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Embedding Sustainability in Urban Road and Bridge Infrastructure: A Standards-Anchored Maturity Assessment of Dubai's Development Programme

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ABSTRACT

Embodied carbon within a city's infrastructure resides predominantly within road and bridge assets but sustainability assessment of urban transport authorities typically focuses upon the sustainability of fleets and operations rather than the sustainability of their infrastructure delivery. The study examines and compares sustainability embedding throughout the lifecycle of Dubai's road and bridge development programme against five global urban transport authorities. The research applies a case study design with comparative policy benchmarking using a Sustainability Embedding Maturity Rubric of four pillars and sixteen indicators drawn from a range of recognized sustainability standards and guidance including PAS 2080, ISO 14001, ISO 20400, EN 15978, Envision, BREEAM Infrastructure, the IS Rating Scheme, the GRI Standards and ISAE 3000. The study focuses solely upon public documentation and does not seek additional information from the authorities under review. Where documentation exists, each cell is scored as documented present or documented absent. Where documentation does not exist for a particular cell, the cell is not scored and this is noted against the authority's total. 37 of 96 cells have been scored as containing documented information. Dubai's road and bridge asset program contains documentation of the program's Organizational Mechanisms (national sustainability framework, certified sustainable procurement policy, project waste target and GRI assured sustainability reporting). However, the same program contains no documentation of carbon related mechanisms at the road and bridge asset's infrastructure stage (a target date and a capital carbon baseline for road and bridge assets). Two of the Authorities reviewed (both who have adopted a named instrument, either PAS 2080, the Sustainable Design Guidelines and Net Zero policy or MKI/DuboCalc) contain documentation of the design-stage carbon assessment and carbon weighted tendering process. Singapore contains documentation of the tender weighting and material mandates for sustainable construction as reported by the authority. The study provides a reusable rubric against a set of recognized standards, with a clear and transparent documentary search protocol and a Gulf region baseline against which other Gulf cities can measure themselves. The study does not assess the authorities against any effectiveness criteria.

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Introduction

Decarbonising transport does not just mean decarbonising fleets. The roads, bridges and tunnels on which cars, buses and trucks travel are typically made of concrete, steel, asphalt and earthworks and carry high amounts of embodied carbon in their construction. Embodied carbon in infrastructure is 'fixed' at the time of construction and cannot be reduced by the operation of cleaner vehicles on the resulting roads, bridges and tunnels. For rapidly growing cities, therefore, a large proportion of the city's emissions budget is spent constructing the transport network before any vehicles travel on it. Dubai is a city in rapid growth. Between 2006 and 2024, for example, the Dubai road network increased from 8,715 lane-kilometres to 18,990. Vehicle bridges and tunnels rose from 129 to 1,070. Also increasing greatly were the 557km of cycling tracks, with a major new program announced for 2024–2027 worth AED 16 billion (Government of Dubai Media Office, 2024). Dubai's commitments to sustainability in transport are made at a number of levels within public policy. The UAE-wide commitment to Net Zero by 2050 is supported by a Dubai-specific strategy, Dubai 2040 Urban Master Plan. RTA has responded with its own specific strategy published as the Sustainability Plan 2021–2025, the Zero-Emissions Public Transportation in Dubai 2050 strategy and RTA's own Sustainability Framework 2030 (Government of Dubai Media Office, 2023; RTA, 2022, 2025). RTA publishes sustainability reports in line with the GRI Standards with reasonable assurance provided by ISAE 3000. It is also certified to ISO 20400 sustainable procurement (RTA, 2025; WAM, 2021). This study looks to establish how far these sustainability commitments have traveled from their domains of operational activity – vehicles, buildings and waste – to road and bridge delivery, where the greatest amount of embodied carbon in infrastructure assets is locked away in their construction.

There are three gaps in current scholarship that this research seeks to address. The first gap concerns the subject matter of transport-authority sustainability, which largely has been restricted to the operational aspects of managing for sustainability in transport such as shifting modes, reducing emissions from transport-fleets, energy in transport-stations and other transport-depots. Road and bridge delivery is analyzed using rating systems applied at a project level, as well as whole-life carbon management (PAS 2080). What is missing from current studies is the infrastructure program or portfolio of policies, specifications, procurement mechanisms and reporting arrangements a transport-authority utilizes from project-to-project in order to embed sustainability in the assets it develops and manages. In other words, there is currently no settled method of measuring embedding. The second gap concerns the lack of evidence relating to the Gulf region on how sustainability in infrastructure delivery is institutionalized by authorities in this region. Although there is increasing interest in sustainability from authorities in the Gulf, scholarly work on the subject of sustainability policy in the UAE construction industry is non-existent (Saradara et al., 2023). There are no published studies that employ a rubric based upon published standards to assess a road program in a Gulf country against its international peers. The third gap concerns methods of benchmarking. Current studies on sustainability benchmarking of transport-authority infrastructure delivery rarely report on the scoring of a benchmarking exercise, and even less frequently outline the amount of information drawn from published documents against the score awarded. In such instances where information is lacking from an authority's published data, the absence is scored as zero while a large volume of information published by an authority is likely to contain some amount of 'sales hype' that would also be scored.

Three research questions are posed in order to address the study's objectives. RQ1 explores the degree to which sustainability-related mechanisms have been made documentable in Dubai's road and bridge development program over its lifecycle. A comparison with the sustainability-related documentation in the road and bridge assets of Singapore, London, Abu

Dhabi, Sydney and the Netherlands is then presented (RQ2). Finally, in order to assist the tests of the study's propositions, a set of testable propositions are generated which represent possible models of sustainability embedding (RQ3).

All evidence is from public documents and thus we can only claim documented presence and concordance, not necessarily effectiveness. The number of cells without any documentation is indicated next to each score. All figures and data are reported as they have been disclosed by the respective authority, including the assurance given. Section 2 outlines the relevant literature relating to whole-life carbon management of road and bridge assets, building rating systems, institutional sustainability embedding and sustainable procurement. Section 3 outlines the design of this study, the corpus used, the rubric used for analysis and the coding process in full. Section 4 presents the results of the study in full, answering each of the three research questions in turn. Section 5 discusses the results of the study, outlines the contribution of the paper and evaluates the testable propositions. Finally, Section 6 concludes the study and outlines the implications for Dubai's RTA and wider Gulf regional sustainability, and suggestions for further research.

Literature and theoretical framework

Whole-life carbon in road and bridge infrastructure

Embodied carbon is 'fixed' at the time of construction of a road or bridge and can only be 'unfixed' later in the life cycle. The environmental burden of a road or a bridge consists of four stages: production, use, maintenance and end-of-life disposal or reuse. The footprint of a pavement is not just a function of the use phase, as most studies have concluded so far.

Santero et al. (2011) established that for roads the majority of the environmental footprint is created before the pavement opens to traffic. Pomponi and Moncaster (2016) established that for the built environment as a whole the majority of the environmental impact is created in the manufacturing stage and that no single measure can reduce the environmental impact sufficiently. De Wolf et al. (2017) identified that current industry practice for assessing embodied carbon in construction products lacks consistency, leading to difficulties in comparison, and that the use of the whole life cycle-assessment approaches, such as PAS 2080 (British Standards Institution, 2023) and EN 15978 (CEN, 2011), can provide more consistent results.

A range of material and process levers to reduce construction-related emissions have been well characterised (Giesekam et al., 2016). Construction-related emissions can be reduced using high-recycled-content asphalt (Zaumanis et al., 2014), lower-CO_2 cement (Scrivener et al., 2018), and a range of other measures to reduce construction-related emissions with significant potential for near-term reduction (Karlsson et al., 2020). However, these levers are underused due to a number of reasons including perceived cost, unclear responsibility, industry culture and poor product-level carbon data. In particular, contract and tender documents are identified as the greatest instrument to overcome these barriers (Giesekam et al., 2016). Construction carbon targets should be derived from a country's national mitigation commitments (Giesekam et al., 2018). Climate change impacts on road pavements have been characterised (Blaauw et al., 2022). In addition to reducing construction-related emissions, road and bridge design can also reduce emissions by favouring non-motorised transport through sustainable street design (Gámez-García et al., 2019). Climate resilience of road and bridge assets is an important counterbalance to mitigate construction-related emissions, and the adaptation advantage of designing road infrastructure to future climate change can be

quantified (Chinowsky et al., 2013). Furthermore, resilience and sustainability should be treated as a single issue (Bocchini et al., 2014), and climate resilience is now entering construction codes and rating tools (OECD, 2018).

Rating systems and standards as embedding instruments

The potential of credit-based building rating has been developed by Fenner and Ryce (2008). Building sustainability assessment tools for transport infrastructure have been reviewed by Bueno et al. (2015) and generally found to be useful but lacking in standardization. A common error made by most indicators related to materials used in building construction is the weights assigned to them are generally based on limited life-cycle data, as reported by Yang and Liu (2018). In order to integrate sustainability assessment into the normal development process of infrastructure projects, rating systems should be integrated with BIM for infrastructure, as proposed by Liu et al. (2018). However, rating tools are generally used for purposes other than certification by experienced users and infrastructure owners, such as shaping policy and building skills to embed sustainability in normal development processes of projects and assets, as reported by Griffiths et al. (2018).

Whole-life carbon management has its own specification. PAS 2080, issued in 2016 and revised in 2023 (British Standards Institution, 2023), places carbon management obligations on the whole value chain across leadership, quantification, target-setting, baselining, monitoring, reporting and procurement (Manidaki & Pantelidou, 2022; McAlinden, 2016). ISO 14001:2015 supplies the management-system architecture (International Organization for Standardization [ISO], 2015); ISO 20400:2017 the sustainable procurement guidance (ISO, 2017); EN 15978 the life-cycle stage boundaries (European Committee for Standardization, 2011); the rating systems their credit structures (Building Research Establishment, 2022; Infrastructure Sustainability Council, 2021; Institute for Sustainable Infrastructure, 2018); and the GRI Standards and ISAE 3000 the disclosure and assurance layer (Global Reporting Initiative, 2021; International Auditing and Assurance Standards Board, 2013). Figure 1 positions these instruments; Table 1 maps them to the rubric's pillars.

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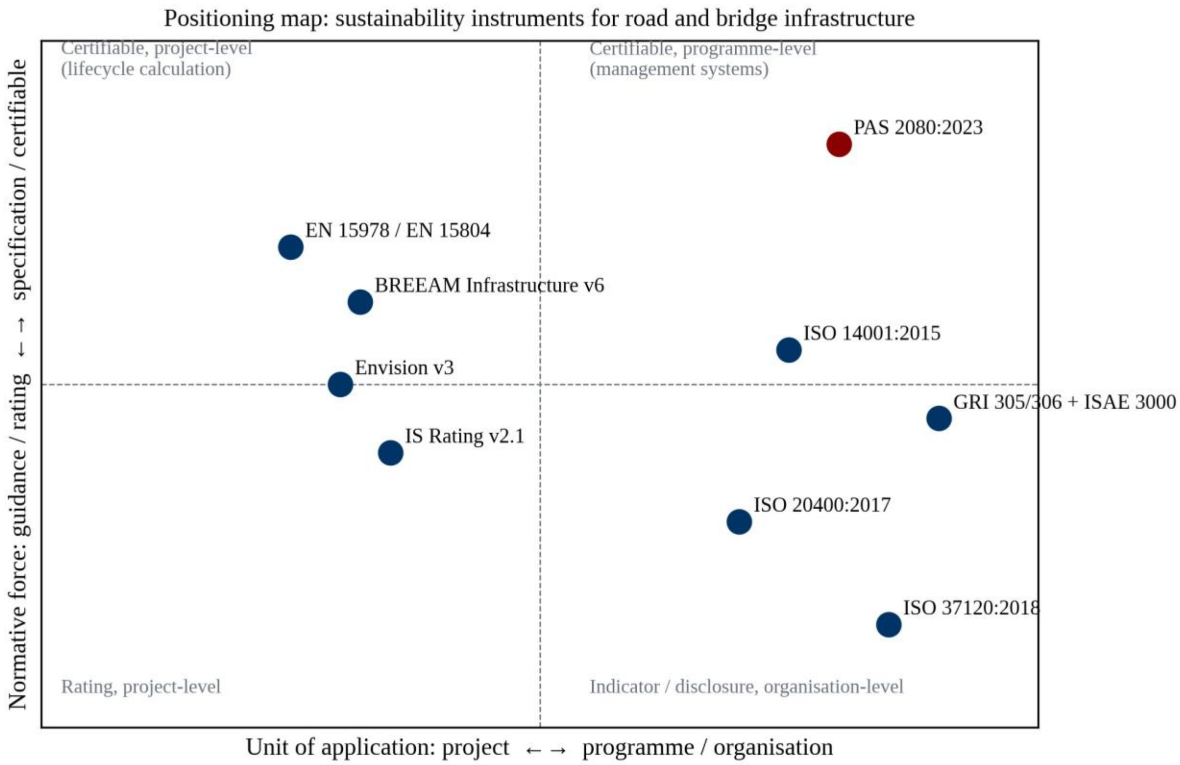

Figure 1. Positioning of sustainability instruments for road and bridge infrastructure by unit of application and normative force.

Table 1. Standards concordance: anchor instruments mapped to rubric pillars

Instrument	Type	P-A Governance and strategy	P-B Design and whole-life carbon	P-C Procurement and materials	P-D Delivery, monitoring and disclosure
PAS 2080:2023	Specification (BSI)	Leadership; carbon management process	Quantification; baselines; targets	Carbon in tenders; supplier requirements	Monitoring; reporting
ISO 14001:2015	Management-system standard	Leadership; policy; objectives	Lifecycle perspective in design	Lifecycle perspective in procurement	Monitoring; audit; review
ISO 20400:2017	Guidance standard	Policy and strategy integration	—	Criteria; supplier engagement	Reporting on procurement outcomes
EN 15978:2011	Calculation standard	—	Modules A1–A5, B, C, D	—	Reporting boundaries
Envision v3	Rating system	Leadership credits	Climate and Resilience; Natural World	Resource Allocation	Verification
BREEAMInfrastructure v6	Rating system	Management; leadership	Resilience; ecology	Resources; materials; waste	Evidence-based assessment
IS Rating v2.1	Rating system	Governance; leadership	Energy and carbon; adaptation	Resource efficiency; materials	Reporting; verification

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GRI 305/306;ISAE 3000	Reporting and assurance	Governance disclosures	—	Supplier assessment	Emissions; waste; independent assurance

Note. Clause references are to the standards as listed in the reference list.

Institutional theory and the institutionalisation of sustainability

Organizations are similar in fields through coercive, mimetic and normative pressure (DiMaggio & Powell, 1983). According to Tolbert and Zucker (1983) a practice, which is made mandatory by the state, diffuses fast and directly. Early adopters are driven by internal need while late adopters are driven by legitimacy reasons. The three pillars of institutions are described by Scott (2014): the regulative, the normative and the cultural-cognitive. Hoffman (1999) describes the way corporate environmentalism develops through different stages with each stage being dominated by a different driver. Jennings and Zandbergen (1995) argue that organizations that are ecologically sustainable are created through institutional processes.

Corporate greening is driven by three reasons: competitiveness, legitimation and ecological responsibility (Bansal & Roth, 2000). In their model of how stakeholder pressure translates into organizational responses, Delmas and Toffel (2004) model how organizations perceive stakeholder pressure and how organizations respond to it. Berrone et al. (2013) found that the combination of regulatory and normative pressure triggers environmental innovation most in organizations that have a performance gap to their peers. The business case and leadership are found to be the strongest drivers for sustainability within organizations by Lozano (2015).

Two key points need to be made about this study. First, the mechanism by means of which pressure is embodied in a set of routine decisions, a policy, a product specification, a public procurement rule and a set of reporting obligations, is documentary and thus easily observable. Second, as stated by Tolbert and Zucker (1983), the pattern of development identified above predicts an asymmetry between the two cases: where there is a national mandate then the embedding of that mandate in the authorities' rules and procedures should be easy to document; however, in the absence of a national mandate the degree to which organizations have embedded sustainability in their key leadership, monitoring and informing processes will vary between organizations and should be influenced by leadership and by pressure from others within the organization's peer group.

Sustainable public procurement as the operative lever

In terms of practical implementation Walker and Brammer (2009) indicated that there is considerable variability within the UK public sector in terms of implementation cost was cited as the greatest barrier to SPP, while top management support was identified as critical to embedded SPP within organizations. The survey was later extended to 20 countries (Brammer & Walker, 2011) and as with the UK based research engagement with SPP was found to depend on catalysts within organizations rather than the existence of policies or legislation exhorting SPP. Sourcing sustainable construction products within procurement has been identified as problematic within the public sector with a number of barriers associated with clients within the UK public sector (Sourani, 2011). In order to deliver green tenders, Testa et al. (2016) found that environmental sustainability in public procurement is not simply a matter of an organization having an environmental management system (EMS) in place. Rather it is a function of the maturity of the EMS. However, the competitive dialogue procedure (Uttam & Le Lann Roos, 2015) can be used to develop sustainability criteria for complex procurement through ICT supported tendering processes.

Maturity models, disclosure and the regional evidence base

Correia et al. (2017) analysed sustainability maturity models and reviewed supply chain practices of several multinational corporations in the infrastructure, facilities and construction sectors. Most of the practices were described by single company cases. Those practices were largely organized by means of grids used for descriptive, prescriptive and also comparative purposes. Willetts et al. (2010) stressed the need for a single sustainability conversation throughout the planning, design and delivery of infrastructure projects. Thacker et al. (2019) linked specific types of infrastructure investment to 72% of Sustainable Development Goals. Reviewing GRI sustainability reporting by public sector organizations, Dumay et al. (2010) noted wide variations in extent of reporting by public sector organizations and found that reporting was often decoupled from management systems and processes.

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Constructs and propositions

Table 2. Theory, construct and proposition mapping

Theoretical lens	Sources	Construct	Indicators	Proposition
Coercive isomorphism; state-mandated diffusion	DiMaggio and Powell (1983); Tolbert and Zucker (1983)	Regulatory anchoring	A3, A4, C4	P1. Mechanisms mapping onto a national mandate are documented present across authorities
Rating tools and specifications as institutional carriers	Griffiths et al. (2018)	Professional anchoring	B1, B4	P2. Design-stage mechanisms are documented where a professional scheme or specification isinstitutionalised
Leadership and business case	Lozano (2015); Bansal and Roth (2000)	Leadership anchoring	A1, A2, B2	P3. Authorities with a named owner and dated targets document more procurement and disclosure mechanisms
Procurement as operative lever	Testa et al. (2016); Sourani (2011)	Procurement anchoring	C1, C2, C3	P4. Strategy documented without contract-layer mechanisms is the most common embedding failure
Decoupling of reporting from management	Dumay et al. (2010); Meehan and Bryde (2011)	Disclosure depth	D2, D3, D4	P5. Assured organisational reporting is documented before asset- or project-level disclosure

To develop a theory-based framework for assessing the embedding of external pressures into the programs of individual transport authorities, this study identifies and bridges a significant theoretical/empirical gap, specifically that there is no standards-based, documentary assessment of a Gulf country road and bridge delivery program compared to best practice programs internationally, and that the scores reported by most benchmarking studies depend on unknown amounts of documentation.

Methods

Design

The research study is a single-case study of Dubai's road and bridge development program. It is a comparative policy benchmarking study of six transport authorities. The unit of analysis is the program and the strategies, specifications, procurement process, reporting and other such mechanisms that are used to deliver roads and bridges. A single publicly traceable document is used as a proxy for a program-level mechanism (embedding). Institutional theory suggests that external pressures on an organization are translated into internal organizational routines through formal policies, specifications, and certification scopes (DiMaggio & Powell, 1983; Scott, 2014). The mechanisms that are used for delivering roads and bridges in infrastructure development are rarely auditable if they are not documented. In other words, tender documents, design standards, and reporting requirements all have to be written. Publicly available documents of a transport authority function as the surface that can be observed of the institutional commitments that are made by that authority (Bowen,

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2009). The study limitations relate to the claims that are made. These are confined to whether certain aspects are mentioned, not mentioned, concordant or comparative. See Figure 2 for the research sequence.

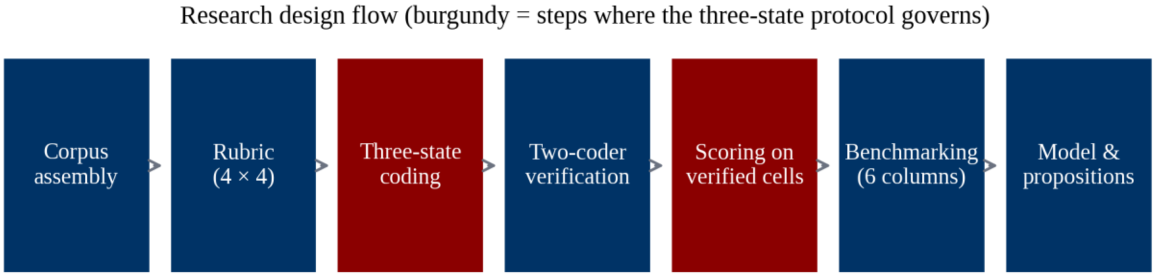

Figure 2. Research design flow.

Case and benchmark selection

Table 3. Authorities assessed

Jurisdiction	Authority	Mandate over roads and bridges	Principal public documents coded
Dubai (case)	Roads and Transport Authority (RTA)	Roads, bridges, tunnels, public transport	Sustainability Plan 2021–2025; Zero-Emissions Public Transportation 2050; Sustainability Framework 2030; sustainability-report releases
Singapore	Land Transport Authority (LTA)	Roads, rail, bridges, tunnels	Sustainability Report 2023/24 (GRI); corporate sustainability page
London	Transport for London (TfL)	Strategic roads, bridges, tunnels, public transport	Corporate Environment Plan board papers; quarterly Sustainability Report; CLC Five Client Carbon Commitments
Abu Dhabi	Integrated Transport Centre (ITC); Abu Dhabi City Municipality (ADM)	Roads, bridges, public transport	ITC news releases; ADM-published road carbon-footprint study
Sydney	Transport for NSW (TfNSW)	State roads, bridges, rail	Net Zero and Climate Change Policy; Sustainable Design Guidelines v4 supporting tools; RAP fact sheet; parliamentary answers
Netherlands	Rijkswaterstaat (RWS)	National roads, bridges, waterways	Climate-neutral 2030 and circular-economy pages;

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			DuboCalc page; news releases; materials dossier

The study employs a purposive selection approach. A published framework is chosen to guide the analysis of the main elements identified within the study (i.e., the integrated role of government in enabling the delivery of infrastructure, the dominant market rating systems used across the jurisdictions, and the main forms of procurement that are practiced within these systems). In addition, in order to draw upon an exemplar from the Gulf region, published information from a single 'peer' jurisdiction that operates under the same federal policy layer as Dubai has been incorporated into the framework. In terms of the individual cells within the framework for the UAE, Abu Dhabi has been selected as a negative case (or a 'structural' peer) given that it is expected to operate within the same federal net-zero commitment and within the same federal procurement policy layer as Dubai. Information that has been published by the authority or government in the city was incorporated within the study's findings in order to identify patterns in terms of the amount and type of information that is made publicly available by the authority (i.e., sixteen cells in total, with information in two of the sixteen cells being published in the public domain).

Corpus and inclusion rule

Included in the analysis are strategy and plan documents from a government authority; annual and sustainability reports; design standards and other public facing information such as factsheets; Parliament documents; and official news releases. The latter are included only where the official news release actually quotes the mechanism. Excluded from the analysis are news reports from third parties including consultancies and the trade press, and register entries and similar documentation that can only be evidenced by a secondary report. Where a cell is evidenced by a third-party-hosted copy of an official document (as opposed to the original) then that cell is not coded. All coded cells are shown with full source, URL locator and extract in Appendix B. The principal documents coded for each of the cities are: for Dubai: RTA documents (2018, 2021, 2022, 2025); Government of Dubai Media Office (2023, 2024); WAM documents (2021, 2025); for Singapore: LTA document (2024); for London: documents from Transport for London (2022, 2025); and the Construction Leadership Council (2024); for Abu Dhabi: Abu Dhabi City Municipality (2017) and United Arab Emirates University (2017) document; for Sydney: Transport for NSW (2019, 2022, 2025) documents and NSW Legislative Council (n.d.) document; and for the Netherlands: Rijkswaterstaat (2023a, 2023c) documents and Rijkswaterstaat, Copper8 and Witteveen+Bos (2023b) document.

Rubric

Table 4. Sustainability Embedding Maturity Rubric

ID	Indicator	Documented present if the corpus contains	Documented absent if	Anchor
A1	Strategy covering road/bridge assets with dated targets	A strategy naming road/bridge infrastructure with at least one quantified, dated target	Scope excludes infrastructure delivery, or targets are for fleet, buildings or operations only	PAS 2080:2023,leadership and carbon-management process; ISO 14001 §6.2
A2	Senior owner named	A director- or board-level role accountable for sustainability covering infrastructure delivery	Governance assigns sustainability to no such role	PAS 2080:2023,leadership roles and responsibilities; ISO 14001 §5.3
A3	Alignment to national net-zero commitment	Explicit reference to the national commitment as driver of the authority's targets	A post-commitment strategy that does not reference it	Giesekam et al. (2018); PAS 2080:2023,alignment of targets with national commitments
A4	Certified EMS	ISO 14001 certification	Scope statement	ISO 14001 §4.3

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	covering infrastructure delivery	whose stated scope includes road/bridge design or construction	excludes infrastructure delivery	
B1	Whole-life carbon assessment required at design	A standard or policy requiring carbon or LCA assessment before design freeze	Design standards address environment without such a requirement	PAS 2080:2023, whole-life carbon quantification at each work stage; EN 15978
B2	Capital-carbon target or baseline for infrastructure	A numeric, dated reduction target for embodied carbon ofworks	Targets for operational emissions only	PAS 2080:2023,baselines and target-setting
B3	Climate-resilience criteria in design standards	Standards or compulsory requirements referencing projected climate risk	Standards reference historical climate only	Envision CR; IS adaptation credit
B4	Rating-system use on a road or bridge project	A road/bridge project certified under Envision, BREEAM Infrastructure/CEEQUAL, ISor Greenroads	Documents state no rating system is used	Griffiths et al. (2018)
C1	Sustainability weighted in tender evaluation	A published weight or scored criterion for sustainability or carbon in works evaluation	Criteria published without a sustainability weight	ISO 20400 §7.3; PAS2080:2023, carbon in procurement
C2	Recycled or low-carbon material specification	Specifications or mandates requiring or permitting recycled asphalt, cement replacement or recycledaggregate with stated limits	Specifications require virgin materials only	Zaumanis et al. (2014); Scrivener et al. (2018)
C3	Supplier carbon or lifecycle data requirement	A tender rule requiring bidders to submit product carbon or lifecycle data	Tender documents contain no such rule	PAS 2080:2023,supply-chain carbon data requirements; EN 15804
C4	Sustainable procurement standard or policy	ISO 20400 certification or an equivalent published policy applying to works	Procurement policy without sustainability provisions	ISO 20400
D1	Construction or recovered-material waste target	A numeric target for diversion or reuse of construction or project waste or recovered road materials	Waste targets for operational waste only	GRI 306; ISO 14001§9.1
D2	Asset-level sustainability data	Indicators disaggregated toroad infrastructure or asset class	Organisation-level aggregation only	GRI 305; ISO 37120(ISO, 2018)

D3	Externally assured sustainability report	An independent assurance statement	Report states assurance not obtained	ISAE 3000; GRI 2-5

ID	Indicator	Documented present if the corpus contains	Documented absent if	Anchor
D4	Project-level outcomes disclosed	Published carbon or sustainability results for a named road or corridor project	Project reporting covers cost and schedule only	PAS 2080:2023,monitoring, reporting and continual improvement

A document may be uncoded when no document in the analyzed corpus has been coded under the present rule or under the absent rule respectively. Note. Clause references are to the standards as listed in the reference list.

Coding, scoring and analysis

Cells in the matrix were coded in two passes by one coder. The first pass used the operational definitions and recorded the following information in the register (Appendix B): state, source, locator and a 40-word maximum word extract from the document. The second pass coded a stratified sample of 24 cells (25% of the total number of cells in the matrix). The second coding was conducted from the source documents and the operational definitions alone, and the coder was blind to the first coding. Agreement on the second coding was 23 out of 24 (95.8%), with Krippendorff's α (nominal) equal to 0.92. The sole disagreement was on London B1 and, following discussion, the clarification made to the definition was that a published client commitment to a specification that in turn mandates carbon assessment counts as a policy requiring assessment. However, a pledge alone with no published weight or material limits does not count as documented. Consequently, three London cells (A1, C1, C2) were recoded as not documented. The second-coding sheet for the 24 cells is a supplementary file. Full double coding of the remaining 72 cells is recorded as future work.

The embedding score is the number of documented-present cells divided by the number of documented cells for each cell; the corresponding pillar score is the same ratio but for the four-indicator pillars individually; and the raw score equals the number of present cells divided by 16 (the total number of cells). The maturity level for an embedding is determined from the embedding score alone for the 10+ documented cells; maturity levels are on a five-level scale as outlined in Appendix A. Note that, because of the nature of the six authorities studied and the largely binary nature of the documentary evidence, no weighting is applied and no inferential statistics are used.

Threats to validity

Note regarding the publication of Authorities: As already mentioned, the publication differences of the Authorities are made transparent by the documentation of the documented numbers of cells and by the Embedding scores not being calculated for undocumented cells. The Benchmark documents were read in English and in Dutch. Only internal texts in Arabic language were not accessible. The Corpus was closed on 7 September 2026. No documents were included that had been published after this date (i.e. after 7 September 2026). For reasons of construct validity, the clause-level anchoring at the published standards was ensured (note 11). By means of identical rule application to all columns of the matrix, coder bias towards the case authority was excluded. The full register of coded documents was delivered to the coders.

Results

Policy ecosystem and RTA milestones (RQ1)

Figure 3. displays the key sustainability milestones for RTA against the broader national and emirate policy. In relation to a layer to address carbon for infrastructure, this was developed prior to the current strategy instruments of RTA and they reference said layer (Government of Dubai Media Office, 2023; RTA, 2022). RTA's earliest documented mechanisms are those of disclosure in the form of a GRI-based sustainability report of 2016 and a reasonable assurance report under ISAE 3000 of 2018, as well as the authority's ISO 20400 certification of 2021 sustainability procurement policies (RTA, 2018, 2021; WAM, 2021). Hence, in relation to the rubric, there are no documented infrastructure-delivery mechanisms; i.e. no capital-carbon targets for road and bridges works, nor any carbon assessment in the design stage required.

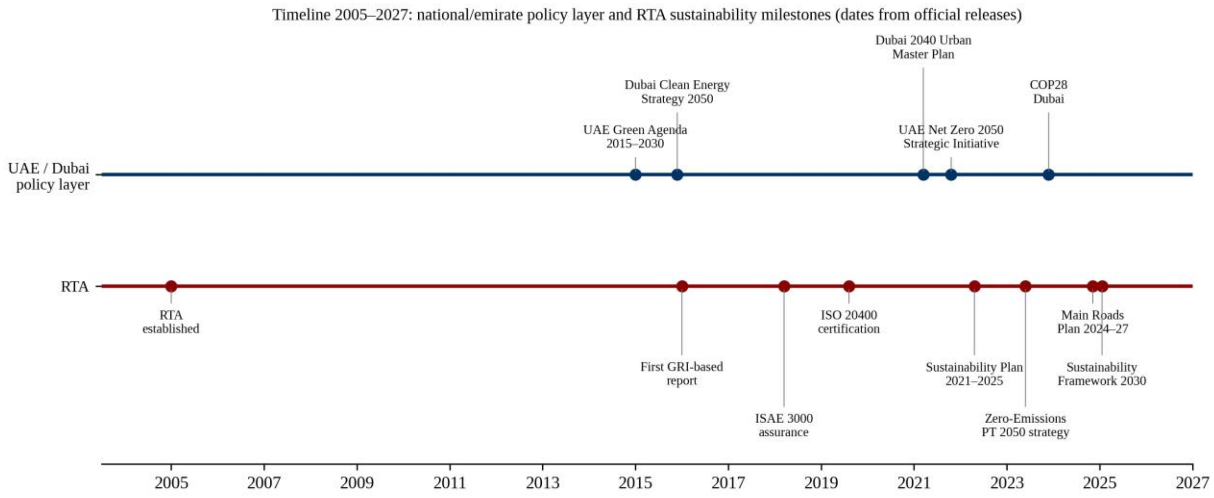

Figure 3. Timeline 2005–2027: national and emirate policy layer and RTA sustainability milestones

The rubric applied to Dubai (RQ1)

Table 5. Dubai: documented cells

ID	State	Evidence
A1	Documented absent	Sustainability Framework 2030 lists dated targets for injuries, fatalities, customer experience, zero-emission public transport (2050) and asset-management maturity (2030); RTA states in 2025 that its net-zero effort is guided by three pillars, public transport, buildings and facilities, and waste management. No quantified target for road or bridge asset delivery (Government of Dubai Media Office, 2023; RTA, 2025; WAM, 2025).
A3	Documented present	The 2050 strategy is aligned with the UAE Net Zero by 2050 Strategic Initiative (Government of Dubai Media Office, 2023).
B2	Documented absent	The 2050 strategy's targets cover buses (10%, 40%, 100%), buildings (74% solar retrofit by 2030; near-zero-energy new buildings from 2025), waste (100% recycling by 2030) and recycled water (40% by 2050); none addresses capital carbon of infrastructure works (Government of Dubai Media Office, 2023).
C4	Documented present	First transport authority globally to obtain ISO 20400:2017 certification from BSI (RTA, 2025).
D1	Documented present	Recycling 100% of the waste of RTA's operations and projects by 2030 (RTA, 2022).

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D3	Documented present	GRI Standards reports with reasonable assurance to ISAE 3000 since 2018; the 2021 report assured for 2017–2021 (RTA, 2022; WAM, 2021).

For Dubai, six of the sixteen cells are documented. There are four organizational cells documented present (alignment statement, certified procurement standard, project-waste target, assured disclosure). Two other organizational cells documented absent are the strategy with dated targets for infrastructure assets and the capital-carbon target. The two current strategy documents restrict their targets to public transport, buildings and operational waste. The ten other cells (design, procurement, reporting of assets etc.) are undocumented. The instruments for the stages of design, procurement and reporting of assets for infrastructure etc. which govern these are not public within the corpus of documents examined.

Comparative matrix (RQ2)

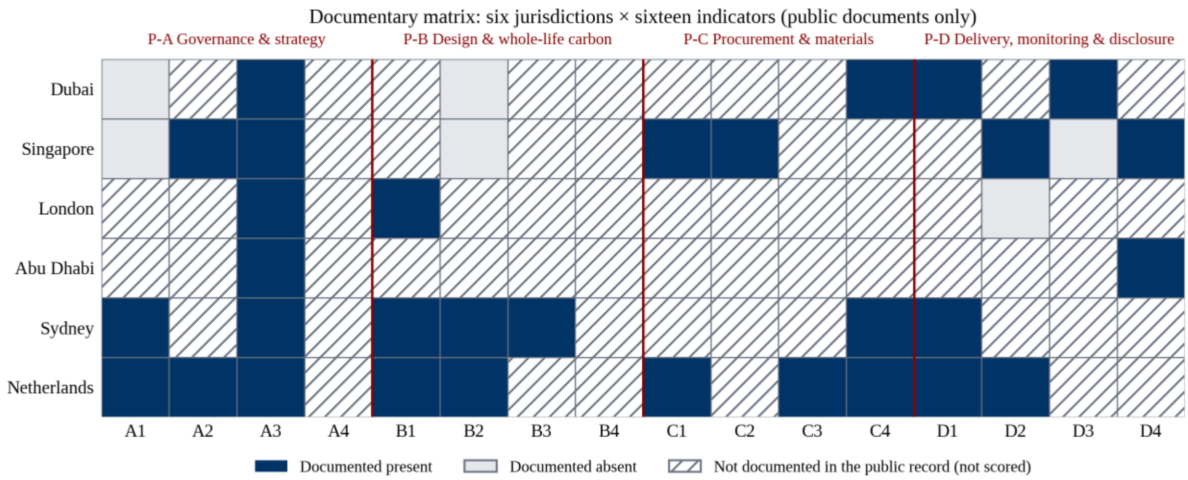

Figure 4. Documentary matrix: six jurisdictions by sixteen indicators (public documents only).

Table 6. Comparative matrix scores (computed from the coded matrix)

Jurisdiction	Present	Absent	Documented	Raw score	Embedding score	Maturity level
Dubai (RTA)	4	2	6	25.0%	66.7%	Not assigned (6 documented)
Singapore (LTA)	6	3	9	37.5%	66.7%	Not assigned (9 documented)
London (TfL)	2	1	3	12.5%	66.7%	Not assigned (3 documented)
Abu Dhabi (ITC/ADM)	2	0	2	12.5%	100.0%	Not assigned (2 documented)
Sydney (TfNSW)	7	0	7	43.8%	100.0%	Not assigned (7 documented)
Netherlands (RWS)	10	0	10	62.5%	100.0%	L4 Integrated

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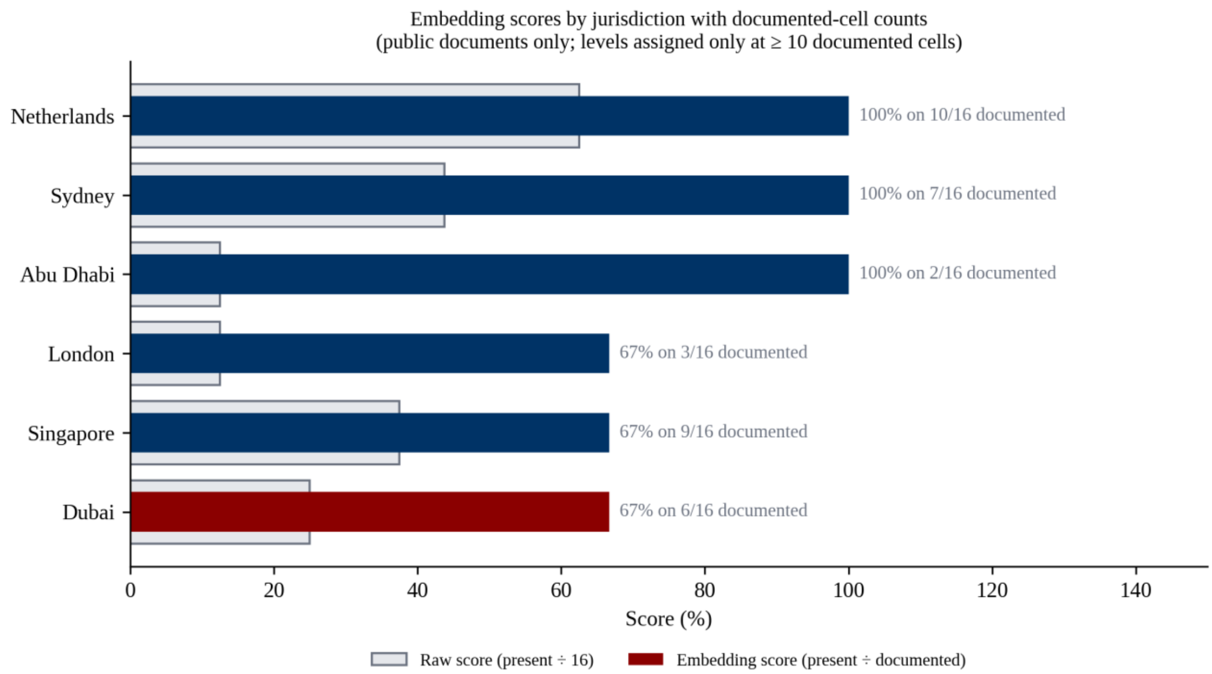

Figure 5. Embedding scores by jurisdiction with documented-cell counts.

Of the ninety-six cells assessed, information has been documented for thirty-seven of them. Rijkswaterstaat is one of the authorities with the most information available (ten cells), of which seven are classified at Level 4. Unfortunately, the authority has not been able to achieve Level 5 for one of the cells (D4). Information is available for all seven cells assessed for Sydney (100%), for two out of three cells for London (67%), whereas one of the absences for London refers to the quarterly sustainability report of London Underground not accounting for emissions on different modes of transport and not relating to individual roads and bridges (D2). Information has been documented for nine of the sixteen cells for Singapore (67%), where three of the absences are stated explicitly in the sustainability reports of the three authorities, including the absence of targets for individual infrastructure assets, a capital-carbon target and external verification of the reports. Information has been documented for six of the nine cells for Dubai (67%), where two of the cells lack information for reasons related to the scope stated in the strategy documents of the two authorities. For Abu Dhabi information has been documented for two out of nine cells (23%), but none of this information relates to the programme as a whole.

Out of the A3 commitment columns, only A3 has been documented for all six authorities. As for the action areas, B1 has been documented for the sustainability reports of London, Sydney and the Netherlands. For C1, sustainability is given due consideration in tendering processes for Singapore and the Netherlands: According to the Singaporean report, the quality score for civil contracts has a weight of 4% and for construction tenders above S$50 million even up to 5% (LTA, 2024). For D3, assured reporting has been documented for Dubai, whereas it has not been possible for Singapore so far. For D4, project-related disclosure has been documented for Singapore (on individual corridors and rail projects) and for Abu Dhabi (a carbon-footprint study for individual roads published by the municipality, see Abu Dhabi City Municipality & United Arab Emirates University [UAEU], 2017).

Positioning by pillar (RQ2)

Table 7. Pillar-level scores (present divided by documented within pillar; documented count in brackets)

Jurisdiction	P-A Governance and strategy	P-B Design and whole-life carbon	P-C Procurement and materials	P-D Delivery, monitoring and disclosure
Dubai	50% (2)	0% (1)	100% (1)	100% (2)
Singapore	67% (3)	0% (1)	100% (2)	67% (3)
London	100% (1)	100% (1)	— (0)	0% (1)

ISSN: 3006-6948 - https://doi.org/10.54878/p56fmw07

Abu Dhabi	100% (1)	— (0)	— (0)	100% (1)
Sydney	100% (2)	100% (3)	100% (1)	100% (1)
Netherlands	100% (3)	100% (2)	100% (3)	100% (2)

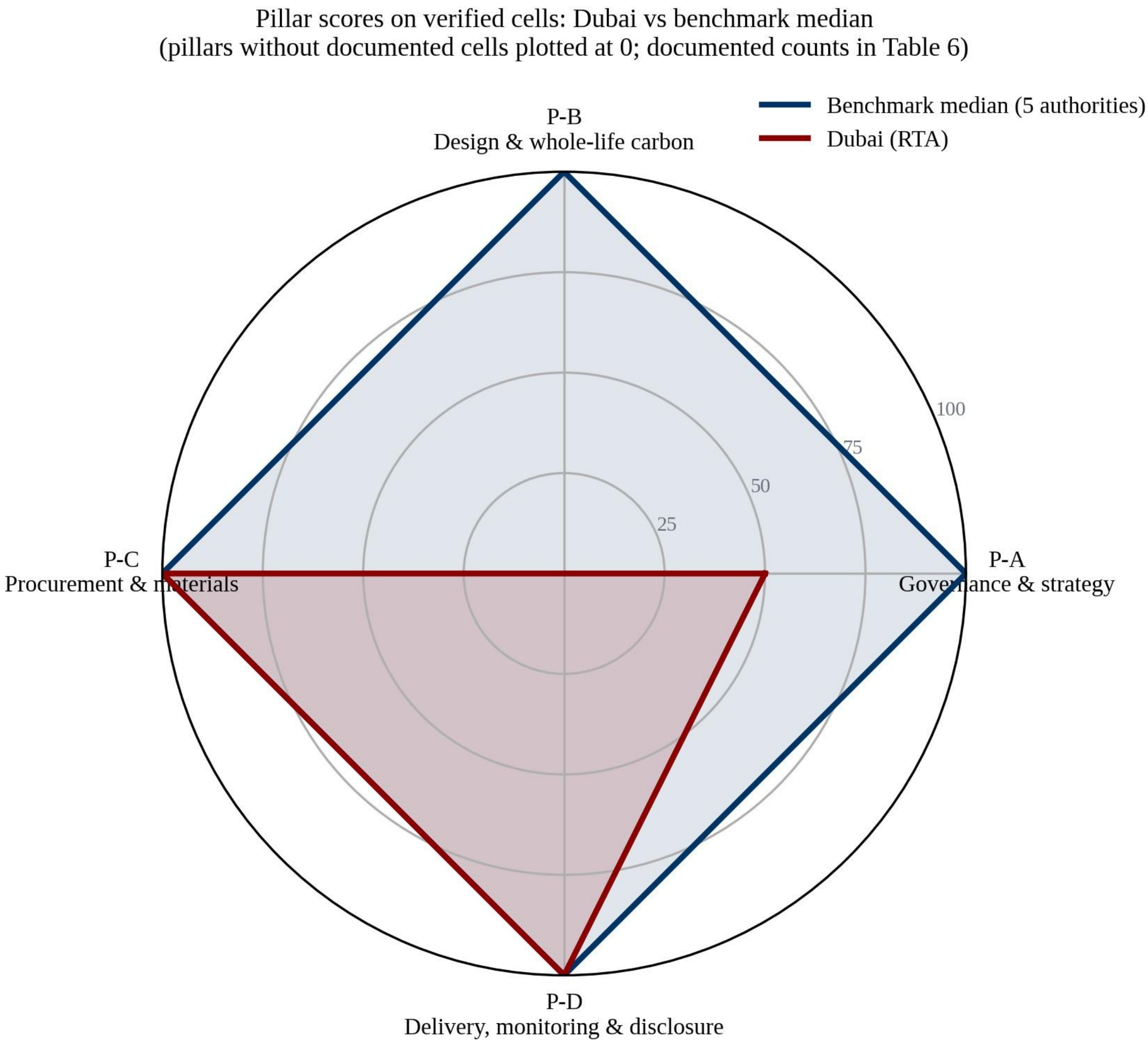

Figure 6. Pillar scores on documented cells: Dubai versus benchmark median.

The shape for Figure 6 is the finding. The "documented strength" for Dubai lies in the procurement and disclosure pillars, each of the corresponding cells is documented at 100% (i.e. certified procurement standard, project-waste target for projects, assured reporting). For the design and the governance pillars there is only one documented cell each. The design pillar's corresponding cell is an absence (i.e. there is nothing documented). The corresponding cells for the governance pillar are split between the two, with national alignment being documented whereas the corresponding cell for the infrastructure-asset target is an absence. The corresponding cells for the procurement pillar of Singapore reveal a stronger procurement pillar as compared to Dubai, with tender weighting and with material mandates documented. Disclosure is less well documented for Singapore, though, as there is no documented assurance for this pillar. The corresponding cells for all three pillars of Sydney and the Netherlands are documented in full for all cells that could have been coded. London has three documented cells, national alignment and PAS 2080 adoption are documented (positive), whereas the corresponding asset-level reporting cell is an absence.

Sustainability Embedding Model (RQ3)

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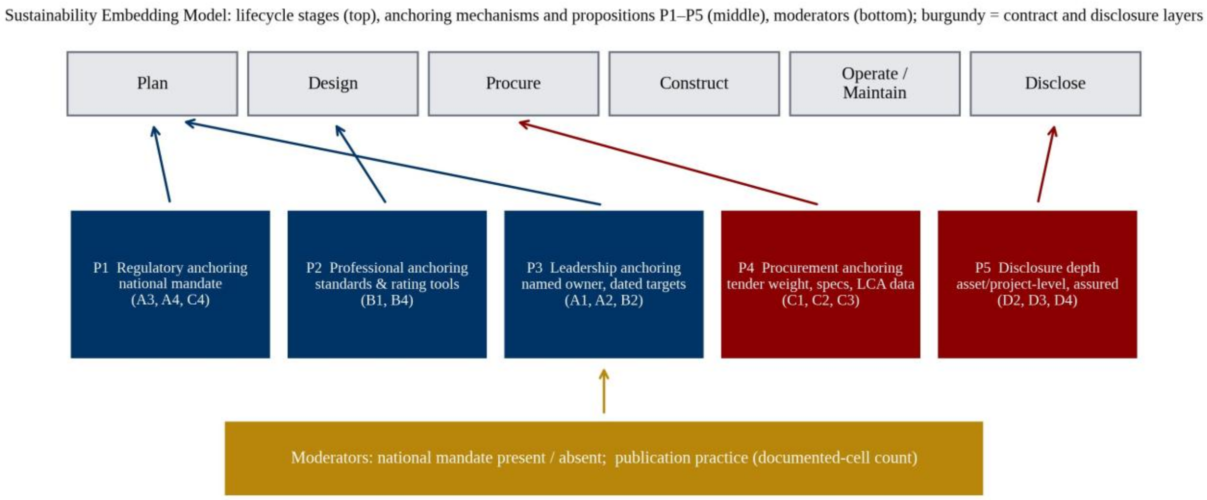

Figure 7. Sustainability Embedding Model: lifecycle stages, anchoring mechanisms and propositions P1–P5.

The model in Figure 7 sets out the five anchoring mechanisms identified in Section 2.6 against the six lifecycle stages of a road and bridge programme, with the national mandate and publication practice as moderators. The national mandate and publication practice of contracts are used as moderators to assess the degree of support for each of the P1 to P5 statements from the fifth column. P1 is supported by A3 and also C4 where there is documentation. P2 is supported in terms of direction, as there is documentation of PAS 2080, Sustainable Design Guidelines or MKI institutionalization where B1 is documented. However, Singapore's documented tender weighting and material mandates, for example, are not as a result of a rating system alone (contra P2, statement B1). P3 can only be read to support P3 for Singapore and the Netherlands as these two Authorities have A2 documented as well as C3. P4 appears to be absence of documentation of the contract provision in the contract layer for Dubai, London and Abu Dhabi. P5 is not supported as stated for Dubai (organisational level reporting assured but no project-level reporting is documented), for Singapore (project-level and asset-level information disclosed but no assurance), and for the Netherlands (asset-class information is documented but no assurance). Formal adjudication of these assertions is set out in Table 8.

Discussion

Findings against the literature

Organisational before infrastructural. RTA's documented mechanisms (an alignment statement, a certified procurement standard, a project-waste target and an assured reporting regime) are exactly the sort of things that an organisation introduces first, as per the institutional theory of organizational change (DiMaggio & Powell, 1983; Tolbert & Zucker, 1983). These mechanisms are visible to the field (Testa et al., 2016), can be certified by third parties and are legible to other organizations within the sector. They are the organization's management system (as opposed to the maturity of the management system) and thus the documented mechanisms that RTA has introduced are good. However, there are two notable absences from the current strategy texts that scope out the targets for public transport, buildings and operational waste. Neither of the current strategy texts set dated targets for road and bridge

assets and/or establish a capital-carbon baseline. The pattern of carbon targets for easy measurement and no targets for large embodied carbon in assets for road and bridge assets is one that Giesekam et al. (2018) previously warned against.

Instruments, not statements. This allows for the coding of London, Sydney and the Netherlands as having design-stage carbon assessment of road and bridge assets (C1) as they all have a named instrument that documents the mechanism, in contrast to mere statements. While the instrument names alone could have been coded as indicators for C1 for these three authorities (see below), in practice, the commitments through the Construction Leadership Council regarding PAS 2080, the Sustainable Design Guidelines compulsory carbon baseline and reduction through DuboCalc/MKI as best-price–quality criterion are also documented. Griffiths et al. (2018) found the same at the program level. The Dutch case above underpinnes the argument by Du et al. (2014) that life-cycle assessment needs to be included in the procurement process, i.e. MKI does not describe the completed bridge, it was the basis on which the bridge was purchased. The percentage of Rijkswaterstaat tenders awarded based on MKI content has risen from 4% in 2017 to 47% in 2022

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(Rijkswaterstaat, 2023a). Note that the case of Singapore is different and also interesting: while there is no rating scheme (LTA, 2024) for the sustainability performance of companies tendering for transport contracts, a published tender-score weight for climate change is disclosed in its own GRI sustainability report.

Many of the cells related to certificate scope (A4), design criteria related to climate change resilience (B3), rating schemes for sustainability (B4) and rules related to supplier's carbon data (C3) are largely absent from the documented practices of many of the authorities studied here. However, the silence of the majority of authorities with respect to these particular issues is of methodological interest here in terms of how one might develop a two-state benchmark to assess these aspects of practices related to sustainability. The practices here documented would have been scored as absence according to such a benchmark, leading to a ranking of practices related to publication of sustainability intentions as opposed to practices that actually embed sustainability.

Contribution

The main contribution of this paper is a sixteen-indicator, standards-anchored Sustainability Embedding Maturity Rubric with a documentary coding protocol that scores only what is documented. The findings from six different transport authorities are presented here but the tool can be easily used by any road authority to map out the different lifecycle stages at which their sustainability commitment turns into pure documentary. Every indicator has been anchored to a specific clause of a published standard and therefore the legitimacy of the standards is transferred to the rubric and the authors' views have been kept to a minimum. A register for re-coding all the results from this study is included in Appendix B.

Propositions adjudicated

Table 8. Proposition adjudication on the documented matrix

Proposition	Evidence cells	Verdict	Basis
P1 Regulatory anchoring	A3 present in 6 of 6; C4 present in 4 of 4 documented	Consistent	The mandate-backed mechanism is the only complete column; C4 is present wherever documented
P2 Professional anchoring	B1 present for London, Sydney, Netherlands; C1 and C2 present for Singapore without a rating scheme	Consistent in direction; not exclusive	Design-stage assessment tracks PAS 2080, SDG v4 and MKI; contract-layer mechanisms can be documented without a rating tool
P3 Leadership anchoring	A2 present for Singapore and the Netherlands, both with procurement mechanisms present	Consistent where documented	Two cases; counterfactual unobserved
P4 Strategy–contract gap	Contract-layer absence: none; contract-layer undocumented: Dubai (three of four cells), London (four of four), Abu Dhabi (four of four)	Restated	The gap manifests as non-documentation of the contract layer where strategy is documented
P5 Disclosure depth	D3 present: Dubai; D3 absent: Singapore; D4	Not consistent	Assurance and asset- or project-level disclosure vary

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	present: Singapore, Abu Dhabi; D2 present: Singapore, Netherlands		independently; reformulated for future work as two dimensions

Limitations

Although thirty-seven of ninety-six cells have been documented, only the Netherlands has reached the ten-cell floor, so here one maturity level has been assigned and five authorities have been reported as documented profiles rather than ranked according to their scores. Second coding of the matrix for the purpose of checking and improving the quality of the register has been done for a 25% stratified sample of all cells ($\alpha = 0.92$). It goes without saying that the register for Sustainability Commitments of Road and Transport Authorities can be extended by any reader. With respect to the rule codes: scope exclusions are counted as absent; silence is not counted as documented as opposed to explicit texts of authorities such as Dubai and Singapore that carry documented absences. Raw and embedding scores of authorities that have been coded for scope are reported side by side in order to make the effect of scope silence visible. A fourth coding state for scope silence is proposed for future work. Internal texts that are written in Arabic only have not been accessible. The rubric used for coding has not been weighted. Its construct validity has been checked by means of standards anchoring instead of by means of an empirical test. No statistical inference has been applied or implied.

Conclusion

So how far have the RTA's sustainability commitments from operations translated into the road and bridge program? Based on what is available on public record, the sustainability commitments of the RTA have traveled as far as the organization's policies and practices but not yet into the assets that are being managed by the organization. The RTA has assured reporting, a certified procurement standard, a project waste target as well as national alignment. However, the RTA does not have any public documentation that sets out a specific sustainability target for road and bridge assets on a particular date, a capital carbon baseline for infrastructure works, a requirement for whole life carbon assessment at the design stage, or even a carbon weight to be used in tender evaluation. However, authorities that have these documented mechanisms have typically adopted a particular instrument or published a rule that makes the mechanism observable. Thus the gap identified here is specific and instrumental and therefore amenable to future research that investigates whether or not filling these documentary gaps could translate into lower embodied carbon for individual projects.

In terms of implications for policy and practice, seeing the absent or undocumented cells for Dubai in the rubric above first and foremost suggests a number of potential steps to sustain an existing commitment to sustainability in road and bridge design and delivery. These potential steps in terms of implications for policy and practice are laid out in the box above. Six cells are needed to be documented in relation to Dubai (all of which would be in relation to a strategy

chapter for infrastructure assets with a capital-carbon baseline year and reduction trajectory, A1, B2). If documentable, these could be structured along the lines of PAS 2080 clauses 5–8 (relating to setting and management of targets and baseline). Four of the missing cells could be addressed by requiring whole-life carbon assessment at design above a capital threshold (of say DIR 2018's AUD $7.4 million), with a project baseline and minimum reduction; this would model Transport for NSW's compulsory requirement for whole-life carbon assessment at design for all road construction projects above this threshold (B1). Three further cells would be addressable by documenting a published, weighted sustainability criterion in tender evaluation (C1). One further cell would be addressable by documenting recycled-content and low-carbon material provisions in road works specifications (C2). And the final ten undocumented cells could be documented by setting out asset-level indicators in the assured report (D2). Further, publication of the design manuals, specifications and tender guidance that govern road and bridge delivery would allow for the ten undocumented cells to be coded against the seven documented cells and a maturity level assigned for Dubai.

This work may be continued in two ways. A project-level study may test the propositions as hypotheses on project-level data, using the documented design and procurement mechanisms as independent variables and the embodied carbon per lane-kilometer and the recycled content as the dependent variables. The controls to be used would be the project type, size, year of implementation and the contractor's tier. The number of predictors would be six and the required type I error probability would be 0.05. The required power would be 0.80 and the medium effect size of 0.25 would require 98 projects. Based on Dubai's plans for the road and bridge programs for the period 2024–2029, sufficient data would exist to test the above hypotheses. The second track of work would be the development of instruments. The matrix could be fully double coded and a weighted version of the rubric could

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be developed through expert elicitation. A fourth coding state for silence within scope could be developed and the future application of the sustainability profiles to other authorities could be investigated.

References

Abu Dhabi City Municipality, & United Arab Emirates University RTTSRC. (2017). Assessing the carbon footprint of road projects and related sustainability initiatives in Abu Dhabi: Technical report II. Abu Dhabi City Municipality.

Arif, M., & Aldosary, A. S. (2023). Urban spatial strategies of the Gulf Cooperation Council: A comparative analysis and lessons learned. Sustainability, 15(18), 13344. https://doi.org/10.3390/su151813344

Bansal, P., & Roth, K. (2000). Why companies go green: A model of ecological responsiveness. Academy of Management Journal, 43(4), 717–736. https://doi.org/10.5465/1556363

Berrone, P., Fosfuri, A., Gelabert, L., & Gomez-Mejia, L. R. (2013). Necessity as the mother of 'green' inventions: Institutional pressures and environmental innovations. Strategic Management Journal, 34(8), 891–909. https://doi.org/10.1002/smj.2041

Blaauw, S. A., Maina, J. W., & Mturi, G. A. J. (2022). Flexible pavement performance and life cycle assessment incorporating climate change impacts. Transportation Research Part D: Transport and Environment, 104, 103203. https://doi.org/10.1016/j.trd.2022.103203

Bocchini, P., Frangopol, D. M., Ummenhofer, T., & Zinke, T. (2014). Resilience and sustainability of civil infrastructure: Toward a unified approach. Journal of Infrastructure Systems, 20(2). https://doi.org/10.1061/(ASCE)IS.1943-555X.0000177

Bowen, G. A. (2009). Document analysis as a qualitative research method.

Qualitative Research Journal, 9(2), 27–40. https://doi.org/10.3316/QRJ0902027

Brammer, S., & Walker, H. (2011). Sustainable procurement in the public sector: An international comparative study. International Journal of Operations & Production Management, 31(4), 452–476. https://doi.org/10.1108/01443571111119551

British Standards Institution. (2023). PAS 2080:2023 Carbon management in buildings and infrastructure. BSI.

Bueno, P. C., Vassallo, J. M., & Cheung, K. (2015). Sustainability assessment of transport infrastructure projects: A review of existing tools and methods. Transport Reviews, 35(5), 622–649. https://doi.org/10.1080/01441647.2015.1041435

Building Research Establishment. (2022). BREEAM Infrastructure Version 6: Technical manual. BRE.

Chinowsky, P., Schweikert, A., Strzepek, N., Manahan, K., Strzepek, K., & Schlosser,

C. A. (2013). Climate change adaptation advantage for African road infrastructure.

Climatic Change, 117(1–2), 345–361. https://doi.org/10.1007/s10584-012-0536-z

Construction Leadership Council. (2024, April). Five Client Carbon Commitments: Setting a path to net zero construction. Construction Leadership Council. https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2024/04/Five-Client-Carbon-Commitments-29.04.24.pdf

Correia, E., Carvalho, H., Azevedo, S. G., & Govindan, K. (2017). Maturity models in supply chain sustainability: A systematic literature review. Sustainability, 9(1), 64. https://doi.org/10.3390/su9010064

De Wolf, C., Pomponi, F., & Moncaster, A. (2017). Measuring embodied carbon dioxide equivalent of buildings: A review and critique of current industry practice. Energy and Buildings, 140, 68–80. https://doi.org/10.1016/j.enbuild.2017.01.075

Delmas, M. A., & Toffel, M. W. (2004). Stakeholders and environmental management practices: An institutional framework. Business Strategy and the Environment, 13(4), 209–222. https://doi.org/10.1002/bse.409

DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. American Sociological Review, 48(2), 147–160. https://doi.org/10.2307/2095101

Du, G., Safi, M., Pettersson, L., & Karoumi, R. (2014). Life cycle assessment as a decision support tool for bridge procurement: Environmental impact comparison among five bridge designs. International Journal of Life Cycle Assessment, 19(12), 1948–1964. https://doi.org/10.1007/s11367-014-0797-z

Dumay, J., Guthrie, J., & Farneti, F. (2010). GRI sustainability reporting guidelines for public and third sector organizations. Public Management Review, 12(4), 531–

548. https://doi.org/10.1080/14719037.2010.496266

European Committee for Standardization. (2011). EN 15978:2011 Sustainability of construction works — Assessment of environmental performance of buildings — Calculation method. CEN.

Fenner, R. A., & Ryce, T. (2008). A comparative analysis of two building rating systems Part 1: Evaluation. Proceedings of the Institution of Civil Engineers – Engineering Sustainability, 161(1), 55–63. https://doi.org/10.1680/ensu.2008.161.1.55

Giesekam, J., Barrett, J. R., & Taylor, P. (2016). Construction sector views on low carbon building materials. Building Research & Information, 44(4), 423–444. https://doi.org/10.1080/09613218.2016.1086872

Giesekam, J., Tingley, D. D., & Cotton, I. (2018). Aligning carbon targets for construction with (inter)national climate change mitigation commitments. Energy and Buildings, 165, 106–117. https://doi.org/10.1016/j.enbuild.2018.01.023

Global Reporting Initiative. (2021). GRI Universal Standards 2021; GRI 305:

Emissions 2016; GRI 306: Waste 2020. GRI.

Government of Dubai Media Office. (2023, May 28). RTA rolls out strategy to transition to zero-emissions operations by 2050. https://mediaoffice.ae/en/news/2023/May/28-05/RTA-rolls-out-strategy-to-transition-to-zero

Government of Dubai Media Office. (2024, November 3). Hamdan bin Mohammed reviews RTA's AED16 billion 2024–2027 Main Roads Development Plan. https://mediaoffice.ae/en/news/2024/november/03-11/hamdan-bin-mohammed-reviews-rta-aed16-billion-2024-2027-main-roads-development-plan

Griffiths, K., Boyle, C., & Henning, T. F. P. (2018). Beyond the certification badge—How infrastructure sustainability rating tools impact on individual, organizational, and industry practice. Sustainability, 10(4), 1038. https://doi.org/10.3390/su10041038

Gámez-García, D. C., Saldaña-Márquez, H., Gómez-Soberón, J. M., Corral-Higuera, R., & Arredondo-Rea, S. P. (2019). Life cycle assessment of residential streets from the perspective of favoring the human scale and reducing motorized traffic flow. Sustainable Cities and Society, 44, 332–342. https://doi.org/10.1016/j.scs.2018.10.018

Hoffman, A. J. (1999). Institutional evolution and change: Environmentalism and the

U.S. chemical industry. Academy of Management Journal, 42(4), 351–371. https://doi.org/10.5465/257008

Infrastructure Sustainability Council. (2021). IS Rating Scheme v2.1: Technical manual. ISC.

Institute for Sustainable Infrastructure. (2018). Envision: Sustainable infrastructure framework guidance manual, version 3. ISI.

International Auditing and Assurance Standards Board. (2013). ISAE 3000 (Revised): Assurance engagements other than audits or reviews of historical financial information. IFAC.

International Organization for Standardization. (2015). ISO 14001:2015 Environmental management systems — Requirements with guidance for use. ISO.

International Organization for Standardization. (2017). ISO 20400:2017 Sustainable procurement — Guidance. ISO.

International Organization for Standardization. (2018). ISO 37120:2018 Sustainable cities and communities — Indicators for city services and quality of life. ISO.

Jennings, P. D., & Zandbergen, P. A. (1995). Ecologically sustainable organizations: An institutional approach. Academy of Management Review, 20(4), 1015–1052. https://doi.org/10.5465/amr.1995.9512280034

Karlsson, I., Rootzén, J., Toktarova, A., Odenberger, M., Johnsson, F., & Göransson,

L. (2020). Roadmap for decarbonization of the building and construction industry—A supply chain analysis including primary production of steel and cement. Energies, 13(16), 4136. https://doi.org/10.3390/en13164136

Krippendorff, K. (2019). Content analysis: An introduction to its methodology (4th ed.). SAGE.

Land Transport Authority. (2024). Sustainability report 2023/24. LTA Singapore. https://www.lta.gov.sg/content/dam/ltagov/who_we_are/statistics_and_publications/re port/pdf/LTA_SR2324.pdf

Liu, Y., van Nederveen, S., Wu, C., & Hertogh, M. (2018). Sustainable infrastructure design framework through integration of rating systems and building information

modeling. Advances in Civil Engineering, 2018, 8183536. https://doi.org/10.1155/2018/8183536

Lozano, R. (2015). A holistic perspective on corporate sustainability drivers. Corporate Social Responsibility and Environmental Management, 22(1), 32–44. https://doi.org/10.1002/csr.1325

Manidaki, M., & Pantelidou, H. (2022). UK PAS 2080 carbon management standard updated in response to net-zero challenge. Proceedings of the Institution of Civil Engineers – Civil Engineering, 175(2), 54. https://doi.org/10.1680/jcien.2022.175.2.54

McAlinden, B. (2016). PAS 2080: World first specification for cutting carbon dioxide emissions in infrastructure. Proceedings of the Institution of Civil Engineers – Civil Engineering, 169(3), 99. https://doi.org/10.1680/jcien.2016.169.3.99

Meehan, J., & Bryde, D. (2011). Sustainable procurement practice. Business Strategy and the Environment, 20(2), 94–106. https://doi.org/10.1002/bse.678

NSW Legislative Council. (n.d.). Answers to questions on notice: Transport for NSW (Budget Estimates). https://parliament.nsw.gov.au/lcdocs/other/19979/

OECD. (2018). Climate-resilient infrastructure (OECD Environment Policy Paper No. 14). OECD Publishing. https://doi.org/10.1787/4fdf9eaf-en

Penadés-Plà, V., Martí, J. V., García-Segura, T., & Yepes, V. (2017). Life-cycle assessment: A comparison between two optimal post-tensioned concrete box-girder road bridges. Sustainability, 9(10), 1864. https://doi.org/10.3390/su9101864

Pomponi, F., & Moncaster, A. (2016). Embodied carbon mitigation and reduction in the built environment – What does the evidence say? Journal of Environmental Management, 181, 687–700. https://doi.org/10.1016/j.jenvman.2016.08.036

Rijkswaterstaat, Copper8, & Witteveen+Bos. (2023b, December 1). Inkopen met MKI in de GWW: Evaluatie en actie-agenda. https://open.rijkswaterstaat.nl/@269293/inkopen-mki-gww-evaluatie-actie-agenda

Rijkswaterstaat. (2023a, November 7). Rijkswaterstaat scoort top 5-positie in ranglijst duurzame aanbesteders [News release]. https://www.rijkswaterstaat.nl/nieuws/archief/2023/11/rijkswaterstaat-scoort-top-5-positie-in-ranglijst-duurzame-aanbesteders

Rijkswaterstaat. (2023c). Kennisdossier materialen 2023. https://open.rws.nl/publish/pages/193496/kennisdossier_materialen_2023.pdf

Rijkswaterstaat. (n.d.). Circulaire economie. https://www.rijkswaterstaat.nl/leefomgeving/duurzaam-werken/circulaire-economie

Rijkswaterstaat. (n.d.). DuboCalc. https://www.rijkswaterstaat.nl/zakelijk/zakendoen-met-rijkswaterstaat/inkoopbeleid/duurzaam-inkopen/dubocalc

Rijkswaterstaat. (n.d.). Klimaatneutraal werken in 2030. https://www.rijkswaterstaat.nl/leefomgeving/duurzaam-werken/klimaatneutraal-werken-in-2030

Roads and Transport Authority. (2018, March 18). First sustainability report for public transport, roads sector based on new standards [Press release]. RTA Dubai.

Roads and Transport Authority. (2021, January 4). RTA releases its annual environmental sustainability report conforming to GRI Standards [Press release]. RTA Dubai.

Roads and Transport Authority. (2022, April 17). RTA endorses five-year sustainability plan 2021–2025 [Press release]. RTA Dubai. https://www.rta.ae/wps/portal/rta/ae/home/news-and-media/all-news/NewsDetails/rta-endorses-5-year-sustainability-plan-2021-2025

Roads and Transport Authority. (2025, January 20). Sustainability Framework featuring three pillars relating to environment, economy, and society [Press release]. RTA Dubai. https://www.rta.ae/wps/portal/rta/ae/home/news-and-media/all-news/NewsDetails/the-framework-features-three-pillars-relating-to-environment-economy-and-society

Röck, M., Saade, M. R. M., Balouktsi, M., Rasmussen, F. N., Birgisdottir, H., Frischknecht, R., Habert, G., Lützkendorf, T., & Passer, A. (2020). Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy, 258, 114107. https://doi.org/10.1016/j.apenergy.2019.114107

Sadar Din, K. M., & Ishak, M. S. B. (2024). Sustainable building construction materials in the United Arab Emirates: A review. Sustainability, 16(15), 6565. https://doi.org/10.3390/su16156565

Santero, N. J., Masanet, E., & Horvath, A. (2011). Life-cycle assessment of pavements. Part I: Critical review. Resources, Conservation and Recycling, 55(9–10), 801–809. https://doi.org/10.1016/j.resconrec.2011.03.010

Saradara, S. M., Khalfan, M. M. A., Rauf, A., & others. (2023). On the path towards sustainable construction—The case of the United Arab Emirates: A review.

Sustainability, 15(19), 14652. https://doi.org/10.3390/su151914652

Scott, W. R. (2014). Institutions and organizations: Ideas, interests, and identities (4th ed.). SAGE.

Scrivener, K. L., John, V. M., & Gartner, E. M. (2018). Eco-efficient cements: Potential economically viable solutions for a low-CO_2 cement-based materials industry. Cement and Concrete Research, 114, 2–26. https://doi.org/10.1016/j.cemconres.2018.03.015

Sourani, A. (2011). Barriers to addressing sustainable construction in public procurement strategies. Proceedings of the Institution of Civil Engineers – Engineering Sustainability, 164(4), 229–237. https://doi.org/10.1680/ensu.2011.164.4.229

Testa, F., Annunziata, E., Iraldo, F., & Frey, M. (2016). Drawbacks and opportunities of green public procurement: An effective tool for sustainable production. Journal of Cleaner Production, 112, 1893–1900. https://doi.org/10.1016/j.jclepro.2014.09.092

Thacker, S., Adshead, D., Fay, M., Hallegatte, S., Harvey, M., Meller, H., O'Regan, N., Rozenberg, J., Watkins, G., & Hall, J. W. (2019). Infrastructure for sustainable development. Nature Sustainability, 2(4), 324–331. https://doi.org/10.1038/s41893-019-0256-8

Tolbert, P. S., & Zucker, L. G. (1983). Institutional sources of change in the formal structure of organizations: The diffusion of civil service reform, 1880–1935. Administrative Science Quarterly, 28(1), 22–39. https://doi.org/10.2307/2392383

Transport for London. (2022, November 16). Corporate Environment Plan: Update (Safety, Sustainability and Human Resources Panel paper). https://board.tfl.gov.uk/documents/s18939/

Transport for London. (2025, December 4). Sustainability report, Quarter 2 2025/26 (Customer Service and Operational Performance Panel paper, Appendix 2). https://board.tfl.gov.uk/documents/s25405/csop20251204-item08c-part1-Appendix%202-Sustanability.pdf

Transport for NSW. (2019). Sustainable Design Guidelines version 4.0: Supporting tools document (ST 146). https://www.transport.nsw.gov.au/system/files/media/documents/2019/Planning-Environment-Sustainability-TfNSW-Sustainable-Design-Guidelines-Supporting-Tools-Document-ST-146.pdf

Transport for NSW. (2022, April). Reclaimed asphalt pavement (Environment and Sustainability fact sheet EMF-WM-FS-0051). https://www.transport.nsw.gov.au/system/files/media/documents/2023/env-fact-sheet-efs-707-reclaimed-asphalt-pavement.pdf

Transport for NSW. (2023). Net zero and climate change policy. https://www.transport.nsw.gov.au/system/files/media/documents/2025/net-zero-and-climate-change-policy.pdf

Uttam, K., & Le Lann Roos, C. (2015). Competitive dialogue procedure for sustainable public procurement. Journal of Cleaner Production, 86, 403–416. https://doi.org/10.1016/j.jclepro.2014.08.031

Walker, H., & Brammer, S. (2009). Sustainable procurement in the United Kingdom public sector. Supply Chain Management: An International Journal, 14(2), 128–137. https://doi.org/10.1108/13598540910941993

WAM. (2021, October 5). RTA releases 6th Sustainability Report 2020. Emirates News Agency. https://wam.ae/en/details/1395302977338

WAM. (2025, June 13). RTA achieves 55% green conversion of staff-use vehicles. Emirates News Agency. https://www.wam.ae/en/article/bk60blg-rta-achieves-55-green-conversion-staff-use

Willetts, R., Burdon, J., Glass, J., & Frost, M. (2010). Fostering sustainability in infrastructure development schemes. Proceedings of the Institution of Civil Engineers – Engineering Sustainability, 163(3), 159–166. https://doi.org/10.1680/ensu.2010.163.3.159

Yang, S.-H., & Liu, J. Y. H. (2018). Multi-criteria life cycle approach to develop weighting of sustainability indicators for pavement. Sustainability, 10(7), 2325. https://doi.org/10.3390/su10072325

Yin, R. K. (2018). Case study research and applications: Design and methods (6th ed.). SAGE.

Zastrow, P., Molina-Moreno, F., García-Segura, T., Martí, J. V., & Yepes, V. (2017). Life cycle assessment of cost-optimized buttress earth-retaining walls: A parametric study. Journal of Cleaner Production, 140, 1037–1048. https://doi.org/10.1016/j.jclepro.2016.10.085

Zaumanis, M., Mallick, R. B., & Frank, R. (2014). 100% recycled hot mix asphalt: A review and analysis. Resources, Conservation and Recycling, 92, 230–245. https://doi.org/10.1016/j.resconrec.2014.07.007