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From Sustainability Recognition to Documented Outcomes: A Systematic Review and Study-Level Evidence Translation Analysis Across Productive Sectors

Jorge Andrés Sarmiento Rojas, Fabián David Güiza Pinzón and Oscar Julian Alarcón Argüello *

Faculty of Engineering, Sede Tunja, Universidad Pedagógica y Tecnológica de Colombia, Tunja 150003, Colombia; jorge.sarmiento02@uptc.edu.co (J.A.S.R.); fabian.guiza@uptc.edu.co (F.D.G.P.)
* Correspondence: oscar.alarcon15@uptc.edu.co

Abstract

Sustainability is widely recognized in project-based and productive-sector research, yet published studies do not always make visible how this recognition enters control routines, resource-allocation rules, and documented outcomes. This systematic review and study-level evidence translation analysis examined 133 unique full-text studies drawn from Scopus and Web of Science evidence matrices covering publications from 2008 to 2026. A bilingual rule-based coding layer organized candidate evidence across ten sustainability-control domains and three stages: recognition (R), operationalization (O), and documented outcome evidence (E). Two independent university professor reviewers, one with a sustainability focus, and one with a statistics focus and each with more than five years of professional experience, then coded the complete corpus under the pre-specified protocol; disagreements were resolved through third-author adjudication. Observed agreement was 0.921 for R, 0.831 for O, and 0.883 for E. In the final matrix, R, O, and E were present in 53.1%, 34.7%, and 45.4% of study-domain observations, respectively, and full R-O-E completion occurred in 29.7%. The pattern was non-nested: documented outcomes were sometimes reported without an explicit account of the operational pathway. Generalized estimating equations confirmed lower odds for O (OR = 0.423, 95% CI 0.378–0.473) and E (OR = 0.703, 95% CI 0.619–0.799) relative to R. A four-class Bernoulli latent-class model minimized BIC and identified stakeholder-governance-transition, lifecycle-system integration, digital-data evidence, and measurement–performance profiles. The resulting Sustainability Evidence Translation Control Architecture locates documentary discontinuities between purpose, controls, decisions, and outcomes while avoiding unsupported claims about symbolic intent, implementation failure, or causal organizational transformation.

Keywords: sustainability management control; project-based organizations; systematic review; evidence translation; productive sectors; manual coding; generalized estimating equations; latent class analysis

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1. Introduction

Organizations increasingly frame sustainability as a strategic imperative, a legitimacy requirement, and a source of long-term value. In productive sectors, however, sustainability is not implemented by declarations alone. It must enter budgets, targets, decision rights, supplier criteria, risk registers, project gates, performance reviews, and post-project learning. This requirement is particularly demanding in project-based organizations be-

cause temporary structures, distributed accountability, and short delivery horizons can disconnect corporate commitments from operational decisions [1–3].

The sustainability literature has progressively expanded beyond the environmental dimension toward economic, social, governance, lifecycle, circularity, resilience, and digital traceability concerns [4–6]. Project management research has followed this movement by redefining success beyond time, cost, and scope, emphasizing stakeholder value, long-term impacts, and sustainability transitions [7–9]. Standards and methodologies such as P5, PRiSM™, PM^2, and lifecycle-based assessment tools have provided practical entry points, while sector-specific routines, such as good manufacturing practices, environmental controls, and traceable production procedures, show how sustainability can become embedded in everyday operations [10–12]. Recent work in Sustainability has also emphasized that environmental change, economic sustainability, digital technology, and governance regulation should be examined as interconnected systems rather than isolated policy or managerial domains [13].

Despite this progress, a persistent implementation problem remains. Studies repeatedly document high awareness but incomplete integration, strong reporting capacity but limited decision influence, and broad stakeholder rhetoric without equivalent evidence of changed outcomes [11,14,15]. This problem is normally described as an intention–implementation gap, an ESG integration challenge, or a lack of methodological maturity. These descriptions are useful but insufficient because they do not distinguish where the translation process breaks down. A concept may be recognized but not operationalized; a control may be designed but not enacted; an action may be reported without documented environmental, social, economic, or systemic outcome evidence.

Management control research offers a strong basis for examining this problem. Diagnostic controls specify targets and monitor deviations; interactive controls direct managerial attention and enable learning; belief and boundary systems define purpose and acceptable conduct; and control packages combine formal and informal mechanisms rather than operating as isolated tools [2,3]. Sustainability management control extends these logics by linking strategy, measurement, stakeholder accountability, and environmental or social performance [1,16–18]. Yet the project and sustainability studies have rarely been analyzed as a sequential translation process from recognition to control and then to study-level evidence.

This study investigates the extent to which published productive-sector research explicitly moves from conceptual recognition of sustainability-control domains to operational controls and documented outcome evidence. The analysis is conducted at the study level and does not directly measure organizational transformation, firm-level maturity, or project-level causal impact. It asks: (RQ1) To what extent do studies in the selected corpus explicitly report recognition, operationalization, and documented outcome evidence for ten sustainability-control domains? (RQ2) Which domains show the highest and lowest rates of reported translation when conditional continuity and full-chain prevalence are considered together? (RQ3) Do studies exhibit statistically distinguishable evidence-reporting profiles according to how sustainability is translated across these stages? The study combines a standardized computational coding layer with complete independent manual review to make the resulting documentary classifications reproducible and auditable.

2. Theoretical Framework

2.1. Sustainability as a Management Control Problem in Project-Based Organizations

Sustainability becomes manageable when broad values are converted into objects of control. These objects include material impacts, quantified targets, process responsibilities, decision thresholds, incentives, audit trails, and escalation rules. The challenge is not simply to add environmental and social indicators to an existing dashboard. It is to align

the control package with the temporal and relational characteristics of projects, including temporary teams, contractors, multiple stakeholders, lifecycle effects, and the separation between project outputs and long-term outcomes [1,18].

Project-based sustainability therefore requires vertical and horizontal integration. Vertical integration connects corporate purpose and portfolio priorities with project selection, funding, governance, and success criteria. Horizontal integration connects design, procurement, operations, stakeholder engagement, risk management, data systems, and end-of-life decisions across the project lifecycle. Research on ESG practices, organizational agility, project maturity, and stakeholder engagement suggests that these connections are often partial rather than systemic [19–22].

The productive-sector context reinforces the need for integrated controls. Construction and infrastructure projects combine high resource intensity, fragmented supply chains, and long-lived impacts. Agriculture and food systems depend on local knowledge, climatic uncertainty, traceability, and community participation. Manufacturing and energy projects require lifecycle design, technology investment, risk controls, and regulatory compliance. The same sustainability concept can therefore require different operational controls depending on sector, scale, institutional conditions, and technological maturity [23–25].

2.2. Evidence Translation: Recognition, Operationalization, and Documented Outcome Evidence

The proposed evidence-translation framework distinguishes three analytically separate stages. Recognition (R) exists when a study explicitly defines or frames a sustainability domain as relevant. Operationalization (O) exists when the domain is connected to a practice, indicator, control mechanism, decision process, responsibility, resource allocation rule, or implementation routine. Documented outcome evidence (E) exists only when a study reports an observed, measured, modelled, statistically associated, verified, or explicitly documented outcome connected to a sustainability-control domain. Statements expressing expected benefits, recommendations, conceptual relevance, potential effects, future opportunities, or generic claims of importance were not coded as documented outcome evidence unless they were accompanied by reported empirical, modelled, analytical, or verification-based evidence.

To avoid conflating recommendations with outcomes, the coding distinguished five evidence-strength levels: 0 = no outcome evidence; 1 = recommendation, expected benefit, or potential effect; 2 = reported association or modelled effect; 3 = observed or measured change; and 4 = verified, audited, or post-project outcome. Only levels 2–4 were treated as documented outcome evidence in the binary E indicator. Level 1 was retained in the supplementary evidence-strength file but was not counted as outcome evidence.

The three stages are sequential but not mechanically deterministic. A study can operationalize a governance mechanism without providing an explicit conceptual definition, or report a digital effect without describing the full control design. Consequently, the framework does not assume that R, O, and E are perfectly nested. Instead, it measures conditional conversion and full reported translation. This is particularly important for emerging topics such as digital assurance and the circular economy, where implementation can precede conceptual stabilization, and for system transitions, where conceptual attention may greatly exceed operational evidence [5,8,26].

2.3. Relationship to Decoupling, Symbolic Adoption, and Implementation-Gap Theory

Classical institutional theory explains how formal structures may become separated from everyday activity when legitimacy requirements and technical demands diverge [27–34]. Later work distinguishes policy–practice decoupling, in which adopted policies are weakly enacted, from means–ends decoupling, in which implemented prac-

tices do not reliably produce intended effects [35–40]. Symbolic adoption is one possible mechanism, as illustrated by the ceremonial use of environmental standards [41–43], but implementation gaps may also arise from ambiguous objectives, resource limitations, competing stakeholder demands, bounded attention, learning processes, and difficult coordination rather than deliberate impression management [44,45].

The R-O-E framework does not replace these theories. R without O is compatible with a policy- or strategy–practice gap, but the documentary code does not establish symbolic intent. O without E is compatible with means–ends decoupling, delayed outcomes, weak measurement, incomplete reporting, or an implementation gap. E without a fully reported R-O pathway may reflect implicit controls, compressed methods reporting, or a genuinely non-sequential evidence structure. R-O-E therefore identifies where the published chain is explicit or discontinuous; decoupling and implementation theories provide candidate explanations that require primary organizational evidence to test.

2.4. Sustainability-Control Domains

Ten domains were defined from the combined extraction matrices and the management-control literature: environmental performance; social and stakeholder inclusion; economic and financial viability; governance and ethics; lifecycle and circularity; measurement and reporting; risk and resilience; digital and data infrastructure; organizational capability; and system transition. These domains are not presented as a new sustainability taxonomy. They are analytical control domains that capture what organizations attempt to direct, measure, coordinate, learn from, and verify. It is represented throughout the Table 1.

Table 1. Operational definition of sustainability-control domains, accepted outcome evidence, and exclusions used to avoid conflating recommendations with documented outcomes.

Domain	Recognition Indicators	Operationalization Indicators	Outcome Evidence Accepted	Not Accepted as Outcome Evidence
Environmental performance	Climate, carbon, energy, water, waste, biodiversity	Emission targets, environmental impact assessment, resource monitoring	Measured reductions, verified environmental performance, modelled or observed ecological effects	Generic environmental concern or expected ecological benefit
Social and stakeholder	Stakeholders, communities, equity, participation, well-being, safety	Engagement routines, co-design, social indicators, grievance or dialogue mechanisms	Documented welfare, trust, participation, safety, distributional or community outcomes	General stakeholder rhetoric or recommendation to engage
Economic and financial	Costs, investment, profitability, competitiveness, long-term value	Lifecycle costing, sustainable finance, budget criteria, economic KPIs	Measured economic performance, savings, investment effects, value creation or cost changes	Claims that sustainability may reduce costs without reported evidence
Governance and ethics	Governance, transparency, ethics, policy, compliance	Decision rights, accountability routines, audits, reporting responsibilities	Verified compliance, legitimacy, accountability, governance performance or documented ethical effects	General policy statement or claim of good governance
Lifecycle and circularity	Lifecycle, circular economy, reuse, recycling, regeneration	Material passports, end-of-life planning, supplier recovery duties, circular procurement	Measured recovery, reuse, lifecycle value, waste reduction or post-project circular outcomes	Potential circular benefits or design aspiration only
Measurement and reporting	Indicators, metrics, ESG, reporting, monitoring	Dashboards, KPIs, audits, measurement protocols, reporting systems	Audited, reproduced, compared or documented performance evidence	Presence of indicators without use or outcome evidence

Table 1. *Cont.*

Domain	Recognition Indicators	Operationalization Indicators	Outcome Evidence Accepted	Not Accepted as Outcome Evidence
Risk and resilience	Risk, resilience, uncertainty, vulnerability, adaptation	Risk registers, scenario thresholds, resilience reviews, contingency rules	Measured risk reduction, resilience performance, adaptation outcomes or modelled risk effects	General recognition of risk or resilience importance
Digital and data	AI, IoT, BIM, blockchain, digital twins, analytics, traceability	Data governance, digital monitoring, interoperability, automated verification	Verified data quality, traceability, prediction, monitoring or ESG-assurance improvement	Technology availability or claims that tools can improve reporting
Organizational capability	Leadership, culture, skills, maturity, learning, agility	Training, roles, incentives, routines, knowledge-management mechanisms	Observed capability improvement, learning effects, agility gains or maturity changes	General capacity-building recommendation
System transition	Socio-technical transition, SDGs, low-carbon systems, ecosystem innovation	Portfolio alignment, policy coordination, cross-project learning, transition governance	Documented sectoral, territorial, policy, portfolio or transition outcomes	Broad transition narrative without specific outcome evidence

3. Materials and Methods

3.1. Design and Corpus Provenance

This study was designed as a systematic review and secondary study-level evidence synthesis with meta-aggregative foundations and quantitative content-analysis procedures. The term meta-aggregative is used because the source matrices were built from extracted full-text findings, explicit study statements, implementation conditions, sustainability-related practices, sectoral information, and meta-aggregable evidence statements. The present article does not claim to be a de novo JBI qualitative meta-aggregation; its contribution is a document-level evidence translation analysis that quantifies how extracted evidence is reported across recognition, operationalization, and documented outcome stages. The completed PRISMA 2020 checklist is provided as Supplementary Material S1.

The unit of analysis was the published study. Therefore, all results refer to evidence-reporting patterns in the scientific literature and should not be interpreted as direct measurements of organizational transformation, firm-level maturity, or project-level causal effects. The review focused on the relationship between sustainability, project management, and productive-sector implementation. Instead of treating sustainability as a general conceptual field, the study examined whether sustainability-related domains move through three evidence stages: recognition, operationalization, and documented outcome evidence. This design allowed the review to assess not only whether sustainability is mentioned in the literature, but whether it is translated into control mechanisms, managerial decisions, and verifiable outcomes.

The evidence base was constructed from structured searches conducted in Scopus and Web of Science Core Collection. The searches were last conducted on 3 May 2026. Both databases were selected because of their broad coverage of peer-reviewed literature in engineering, project management, sustainability, business, environmental sciences, social sciences, and productive-sector studies.

The searches were restricted to articles and review articles. English and Spanish publications were retained. The Scopus search retrieved 62 records, and the Web of Science Core Collection search retrieved 73 records, producing an initial database evidence base of 135 records. These records were exported and organized into two curated evidence matrices for full-text coding and consolidation.

Records were consolidated through DOI verification, title normalization, author–year comparison, reference checking, and full-text verification. Two duplicate studies were identified and removed. Two records with incomplete bibliographic information were recovered from their corresponding full-text documents and retained after verification. No additional records were excluded after consolidation because all retained studies satisfied the eligibility criteria and contained extractable evidence relevant to the review objective. The final analytic corpus therefore comprised 133 unique full-text studies.

The review was not prospectively registered, and no external protocol was deposited in a public registry. The working protocol used for this study is documented in the Supplementary Materials, including the search equations, eligibility criteria, corpus provenance, extraction fields, coding dictionary, domain-stage rules, study-level coding matrix, translation metrics, statistical outputs, sensitivity analyses, and executable analysis script. Since no registered protocol was prepared, no protocol amendments were applicable.

Studies were eligible for inclusion when they met all the following criteria:

(i) They addressed sustainability, sustainable development, ESG, triple bottom line, circularity, resilience, stakeholder value, environmental sustainability, social sustainability, economic sustainability, or related sustainability-control dimensions;
(ii) They were connected to project management, sustainable project management, project governance, project-based organizations, productive sectors, agroindustry, agriculture, agri-food systems, rural production, or implementation contexts;
(iii) They included managerial, financial, risk-related, stakeholder-related, operational, or implementation-oriented evidence;
(iv) They provided full-text information that allowed extraction and coding of at least one sustainability-control domain; and
(v) They allowed classification of evidence into one or more of the three evidence-translation stages: recognition, operationalization, and documented outcome evidence.

Records were excluded when they were duplicated, did not correspond to articles or review articles, did not provide recoverable bibliographic information, lacked full-text evidence for coding, or did not address the relationship between sustainability and project management or implementation in productive-sector contexts. No study was excluded on the basis of methodological design alone, because the review sought to synthesize conceptual, empirical, and applied evidence across a multidisciplinary field.

The studies were grouped for synthesis according to ten sustainability-control domains: environmental performance, social and stakeholder inclusion, economic and financial viability, governance and ethics, lifecycle and circularity, measurement and reporting, risk and resilience, digital and data infrastructure, organizational capability, and system transition. Within each domain, evidence was classified into three stages: recognition, operationalization, and documented outcome evidence. This grouping strategy was used to evaluate whether each domain remained at the level of conceptual recognition, advanced toward managerial operationalization, or produced documented evidence of change.

The selection process was carried out in four sequential steps. First, all records retrieved from Scopus and Web of Science Core Collection were exported with their bibliographic information, abstracts, keywords, DOI, source title, publication year, document type, and language. Second, records were screened according to document type, language, thematic relevance, and connection with the review objective. Third, the retained records were checked for full-text availability and extractable evidence. Fourth, the final corpus was consolidated after duplicate removal, reference normalization, and full-text verification.

The screening and consolidation process was conducted by the author team. Records with unclear bibliographic information or uncertain eligibility were discussed and resolved by consensus under the supervision of the senior author. No automation tool was used to

make final inclusion or exclusion decisions. Computational tools were used only for data organization, coding support, statistical analysis, and reproducibility.

Data were collected from harmonized fields across the evidence matrices and, where necessary, verified directly in the full-text documents. The extracted fields included sustainability definitions, contextual application, practice guidelines, required adaptations, trends, sectoral influence, triple-impact criteria, sustainability–project management links, contextual implementation considerations, reported changes in project management, meta-aggregable findings, abstracts, keywords, year of publication, source, DOI, and sectoral classification.

The data items sought for synthesis were the presence or absence of each sustainability-control domain at the recognition, operationalization, and documented-outcome stages. Other variables included publication year, database source, document type, sector, bibliographic traceability, full-text availability, and evidence explicitness. When bibliographic information was incomplete but recoverable from the full text, the record was retained and the missing information was completed. When a study did not explicitly report a domain or evidence stage, the corresponding code was assigned as absent rather than inferred. The PRISMA process is represented in Figure 1.

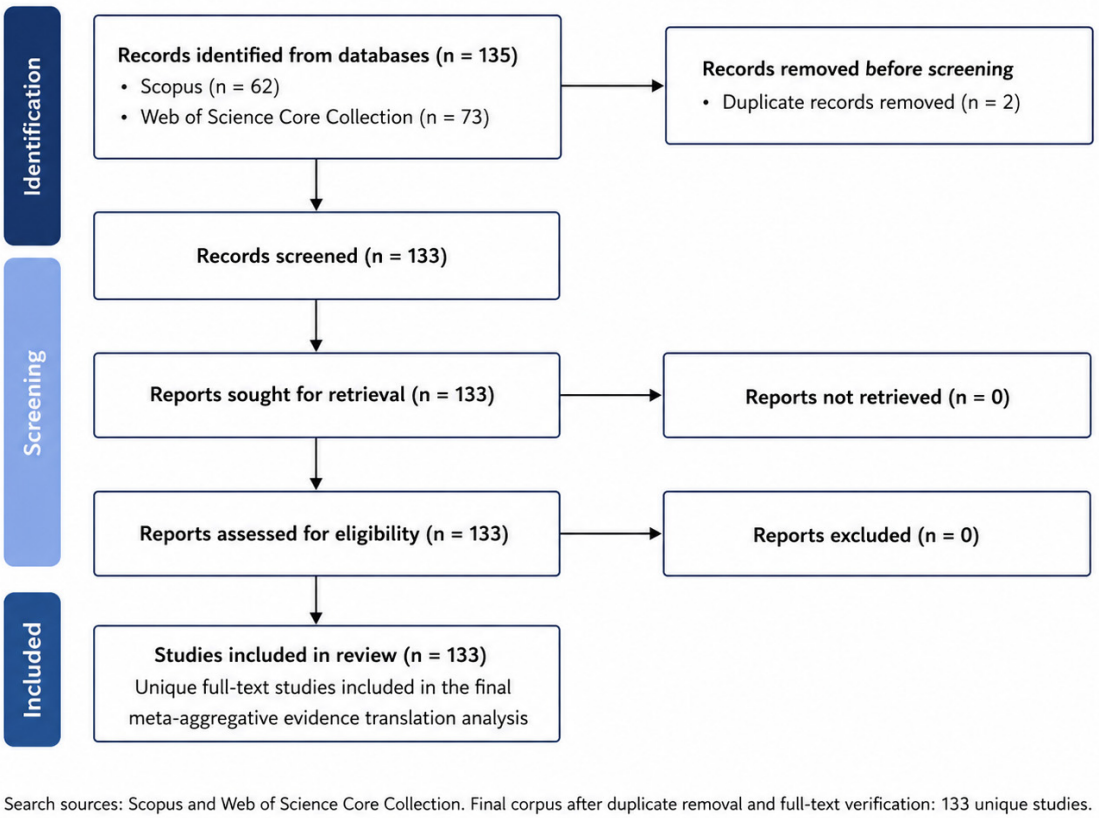


Figure 1. PRISMA flow diagram for study identification, screening, eligibility assessment, and inclusion. The database search identified 135 records, including 62 from Scopus and 73 from the Web of Science Core Collection. After duplicate removal (n = 2), 133 records remained for screening, retrieval, and full-text eligibility assessment. No reports were excluded after full-text verification, and the final analytic corpus comprised 133 unique full-text studies included in the meta-aggregative evidence translation review. Source: Authors' own elaboration based on Scopus and Web of Science Core Collection search records.

3.2. Data Structure and Integrated Coding Protocol

The unit of analysis was the study. Eleven source fields were harmonized across matrices: sustainability definition, contextual application, practice guidelines, required

adaptations, trends, sectoral influence, triple-impact criteria, sustainability–project management links, contextual implementation considerations, reported changes in project management, and meta-aggregable findings. Abstracts and keywords were also retained where available.

The first coding layer used sentence-level rule-based classification to generate a standardized R-O-E matrix and organize candidate evidence excerpts for every study–domain–stage position. The pre-specified bilingual English–Spanish dictionary required explicit domain terminology in the relevant extraction fields. Recognition required a conceptual domain reference. Operationalization required a domain reference linked to an action or control verb, such as integrate, implement, monitor, evaluate, allocate, coordinate, align, establish, or control. Documented outcome evidence required a results-oriented statement linked to an evidence verb, such as demonstrate, associate, predict, improve, reduce, increase, affect, confirm, transform, verify, or document. This computational layer supported consistent corpus-wide detection and coding traceability; it did not determine study inclusion or exclusion.

Explicit negation or absence statements, including not reported, not specified, does not address, no evidence, and no operationalization, were not treated as positive evidence. The dictionary included conceptually equivalent terms needed for multidisciplinary coverage, while matched excerpts, field assignments, and negation rules were retained for auditability. When a domain-stage statement was not explicit, the corresponding binary code was zero rather than inferred.

Complete manual coding and quality assurance were conducted independently by two professionals with profiles directly relevant to the task. Both are university professors with more than five years of professional experience; one has a sustainability-focused profile and the other a statistics-focused profile. Each reviewer coded all 133 studies across ten domains and three stages, equivalent to 1330 study-domain units and 3990 binary decisions. The work began immediately after receipt of the editorial response, was completed over ten calendar days, and closed on 20 August 2026.

Inter-coder reproducibility was assessed separately for R, O, and E using observed agreement, Cohen's kappa, and Gwet's AC1. A third author adjudicated every disagreement against the extracted evidence and pre-specified protocol. The process covered 485 stage-level disagreements across 330 study-domain units (105 R, 225 O, and 155 E). The final matrix contains no unresolved coding cells.

The adjudicated decisions constituted the study-level inferential matrix used for prevalence, pathway, DTC, bootstrap, GEE, latent-class, and sensitivity analyses. The automated candidate matrix, both independent reviewer matrices, evidence excerpts, disagreement records, adjudication trail, and diagnostic comparisons are retained in Supplementary Material S2.

3.3. Translation Metrics

For each domain d, recognition prevalence was calculated as $R_d = n(R = 1)/N$, operationalization prevalence as $O_d = n(O = 1)/N$, and documented-outcome prevalence as $E_d = n(E = 1)/N$. Full reported translation was calculated as $F_d = n(R = 1, O = 1, E = 1)/N$.

Because R, O, and E were not assumed to be perfectly nested, all eight possible R–O–E configurations were also computed: 000, 001, 010, 011, 100, 101, 110, and 111. This allowed the analysis to distinguish complete reported translation from alternative reporting pathways, such as operationalization without explicit recognition or outcome evidence without a fully described control pathway.

For the sequential interpretation of translation, two conditional probabilities were estimated: C_RO,d = P(O = 1 | R = 1) and C_ROE,d = P(E = 1 | R = 1, O = 1). The sequential Domain Translation Coefficient was then calculated as:

$$DTC_seq,d = \sqrt{(C_RO,d \times C_ROE,d)}$$

The coefficient is used as an exploratory comparative descriptor of reported evidence continuity across stages. It is not interpreted as a validated maturity score, a causal measure, or direct evidence of organizational transformation. Because DTC_seq can produce similar values under different prevalence structures, it is interpreted together with full R–O–E completion rates and the eight pathway configurations.

3.4. Statistical Analysis and Robustness

Uncertainty for prevalence, full translation, and DTC was estimated with 5000 non-parametric bootstrap resamples at the study level. The primary GEE model estimated the probability that a study–domain–stage observation was coded as present. It used a binomial family, logit link, robust covariance estimator, and exchangeable working correlation structure to account for the 30 repeated binary observations contributed by each study. The model was specified as:

$$\text{logit}[P(Y_ids = 1)] = \text{beta_0} + \text{beta_1Stage_O} + \text{beta_2Stage_E} + \text{sum gamma_dDomain_d}$$

where Y_ids is the binary coding outcome for study i, domain d, and stage s. Recognition was the reference stage and environmental performance the reference domain. The stage coefficients tested whether O and E differed from R after adjustment for domain composition. Joint Wald tests assessed stage and domain effects [29].

Bernoulli latent-class models with two through six classes were estimated from the 30 indicators [30]. Each model used 100 random starts, a maximum of 500 expectation–maximization iterations, convergence tolerance of 1×10^{-7}, fixed model-specific seeds, Dirichlet initialization for class weights, random initial item probabilities between 0.15 and 0.85, and Jeffreys-type regularization. Selection considered unpenalized log-likelihood, number of free parameters, BIC, AIC, class size, replicated optima, posterior probabilities, normalized entropy, and substantive interpretability. Because the sample contained 133 studies and 30 binary indicators, the classes were interpreted as documentary profiles rather than organizational types.

Temporal robustness was examined by comparing publication year and the proportion of studies published from 2023 onward across the selected classes. Sectoral differences were tested across construction/infrastructure, agriculture/food, and other sectors. Analyses used fixed random seeds and are fully documented in Supplementary Material S2. Bootstrap resampling used seed = 42; all domains retained 5000 valid iterations, so no zero-denominator failures occurred. The intervals quantify sampling variability within the selected corpus but do not incorporate uncertainty from upstream study selection or textual classification [31].

4. Results

4.1. Corpus Characteristics

The 133-study corpus was strongly contemporary: 33 studies were published in 2025, 21 in 2024, 19 in 2023, 17 in 2021, 13 in 2022, and 12 in 2020. Earlier publications were retained because they established foundational links between project management, stakeholder value, environmental performance, and sustainable production. The concentration

of recent studies confirms rapid expansion, but the sector distribution also shows that knowledge remains dominated by construction and infrastructure.

Qualitatively, the evidence base covered a wide range of managerial objects: ESG metrics and disclosure, sustainable project maturity, stakeholder engagement, lifecycle assessment, circular business models, digital traceability, organizational agility, project finance, resilience, climate transitions, and sector-specific operational practices. The breadth of the corpus made it possible to compare not merely whether a topic appeared, but how far it travelled from conceptual recognition into controls and documented effects.

To preserve readability, the complete 133-study list is reported in Supplementary Material S2, Table S1 (worksheet S1_Corpus), rather than reproduced in the main text. The supplementary crosswalk links Study_ID 1–133 to the full reference, publication year, primary sector, harmonized sector group, and DOI or bibliographic traceability key.

4.2. Recognition, Operationalization, and Evidence Pathways

The integrated coding process produced a complete matrix of 1330 study–domain observations and 3990 stage decisions. Inter-coder observed agreement was 92.1% for R, 83.1% for O, and 88.3% for E. Cohen's kappa was 0.843, 0.607, and 0.764, respectively, while Gwet's AC1 was 0.842, 0.709, and 0.771. These values indicate strong overall reproducibility and show that operationalization required the greatest interpretive attention because it depends on whether a reported action, indicator, responsibility, or allocation rule functions as an explicit control.

All eight R-O-E configurations were retained rather than forcing a monotonic sequence. The 111 pattern represents full reported translation; 100 indicates recognition without operationalization or documented outcome evidence; 110 indicates recognition and operationalization without E; and 101 identifies recognition and documented outcome evidence without an explicit operational account. Configurations beginning with zero were uncommon, indicating that operationalization or evidence without recognition was rare. The main non-nested pathway was instead 101, particularly in organizational capability (47 studies), measurement and reporting (30), system transition (29), environmental performance (28), and economic and financial viability (23). The R-O.E pathway configuration is presented in Table 2.

Table 2. R-O-E pathway configurations by sustainability-control domain. Values are study counts over the final corpus (N = 133). R = recognition; O = operationalization; E = documented outcome evidence.

Domain	000	001	010	011	100	101	110	111
Environmental performance	39	1	1	1	7	28	6	50
Social and stakeholder	43	1	1	1	4	17	5	61
Economic and financial	52	0	0	1	9	23	4	44
Governance and ethics	69	0	0	0	3	18	8	35
Lifecycle and circularity	112	0	0	0	4	0	4	13
Measurement and reporting	63	1	0	0	5	30	6	28
Risk and resilience	86	1	0	1	4	5	5	31
Digital and data	89	0	0	1	4	2	4	33
Organizational capability	8	0	0	0	7	47	8	63
System transition	51	0	0	1	6	29	9	37

Across the ten domains, recognition was present in 53.1% of study-domain observations, operationalization in 34.7%, and documented outcome evidence in 45.4%; full R-O-E completion occurred in 29.7%. The GEE confirmed stage differences after adjustment for domain and repeated observations. Relative to R, O had lower odds of being present (beta = −0.860, robust SE = 0.057, OR = 0.423, 95% CI 0.378–0.473, $p < 0.001$), while E also

had lower odds (beta = −0.352, robust SE = 0.065, OR = 0.703, 95% CI 0.619–0.799, $p < 0.001$). The working correlation was 0.050; the joint stage test was chi-square = 272.441 (df = 2, $p < 0.001$), and the joint domain test was chi-square = 228.560 (df = 9, $p < 0.001$). In Figure 2 the prelevance of R, O and E codes is shown.

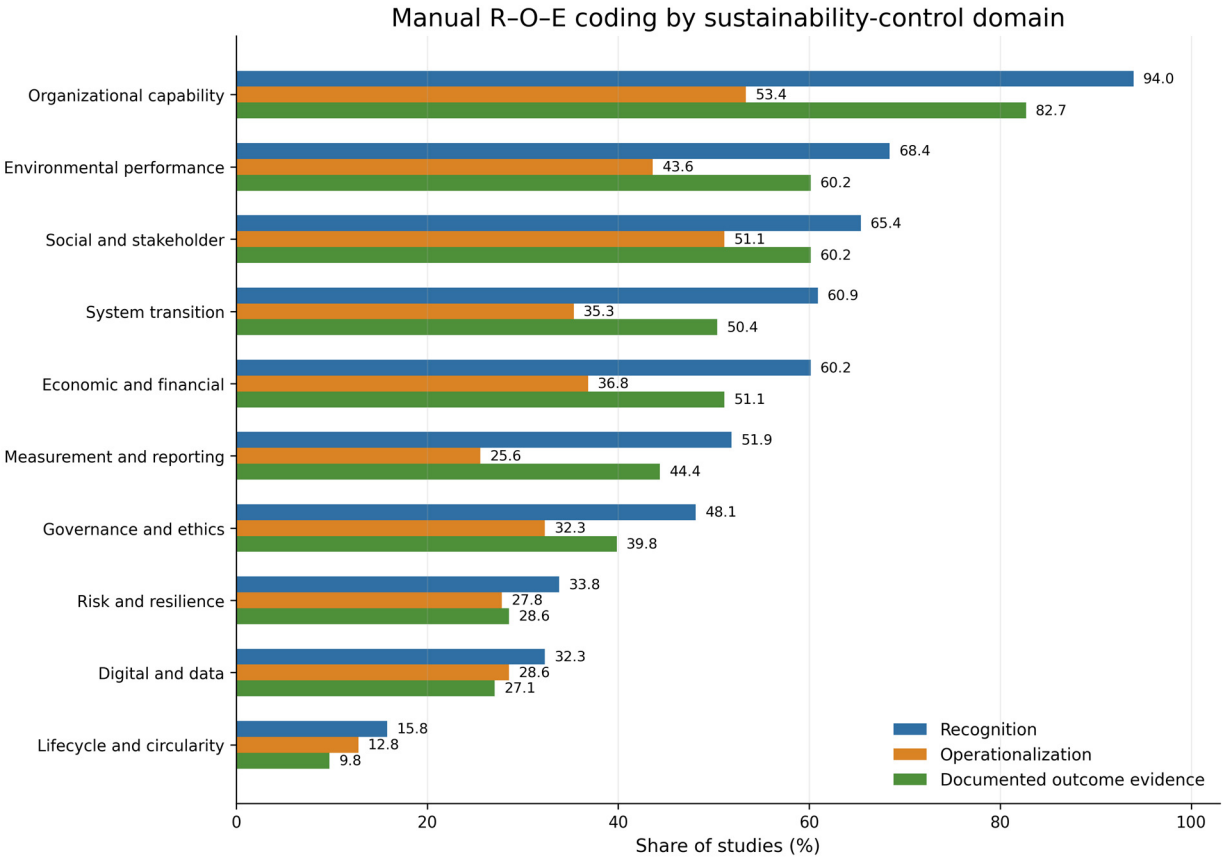


Figure 2. Prevalence of R, O, and E codes across sustainability-control domains. Percentages represent explicit study-level documentary evidence rather than direct measurements of organizational implementation.

The absolute prevalence pattern was domain-specific. Organizational capability had the highest recognition (94.0%) and documented outcome prevalence (82.7%), while social and stakeholder evidence showed the highest full R-O-E completion (45.9%). Environmental performance combined 68.4% recognition with 60.2% outcome evidence, but operationalization was present in 43.6%. Measurement and reporting showed 51.9% recognition, 25.6% operationalization, and 44.4% outcome evidence, illustrating the recurring 101 pathway in which performance or reporting results are visible without a fully described control routine.

4.3. Domain Translation Coefficients

Digital and data had the highest conditional DTC (0.876; 95% CI 0.795–0.941), followed by social and stakeholder (0.837; 95% CI 0.776–0.892) and risk and resilience (0.830; 95% CI 0.739–0.905). These values indicate strong continuity among the subset of studies reaching the prior stages, but they do not imply broad domain coverage. Digital and data, for example, achieved only 24.8% full R-O-E completion, while risk and resilience achieved 23.3%.

Lifecycle and circularity presents the clearest reason for reading DTC together with absolute prevalence. Its DTC was 0.787 and P(E | R,O) was 0.765, yet recognition occurred in only 15.8% of studies and full completion in 9.8%. Conversely, organizational capability had

a lower conditional DTC of 0.710 because operationalization was not always explicit, even though it had the highest recognition and outcome prevalence and 47.4% full completion. Measurement and reporting reached a DTC of 0.637 and 21.1% full completion; the domain is therefore visible in outcomes but less consistently connected to an explicit operational pathway. Figure 3 represents the sequential translation coefficients from manual coding.

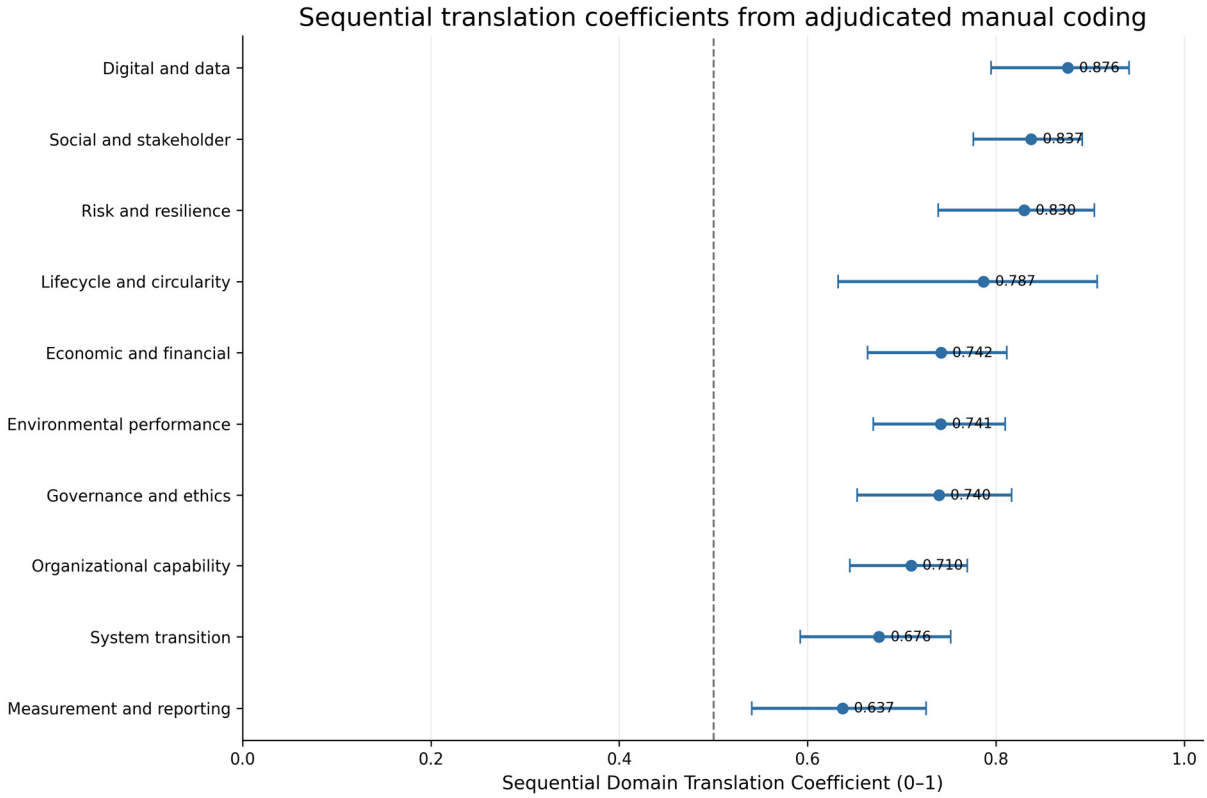


Figure 3. Sequential Domain Translation Coefficients with percentile 95% bootstrap confidence intervals. The dashed line is a visual reference and not a validated maturity threshold.

Table 3 summarizes the prevalence of the Recognition (R), Operationalization (O), and Evidence of change (E) stages across the ten analytical domains, together with the corresponding conditional translation probabilities and sequential Domain Translation Coefficient (DTC_seq).

Table 3. Domain prevalence, conditional translation, and sequential DTC with percentile 95% bootstrap confidence intervals based on 5000 study-level resamples.

Domain	R	O	E	Full R-O-E	P(O | R)	P(E | R,O)	DTC_seq (95% CI)
Environmental performance	68.4%	43.6%	60.2%	37.6%	0.615	0.893	0.741 (0.670–0.810)
Social and stakeholder	65.4%	51.1%	60.2%	45.9%	0.759	0.924	0.837 (0.776–0.892)
Economic and financial	60.2%	36.8%	51.1%	33.1%	0.600	0.917	0.742 (0.664–0.812)
Governance and ethics	48.1%	32.3%	39.8%	26.3%	0.672	0.814	0.740 (0.653–0.816)
Lifecycle and circularity	15.8%	12.8%	9.8%	9.8%	0.810	0.765	0.787 (0.632–0.907)
Measurement and reporting	51.9%	25.6%	44.4%	21.1%	0.493	0.824	0.637 (0.541–0.726)
Risk and resilience	33.8%	27.8%	28.6%	23.3%	0.800	0.861	0.830 (0.739–0.905)
Digital and data	32.3%	28.6%	27.1%	24.8%	0.860	0.892	0.876 (0.795–0.941)
Organizational capability	94.0%	53.4%	82.7%	47.4%	0.568	0.887	0.710 (0.645–0.769)
System transition	60.9%	35.3%	50.4%	27.8%	0.568	0.804	0.676 (0.592–0.752)

4.4. Latent Evidence-Reporting Profiles

The four-class solution minimized BIC (4693.076) while retaining high classification quality (normalized entropy = 0.986). Mean maximum posterior probability was 0.995, the minimum was 0.803, and no study fell below 0.80. The selected solution therefore offered a stable descriptive summary without requiring the smaller residual classes generated by five- and six-class models. The profiles describe combinations of reported evidence; they are not types of organizations, sectors, or projects.

The stakeholder–governance–transition profile (n = 51) combined high social/stakeholder probabilities (R = 0.87, O = 0.72, E = 0.80) with organizational capability (0.97, 0.51, 0.82), governance/ethics, and system-transition evidence, but showed little lifecycle, measurement, or digital evidence. The lifecycle-system integration profile (n = 16) was distinguished by lifecycle/circularity (0.97, 0.97, 0.78), system transition (0.84, 0.79, 0.50), and relatively broad environmental, economic, and capability evidence.

The digital–data evidence profile (n = 28) had near-complete digital probabilities (0.95, 0.95, 0.98) together with high organizational capability and a measurement pattern in which R and E were visible but O was less explicit. The measurement-performance profile (n = 38) was dominated by measurement/reporting (0.99, 0.63, 0.96), organizational capability (0.91, 0.50, 0.83), and comparatively strong environmental and economic evidence, while digital and lifecycle probabilities were close to zero. The four profiles thus capture different documentary routes through which sustainability is connected to controls and outcomes rather than through a single evidence-intensity gradient.

Figure 4 presents the conditional R-O-E probabilities associated with the four-class latent solution, allowing the internal translation patterns of each class to be compared across Recognition, Operationalization, and Evidence of change.

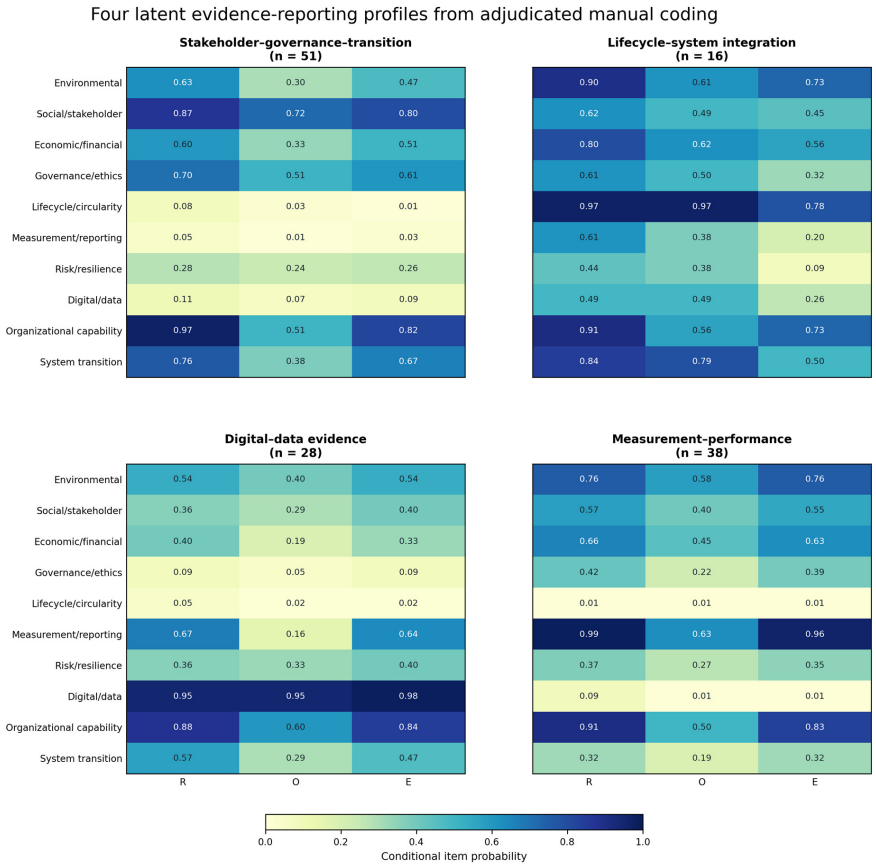


Figure 4. Conditional R-O-E probabilities for the four-class latent solution. Labels summarize evidence-reporting patterns and do not imply organizational archetypes.

Table 4 presents the comparison of the Bernoulli latent-class models estimated from the final 30-indicator matrix. The competing solutions were evaluated using the corresponding model-fit criteria to determine the most appropriate number of latent classes while balancing statistical fit and interpretability.

Table 4. Bernoulli latent-class model comparison based on the final 30-indicator matrix.

Classes	Parameters	Log-Likelihood	BIC	AIC	Entropy	Mean Max Posterior	Min Max Posterior	Class Sizes
2	61	−2262.889	4824.090	4647.779	0.894	0.974	0.582	90, 43
3	92	−2146.625	4743.162	4477.250	0.971	0.990	0.760	38, 57, 38
4	123	−2045.782	4693.076	4337.563	0.986	0.995	0.803	38, 28, 51, 16
5	154	−1974.796	4702.706	4257.592	0.977	0.990	0.831	42, 21, 27, 7, 36
6	185	−1919.296	4743.307	4208.592	0.988	0.994	0.735	28, 11, 7, 38, 22, 27

4.5. Temporal and Sectoral Sensitivity

Publication year did not differ across the four classes (Kruskal–Wallis H = 0.379, df = 3, p = 0.945); every class had a median publication year of 2023. The distribution of studies published from 2023 onward also did not differ by class (chi-square = 2.147, df = 3, p = 0.542). These results do not demonstrate temporal equivalence; they indicate that the selected corpus did not provide evidence of a systematic recent shift toward one documentary profile.

Sector composition was likewise not statistically distinguishable across classes (chi-square = 8.087, df = 6, p = 0.232). The absence of a detected association should be interpreted cautiously because sector groups were uneven and the profiles cut across common managerial mechanisms such as measurement, stakeholder governance, organizational capability, digital assurance, and lifecycle control.

5. Discussion

The results describe patterns in published evidence rather than direct measurements of organizational practice [43–47]. A discontinuity among R, O, and E does not by itself establish that a control is absent, ceremonial, or ineffective. It indicates that the selected studies do not always report the complete documentary linkage among sustainability purpose, operational mechanisms, and outcomes. Study design, reporting conventions, terminology, time lags, and the scope of extracted evidence all influence which stages are visible [48–50].

5.1. From Recognition to Explicit Control Pathways

The central pattern is not a simple decline from recognition to outcomes. Recognition was the most common stage, but documented outcome evidence exceeded operationalization [51–58]. This means that the main break in the published chain lies in the explicit description of control design and enactment. Many studies report an outcome, association, modelled effect, or performance result without specifying how sustainability entered targets, responsibilities, budgets, decision rights, project gates, or feedback routines [54–62]. The prevalence of the 101 configuration supports this interpretation.

This distinction changes how maturity should be interpreted. Literature can contain many measured or modelled outcomes while still providing an incomplete account of the mechanisms that connected sustainability purpose to those outcomes [63–66]. Conversely, the presence of plans, indicators, standards, and stakeholder processes does not establish that they influenced resource allocation or produced sustainable value. The R-O-E

framework therefore separates control visibility, control enactment, and outcome evidence instead of using any one of them as a proxy for the others [1,16–18,67–70].

The reliability pattern reinforces the conceptual importance of O. Recognition and outcomes are often signalled by explicit terminology, definitions, measures, or reported effects [68,70–74]. Operationalization requires a more demanding judgement about whether the study describes a control mechanism rather than a general activity or recommendation. Making that boundary explicit improves the reproducibility of evidence translation analysis and identifies what future studies must report to establish a credible line of sight from sustainability commitments to decisions [75–80].

5.2. Alternative Explanations for Documentary Discontinuities

The observed pathways are compatible with, but do not prove, different forms of decoupling. R without O resembles policy–practice decoupling because sustainability is formally visible without an explicit operational mechanism [75,76,81–84]. O without E resembles means-ends decoupling or an implementation gap because a practice is described without evidence of its intended effect [85–90]. E without O, however, warns against treating every discontinuity as ceremonial adoption: a study may compress its method, foreground results, rely on implicit controls, or report a modelled effect without narrating the operational sequence [91–100].

Symbolic adoption is consequently one explanation among several. Environmental or ESG systems can be used ceremonially [95,96,101–106], but gaps may also result from ambiguous objectives, conflicting stakeholder demands, inadequate resources, learning processes, measurement lag, fragmented responsibility, or reporting conventions [107–110]. Determining intent, actual enactment, and causal effects would require primary organizational data, process tracing, longitudinal observation, and linked control-and-outcome records [90–98,111–113]. The contribution of R-O-E is to locate the documentary break and make these competing explanations testable.

5.3. Domain-Specific Implications

Organizational capability and social-stakeholder evidence are the most prominent integrated domains. Their high recognition, outcome prevalence, and full-chain completion suggest that sustainability is frequently framed through leadership, learning, participation, stakeholder relations, and organizational change [114–118]. Even here, operationalization remains less visible than outcomes, indicating the need to describe how competencies, governance roles, and stakeholder inputs alter project selection, resource allocation, and review processes [118–122].

Digital/data, risk/resilience, and lifecycle/circularity show strong conditional continuity once a study reaches R and O, but their absolute prevalence remains limited. Digital infrastructures such as AI, IoT, BIM, blockchain, digital twins, and analytics can strengthen traceability and verification only when data provenance, interoperability, responsibility, and decision use are governed [5,34,123–130]. Risk and resilience require explicit ownership, scenario thresholds, review frequency, and feedback into portfolio and design decisions [32,33]. Lifecycle and circularity require project gates, material passports, supplier obligations, end-of-life responsibilities, and verified recovery outcomes rather than general circular-economy aspirations [6,26,60–67,100–103,131–137].

Measurement and reporting forms a distinct performance-oriented route. The domain has visible recognition and documented outcomes but comparatively weak operationalization, and its latent profile is associated with environmental, economic, and organizational-capability evidence [138–143]. The implication is not that measurement is unimportant; it is that reported metrics and results need a clearer connection to decision rights, escalation

rules, incentives, resource allocation, and corrective action. Economic-financial evidence similarly benefits from established owners, frequencies, thresholds, and incentive links, which can inform the design of equivalent accountability mechanisms for environmental and social outcomes [45–50,144–146].

System transition illustrates the boundary between project-level control and broader change. Projects are increasingly described as vehicles for socio-technical transitions, low-carbon diffusion, ecosystem innovation, and SDG implementation [8,25,65,78,110–112,147–152]. Yet a complete account requires portfolio coordination, policy alignment, cross-project learning, and outcome tracking beyond project closure. The stakeholder–governance–transition and lifecycle-system profiles show that different control combinations can support this broader orientation, but the corpus does not establish their causal effectiveness.

5.4. Sustainability Evidence Translation Control Architecture

Figure 5 integrates the findings into a four-layer control architecture. The recognition layer defines purpose, materiality, values, and the sustainability domains that matter. The control-design layer translates that purpose into targets, indicators, budgets, responsibilities, boundaries, and review mechanisms. The project-enactment layer embeds controls in lifecycle decisions, procurement, risk management, stakeholder dialogue, and resource allocation. The evidence layer verifies whether environmental, social, economic, governance, circular, resilience, digital, capability, and transition outcomes changed.

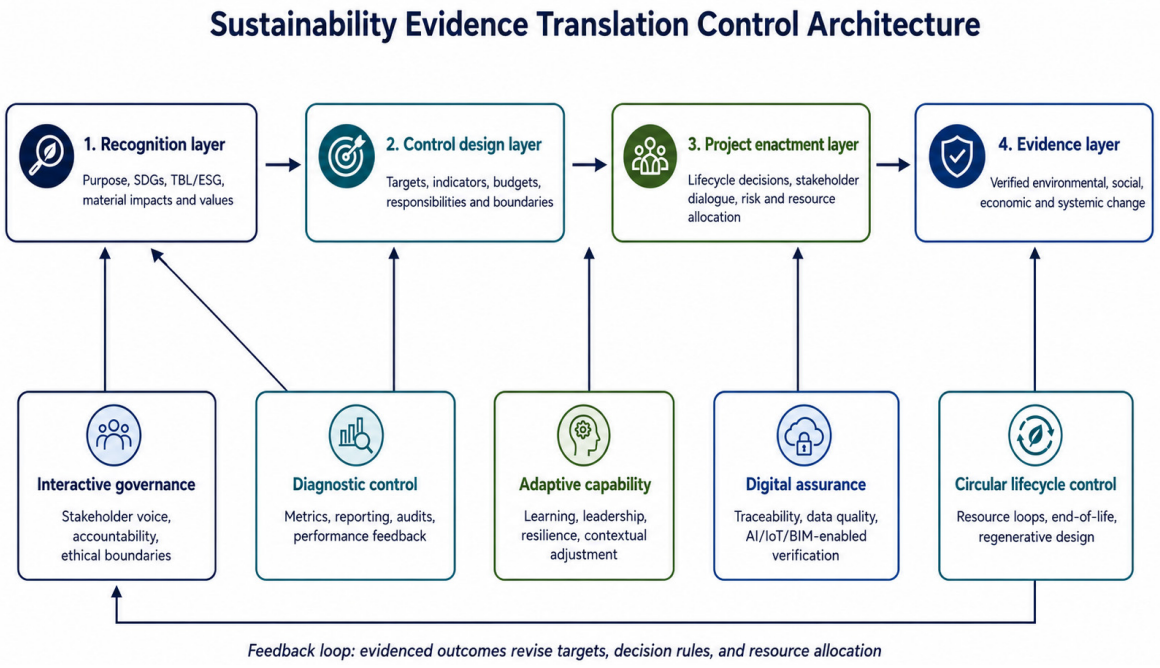


Figure 5. Proposed Sustainability Evidence Translation Control Architecture. The architecture is a theoretically informed conceptual synthesis for future empirical validation and not a tested causal model.

Five enabling control systems connect the layers. Interactive governance creates stakeholder voice, accountability, and ethical boundaries. Diagnostic control provides metrics, audits, and performance feedback. Adaptive capability supports learning, leadership, resilience, and contextual adjustment. Digital assurance protects traceability and data quality. Circular lifecycle control extends accountability to resource loops and end-of-life outcomes. The feedback loop is essential because evidence must revise targets, decision rules, investment criteria, and portfolio priorities.

The architecture differs from a checklist because it treats sustainability as a chain of documented translations rather than a collection of isolated practices. A weak or unreported link limits the ability to attribute an outcome to a sustainability control. DTC_seq summarizes conditional continuity, while configuration counts and absolute prevalence show how broad that continuity is. The architecture is a theoretically informed synthesis for future empirical testing and should not be interpreted as a validated causal model [2].

5.5. Implications for Research and Practice

For researchers, the framework creates a basis for more discriminating dependent variables. Future studies should avoid treating the presence of a sustainability plan or metric as evidence of implementation. Outcomes should include changed decisions, allocation effects, lifecycle consequences, stakeholder distributions, and post-project system impacts. Longitudinal designs, comparative case studies, and linked project–portfolio datasets are especially needed.

For practitioners, the framework can be used as a documentary control audit. R without O prompts examination of design, ownership, resource allocation, and implementation. O without E prompts examination of enactment, measurement, time lag, and feedback. E without a visible R-O pathway prompts examination of reporting completeness, method transparency, and causal traceability. The objective is not to maximize the number of indicators, but to establish a credible line of sight from sustainability purpose to controlled decisions and verified value. Table 5 translates the main evidence-translation gaps identified in the analysis into corresponding control-system responses, research requirements, and practical tests.

Table 5. Research and managerial implications of the identified evidence-translation gaps.

Observed Gap	Control-System Response	Research Requirement	Practical Test
High recognition, weak evidence	Link sustainability objectives to decision rights, incentives, and post-project review	Test causal pathways from control use to outcomes	Can a target change project selection, design, procurement, or funding?
Reporting dominates transformation	Combine diagnostic indicators with interactive learning and escalation	Distinguish reporting quality from decision influence	What decision changed because the indicator was reviewed?
Circularity and lifecycle underdeveloped	Assign end-of-life responsibilities and lifecycle thresholds	Measure material recovery and lifecycle value after closure	Who owns residual impacts and when are they verified?
Digital assurance has low prevalence	Control data provenance, interoperability, and auditability	Evaluate digital tools against verified ESG outcomes	Can the evidence be traced, reproduced, and challenged?
System transition lacks operational controls	Connect projects, portfolios, policy, and territorial outcomes	Develop cross-project and post-closure transition metrics	How does the project alter the wider system rather than only its own footprint?

6. Limitations

The analysis depends on evidence matrices and is therefore conditional on their search, eligibility, extraction, and consolidation decisions. Its strength is complete full-text coverage of the retained corpus; its limitation is inherited selection and extraction bias. The PRISMA flow, checklist, search equations, eligibility criteria, corpus rows, and references improve transparency but do not remove these dependencies.

The R-O-E codes identify explicit textual evidence and cannot infer unreported practices. Complete independent manual review improves criterion validity but remains interpretive. Both coders had relevant sustainability and statistics profiles, more than five years of professional experience, and full corpus coverage; nevertheless, O showed lower

agreement than R or E and required more adjudication. Conversely, a reported association or modelled effect does not establish causality or verified organizational transformation.

The corpus includes conceptual papers, reviews, case studies, cross-sectional empirical studies, modelling studies, and methodological frameworks. These designs do not provide equivalent strength of evidence, but all contribute to document-level prevalence. A conventional risk-of-bias or effect-certainty assessment was not applied because the study does not pool comparable intervention effects. The results should therefore be understood as evidence-reporting patterns rather than weighted estimates of organizational effectiveness.

DTC_seq is an exploratory comparative descriptor and can be high when absolute domain prevalence is low. It must be interpreted together with full R-O-E prevalence and the eight configurations. The four latent classes summarize 30 binary indicators in a sample of 133 studies and are not organizational archetypes. Temporal and sectoral null results may reflect limited power, uneven groups, and the cross-sector nature of several control mechanisms.

Future research should test the framework in independent corpora and primary organizational settings. Longitudinal case studies, linked project–portfolio datasets, expert validation, and process tracing are required to establish whether the controls identified in documents actually change project selection, resource allocation, stakeholder decisions, lifecycle performance, and post-project learning.

7. Conclusions

This study examined how 133 productive-sector studies report the movement of sustainability-control domains from recognition to operationalization and documented outcome evidence. Recognition was present in 53.1% of study–domain observations, operationalization in 34.7%, and documented outcome evidence in 45.4%, with 29.7% full R-O-E completion. The pattern is not simple attrition: outcomes are sometimes visible without a complete account of the control mechanisms connecting purpose, decisions, and results.

Domain-level analysis shows why conditional continuity and absolute prevalence must be considered together. Digital/data, risk/resilience, social/stakeholder, and lifecycle/circularity displayed strong conditional translation among studies reaching the earlier stages, but several had limited full-chain coverage. Organizational capability and social/stakeholder evidence had the broadest completion, while measurement/reporting formed a distinctive profile in which results were more visible than operational routines. The four latent classes further demonstrated that published evidence is organized through different stakeholder, lifecycle, digital, and performance-oriented configurations.

The principal contribution is a structured way to distinguish what the literature recognizes, how it reports operational control, and what outcomes it documents. These discontinuities are compatible with policy–practice gaps, means–ends gaps, incomplete reporting, delayed effects, or symbolic adoption, but they do not prove any one explanation. The Sustainability Evidence Translation Control Architecture converts the findings into an agenda for stronger reporting and future primary-data validation across purpose, controls, project enactment, outcomes, and feedback.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su18178921/s1, Supplementary Material S1 contains the completed PRISMA 2020 checklist documenting identification, screening, eligibility, corpus construction, and reporting locations. Supplementary Material S2 contains the complete 133-study corpus in Table S1 (worksheet S1_Corpus), linking Study_ID, full reference, year, primary sector, harmonized sector group, and DOI or traceability key. It also contains search provenance, codebooks, evidence excerpts, the automated candidate matrix, independent coder A and coder B matrices, adjudication

trail, final 30-indicator matrix, reliability diagnostics, R-O-E configurations, DTC and bootstrap outputs, GEE results, latent-class diagnostics and profiles, class assignments, and temporal and sectoral sensitivity analyses. The validated package is dated 20 August 2026.

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