Mapping the Evidence on Integrated Governance, Risk, and Compliance (GRC) Frameworks in Infrastructure Development Organizations: A Scoping Review (2015–2025)

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Abstract: *Background. Infrastructure is uniquely consequential: its assets are capital-intensive, long-lived, safety-critical, and publicly accountable, so failures of governance, risk management, or compliance in the organizations that deliver it are borne by whole societies through megaproject overruns, corruption scandals, regulatory breaches, and unmet sustainability commitments. Yet these three functions are usually run separately, under separate standards. Their integration is widely advocated, invoked under many inconsistent labels, and has never been mapped for this sector.*

Objective. To map the extent, nature, and distribution of the evidence on integrated governance, risk, and compliance (GRC) frameworks in infrastructure development organizations over 2015–2025, and to identify how integration is conceptualised, which frameworks and standards are used, what enables or obstructs implementation, and what gaps remain.

Methods. The review followed established scoping review methodology and is reported against the PRISMA extension for scoping reviews. Eligibility used a Population–Concept–Context frame with integrated GRC as an umbrella construct. Scopus was searched on 25 October 2026; records were screened in two stages and charted on setting, sector, design, GRC dimensions, framework or standard, and the locus of integration.

Results. Thirty-nine of 215 records met eligibility, spanning fourteen countries. The evidence is dominated by construction firms (22 studies) and by enterprise risk management, with a marked rise after 2022. Integration attaches to five distinct loci: the enterprise risk process, the project lifecycle, the conduct of organizational actors, the management-control and information architecture, and institutional oversight. Only five studies addressed governance, risk, and compliance together, and none evaluated an integrated framework empirically. Apparent disagreement over whether regulation enables or impedes integration dissolves once the commitment to adopt is separated from the capacity to implement.

Conclusions. Integrated GRC is a recognised but under-specified aspiration in infrastructure organizations, and the evidence is contractor-centred, cross-sectional, and almost devoid of outcome evaluation. Theoretically, the review

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links its findings to institutional, legitimacy, resource-based, and dynamic-capabilities perspectives and proposes that integrated GRC is best understood not as a compliance function but as a dynamic governance capability that strengthens organizational resilience and infrastructure delivery performance.

Keywords: Governance, Risk and Compliance; Enterprise Risk Management; Compliance Governance; Project Governance; Infrastructure Development; Megaprojects

Introduction

Infrastructure development organizations plan, finance, deliver, and operate the assets on which economies depend: roads, rail, ports, airports, water systems, and energy networks. They include public works agencies, state-owned enterprises, utilities, port and airport operators, developers, and the large contractors that build on their behalf. Their capital programmes are costly, long-lived, technically complex, and politically exposed, and megaprojects in particular are prone to cost overruns, schedule slippage, and benefit shortfalls that recur across sectors and countries [1]. Controlling these exposures is therefore a central managerial and public-policy objective.

Infrastructure differs from most other organizational settings in ways that make governance, risk, and compliance unusually consequential. Its assets are capital-intensive and long-lived, so decisions taken at the front end lock in costs and risks for decades. They are frequently natural monopolies or essential services, financed or guaranteed by the state, so failures are borne by taxpayers and service users rather than by shareholders alone. Delivery is project-based and multi-party, spreading accountability across owners, financiers, contractors, and regulators. And the work is safety-critical, heavily regulated, and politically visible. Together, these features mean that a weakness in any one function quickly becomes a weakness in the whole delivery system.

The practical stakes are correspondingly high. Megaproject failures are the rule rather than the exception: nine out of ten megaprojects overrun their budgets, and cost overruns of 50% or more in real terms are common [1]. Governance scandals and compliance breaches compound these losses. In the largest foreign-bribery case on record, a construction and engineering conglomerate and its petrochemical affiliate agreed to pay at least US$3.5 billion in global penalties after paying hundreds of millions of dollars in bribes across three continents to win business [2]. At the same time, ESG pressures and sustainability requirements are expanding the obligations that infrastructure organizations must govern, from investor-facing ESG frameworks in water utilities [3] and sustainability-aligned risk management in construction [4] to the expectation that megaprojects contribute to the Sustainable Development Goals [5] and secure a social licence to operate in host communities [6]. Fragmented governance, risk, and compliance arrangements are poorly suited to this combination of financial, ethical, regulatory, and sustainability exposure.

Three organizational functions carry most of that burden. Governance sets direction, allocates decision rights, and holds managers to account; risk management identifies and treats the uncertainties that threaten objectives; and compliance ensures that the organization meets its legal, regulatory, and ethical obligations. Each has developed its own body of practice and its own reference standards, notably the COSO framework for enterprise risk management [7], ISO 31000 for risk management [8], and ISO 37301 for compliance management systems [9]. In practice, the three functions often sit in separate units, report through separate lines, and rely on separate registers, assurance activities, and information systems.

Integrated governance, risk, and compliance (GRC) addresses this fragmentation. In the most widely cited definition, integrated GRC is a holistic approach that ensures an organization acts ethically and in accordance with its risk appetite, internal policies, and external regulations, through the alignment of strategy, processes, technology, and people [10]. The promise is a single, coordinated capability that reduces duplication, closes gaps between functions, and gives decision-makers a coherent view of the uncertainties and obligations attached to each decision. The concept is well established in financial services and information technology, but how far, and in what form, it has reached infrastructure development organizations remains unclear.

For all its evident relevance, integration lacks a settled name in the infrastructure literature. It surfaces under a shifting vocabulary: “enterprise risk management”, “risk governance”, “integrated governance”, “project governance”, “compliance governance”, “combined assurance”, and “ESG governance”, each carrying its own definition, unit of analysis, and disciplinary home. Studies are dispersed across construction management, accounting and management control, systems engineering, planning, and law. This terminological fragmentation obscures cumulative understanding: findings are hard to compare across studies, and it is unclear whether these labels describe a single phenomenon or several related ones.

Existing syntheses do not resolve the problem. Renault et al. [11] reviewed the drivers of and obstacles to enterprise risk management in construction firms; Al Qudah et al. [12] mapped 676 publications on construction risk management and identified enterprise risk management as one of three research clusters; Clements et al. [13] reviewed infrastructure governance across sectors and identified the understanding and application of integrated governance as a gap; and Halder and Batra [14] mapped ethical discourse in construction, including compliance and ESG. Each addresses one function or one sector of the problem. None examines the integration of governance, risk, and compliance as an object of synthesis, and none is specific to infrastructure development organizations as a population. Integrated GRC consequently appears in the review literature as an aspiration or a passing reference rather than as a mapped body of evidence. That is the gap the present review sets out to address.

The review also makes a theoretical contribution. Beyond mapping the evidence, it interprets the findings through four established organizational perspectives: institutional theory [15], legitimacy theory [16], the resource-based view [17], and dynamic capabilities [18]. Together these explain why infrastructure organizations commit to integration, why many struggle to implement it, and how successful integration occurs. On this basis the review proposes a five-

locus framework of GRC integration and reconceptualises integrated GRC as a dynamic governance capability rather than a compliance function.

This scoping review was accordingly conducted to map and synthesise the existing evidence on integrated GRC frameworks in infrastructure development organizations over the decade 2015–2025. It pursued five objectives: (a) to map the existing literature on governance, risk, and compliance integration in these organizations; (b) to identify how integration is defined and conceptualised, and the loci at which it occurs; (c) to identify the frameworks, standards, and implementation approaches reported; (d) to examine the factors that enable or obstruct implementation; and (e) to identify research gaps and recommend priorities for future research, policy, and practice.

These objectives are addressed through one main research question, "What is the nature and extent of the evidence on integrated governance, risk, and compliance (GRC) frameworks in infrastructure development organizations between 2015 and 2025?", and four sub-questions:

RQ1: How is integrated GRC defined and conceptualised in infrastructure development organizations, and at what organizational loci does integration occur?

RQ2: What frameworks, standards, and implementation approaches have been proposed or applied?

RQ3: What organizational, regulatory, and contextual factors enable or obstruct the implementation of integrated GRC?

RQ4: What are the major research trends, evidence gaps, and future research priorities?

Materials and Methods

2.1 Design and reporting

This study is a scoping review, conducted in line with the methodological framework of Arksey and O'Malley [19], strengthened by the recommendations of Levac et al. [20] and the guidance of the Joanna Briggs Institute [21]. A scoping design was chosen because the aim was to map the extent, range, and nature of the evidence and to expose its gaps, rather than to estimate a pooled effect or answer a single narrowly framed question [22]. The review also draws the findings together in a narrative and thematic synthesis, so as to bring out the patterns and gaps in the literature and to support conclusions relevant to policy and practice. Reporting follows the PRISMA-ScR checklist [23], and the selection process is presented using the PRISMA 2020 flow-diagram format [24].

The data charted in this review are drawn from the published studies cited. The screening log, with the decision and coded reason for every record, and the data-charting form for the included studies are provided as Supplementary File S1; the completed PRISMA-ScR checklist is provided as Supplementary File S2. No other data were generated or analysed.

2.2 Eligibility criteria (Population–Concept–Context)

Eligibility criteria were established using the Population–Concept–Context (PCC) framework to ensure a systematic and transparent study selection process. The population comprised infrastructure development organizations involved in the planning, financing, delivery,

operation, or management of physical infrastructure. These included public agencies and authorities, state-owned enterprises, utilities, port and airport operators, developers, contractors, and organizations responsible for major capital projects and megaprojects.

The concept of interest was integrated governance, risk, and compliance (GRC), broadly defined to encompass studies examining the coordination or integration of governance, risk management, and compliance functions at organizational, project, or sectoral levels. Eligible studies included those addressing integrated GRC frameworks, enterprise risk management linked to governance and compliance, risk governance, project and megaproject governance incorporating risk or compliance dimensions, and compliance governance systems. To capture the diverse terminology used across the literature, studies were included when they examined at least two of the three GRC functions in an integrated manner or when a single function was explicitly embedded within an enterprise-wide or organization-wide management system.
The context covered the planning, delivery, operation, and oversight of physical infrastructure across sectors such as construction, transportation, water, energy, and other infrastructure-intensive industries. Studies conducted at enterprise, project, programme, or sector levels were eligible, including those with national, multi-country, or global perspectives, provided that the population criterion was satisfied.

To ensure methodological quality and relevance, only peer-reviewed journal articles, review papers, and conference proceedings published in English between 2015 and 2025 were considered. The detailed inclusion and exclusion criteria applied during title, abstract, and eligibility screening are presented in Table 1.

Table 1

Inclusion and exclusion criteria based on the Population–Concept–Context (PCC) framework

Phase / dimension	Criteria
Title/abstract screening (inclusion)	Peer-reviewed journal article, review, or conference paper; addresses governance, risk management, and/or compliance in an organizational setting; concerns physical infrastructure or construction; published 2015–2025 in English.
Eligibility assessment (inclusion)	Population is an infrastructure development organization (public agency, state-owned enterprise, utility, port or airport operator, developer, contractor, or capital-project owner); at least two GRC functions examined together, or one examined as part of an enterprise-wide or integrated system; study reports a framework, model, practice, or empirical finding relevant to integration.
Exclusion	E1: organization has no infrastructure-delivery role (e.g., banks, hospitals, universities, agriculture). E2: no governance, risk, or compliance dimension (purely technical, political, or environmental analysis). E3: “infrastructure” used only in the IT, data, or digital sense (cloud, blockchain, AI infrastructure). E4: no abstract, editorials, books, and book chapters; duplicates.

Note. Exclusion codes E1–E4 were assigned to every excluded record and are reported with the screening log in Supplementary File S1.

2.3 Search strategy

Search terms were derived from the review objectives and the PCC framework and organised into two conceptual blocks: (i) governance, risk, and compliance terms; and (ii) infrastructure and construction-organization terms. Within each block, synonyms and spelling variants were combined with OR, and the two blocks were joined with AND, so that a retrieved record had to address both a GRC function and an infrastructure or construction setting. A proximity operator (governance W/5 complian*) was used to capture studies that discuss governance and compliance together without using the GRC label. The terms were tested and refined iteratively before the strategy was fixed.

The search was conducted in Scopus. Methodological guidance for scoping reviews does not prescribe a fixed number of databases; rather, it asks that the search be as comprehensive as is feasible and, above all, transparent and reproducible [20, 21, 23]. Scopus was chosen as the single source because of its broad multidisciplinary indexing of the engineering, construction management, accounting, and public administration literatures on which this topic draws. Reliance on one database and on English-language, peer-reviewed sources is acknowledged as a limitation (Section 4.6), where adding a second database and supplementary citation searching are identified as priorities for future updates.

The search was restricted to the decade 2015–2025, which spans the publication of the current editions of the principal reference standards for enterprise risk management and compliance [7–9] and keeps the review current. The search was run on 25 October 2026. The full Scopus string and the applied filters are given in Appendix A (Table A1).

2.4 Screening and data charting

Screening followed the two-stage PRISMA-ScR process. All 215 records were exported from Scopus with citation details, affiliations, abstracts, and keywords into a screening log (Supplementary File S1), and one duplicate was removed.

Stage 1: title and abstract screening. Both authors (A.A. and I.R.E.) independently screened the titles, abstracts, and keywords of all 214 remaining records against the criteria in Table 1. To support consistency across a large and terminologically diverse set of records, an AI tool (Claude, Anthropic) was used to generate preliminary include, exclude, or uncertain suggestions with a coded reason for each record; these suggestions were advisory only, and every decision was made by the reviewers against the published criteria. Each excluded record was assigned one coded reason (E1–E4) so that the basis of every exclusion is auditable. Records that clearly met the criteria were retained, and records whose eligibility could not be determined from the title and abstract were classified as uncertain and carried forward.

Stage 2: eligibility assessment. The 45 retained and uncertain records were then assessed in detail against the population and concept criteria. Each record was checked for whether the organization studied had an infrastructure-delivery role and whether at least two GRC functions

were examined together or one was embedded in an enterprise-wide system. Six records were excluded at this stage, each with a coded reason, and 39 were included.

Validation and resolution of disagreements. Both authors screened all records independently against the criteria in Table 1 and then compared their decisions. Disagreements were resolved through discussion until consensus was reached, and the agreed decision and reason were recorded in the screening log. The completed log, with the stage, decision, and coded reason for every record, is provided in Supplementary File S1 so that each decision can be audited.
Data were charted on a structured template capturing bibliographic details; country or setting; organization type and infrastructure sector; study design and analytic method; the GRC functions examined (governance, risk, compliance); any framework, standard, or theory used; key findings; and author-stated gaps. The flow of records is reported in a PRISMA-ScR flow diagram in Section 3.1, and the full characteristics of the included studies appear in Appendix B (Table B1).

The locus of integration was coded in two steps. First, each study's treatment of governance, risk, and compliance was coded inductively into descriptive categories of what was being integrated and how. Second, these categories were grouped into higher-order loci on a single organising criterion: what the integration attaches to. Five loci emerged: the enterprise-wide risk process; the project lifecycle and the investment decisions taken within it; the conduct of organizational actors; the management-control and information architecture; and institutional and sector-level oversight. Each study was assigned to one primary locus.

Four simplifications were made in charting and are stated here so that the mapping can be interpreted accordingly. First, each study was assigned to a single primary locus and a single primary sector, although several touched more than one. Second, heterogeneously labelled constructs (enterprise risk management, risk governance, compliance governance, and others) were mapped onto the single umbrella construct of integrated GRC, which enables comparison but necessarily aggregates concepts that the primary studies treated as distinct. Third, a study was coded as addressing all three GRC functions only where governance, risk, and compliance were each examined as a substantive element rather than mentioned in passing. Fourth, where a framework or standard was not named in the abstract, it was charted as not reported; charting was based on titles, abstracts, keywords, and bibliographic metadata.

2.5 Methodological quality appraisal

Consistent with JBI guidance for scoping reviews, no formal critical appraisal of the included studies was undertaken, because the purpose of the review was to map the extent and nature of the evidence rather than to weight or pool findings [21, 22]. Study design is nevertheless charted for every included study (Appendix B), so that the strength of the evidence base can be characterised descriptively in Section 3.2 and taken into account in the interpretation offered in Section 4.

Results

3.1 Study selection

The structured search of Scopus returned 215 records. Before screening, one duplicate, a conference version of a journal study, was removed, leaving 214. These were screened by title, abstract, and keywords, and 169 were excluded: 90 because "infrastructure" was used only in the IT, data, or digital sense (E3), 42 because the organization had no infrastructure-delivery role (E1), 36 because the study had no governance, risk, or compliance dimension (E2), and 1 for having no abstract (E4). The remaining 45 records were assessed for eligibility, and a further six were excluded: three had no GRC dimension (a political analysis of a water-transfer megaproject, a teaching study, and a technical natural-hazard assessment), two concerned organizations outside the population, and one addressed operational-technology cybersecurity rather than organizational GRC. Thirty-nine studies were therefore included. Their full characteristics appear in Appendix B (Table B1), and the selection process is summarised in the PRISMA-ScR flow diagram (Fig. 1).

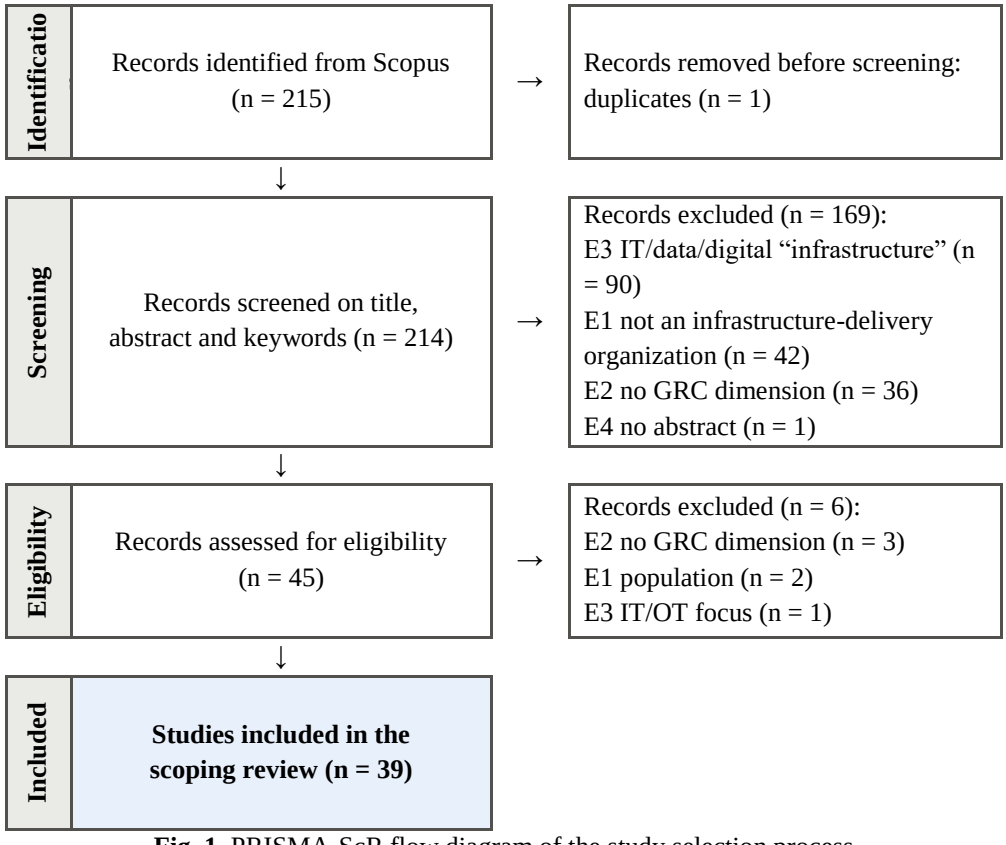


Fig. 1. PRISMA-ScR flow diagram of the study selection process

The size of the corpus is itself a result, and is reported here with its denominator. Of the 214 records screened, 90, or 42%, were retrieved only because of the IT sense of "infrastructure", and only 45 combined an infrastructure organization with a governance, risk, or compliance

focus. Thirty-nine studies over a full decade is a modest evidence base for a sector that commits a substantial share of public capital and in which governance failures are frequently implicated in project under-performance [1].

Five features of the review explain why the final corpus is limited to 39 studies, and each is a deliberate consequence of the eligibility design rather than an artefact of screening. First, the concept criterion was demanding: a study had to examine at least two GRC functions together, or embed one within an enterprise-wide system, so the large literature on stand-alone project risk analysis, safety management, or regulation was excluded by design (E2, n = 39 across both stages). Second, the population criterion restricted the review to organizations with an infrastructure-delivery role, excluding the substantial GRC literature on banks, insurers, hospitals, and universities, where integrated GRC research has historically concentrated (E1, n = 44). Third, the term "infrastructure" is polysemous, and more than two in five of the screened records used it in the IT or digital sense (E3, n = 91). Fourth, the search was limited to one database, to peer-reviewed English-language sources, and to 2015–2025. Fifth, and most substantively, integrated GRC remains an emerging topic in infrastructure research. The small corpus is therefore itself a finding: the integration of governance, risk, and compliance in infrastructure organizations has attracted far less scholarly attention than its practical importance warrants.

3.2 Characteristics and distribution of the evidence

The 39 included studies comprise 19 journal articles (48.7%), 15 conference papers (38.5%), and 5 reviews (12.8%). Table 2 shows how publication has grown across the review period. Output was modest and uneven in the first half of the decade: eight studies (20.5%) appeared in 2015–2017, half of them from a single programme of research on enterprise risk management in Chinese construction firms [25–28], and only one study appeared in 2017. Thirteen studies (33.3%) were published in 2018–2022, a period in which attention widened from enterprise risk to capital-project governance, port resilience, and public–private partnerships. The final three years account for eighteen studies (46.2%), including eight (20.5%) in 2025 alone, the highest annual output in the period. Nearly half of the evidence base is therefore less than three years old. This acceleration coincides with the growth of ESG reporting, sustainability-oriented risk management, and digital and AI governance in the corpus, and suggests that integrated GRC in infrastructure is an emerging rather than a mature field of research.

Table 2: Publication growth in integrated GRC research within infrastructure development organizations (2015–2025)

Year	Studies (n)	Share (%)	Cumulative (n)	Cumulative share (%)
2015	4	10.3	4	10.3
2016	3	7.7	7	17.9
2017	1	2.6	8	20.5
2018	2	5.1	10	25.6
2019	2	5.1	12	30.8

Year	Studies (n)	Share (%)	Cumulative (n)	Cumulative share (%)
2020	3	7.7	15	38.5
2021	3	7.7	18	46.2
2022	3	7.7	21	53.8
2023	6	15.4	27	69.2
2024	4	10.3	31	79.5
2025	8	20.5	39	100.0
Total	39	100.0		

Note. Sub-periods: 2015–2017, 8 studies (20.5%); 2018–2022, 13 studies (33.3%); 2023–2025, 18 studies (46.2%). Percentages are of the 39 included studies.

Table 3 shows the geographical distribution of the 39 studies included in the review. The United States contributes the largest share of publications (n = 8; 20.5%), followed by China (n = 4; 10.3%), while Singapore and Malaysia each account for three studies (7.7% each). The United Arab Emirates, Indonesia, Brazil, and Russia contribute two studies each (5.1% each). In total, the literature represents fourteen countries, demonstrating growing international interest in integrated Governance, Risk, and Compliance (GRC) practices within infrastructure development organizations. However, the evidence base remains concentrated in a relatively small number of countries, particularly developed and rapidly industrializing economies: East and Southeast Asia together account for twelve studies (30.8%) and North America for eight (20.5%), whereas Africa contributes three (7.7%), South Asia one (2.6%), and Latin America two (5.1%). Six studies (15.4%) adopt a global or multi-country perspective, whereas one study (2.6%) does not specify its geographical setting. This distribution suggests that knowledge on integrated GRC remains unevenly developed across regions, highlighting the need for further empirical research in underrepresented geographical contexts, particularly in Africa, South Asia, and other emerging infrastructure markets.

Table 3: Geographic distribution of included studies on integrated GRC frameworks in infrastructure development organizations

Region	Country / setting	Studies (n)	Share (%)	Region total (n, %)
North America	United States	8	20.5	8 (20.5)
East and Southeast Asia	China	4	10.3	12 (30.8)
	Singapore	3	7.7	
	Malaysia	3	7.7	
	Indonesia	2	5.1	
Middle East	United Arab Emirates	2	5.1	3 (7.7)

Region	Country / setting	Studies (n)	Share (%)	Region total (n, %)
	Lebanon	1	2.6	
Latin America	Brazil	2	5.1	2 (5.1)
Europe	Russia	2	5.1	2 (5.1)
Africa	South Africa	1	2.6	3 (7.7)
	Nigeria	1	2.6	
	Malawi	1	2.6	
South Asia	India	1	2.6	1 (2.6)
Oceania	Australia	1	2.6	1 (2.6)
Global or multi-country	—	6	15.4	6 (15.4)
Not reported	—	1	2.6	1 (2.6)
Total	14 countries	39	100.0	39 (100.0)

Note. Each study is assigned to the country in which it was set; global and multi-country studies are counted separately. Percentages are of the 39 included studies.

Table 4 presents the sectoral distribution and methodological characteristics of the included studies. Construction is the dominant sector, accounting for 22 of the 39 studies (56.4%), highlighting the strong relevance of governance, risk, and compliance (GRC) issues in managing complex construction projects and infrastructure delivery environments. Energy and oil and gas represent the second-largest sectoral grouping (n = 5; 12.8%), followed by cross-sector infrastructure, megaprojects, and public–private partnerships (n = 4; 10.3%). Water infrastructure and ports and airports each contribute three studies (7.7% each), while industrial capital projects and multi-sector listed companies are represented by a single study each (2.6% each). The concentration of research within construction-related settings indicates that current knowledge on integrated GRC frameworks is largely shaped by project-based and capital-intensive industries. Conversely, the absence of rail, road, and telecommunications infrastructure as distinct contexts suggests significant gaps in the literature and opportunities for future sector-specific investigations.

Methodologically, the evidence rests on reviews (n = 9; 23.1%), cross-sectional questionnaire surveys (n = 8; 20.5%), framework, tool, or model development (n = 7; 17.9%), qualitative case and field studies (n = 7; 17.9%), conceptual or practitioner papers (n = 6; 15.4%), and multi-method designs (n = 2; 5.1%). Primary data were collected in 17 studies (43.6%), through surveys, qualitative case or field work, and multi-method designs, and only two (5.1%) follow organizations over time or across multiple cases [29, 30]. Explicit theoretical lenses are used in six studies (15.4%), including fraud diamond theory, organizational ethical climate, governmentality, management-control anchor practices, and the social licence to operate (Appendix B, Table B1).

Table 4: Sectoral distribution and methodological characteristics of included studies

Characteristic	Category	Studies (n)	Share (%)
Infrastructure sector	Construction	22	56.4
	Energy and oil and gas	5	12.8
	Cross-sector infrastructure, megaprojects, and PPPs	4	10.3
	Water	3	7.7
	Ports and airports	3	7.7
	Industrial capital projects	1	2.6
	Listed companies (multi-sector)	1	2.6
Study design	Review (systematic, bibliometric, or narrative)	9	23.1
	Cross-sectional questionnaire survey	8	20.5
	Framework, tool, or model development	7	17.9
	Qualitative case or field study	7	17.9
	Conceptual or practitioner paper	6	15.4
	Multi-method design	2	5.1
Document type	Journal article	19	48.7
	Conference paper	15	38.5
	Review	5	12.8

Note. Each study is allocated to one primary sector and one primary design; each panel sums to 39 studies (100%).

Table 5 maps the relationship between sectoral contexts and the five identified loci of GRC integration to reveal patterns of evidence concentration and research coverage. The findings show that existing scholarship is unevenly distributed, with certain sectors and integration loci receiving substantially greater attention than others: 13 of the 39 studies (33.3%) concern the enterprise risk process in construction alone, while 21 of the 35 sector–locus cells (60.0%) contain no study at all. This uneven distribution suggests that current understanding of integrated GRC practices is shaped primarily by a limited set of organizational and project environments. Blank cells represent combinations of sector and integration locus for which no evidence was identified, indicating areas where empirical research remains underdeveloped. These gaps may reflect emerging research opportunities, particularly in infrastructure sectors and governance dimensions that have received little scholarly attention despite their increasing strategic importance.

Table 5: Distribution of studies by sector and locus of GRC integration (count of studies; blank = no evidence located)

Locus of integration	Construction	Energy, oil & gas	Water	Ports & airports	Cross-sector / PPP	Industrial projects	Listed firms	Total
Enterprise risk process	13		1				1	15
Project lifecycle and investment decisions	2	2		3	1	1		9
Conduct of organizational actors	5							5
Management-control and information architecture	2	3	1					6
Institutional and sector oversight			1		3			4
Total	22	5	3	3	4	1	1	39

Note. Counts are allocations to each study's primary locus and primary sector (Section 2.4). Blank cells, for example any study of conduct or compliance outside construction, or of institutional oversight in energy and transport, denote combinations for which no evidence was located.

3.3 Conceptualisation and loci of integration (RQ1)

Table 6 synthesizes the various forms of Governance, Risk, and Compliance (GRC) integration identified across the reviewed literature and groups them according to the five loci of integration developed in this review. The analysis reveals that fully integrated GRC frameworks remain uncommon within infrastructure-related research, and the term "integrated GRC" itself is rarely used. Of the 39 included studies, only five (12.8%) explicitly examined governance, risk, and compliance as interconnected organizational functions: an IT GRC architecture combining COBIT 2019 and the NIST Cybersecurity Framework for an Indonesian contractor [31]; a digital-compliance system integrating governance, interoperability, and risk management for artificial intelligence in energy infrastructure [32]; an industry-wide ESG framework co-developed with thirteen water utilities [3]; a participative risk-governance model aligning worker risk perception with safety compliance [33]; and a proposal to integrate project governance and compliance into the management of oil and gas megaprojects [34].

The majority of studies (n = 34; 87.2%) instead examined partial forms of integration, most commonly through the alignment of governance and risk management processes or through the implementation of enterprise-wide risk systems with governance implications. In many cases, compliance was embedded indirectly within governance or risk-management arrangements rather than being addressed as a distinct component of an integrated GRC framework. This finding suggests that the literature remains fragmented, with researchers and practitioners frequently focusing on individual governance, risk, or compliance challenges rather than adopting a holistic organizational perspective.

Table 6: Forms of governance, risk, and compliance (GRC) integration across the literature

Locus	What is integrated	Evidence (studies)	n
Enterprise risk process	Risk management extended across the whole organization, with board and senior-management oversight; maturity, drivers, hindrances, and performance of ERM	[4, 11, 12, 25–28, 35–42]	15
Project lifecycle and investment decisions	Risk analysis and governance embedded in stage gates, capital-project assurance, and the prioritisation of infrastructure investments	[5, 34, 43–49]	9
Conduct of organizational actors	Compliance attitudes, rule violations, ethics, and safety compliance shaped by pressure, internal control, and ethical climate	[14, 33, 50–52]	5
Management-control and information architecture	Risk linked to performance management, internal control and audit, IT governance, ESG reporting, and data or AI compliance systems	[3, 29, 31, 32, 53, 54]	6
Institutional and sector oversight	Public-sector governance, regulation, and legitimacy across PPPs, sector programmes, and transnational infrastructure projects	[6, 13, 30, 55]	4

Note. Each study is allocated to one primary locus; all 39 included studies appear once. The five studies addressing all three GRC functions sit in three loci: project lifecycle [34], conduct of actors [33], and management-control and information architecture [3, 31, 32].

By categorizing these integration approaches according to their locus of application, Table 6 demonstrates that integration occurs through multiple organizational mechanisms, including

enterprise risk processes, project governance practices, management-control systems, organizational behaviour, and sector-level oversight arrangements. The table therefore highlights both the diversity of integration approaches and the absence of a universally adopted model of integrated GRC within infrastructure organizations.

These five loci are not independent; together they describe where, in an infrastructure organization, governance, risk, and compliance can be joined, and each corresponds to a distinct point of intervention. This framing is the review's principal conceptual contribution. The first locus, the enterprise risk process, is the most developed. Here integration means extending risk management from the project to the enterprise, with the board and senior management accountable for the whole [11, 26]. Studies in this locus examine adoption, maturity, and performance in contractors, developers, and utilities [35, 39, 42], propose mechanisms and decision-support tools [27, 37, 38], and extend ERM toward sustainability [4, 36].

The second locus, the project lifecycle, joins risk and governance at the points where investment decisions are made. Integration here is procedural: risk analysis is embedded in stage gates and assurance reviews [44, 49], project management offices carry governance and compliance functions [46], and a distinctive systems-engineering stream models enterprise risk as the disruption of the priority order among port and airport investments [45, 47, 48]. The third locus, the conduct of organizational actors, treats compliance as behaviour. Rule violations are traced to project pressure, weak internal control, and organizational culture [50, 51], and governance is framed as the design of ethical climate, emergency-management arrangements, and participative safety processes [14, 33, 52].

The fourth locus, the management-control and information architecture, joins the functions through the systems that carry information to decision-makers: the balanced scorecard [29], internal-control audit [53], IT governance and cybersecurity frameworks [31], ESG reporting [3], and data and AI compliance regimes [32, 54]. The fifth locus, institutional and sector oversight, places integration outside the single organization, in the relationship between public authorities, private partners, and affected communities: the lifecycle governance of public–private partnerships [30], sector programmes and compliance regimes [55], the social licence of transnational projects [6], and integrated infrastructure governance across sectors [13]. Bounding the fragmented vocabulary in this way lets heterogeneously labelled studies be compared and gives future primary research a shared vocabulary and a common target for framework design.

3.4 Frameworks, standards, and implementation approaches (RQ2)

Generic enterprise risk management is the dominant reference model, framing most of the fifteen studies in the enterprise-risk locus and several beyond it, usually without specification of a particular standard. Formal standards are named in only four studies: ISO 31000:2018 and the RIMS ERM maturity model in Indonesian contractors [42]; COBIT 2019 and the NIST Cybersecurity Framework in an IT GRC architecture [31]; ISO/IEC 38507, 22989, and 23894 alongside the EU AI Act in an energy-sector compliance system [32]; and a national emergency-management directive on Malaysian construction sites [52]. The COSO ERM framework, ISO 37301, and the OCEG GRC Capability Model, the principal integrative

references in the wider GRC field [7, 9, 10], were not reported in the abstract of any included study.

Six implementation approaches recur. Maturity assessment diagnoses the state of ERM and prescribes improvement actions, most elaborately in a knowledge-based decision-support system with 16 maturity criteria, 66 best practices, and 191 action plans [27, 42]. Anchoring integrates risk into an established control practice rather than running it as a parallel system [29]. Stage-gate embedding places risk analysis and assurance at the decision points of the capital-project lifecycle [44, 49]. Structural assignment locates governance and compliance responsibilities in a dedicated unit such as a project management office [46]. Participative design builds compliance through dialogue with the workforce rather than top-down enforcement [33]. And risk-based assurance prioritises internal controls for audit according to their weighted interdependence [53]. Evidence on approaches that have actually been implemented and evaluated, however, remains scarce: only the Búzios 7 case reports a measured outcome, a five-month reduction in the final-investment-decision gate attributed to integrated governance and independent technical assurance [49].

3.5 Enablers and barriers (RQ3)

The evidence sorts the influencing factors into four interacting layers. Leadership factors dominate: senior-management commitment is the most frequently reported enabler and, where absent, the root barrier, exerting the strongest driving power in a structural model of sixteen barriers in the UAE [4] and recurring in Singapore, China, and Nigeria [26, 28, 41]. Resource factors follow: insufficient time, money, and people ranked as the top hindrance to ERM in Chinese construction firms [25, 26], while strong ERM foundations such as procedures, infrastructure, and methods supported sustainability risk management [36]. Organizational factors include structure, a common mindset, internal control, data quality, and ethical climate [29, 50, 51].

Institutional and regulatory factors complete the picture, and they cut both ways. Regulatory pressure, government ownership, and firm size were associated with stronger ERM implementation [28], and regulatory and reputational pressure raised compliance attitudes [50]. Yet legal-compliance requirements were reported as a high-impact inhibitor in Indonesian contractors [42], regulatory loopholes weakened public-sector governance of partnerships [30], and the management of sector programmes toward statistical targets confounded governance frameworks and compliance regimes [55]. Taken together, the evidence suggests that the obstacles to integration lie less in the absence of frameworks than in leadership attention, implementation capacity, and the quality of the institutional environment.

3.6 Research trends, evidence gaps, and priorities (RQ4)

The mapping shows a field developing in three stages: from the diagnosis of ERM adoption in construction firms in 2015–2017 [25–27], through the extension of risk and governance to the project lifecycle and public–private partnerships in 2018–2021 [30, 44, 45], to a diversification after 2022 into compliance behaviour, ethics, ESG, data, and artificial-intelligence governance [3, 14, 32, 50]. The evidence is nonetheless stronger in describing the components of integration than in demonstrating integration itself. The salient gaps are these: no empirically tested

integrated GRC framework; a population concentrated on contractors; a reliance on cross-sectional, perceptual, and conceptual evidence; an absence of outcome measures; sparse use of formal standards; geographic imbalance; and limited attention to digital GRC. These gaps are charted in Table 7 and set the agenda pursued in Section 5.

Table 7: Evidence gaps charted from the included studies, with a recommended study design and outcome measure for each

Gap	Evidence from mapping	Recommended design	Outcome measure
Integration untested	5 of 39 studies address all three functions; none evaluates an integrated framework empirically	Qualitative multiple-case studies of integrated GRC in large infrastructure organizations	Integration maturity; decision quality; duplication of assurance
Population concentration	22 of 39 studies on construction firms; public owners appear mainly in conceptual or sector-level work	Case studies of public authorities, state-owned developers, and megaproject delivery bodies	Governance arrangements, decision rights, and accountability lines
Design limitations	8 cross-sectional surveys, 9 reviews, 6 conceptual papers; 2 longitudinal or multiple-case studies	Longitudinal process studies and comparative case designs	Change in GRC structures and practices over time
Outcome limitations	Implementation level and perceptions dominate; 1 study reports a measured outcome	Outcome-linked studies combining archival and performance data	Cost and schedule performance; compliance incidents; risk exposure
Standards	4 studies name a formal standard; COSO ERM and ISO 37301 not reported	Comparative analysis of standards adoption and alignment	Degree of alignment among COSO, ISO 31000, and ISO 37301 in use
Geography	United States and East Asia lead; Gulf, Africa, and Latin America thinly covered	Primary studies in under-represented regions, including the Gulf states and Africa	Context-specific enablers and barriers
Digital GRC	3 studies examine IT, data, or AI governance	Design-science and case studies of GRC platforms	Integration of risk, control, and compliance data; audit efficiency

Note. Gaps are charted from the author-stated limitations and future-research statements of the included studies together with the cross-study mapping reported in Sections 3.2–3.5.

Discussion

Read against its objectives, this review shows that integrated GRC is a recognised but under-specified aspiration in infrastructure development organizations rather than an established practice. Three features of the mapped evidence stand out and warrant closer interpretation: the dominance of risk over governance and compliance, the distribution of integration across distinct organizational loci, and the role of leadership as a precondition rather than a component of integration. Taking the first of these, the literature approaches integration almost entirely from the risk side. Fifteen of the 39 studies sit in the enterprise-risk locus, and in most of the rest risk is the function to which governance or compliance is attached. Governance appears chiefly as top-management commitment and oversight, and compliance as either an external pressure or a behavioural outcome. Integration, in other words, is typically pursued by enlarging risk management rather than by designing a joint capability.

The second feature is the distribution of integration across loci. An infrastructure organization can join governance, risk, and compliance in its enterprise risk process, at the gates of its project lifecycle, in the conduct of its people, in its management-control and information systems, or in its relationships with regulators and partners, and these are different undertakings with different owners. A contractor may achieve a mature ERM process and still run compliance as a separate legal function; a public authority may align its stage gates with risk assurance and still lack an enterprise-wide view. Treating integration as a single undifferentiated property, as much of the literature implicitly does, risks measuring a composite that no organization holds in that form. The loci set out in Section 3.3 are intended to retain these distinctions while allowing the studies to be compared.

4.1 Convergence with established governance and risk scholarship

The findings are consistent with several literatures beyond infrastructure, which provides additional support for the mapped patterns. The primacy of senior-management commitment corresponds to the central place that governance and culture occupy in the current COSO framework, which presents enterprise risk management as integrated with strategy and performance rather than as a stand-alone process [7]. The finding that risk and compliance are integrated mainly through existing management systems is consistent with the frame of reference for integrated GRC, in which integration is achieved through the alignment of processes, technology, and people rather than through a new organizational layer [10]. And the concentration of governance attention on megaprojects and capital-project decisions is consistent with the megaproject literature, in which the quality of front-end governance is a principal determinant of whether cost and benefit targets are met [1]. The infrastructure evidence thus locates integrated GRC within established bodies of governance and risk research while showing that its sector-specific form remains largely unexamined.

4.2 Theoretical interpretation: connecting the findings to organizational theory

The mapped findings can be explained, and not only described, by four established organizational theories. Table 8 links each principal finding to the theory that best accounts for it. Read together, the four theories explain why infrastructure organizations commit to integrated GRC, why many struggle to implement it, and how integration succeeds where it does.

Table 8: Connecting the principal findings of the review to organizational theory

Finding	Evidence from the review	Theory	Theoretical interpretation
Leadership commitment is the decisive enabler; its absence is the root barrier	Senior-management commitment dominant across the UAE, Singapore, China, and Nigeria [4, 26, 28, 41]	Institutional theory [15, 56]	Coercive, normative, and mimetic pressures reach the organization through its leaders, who decide whether GRC is adopted substantively or only ceremonially; without commitment, formal structures risk being decoupled from practice.
Resource constraints are the leading hindrance to implementation	Insufficient time, money, and people ranked first; strong ERM foundations enable sustainability risk management [25, 26, 36]	Resource-based view [17]	Integrated GRC depends on valuable and scarce resources such as skilled people, data, and systems; differences in these resources explain why organizations under similar pressures achieve very different levels of integration.
Integration succeeds through anchoring to existing control practices	ERM gained traction when tied to the balanced scorecard; risk embedded in stage gates [29, 44, 49]	Dynamic capabilities [18]	Integration is the reconfiguration of existing routines rather than the addition of a new function: organizations sense risk and compliance demands, seize them through trusted practices, and reconfigure those practices over time.

Finding	Evidence from the review	Theory	Theoretical interpretation
Compliance is driven by regulatory, reputational, and community pressure	Regulatory and reputational pressure raise compliance; social licence and sector compliance regimes shape conduct [6, 50, 55]	Legitimacy theory [16]	Infrastructure organizations comply in order to secure and maintain pragmatic, moral, and cognitive legitimacy with regulators, funders, and communities; ESG reporting and social licence are contemporary expressions of this need.

Note. The theories are complementary rather than competing: institutional and legitimacy theories explain the commitment to integrate, the resource-based view explains differences in capacity, and dynamic capabilities explain how integration is achieved in practice.

Institutional theory explains why leadership commitment emerges as the decisive enabler. Infrastructure organizations operate in dense institutional fields, shaped by regulators, funders, professional bodies, and peer organizations, which exert coercive, normative, and mimetic pressures toward recognised governance practices [15]. These pressures are translated into structures by senior managers, and where commitment is weak the result is the ceremonial adoption of risk and compliance frameworks that remain decoupled from day-to-day decisions [56]. This reading accounts for the recurring finding that leadership, rather than the choice of framework, determines whether integration takes hold. Legitimacy theory complements this explanation for compliance specifically. Compliance behaviour in the corpus is driven by regulatory and reputational pressure and by the need for a social licence to operate, which are forms of the pragmatic, moral, and cognitive legitimacy that organizations must secure from their audiences [16]. Growing ESG and sustainability expectations extend the range of audiences whose approval infrastructure organizations must earn.

The resource-based view explains why commitment alone is insufficient. Integration requires valuable and scarce resources, including skilled people, reliable data, and connected information systems, and the leading hindrance across the corpus is precisely a shortage of such resources [17]. Organizations exposed to the same institutional pressures therefore achieve very different levels of integration. Dynamic capabilities theory, finally, explains how integration succeeds. The cases in which integration gained traction did not add a new GRC layer; they reconfigured existing routines, such as the balanced scorecard and the capital-project stage gate, to carry risk and compliance information [18]. Integration, on this view, is an organizational capability to sense emerging risk and compliance demands, seize them through trusted routines, and reconfigure those routines as conditions change.

Taken together, these perspectives support the central theoretical proposition of this review: integrated GRC is best understood not as a compliance function but as a dynamic governance capability. Institutional and legitimacy pressures supply the motive to integrate, organizational resources set the capacity to do so, and dynamic capabilities determine whether that capacity is

mobilised into reconfigured, integrated practice. The divergence over regulation examined next is a direct expression of this tension between motive and capacity.

4.3 Commitment versus capacity: resolving the divergence over the role of regulation

Against this broad convergence, the mapping identifies a divergence over the role of regulation which, on closer examination, is largely apparent rather than substantive. One set of findings treats regulation as an enabler: regulatory pressure was associated with stronger top-management commitment and with the execution and integration of ERM in international contractors [28], and it raised the compliance attitudes of construction companies [50]. Another treats it as an obstacle: legal-compliance requirements were a high-impact inhibitor of ERM in Indonesian contractors [42], and loopholes and inconsistent rules weakened public-sector governance of partnerships [30]. These results appear to contradict one another.

The contradiction largely dissolves, however, once two questions are held apart. Regulation can raise an organization's commitment to adopt risk and compliance practices while, at the same time, consuming the capacity it needs to implement them in an integrated way. External pressure motivates boards and managers to act; but where obligations are numerous, fragmented, or poorly specified, compliance absorbs the time, money, and people that integration would require, and the very resource shortfall that the ERM literature identifies as the leading hindrance is aggravated [25, 26]. Much of the apparent inconsistency is an artefact of conflating these two questions, which the primary studies rarely separate: whether an organization is motivated to integrate, and whether it is able to. Once separated, a positive effect on commitment and a negative effect on capacity are not rivals but complements.

The practical consequence is a measurement recommendation. Future studies should treat commitment to integrated GRC and capacity to implement it as two distinct outcomes, measured separately, and should characterise the regulatory environment by its coherence as well as its stringency. Without that separation, findings on regulation cannot be compared across studies, and the field will continue to generate apparent contradictions that are artefacts of measurement. The same logic suggests that regulators seeking more integrated GRC should attend to the coherence of the obligations they impose, not only to their enforcement.

4.4 Novel contributions revealed by the mapping

The mapping also identifies three developments that are new relative to the earlier, largely construction-centred ERM literature. The first is integration by anchoring. Huber et al. [29] show that ERM gained traction in a large energy corporation when it was integrated with the balanced scorecard, an established anchor practice, and that ERM in turn changed the scorecard rather than simply executing its scripts. Comparable logic appears where risk analysis is embedded in an existing stage-gate process [44, 49]. Together these findings shift attention from building a separate GRC system to attaching governance, risk, and compliance to the control practices an organization already trusts.

The second is a systems view of enterprise risk. A stream of work on ports and airports models enterprise risk as the disruption of the priority order among investment initiatives under alternative scenarios and stakeholder perspectives [45, 47, 48]. This links risk directly to

investment governance, the decisions that matter most in infrastructure, and offers a quantitative bridge between the risk register and the capital plan. The third is the extension of GRC to data and artificial intelligence. Studies of IT GRC in construction, big-data regulation, and AI compliance in energy infrastructure [31, 32, 54] indicate that digital governance is becoming a new site at which the three functions must be joined. Together these developments indicate that integrated GRC is being reconceived as a property of an organization's existing decision and control systems, rather than as an additional function. The present review contributes to that reframing by bounding the loci at which integration can occur.

4.5 Implications for practice and policy

The practical significance of these findings lies in the failures that integrated GRC is meant to prevent. Megaproject overruns often originate in front-end decisions taken without a joined-up view of risk, governance, and obligations [1]; governance scandals and compliance breaches, such as the bribery of public officials to win infrastructure contracts, expose weaknesses that separate risk and compliance functions fail to detect [2]; and ESG pressures and sustainability requirements now add environmental, social, and community obligations that cut across all three functions [3, 4, 6]. Organizations that treat these exposures in silos are poorly placed to manage their interactions.

For practice, the recurring finding is that integration depends on leadership before it depends on frameworks. The mapped evidence points toward establishing clear board-level ownership of risk and compliance; assessing ERM maturity with a recognised model and acting on the gaps identified; attaching risk and compliance to the control practices that already carry authority in the organization, such as the performance scorecard and the capital-project stage gates; and assigning integrative responsibilities to a defined unit, such as a project management office or a combined-assurance function. Because the evidence identifies resource shortfall as a persistent hindrance, integration should be sequenced so that it reduces duplicated assurance effort rather than adding to it.

For policy, the evidence supports a shift from adding obligations toward making them coherent. Because regulation can raise commitment while consuming capacity (Section 4.3), regulators and funding agencies are more likely to promote integrated GRC by harmonising overlapping requirements, specifying reporting that spans governance, risk, and compliance, and recognising combined assurance, than by multiplying separate mandates. In public–private partnerships, the evidence points to standardised regulation, common measurement tools, and training for the public sector across the whole project lifecycle [30]. Given the geographic concentration of the underlying studies, these directions are most firmly grounded for the settings studied and should be adapted, and evaluated, as they are extended elsewhere.

4.6 Strengths and limitations

This review has several strengths. It was conducted and reported in accordance with the PRISMA-ScR framework, which supports transparency and reproducibility in the search, selection, and charting of evidence. It addressed integration as an object of synthesis, which earlier reviews of construction risk management and infrastructure governance had recorded only incidentally [11–13], and it did so through an explicit umbrella construct that allowed

studies using very different terminology to be assembled and compared. Every excluded record carries a coded reason, and by charting conceptualisation, frameworks, enablers, and gaps against a common set of research questions, the review produces an integrated map of a fragmented field and an agenda calibrated to its actual state of development.

These strengths are balanced by limitations inherent in the method and its execution. As a scoping review, the exercise maps the breadth and distribution of the evidence and does not appraise or pool the results of individual studies, so it can describe the landscape of findings but cannot adjudicate which reported relationships are the most robust. The search was restricted to a single database and to peer-reviewed, English-language sources, which may have excluded relevant grey literature, practitioner reports, and non-English scholarship, an exclusion likely to compound the geographic imbalance the review documents. The broad infrastructure term retrieved many IT-infrastructure records while possibly missing studies that describe infrastructure organizations as "public works authorities" or "asset owners". No supplementary backward or forward citation searching was undertaken. Future updates should add at least one further database and systematic citation searching.

Two further limitations concern the review's own analytic choices. The allocation of studies to five loci of integration (Table 6) is interpretive and rests on a single organising criterion; a possibility of classification bias remains despite the use of that explicit criterion. And charting was based on titles, abstracts, keywords, and bibliographic metadata, so frameworks or standards described only in the full texts may be under-reported. Finally, because the underlying literature relies heavily on perceived, self-reported, and conceptual evidence, the review inherits that limitation: it maps what organizations and authors say about integration, not what integration demonstrably achieves.

Conclusions

Infrastructure organizations govern assets on which entire societies depend, yet this review shows that the integration of governance, risk, and compliance in these organizations remains more an aspiration than a practice. The evidence is small, recent, and concentrated in construction contractors, and it describes the components of integration far more convincingly than it demonstrates integration itself. The review contributes a five-locus framework that specifies where integration can occur, a resolution of the apparent conflict over regulation through the distinction between commitment and capacity, and a theoretical account that connects the field to institutional, legitimacy, resource-based, and dynamic-capabilities perspectives.

The central message of this review is that integrated GRC should be viewed not as a compliance function but as a dynamic governance capability. Treated as a compliance function, GRC becomes a growing set of separate controls that consumes resources, satisfies regulators, and leaves the organization exposed at the joints between functions. Treated as a capability, it becomes the means by which infrastructure organizations sense emerging risks and obligations, integrate them into the decisions that shape their assets, and adapt as regulatory, ESG, and sustainability demands evolve. Building this capability will require research that follows large

public and private infrastructure organizations over time, compares how they combine COSO ERM, ISO 31000, and ISO 37301 in practice, and links integration to outcomes that matter. In an era of megaproject failures, governance scandals, and rising sustainability expectations, integrated GRC is not an administrative refinement: it is a foundation of organizational resilience and of the reliable delivery of the infrastructure on which societies depend.

Supplementary Materials

Supplementary File S1. Screening log for all 215 records, with the decision and coded exclusion reason for each, together with the data-charting form for the 39 included studies. Studies are identified as S01–S39 and correspond to the S-ID column of Table B1.

Supplementary File S2. Completed PRISMA-ScR checklist, page-referenced to this manuscript.

Author Contributions

Conceptualization, A.A. and I.R.E.; methodology, A.A. and I.R.E.; formal analysis, A.A.; investigation, A.A.; data curation, A.A.; writing — original draft preparation, A.A.; writing — review and editing, I.R.E.; supervision, I.R.E. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

All data supporting the findings of this review are derived from the published studies cited in the reference list and charted in Appendix B (Table B1). The full electronic search strategy is given in Appendix A, and the screening log and charting form are provided as Supplementary File S1. No new primary data were generated or analysed in the course of this review.

Ethical Considerations

Not applicable. This study is a scoping review of previously published, publicly available literature. It involved no human or animal participants, no primary data collection, and no personally identifiable information, and therefore did not require ethical approval or informed consent.

Use of Artificial Intelligence

The authors acknowledge the use of the generative artificial intelligence tool Claude (Anthropic) during the preparation of this manuscript, to generate advisory pre-screening suggestions (Section 2.4), to assist with charting study characteristics from titles and abstracts, and to assist with drafting and editing text. All screening decisions, the charting, and the synthesis, interpretation, and conclusions were reviewed, verified, and approved by the authors, who bear full responsibility for the final content, including its originality, accuracy, integrity, and validity. Artificial intelligence is not listed or cited as an author.

Conflicts of Interest

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

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References

Flyvbjerg, B. (2014). What you should know about megaprojects and why: An overview. *Project Management Journal, 45*(2), 6–19. https://doi.org/10.1002/pmj.21409

U.S. Department of Justice, Office of Public Affairs. (2016, December 21). *Odebrecht and Braskem plead guilty and agree to pay at least $3.5 billion in global penalties to resolve largest foreign bribery case in history* (Press Release No. 16-1515). https://www.justice.gov/archives/opa/pr/odebrecht-and-braskem-plead-guilty-and-agree-pay-least-35-billion-global-penalties-resolve

Hamilton, K., & Zhang, H. (2025). Developing an Environmental, Social, and Governance Framework for Water Utilities. In *Proceedings - WEFTEC 2025: 98th Water Environment Federation Technical Exhibition and Conference*. https://doi.org/10.2175/193864718825160014

Almashhour, R., Qazi, A., Al-Mhdawi, M. K. S., Daghfous, A., Ayyub, B. M., & O'Connor, A. (2025). Analyzing Barriers to Sustainable Enterprise Risk Management in the Construction Sector: A Delphi Method and Interpretive Structural Modeling Approach. *Sustainability (Switzerland), 17*(21), Article 9498. https://doi.org/10.3390/su17219498

Sankaran, S., Müller, R., & Drouin, N. (2020). Creating a 'sustainability sublime' to enable megaprojects to meet the United Nations sustainable development goals. *Systems Research and Behavioral Science, 37*(5), 813–826. https://doi.org/10.1002/sres.2744

Zhang, Z. (2024). Analysing Local Environmental Disputes and Governance in Belt and Road Host Countries: Establishing Legitimacy through the Social License to Operate (SLO). *Lex Localis, 22*(4), 17–53. https://doi.org/10.52152/22.4.17-53(2024)

Committee of Sponsoring Organizations of the Treadway Commission. (2017). *Enterprise risk management: Integrating with strategy and performance*. COSO.

International Organization for Standardization. (2018). *ISO 31000:2018 Risk management — Guidelines*. ISO.

International Organization for Standardization. (2021). *ISO 37301:2021 Compliance management systems — Requirements with guidance for use*. ISO.

Racz, N., Weippl, E., & Seufert, A. (2010). A frame of reference for research of integrated governance, risk and compliance (GRC). In B. De Decker & I. Schaumüller-Bichl (Eds.), *Communications and multimedia security* (pp. 106–117). Springer. https://doi.org/10.1007/978-3-642-13241-4_11

Renault, B. Y., Agumba, J. N., & Balogun, O. A. (2016). Drivers for and Obstacles to Enterprise Risk Management in Construction Firms: A Literature Review. *Procedia Engineering, 164*, 402–408. https://doi.org/10.1016/j.proeng.2016.11.637

Al Qudah, S. M. A., Fuentes-Bargues, J. L., & Ferrer-Gisbert, P. S. (2024). Bibliometric analysis of the literature on risk management in the construction sector: Exploring current and future trends. *Ain Shams Engineering Journal, 15*(8), Article 102843. https://doi.org/10.1016/j.asej.2024.102843

Clements, R., Alizadeh, T., Kamruzzaman, L., Searle, G., & Legacy, C. (2023). A Systematic Literature Review of Infrastructure Governance: Cross-sectoral Lessons for Transformative Governance Approaches. *Journal of Planning Literature, 38*(1), 70–87. https://doi.org/10.1177/08854122221112317

Halder, A., & Batra, S. (2024). Navigating the Ethical Discourse in Construction: A State-of-the-Art Review of Relevant Literature. *Journal of Construction Engineering and Management, 150*(3), Article 03124001. https://doi.org/10.1061/JCEMD4.COENG-13880

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

Suchman, M. C. (1995). Managing legitimacy: Strategic and institutional approaches. *Academy of Management Review, 20*(3), 571–610. https://doi.org/10.5465/amr.1995.9508080331

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99–120. https://doi.org/10.1177/014920639101700108

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509–533. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology, 8*(1), 19–32. https://doi.org/10.1080/1364557032000119616

Levac, D., Colquhoun, H., & O'Brien, K. K. (2010). Scoping studies: Advancing the methodology. *Implementation Science, 5*, Article 69. https://doi.org/10.1186/1748-5908-5-69

Peters, M. D. J., Godfrey, C., McInerney, P., Munn, Z., Tricco, A. C., & Khalil, H. (2020). Chapter 11: Scoping reviews. In E. Aromataris & Z. Munn (Eds.), *JBI manual for evidence synthesis*. JBI. https://doi.org/10.46658/JBIMES-20-12

Munn, Z., Peters, M. D. J., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology, 18*, Article 143. https://doi.org/10.1186/s12874-018-0611-x

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., et al. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine, 169*(7), 467–473. https://doi.org/10.7326/M18-0850

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Zhao, X., Hwang, B.-G., & Low, S. P. (2015). Enterprise risk management in international construction firms: Drivers and hindrances. *Engineering, Construction and Architectural Management, 22*(3), 347–366. https://doi.org/10.1108/ECAM-09-2014-0117

Zhao, X., Hwang, B.-G., Pheng Low, S., & Wu, P. (2015). Reducing hindrances to enterprise risk management implementation in construction firms. *Journal of Construction Engineering and Management, 141*(3). https://doi.org/10.1061/(ASCE)CO.1943-7862.0000945

Zhao, X., Hwang, B.-G., & Low, S. P. (2016). An enterprise risk management knowledge-based decision support system for construction firms. *Engineering, Construction and Architectural Management, 23*(3), 369–384. https://doi.org/10.1108/ECAM-03-2015-0042

Zhao, X., & Singhaputtangkul, N. (2016). Effects of firm characteristics on enterprise risk management: Case study of Chinese construction firms operating in Singapore. *Journal of Management in Engineering, 32*(4), Article 05016008. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000434

Huber, C., Kraus, K., & Meidell, A. (2025). Integrating the balanced scorecard and enterprise risk management: Exploring the dynamics between management control anchor practices and subsidiary practices. *Management Accounting Research, 66*, Article 100924. https://doi.org/10.1016/j.mar.2024.100924

Wang, N., Ma, M., & Liu, Y. (2020). The whole lifecycle management efficiency of the public sector in PPP infrastructure projects. *Sustainability (Switzerland), 12*(7), Article 3049. https://doi.org/10.3390/su12073049

Utami, F. A., & Hakim, L. (2025). COBIT-NIST Synergy: A Proposed Architecture for Integrated IT Governance, Risk, and Compliance. In *Proceedings of the 2025 IEEE International Conference on Technology, Informatics, Management, Engineering and Environment, TIME-E 2025*, 115–120. https://doi.org/10.1109/TIME-E68804.2025.11512763

Salas-Riega, J., Riega-Viru, Y., Alvarado-Huanatico, N., Ninaquispe-Soto, M., Tipismana-Neyra, M., & Nilupu-Moreno, K. (2025). Artificial Intelligence: Governance and Compliance in the Energy Sector. In *Proceedings of the 2025 IEEE 5th International Conference on Advanced Learning Technologies on Education and Research, ICALTER 2025*. https://doi.org/10.1109/ICALTER69698.2025.11355075

Hinsberg, K., Nadesan, M., & Lamanna, A. (2024). Communicative Framework Development for Construction Risk Governance: An Analysis of Risk and Trust Perception for Organizational Sustainability. *Sustainability (Switzerland), 16*(13), Article 5794. https://doi.org/10.3390/su16135794

Asrilhant, B., & Beyda, T. T. (2015). Understanding complexity and uncertainty in E&P mega projects: The need for a new managerial approach. In *OTC Brasil 2015: The Atlantic: From East to West - An Ocean of Innovation*, 720–724.

Ibrahim, F. S., & Esa, M. (2017). A study on enterprise risk management and organizational performance: Developer's perspective. *International Journal of Civil Engineering and Technology, 8*(10), 184–196.

Manab, N. A., & Aziz, N. A. A. (2019). Integrating knowledge management in sustainability risk management practices for company survival. *Management Science Letters, 9*(4), 585–594. https://doi.org/10.5267/j.msl.2019.1.004

Borkovskaya, V. G., & Passmore, D. (2020). Behavioral engineering model to identify risks of losses in the construction industry. *Smart Innovation, Systems and Technologies, 138*, 243–250. https://doi.org/10.1007/978-3-030-15577-3_24

Kaverzina, L., Litvin, E., Dorofeeva, V., & Nikiforova, V. (2021). Risk management in construction sphere. *E3S Web of Conferences, 263*, Article 05020. https://doi.org/10.1051/e3sconf/202126305020

Sharma, U., Chapman, T., & Garrison, S. W. (2021). Addressing Risks Across the Organization: Enterprise Risk Management. *Journal - American Water Works Association, 113*(5), 54–62. https://doi.org/10.1002/awwa.1727

Motaleb, O., & El-Refae, G. A. (2022). Risk mitigation of stakeholders management in construction industry via ERM methodology during COVID-19. In *CESARE Conference Publications*.

Oyeyipo, O. O., & Osuizugbo, I. C. (2023). Factors Influencing Enterprise Risk Management Implementation of Construction Firms in Lagos State, Nigeria. *Practice Periodical on Structural Design and Construction, 28*(2), Article 04023010. https://doi.org/10.1061/PPSCFX.SCENG-1164

Tsaniyah, L., Susilowati, F., & Adipradana, A. Y. (2023). Study of enterprise risk management on large contractors in Indonesia. *AIP Conference Proceedings, 2629*(1), Article 070001. https://doi.org/10.1063/5.0128827

Hamad, J. A., Zgheib, Y., & Fares, M. (2018). Project management: Risk mitigation in a volatile environment. In *Proceedings of the 31st International Business Information Management Association Conference, IBIMA 2018: Innovation Management and Education Excellence through Vision 2020*, 4095–4106.

Kumar, A., & Prabhaker, S. P. (2018). Value enhancement in Project delivery through RAVE (Risk Analysis & Value Engineering) at Tata Steel. In *SAVE 2017 Value Summit: Celebrating 70 Years of Value*.

Almutairi, A., Collier, Z. A., Hendrickson, D., Palma-Oliveira, J. M., Polmateer, T. L., & Lambert, J. H. (2019). Stakeholder mapping and disruption scenarios with application to resilience of a container port. *Reliability Engineering and System Safety, 182*, 219–232. https://doi.org/10.1016/j.ress.2018.10.010

Ershadi, M., Jefferies, M., Davis, P., & Mojtahedi, M. (2021). Comparative Analysis of PMO Functions between the Public and Private Sectors: Survey of High-Performing Construction Organizations. *Journal of Construction Engineering and Management, 147*(11), Article 04021151. https://doi.org/10.1061/(ASCE)CO.1943-7862.0002181

Baker, R. M., Polmateer, T. L., Marcellin, M. C., Chen, T. D., Riggs, R. J., Iqbal, T., Hendrickson, D. C., Slutzky, D. L., & Lambert, J. H. (2023). Mixed-Integer Programming with Enterprise Risk Analysis for Vehicle Electrification at Maritime Container Ports. In *2023 IEEE Symposium Series on Computational Intelligence, SSCI 2023*, 1759–1766. https://doi.org/10.1109/SSCI52147.2023.10372051

Jabs, N. D., Loose, D. C., Gunn, M. C., Colosi, L. M., & Lambert, J. H. (2025). Managing Disruption of Enterprise System Order in Resilience of Supply of Aviation Fuels. In *TEMSCON Global 2025 - 2025 IEEE Technology and Engineering Management Society Conference - Global, Conference Proceedings*. https://doi.org/10.1109/TEMSCONGlobal64363.2025.11238314

Nascimento, R., Rosa, F., Lima, F., Maués, R., Carrião, P., Ribeiro, R., Navarini, J., & Gomes, A. (2025). Búzios 7 Capital Project-From Conception to Execution. In *Proceedings of the Annual Offshore Technology Conference*. https://doi.org/10.4043/35587-MS

Liu, J., Wang, Y., & Wang, Z. (2022). Effect of Pressure on Construction Company Compliance Attitudes: Moderating Role of Organizational Ethical Climate. *Journal of Construction Engineering and Management, 148*(11), Article 04022125. https://doi.org/10.1061/(ASCE)CO.1943-7862.0002400

Liu, J., Wang, Y., & Wang, Z. (2023). Multidimensional drivers: exploring contractor rule violations in the construction industry. *Engineering, Construction and Architectural Management, 30*(4), 1496–1518. https://doi.org/10.1108/ECAM-10-2021-0928

Samsudin, K., Sansuddin, N., Hussin, M. F., Kamarudin, A. H., Hapani, M., & Hashim, A. F. (2023). A Review of Emergency Management Governance at Construction Sites in Malaysia. *Jurnal Kejuruteraan, 35*(2), 275–285. https://doi.org/10.17576/jkukm-2023-35(2)-02

Dister, C. J., Jablonski, A., & Browning, T. R. (2015). Applying DSM methodology to rank risk of internal controls in critical infrastructure enterprises. In *Modeling and Managing Complex Systems - Proceedings of the 17th International DSM Conference*, 123–136. https://doi.org/10.3139/9783446447264.012

Sharma, V., Garg, S., Patil, S., Sharma, H., & Gajjar, D. (2025). Regulatory Framework and Data Governance around Big Data in the Construction Industry. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 17*(4), Article 04525067. https://doi.org/10.1061/JLADAH.LADR-1360

Akpabio, E. M., Mwathunga, E., & Rowan, J. S. (2022). Understanding the challenges governing Malawi's water, sanitation and hygiene sector. *International Journal of Water Resources Development, 38*(3), 426–446. https://doi.org/10.1080/07900627.2021.1897947

Meyer, J. W., & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American Journal of Sociology, 83*(2), 340–363. https://doi.org/10.1086/226550

Appendix A. Search Strategy

Table A1: Scopus search string, filters, and results

Element	Specification
Database	Scopus (Elsevier)
Date of search	25 October 2026
Fields	Title, abstract, and keywords (TITLE-ABS-KEY)
Search string	TITLE-ABS-KEY (("governance, risk and compliance" OR "integrated GRC" OR "GRC framework*" OR (governance W/5 complian*) OR "integrated governance" OR "enterprise risk management") AND (infrastructure OR megaproject* OR "mega project" OR "capital project" OR "construction industry" OR "construction organization" OR "construction organisation" OR "public works"))
Filters	PUBYEAR > 2014 AND PUBYEAR < 2026; LANGUAGE (English); DOCTYPE (article, review, conference paper)
Records retrieved	215 (131 articles, 71 conference papers, 13 reviews)

Appendix B. Characteristics of the Included Studies

Table B1: Characteristics of the included studies (n = 39), ordered by year

S-ID	Study	Country	Sector	Design	Locus	GRC	Key finding
S01	Asrilhant and Beyda (2015) [34]	Brazil	Energy, oil and gas	Conceptual paper	Project lifecycle	G, R, C	Proposes integrating project governance and compliance with collaboration and knowledge management to handle complexity and uncertainty in E&P megaprojects.
S02	Dister et al. (2015) [53]	USA	Energy, oil and gas	Method application	Control architecture	R, C	Design structure matrix ranks internal controls to guide audit scope, depth, and frequency in critical-infrastructure ERM.

S-ID	Study	Country	Sector	Design	Locus	GRC	Key finding
S03	Zhao et al. (2015) [25]	Singapore	Construction	Survey (n = 35)	Enterprise risk	R	13 drivers and 22 hindrances; improved decision-making the top driver, insufficient resources the top hindrance.
S04	Zhao et al. (2015) [26]	China	Construction	Survey (n = 119); SEM	Enterprise risk	R, G	20 critical hindrances in three groups; lack of senior support drives resource and data gaps.
S05	Renault et al. (2016) [11]	South Africa	Construction	Literature review	Enterprise risk	R, G	15 drivers and 34 obstacles; the board and senior management must oversee ERM.
S06	Zhao et al. (2016) [27]	Singapore	Construction	Tool development; expert validation	Enterprise risk	R	Decision-support system with 16 maturity criteria, 66 practices, and 191 action plans; 83.7–92.9% accuracy.
S07	Zhao and Singhaputtangkul (2016) [28]	Singapore	Construction	Survey (n = 35); PLS-SEM; interviews	Enterprise risk	R, C, G	Regulatory pressure, government ownership, and firm size raise ERM implementation.
S08	Ibrahim and Esa (2017) [35]	Malaysia	Construction	Critical review	Enterprise risk	R	Links ERM to organizational performance; calls for empirical study of Malaysian housing developers.
S09	Hamad et al. (2018) [43]	Lebanon	Construction	Case study; interviews	Project lifecycle	R	Project risk management supported business survival in a volatile environment.

S-ID	Study	Country	Sector	Design	Locus	GRC	Key finding
S10	Kumar and Prabhaker (2018) [44]	India	Industrial capital projects	Case study	Project lifecycle	R, G	Embedding risk analysis and value engineering in the stage-gate process improved predictability and project returns.
S11	Almutairi et al. (2019) [45]	USA	Ports and airports	Model development	Project lifecycle	R, G	Joint stakeholder–scenario modelling reorders port investment priorities; congestion the most disruptive scenario.
S12	Manab and Aziz (2019) [36]	Malaysia	Listed companies	Survey; PLS-SEM	Enterprise risk	R	ERM bases and resilience predict company survival; knowledge management moderates the resilience effect.
S13	Borkovskaya and Passmore (2020) [37]	Russia	Construction	Conceptual model	Enterprise risk	R	Behavioral Engineering Model identifies and prioritises loss risks for enterprise risk systems.
S14	Sankaran et al. (2020) [5]	Global	Cross-sector / PPP	Conceptual paper	Project lifecycle	G	Megaprojects need an integrated governance structure to deliver SDG benefits.
S15	Wang et al. (2020) [30]	China	Cross-sector / PPP	Multiple case study	Institutional oversight	G, C	Loopholes across the PPP lifecycle; integrated governance model and standardised regulation proposed.

S-ID	Study	Country	Sector	Design	Locus	GRC	Key finding
S16	Ershadi et al. (2021) [46]	Australia	Construction	Survey	Project lifecycle	G, C	Public and private PMOs differ on benchmarking, project-management compliance, and project governance.
S17	Kaverzina et al. (2021) [38]	Russia	Construction	Conceptual and analytical	Enterprise risk	R	Systematises construction risks and proposes an enterprise risk-management mechanism.
S18	Sharma et al. (2021) [39]	USA	Water	Practitioner paper	Enterprise risk	R, G	ERM requires senior buy-in, stakeholder engagement, and triple-bottom-line principles.
S19	Akpabio et al. (2022) [55]	Malawi	Water	Qualitative field study	Institutional oversight	G, C	Management toward statistical targets confounds governance frameworks and compliance regimes.
S20	Liu et al. (2022) [50]	China	Construction	Survey (n = 209); PLS-SEM	Actor conduct	C, G	Project pressure lowers and regulatory and reputational pressure raise compliance attitudes; ethical climate moderates.
S21	Motaleb and El-Refae (2022) [40]	UAE	Construction	Literature review	Enterprise risk	R, G	Eight stakeholder parameters, including risk auditing and standardisation, strengthen ERM in crises.
S22	Baker et al. (2023) [47]	USA	Ports and airports	Optimisation model; risk register	Project lifecycle	R	Risk register and optimisation support ERM for a $1.5 billion port electrification plan.

S-ID	Study	Country	Sector	Design	Locus	GRC	Key finding
S23	Clements et al. (2023) [13]	Global	Cross-sector / PPP	Systematic review	Institutional oversight	G	Integrated governance identified as an under-developed area of infrastructure governance research.
S24	Liu et al. (2023) [51]	China	Construction	Interviews; DEMATEL-ANP	Actor conduct	C, G	Pressure, weak internal control, and culture drive contractor rule violations.
S25	Oyeyipo and Osuizugbo (2023) [41]	Nigeria	Construction	Survey (n = 96)	Enterprise risk	R, G	Top-management and organizational factors inhibit ERM; ownership type made no difference.
S26	Samsudin et al. (2023) [52]	Malaysia	Construction	Document review; expert validation	Actor conduct	G, C	Significant gaps in emergency-management governance and compliance on construction sites.
S27	Tsaniyah et al. (2023) [42]	Indonesia	Construction	Survey and interviews	Enterprise risk	R, C	61% of large contractors at the highest RIMS maturity level; legal compliance a high-impact inhibitor.
S28	Al Qudah et al. (2024) [12]	Global	Construction	Bibliometric review	Enterprise risk	R	676 publications in three clusters, one being ERM in construction.
S29	Halder and Batra (2024) [14]	Global	Construction	Mixed-method review	Actor conduct	G, C	Maps ethics themes, including compliance and ESG, at macro, meso, and micro levels.

S-ID	Study	Country	Sector	Design	Locus	GRC	Key finding
S30	Hinsberg et al. (2024) [33]	USA	Construction	Review; conceptual framework	Actor conduct	G, R, C	Participative framework aligns worker risk perception with governance to raise safety compliance.
S31	Zhang (2024) [6]	Multi-country	Cross-sector / PPP	Legal analysis; case studies	Institutional oversight	G, C	Integrated hard- and soft-law governance model to secure social licence for BRI projects.
S32	Almashhour et al. (2025) [4]	UAE	Construction	Systematic review; Delphi; ISM-MICMAC	Enterprise risk	R, G	16 barriers; lack of senior commitment the root barrier; weak governance reinforces the others.
S33	Hamilton and Zhang (2025) [3]	USA	Water	Collaborative framework development	Control architecture	G, R, C	Customisable, industry-wide ESG framework co-developed with 13 utilities.
S34	Huber et al. (2025) [29]	Not reported	Energy, oil and gas	Longitudinal case study	Control architecture	R, G	ERM gained traction when integrated with the balanced scorecard anchor practice.
S35	Jabs et al. (2025) [48]	USA	Ports and airports	Method demonstration	Project lifecycle	R, C	ERM tool tracks disruption across an aviation biofuel supply chain, including regulatory compliance.
S36	Nascimento et al. (2025) [49]	Brazil	Energy, oil and gas	Case report	Project lifecycle	G, R	Integrated governance and assurance cut the final-investment-decision gate by five months.

S-ID	Study	Country	Sector	Design	Locus	GRC	Key finding
S37	Salas-Riega et al. (2025) [32]	Multi-country	Energy, oil and gas	Comparative review	Control architecture	G, R, C	Digital-compliance system aligned with ISO/IEC standards integrating governance and risk for AI in energy.
S38	Sharma et al. (2025) [54]	USA	Construction	Systematic review; content analysis	Control architecture	G, C	Regulatory framework for big-data governance in construction proposed.
S39	Utami and Hakim (2025) [31]	Indonesia	Construction	Framework design; illustrative case	Control architecture	G, R, C	COBIT–NIST architecture maps governance processes to security controls in a contractor.

Note. GRC: functions examined as substantive elements (G = governance, R = risk, C = compliance). Locus: primary locus of integration (Section 2.4). Charting based on titles, abstracts, keywords, and bibliographic metadata.