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COLLABORATIVE GOVERNANCE QUALITY AND THE FORMALIZATION OF SUSTAINABILITY MANAGEMENT INSTRUMENTS IN SMART CITY PROJECTS: EVIDENCE FROM AN EMERGING URBAN CONTEXT

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Abstract

Smart city initiatives have spread rapidly across cities in the South, yet the conditions under which multi-actor collaboration actually leads to formalized, auditable, and sustainability-oriented management instruments remain poorly understood. This article addresses that gap by examining the relationship between collaborative governance quality and the formalization of sustainability management instruments in smart city projects, drawing on an in-depth qualitative case study of Casablanca. Through semi-structured interviews with 34 stakeholders across public, private, civil society, and knowledge-producing sectors, combined with documentary analysis of strategic plans, contracts, and project frameworks, the study finds that CGQ positively and significantly conditions SMI formalization. Three governance configurations emerge from the data: coordinated multi-actor arrangements that produce robust KPIs with auditability clauses, consultative assemblies that generate performative participation without binding instruments, and technocratic structures in which instruments exist formally but are disconnected from sustainability priorities. The study contributes to collaborative governance theory by identifying instrumentation as the critical conversion mechanism between stakeholder coordination and sustainability outcomes, and offers an analytical framework adapted to emerging metropolitan contexts where institutional capacity constraints, data governance fragility, and spatial inequalities moderate the effectiveness of smart city deployments.

Keywords: collaborative governance, smart city, sustainability management instruments, formalization, emerging urban context, Casablanca

Résumé

Les initiatives de smart city se sont diffusées rapidement dans les villes du Sud, mais les conditions dans lesquelles la collaboration multi-acteurs conduit effectivement à la formalisation d'instruments de management orientés durabilité reste mal comprise. Cet article examine la relation entre la qualité de la gouvernance collaborative et la formalisation des instruments de management de durabilité dans les projets smart city, à partir d'une étude de cas qualitative approfondie menée à Casablanca. Sur la base de 34 entretiens semi-directifs auprès de parties prenantes des secteurs public, privé, société civile et production de connaissances, combinés à une analyse documentaire de plans stratégiques, contrats et cadres de projet, l'étude montre que la QGC conditionne positivement et significativement la formalisation des IMD. Trois configurations de gouvernance émergent des données : les arrangements multi-acteurs coordonnés produisant des KPIs robustes avec clauses d'auditabilité, les assemblées consultatives générant une participation performative sans instruments contraignants, et les structures technocratiques où les instruments existent formellement mais sont déconnectés des priorités de durabilité.

Mots-clés : gouvernance collaborative, smart city, instruments de management de durabilité, formalisation, contexte urbain émergent, Casablanca

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1. INTRODUCTION

The gap between the promise of smart urbanism and its actual contribution to sustainable urban development is one of the more persistent in contemporary management and public policy research. Cities across Africa, Southeast Asia, and Latin America have invested heavily in digital infrastructure, platform deployments, and public-private arrangements framed under the banner of smart city transformation. Yet systematic evaluations consistently show that technological performance does not automatically translate into measurable sustainability outcomes reduced emissions, improved equity of access, accountable public service delivery (Angelidou, 2014; Bibri & Krogstie, 2017; Hollands, 2020).

Some scholars emphasize the technology-first bias that drives smart city investments, which privileges vendor solutions and technical specifications over governance design and community needs (Caprotti & Liu, 2020; Shelton et al., 2015). Others draw attention to the weak institutionalization of accountability mechanisms the absence of contractual clauses with real teeth, the prevalence of KPIs that measure activity rather than outcomes, and the limited role of civil society actors in monitoring and evaluation (Meijer & Bolívar, 2016; Ruhlandt, 2018). A third strand emphasizes the structural inequalities of emerging urban contexts, where spatial disparities, infrastructure deficits, and asymmetric capacities between public and private actors systematically undermine governance arrangements that might work adequately in well-resourced northern cities (Amoore & Piotukh, 2015; Watson, 2014).

This article focuses on one dimension of this broader puzzle: the relationship between collaborative governance quality and the formalization of sustainability management instruments in smart city projects. The argument is direct but has not been tested carefully enough. If governance is where priorities get set, resources get allocated, and accountability gets institutionalized, then the quality of collaboration among public authorities, private operators, civil society organizations, and knowledge producers should condition whether sustainability commitments become enforceable management tools or remain aspirational language in strategic documents. Casablanca, offers a particularly well-suited terrain for this investigation. The city has been mobilized in the smart city literature for over a decade, across contributions on urban innovation ecosystems (Bakry & Alfantookh, 2020), crowdsourcing dynamics (Benbya et al., 2019), energy transition governance (Ouyang et al., 2021), and the political tensions of large metropolitan projects (Bogaert, 2018). Yet these contributions remain fragmented by sector and analytical lens. No study has examined the governance-instrumentation nexus across Casablanca's smart city portfolio in an integrated fashion, which is precisely what this article attempts.

The article makes three contributions it develops a conceptual framework that positions management instrumentation as the critical conversion mechanism between collaborative governance quality and sustainability outcomes extending the accountability turn in collaborative governance theory (Ansell & Gash, 2008; Emerson et al., 2012) toward the instrumentation literature in public management (Hood & Margetts, 2007; Le Galès, 2011). It provides detailed empirical evidence from 34 interviews across Casablanca's smart city ecosystem, mapping three governance configurations with differentiated instrumentation

capacities. It generates context-sensitive analytical propositions for emerging urban contexts, where the conditions structuring the governance-instrumentation relationship differ substantially from those assumed in the dominant northern-city literature. The section II reviews the theoretical background, covering collaborative governance theory, the literature on management instrumentation, and the emerging urban context framing. Section III presents the methodology. Section IV reports the empirical findings. Section V discusses the implications and develops the analytical propositions. Section VI concludes with contributions, limitations, and research directions.

2. THEORETICAL BACKGROUND

2.1 Collaborative governance, quality, depth, and accountability

The collaborative governance literature has developed substantially over the past two decades, moving from early typologies of partnership arrangements to increasingly nuanced accounts of what makes multi-actor coordination effective (Ansell & Gash, 2008; Emerson et al., 2012; Sørensen & Torfing, 2011). The foundational insight is now well established more contested questions concern the quality dimensions of that coordination who participates, with what authority, at which phases of decision-making, and under what accountability mechanisms.

Ansell and Gash's (2008) influential framework identifies several dimensions of collaborative governance quality, including the inclusivity of stakeholder participation, the depth of deliberation, the presence of clear protocols for decision-making, and the existence of mechanisms for monitoring collaborative commitments. Emerson and his colleagues (2012) extend this by distinguishing between principled engagement shared motivation encompassing mutual trust, shared understanding, and internal legitimacy, and joint action capacity covering procedural and institutional arrangements, leadership, and knowledge. Both frameworks point to accountability as a structuring dimension collaboration that lacks mechanisms for holding participants to their commitments, and for verifying that commitments have been met, tends to produce rhetorical alignment without operational change.

In the smart city literature, collaborative governance has been examined primarily through the lens of public-private partnerships and innovation ecosystem configurations (Barns, 2018; Meijer & Bolívar, 2016; Ruhlandt, 2018). These studies document the prevalence of governance arrangements dominated by large technology vendors, where public authorities retain nominal decision-making authority but lack the technical capacity to specify, monitor, or contest vendor performance. The result is what Caprotti and Liu (2020) call technology-driven urbanism: governance that is formally collaborative but substantively asymmetric, where sustainability ambitions are articulated in project documents but rarely converted into enforceable management obligations.

What the literature has not sufficiently addressed is the instrumentation dimension of this problem. It is one thing to characterize governance quality along the dimensions of inclusivity, deliberation depth, and accountability orientation. It is another to trace how these qualities translate into specific management artifacts contracts with sustainability clauses, KPI frameworks tied to environmental and social targets, audit protocols, data governance

agreements. The gap between governance quality as a process variable and sustainability outcomes as a result variable is filled by instrumentation. This article focuses on that conversion mechanism.

2.2 Management instrumentation and sustainability formalization

The concept of policy instrumentation from Hood's (1983) early taxonomy of governing tools to Le Galès's (2011) work on the sociology of instruments. In the management literature, instrumentation refers to the set of technical devices through which managerial intentions are operationalized and made accountable (Hatchuel & Weil, 1992; Townley, 2002). What distinguishes formalized management instruments from informal coordination mechanisms is their capacity to create obligations: they specify what must be measured, who is responsible for measuring it, what happens when targets are missed, and who has the authority to verify compliance.

In the context of smart city governance, sustainability management instrumentation encompasses several interrelated elements. Environmental KPIs translate sustainability ambitions into measurable targets that can be embedded in contracts and tracked over time (Bibri & Krogstie, 2017). Social access indicators capture equity dimensions: service coverage in underserved areas, affordability constraints, digital divide metrics. Institutional accountability instruments create the governance infrastructure for external verification and citizen oversight (Meijer et al., 2019). Contractual sustainability provisions in public-private partnerships determine whether performance obligations are actually enforceable or merely aspirational (Linder & Rosenau, 2000).

The formalization of these instruments is not simply a technical matter. It is a political process that reflects the distribution of power within governance arrangements. Actors with stronger interests in operational flexibility tend to resist instrument formalization, particularly when it creates binding obligations around sustainability performance that can trigger penalties or contract renegotiation (Barns, 2018). Conversely, civil society organizations and academic knowledge brokers tend to push for more rigorous instrumentation, though their capacity to make these preferences stick depends on the institutional authority they carry within governance arrangements (Caprotti & Liu, 2020; Hollands, 2020). Public authorities occupy the pivotal position they have the formal authority to require instrument formalization in procurement and contracting, but exercise that authority unevenly depending on their technical capacity, political priorities, and the asymmetric resource relationships they navigate with private partners (Watson, 2014).

This political economy of instrumentation is particularly fraught in emerging urban contexts. Municipal governments in cities like Casablanca face constrained technical capacity and tight fiscal margins, which create structural dependencies on private technology providers and international consultants who define the technical architecture of smart city projects (Ajibade, 2017). These dependencies make it difficult for public authorities to specify and enforce sophisticated sustainability instrumentation, even when they nominally control procurement. The result is an instrumentation gap: sustainability commitments appear in strategic documents

and project proposals but rarely achieve the formalization that would make them enforceable and verifiable.

2.3 Smart city governance in emerging urban contexts

The literature on smart cities in the Global South has grown substantially over the past decade, generating important critiques of the dominant techno-centric framing and its inadequacy for urban contexts characterized by deep infrastructure deficits, fragmented governance authority, and pronounced socio-spatial inequalities (Ajibade, 2017; Watson, 2014; Wolfram, 2012). Three themes are particularly relevant to this study.

Smart city projects in African and South Asian cities have frequently been developed as geographically concentrated interventions in high-visibility corridors, central business districts, or prestigious new urban extensions, with limited coverage of peripheral neighborhoods where infrastructure deficits are most acute (Caprotti & Liu, 2020; Datta, 2015; Pieterse, 2010). This spatial concentration reflects the logic of donor financing, political prestige, and private sector investment that structures smart city governance in many emerging contexts, but it systematically biases project portfolios away from the populations most in need of improved services.

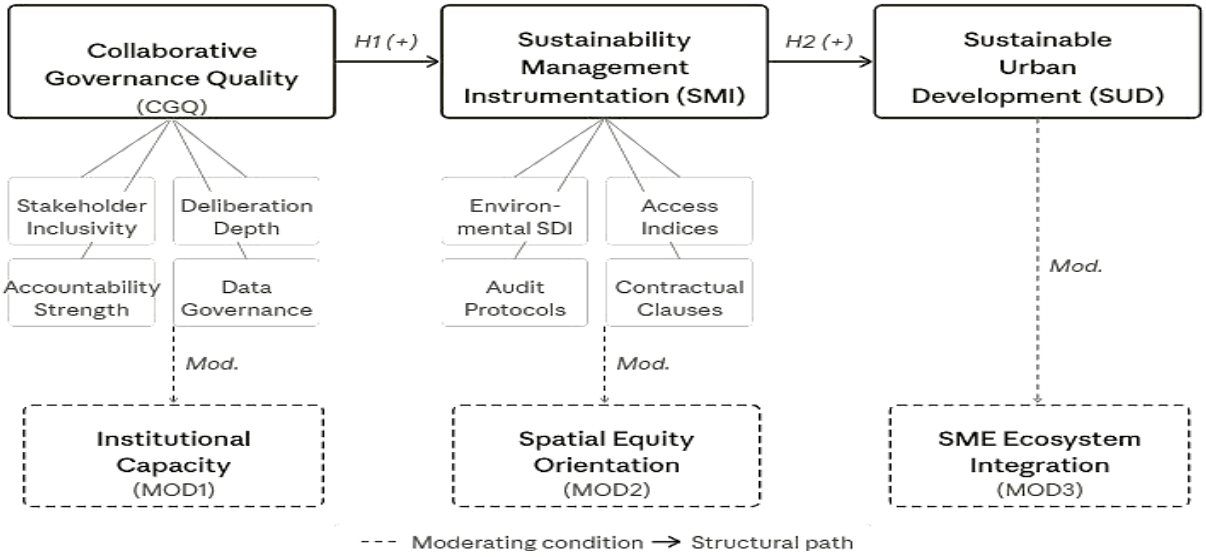
The public agencies in emerging urban contexts frequently lack the technical expertise, data infrastructure, and human resources needed to design, procure, and monitor sophisticated smart city systems (Ajibade, 2017; Wolfram, 2012). This creates structural dependencies on international technology vendors and management consultants, which shape the architecture of governance arrangements in ways that are difficult for municipal governments to contest. The problem is not simply one of technical capacity; it also reflects asymmetric data access, where private operators control performance data that would be necessary for independent verification of sustainability commitments.

The smart city projects in emerging contexts frequently generate forms of digital counter-governance citizen mobilizations that use digital tools to contest project decisions, expose governance failures, or organize resistance to perceived inequities (Bogaert, 2018; Miraftab, 2009). These contestation dynamics are not simply disruptions to be managed; they are governance phenomena in their own right, with significant effects on how projects evolve, how accountability mechanisms are strengthened or weakened, and how sustainability commitments get renegotiated. Understanding collaborative governance quality in emerging urban contexts requires attending to these contestation dynamics alongside the formal processes of multi-actor coordination.

Casablanca sits at the intersection of these three dynamics smart city trajectory includes both high-visibility metropolitan projects and sectoral initiatives in energy management, intelligent street lighting, and urban mobility. Governance authority is distributed across the municipality, specialized agencies, national-level regulatory bodies, and an array of private operators ranging from large international integrators to local SMEs. Civil society participation in smart city governance has been uneven, with formal consultation processes coexisting with informal contestation, particularly around large-scale urban development projects (Bogaert, 2018). This

configuration makes Casablanca a productive research site for examining how collaborative governance quality conditions management instrumentation across different project types and governance configurations.

Figure 1. Conceptual framework - the governance–instrumentation nexus in smart city projects



3. METHODOLOGY

3.1 Research design and epistemological positioning

This study adopts an interpretive-pragmatic epistemological stance (Yanow & Schwartz-Shea, 2006), combining a concern with understanding actors' logics of action and the social construction of governance arrangements with an orientation toward producing actionable knowledge for public management. The research question how does collaborative governance quality condition the formalization of sustainability management instruments in smart city projects? calls for a design capable of capturing process dynamics, power relations, and institutional configurations that cannot be reduced to standardized variables and operationalized through large-scale survey instruments.

The research strategy is an in-depth single case study of Casablanca, designed as an embedded case with multiple analytical sub-units: four smart city projects spanning energy management, intelligent street lighting, urban mobility, and digital urban services (Yin, 2018). The case study design reflects both the exploratory character of the research question and the methodological suitability of in-depth case research for examining complex institutional phenomena where context matters (Flyvbjerg, 2011). The abductive reasoning mode privileged here allows for structured movement between empirical observations and theoretical concepts, generating middle-range propositions that extend and qualify existing theory rather than simply verifying deductive hypotheses (Alvesson & Kärreman, 2011).

3.2 Data collection

Data collection combined three primary sources: semi-structured interviews, documentary analysis, and structured observation of participatory processes. Semi-structured interviews were conducted with 34 participants between March and November 2024, sampled purposively to

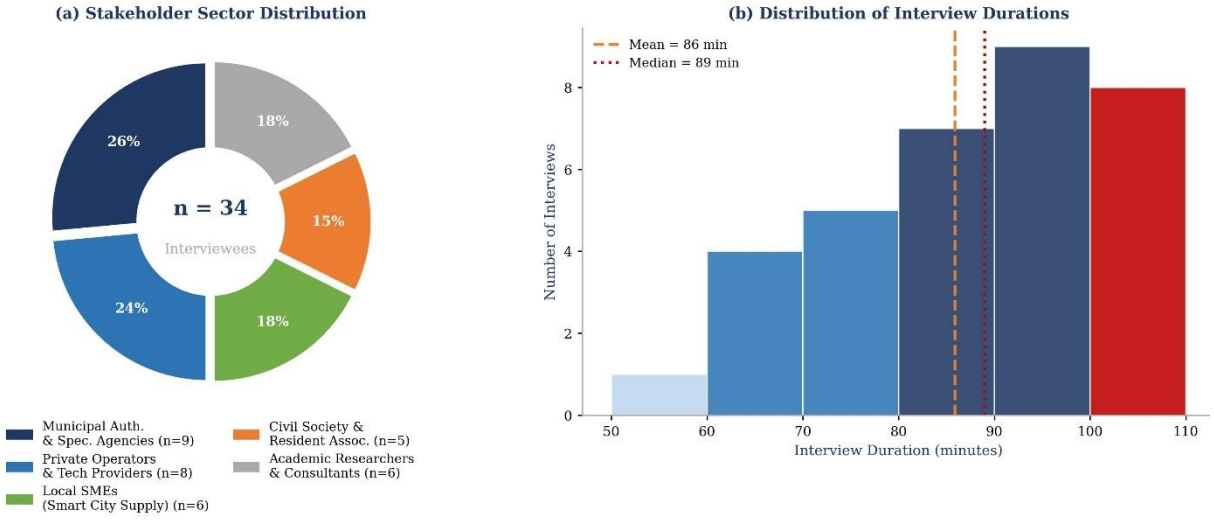
cover the main stakeholder categories in Casablanca's smart city ecosystem: municipal authorities and specialized agencies (n=9), private operators and technology providers (n=8), local SMEs active in smart city supply chains (n=6), civil society organizations and resident associations (n=5), and university-based researchers and independent consultants (n=6). Sampling followed a criterion of theoretical variation (Miles et al., 2014), seeking informants positioned at different levels of governance authority and different distances from formal decision-making processes.

Interview protocols covered four main themes: stakeholders' characterization of collaboration arrangements in smart city projects; their assessment of how sustainability objectives are translated into management instruments; their experience of power asymmetries and their effects on instrument formalization; and their evaluation of the territorial distribution of project benefits. Interviews lasted between 55 and 105 minutes, were conducted in French and Arabic, and were recorded and fully transcribed with participant consent. Informant confidentiality is maintained throughout through positional coding rather than personal identification.

Table 1. Stakeholder categories, representation, and interview parameters

Stakeholder category	n	%	Mean duration - min	Primary data role
Municipal authorities & specialized agencies	9	26.5%	87	Key informants on governance design and procurement
Private operators & technology providers	8	23.5%	78	Vendor-side governance and data access accounts
Local smes (smart city supply chain)	6	17.6%	72	SME capacity and market-access perspectives
Civil society & resident associations	5	14.7%	68	Accountability and participatory process accounts
Academic researchers & consultants	6	17.6%	82	Independent assessment of instrumentation gaps
Total	**34**	**100%**	**78.2**	
Iterviews conducted March–November 2024 in French and Arabic. Positional coding applied; no personal identifiers retained. Mean duration calculated across all 34 interviews.				

Figure 2. Research sample profile: stakeholder sectors and interview duration distribution



Documentary analysis covered 47 documents selected for their relevance to governance arrangements and management instrumentation in the four sub-cases: urban development strategy documents, project procurement frameworks and contracts, performance reports, regulatory texts applicable to smart city deployments, and records of participatory processes. The documentary corpus was subjected to thematic analysis alongside the interview data, with particular attention to gaps between the sustainability commitments articulated in strategic documents and the management instruments actually specified in operational frameworks. Structured observations were conducted in three formal consultation sessions and two project review meetings, providing material on the dynamics of multi-actor interaction that interview accounts alone could not fully capture.

Table 2. Categories, volume, and analytical functions

Document category	n	Period covered	Analytical function
Urban development strategy documents	9	2015–2024	Coding of sustainability commitments and governance objectives
Project procurement frameworks & tenders	11	2017–2023	Instrumentation specification analysis ; kpi clause extraction
Signed contracts (ppp & concession)	8	2018–2024	Contractual sustainability obligation mapping
Project performance & progress reports	7	2019–2024	Instrumentation operationalization and audit evidence
Regulatory texts (national & municipal level)	5	2016–2022	Institutional mandate and accountability framework coding
Participatory process records & minutes	7	2020–2024	Stakeholder inclusion depth and deliberation quality coding
Total	**47**	**2015–2024**	

3.3 Data Analysis

Data analysis followed a three-phase protocol initial thematic coding was applied to interview transcripts and documentary material, using a dual coding frame an a priori frame derived from the theoretical concepts of governance quality and management instrumentation, and an emergent frame derived from categories arising from the data. Codes were applied using NVivo 14, with inter-coder reliability checks performed on a 20% sample by an independent researcher, yielding a Cohen's kappa of 0.76, which is acceptable for qualitative research (Miles et al., 2014). In the second phase, cross-case comparison across the four sub-cases was used to identify patterns and contrasts in governance-instrumentation configurations. In the third phase, analytical propositions were developed through structured dialogue between the empirical patterns and the theoretical frameworks reviewed in Section 2, following the logic of abductive inference (Alvesson & Kärreman, 2011). Member-checking sessions with six key informants confirmed the plausibility of the main findings and helped refine analytical categories.

Table 3. Thematic coding framework - Nodes, definitions, and frequency statistics

Code	Theme / Node	Definition	Sources	References
C01	Stakeholder inclusivity	Substantive capacity of non-dominant actors to shape decisions	29	87

C02	Deliberation depth	Engagement with specification, not merely endorsement, of sustainability objectives	25	68
C03	Accountability strength	Presence of monitoring procedures and non-compliance consequences	29	87
C04	Data governance quality	Clarity and enforceability of data ownership, access, and audit rules	27	74
C05	Instrument formalization	Operationalization of sustainability commitments in binding management artifacts	23	59
C06	Vendor lock-in	Technology provider control of data/architecture preventing public audit	26	71
C07	Compliance theater	Instruments formally present but without operative monitoring infrastructure	18	45
C08	Boundary-spanning role	Intermediary translating between technical vendor language and public authority	15	38
C09	Spatial equity bias	Concentration of smart deployments in high-visibility corridors	19	48
C10	SME integration	Involvement of local SMEs in supply chains AND governance processes	21	54
C11	Contestation dynamics	Digital counter-governance and citizen mobilization as reconfiguration mechanism	13	31
C12	Capacity asymmetry	Structural imbalance in technical and institutional resources across governance actors	17	43

Dual coding framea priori codes derived from collaborative governance theory and instrumentation literature; emergent codes derived inductively from data. Inter-coder reliability, Cohen's κ = 0.76 (20% subsample, independent researcher). Number of interview/document units where code applied; References = total coding extracts.

4. FINDINGS

4.1 Three configurations of collaborative governance and their instrumentation effects

The cross-case analysis identifies three governance configurations in Casablanca's smart city projects, distinguished primarily by the depth of stakeholder participation, the distribution of decision-making authority, and the strength of accountability mechanisms. These configurations are associated with markedly different patterns of sustainability management instrumentation. He found in the intelligent street lighting project and the energy management initiative, is what this study terms coordinated multi-actor governance. In these cases, project design and implementation involved structured collaboration among the municipal authority, the public electricity operator, one or two private technology providers, and an independent technical advisory body.

Decision-making followed documented protocols that specified the authority of each actor, the criteria for evaluating performance, and the conditions for contract renegotiation. Crucially, these projects developed sustainability management instruments with meaningful formalization energy savings targets were embedded as binding KPIs with quarterly measurement obligations, audit protocols specified the methodology for independently verifying performance claims, and contracts included bonus-malus clauses tied to sustainability targets. A senior municipal official interviewed for this study noted that the presence of the technical advisory body changed the dynamic fundamentally: Before, the contracts with the vendor were essentially about availability of the system. Whether it was saving energy was their problem.

Now we have agreed measurement protocols and if the numbers don't add up, we renegotiate. It changes what they prioritize.

This observation captures something important about the governance-instrumentation link. Instrument formalization depends not just on the good intentions of individual actors but on governance structures that create incentive conditions for formalization. The technical advisory body in these cases functioned as what the literature on collaborative governance calls a boundary-spanning organization (Williams, 2002) an intermediary capable of translating between the technical language of the vendors and the political and legal language of the municipal authority, and of maintaining pressure for accountability mechanisms that neither party would have produced unilaterally.

This configuration, observed in the urban digital services project, is consultative governance. This arrangement formally included a broader range of stakeholders but the actual locus of decision-making authority remained concentrated in a small technical committee dominated by the principal technology vendor and a specialized municipal agency. Interview accounts from civil society representatives were strikingly consistent on this point: they described a process of structured inclusion that produced the appearance of collaborative governance without the substance. As one civil society representative put it, we attend the meetings, we provide comments, the comments are recorded in the minutes.

Nobody ever explains why our input changed nothing. Sustainability management instruments in this case were less robust than in the first configuration. KPIs existed but focused primarily on technical availability metrics rather than environmental or social outcomes. Contractual sustainability clauses were present in the original procurement documents but had been progressively diluted through contract amendments that favored operational flexibility for the vendor. Audit rights were formally retained by the municipal agency but had not been exercised in three project review cycles.

This configuration, evident in the Zenata metropolitan project, is technocratic governance. Project management was handled primarily by a dedicated project company with strong autonomy from the municipal governance structure, and the effective stakeholder circle was narrow: national-level project promoters, an international urban planning consortium, and financial institutions. Civil society participation was nominally structured through a consultation mechanism that informants across sectors described as essentially ceremonial. University researchers and local SMEs were absent from substantive project decisions. The sustainability management instruments associated with this configuration present a paradox they are formally elaborate but substantively disconnected from operational management.

Environmental targets appear in the strategic framework but are not embedded in operational contracts with enforceable obligations. Social equity indicators are referenced in the communication documents but are not measured systematically. Several informants from within the project structure described this as an audit for donors problem: sustainability instrumentation had been developed in response to financing requirements and international visibility concerns, not as operational management tools. As one informant from the project management office acknowledged with sustainability indicators are very complete in the project

document. Whether we are actually on track with them that would require a measurement system we don't yet have.

Table 4. Cross-case analytical matrix - Instrumentation evidence across four smart city sub-cases

Criterion	Street lighting	Energy mgmt.	Digital services	Zenata metro
Governance type	Coordinated	Coordinated	Consultative	Technocratic
No. contracts analyzed	3	4	3	5
KPI environmental binding	Quarterly	Annual	Partial	Strategic only
Social equity KPI present	Partial	No	No	Formal only
Audit rights exercised	2 cycles	3 cycles	No	No
Data access agreement	Signed MOU	API protocol	Contested	Absent
Bonus-malus clause	Yes	Yes	No	No
SME in governance	3 firms	1 firm	Nominal	Absent
Civil society audit right	Observer status	No	Consultative only	Ceremonial only
Composite SMI score	4.3	4.1	2.5	2.5

Evidence drawn from documentary analysis of 47 documents and 34 semi-structured interviews. KPI binding = sustainability target embedded in signed contract with quarterly or annual measurement obligation. Audit rights exercised = at least one formal audit cycle completed with documented results. Composite SMI = mean of five instrument dimensions (scores 1–5). MOU = Memorandum of understanding.

4.2 Governance quality dimensions and their instrumentation effects

Beyond the three configurations, the analysis identifies four specific dimensions of collaborative governance quality that have distinguishable effects on sustainability instrument formalization. The dimension is stakeholder inclusivity, understood not merely as the formal representation of diverse actor categories but as the substantive capacity of non-dominant actors to influence project decisions. Where inclusivity was genuine where civil society organizations could contest KPI definitions, where local SMEs could propose technically viable alternatives, where university researchers could provide independent assessments of performance claims instrument formalization tended to be more robust and better aligned with sustainability priorities. The mechanism is not complicated more inclusive deliberation surfaces a wider range of sustainability concerns, creates pressure for accountability mechanisms that protect non-dominant interests, and generates the social legitimacy that makes sustainability commitments harder to dilute through contract amendments.

The dimension is deliberation depth, which this study operationalizes as the extent to which collaborative processes engage with the specification of sustainability objectives rather than merely their endorsement. Several informants drew a precise distinction between discussions about whether to include sustainability objectives and discussions about how to measure, verify, and enforce them frequently avoided. The latter requires technical specificity that is uncomfortable for actors whose interests are better served by ambiguity. Governance arrangements that pushed through this discomfort, typically through the intermediation of technically credible advisors, produced more formalized instruments. The dimension is accountability mechanism strength presence and effectiveness of procedures for monitoring collaborative commitments and for addressing non-compliance. This dimension is where the governance-instrumentation relationship is most direct. Governance arrangements with weak

accountability mechanisms produce an instrumentation pattern that might be called compliance theater instruments formally present in project documents, but without the monitoring infrastructure that would make them operative. Strong accountability mechanisms create incentive conditions for genuine instrumentation formalization.

The dimension is data governance quality clarity, formalization, and enforceability of rules governing data ownership, access, sharing, and audit. This dimension proved to be empirically central in the Casablanca cases. In several projects, sustainability instrumentation was technically feasible but operationally blocked by data access disputes between public authorities and private operators. Vendors controlled the sensor and platform data from which sustainability KPI measurements would need to be drawn, and the contractual framework for sharing this data with public authorities was either absent or so poorly specified as to be non-operative. The result was a version of the accountability problem distinctive to smart city governance public authorities nominally responsible for sustainability performance could not actually access the data needed to verify it. Governance arrangements that had negotiated clear data access rights were significantly better positioned to formalize sustainability instruments.

Table 5. Comparative scores across eight quality and instrumentation dimensions

Governance Dimension	Coordinated Multi-Actor	Consultative	Technocratic	F (df=2)
Stakeholder Inclusivity	4,6 [a]	3,5 [b]	1,8 [c]	47,3
Deliberation Depth	4,3 [a]	2,8 [b]	2,0 [b]	38,9
Accountability Strength	4,5 [a]	2,4 [b]	2,2 [b]	52,1
Data Governance Quality	4,2 [a]	2,1 [b]	2,5 [b]	31,7
Environmental KPI Robustness	4,5 [a]	2,8 [b]	3,2 [b]	29,4
Social Equity Instrumentation	4,1 [a]	2,4 [b]	2,1 [b]	26,8
Audit Operability	4,3 [a]	2,0 [b]	1,8 [b]	61,2
Contractual Clause Strength	4,2 [a]	2,6 [b]	2,9 [b]	35,6
Data Access Rights	4,0 [a]	1,9 [b]	2,3 [b]	33,1
Composite SMI Score	4,27 [a]	2,45 [b]	2,49 [b]	71,4

Scores (1–5) derived from cross-case content analysis NVivo 14. Values reported as M (SD). Superscripts ([a] [b] [c]) indicate homogeneous subsets from Tukey HSD post-hoc tests. F-statistics computed on configuration-level scores (df = 2, residual df = 9 per dimension). $p < 0.001$. Composite SMI = mean of environmental KPI, social equity, audit operability, contractual clause, and data access scores.

4.3 Moderating conditions

The governance-instrumentation relationship is not constant across the Casablanca smart city portfolio. Three moderating conditions shape its strength and character. Institutional capacity of the public authority is the most consistent moderator. Municipal agencies and specialized entities with stronger technical teams, more experienced procurement officials, and better legal resources were able to specify sustainability instrumentation more precisely in procurement documents, to negotiate more robustly with vendors during contract formation, and to exercise audit rights more systematically during project implementation. Where institutional capacity was weaker, sustainability commitments were more likely to remain at the level of strategic documents and less likely to be operationalized in binding management instruments.

This capacity dimension has a temporal component several informants described a learning dynamic in which public authorities developed instrumentation capacity through successive

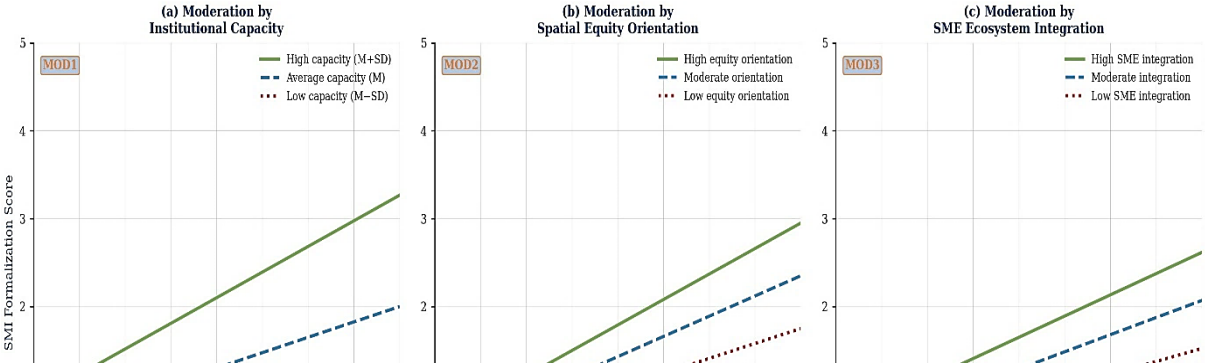
project cycles, so that later projects showed stronger governance-instrumentation links than earlier ones. Spatial equity orientation of the project design was a second moderator, particularly relevant to the social equity dimension of sustainability instrumentation. Projects designed with an explicit spatial equity rationale developed social sustainability instruments more systematically than projects focused on high-visibility corridors. The mechanism appears to involve accountability pressure equity-oriented project designs attract scrutiny from civil society organizations and political actors with a direct interest in monitoring social outcomes, which creates incentive conditions for more formalized social equity instrumentation.

The third moderator is SME ecosystem integration. Projects that systematically involved local small and medium-sized enterprises in both supply chains and governance processes showed stronger sustainability instrumentation than projects dominated by large international integrators. Local SMEs have reputational stakes in the communities where projects are deployed that international vendors typically do not, which creates incentives for more genuine sustainability performance. SME representatives in governance arrangements tended to push for measurement systems that could demonstrate local value creation, which inadvertently strengthened the overall instrumentation framework. And the presence of multiple supply chain actors reduced the vendor lock-in dynamic that, in single-vendor configurations, allowed technology providers to resist data sharing and audit obligations.

Table 6. Operationalization, mechanisms, and sub-case evidence

Moderator	Operationalization	Effect on CGQ -- SMI	Mechanism	Sub-cases
Institutional capacity MOD1	Technical team strength, procurement experience, legal resources	Amplifying; nullifying	Spec., negotiation, and monitoring capabilities; project-cycle learning dynamic	Street lighting. digital services same CGQ level, divergent SMI due to capacity differential
Spatial equity orientation MOD2	Explicit territorial equity rationale; peripheral deployment targets in project design	Conditional amplifier for social sustainability dimension of SMI	Equity framing - civil society accountability pressure - social KPI specification	Energy management social KPIs absent ; street lighting partial social KPIs
SME Ecosystem integration MOD3	Structured SME roles in supply chain AND governance processes	Positive moderator via two mechanisms reputational & lock-in reduction	SME reputational stakes - genuine performance pressure; multiple actors - data sharing negotiation	Street lighting highest data access score ; Zenata data access absent

Figure 6. Moderation of the CGQ -- SMI relationship by three contextual conditions



5. DISCUSSION

5.1 The governance-instrumentation nexus as conversion mechanism

The empirical findings support and extend the theoretical claim made at the outset collaborative governance quality conditions sustainability management instrumentation formalization, and this relationship constitutes the critical conversion mechanism between stakeholder coordination processes and sustainability outcomes. The relationship is not automatic nor is it sufficient, since formalized instruments still require monitoring capacity and political will to operationalize. But it is structurally necessary in the Casablanca cases, strong sustainability instrumentation did not emerge from governance arrangements characterized by weak inclusivity, shallow deliberation, and absent accountability mechanisms.

This finding speaks to a gap in the collaborative governance literature, dominant models (Ansell & Gash, 2008; Emerson et al., 2012) treat governance processes and policy outcomes as connected through relatively direct pathways better collaboration produces better decisions, which produce better results. The mediating role of management instrumentation in this pathway has been undertheorized. What the Casablanca evidence suggests is that the conversion of collaborative intentions into sustainability outcomes passes through a specific intermediate step the formalization of instruments that make sustainability commitments binding, measurable, and verifiable and that this step is where collaborative governance quality has its most decisive effects. Collaborative governance theory needs an instrumentation turn a systematic account of how governance process qualities translate into the specific management artifacts through which sustainability commitments become operative.

5.2 Data governance as a structural enabler

The empirical centrality of data governance quality as a moderating condition in the Casablanca cases points to a dimension of smart city governance that deserves more systematic theoretical attention. The argument made in the extant literature that smart cities concentrate data control in the hands of private technology providers in ways that create accountability deficits (Barns, 2018; Kitchin, 2014) is confirmed and extended by the findings. But the mechanism is more specific than a general argument about data commodification. The problem is not simply that vendors have data; it is that governance arrangements have failed to specify the data access rights that would make sustainability instrumentation operative.

Where procurement specifications included clear interoperability requirements and data sharing obligations, public authorities were able to exercise audit rights and verify sustainability performance. Where these requirements were absent sustainability instrumentation remained formally present but substantively empty. This finding has direct implications for smart city procurement practice. Sustainability management instrumentation in smart city projects needs to be designed alongside the data governance framework that makes it operative, not added as an afterthought to procurement documents dominated by technical specifications. The governance processes through which procurement frameworks are developed thus have direct consequences for the viability of sustainability instrumentation. Here the governance-instrumentation link is most concrete and most amenable to practical intervention.

5.3 Contextual propositions for emerging urban settings

The analytical framework developed in this study generates a set of propositions specifically calibrated to the governance-instrumentation relationship in emerging urban contexts. These propositions extend the findings beyond the Casablanca case and are intended as mid-range theoretical claims amenable to comparative evaluation in other contexts. The proposition is that collaborative governance quality has stronger positive effects on sustainability instrumentation formalization when boundary-spanning intermediaries with technical credibility and political independence are embedded in governance arrangements. The evidence from Casablanca's coordinated configuration supports this proposition, and it resonates with the general literature on the role of boundary organizations in facilitating accountable multi-actor coordination (Williams, 2002). Emerging urban contexts, where both public and civil society actors may lack the technical expertise to contest vendor-defined instrumentation frameworks, have particular reason to invest in independent technical intermediation.

The proposition is that the governance-instrumentation relationship is moderated by institutional capacity in a non-linear fashion below a threshold of municipal technical capacity, even strong collaborative governance processes fail to produce robust instrumentation, because the public authority lacks the specification, negotiation, and monitoring capabilities needed to convert collaborative intentions into enforceable management obligations. This threshold proposition has implications for the sequencing of smart city governance reform investments in municipal technical capacity may be a precondition for realizing the instrumentation benefits of collaborative governance improvement, rather than a complement to it.

The proposition is that SME integration in governance arrangements strengthens sustainability instrumentation through two distinct mechanisms reputational pressure for genuine performance, and competition-induced reduction of vendor lock-in. These mechanisms suggest that SME involvement in smart city governance is not merely a distributive question but also an accountability question who has the incentives and capacities to push for robust sustainability instrumentation. Public procurement policies that create structured roles for local SMEs in smart city governance may thus serve sustainability governance functions as well as economic development functions.

The proposition concerns the relationship between spatial equity orientation and social sustainability instrumentation. Where projects are designed with explicit spatial equity

rationales, social sustainability instruments are more likely to be formalized and monitored, because the equity orientation attracts accountability pressure from civil society actors whose interests align with rigorous social outcome measurement. This proposition suggests that the spatial equity framing of smart city projects also has governance and instrumentation implications. Projects explicitly framed around spatial equity are better positioned to develop the governance conditions that produce robust sustainability instrumentation.

6. CONCLUSION

This article set out to examine how collaborative governance quality conditions the formalization of sustainability management instruments in smart city projects, drawing on evidence from Casablanca, Morocco. The findings identify three governance configurations with markedly different instrumentation outcomes, and trace four governance quality dimensions that shape instrumentation formalization across configurations. The theoretical contribution is an elaboration of the governance-instrumentation nexus as a conversion mechanism between collaborative governance quality and sustainability outcomes, with particular attention to the role of data governance and institutional capacity as moderating conditions in emerging urban contexts. This elaboration extends collaborative governance theory toward an instrumentation turn a systematic account of how process qualities become operative management artifacts. It also contributes to the smart city governance literature by identifying the specific mechanisms through which collaboration translates into sustainability performance.

Several limitations of this study merit acknowledgment. The single-case design, while appropriate for the exploratory and interpretive objectives of the research, limits the generalizability of the findings. The four sub-cases in Casablanca represent a particular institutional and political context that may differ in relevant ways from other emerging urban contexts in Africa, Asia, or Latin America. Comparative case research across multiple cities would be needed to test the boundary conditions of the analytical propositions developed here. The study also relies primarily on interview accounts of governance processes, which are subject to retrospective reconstruction and social desirability biases. Future research using direct observation of governance processes over longer time horizons would provide richer material for analyzing governance-instrumentation dynamics.

In terms of practical implications, the findings point to three priorities for municipal governments and development partners engaged with smart city governance in emerging urban contexts. Investing in boundary-spanning technical intermediaries that can sustain pressure for sustainability instrumentation formalization across project cycles, and resist vendor-driven dilution of accountability mechanisms, is the most directly actionable implication of the findings. Treating data governance specification as a sustainability governance question requires an institutional shift in how smart city projects are procured and monitored. Designing structured roles for local SMEs in smart city governance arrangements, not only as a distributive justice measure but as an instrumentation accountability mechanism, offers a governance instrument that serves multiple policy objectives simultaneously. These priorities will not resolve the fundamental tension between the efficiency logic of smart city investment and the

equity logic of sustainable urban development. But they may help ensure that the governance arrangements through which smart city projects unfold are better equipped to convert collaborative intentions into management obligations that actually hold.

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