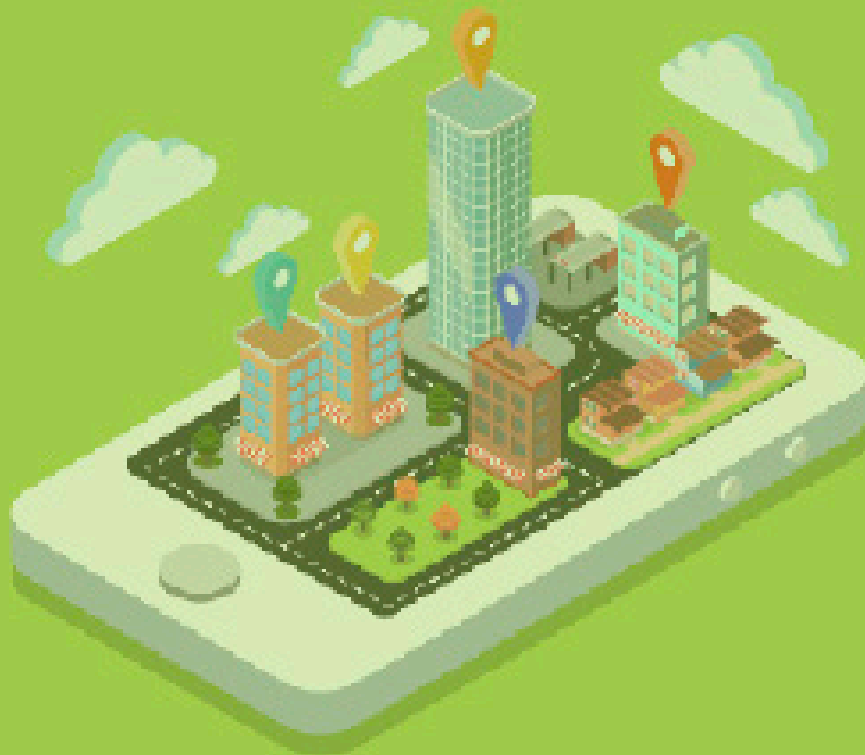




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## From Vision to Institution: Institutionalizing Integrated Humanization (IH) in Gulf Urban Planning Frameworks

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### ABSTRACT

Integrated Humanization (IH) has matured into a Gulf-centric paradigm built on five interdependent pillars: urban planning, humanization, public transport, road engineering, and micromobility. Building on four earlier studies that conceptualized, ecologized, engineered, and evaluated/governed IH, this article addresses the remaining barrier: institutionalization. For the first time, official planning and technical outputs - including the Greater Muscat Structure Plan (GMSP), Action Area Plans (AAPs), and the Oman National Transport Model (ONTM) - are synthesized as primary evidence. Findings indicate that, in the absence of integration, BAU 2040 trends toward slower private speeds and higher congestion; under the structured GMSP scenario with transit and travel-demand management, public transport reaches ~26% and average private speeds ~60 km/h, whereas the BAU 2040 case trends to ~25 km/h average speeds, indicating high congestion. These values are derived from ONTM-based scenario results reported in the Greater Muscat Structure Plan (Vol. 3, 2023). Building on GMSP and ONTM, this paper operationalizes their strengths by coupling key outputs to delivery KPIs through a light-weight institutional mechanism. We decode delivery-layer taxonomies - Street Composition, Lane Width, and the Public Realm - commonly used in 2024 detailed design reports, and re-specify them under IH via the Institutional Maturity Index (IH-IMI) and the Access-Shed Thermal Index (ASTI). An operational mini-spec for ASTI and a compliance-procurement mapping are introduced to translate these indicators into contracts, dashboards, and acceptance gates. As a regional benchmark, Abu Dhabi's Public Realm Design Manual (2017; 2020) and the Sahel Accessibility Rating System codify sidewalks, shading, and public-space performance as design criteria and compliance checks, demonstrating regulation-grade practice, though not yet systematically linked to transport models and road codes. By situating IH within an institutional framework - revised design codes, an Urban Neighborhood Code, and integrated modeling - the article argues that institutionalizing IH is the critical next step for Gulf cities, converting plans, models, and manuals into enforceable, dashboard-tracked obligations and helping realize the modeled benefits of GMSP in climate-responsive, human-centered access.

### INTRODUCTION

GMSP establishes the metropolitan backbone and evidence base for Oman's urban mobility transformation. Building on that foundation, Integrated Humanization (IH) focuses on the "last-mile" institutional wiring - codes, KPIs, and dashboards - so the modeled benefits of GMSP and ONTM are realized in delivery. Gulf cities more broadly are undergoing rapid demographic, economic, and spatial change, and national strategies such as Oman Vision 2040 place livability, sustainable mobility, and climate adaptation at the center of policy. Yet, despite major investments in corridors, housing, and infrastructure, everyday mobility remains shaped by congestion, car dependence, and heat stress. Turning vision into lived accessibility requires a mechanism that links plans, models, and manuals to delivery. While this metropolitan framework sets a robust strategic direction, the translation of its modeled outcomes into day-to-day implementation remains a key institutional challenge.

### The Practical Gap

The gap is institutional rather than technical. Cities possess

advanced plans (e.g., metropolitan frameworks), models (e.g., multi-modal transport models), and engineering manuals; what is often missing is the coupling that binds these instruments to field-audited obligations. In practice, the delivery vocabulary - Street Composition, Lane Width, and the Public Realm - is still governed by legacy, throughput-oriented templates, with shade continuity and protected micromobility specified less explicitly. For 2040, business-as-usual (BAU) trends point toward slower private speeds and higher congestion; structured scenarios with transit and travel-demand management improve mode share and speeds, but only if their criteria are embedded in approvals and contracts.

### Objective

This article advances Integrated Humanization (IH) from vision to institution. Specifically, it translates the delivery-layer terms (Street Composition, Lane Width, Public Realm) into measurable, enforceable obligations using two tools:

- IH-IMI (Institutional Humanization – Institutional

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Maturity Index): assesses readiness across mandate, data/models, budgeting/programming, and codes/enforcement.

- ASTI (Access-Shed Thermal Index): quantifies thermally effective walking/micromobility access and feeds it into decision dashboards.

### Conceptual Framework

Integrated Humanization (IH): IH is a Gulf-centric framework spanning five interdependent pillars: urban planning, humanization, public transport, road engineering, and micromobility. Earlier studies developed IH conceptually, demonstrated ecological and engineering applications (including reinterpretation of highway standards), and proposed evaluation/governance logics. Building on that arc, this paper reframes the delivery vocabulary as IH KPIs with explicit code/contract hooks.

### Evidence Base and Approach

The analysis mobilizes four official instruments as primary evidence: the Greater Muscat Structure Plan (GMSP, 2023), Action Area Plans (AAPs, 2023), the Oman National Transport Model (ONTM, 2020), and detailed engineering outputs (2024–2025). In brief:

- BAU trends to 2040 indicate slower private speeds and increased congestion.
- Structured GMSP scenarios with transit and TDM improve mode share and speeds.
- Detailed design practice codifies speed, lane-width, and junction efficiency more explicitly than shade, protected continuity, or thermal comfort. To convert these insights into delivery, the paper specifies KPIs, their enforcement instruments (codes/contracts), and where they live in project documents and dashboards.

### Regional Benchmark and Positioning

Abu Dhabi's Public Realm Design Manual (2017; 2020) and the Sahel Accessibility Rating System demonstrate that sidewalks, shading, and public-space performance can be codified with compliance checks. However, such standards are not yet systematically linked to transport models, action-area planning, or highway codes. IH provides that cross-pillar link by: (i) proposing a HDS-IH addendum for context-based lane widths and thermal packages, (ii) adopting an Urban Neighborhood Code for shaded access-sheds and protected continuity, and (iii) wiring IH-IMI/ASTI into ONTM dashboards so human-thermal accessibility is tracked alongside congestion.

### Contribution

The paper delivers a KPI-and-Code roadmap: it defines core IH KPIs, maps each to an enforcement lever and document location, and specifies dashboard injection points. The result is an institutional coupling that binds plans, models, and manuals to field-audited outcomes - turning climate-responsive, human-centered mobility from aspiration into deliverable practice.

## LITERATURE REVIEW

### Integrated Humanization in Previous Research

The evolution of Integrated Humanization (IH) across four published studies reflects its multidimensional character. Each article reinforced IH as a Gulf-centric framework built on five pillars - urban planning, humanization, public transport, road engineering, and micromobility:

- Article 1 introduced IH as a paradigm synthesizing the five pillars into a Gulf-specific grammar for urbanism.
- Article 2 operationalized IH through Blue-Green Corridors, showing how ecological infrastructure could serve as a physical spine where the pillars converge.
- Article 3 reinterpreted Oman's Highway Design Standards 2017, embedding shaded pedestrian routes, micromobility corridors, and public transport integration into road engineering.
- Article 4 advanced IH into governance, proposing evaluation metrics and institutional accountability mechanisms that cut across the five pillars.

Together, these contributions established IH as more than a design philosophy: they positioned it as a comprehensive paradigm that aligns urban form, transport systems, engineering practice, and human-centered design under Gulf climatic and cultural conditions.

### Insights from Official Planning Documents

In parallel, Oman has produced major planning and technical documents that expose persistent structural gaps.

- Greater Muscat Structure Plan (GMSP, 2023): the largest metropolitan framework, which forecasted that even with full Bus Rapid Transit (BRT) and Light Rail Transit (LRT) rollout under Vision 2040, congestion in 2040 would remain close to 2022 baselines. This highlights the limits of infrastructure-heavy approaches absent institutional integration.
- Action Area Plans (AAPs, 2023): introduced local-scale interventions (redevelopment, regeneration, transit-led development, economic corridors) using tools such as TOD and the Blue Spine. Yet without cross-sectoral ownership, they may remain policy scaffolds without a defined implementing anchor rather than implemented realities.
- Oman National Transport Model (ONTM, 2020): a sophisticated PTV Visum-based model integrating passenger and freight forecasts. While technically advanced, its outputs have been underutilized where implementing anchors are not yet defined translates model results into integrated policies.

- Detailed Design Reports (2024–2025): apply HDS 2017 in practice, prioritizing lane width, speed, and vehicle flow while addressing shade, micromobility, and thermal comfort less explicitly within standard approval checklists.

These documents reveal a paradox: Oman has visions (Vision 2040), models (ONTM), and manuals (HDS 2017), but the absence of institutional integration

prevents these tools from delivering livable outcomes.

### Identified Research Gap

Synthesizing IH research and Oman's planning documents reveals a consistent gap:

- Academic contributions defined IH conceptually, ecologically, technically, and in governance terms.
- Official documents demonstrate technical rigor but remain car-centric and fragmented.

The missing element is institutional embedding - a mechanism that unites design codes, models, and plans across the five pillars.

### Delivery-Layer Taxonomy in Omani Detailed Designs (2024–2025)

In detailed engineering designs, three delivery-layer terms structure how the right-of-way (ROW) is organized:

- Street Composition – the allocation of carriageways, medians, sidewalks, parking, street furniture, transit stops, and utilities.
- Lane Width – the governing dimension that fixes speed, capacity, and safety outcomes.
- Public Realm – not “landscaping,” but a thermal-social infrastructure package: continuous shade, arcades/canopies, trees, high-albedo pavements, inclusive access, rest points, and safe crossings.

These terms have become the operative vocabulary of delivery. Under current practice, they are ordered to favor vehicular efficiency. Under IH, they are re-specified as performance obligations - measurable KPIs linked to IH-IMI (institutional maturity) and ASTI (thermal accessibility).

### Public Realm in Abu Dhabi: A Benchmark for Codification

As a regional precedent, Abu Dhabi's Public Realm Design Manual (2017; updated 2020) and the Sahel Accessibility Rating System illustrate how humanization elements can be codified as design criteria and compliance checks. The manual specifies high shading ratios (e.g., 70–80%) for primary pedestrian corridors, minimum sidewalk widths of  $\geq 2.4$  m, rest points at  $\leq 500$  m on primary corridors and  $\leq 1000$  m on secondary corridors (per PRDM); IH proposes an enhanced option of  $\leq 200$ – $250$  m on Class-A thermal access paths where ASTI indicates depressed effective reach. These measures help elevate the public realm from ornament to infrastructure with performance standards.

Yet, even this advanced benchmark remains siloed: it governs streetscape design but is not systematically linked to transport modeling (ONTM-type tools), Action Area Plans, or road-engineering manuals. IH therefore extends the Abu Dhabi precedent into a cross-pillar institutional framework, ensuring that public-realm standards are tied into modeling, codes, budgets, and neighborhood-scale planning.

### Box 1. Glossary of Delivery Terms under IH

- Street Composition (IH-spec): ROW allocation

by a human-first hierarchy: Shade → Walking → Micromobility → Transit → Private cars; crossings and junction safety are non-negotiable.

- Lane Width (IH-spec): Context bands tied to speed regimes and reallocation: 3.0–3.25 m (neighborhood), 3.25–3.5 m (collector),  $\geq 3.5$  m (special/emergency/bus lanes).
- Public Realm (IH-spec): Thermal-performance package: continuous shade 60–80% on access paths, cool pavements, sidewalks  $\geq 2.4$  m, rest points:  $\leq 500$  m (primary) /  $\leq 1000$  m (secondary); IH-enhanced  $\leq 200$ – $250$  m on Class-A thermal access.

## MATERIALS AND METHODS

### Research Design

This study adopts a qualitative, document-based research design aimed at bridging the gap between conceptual frameworks and institutional practice in Gulf urbanism. Unlike quantitative transport modeling or empirical surveys, the methodology emphasizes interpretive synthesis - analyzing how multiple sources of evidence converge around the five pillars of Integrated Humanization (IH). This approach enables a critical assessment of both academic discourse and official planning outputs, positioning IH within the lived realities of Gulf cities.

### Materials & Sources

Two categories of materials are analyzed:

(A) Scholarly contributions on Integrated Humanization, namely the four previously published articles, which established IH conceptually, ecologically, technically, and in governance terms.

(B) Official planning and technical documents, including the Greater Muscat Structure Plan (2023), Action Area Plans (2023), Oman National Transport Model (2020), and detailed design practices (2024–2025). Together, these materials span national visions, metropolitan frameworks, advanced modeling tools, and delivery-level design manuals.

### Methodology

The analysis proceeded in three stages:

- Stage 1: Content Analysis of Academic Literature.

Each of the four IH articles was coded according to the five pillars, with particular focus on their relevance for institutionalization (e.g., governance models, ecological strategies, engineering adaptations).

- Stage 2: Document Analysis of Official Plans and Manuals.

Planning documents were systematically reviewed using qualitative content analysis (QCA). Specific attention was given to the delivery-layer categories common in detailed design: Street Composition, Lane Width, and Public Realm. These were translated into IH-KPIs such as shade percentage, protected micromobility continuity, and context-based lane-width bands. In parallel, higher-level outputs (e.g., ONTM forecasts, AAP typologies) were

coded against IH pillars. This allowed cross-comparison between delivery-level practices and strategic planning visions. In addition to Omani planning documents, the review incorporated Abu Dhabi's Public Realm Design Manual (2017; updated 2020) and the Sahel Accessibility Rating System as a regional benchmark. This allowed the analysis to contrast Oman's varying degrees of institutional uptake across agencies and program stages with a Gulf precedent where humanization standards have been codified into enforceable design obligations.) see Box 1 for IH-spec definitions(

- Stage 3: Comparative Synthesis.

Findings from Stages 1 and 2 were synthesized into a cross-pillar alignment matrix (Table 3, Results & Discussion) and two implementation tables (Tables 1–2, Materials & Methods). This suggests that, while IH is conceptually multiscalar, delivery is still governed by legacy, throughput-oriented geometry unless reframed through IH-IMI and ASTI.

The study benefited from prior professional involvement in the Greater Muscat Structure Plan, providing firsthand familiarity with the instruments reviewed. To maintain analytic neutrality, interpretations were triangulated with official documents, and the emphasis is on methodological translation rather than institutional evaluation.

### The IH Institutional Maturity Index (IH-IMI): Definition, Tiers, and Upgrade Logic

This paper operationalizes institutional integration through the IH-IMI, a five-tier index that scores agencies and programs across four dimensions: (1) Mandate & Authority, (2) Data & Models, (3) Budgeting & Programming, and (4) Codes & Enforcement. The tiers - Initial, Defined, Integrated, Accountable, Optimized - represent a progression from ad-hoc efforts to a closed-loop, evidence-driven delivery system.

- Initial: Projects reference livability, but responsibilities are fragmented; models are consulted episodically; budgets and codes follow vehicle-throughput logics.

- Defined: Roles are documented (e.g., TOD briefs), but ONTM outputs and neighborhood standards are not binding; the public realm remains an "amenity."

- Integrated: A cross-pillar authority can reallocate ROW; ONTM scenarios inform scheme selection; contracts include thermal and micromobility KPIs.

- Accountable: Annual plans carry IH KPIs (e.g., shade coverage, protected-lane continuity) with public dashboards; approvals can be withheld for non-compliance.

- Optimized: Continuous improvement closes the loop: ONTM dashboards track human-centric KPIs, audits inform next-year budgets, and codes evolve accordingly.

An upgrade pathway accompanies the index: (a) issue an HDS-IH Addendum to codify lane-width bands and thermal packages; (b) adopt an Urban Neighborhood Code mandating shaded access-sheds and protected micromobility continuity; (c) embed ONTM-linked KPIs in approvals, contracts, and O&M manuals; and (d) publish annual IH scorecards. In practice, IH-IMI

dimensions can be tied to design/construction/handover gate reviews so annual programming aligns with KPI performance.

### The Access-Shed Thermal Index (ASTI): Concept, Inputs, and Decision Use

ASTI translates climate into access geometry. It merges geometric catchments (e.g., 800–1,200 m from stations) with thermal exposure and comfort infrastructure to estimate the effective access-shed under hot-arid conditions. Three input families drive the index:

1. Exposure: hourly/global radiation proxies, mean radiant temperature ( $T_{mrt}$ ), and PET/UTCI bands from microclimate audits or city weather datasets.

2. Mitigation: continuous shade ratio along walk/micromobility paths (canopies, arcades, tree crowns), cool-material specifications, misting/water points, and rest intervals.

3. Continuity & Safety: protected micromobility links, gradient thresholds, conflict-free crossings, and gender-sensitive wayfinding and lighting.

ASTI outputs a coverage factor (0–1) that rescales geometric buffers; for example, a nominal 1.0 km radius may yield an effective 0.55–0.70 km without shade, or  $\geq 0.90$  with  $\geq 70$ –80% shade and protected lanes. Planners use ASTI to (i) size the required thermal package per station, (ii) prioritize corridor retrofits where access collapses seasonally, and (iii) feed ONTM dashboards so thermal accessibility is tracked alongside congestion and speeds.

Alignment with GMSP access KPIs. The GMSP Implementation Plan includes an indicator, "Population within walking distance of levels 1, 2, and 3 stops," noting that it can be computed in GIS and may require further accessibility analysis. ASTI provides that analysis by replacing geometric buffers with thermally adjusted access-sheds; operationally:  $ASTI\text{-effective coverage} = \text{geometric coverage} \times ASTI\text{ factor}$ . This turns "within walking distance" into a climate-valid accessibility KPI that can be reported to dashboards and gate reviews, leveraging ONTM's Dashboard & Analysis Toolkit (fields stored as user-defined attributes and imported into the main model).

### IH-IMI vs ASTI: Two Sides of Integrated Humanization

- IH-IMI (Institutional Humanization – Institutional Maturity Index): A governance tool that measures how ready institutions are to embed Integrated Humanization across codes, budgets, models, and enforcement. It defines a pathway from Initial to Optimized maturity.

- ASTI (Access-Shed Thermal Index): A climatic-engineering tool that measures how far people can actually walk or cycle in hot-arid conditions. It factors in shade, cool materials, and safety to redefine real access-sheds around stations and neighborhoods.

### ASTI Inputs Mini-Spec

This mini-spec enables quick, defensible ASTI deployment without exhaustive micro-simulation. It standardizes

inputs, computation, and outputs for integration into GMSP/ONTM dashboards.

**A1. Purpose**

To convert geometric “walking distance” into a thermally valid access-shed for walking/micromobility in hot-arid conditions.

**A2. Input Families & Acceptable Proxies**

1. Exposure (Thermal Load)
  - Primary proxy: hourly/seasonal global solar radiation or Tmrt (mean radiant temperature) bands; seasonal PET/UTCI if available.
  - Temporal window: peak seasonal months; daytime operating hours for transit/schools.
2. Mitigation (Comfort Infrastructure)
  - Continuous shade ratio along candidate paths (canopies, arcades, tree crowns, colonnades).
  - Surface coolness: high-albedo/cool materials (specify reflectance class in specs).
  - Rest points: spacing per class ( $\leq 500$  m primary /  $\leq 1000$  m secondary; IH-enhanced  $\leq 200-250$  m on Class-A thermal access).
3. Continuity & Safety (Usability)
  - Protected micromobility continuity (segregation/barriers, conflict-free junctions).
  - Gradient thresholds and safe crossings (signalized or grade-separated where necessary).
  - Lighting/wayfinding with gender-sensitive design cues.

**A3. Computation (Pragmatic Rule-Set)**

- Start with a geometric buffer (e.g., 1.0–1.2 km for stations; 400–800 m for schools).
- Compute an ASTI Factor (0–1) using a simple scoring:
  - Exposure band (seasonal peak):  $E \in \{0.3, 0.5, 0.7, 0.9\}$  (higher is cooler).
  - Mitigation continuity (shade + cool materials + rest points):  $M \in \{0.4, 0.6, 0.8, 1.0\}$ .
  - Protected continuity & safety:  $C \in \{0.5, 0.7, 0.85, 1.0\}$ .
  - $ASTI\ Factor = \min(1.0, 0.35 \cdot E + 0.35 \cdot M + 0.30 \cdot C)$ .
  - Derive ASTI-Effective Coverage:
    - People/jobs within ASTI-adjusted shed = (geometric coverage)  $\times$  ASTI Factor.

The scoring weights were calibrated heuristically for Gulf hot-arid contexts and can be refined through field audits and

thermal-camera validation. Weights calibrated heuristically from Gulf walkability and thermal-comfort literature (Johansson & Emmanuel, 2012; Rahman *et al.*, 2023).

**A4. Classification (Access Classes)**

- Class A (Priority): ASTI Factor  $\geq 0.85$  - target  $\geq 70-80\%$  shade; protected continuity  $\geq 80\%$ ; rest points  $\leq 250$  m.
- Class B (Target): ASTI Factor  $0.70-0.85$  - shade  $\geq 60-70\%$ ; continuity  $\geq 70-80\%$ .
- Class C (Deficit): ASTI Factor  $< 0.70$  - schedule retrofit (shade trees/canopies, barriered links, crossings).

**A5. Output & Dashboard Wiring**

- Maps: choropleth of ASTI-effective sheds vs geometric buffers; line heatmaps for shade continuity.
- KPIs: ASTI-Effective Coverage (% residents/jobs); SRS (% stations passing).
- Cadence: update semi-annually (seasonal window) and at each design gate for priority projects.
- Data fields: store ASTI Factor and component scores (E/M/C) as user-defined attributes for import into the ONTM/GMSP KPI registry.

**A6. Quick-Start Checklist**

- Build a shade continuity layer (trees/canopies/arcades, coverage by segment).
- Digitize protected links and crossing treatments; assign continuity scores.
- Run the rule-set to get ASTI Factors; publish Class A/B/C maps and gap list.
- Tie Class A corridors/stations to the next-year program and BoQ allowances.

**KPI Definitions and Enforcement Mapping**

To translate institutionalization into auditable delivery, Table 1 defines the IH KPIs - their formulas, enforcement instruments (code/contract levers), document placement (drawings/specs/BoQ/permits), and verification cadence - while Table 2 maps their integration into the ONTM dashboard. Together, these specifications upgrade shade, continuity, and lane-width bands from guidance to pay-linked acceptance criteria subject to approval, withholding, or corrective action.

**Table 1:** Core IH KPIs  $\leftrightarrow$  Enforcement Instrument  $\leftrightarrow$  Document Placement and Verification

Pillar	KPI (definition / formula)	Baseline & Target	Enforcement Instrument	Document Placement (drawings/specs/BoQ/permits)	Verification & Frequency
Humanization	Summer Shade Coverage on Access Paths [Shade_Coverage% = (Length of ASTI-validated shaded segments) $\div$ (Total required access-path length) $\times$ 100]	Baseline: pre-works site audit. Target: $\geq 70\%$ on primary station/school approaches; $\geq 60\%$ on local network.	Urban Neighborhood Code + HDS-IH Addendum	Project specs; AAP/TOD briefs; canopy/arcade/tree details; BoQ line items with performance allowances.	Peak-season field audit before handover; quarterly during operations.

Micromobility	Protected Continuity within 1.2 km of stations/schools [Continuity% = (Protected, continuous length) ÷ (Total required length) × 100]	Baseline: network inventory. Target: ≥80% protected continuity.	BoQ-tied items + drawing approval requirements + O&M SOPs	Typical cross-sections; barrier/signage sheets; schedule of items for protected lanes.	Monthly during works; acceptance-ride at handover; quarterly in service.
Road Engineering	Context Lane-Width Compliance [%Compliance = (Length complying with bands 3.0–3.25 / 3.25–3.50 / ≥3.50 m by context) ÷ (Total length) × 100]	Baseline: design review. Target: 100% with justified, approved exceptions.	HDS-IH Addendum (mandatory) + safety audit	Horizontal/vertical geometry and sections; acceptance criteria; design review checklists.	Desk check at design; as-built measurement at handover; annual deviation review.
Public Transport	Station Readiness Score (SRS) = 4 component checks (binary) : shade ≥ target; protected continuity ≥ target; safe crossings; rest points: ≤500 m (primary) / ≤1000 m (secondary); IH-enhanced ≤200–250 m on Class-A thermal access.	Baseline: 0–1 pre-intervention. Target: 100% for priority stations.	TOD/ORAT requirements + operator SLA	ORAT acceptance checklist; operating specs; performance clauses.	Pre-opening inspection; quarterly in operations.
Urban Planning	ASTI-Effective Coverage of residents/jobs within service area [ASTI_Coverage% = (Population/area within thermally adjusted access shed) ÷ (Population/area within geometric buffer) × 100]	Baseline: existing conditions. Target: ≥70% within priority AAP/ TOD areas.	Urban Neighborhood Code + permitting link	Permit/approval conditions; AAP requirements; compliance maps; GMSP KPI register cross-reference.	Annual update or upon each detailed-plan revision; report alongside the “walking distance” KPI.

**Implementation Note**

tie each KPI to a payment milestone and an acceptance criterion so that non-conformance triggers either withheld payment or corrective works prior to handover. To prevent KPIs from stalling on paper, Table 2 maps

injection points in the ONTM dashboard - tab, field/layer, data type/source, computation, update cadence, and visualization - so IH-IMI and ASTI become first-class decision signals across scenarios, network performance, project gating, and global outputs.

**Table 2:** Wiring IH-IMI & ASTI into the ONTM dashboard

ONTM Tab / Module	New Field / Layer	Data Type	Data Source	Short Computation	Update Cadence	Visualization
KPIs (Global)	IH-IMI Score (by agency/ program)	Scalar (0–5)	Annual institutional audit (Mandate / Data / Budget / Codes)	Weighted average of the four dimensions	Yearly	Gauge/dial with threshold colors
Governorate / Zone KPIs	Shade Coverage Layer	Linear layer with attributes	Field audit + GIS/shadow imagery	Shade% = shaded ÷ total length	Quarterly	Line heatmap by % coverage

Active Modes	Protected Continuity Index	Edge attribute on active-mode network	As-built + safety inventory	Continuity% = continuous protected ÷ required	Monthly during works; quarterly ops	Network styling by continuity
Public Transport	Station Readiness Score (SRS)	Point attribute (stations)	ORAT + handover audit	4 binary tests → % score	Pre-opening; quarterly	Station icons with pass/fail badges
Scenarios	ASTI Coverage (Scenario-Adjusted)	Scalar + polygon layer	Simplified microclimate inputs + shade measures	Share of pop/jobs in ASTI shed	Per scenario run	Choropleth of ASTI-covered areas
Network Performance	Lane-Width Compliance Tracker	Edge attribute	Design review + as-built survey	% links meeting context bands	At design; at handover	Network layer with non-compliance flags
Projects	Gate Compliance (Design / Construction / Handover)	Boolean per gate	Supervision and PM reports	Pass/fail vs. KPI thresholds	Monthly	Project gate status board
Global Outputs	ASTI-Weighted Accessibility (residents/jobs within thermal shed)	Scalar + map	ASTI output + census/land-use	Accessibility adjusted by ASTI factor	Semi-annual	Bar charts + access maps

**Practical Note**

start with three “low-friction” adds - SRS, Lane-Width Compliance, and Shade Coverage - then enable ASTI-Weighted Accessibility once the shade layer stabilizes, shifting emphasis from vehicle speed to human reach. To strengthen the institutional traceability of the IH indicators, Table 3 presents a crosswalk linking each KPI to its enforcement instrument and its corresponding placement within project documents. The mapping is derived from publicly available outputs of the Greater Muscat Structure Plan (GMSP Volumes 2 and 3) and

the Action Area Plans (Stage 4A, 2023), as published by the Ministry of Housing and Urban Planning (MOHUP), together with the Oman National Transport Model (ONTM v4) by the Ministry of Transport, Communications and Information Technology (MTCIT). All delivery-level interpretations - such as lane-width bands, shading targets, and continuity indices - are introduced in this article as policy proposals under the IH framework, not extracted from any unpublished documents.

**Table 3:** Evidence Crosswalk – KPI ↔ Enforcement Lever ↔ Document Slot ↔ Verification

KPI	Enforcement Lever	Project Document Slot	Verification Step
Shade Coverage (≥ 70% primary / ≥ 60% local)	Urban Neighborhood Code + HDS-IH Addendum (proposed within this article)	Technical specifications; canopy/arcade/tree details; BoQ line items; AAP / TOD briefs	Field audit before handover; seasonal inspection during operations
Protected Continuity ≥ 80% within 1.2 km of stations / schools	BoQ clauses + drawing approval requirements + O&M SOPs	Typical cross-sections; barrier / signage schedules; active-mode network maps	Monthly during works; acceptance ride at handover; quarterly in operation
Context Lane-Width Compliance [% of segments meeting context bands 3.0–3.25 / 3.25–3.50 / ≥ 3.50 m]	HDS-IH Addendum (mandatory once adopted) + Safety Audit	Horizontal / vertical geometry sheets; design review checklists; as-built surveys	Design-stage desk check; handover measurement; annual deviation review

ASTI-Effective Coverage of population / jobs within service area	Planning permit condition + inclusion in AAP KPI register + integration into ONTM dashboard	GIS layer with shade / continuity attributes; dashboard data fields	Semi-annual update aligned with “within walking distance” KPI in GMSP Vol. 2
Station Readiness Score (SRS) (shade / continuity / safe crossings / rest points)	TOD / ORAT requirements + operator SLA	ORAT acceptance checklists; handover forms; O&M manual clauses	Pre-opening inspection; quarterly operational review

**Compliance & Procurement Hooks (From KPIs to Contracts and Acceptance)**

This subsection clarifies where each IH KPI lives in everyday delivery - so that compliance shifts from guideline to pay-linked obligation.

**Drawings & Design Review (Gate: Design):**

- Include a Lane-Width Compliance checklist on the geometry sheets and in the formal design review form.
- Stamp ASTI-effective access maps on station-area drawings (1.0–1.2 km buffers + shaded continuity overlay).
- Mark shade packages (canopies/arcades/trees, albedo specs) on cross-sections and typical details.

**Technical Specifications (Gate: Tender/Contract):**

- Specify minimum shading ratios (e.g., ≥70% primary approaches; ≥60% local) and rest-point intervals (≤500 m primary / ≤1000 m secondary; IH-enhanced ≤200–250 m on Class-A thermal access).
- Define protected-continuity standards (barrier types, conflict-free crossings, gradients) within active-mode sections.
- Include material performance for cool pavements and canopy durability (reflectance/maintenance).

**Bill of Quantities (Gate: Pricing & Measurement):**

- Create explicit BoQ line items for shade structures, tree packages, cool-material upgrades, protected-lane barriers, and access-wayfinding.
- Add Performance Allowances tied to the KPIs (e.g., a measured allowance per percentage point of Shade Coverage achieved above baseline up to the target).

**Permits & AAP/TOD Briefs (Gate: Approvals):**

- Make ASTI-effective coverage and Station Readiness Score (SRS) permit conditions for priority areas.
- Embed KPI thresholds in AAP/TOD briefs (station influence areas, school corridors, regeneration sites).

**ORAT & O&M (Gate: Pre-Opening / Operations):**

- Use the SRS checklist (shade / continuity / safe crossings / rest points) as an ORAT acceptance test before opening.
- Transfer KPIs into operator SLAs (seasonal inspections for shade coverage; continuity audits; corrective timelines).

**Payment & Acceptance (Gate: Handover):**

- ink payment milestones to pass/fail thresholds for

Lane-Width Compliance, Shade Coverage, and Protected Continuity.

- Withhold final acceptance or trigger corrective works if audited values fall below targets.

To reinforce compliance, performance allowances can be embedded in the BoQ or payment schedule, linking KPI achievement to partial payments. Structurally, they assign small allowances for meeting shading, continuity, and lane-width targets verified through standard design reviews and field audits. Measurement focuses on observable outcomes - such as verified shade coverage or protected continuity - rather than financial metrics, ensuring that delivery quality becomes a tangible pay-linked obligation without introducing prescriptive formulas.

**Limitations**

Three limitations are acknowledged: (i) reliance on secondary documents rather than field data; (ii) uncertainty in forecast-based models such as ONTM; and (iii) contextual variations across Gulf cities. To strengthen validity, findings were triangulated across multiple document types - strategic plans, transport models, engineering manuals, and codified public realm standards - mitigating the inherent limitations of relying solely on secondary sources.

**Research Contribution**

By combining academic and policy perspectives, this methodology introduces a novel analytical lens. It demonstrates how the five IH pillars can be traced across scales - from neighborhood shading standards to metropolitan transport models. Finally, it provides a delivery-layer translation: converting Street Composition, Lane Width, and the Public Realm from drawing notes into enforceable IH KPIs and institutional mandates.

**RESULTS & DISCUSSION**

**Persistent Congestion despite Vision 2040 Investments**

Building on the Greater Muscat Structure Plan (GMSP) and the Oman National Transport Model (ONTM, 2020), the analysis highlights why GMSP’s scenario framework is pivotal for advancing Oman’s Vision 2040 mobility objectives. As reported in GMSP, “Future Scenarios Considered,” the Business-as-Usual (BAU 2040) scenario trends toward an average private-vehicle speed of approximately 25 km/h, whereas the integrated GMSP + TDM scenario achieves roughly 60 km/h and a public-transport mode share of about 26 percent. These results confirm the strategic value of

the GMSP modeling framework: even with full BRT and metro roll-out, sustained network performance depends on complementary delivery mechanisms that secure the supporting environment - continuous shade, context-based lane widths, and protected micromobility continuity. By wiring shading and continuity KPIs into approvals and acceptance gates, the modeled gains evidenced in GMSP can be more reliably realized on the ground, strengthening the plan’s transition from vision to implementation and reinforcing its role as the national benchmark for integrated mobility planning.

**Operational Implication**

Once wired to ONTM dashboards, the GMSP “within walking distance” KPI is reported in two forms: the conventional geometric buffer and the ASTI-effective value. Where heat depresses access, the ASTI-effective value reveals the gap and prioritizes shade/continuity interventions.

**ONTM: Advanced Tool, Limited Integration**

The ONTM manual (v4) demonstrates technical sophistication - multi-modal forecasting, freight-

passenger integration, and policy scenario testing. Yet three practical constraints are evident to date:

- Workflow anchoring: model outputs are not systematically embedded in planning approvals.
- Metric focus: performance indicators prioritize speeds and volumes, with limited coverage of thermal comfort, shading continuity, or micromobility uptake.
- Behavioral sensitivity: gendered mobility preferences and climate-related aversion to walking are not explicitly modeled.

As long as ONTM remains not fully anchored in approval workflows, its insights will have limited influence on delivery. Under the IH approach, ONTM outputs would be integrated with IH-IMI scoring (Data/Models) and ASTI layers, making thermal accessibility as measurable as congestion forecasts.

To operationalize the link between ONTM outputs and on-ground performance audits, Table 4 presents the Station Readiness Score (SRS) checklist. It serves as an ORAT (Operational Readiness and Transfer) tool to verify that thermal comfort, shade continuity, safe crossings, and rest-point intervals meet IH and ASTI performance thresholds prior to station commissioning.

**Table 4:** Station Readiness Score (SRS) – ORAT/Operations Checklist

Station ID	Shade $\geq$ Target (✓/X)	Protected Continuity $\geq$ 80% (✓/X)	Safe Crossings (✓/X)	Rest Points Spacing (✓/X)	SRS %	Action Required
LRT-01 (Al Khuwair)	✓	✓	✓	✓	100	None
BRT-03 (Mabaila)	X	✓	✓	X	50	Add arcade + rest benches $\leq$ 250 m
Local Stop (LS-07)	✓	X	✓	✓	75	Provide protected lane to school corridor

*Verified from: GMSP Vol. 3 (Fig. 6.47 Urban Environment Around Stations) and AAP KPIs linking accessibility within 5–15 min walk/cycle zones.*

**Decoding Delivery Terms in Detailed Designs**

Detailed design reports (e.g., recent detailed design reports, 2024) reveal the persistence of legacy throughput-oriented settings in geometry and cross-section templates.

- Street Composition (current): ROW starts with carriageway capacity, followed by peripheral sidewalks and landscaping.
- IH reinterpretation: allocation begins with shaded pedestrian continuity and protected micromobility, then transit, with residual width for private cars.
- Lane Width (current): 3.65 m lanes dominate, consuming ROW and encouraging speed.
- IH reinterpretation: context bands (3.0–3.25 m in neighborhoods, 3.25–3.5 m in collectors,  $\geq$ 3.5 m for special lanes). Released width is reallocated to shade and micromobility.
- Public Realm (current): treated as amenity landscaping, not core infrastructure.

- IH reinterpretation: a thermal-performance package: summer shading  $\geq$ 70%, high-albedo surfaces, rest points at  $\leq$ 500 m on primary corridors and  $\leq$ 1000 m on secondary corridors (per PRDM); IH proposes an enhanced option of  $\leq$ 200–250 m on Class-A thermal access paths where ASTI indicates depressed effective reach.

**Integration with IH tools**

These delivery terms feed into IH-IMI (Codes/Enforcement, Budget/Programming) and ASTI (shaded catchment mapping). ONTM dashboards can host these KPIs alongside traditional congestion outputs. The fragmented alignment across Oman’s planning instruments is summarized in Table 5, which compares their treatment of IH pillars, delivery terms, and required IH actions.

**Table 5:** Cross-Pillar Alignment Matrix across Omani Planning Instruments (with Delivery Terms & IH Actions)

Source	Urban Planning	Humanization	Public Transport	Road Engineering	Micromobility	Delivery Terms Observed	Required IH Action
GMSP (2023)	Macro corridors & TOD intent	Minimal at neighborhood scale	Metro/BRT planned; 2040 ≈ 2022 congestion	Indirect	Neglected	Corridor-level focus; no binding lane-width/shade specs	Bind TOD briefs to IH lane-width bands; require shade % and protected access in station areas
AAPs (2023)	TODs, Blue Spine, typologies	Partial	Transit-focused	Weak; tied to 2017 code	Minimal	Public realm noted; micro-scale absent	Add IH KPIs (shade %, continuity) to AAP briefs; require ASTI-validated access-sheds
ONTM (2020)	LU-transport modeled	Not in metrics	Ridership/scenarios	Strong car metrics	Absent	KPIs lack shade/continuity/width compliance	Link dashboards to thermal access & continuity; track lane-width compliance
Detailed Designs (2024–25)	Vehicle-first layouts	Peripheral	Externalized	3.65 m defaults	Absent	Street Composition/Lane Width/Public Realm prioritize cars	Invert hierarchy; codify thermal package and continuity
HDS (2017)	Functional hierarchy	None	Not addressed	Speed/capacity priority	None	Lane-width defaults drive car priority	Issue HDS-IH Addendum to update geometry & thermal obligations

**Detailed Design and the Car-Centric Legacy**

Flagship detailed designs still privilege vehicular efficiency. Three delivery levers illustrate the emphasis - and its remedy:

- Lane Widths. Default 3.65 m lanes persist in neighborhood contexts, inflating design speeds and crowding out shade and micromobility. IH-spec bands - 3.0–3.25 m (neighborhood), 3.25–3.50 m (collectors), ≥3.50 m (special/emergency/bus) - free ~1.6 m on a 24 m section (four lanes), enough for a 2.0 m protected micromobility lane plus wider shaded sidewalks.

- Street Composition. Current practice sequences carriageway first, then sidewalks/landscaping. IH sequencing inverts this: Shade → Walking →

Micromobility → Transit → Private cars, with protected crossings as non-negotiable.

- Public Realm. Treated as amenity rather than thermal infrastructure. IH thermal package sets summer shading ≥70%, high-albedo surfaces, rest points at ≤500 m (primary) / ≤1000 m (secondary); with an IH-enhanced ≤200–250 m cadence on Class-A thermal access where warranted by ASTI; inclusive crossings.

Embedding these as contractual KPIs and code clauses - audited at handover - turns drawings into enforceable outcomes. To illustrate how the reinterpretation of cross-section geometry translates into measurable design actions, Table 6 summarizes the context-based lane-width bands as derived from the outcomes of the Greater

Muscat Structure Plan. It demonstrates how reallocating excess carriageway width toward shaded sidewalks and protected micromobility corridors transforms

conventional geometry into a vehicle for livability and human-centered accessibility.

**Table 6:** Context-Based Lane-Width Bands and Reallocation Ledger

Context	Lane Width (m)	Existing Typical Section	Freed Width (m)	Reallocation Plan	Safety Note
Neighbourhood Street	3.00	3.65	0.65 per lane	2.0 m protected bike + tree-lined sidewalks	Calmed speed ≤ 40 km/h
Collector Street	3.25 – 3.50	3.65	0.30–0.40	Extra buffer + shade arcade	Speed ≤ 50 km/h
Primary Corridor (BRT)	≥ 3.50 (bus/emergency)	-	N/A	Maintain capacity; allocate median for trees	Dedicated bus lane
Sikka/Local Lane	≤ 3.00 (shared)	3.25	0.25	Continuous shade by building massing	≤ 25 km/h traffic calming

**Analytical Synthesis: Why the System Underperforms**  
Cross-reading strategic plans, modeling outputs, and detailed designs reveals a consistent mechanism rather than isolated flaws:

1. Policy–Project Decoupling. Ambitious constructs (TODs, regeneration corridors) are not translated into drawings with enforceable shade, lane reallocation, and station-area obligations. Delivery recycles familiar cross-sections and capacity targets.
2. Model–Code Asymmetry. ONTM can test scenarios, yet binding manuals and approvals still encode car-first geometry. Insights from models cannot penetrate projects when codes lag.
3. Scale Mismatch under Heat. Region-scale corridors are planned as backbones, but neighborhood-scale thermal realities are treated as optional “greening,” truncating catchments and suppressing mode shift. IH-IMI and ASTI provide a parsimonious explanation and remedy: underperforming outcomes are the emergent property of weak coupling among pillars. Institutionalizing IH tightens those couplings and redefines success criteria at the delivery layer.

**AAPs: Policy Scaffold without Institutional Anchor**

The revised Action Area Plans (Stage 4A) introduced Transit-Oriented Development typologies and the Blue Spine corridor. These demonstrate sophisticated urban design thinking. Yet, two weaknesses undermine them:

- Institutional fragmentation (MoHUP, MoTCIT, municipalities operate under distinct remits).
- Neglect of micro-scale interventions (shaded walkways, micromobility parking, gender-sensitive design).

Without an IH authority, AAPs risk remaining policy scaffolds with limited delivery traction without an implementing anchor.

**Bis. Operationalizing IH via IH-IMI and ASTI**

IH-IMI baselines institutional readiness (mandate, budget,

codes, models), while ASTI quantifies shaded catchments and micromobility viability. For implementation details - including KPI formulas, enforcement hooks, and dashboard integrations, see Table 1 and Table 2 in Materials & Methods. The 3.65 m→3.25 m reallocation example remains illustrative of how KPIs convert into section-level design choices without prescriptive emphasis.

**Institutionalizing IH: The Missing Piece**

Synthesizing across all instruments - GMSP, AAPs, ONTM, Detailed Designs, the missing link is institutional. Gulf cities have visions, codes, and models, but no cross-pillar body ensures alignment. Proposed solutions:

- HDS-IH Addendum: define lane-width bands, mandate thermal public realm packages.
- Urban Neighborhood Code: codify shading %, micromobility continuity, safe crossings in contracts and approvals.

**Gulf-Wide Relevance**

The institutional pattern observed in Muscat is not idiosyncratic. Riyadh is deploying metro and BRT at scale, yet station areas frequently lack codified shade and protected micromobility continuity. Doha’s FIFA-accelerated network faces a similar first/last-mile gap where climate reduces practical reach without thermal infrastructure. Dubai has achieved high-quality transit corridors, but local street manuals still encode generous lanes that suppress ROW reallocation in several districts. Kuwait is advancing urban redevelopment under severe heat-stress conditions while codes remain vehicle-centric. Three regional lessons follow. First, infrastructure without institutional coupling yields underwhelming modal shift. Second, codes determine outcomes; unless lane-width bands, shade ratios, and continuity are mandatory, delivery reverts to car defaults. Third, models must count what matters; dashboards that ignore thermal access

and protected continuity cannot steer programs toward human-centered results. Institutionalizing IH offers a transferable Gulf grammar: issue an addendum to each city's highway manual; adopt an Urban Neighborhood Code for shaded access-sheds; wire dashboards to human-centric KPIs; and publish annual IH-IMI scorecards to drive continuous improvement.

## CONCLUSION

This article advances Integrated Humanization (IH) from a conceptual and evaluative framework into a policy and institutional proposal. Drawing on Oman's core planning and technical outputs—the Greater Muscat Structure Plan (GMSP), Action Area Plans (AAPs), the Oman National Transport Model (ONTM), and detailed design practices—it shows that congestion in 2040 will likely remain near 2022 levels unless institutional integration links these instruments together.

The study decodes delivery-layer terms—Street Composition, Lane Width, and Public Realm—which in current practice prioritize vehicle throughput over shade and micromobility. Under IH, these are reframed as measurable performance obligations operationalized through two indices: IH-IMI (Institutional Humanization–Institutional Maturity Index) and ASTI (Access-Shed Thermal Index). Regional precedents such as Abu Dhabi's Public Realm Design Manual and the Sahel Accessibility Rating System demonstrate codified humanization standards but remain disconnected from transport models and road codes. IH bridges this gap by embedding public-realm metrics into an integrated framework where plans, models, and manuals share enforceable KPIs.

The article confirms that Gulf cities face not a technical deficit but an institutional one. Tools such as the HDS–IH Addendum and the Urban Neighborhood Code enable measurable enforcement through contracts, permits, and ONTM dashboards—turning climate-responsive design into auditable delivery.

This paper concludes the institutional phase of the IH research series. The forthcoming sixth paper, “From Vision to System in the Gulf,” advances IH into its operational phase through T-NEVs, pilot programs, unified mobility platforms, and the Smart Urban Mobility Authority (SUMA)—completing IH's transition from framework to applied system.

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