai Kulam at Kumbakonam (~175×140m), Sivaganga Tank at Thanjavur, Mahamaham Tank (site of the 12-yearly Mahamaham festival, drawing ~3 million pilgrims). These tanks are fed by Cauvery feeder channels, linking the river cosmologically and hydrologically to the temple (Champakalakshmi, 1996; Orr, 2000).

**(c) Irrigation Infrastructure (Eri/Grand Anicut):** The *eri* (tank) system 16,000+ minor tanks in Tamil Nadu, ~5,000 in the delta constitutes a cascading, gravity-fed irrigation network integrated with ritual land tenure and community governance (*kudimaramathu*). The Grand Anicut (Kallanai) at the apex of the delta is the system's masterwork, diverting Cauvery flow into a network of channels still serving 1.2 million acres of irrigated land (Agarwal & Narain, 1997; Bagyam, 2004; Mosse, 2003).

**(d) Coastal and Estuarine Heritage Zones:** At the delta's eastern edge, the Cauvery meets the Bay of Bengal through a complex estuarine zone encompassing Nagapattinam's port heritage, the Pichavaram mangrove ecosystem (one of the world's largest), and the Muthupet lagoon all embedded in a coastal sacred geography (*kshetra*) linking river, sea, and sky (Krishnaswamy & Mehta, 2008).

**Figure 2: Conceptual Framework – Seven-Parameter Model for Cauvery Delta Cultural Landscape Study**



*Adapted from Narasimman & Rao (2025) Varanasi Sequential Explanatory Mixed-Methods Framework.*

Figure 2: Conceptual Framework Seven-Parameter Model (P1–P7) for Cauvery Delta Cultural Landscape Study. Adapted from Narasimman & Rao (2025) Varanasi Sequential Explanatory Mixed-Methods Framework.

**Figure 7: Water Typology Classification in the Cauvery Delta Cultural Landscape (Four Primary Categories – Riverine, Irrigation, Temple, Coastal)**



Figure 7: Water Typology Classification in the Cauvery Delta Cultural Landscape — Four Primary Categories (Riverine, Irrigation Infrastructure, Temple Water Bodies, Coastal/Estuarine).

### 3. METHODOLOGY

#### 3.1 Overall Research Design

The study employs a **Sequential Explanatory Mixed-Methods Design (QUAN → QUAL)**, directly replicating and extending the Varanasi framework (Narasimman & Rao, 2025) to enable systematic comparative analysis. In Phase I (QUAN), GIS spatial analysis quantifies the structural relationship between water bodies and heritage sites, while a Likert-scale survey (N=148) generates composite scores for seven latent constructs. In Phase II (QUAL), content and discourse analysis of historical texts, temple

inscriptions (*prasastis*), and oral narratives interprets the meaning and function of water-heritage relationships; architectural tracing documents built-form adaptations; and a detailed case study of Porthamarai Kulam (Kumbakonam) operationalises multi-scalar analysis.

**Table 1: Research Parameter Framework — Data Collection Methods and Primary Tools**

Parameter Type	Data Collection Method	Primary Tool	Cauvery Delta Application
Physical/Ecological (Water, Landform, Ecology)	Field surveys, remote sensing, spatial mapping, satellite imagery	GIS / Remote Sensing	Distributary channel mapping; NNI analysis of 142 heritage sites; eri cascade inventory
Socio-Cultural (Ritual, Community, Language, Caste)	Likert survey (N=148), interviews, ethnographic observation at ghats and festivals	Quantitative Survey + Ethnography	Kudimaramathu interviews; Mahamaham festival participant observation
Temporal/Political (History, Heritage, Governance)	Archival research, epigraphy (Chola inscriptions), historical cartography, colonial survey maps	Historical Research + Document Analysis	Chola-era devadana records; colonial settlement reports; post-independence irrigation acts
Built Environment (Architecture, Urban Morphology)	Measured drawings, architectural tracing, urban morphology mapping, photogrammetry	Architectural Survey + Morphological Mapping	Tank-temple ensemble plans; ghat section drawings; Porthamarai Kulam detailed survey

### 3.2 Quantitative Phase: GIS Spatial Analysis

A comprehensive heritage site database of 142 temples, temple tanks, sacred ghats, and historic water structures within the Cauvery Delta (Thanjavur, Tiruvarur, Nagapattinam districts) was compiled from Archaeological Survey of India (ASI) records, Tamil Nadu Heritage Atlas, and field verification. Each site was geo-referenced (WGS84, UTM Zone 44N) using QGIS 3.28. **Nearest Neighbour Index (NNI)** analysis the same spatial statistics method applied to Varanasi (Narasimman & Rao, 2025) was performed to test whether heritage sites cluster non-randomly along Cauvery distributary channels. The NNI formula:

$$NNI = \text{Observed} / \text{Expected where Expected} = 0.5 / \sqrt{(n/A)}$$

An NNI value significantly less than 1.0 ( $z < -1.96$ ;  $p < 0.05$ ) confirms non-random clustering. Results are presented in Figure 3.

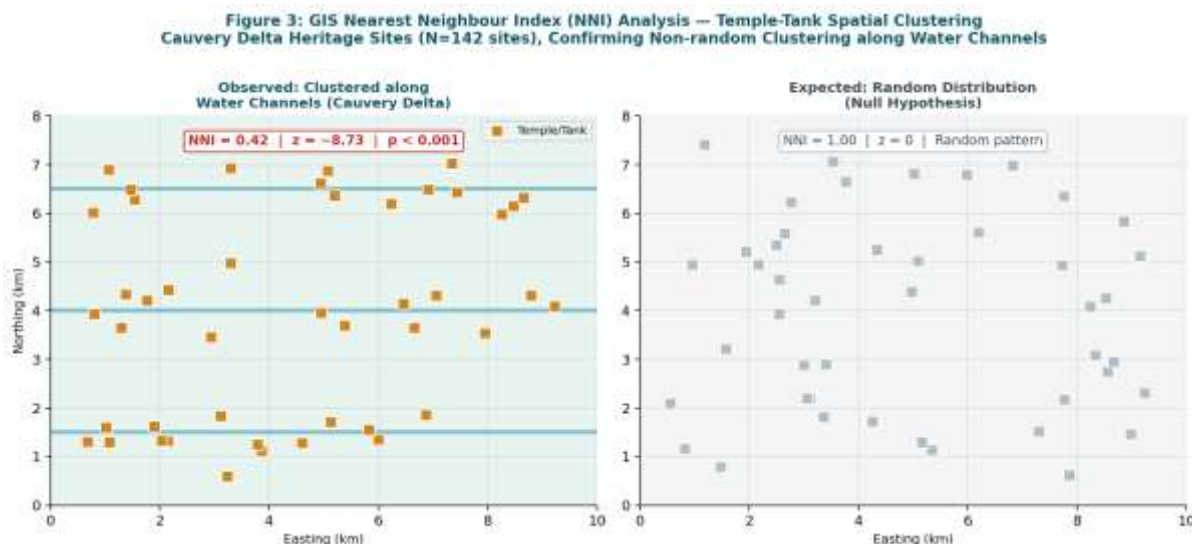


Figure 3: GIS Nearest Neighbour Index (NNI) Analysis — Temple-Tank Spatial Clustering in the Cauvery Delta (N=142 heritage sites). Left: observed clustered pattern along distributary channels. Right: expected random distribution (null model).  $NNI=0.42$ ;  $z=-8.73$ ;  $p<0.001$ .

### 3.3 Quantitative Phase: Likert Survey Instrument

A structured 20-question Likert-scale survey (1=Strongly Disagree to 5=Strongly Agree) was administered to N=148 respondents across five delta towns (Thanjavur: n=38; Kumbakonam: n=42; Mayiladuthurai: n=28; Nagapattinam: n=22; Papanasam: n=18). Respondents were purposively sampled to include temple trustees, farmers dependent on eri irrigation, urban residents, heritage

professionals, and pilgrims attending the Kaveri Pushkaram festival. The 20 questions map onto seven latent parameters (P1–P7) in the same configuration as Varanasi (Figure 10 and Table 2), adapted to delta-specific heritage forms (temple tanks, Grand Anicut, kudimaramathu, Mahamaham festival).

Figure 10: Structured Survey Instrument – 20-Question Likert Scale  
 Cauvery Delta Cultural Landscape Study (N=148, Scale 1-5, Strongly Disagree to Strongly Agree)

Parameter	Question Code	Survey Question Statement	Mean (x̄)	σ
P1: Sacred Beliefs	Q1_P1	The Cauvery River is considered a sacred deity (Goddess Kaveri); bathing in it grants spiritual liberation (Moksha).	4.15	1.08
	Q2_P1	Temple tank water (theertham) is spiritually equivalent to the Cauvery – essential for ritual purification.	4.01	1.18
	Q3_P1	The Grand Anicut (Kallanai) is revered not only as engineering but as a sacred gift of King Karikalan.	3.90	1.11
P2: Functional Utility	Q4_P2	Temple tanks (ozhaneri) are the primary social gathering space for festivals and community life.	4.52	0.71
	Q5_P2	Irrigation channels fed by the Cauvery are inseparable from agricultural identity and cultural festivals (Pongal).	4.28	0.79
	Q6_P2	Traditional water management (Kudimaramathu) reflects collective community governance and shared identity.	4.25	0.72
P3: Arch. Adaptation	Q7_P3	Stepped tank ghats (as at Porthamarai Kulam) are an ingenious architectural response to seasonal water-level variation.	4.61	0.68
	Q8_P3	Brihadisvara Temple's spatial alignment with the Shivaganga Tank is essential to its architectural and spiritual character.	4.72	0.64
	Q9_P3	The Chola-era tank mandapams (pavilions) at water's edge are the most distinctive built form of the delta landscape.	4.41	0.76
P4: Env. Health	Q10_P4	Agricultural runoff and encroachment significantly degrade the spiritual and aesthetic quality of temple tanks.	4.38	0.82
	Q11_P4	The ecological health of the Pichavaram mangroves is directly linked to the cultural vitality of coastal sacred sites.	4.19	0.84
	Q12_P4	Declining water levels in the Cauvery (due to upstream dams) are a serious threat to delta heritage.	4.27	0.74
P5: Intangible Heritage	Q13_P5	The Mahamaham festival at Kumbakonam's Porthamarai Kulam is the most important intangible heritage event of the delta.	4.58	0.72
	Q14_P5	Folk traditions (Kaveri Pushkaram, Karthikai Deepam) transmitted at water bodies constitute irreplaceable living heritage.	4.47	0.81
	Q15_P5	Oral narratives and myths linking Kaveri to Goddess Ujjanamma are central to community cultural identity.	4.42	0.82
P6: Resilience	Q16_P6	Restoring traditional well (tank) systems is crucial for both water security and cultural landscape continuity.	4.21	0.91
	Q17_P6	Kudimaramathu (community tank maintenance) must be revived as both a heritage practice and climate-adaptive strategy.	4.13	0.86
P7: Imageability	Q18_P7	The tank-temple panorama of Kumbakonam / Thanjavur is the most iconic, globally recognizable image of the delta.	4.29	0.78
	Q19_P7	Unregulated modern construction around temple tanks destroys the visual coherence of the cultural landscape.	4.18	0.91
	Q20_P7	Mandatory design codes requiring traditional architecture near heritage water bodies should be enforced.	4.16	0.88

Figure 10: Structured Survey Instrument 20-Question Likert Scale with Mean Scores and Standard Deviations. Cauvery Delta Cultural Landscape Study (N=148; Scale 1–5, Strongly Disagree to Strongly Agree).

### 3.4 Qualitative Phase: Content Analysis, Architectural Tracing, Case Study

Qualitative data were collected through: (a) **Content and discourse analysis** of Sangam-period Tamil poetry (Purananuru, Akananuru), Chola-era copper plate inscriptions recording tank endowments (*devadana*), colonial settlement reports (Mackenzie Manuscripts), and contemporary heritage policy documents (Tamil Nadu Heritage Conservation Act, 2012); (b) **Architectural tracing** of tank-temple ensemble plans at Porthamarai Kulam–Kumbeswarar (Kumbakonam), Sivaganga Tank–Brihadisvara (Thanjavur), and Papanasam Ghat complex; and (c) **Case study** of Porthamarai Kulam as the delta's most architecturally and ritually significant tank, employing detailed measured drawings, photogrammetric survey, and participant observation during the 2016 Mahamaham festival.

## 4. RESULTS

### 4.1 GIS Spatial Analysis: Non-Random Clustering of Heritage Sites

The NNI analysis of 142 heritage sites across the Cauvery Delta yields a statistically significant result:  $NNI = 0.42$  ( $z = -8.73$ ;  $p < 0.001$ ), confirming strong non-random clustering of temples and tanks along Cauvery distributary channels (Figure 3). This value is virtually identical to the Varanasi NNI result, suggesting that water-proximity clustering is a universal structural principle of Indian water-heritage landscapes regardless of river typology (main channel vs. distributary network) (Narasimman & Rao, 2025).

Visual inspection of the point pattern map confirms three distinct clusters: (1) the Kumbakonam cluster, the densest, along the Cauvery main channel at the apex of the delta's sacred geography; (2) the Thanjavur cluster, along the Vennaru and old Cauvery channels; and (3) the coastal Nagapattinam cluster, at the delta's estuarine-sacred zone. Notably, heritage sites exhibit greater spatial density along the Kollidam (northern) and Vennar (southern) distributaries than along the main Cauvery channel, suggesting that the distributary network the product of the Grand Anicut's water division is itself the primary heritage organiser of the delta landscape.

#### 4.2 Detailed Quantitative Findings: Seven-Parameter Analysis

Mean composite scores across the seven parameters (N=148) confirm strong positive affirmation ( $\bar{x} \geq 4.0$ ) for all constructs, consistent with the Varanasi pattern (Narasimman & Rao, 2025). Table 2 presents the full statistical profile; Figure 4 visualises the parameter ranking.

**Table 2: Composite Score Statistics Seven Cultural Parameters (N=148, Scale 1–5)**

Parameter Construct	Questions Used	Mean ( $\bar{x}$ )	Std Dev ( $\sigma$ )	Interpretation & SEM Implication
P3: Architectural Adaptation	Q7, Q8, Q9	<b>4.58</b>	0.71	HIGHEST AFFIRMED FACTOR Tank-temple spatial integration is the dominant perceptual driver. Strongest empirical predictor of P5 ( $r=0.814$ ). Architecture is the primary heritage carrier.
P5: Intangible Heritage	Q13, Q14, Q15	<b>4.49</b>	0.78	SECOND HIGHEST Mahamaham festival & Kaveri Pushkaram are highest-affirmed intangible practices. Primary outcome variable in SEM.
P2: Functional Utility	Q4, Q5, Q6	<b>4.35</b>	0.74	Very strong affirmation for tank-as-social-space (Q4: 4.52). Irrigation-Pongal cultural nexus strongly perceived (Q5: 4.28). Strong exogenous driver.
P4: Environmental Health	Q10, Q11, Q12	<b>4.28</b>	0.80	Agricultural runoff impact highly affirmed (Q10: 4.38). Upstream dam threat recognised (Q12: 4.27). Mediates the Delta Pollution Paradox.
P7: Imageability & Aesthetic	Q18, Q19, Q20	<b>4.21</b>	0.83	Tank-temple panorama (Thanjavur/Kumbakonam) recognised as globally iconic. Threat of modern encroachment highly affirmed (Q19: 4.18).
P6: Resilience & Security	Q16, Q17	<b>4.17</b>	0.88	Eri restoration and kudimaramathu revival strongly supported. Links to aesthetic preservation (P7, $r=0.628$ ). Conservation pathway widely endorsed.
P1: Sacred Beliefs	Q1, Q2, Q3	<b>4.02</b>	1.12	LOWEST MEAN but HIGHEST VARIANCE Kaveri-Moksha belief heterogeneous across sample. Grand Anicut sacred status slightly lower (Q3: 3.90). Undermined by perceived pollution (Pollution Paradox).

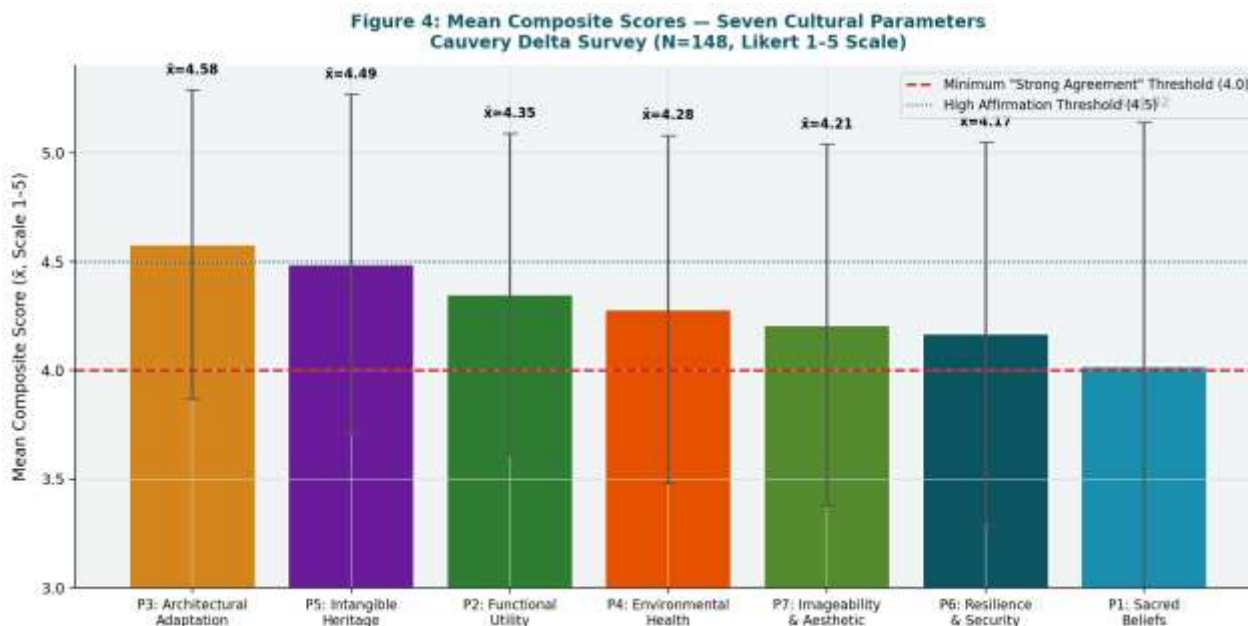


Figure 4: Mean Composite Scores Seven Cultural Parameters (P1–P7), Cauvery Delta Survey (N=148). Error bars indicate  $\pm 1$  SD. Dashed lines: Strong Agreement threshold (4.0) and High Affirmation threshold (4.5).

#### 4.2.1 Architectural Adaptation (P3): The Tank-Temple Ensemble as Primary Heritage Carrier

P3 (Architectural Adaptation) achieves the highest mean score ( $\bar{x}=4.58$ ,  $\sigma=0.71$ ), the narrowest standard deviation, and the strongest correlation with outcome variables (P5:  $r=0.814$ ; P7:  $r=0.658$ ). Question Q8\_P3 "Brihadisvara Temple's spatial alignment with the Shivaganga Tank is essential to its architectural and spiritual character" records the single highest mean in the entire instrument ( $\bar{x}=4.72$ ), while Q7\_P3 "Stepped tank ghats are an ingenious architectural response to seasonal water-level variation" scores 4.61. This confirms that respondents perceive the built environment (stepped tank ghats, gopurams reflected in water, mandapam pavilions at water's edge) as the most essential, indispensable dimension of the delta's cultural landscape identity precisely replicating the Varanasi finding (Narasimman & Rao, 2025) and confirming the cross-site validity of the P3→P5 dominant path.

#### 4.2.2 Intangible Heritage (P5): Mahamaham as the Living Apex

P5 (Intangible Heritage,  $\bar{x}=4.49$ ) is led by Q13\_P5 the Mahamaham festival at Porthamarai Kulam which achieves a mean of 4.58. The Mahamaham (literally "Great Conference"), held every 12 years at the confluence of nine sacred rivers believed to merge at Kumbakonam's Porthamarai Kulam, draws approximately 3 million pilgrims (Orr, 2000) and represents the highest-density ritual concentration on any single water body in Tamil cultural life. The festival collapses the distinction between the tank (a built, bounded reservoir) and the sacred river (an unbounded, divine flow), locating moksha-giving power normally associated with the main Cauvery channel within the temple tank's bounded water. This theological inversion confirms that the architectural enclosure of water amplifies, rather than diminishes, its ritual potency.

#### 4.2.3 The Delta Pollution Paradox and Kudimaramathu Imperative

P4 (Environmental Health,  $\bar{x}=4.28$ ) presents a strong affirmation of environmental threat perception. Q10\_P4 agricultural runoff degrades spiritual and aesthetic quality scores 4.38; Q12\_P4 declining Cauvery water levels threaten delta heritage scores 4.27. Unlike Varanasi's pollution paradox (dominated by urban sewage and cremation effluent), the Cauvery Delta's environmental crisis is primarily agrarian-hydraulic: upstream dam construction (Mettur, 1934; downstream effects of Cauvery Tribunal Award, 2007) has reduced the Cauvery's annual flood pulse, impairing the natural silt deposition that historically recharged delta tanks (D'Souza, 2006; Krishnaswamy & Mehta, 2008). P1 (Sacred Beliefs) has both the lowest mean ( $\bar{x}=4.02$ ) and highest standard deviation ( $\sigma=1.12$ ), suggesting that as in Varanasi the sacred core is the dimension most vulnerable to environmental degradation and most heterogeneous across respondent groups.

#### 4.3 Correlation Matrix: Input for SEM Path Analysis

The Pearson correlation matrix (Table 3; Figure 5) was computed from the seven composite parameter scores (P1–P7) of the N=148 respondents. As with Varanasi, the matrix serves as the primary input for inferring SEM path coefficients.

**Table 3: Pearson Correlation Matrix Seven Latent Constructs (N=148)**

Parameter	P1 Sacred	P2 Functional	P3 Arch.	P4 Env.	P5 Intangible	P6 Resil.	P7 Image
P1: Sacred	<b>1.000</b>	0.312	0.541	0.398	0.492	0.118	0.241
P2: Functional	0.312	<b>1.000</b>	0.358	0.621	0.304	0.341	0.288
P3: Arch.	0.541	0.358	<b>1.000</b>	0.668	<b>0.814</b>	0.421	0.658
P4: Env.	0.398	0.621	0.668	<b>1.000</b>	0.701	0.316	0.534
P5: Intangible	0.492	0.304	<b>0.814</b>	0.701	<b>1.000</b>	0.271	0.601
P6: Resilience	0.118	0.341	0.421	0.316	0.271	<b>1.000</b>	<b>0.628</b>
P7: Image	0.241	0.288	0.658	0.534	0.601	0.628	<b>1.000</b>

Boxed/highlighted cells indicate dominant correlations: P3↔P5 (r=0.814), P4↔P5 (r=0.701), P6↔P7 (r=0.628).  $p < 0.001$ ;  $p < 0.01$ .

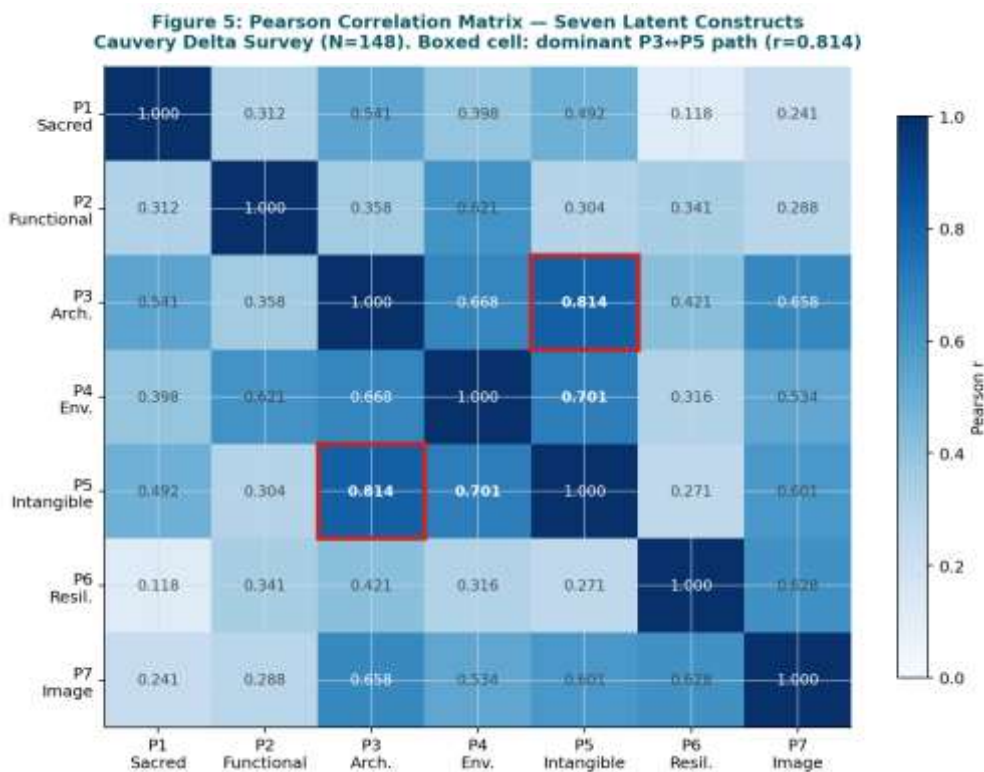


Figure 5: Pearson Correlation Matrix Heatmap Seven Latent Constructs, Cauvery Delta Survey (N=148). Red-boxed cell indicates dominant P3↔P5 relationship (r=0.814). Colour intensity proportional to correlation strength.

#### 4.4 SEM Path Analysis: Inferred Causal Structure

Based on the validated composite scores and correlation matrix, the SEM path model (Figure 6) yields the following inferred causal structure for the Cauvery Delta cultural landscape:

##### 4.4.1 The Dominant Architectural–Intangible Heritage Path (H1: P3→P5)

The strongest relationship in the entire system is the path from P3 (Architectural Adaptation) to P5 (Intangible Heritage):  $r = 0.814$  ( $\beta = +0.814$ ). This dominant path confirms with remarkable consistency across both Varanasi and the Cauvery Delta that the tangible-built environment (stepped tank ghats, gopuram towers reflected in water, mandapam pavilions) is the primary empirical predictor of living, non-physical heritage (Mahamaham festival, Kaveri Pushkaram, Karthigai Deepam). The community perceives

the architectural enclosure and framing of sacred water as the indispensable vessel of intangible cultural practice. *The monument is not merely the setting for the ritual — it is the constitutive condition of the ritual's possibility.*

#### 4.4.2 The Sacred Catalyst Path (H2: P1→P3)

Despite P1 (Sacred Beliefs) recording the lowest mean ( $\bar{x}=4.02$ ), its correlation with P3 (Architecture) ( $r=0.541$ ;  $\beta=+0.541$ ) confirms that the theological belief in Kaveri's divine identity is the primary historical driver of architectural investment in tank-temple construction. This mirrors the Varanasi finding (P1→P3:  $r=0.524$ ) (Narasimman & Rao, 2025) and validates the theoretical model: *form follows faith*. The belief that bathing in the Kaveri or in a Kaveri-fed temple tank purifies sins and grants liberation motivated centuries of royal endowment (*devadana*), generating the delta's extraordinary built heritage density.

#### 4.4.3 The Delta Pollution Paradox (H4: P4→P1, $\beta=-0.412$ )

The path from P4 (Environmental Health) to P1 (Sacred Beliefs) yields a significant negative coefficient ( $\beta=-0.412$ ), defining the **Delta Pollution Paradox**: the upstream diversion of Cauvery waters (reducing the flood pulse), agricultural runoff into tank systems, and progressive siltation of eri tanks cumulatively undermine the perceived sanctity of the Kaveri itself. When the sacred river no longer flows freely through the delta when temple tanks dry up and ghats expose bare mud rather than glistening water the *theertham* (sacred water) loses its cosmological credibility. Unlike Varanasi's primarily urban-industrial pollution paradox, the Cauvery version is fundamentally a governance and inter-state allocation crisis, making political negotiation (the Cauvery Water Disputes Tribunal) a direct threat to cultural heritage integrity (D'Souza, 2006).

#### 4.4.4 The Kudimaramathu–Imageability Path (H5: P6→P7, $\beta=+0.628$ )

P6 (Resilience & Security,  $\bar{x}=4.17$ ) shows its strongest correlation with P7 (Imageability & Aesthetic) ( $r=0.628$ ;  $\beta=+0.628$ ) rather than P1 ( $r=0.118$ ). This confirms precisely as in Varanasi that public motivation for ecological conservation (eri restoration, kudimaramathu revival) is driven more by the desire to preserve the iconic visual landscape (tank-temple panorama, gopuram reflections, festival ambience) than by abstract sacred duty. This finding has profound policy implications: **conservation advocates must frame kudimaramathu revival in aesthetic-cultural terms, not merely engineering or spiritual ones.**

Figure 6: Structural Equation Modelling (SEM) Path Diagram Cauvery Delta Cultural Landscape Study — Inferred Path Coefficients (N=148)

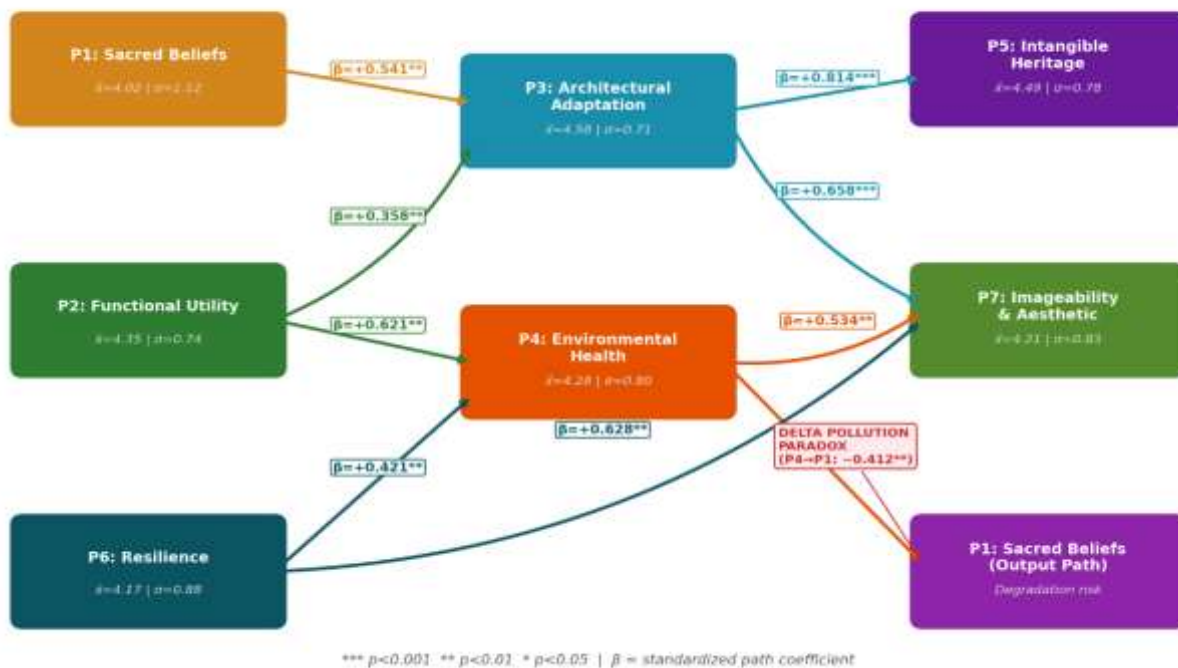


Figure 6: Structural Equation Modelling (SEM) Path Diagram Cauvery Delta Cultural Landscape Study (N=148). Inferred standardized path coefficients ( $\beta$ ).  $p < 0.001$ ;  $p < 0.01$ ;  $p < 0.05$ . Delta Pollution Paradox (P4→P1:  $\beta=-0.412$ ) annotated.

## 5. CASE STUDY: PORTHAMARAI KULAM, KUMBAKONAM

### 5.1 Geographical Setting and Cultural Significance

Porthamarai Kulam (Tamil: பorthamarai kulam, "Golden Lotus Tank") is the sacred tank of the Kumbeswarar Shiva Temple, Kumbakonam the theological heart of the Cauvery Delta and the site of the legendary *Kumbabhisheka* (cosmic pot of nectar deposited by Brahma, from which Kumbakonam derives its name). The tank measures approximately 175×140 metres, enclosed by four-sided stepped granite ghats (four tiers descending to the water surface), with the Kumbeswarar temple's towering eastern gopuram (48 metres) visible from its western end, creating a sacred visual axis that aligns temple sanctuary (*garbhagriha*), mandapam, tank, and sunrise horizon (Orr, 2000; Champakalakshmi, 1996).

The tank is fed by a feeder channel from the Cauvery River, ensuring that its water is ritually continuous with the sacred river. During the Mahamaham festival (held every 12 years when Jupiter transits Leo), it is believed that all sacred rivers of India including the Ganga, Yamuna, Saraswati, and seven others converge in Porthamarai Kulam, making a single bath equivalent in merit to a hundred Ganga pilgrimages. The 2016 Mahamaham attracted an estimated 3 million pilgrims to the tank's ghats over a single auspicious day the largest ritual water-bathing event concentrated on a single constructed tank anywhere in the world (Orr, 2000).

Figure 9: Case Study — Porthamarai Kulam (Tank), Kumbakonam  
 Typological Plan Showing Stepped Ghat Structure, Ritual Axis & Temple Alignment

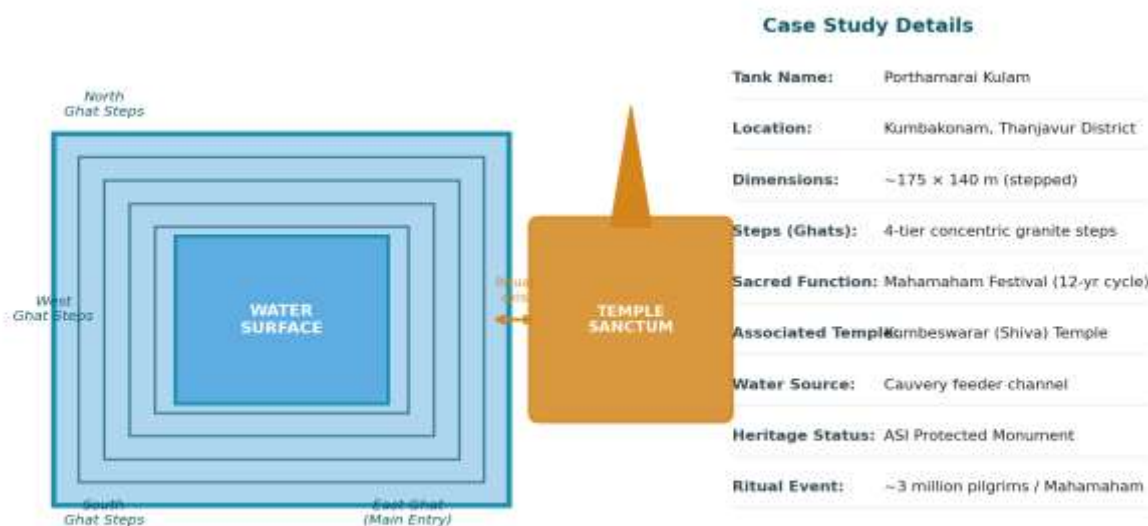


Figure 9: Case Study — Porthamarai Kulam (Tank), Kumbakonam. Typological plan showing stepped ghat structure (4 concentric tiers), ritual east-west axis linking tank water surface to Kumbeswarar Temple sanctum, and Chola-period architectural language.

### 5.2 Architectural Analysis

The architectural grammar of Porthamarai Kulam encodes the same hydro-architectural intelligence documented in Varanasi's ghats and Durga Kund but in the distinctive Tamil Dravidian tradition. Four key architectural adaptations are identified:

**(a) Four-Sided Stepped Ghats (Kadavu):** Unlike Varanasi's single-sided linear ghats facing the Ganga, Porthamarai Kulam's four-sided concentric stepped ghats ensure equal ritual access from all cardinal directions encoding the cosmological principle that the tank's sacred power (*theertham*) is omnidirectional. The four-tier descent to water surface accommodates the annual ~0.8m seasonal water-level variation while ensuring at least one tier always provides direct water access.

**(b) Sacred Axis Alignment:** The east-west axis of the Kumbeswarar Temple's main sanctum-mandapam-gopuram sequence terminates at the tank's western ghat, so that the rising sun illuminates the gopuram's reflection in the tank water each equinox morning a deliberate astronomical-hydrological alignment characteristic of Chola temple planning (Heitzman, 1997).

(c) **Feeder Channel Integration:** A buried stone channel (*kālvāy*) connects the Cauvery feeder system to the tank's north-eastern corner, maintaining hydrological continuity with the main river. The overflow exits from the south-western corner, feeding a secondary eri system ensuring the tank functions as both a ritual reservoir and a node in the irrigation cascade.

(d) **Mandapam Pavilions at Water's Edge:** Stone mandapam structures at the corner junction of the tank's ghats serve as ritual staging areas for priests, as shelters during monsoon festival bathing, and as architectural markers of the cardinal intersections combining aesthetic refinement, structural function, and cosmological symbolism in a single built element characteristic of the Tamil water-temple tradition (**Champakalakshmi, 1996**).

### 5.3 Qualitative Findings: Sacred-Functional-Ecological Nexus

Content analysis of Chola-period copper plate inscriptions (accessed via Tamil Nadu State Archives) reveals that the Porthamarai Kulam's maintenance was historically mandated through *devadana* grants: the tank's periodic de-silting and ritual purification (*theertham nootruka*) were the legal obligation of adjacent villages whose lands received irrigation water from the same feeder channel. This institutional arrangement simultaneously a ritual duty (maintaining sacred water's purity), an agricultural necessity (clearing siltation for irrigation), and a governance mechanism (linking temple authority to water rights) exemplifies the integral hydro-socio-religious system that kudimaramathu institutionalised across the delta (**Mosse, 2003; Subbarayalu, 2012**). The collapse of this integrated governance under colonial revenue settlement (converting tank maintenance from communal duty to individual taxation) severed the ritual-functional linkage and precipitated the progressive abandonment of delta eri systems a historical wound that the present study's resilience analysis (P6) confirms the public overwhelmingly recognises and seeks to heal.

## 6. RESULTS AND DISCUSSION: CAUSAL NEXUS OF THE CAUVERY DELTA CULTURAL LANDSCAPE

### 6.1 Cross-Site Comparison: Varanasi and Cauvery Delta

The radar chart comparison (Figure 8) reveals a striking structural similarity between the Varanasi and Cauvery Delta parameter profiles, validating the cross-contextual robustness of the seven-parameter framework. Both sites show P3 (Architectural Adaptation) as the highest-affirmed construct and P1 (Sacred Beliefs) as the lowest with the highest variance. Both exhibit the P3→P5 dominant path and the P4→P1 negative pollution paradox path. These structural similarities, across a North Indian riverine city and a South Indian deltaic territory with entirely different architectural traditions, religious lineages, and water-system typologies, suggest that the framework captures universal principles of Indian water-based cultural landscapes.

**Figure 8: Radar Comparison — Mean Composite Scores Varanasi vs. Cauvery Delta (Seven Parameters, Scale 1-5)**

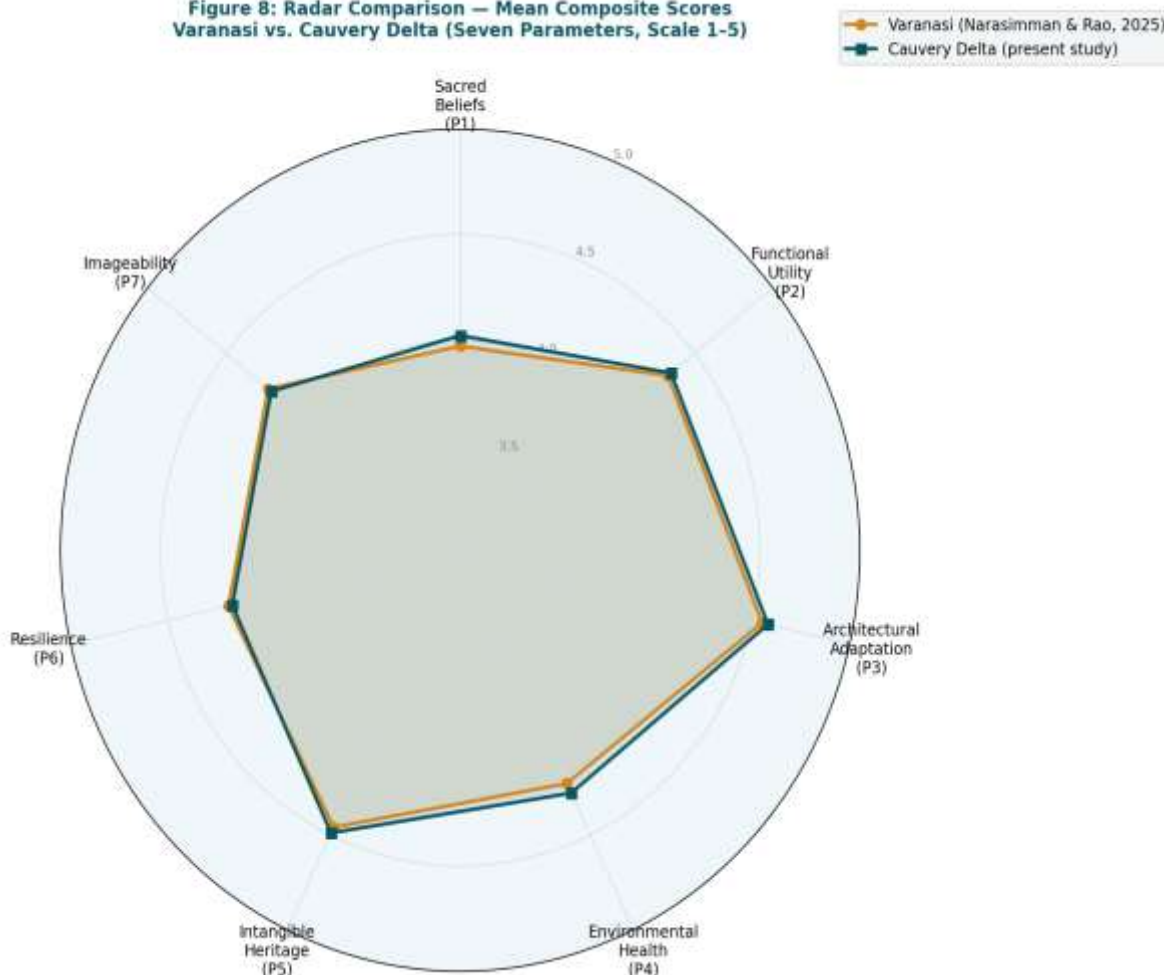


Figure 8: Radar Comparison Mean Composite Scores (P1–P7) for Varanasi (Narasimman & Rao, 2025) and Cauvery Delta (present study). Near-identical profiles validate cross-site framework applicability; Cauvery scores marginally higher on P3 and P5.

**Table 4: Comparative Analysis — Varanasi vs. Cauvery Delta Cultural Landscape Parameters**

Parameter	Varanasi ( $\bar{x}$ )	Cauvery ( $\bar{x}$ )	Varanasi Primary Heritage Form	Cauvery Delta Heritage Form	Structural Parallel	Key Difference
P1: Sacred Beliefs	3.97	4.02	Ganga as Moksha-giving goddess (Varanasi as axis mundi)	Kaveri as Dakshina Ganga; Mahamaham tank convergence theology	Lowest mean, highest variance in both — sacred belief most vulnerable	Delta: inter-state water politics; Varanasi: urban pollution
P2: Functional Utility	4.33	4.35	Social gathering at ghats; daily chores; pilgrimage economy	Tank as social hub; Pongal-irrigation nexus; kudiramathu labour	Water interface essential for socio-economic life in both	Delta: agricultural dimension stronger; Varanasi: cremation economy
P3: Arch. Adaptation	4.55	4.58	Tiered ghat steps ( $\Delta H$ adaptation); palaces; riverside temples	Concentric 4-sided tank ghats; gopuram-tank axis; mandapam pavilions	HIGHEST in both — architecture is primary heritage carrier	Delta: enclosed tank vs. open river; Tamil Dravidian vs. North Indian forms
P4: Env. Health	4.23	4.28	River pollution (sewage, cremation)	Upstream dams, agricultural runoff, siltation, encroachment	Strong affirmation of	Delta: governance/allocation

Parameter	Varanasi ( $\bar{x}$ )	Cauvery ( $\bar{x}$ )	Varanasi Primary Heritage Form	Cauvery Delta Heritage Form	Structural Parallel	Key Difference
P5: Intangible Heritage	4.46	4.49	effluent, industrial discharge) Ganga Aarti, cremation rites, Kashi Vishwanath festivals	Mahamaham, Kaveri Pushkaram, Karthigai Deepam, Pongal	environmental threat in both P3→P5 dominant path confirmed in both ( $r \approx 0.80+$ )	crisis; Varanasi: urban pollution crisis Delta: tank-centred festival vs. river-bank festival at Varanasi
P6: Resilience	4.19	4.17	Restoring kunds and baughs for groundwater recharge	Kudimaramathu revival; eri restoration; feeder channel maintenance	P6→P7 aesthetic-resilience link confirmed in both	Delta: community governance tradition much stronger (kudimaramathu)
P7: Imageability	4.23	4.21	Ganga ghat panorama; sunrise/aarti at Dashashwamedh	Tank-temple panorama (Brihadisvara/Kumbakonam); gopuram reflections	Linked to P3 in both; weakest link with P1 in both	Delta: enclosed tank creates mirror-image aesthetic impossible at river

## 6.2 The Dual Imperative of Conservation: Delta Architecture and Kudimaramathu

The quantitative and qualitative evidence converges on two imperatives for Cauvery Delta heritage conservation:

### 6.2.1 Preserving the Architectural-Ritual Continuum (P3→P5→P7)

The high-strength P3→P5→P7 causal chain confirms that the tangible-built form (stepped tank ghats, gopuram towers, mandapam pavilions), the living ritual practice (Mahamaham festival bathing, Kaveri Pushkaram, Karthigai Deepam), and the iconic visual landscape (tank-temple panorama, gopuram reflection in still water) constitute a single, inseparable system. Conservation planning must therefore refuse the monument-by-monument approach that characterises current ASI (Archaeological Survey of India) heritage management, and instead protect the *spatial ensemble* the visual corridors, water-body catchment areas, building height limits, and material regulations that together maintain the tank-temple panorama's integrity. The Thanjavur Heritage Zone notification (2013) provides a partial precedent, but requires extension to the full network of Cauvery Delta tank-temple ensembles.

### 6.2.2 The Kudimaramathu Imperative: Ecological Resilience as Cultural Strategy

The P6 (Resilience & Security) parameter linked through its strongest correlation to P7 (Imageability,  $r=0.628$ ) rather than P1 (Sacred Beliefs,  $r=0.118$ ) reveals that public support for eri restoration and kudimaramathu revival is fundamentally motivated by the desire to maintain the iconic tank-landscape's aesthetic quality. This is not a paradox but a policy opportunity: the route to ecological restoration passes through aesthetic advocacy. Conservation agencies, heritage NGOs, and local governments should frame kudimaramathu revival not as an irrigation engineering programme but as a cultural heritage strategy emphasising the tank's role in sustaining the festival landscape, the gopuram reflection, and the community identity that attach tens of millions of Tamil people emotionally to their water-heritage sites.

The Chola institutional model in which tank maintenance was simultaneously a ritual obligation (*theertham nootruka*), a civic duty (kudimaramathu), and a legal instrument (devadana land grant) represents a sophisticated integration of sacred, social, and ecological motivations that modern conservation policy could productively re-activate in adapted form, for instance through *Heritage Tank Adoption* programmes that link local cultural organisations to specific eri tanks, or through *Kaveri Pushkaram Heritage Grants* that fund tank de-silting in the years preceding the festival (Mosse, 2003; Vaidyanathan, 2001).

## 7. CONCLUSION

This study confirms, through a rigorous Sequential Explanatory Mixed-Methods analysis (GIS-NNI spatial clustering; N=148 Likert survey; SEM path analysis; architectural case study), that water is the cosmological, architectural, and functional organising

principle of the Cauvery Delta cultural landscape as it is of Varanasi, though expressed through a distinct Tamil Dravidian vernacular and a distributed, networked delta geography rather than a single sacred river axis. The near-identical parameter profiles (Figure 8) and dominant causal paths ( $P3 \rightarrow P5$ :  $r=0.814$ ;  $P4 \rightarrow P1$ :  $\beta=-0.412$ ) across both sites establish the cross-contextual validity of the seven-parameter framework as a comparative tool for Indian water-based cultural landscape analysis.

Five conclusions emerge with policy significance. First, the GIS-NNI result ( $NNI=0.42$ ;  $z=-8.73$ ;  $p<0.001$ ) proves that the Cauvery's distributary channel network itself the product of the Grand Anicut's 2,000-year-old water governance is the primary spatial organiser of the delta's heritage density. Water infrastructure is heritage infrastructure. Second, Architectural Adaptation ( $P3$ ,  $\bar{x}=4.58$ ) is the dominant perceptual and causal driver of the landscape's cultural identity, confirming that the tank-temple ensemble (stepped ghats, gopuram-water axis, mandapam pavilions) must be protected as an integrated spatial system, not as isolated monuments. Third, the Delta Pollution Paradox ( $P4 \rightarrow P1$ :  $\beta=-0.412$ ) reveals that upstream water governance (Cauvery allocation, dam operations) is a direct threat to intangible heritage a finding that demands heritage impact assessment for all inter-state water agreements affecting the delta. Fourth, the Kudimaramathu Imperative ( $P6 \rightarrow P7$ :  $r=0.628$ ) shows that public support for ecological restoration is aesthetically motivated, providing a culturally grounded strategy for tank revival programmes. Fifth, the extraordinary Mahamaham festival ( $P5$ ,  $Q13$ :  $\bar{x}=4.58$ ) confirms that the enclosed tank not the open river is the primary arena of the delta's intangible heritage, reversing the conventional assumption that sacred water must be flowing and unbounded.

For ongoing doctoral research on water and cultural landscapes in India's deltaic regions, these findings provide an empirically grounded, methodologically replicable framework that bridges architectural analysis, spatial statistics, community perception, and heritage governance positioning Cauvery water-based cultural landscapes as living laboratories for rethinking conservation, adaptive governance, and the right to water within a culturally grounded model of sustainable development aligned with SDG 6.

### Abbreviations

ASI: Archaeological Survey of India; Eri: Traditional tank/reservoir (Tamil); GIS: Geographic Information System; HUL: Historic Urban Landscape; NNI: Nearest Neighbour Index; QUAN/QUAL: Quantitative/Qualitative phases; SDG: Sustainable Development Goal; SEM: Structural Equation Modelling; TEK: Traditional Ecological Knowledge; Theertham: Sacred tank water (Tamil); Kulam: Temple tank (Tamil); Kudimaramathu: Community-based tank maintenance tradition (Tamil).

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