

Indicators, Strategies, and Rule Settings for Sustainable Public–Private Infrastructure Partnerships: From Literature Review towards Institutional Designs

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Abstract: Public–private partnerships (PPPs)-driven infrastructure projects frequently disappoint in terms of sustainability outcomes. This paper substantiates this. It develops and presents an institutional design that can integrate environmental and social sustainability principles into PPP infrastructure projects (sustainable PPPs). The institutional design includes principles for the planning processes (preparation, procurement, contracting) and outcome indicators. The paper builds upon and synthesizes extant research through a literature review that employs the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statements. The review covers the appropriateness of the used indicators for the investigation and measurement of environmental and social sustainability policy strategies designed to enhance sustainability and institutional intercalation. About the latter, a specific lens to focus on the relationships between the institutional design characteristics (the rule settings) of planning processes and the sustainability outcomes is developed based on three variables within the institutional analysis and development (IAD) framework of Ostrom. Consequently, rule settings that enable the investigation of the institutional process preconditions for sustainable PPPs and the evaluation of the sustainability outcomes are amalgamated. Our study indicates that the IAD framework provides a useful theoretical lens to harmonize and categorize process principles to achieve the rule settings that guide involved actors towards sustainable PPPs and place lenses on the envisioned environmental and social sustainability outcomes.

Keywords: indicators; infrastructure projects; public–private partnerships; rule settings; steering strategies; sustainability



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1. Introduction

PPP infrastructure projects in transportation, electricity, telecommunications, water, and sanitation are essential to development in situations where public finance is not sufficiently available. PPPs are arrangements through which private actors enter into an agreement to fund public-infrastructure-hinged services [1]. According to Woetzel et al. [2], PPPs have been touted as a veritable model to reduce the huge global infrastructure gaps, appraised at about US\$800 billion to US\$1 trillion per year, and deepen efficiency outcomes, simultaneously.

Hueskes et al. [3] posit that due to some intrinsic characteristics, such as the utilization of lengthy infrastructure agreements, the handover of definite risks to the private actors, and a concentration on the stipulation of project out-turns in place of project inputs, distinct tasks are incorporated or tied-up within one agreement, such as design, construct, finance, maintain and/or operate [3]. As observed by another researcher [4], PPPs are a clever means to contrive a durable and broad-scale infusion of sustainable technologies and attributes [4]. Therefore, because of their capacity to produce socio-ecological benefits through the incorporation of ecological and social goals contiguous to economic considerations, PPPs are well-suited for sustainability. For instance, since contractors bear the

cost of actualizing infrastructures, they have the incentives to consider energy efficiencies that can create sustainable buildings with low energy consumption [5]. Consequently, Berrone et al. [6] notes that governments and practitioners worldwide increase the usage of PPPs as a unique instrument to attain sustainability principles in infrastructure projects.

Quality infrastructure propels economic growth and social well-being, while a lack limits productivity and access to jobs, markets, healthcare, and education for billions of people globally. Moreover, Lenferink et al. [7] assert the underperformance of PPP infrastructure projects within the context of environmental and social sustainability outcomes. Further, since experiences with PPPs are varied, effectuating the realization of public actors' sustainable development agendas based on these arrangements is not short of challenges [8,9]; sustainable PPPs will require a consideration of these issues and challenges.

A critical challenge of sustainable PPPs is said to be the inadequacy of institutional designs that should be able to create patterns of interactions among actors toward sustainability outcomes at the planning stages [10]. The global massive infrastructure gaps create a hunger for private investments and there are indications that the satisfaction of this hunger might be undertaken with too little public institutional capacity, especially in less developed countries. Institutional designs are the rules that establish and control the interactivity among actors in a cooperative situation to accomplish determined policy objectives [11].

Hayllar [12] contends that academics should contribute more regarding the analysis and importance of influential institutional characteristics, such as factors and principles for PPP project planning that can deal with collective action problems and undesired outcomes. Nonetheless, Matos-Castaño et al. [13] submit that most studies that have analyzed institutions and PPP project outcomes have been specifically focused on how to appreciate institutional transposes that occur in the context of PPPs and their permissible environment, the allocation of great emphasis on the diversity of responses coming from different institutional contexts, and the large neglect of sustainable development outcomes. Additionally, studies on sustainability relevant to institutions have focused mainly on economic sustainability [14,15], without consideration of social and environmental outcomes. Moreover, in practice, the allocation of the costs and returns of PPPs is not always considered fair.

The integration of sustainable development principles into the largely economic-based legal framework of PPPs has been recommended [4]. However, the available studies still fail to include and assess regulative frameworks that have the capability to create and propel the interrelatedness between actors toward envisioned sustainability outcomes. Additionally, Malvestio et al. [16] contend that factors that influence sustainable PPPs early in the planning processes were not considered. The resultant lack of knowledge, according to Bakhtawar et al. [17], creates a barrier to sustainable PPP planning where minimal considerations to pointedly address sustainability-related objectives subsist.

As stated by one researcher [18], environmental sustainability needs to shift from the conduct of environmental impact assessments (EIA) as a requirement for construction permits toward sustainability integration across the PPP stages. This implies the connection of environmentally sustainable lenses and considerations much earlier in the process and an in-depth connection to the integrity and productivity of ecosystems and environmental quality indicators. As per social sustainability, Hueskes et al. [3] claim that one of the major drawbacks is how to measure and enforce social sustainability norms in PPPs. Such scenarios, regarding environmental and social sustainability, make sustainable PPPs difficult to consider early and fully. Therefore, a perspective on how to monitor efforts upon this, continuously and qualitatively, during the planning process and later during the operational phase requires attention. These lenses are crucial to institutional designs for sustainable PPP planning.

Sustainability assessments are required for a shift toward sustainability [19]. Donnelly et al. [20] aver that the evaluation of sustainable development is congruent with the induction of indexes for social, environmental, and economic objectives designed to ascertain the promotion of sustainable development in infrastructure projects. For in-

stance, the GREENROAD system evaluates sustainability considerations in road projects according to obligatory demands and optional tasks structured into the environment and water, access and equity, construction activities, material resources, and pavement technologies [21]. The Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL), as observed by He et al. [22], evaluates the sustainability of infrastructure through 12 critical aspects.

Further, Aguado et al. [23] cite the Index of Contribution of the Structure to Sustainability (ICES) model for concrete structures as an inventory hinged on the Leadership in Energy and Environmental Design criteria in road projects. Likewise, Ugwu et al. [24] indicate that the Sustainability Appraisal in Infrastructure Projects (SUSAIP) indicator system is an evaluation framework for bridge infrastructures. Additionally, the Technical Sustainability Index (TSI) indicator-based model measures power infrastructure [25]. Furthermore, the evaluative principles on sustainability proposed by another researcher [26] are based on the definition given by the Rio Declaration and Agenda 21. The sustainability assessment criteria elaborated by Gibson et al. [27] evaluate river basin infrastructures. The discussion framework of one study [28] consists of three dimensions: ecological front print; closed-loop; and nature and environment.

As opined by Hueskes et al. [3] and He et al. [22,29], the principles and criteria highlighted by organizations and scholars, respectively, have been utilized as core criteria for the sustainable development evaluation of PPP infrastructure projects by different scholars. Hoeft et al. [30] confirm that several articles delineated indicators for the evaluation of sustainable development considerations in infrastructure projects which, nonetheless, vary in their characteristics, categorization, and attributes of the indicators; this is because of concerns about specific projects or construction methods that require definite stipulations. Nonetheless, Ferrarez et al. [31] and Morse et al. [32] recognize the delineation of appropriate indicators as an immense confrontation in sustainability evaluation.

In addition, demand for further evolution of suitable and unbiased indicators and models for the assessment of sustainable development principles at the major stages of infrastructure conceptualization, design, construction, and operation [10,33], exists. Particularly regarding sustainable PPPs, prior research has shown that there:

- is too little consensus on the delineation of sustainability process principles and their indicators, both for environmental and social sustainability.
- are inconsistencies in various checklists used for the various environmental and social sustainability outcome principles and their indicators
- is a need for knowledge on appropriate institutional frameworks that can foster sustainable PPPs at the planning stages.

The goal of this article is to answer the question: what are the rules that can create patterns of interaction between the planning stages of PPP infrastructure projects and the environmental and social sustainability concerns? To adequately answer this question, three sub-questions are devised; these are:

1. Which outcome indicators regarding infrastructure-related sustainability concerns are addressed in the literature, both about environmental and social sustainability?
2. Which process-steering strategies and indicators guiding towards the envisioned sustainable PPPs are addressed in the literature, both about environmental and social sustainability?
3. How can the effective employment of applied steering strategies in the planning stages of PPPs be connected to institutional rule settings in a principal governance framework?

The paper aims (i) to delineate the required indicators on sustainability outcomes and processes related to sustainable PPPs, especially regarding social and environmental concerns; (ii) to assess steering strategies as they are applied to influence patterns of interaction during the PPP planning stages; and (iii) to enlighten the systematic analysis and development context of these steering strategies, i.e., the rule settings, to apply the steering

strategies to their full potential. This is accomplished through a two-pronged literature review where identified rule types, as specified in the IAD framework [34], are linked with environmental and social sustainability outcomes and process indicators; the latter is referred to as the steering strategies. This synthesis depicts the strengths and strategies of the extant indicators, which provide a foundation for the evolution of evaluation criteria on the rules for sustainable PPPs. Such reductionist contributions are necessary as they offer the area of study a prevalent and conclusive benchmark for sustainable PPP assessment at the planning stages.

In Section 2, the research methodology is described. Some of the major results are presented in Section 3. After the synthesis of sustainability indicator issues, an evaluative framework for sustainable PPPs is offered and discussed in Section 4. Here, distinctive features of rule settings and network lenses as institutional conditions for the effective employment of steering strategies towards sustainable PPPs at the planning stages are discussed. Some propositions for future research conclude the paper in Section 5.

2. Materials and Methods

This section reports the methodology used to answer each of the three research sub-questions.

2.1. Systematic Literature Review

A systematic literature review (SLR) was employed to answer Questions 1 and 2 through the collection and examination of published academic articles. A SLR seeks to encapsulate previous work, lengthen hypotheses, and assess a body of work with analytical perspectives [35]. Tranfield et al. [36] avouched that SLRs play a crucial role in data-rooted procedures. Cooke et al. [37] confirmed that by the promotion of methodical, replicable, and transpicuous practices, the SLR is suitable for resolutions, courses of action, and interpretations made by the reviewer. Therefore, a review of literature in a concise form that hubs on environmental and social sustainability is conducted to build and advance rule settings on sustainable PPPs.

The SLR protocol utilized in this paper evolved from a pre-defined structure, inherent to the step-by-step procedure characteristic of the PRISMA statements, as delineated by Moher et al. [38]. This procedure was selected for three reasons. Foremost, it helps to build up the details and exploration procedure of this study. Next, the PRISMA statements support literature review research on sustainable PPP, as utilized by Le et al. [39] for a related procedure. Last, according to Liberati et al. [40], in terms of dependability and viability, the SLR advanced by the PRISMA statements ensures the duplicability of this study. The procedure utilized to carry out the SLR is described in Figure 1.

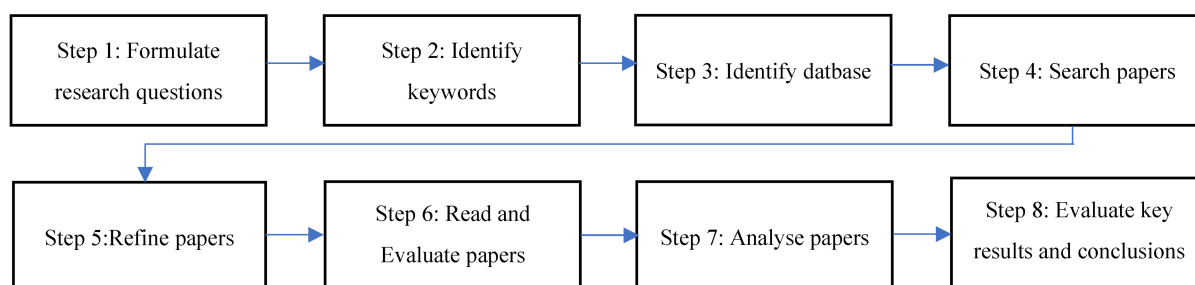


Figure 1. Stages in the SLR, adapted from a study by Le et al. [39] (p. 4).

2.1.1. Search Strategy

Sustainability and PPP are interconnected and are known for being multi-disciplinary. Peer-reviewed articles related to sustainable PPP outcomes and process principles with their indicators were identified and gathered from databases provided by six widely-recognized, high-quality, and multi-disciplinary publishers. These were Elsevier, Emerald, Springer,

Wiley, MDPI, and Taylor and Francis. The search for correlated articles was arranged as a structured keyword search. The search was initially carried out in September 2022 and subsequently updated in January 2023. The search arrangement started an in-depth pattern as follows: “TITLE-ABS-KEY (Sustainable PPPs)”. Details about the SLR search and refinement procedure are illustrated in Figure 1. The ‘Search papers’ (step 4 in Figure 1) step is the initial stage, while ‘Read and evaluate papers’ (step 6 in Figure 1) is the last stage.

2.1.2. Selection of Articles

The preliminary outcome of the search procedures, with the use of ‘title/abstract/keyword,’ resulted in 31,008 articles from the 6 itemized databases. The search procedure recommenced with an assemblage of peer-reviewed articles published in the English language; as a result, 22,476 articles held out. Literature review articles were not considered in this study to eradicate any possible predisposition from erstwhile reviews. Further, the exploration was reduced to only current publications within a 10-year range, which reduced the literature search to 13,599 articles. Furthermore, irrelevant subjects, such as Physics and Astronomy, Medicine, Pharmacology, Toxicology and Pharmaceuticals, Immunology and Microbiology, Computer Science, Biochemistry, Agricultural and Biological Sciences, Chemical Engineering, Chemistry, Psychology, Earth and Planetary Sciences, Genetics and Molecular Biology, Mathematics, Neuroscience, and Arts and Humanities, were excluded. Finally, 754 articles were selected.

In addition, these articles’ titles, abstracts, and contents were reviewed punctiliously to sieve those that advance the research problems. Among the 754 selected articles presented in Table 1, some studies explored economic sustainability in PPP infrastructure projects whereas others concentrated on sustainability in dissimilar subparts of PPP, such as the provision of maternal health care, school children feeding schemes, and agricultural production. As mentioned, only infrastructure PPP projects were considered in this research. Additionally, both experiential and non-experiential articles were considered in the search. The basis for the inclusion of articles in the eventual list is that the littlest indicator of either environmental or social outcomes, or the process principle, are considered.

Finally, 32 out of 754 studies as presented in Table 1, were chosen for additional analysis. Notably, just 4.2% of all articles in the review related to sustainable PPPs. This revealed a slim relation and presumed significant gaps in integration, especially in terms of environmental and social outcomes.

Table 1. Steps to decide on suitable articles for the SLR.

Search Steps	Keyword String	Wiley	Springer	Taylor & Francis	Emerald	MDPI	Elsevier	Total
1	Title-ABS-KEY (Sustainable PPPs)	8087	2301	6453	644	95	13,428	31,008
2	Restriction of search to English journal articles	6642	491	5549	444	86	9264	22,476
3	Restriction of search to recent studies (from 2013 to 2022)	3475	369	3087	365	84	6219	13,599
4	Exclusion of irrelevant subject areas	159	106	109	165	45	170	754
5	Study of titles, abstracts, and details of the articles.	2	1	3	6	7	13	32

2.1.3. Analysis and Synthetization

The content analysis method was utilized to draw out and hypothesize pertinent information from the selected articles. Content analysis is logical for the conduct of SLR [41].

The procedure has been utilized in diverse and recent literature reviews [39,42,43]. In this study, the key indicators of the outcome and process of environmental and social sustainability dimensions reflected in each published article were identified and recorded. On the completion of the analysis, the findings were debated in detail among the authors and ultimately concluded.

2.1.4. Limitations

The literature review accomplished in this research was substantial but not all-inclusive. While the 6 databases utilized provided a wide reportage of the published articles, not all peer-reviewed publications were captured. Therefore, it is likely that pertinent articles on sustainable PPP outcome principles and processes were overlooked. For instance, this article considered 32 papers. However, the SLR conducted by Akomea-Frimpong et al. [44] identified 60 articles on the topic of sustainable PPPs. The variation in figures could be explicated by the utilization of diverse repositories and keywords. The use of the term ‘Sustainable PPPs’ in the exploration conducted as part of this investigation may have also steered to a smaller paper count. However, the papers considered in this review provided a logical representation of the research on sustainability outcome principles and processes.

2.2. Analytical Framework

According to one paper [14], the comprehension of institutions facilitates the process of prioritization, empowers the execution of several sustainability goals, and also reinforces the implementation of political decisions necessary for sustainable development. Similarly, the reputation of sustainability for the sake of driven advantage is linked with institutions [45]. Matos-Castaño et al. [13] observed that a favorable institutional environment is a situation where governments realize the demands of PPPs which enable partners to enter into sustainable PPP arrangements in which instruments akin to legal frameworks (legislations, policies, and regulations) provide a guide to the realization of mutually allowable risk mitigation, transparency, and sustainable development.

Institutions are paramount because they are deliberate creations that shape information and establish the inducement to act or not act in a particular situation and, hence, the imposition of restrictions on the range of possible conduct and practicable reforms [46]. The difference between institutions from other structures of the ‘organizational analysis’ is the pivot on rules [47]. There are formal rules (e.g., constitutions, codes, statutes, etc.) and informal rules (e.g., customs, beliefs, tradition-based conventions) [48]. Rules are measures that prohibit, allow, or need some activity or results; penalties are allowed if compliance is absent [49].

However, the balance of rule-structured relationships depends on an apportioned interpretation of the regulations, as outlined by Ostrom et al. [50]. The challenge then is to know the rules that are requisite for the institutional analysis of sustainable PPPs. A multitude of distinct rules is used to organize compounded action situations [51]. Authors have been confined to the perpetual classification of rules that are not related to the method most useful for conceptual delineation [34]. However, classification is requisite to advance the science around rules [51]. Since the ultimate ambition is to evaluate and design the steering strategies for sustainable PPPs, as well as the institutional rule settings that facilitate such use, the arguments lead us to the IAD framework. The IAD framework resolved this issue via the categorization of rules by their effect on the components of an action situation (Figure 2).

In the IAD framework, Ostrom [34] elaborated a typology of rules that contextualize an action arena. In the IAD words, we would refer to this as the social setting in which the PPP is prepared, procured, and contracted, which could be in various social settings or ‘action arenas’ [10,46]. In essence, action situations derived from the IAD framework can respond to past deficiencies and increasingly complex challenges related to the creation of patterns of interactions between PPP infrastructure project planning and sustainability concerns. The pattern of interaction in relevant action arenas is thus understood as being

related to and influenced by the physical conditions, the community attributes, and the rules; there are ‘rules-in-form’ as they are codified and ‘rules-in-use’ as they are interpreted in the social setting of the involved actors.

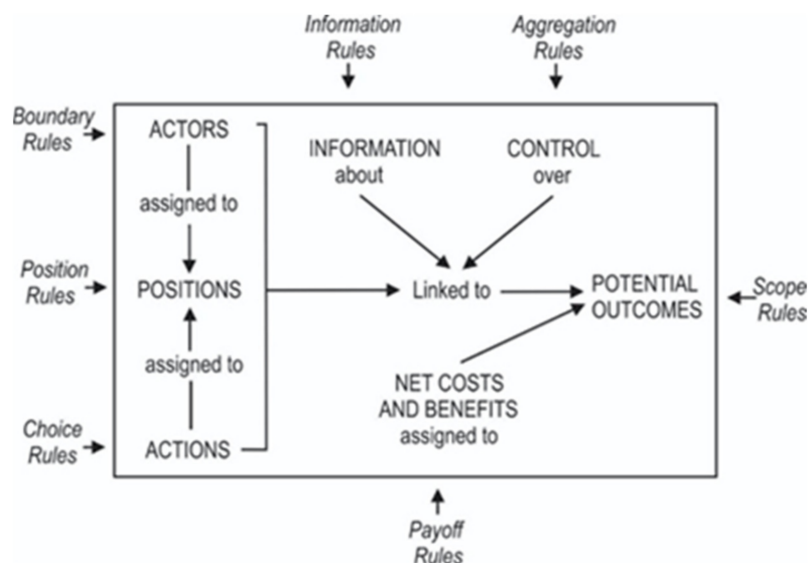


Figure 2. Rules that affect the composition of an action situation [51] (p. 189).

In addition, PPP rules will not contribute to sustainability outcomes without interaction patterns that are rationally connected with such behavior in the action environment. Therefore, we argue that sustainable PPPs will be effectively achieved only when thorough attention is paid to the institutional settings that can create patterns of interactions for sustainability behavior at the planning stages by applying the steering strategies targeting the indicators. A small number of studies distinctly focus on how rules and influences thereof impact and dictate urban infrastructures [45]. The work of Elinor Ostrom represents an important theoretical starting point for analyzing and classifying rules [34]. Ostrom’s Institutional Analysis Development (IAD) framework proposes a structure for a systematic and detailed analysis of rules within collective action. As sustainable PPP planning is a matter of collective action structured by sets of rules, the IAD framework provides important fundamentals for analyzing rules and changes thereof [48,49].

The optimization of the impacts of a PPP is, of course, related to the bio-physical situations and how these are influenced by envisioned infrastructure; it is also related to how the envisioned infrastructure influences the community and thereby the attributes of the community, as depicted in Figure 3. Both foci need to be explicitly addressed in the action arenas in sustainable PPPs. This relates to a scale-up of the principles and indicators for environmental and social sustainability.

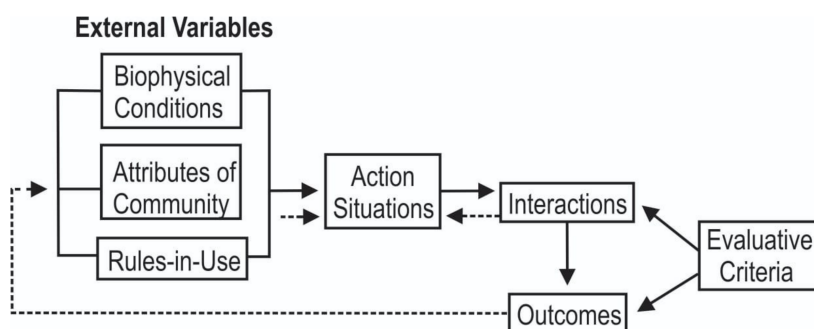


Figure 3. The IAD framework [51] (p. 15).

As it were, and at any moment in time, the characteristics of the biophysical system (such as quality, vulnerability, and resilience), as well as the characteristics of the community (such as equality, equity, fairness, transparency, receptivity, vulnerability, and activism), will be an echo from the past, just as the written rules and working rules. In the model, there is a difference between the analytical perspective, the three boxes as they are in reality, and the envisioned better state in the evaluative criteria. This will be a functional infrastructure that offers socio-economically relevant services to communities in a socio-ecological manner; it will be sustainable in its impacts upon the bio-physical system (related to environmental sustainability and ecological indicators) and from the perspectives of the attributes of the community (related to the social sustainability and social equity indicators).

This paper accepts the IAD framework as a widely acknowledged analytical framework that links patterns of behavior in multi-actor processes to rule settings, as well as evaluative criteria. This framework helps us to synthesize the discoveries from the literature review in the run-up to answering Sub-question 3. About Sub-questions 1 and 2, and their elaboration in Sections 3.1 and 3.2, the framework provides an argument to distinguish outcome indicators and process principles and indicators.

In this study, the outcome is referred to as sustainable PPP, which we earlier defined as the integration of environmental and social sustainability principles in PPP infrastructure planning. It also suggests that our study focuses on the immediate outcomes at the planning stages of preparation, procurement, and contract, rather than the ultimate outcomes of sustainability at the operational stages. Focusing on such outcomes will mean analyzing the outcome indicators regarding infrastructure-related sustainability concerns in terms of environmental and social sustainability. Further, in sustainable PPP action situations, actors cooperate, negotiate, challenge each other, and produce and share information and resources for use. As these interaction processes become regularized and observable, they give rise to patterns of interaction. Focusing on patterns of interaction implies identifying the process steering strategies that influence sustainable PPPs in terms of both environmental and social sustainability.

The IAD framework rules that affect the elements of an action situation (Figure 2) are employed in Section 4 to synthesize the encountered indicators, alongside the environmental and social sustainability steering strategies, and attain rule settings for sustainable PPP evaluation at the planning stages. Such an approach is crucial for our mission to develop parsimonious rule settings that can monitor processes and assess outcomes while interlinking both. This creates a route toward institutional designs for sustainable PPPs. Figure 4, illustrates the research design of the study.

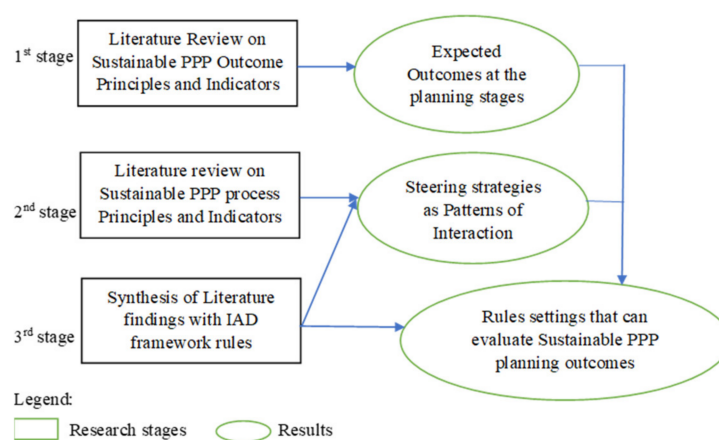


Figure 4. Research design, including stages and results.

3. Results and Discussion

In this section, an overview of sustainability outcomes and process principles and their indicators, as addressed in PPP literature, is provided. This answers sub-research Questions

1 and 2, respectively. In both cases, the results are presented, analyzed sequentially and contextualized by detailed reports of the literature in Tables 2–7.

3.1. Sustainability Outcome Principles and Indicators

Sustainability is a development that achieves the demand of the current generation whilst allowing the potential of later generations to achieve their own needs [52]. As observed by one researcher [53], there is no global agreement on how to represent sustainability; its intrinsic blurriness and analytical pliability add to its broad appeal. Sustainability comprises three pillars: environmental or planet or environment; economic or profit or economy; and social or people or equity. Berrone et al. [6,19] acknowledged that, for PPPs to advance sustainable infrastructure development, socio-ecological considerations must be prioritized. Hence, this research effort is limited to the environmental and social sustainability of huge-scale infrastructure projects.

In terms of environmental sustainability, there is a high negative environmental effect regarding energy, material, and waste [54]. There are also discussions on the delineation of social sustainability and its indicators or components by Xiahou et al. [55] and Wang et al. [56]. The topic is still open for discussion regarding the distinct demands of societies or countries and can be organized to separate areas and societal needs [53]. Indicators on sustainability outcome principles have been published by Hoeft et al. [30] and Ferrarez et al. [31]; however, no proper classifications of indicators for these principles were found for sustainable PPPs.

Table 2 presents a summary of indicators for environmental and social sustainability outcome principles in PPP infrastructure projects, as found in the literature. The principles and indicators are based on the works of Hueskes et al. [3] and Patil et al. [57] and should be viewed as interpretive rather than exhaustive. The delineation in Table 2 shows that environmental sustainability in PPP relates to efficient project implementation, ecological compatibility, and resource utilization efficiency and maintenance. Social sustainability in PPPs relates to stakeholders' empowerment, quality of life, and 'social justice'.

Table 2. Sustainable PPP Outcome Principles and Indicators.

Sustainability Pillar	Outcome Principles	Indicators	Examples	Sources
Environmental	Efficient Project Implementation	Clean Air	Measures reducing CO ₂ emissions	Bakhtawar et al. [17], Patil et al. [19], Hoeft et al. [30].
		Noise Level	Measures reducing noise vibrations	Lenferink et al. [7], Sweere [29], Hoeft et al. [30].
		Water	Water protection (less use of water) and quality	Patil et al. [19], He et al. [22], Sweere [29].
	Ecological Compatibility	Biodiversity	Protection of fauna and flora	Berrone et al. [6], Sweere [29], Hoeft et al. [30].
		Landscape Conservation	Efficient land use; Conserving or replanting trees and vegetation	Bakhtawar et al. [17], Sweere [29], Hoeft et al. [30].
	Resource Utilization Efficiency and Maintenance	Material and Design	Environmental friendly materials, contextual fit in the environment, innovation, multi-functional design, local materials	Hueskes et al. [3], Koppenjan [4], He et al. [22].
		Energy	Use of renewable energy and efficiency	Hueskes et al. [3], Patil et al. [19], Sweere [29]

Table 2. Cont.

Sustainability Pillar	Outcome Principles	Indicators	Examples	Sources
Social	Stakeholders Empowerment	Participation and Co-creation	Citizens and stakeholders involved in the decision making	Koppenjan [4], He et al. [22]
		Education and Training	Capacity-building measures	Xiahou et al. [55], Wang et al. [56].
	Quality of Life	Health and Safety	Construction site safety management and management	Bakhtawar et al. [17], Patil et al. [19], Wang et al. [56].
		Local and Societal Needs	Meeting the demands of the local community	Berrone et al. [6], Boström [53], Wang et al. [56].
	Social Justice	Emancipation and Equity (inclusiveness)	Accessibility for people with disabilities; affordability; promoting diversity; inclusion	Berrone et al. [6] Patil et al. [19], Xiahou et al. [55],
		Labor and Human Rights	Labor rights, non-discrimination, local employment	Patil et al. [19], Boström [53], Wang et al. [56].
		Public Meeting	Measures that stimulate social cohesion	Berrone et al. [6], Wang et al. [56].

Elicited from Table 2, in a reductionist approach, the key indicators for environmental sustainability outcomes (ESO), as shown in Table 3, are expressed as (1) Clean Air, (2) Noise, (3) Water, (4) Biodiversity, (5) Landscape Conservation, (6) Material and Design, and (7) Energy. Social sustainability outcomes (SSO), as shown in Table 4, are expressed as (1) Participation and Co-creation, (2) Education and Training, (3) Health and Safety, (4) Local and Societal Needs, (5) Emancipation and Equity, (6) Labor and Human Rights, and (7) Public Meeting. A set of examples that explains how each indicator was interpreted in the analysis can be seen in Table 2. We admit to the fact that there may be more indicators. This paper does not cover every possible relevant indicator. The emphasis is on the heuristic elements of our method, which is the key innovative element; completeness is viewed as secondary.

3.1.1. Overview of Environmental Sustainability Outcome Indicators in the Literature

In terms of EOI, efficient project implementation principles were explicitly addressed and accounted for in 25 (48%) of the indicators. The majority of the papers reviewed under efficient project implementation focused extensively on Clean Air; the overall count was 15 (29%), as Table 3 shows. Noise Level, which was addressed in six (12%), and Water Issues, which was addressed in four (8%), received considerable attention. A huge focus on Clean Air is to be expected because CO₂ emissions are the main instigator of global climate change and negative environmental externalities. With a huge global call for CO₂ reduction, Khan et al. [58] observed that technological innovations have a consequential effect on its curtailment.

Table 3. Delineation of environmental sustainability outcome principles and their indicators.

Study	Efficient Project Implementation			Ecological Compatibility		Resource Utilization Efficiency		
	EOI 1	EOI 2	EOI 3	EOI 4	EOI 5	EOI 6	EOI 7	Sum
Xiahou et al. [55]	X	X						2
Hoefst et al. [30]	X			X	X	X	X	5
Bakhtawar et al. [17]				X		X		2

Table 3. Cont.

Study	Efficient Project Implementation		Ecological Compatibility			Resource Utilization Efficiency		Sum
	EOI 1	EOI 2	EOI 3	EOI 4	EOI 5	EOI 6	EOI 7	
Patil et al. [59]	X						X	2
Nizkorodov [60]			X				X	2
Schahbaz et al. [61]	X						X	2
Khan et al. [58]	X						X	2
Li et al. [62]	X		X		X	X	X	5
Berrone et al. [6]	X					X	X	3
Chen et al. [63]	X	X	X	X				4
Dolla and Laishram [64]	X					X		2
Yaun et al. [65]	X	X						2
Gao [66]						X		1
Malvestio et al. [16]	X	X	X	X	X			5
Agarchand and Laishram [67]	X						X	2
Kivila et al. [68]	X	X						2
Spraul and Thaler [69]					X		X	2
Cedrick [70]							X	1
Koscielniak and Gorka [71]							X	1
Patil and Laishram [19]	X			X			X	3
Villabo-Romero et al. [72]	X	X						2
Sum	15	6	4	5	4	6	12	52

EOI: Environmental outcome indicators. EOI 1: Clean Air. EOI 2: Noise Level. EOI 3: Water. EOI 4: Biodiversity. EOI 5: Landscape Conservation. EOI 6: Material and Design. EOI 7: Energy. X: the presence of the delineated indicator in the cited article.

PPP infrastructure projects are useful instruments in this regard because of the technological expertise the private actors bring into the partnership.

Ecological Compatibility principles are also obvious in the literature. Table 3, shows that the highest number of indicators on Ecological Compatibility principles relate to Biodiversity, which was addressed in five (10%) cases. This includes design requirements for access to animals [17], remote wildlife studies to minimize disturbance and save biodiversity [30], and boundaries of protected areas [16]. Landscape Conservation, which was accounted for in four (8%) indicators, was also addressed in the literature but stands as one of the least considered environmental outcomes.

Indicators on Resource Utilization Efficiency principles were also addressed in the literature. In total, 12 (23%) of the indicators demonstrated a high focus on energy. This was expected because a large percentage of the emissions in the world are due to unrestricted energy use [73]. The renewable energy considerations connected to PPP infrastructure projects are solar photovoltaic installation parks, wind farms, renewable generation biogas plants, and biogas plants [70]. Material and Design (12%) also received considerable attention.

3.1.2. Overview of Social Sustainability Outcome Indicators in the Literature

An analysis of the delineation of SOI reveals that, although all three identified principles were addressed in the literature, only Berrone et al. [6] suggested indicators for each of the principles. Social Justice was the most explicitly addressed principle in the literature with 25 (42%) of the indicators. This was expected because certain PPP agreements are mostly shrouded in secrecy, to the detriment of the end users. In terms of Social Justice, Labor, and Human Rights ranked the highest, with 10 (17%) of the indicators. Emancipation and Equity, addressed in 8 (13%) cases, and Public Meeting, addressed in 7 (12%) cases, were also touched on.

Table 4. Delineation of social sustainability outcome principles and their indicators.

Study	Stakeholder's Empowerment	Quality of Life		Social Justice				Sum
	SOI 1	SOI 2	SOI 3	SOI 4	SOI 5	SOI 6	SOI 7	
Xiahou et al. [55]	X			X	X	X	X	5
Hoefl et al. [30]	X	X	X	X		X		5
Bakhtawar et al. [17]			X			X		2
Patil et al. [59]	X	X					X	3
Wang et al. [56]		X	X	X	X	X	X	6
Selim and Elgohary [74]	X	X	X				X	4
Xiong et al. [75]		X						1
Spoann et al. [76]	X	X						2
Berrone et al. [6]	X	X	X	X	X	X	X	7
Spraul and Thaler [69]	X	X				X		3
Li et al. [62]						X	X	2
Chen et al. [63]			X			X	X	3
Yuan et al. [65]	X	X	X		X	X		5
Gao [66]			X					1
Malvestio et al. [16]	X				X			2
Agarchand and Laishram [67]		X						1
Patil and Laishram [19]	X	X			X	X		4
Villabo-Romero et al. [72]					X			1
Lenferink et al. [7]	X							1
Ng et al. [77]	X				X			2
	12	11	8	4	8	10	7	60

SOI: Social outcome indicators. SOI 1: Participation and Co-creation. SOI 2: Education and Training. SOI 3: Health and Safety. SOI 4: Local and Societal Needs. SOI 5: Emancipation and Equity. SOI 6: Labor and Human Rights. SOI 7: Public Meeting. X: the presence of the delineated indicator in the cited article.

Stakeholder Empowerment, addressed in 23 (38%) cases, was hugely subscribed. Participation and Co-creation, with 12 (20%) mentions, ranked the highest within the Stakeholder Empowerment principles. Participation and Co-creation focused on collaboration [30], social issues in decision making [16], support for local enterprises [69], and inclusiveness [7]. Education and Training, which was addressed in 11(18%) cases, was also a clear-cut indicator. This entails capacity development of the government team [74] and increased knowledge of sustainability among team members [19].

Quality of Life was also an obvious social sustainability outcome principle in the literature. Within the Quality of Life category, Health and Safety had eight (13%) mentions and Local and Societal Needs were addressed in four (7%) cases. Health and Safety focused on safe workplaces [56], people's health [74], and safety procedures [65]. Local and Societal Needs centralized fair competition [56], societal development [55], and participation without discrimination [6].

3.1.3. Summary

Overall, the results show that social sustainability indicators were slightly more addressed in the literature than environmental sustainability outcomes, with an emphasis on Participation and Co-creation. However, Clean Air from the environmental sustainability outcomes had the highest consideration among the sustainability outcome indicators. A delineation of the environmental sustainability outcomes shows no overlap with the social sustainability outcomes. This indicates that environmental sustainability outcomes, essentially, are not an extension of social sustainability outcomes. While environmental sustainability in PPP infrastructure projects is predominately linked to effective project implementation, social sustainability is linked to social justice.

3.2. Sustainability Process Principles Indicators and Strategies

Recently, scholars and practitioners took into account the impacts of the PPP decision-making processes on sustainability [10,29,69]. For instance, one researcher [10] analyzed the improvement of a potable water supply in Indonesia using the 'build-operate and transfer' model of PPP; they identified the decision-making sequence for sustainable PPPs regarding

environmental and social outcome principles and indicators. As posited by Plamonia [10], PPP can be pursued under the umbrella of three social processes: preparation, procurement, and contracting. Preparation deals with ambitions, the collection of facts, and the capture of interests. Procurement is about the selection of the concessionaires most capable of dealing with ambitions. Contracting sets out agreed contractual arrangements that can lead to sustainability. This implies that PPP process principles thrive at different decision-making phases and each phase includes instruments that could influence sustainability.

However, PPP institutional process design leaves much to be desired, with significant impacts on outcomes [10]. Therefore, the social arena in which preparation, procurement, and contracting take place creates sub-processes to actualize sustainable PPPs at the planning stages. In sum, PPP internal components noted as ‘structure’ and ‘process’ components affect sustainability-linked outputs [69]. The heightened interest in sustainable PPPs’ process principles has resulted in several indicators being utilized to delineate them. There exists a broad variety of sustainable development indicators used by diverse scholars [22,29,78]. The choice of independent indicators hangs on the outlook of diverse stakeholder groups and interested parties. As such, the preferred indicators may be quite different because they are needed at different PPP spatial scales. However, the choice of indicators effectively determines the “perspectives” through which sustainable PPPs can be viewed; thereby, they have a huge influence on decisions and judgments.

Table 5 presents meta-indicators that group the operational indicators of Table 2. The principles and indicators presented are based on a specific group of studies [10,19,79]. The delineation in Table 5 shows that the environmental and social sustainability process relates to preparation, procurement, and contracting as sub-processes for sustainable PPPs at the planning stages. Leveraging the information in Table 5 in a reductionist approach, the meta-indicators for environmental sustainability are (1) Assessment of Environmental Impacts and Mitigation Options, (2) Support Systems and schemes are used, (3) Available Environmental Policy, (4) Awareness of Environmental Sustainability Criteria explicit to project and location, (5) Competition on Environmental Sustainability Criteria, (6) Active Involvement of Civil Groups in judging the bids, and (7) Procedure to Monitor and Revise the Contract.

The meta-indicators for social sustainability are (1) an assessment tool for stakeholders’ participation, such as building information modeling; (2) a special purpose company that is jointly owned by the government, users, and private developers for the development of PPP projects as an alternative institutional mechanism; (3) the use of two-way communication in participative forms; (4) a platform for close debate during the bidding stage via a strategic communication plan as part of a procurement policy; (5) fairness and process auditors who are appointed as third-party experts to monitor the procurement process; (6) an independent and technical review panel that can scrutinize the PPP project and safeguard sustainability during the bidding process; and (7) main contractor–subcontractor relationships.

Table 5 includes a set of process principles and indicators, as well as matching steering strategies and examples found in the literature review, to explain the functionality of each indicator as interpreted in the analysis. This paper employs the term “steering strategies” as an enhancement prescription that delineates the direction by which practices in sustainable PPP shall be governed. Steering strategies institutionalize a procedure that is reflected in the way sustainable PPP processes operate, that is, in the actors participating in policymaking, and in actors’ decision-making powers and interactions.

Table 5. Sustainable PPP process principles and indicators. ESS: Environmental Steering Strategies; SSS: Social Steering Strategies.

Sustainability Pillar	Process Principles	Indicators	Steering Strategies	Sources	Explanation
Environmental Sustainability	Prepare	Assessment of Environmental Impacts and Mitigation Options	Evidence towards EIA for better life-cycle performance (ESS 1).	Koppenjan [4], Shahbaz et al. [61]	Proof that guidelines towards EIA are applied i.e., conforming contractors to systems engineering standards such as ISO 15288
		Support Systems and Schemes are used	Incentives or subsidies to private partners that can provide more environmental sustainability expertise (ESS 2).	Bakhtawar et al. [17], Patil and Laishram [19]	Involved public-private actors show that they use incentives maximally to connect environmental expertise.
		Available Environmental Policy	Liability and compensation for environmental impacts (ESS 3).	Berrone et al. [6], Grasman et al. [79]	Public-private actors are aware of environmental regulations and amend their behavior accordingly to avoid environmental externalities and liabilities.
	Procure	Awareness of Environmental Sustainability Criteria explicit to Project and Location.	Additional points are given to bids that include innovation related to the reduction of environmental problems (ESS 4).	Hueskes et al. [3], Patil and Laishram [19], Grasman et al. [79]	Award criteria are not based on price alone but on quality, and avoiding environmental externalities i.e., by application of MEAT criteria (Most Economically Advantageous Tender).
		Competition on Environmental Sustainability Criteria	Prequalification is based on experience in environmental sustainability practices as demonstrated by relevant certifications (ESS 5).	[19], Dolla and Laishram [64] Yaun et al. [66]	Terms of reference that focus on proven expertise or skills in environmental sustainability practices.
		Multi-actor Dialogue	Active involvement of environmental civil groups in judging the bids (ESS 6)	Leferink et al. [7], Grasman et al. [79]	Involvement of stakeholders and outside expertise in the procurement process.
	Contract	Procedure to Monitor and Revise the Contract	Contract review provision in between and updating agreements to do justice to new technological findings, and socio-economic and political realities (ESS 7).	Koppenjan [4], Berrone et al. [6], Patil et al. [59]	Contracts are monitored periodically and procedures are in place to revise the contract, settle disputes and terminate the contract.

Table 5. Cont.

Sustainability Pillar	Process Principles	Indicators	Steering Strategies	Sources	Explanation
Social Sustainability	Prepare	Efforts on Assessing Social Impacts on the Local Community.	Assessment tools for stakeholders' participation such as building information modeling (SSS 1).	Bakhtawar et al. [17], Hoeft et al. [30], Li et al. [62]	Use of impact analysis and simulation techniques to highlight probabilistic risks
		Inclusion of Stakeholders through a Special-purpose Company	A special purpose company that is jointly owned by the government, users, and private developers for the development of PPP projects as an alternative institutional mechanism (SSS 2).	Berrone et al. [6], Gao [66], Xiong et al. [75]	An external board that can deepen sustainability at the planning stages.
		Community Involvement through Participation	Use of two-way communication in participative forms (SSS 3).	Xiahou et al. [55], Selim [74] Bai et al. [76]	Project information is freely available for instance, activities are organized to involve the local community to comment and connect online
	Procure	Clear Bid Strategy	A platform for close debate during the bidding stage via a strategic communication plan as part of the procurement policy (SSS 4).	Patil et al. [59], Gao [66]	The tender document defines the service standard to be achieved especially the impact and risks related to the community.
		3rd Party Probity Arrangements	Fairness and process auditors are appointed as third-party experts to monitor the procurement process (SSS5).	Berrone et al. [6], Hoeft et al. [30]	The third-party review takes place and it is taken seriously.
		Project Scrutiny	An independent and technical review panel that can scrutinize the PPP project and safeguard sustainability during the bidding process (SSS 6).	Wang et al. [56], Yaun et al. [65]	A panel of experts in charge of reviewing the candidates, especially their efforts at minimizing impact and risks on the local community
	Contract	The Contract is Finalized based on the Relationship among Stakeholders.	Main contractor-subcontractor relationships (SSS 7).	Berrone et al. [6], Patil and Laishram [19], and Gao [66]	The process to monitor and adjust the contract to integrate expertise, information, and insights.

3.2.1. Environmental Sustainability Process Principles Indicators and Strategies in the Literature

A compendious study of the pivotal principle indicators and matching strategies for the environmental sustainability process (ESP) is provided in Table 6. The analysis showed that Support Systems and Schemes, as well as Procedures to Monitor and Revise the Contract were the most frequently addressed. The Support System and Schemes indicator was acknowledged in 10 of the 50 (20%) indicators while the Procedure to Monitor and Revise the Contract was acknowledged in nine (18%) of the indicators. In numerous cases, these indicators were addressed utterly via reference to the definition of environmental

sustainability. The substantial attention on these two indicators mirrors their importance in ESP and the need for them to be emphasized in sustainable PPPs.

Table 6. Delineation of environmental sustainability process principles and their indicators.

Study	Prepare			Procure			Contract	
	ESPI 1	ESPI 2	ESPI 3	ESPI 4	ESPI 5	ESPI 6	ESPI 7	Sum
Hoeft et al. [30]	X							1
Patil et al. [59]	X	X	X	X	X		X	6
Nizkorodov [60]	X	X				X	X	4
Khan et al. [58]		X						1
Schahbaz et al. [61]		X						1
Selim and El-Gohary [74]		X				X	X	3
Chen et al. [63]	X							1
Spoann et al. [76]		X						1
Berrone et al. [6]			X			X	X	3
Gao [66]						X		1
Malvestio et al. [16]	X							1
Dolla and Laishram [64]		X	X	X	X		X	5
Kivila et al. [68]			X	X				2
Agarchand and Laishram [67]			X	X	X	X		4
Cedrick [70]			X					1
Ruis et al. [80]		X						1
Patil and Laishram [19]	X	X	X	X			X	5
Villabo-Romero et al. [72]							X	1
Koppenjan [4]		X		X		X	X	4
Lenferink et al. [7]				X	X	X	X	4
	6	10	7	7	4	7	9	50

ESPI: Environmental sustainability process indicator. ESPI 1: Assessment of Environmental Impacts and Mitigation Options. ESPI 2: Support Systems and Schemes are used. ESPI 3: Available Environmental Policy. ESPI 4: Awareness of Environmental Sustainability Criteria explicit to Project and Location. ESPI 5: Competition on Environmental Sustainability Criteria. ESPI 6: Multi-actor Dialogue. ESPI 7: Procedure to Monitor and Revise the Contract. X: the presence of the delineated indicator in the cited article.

Other indicators were also addressed in the delineation of ESPI. Available Environmental Policy, Awareness of Environmental Sustainability Criteria explicit to Project and Location, and Multi-actor Dialogue were each addressed in seven (14%) of the indicators. Assessment of Environmental Impacts and Mitigation Options was acknowledged in six (12%) of the indicators and was considered in many ways. These are policies that result in environmentally favorable and well-turned-out developments [59], functional environment behaviors [63], environmental effect review reports [60], and strategic environmental assessments [16]. In general, the outcomes reveal that there was good coverage of ESPI, though individual authors unequivocally highlighted distinct aspects. In one of the most exhaustive delineations, six of the seven indicators were furnished by Patil et al. [59]. In total, five indicators each were provided by Patil and Laishram [19] and Dolla and Laishram [64].

3.2.2. Social Sustainability Process Principles Indicators and Strategies in the Literature

As per SSPI and principles, the most commonly addressed indicators were Community Involvement through Participation and Project Scrutiny. Community Involvement through Participation was addressed in 12 (28%) of the published indicators. Project Scrutiny appeared in seven (16%) of the indicators; meanwhile, six (14%) of the indicators addressed the Inclusion of Stakeholders through a Special-purpose Company. Lenferink et al. [7] argued that partnering, strategic alliances, project alliances, and joint ventures are initiatives that can foster stakeholder inclusion in sustainable PPPs. Xiong et al. [74] alluded that collaboration through joint ventures brings companies with the required skill sets together.

Co-ownerships will reduce private-sector perceived risks and transform societal resistance to support [4].

Clear Bid Strategy was also addressed by six (14%) definitions. Patil et al. [59] referred to a clear bid strategy as a procurement policy. Berrone et al. [6] linked it to tender documents that indicate service standards to be achieved. Kivilä et al. [68] highlighted it as a public procurement plan, while another researcher [67] implied online procurement data provision.

Third-party Probity Arrangements were addressed by five (12%) of the SSPI. Patil et al. [59] explicitly referred to third-party probity as the involvement of fairness and process auditors, another researcher [67] referenced it as the involvement of independent experts that examine the bid process. Ng et al. [77] suggested that it is a specialist group that provides a channel for users to express their comments.

The notion of Efforts to Assess Social Impacts on the Local Community was addressed by four (9%) of the indicators, as Table 7 illustrates. The Contract Finalized based on the Relationship among Stakeholders was addressed by three (7%) of the indicators. Altogether, the most extensive delineations as per the SSI were the seven indicators provided by Patil et al. [59]. However, Kościelniak and Górka [71] and Ng et al. [77] addressed five each.

Table 7. Delineation of social sustainability process principles and their indicators.

Study	Prepare			Procure			Contract	
	SSPI 1	SSPI 2	SSPI 3	SSPI 4	SSPI 5	SSPI 6	SSPI 7	Sum
Hoeft et al. [30]		X	X					2
Nizkorodov [60]			X					1
Patil et al. [59]	X	X	X	X	X	X	X	7
Bakhtawar et al. [17]	X							1
Wang et al. [56]			X					1
Selim and Elgohary [73]		X	X					2
Xiong et al. [74]		X	X					2
Berrone et al. [6]			X	X				2
Yaun et al. [65]	X					X		2
Gao [66]						X		1
Dolla and Laishram [64]					X	X		2
Agarchand and Laishram [67]			X	X	X	X		4
Kivilä et al. [68]			X	X				2
Patil and Laishram [19]			X	X	X	X	X	5
Koppenjan [4]		X						1
Ng et al. [77]	X		X	X	X	X		5
Lenferink et al. [7]		X	X				X	3
	4	6	12	6	5	7	3	43

SSI: Social sustainability process indicators. SSI 1: Efforts on assessing social impacts on the local community. SSI 2: Inclusion of stakeholders through a special purpose company. SSI 3: Community involvement through participation. SSI 4: Clear bid strategy. SSI 5: 3rd party probity arrangements. SSI 6: Project scrutiny. SSI 7: Contract finalized based on the relationship among stakeholders. X: the presence of the delineated indicator in the cited article.

3.2.3. Summary

The results show that all the ESI and SSI were adequately addressed across the three planning stages. However, in both cases, the preparation stage addressed the highest number of indicators. This attests to the imperativeness of adequate and enlightened preparatory processes regarding sustainable PPPs. The ESI indicators showed more indicators with emphasis on support systems and schemes at the preparation stage. Likewise, the SSI also emphasized the highest number of indicators at the preparation stage.

3.3. Overview

An analysis of the findings reveals that sustainable PPPs began with a focus on the merger of sustainability outcome considerations with the planning process principles. The

need to infuse social considerations in PPP infrastructure projects is thus well-entrenched in the literature, a position underscored by Hueskes et al. [3] and Wang et al. [56]. Analogous to the continued growth of research on environmental sustainability, a more comprehensive purview of social sustainability and its incorporation within PPP infrastructure projects has emerged. The findings also show diverse ways in which both environmental and social sustainability are delineated.

A cogitation of indicators on environmental and social sustainability outcomes and process principles (i.e., 28 in total) was analyzed; the delineation provided by Berrone et al. [6] and Patil et al. [59] addressed the vast number of independent attributes, with a total of seven each. Four of the most holistic delineations are from the social sustainability list. This sums up the fact that the social sustainability delineations principally did a better job at superscribing the sustainability indicators. These results revealed that not one of the considered delineations fully addressed the identified indicators on both environmental and social sustainability outcomes and process principles. This is probably a result of the many divergent conceptualizations of both environmental and social sustainability and the inclination on the part of the scholars to develop a commensurately unique delineation.

In the heuristic perspective of this article, the completeness of environmental and social indicators is not an obstacle, as long as (environmental and social) process strategies enable process actors in situ to identify the relevant indicators.

4. Rule Setting for Sustainable PPPs

With the utilization of a reductionist approach, as well as the literature review findings, Sub-research Questions 1 and 2 were answered. The final step and the ambition of this study were addressed in the third sub-research question. With the distinguished ESS and SSS from the literature review in mind, the observation that a smooth seven-rule typology might ignore the multiplicity of formal and informal rules and that, in practice, rules might overlap [34] gains momentum. In order to deeply analyze rule setting for sustainable PPPs, we developed three taxonomies of rules based on Ostrom's seven sets of rules (see Figure 2). This was conducted in an effort to create an analytical and design lens that is as simple as possible and very close to how the steering strategies are envisioned to influence the patterns of interaction. The taxonomies are position–boundary–choice rules, scope–payoff rules, and information–aggregation rules.

In this paper, we thus argue that sustainable PPPs can be evaluated by rule settings that effectively synthesize outcome indicators and patterns of interaction. In this light, our analysis focuses only on three variables of the IAD framework (outcomes, patterns of interactions, and evaluation criteria). By outcomes, we imply the sustainable PPP outcome principles and indicators, as illustrated in Table 2 and delineated further in Tables 3 and 4. The patterns of interactions are the environmental and social sustainability steering strategies principles delineated in Table 5. The evaluative criteria represent the rule settings that synthesize both outcome principles and indicators and steering strategies for effective sustainable PPP planning.

A taxonomy of the IAD rules is important to sustainable PPP evaluation as it helps to categorize and combine both environmental and social sustainability steering strategies in a cheese-pairing manner. This is achieved as follows: the IAD framework rules, delineated in Table 8, are used as a lens to synthesize the distinguished steering strategies for environmental sustainability (ESS) and social sustainability (SSS) in Table 5 (fourth column), respectively. With the distinguished ESS and SSS from the literature review in mind, the observation from that a smooth seven-rule typology might ignore the multiplicity of formal and informal rules and that, in practice, rules might overlap and gain momentum [34] gains momentum. Distinguished ESS and SSS readily connect to various elements in the rule settings depicted by Ostrom and are included in the first columns of Table 8.

Table 8. Categories and roles of the IAD Framework rules, Cole [47] (p. 837), third column by authors.

Type of Rule	Function of Rules	ESS and SSS, Rule Settings, and Functioning of Rules (As Regards Sustainable PPPs)
Position	“Create positions (e.g., member, judge, voter, representative) that actors may hold”.	ESS and SSS in Table 9 align to one or more of these three rule functions target, with sustainable PPPs in mind, (i) the configuration of actor positions in action situations as regards PPPs, (ii) the characteristics of involved actors in terms of cognitions, motivations, and resources, i.e., what the involved actors may know, strive for, and capable of and (iii), how they come into or exit from the action situation, what they must and can undertake in the (collective) action situation.
Boundary	“Define (1) who is eligible to hold a certain position, (2) the process by which positions are assigned to actors (including rules of succession), and (3) how positions may be exited”.	
Choice	“Prescribe actions actors in position must, must not, or may take in various circumstances”.	
Aggregation	“Determine how many, and which, players must participate in a given collective or operational-choice decision”.	ESS and SSS in Table 9 align to one or more of these two rule functions targeted with sustainable PPPs in mind (i) how many and which actors are involved and (ii) how data, information and knowledge gathering, and processing as regards environmental and social sustainability should be taken aboard.
Information	“Authorize channels of information flows available to participants, including assignation of obligations, permissions, or prohibitions on communication”.	
Pay-off	“Assign rewards or sanctions to particular actions that have been taken or on outcomes”.	
Scope	“Delimit the range of possible outcomes. In the absence of a scope rule, actors can affect any physically possible outcomes”.	ESS and SSS in Table 9 aligned to one or more of these two rule functions target with sustainable PPPs in mind (i) to what extent impacts upon environmental and social sustainability of projects can be neglected and (ii) what the consequences imposed upon actors, action situation and decisions can be.

Table 9. Rule Settings as Institutional Conditions for Effective Employment of Steering Strategies towards Sustainable PPPs at the Planning Stages.

Ostrom Rule Types	Action Situation (Preparation)		Action Situation (Procurement)		Action Situation (Contract)	
	ESS	SSS	ESS	SSS	ESS	SSS
Position–Boundary–Choice		SSS 2	ESS 5	SSS 5 SSS 6	ESS 7	
Scope–Payoff	ESS 2		ESS 4			SSS 7
Information–Aggregation	ESS 1 ESS 3	SSS 1 SSS 3 SSS 4	ESS 6			

The combination of rules in Table 8 supports our final effort to categorize and delineate ESS and SSS as derived from the literature review through an analytical lens provided by Ostrom’s IAD variables; it allows us to reason upon gaps that may be held responsible for disappointing sustainability outcomes of PPP. This led to efforts to steer strategies to close the gaps and create the institutional design to deal with this. Through this procedure, there is potential to form institutional design by a further elaboration of rule settings and consider how they are implemented in the action situations (preparation, procurement, and contracting) and steering strategies. While IAD refers to these in the neutral language (evaluative criteria), for our goal in this article, as well as in further research based upon this effort, the steering strategies and potential for institutional design, as communicated by this procedure in Table 9, are of interest. Efforts that can both focus on the gaps and also improve the ESS and SSS as derived from the literature are heightened.

In terms of position–boundary–choice taxonomy, position rules shape the functions actors are allotted to achieve sustainable PPPs, such as the appointment of an external board that can deepen sustainability at the planning stages, fairness and process auditors that allow third-party arrangements to foster sustainability at the procurement stages, or independent and technical review panels that can scrutinize PPP projects and safeguard sustainability during the bidding process. The position rules regulate to what extent actors are permitted to act, take measures from a string of options, or make decisions [34]. Next, boundary rules control which actor is competent enough to be admitted to take a position or leave a position, such as prequalification, that is based on experience in environmental sustainability practices, as demonstrated by relevant certifications. Boundary rules also influence the contexts that are needed to take up or quit a position, such as a platform for close debate during the bidding stage via a strategic communication plan as part of procurement policy. Thirdly, choice rules stipulate measures that actors in a position should, should not, or can take in diverse scenarios, such as procedures that monitor and revise contracts to cater to new technological findings and socioeconomic realities that foster sustainability.

In terms, of scope–payoff rules, scope rules demarcate the results and impact a known outcome variable that should, should not, or can be impacted as a consequence of the steps taken within the sustainable PPP action situations. In sustainable PPPs, for example, tender documents define the service standard to be achieved especially as it relates to the impact and risks related to a community. Further, payoff rules state benefits or penalties that are associated with the definite measures taken or results attained. These relate to inducement or state aid to private actors that can impart more environmental sustainability expertise. Additionally, payoff rules in sustainable PPPs involve additional points given to bids that include innovation related to the reduction of environmental problems.

In terms of information–aggregation rules, information rules refer to the channel of information flow that is accessible to partners regarding the action situation and the other partners; for instance, evidence towards EIA for better life-cycle performance and the use of two-way communication in participative forms are essential to sustainable PPPs. Additionally, information rules specify actors' goals, motives, and strategies. For example, the use of simulation techniques to highlight probabilistic risks and the available environmental policy are required for sustainable PPPs. Aggregation rules regulate how many and which actors must partake in a stated joint or workable-choice decision. In this sense, multi-actor dialogue where there is the active involvement of environmental civil groups in judging the bids is a prerequisite for sustainable PPPs.

The rules set for sustainable PPPs propose in this study have the potential to ensure that ingrained to the attainment of the worth of money in PPP infrastructure projects is a well-built and supportive legal framework that aims to institute, preserve and stimulate partnerships between the public and private actors for the profit of socio-ecological goals as a whole [18]. Listed below are some advantages of the rules set regarding potential regulative frameworks on sustainable PPP planning:

- Obligingness with extant environmental and social sustainability rules and strategies;
- Government stimulus on the long-term stability of PPPs;
- Contexts and benchmarks for the entry of private partners into PPP;
- Competitive bidding system for PPP contracts;
- Supervision and regulation of EIA and the Social Impact Assessment;
- Entrance and assurance to the private sector regarding the right to enter and be dynamic in partnerships with the contracting authority;
- Role of the public sector, including the transfer of decision making.

5. Conclusions

The soar on the upshot for infrastructure projects procured via PPP will need not only the integration of environmental or social sustainability principles but also the connection of institutional designs to the structure of projects, particularly in the planning procedure.

Accordingly, the discussion about sustainable PPPs pursuing the quest to propel private investments connected to infrastructure projects and enhance investment budgets must be addressed. Therefore, institutional and legal instruments that monitor and enforce the application of steering strategies and enhance environmental and social sustainability goals at the planning stages are required.

A careful scope towards the central research interest, distinguished and addressed with three research sub-questions through a systematic literature review and acknowledged framework (IAD framework), has driven efforts that synthesize institutional design options for the effective application of identified steering strategies and enhanced sustainability indicators; we hope to contribute to scholarly debate and professional practice. In accordance, the approach and outcomes are reported.

This study suggests fourteen steering strategies that unpack the relationship between the process principles required for sustainable PPPs and the outcome indicators regarding environmental and social sustainability. Based upon the IAD framework's seven rule types, three taxonomies of rules (position–boundary–choice, scope–payoff, and information–aggregation) were synchronized with the identified steering strategies required for sustainable PPP and presented as the institutional designs that propel an initial effort to assess sustainable PPP planning. In doing so, we contribute to the existing literature in different approaches.

Foremost, the bulk of the latest conceptual frameworks and assessment mechanisms used to evaluate sustainable development principles in PPP infrastructure projects are principally focused on economic principles. This study lengthens this small hub and put-forward rule settings that can propel well-structured and balanced legal frameworks that can tap into the environmental and social sustainability benefits of PPPs.

Next, a major challenge that confronts public procurers who want to integrate sustainability criteria into policy initiatives relates to the measurability and enforceability of these criteria, especially social sustainability norms. The steering strategies proposed in this study are measurable indicators that are easy to apply across the planning stages of PPP infrastructure projects.

Additionally, we bridge the literature on sustainable PPPs and institution designs. While previous research has shown the importance of institutional arrangements and PPP project outcomes, especially in terms of socio-ecological progress, the requisite tools used to achieve such collaborations are rather limited. Our rule settings in this study offer the possibility to academics absorbed in this domain to investigate the scope at which, and under which contexts, PPP institutional designs can add to the attainment of environmental and social sustainability objectives.

Additionally, we contribute to the expanding IAD framework studies that investigate PPPs. Despite the growth in the relevance of sustainable PPPs in the scholarly realm, there is a shortage of research that acknowledges the contribution of the IAD framework rules in achieving them. It is manifestly given that sustainability is among the factors considered when analyzing outcomes within the IAD framework. We, therefore, bring the synergy between institutional designs and PPP to the forefront of the sustainability agenda by categorizing rule settings into taxonomies that can be easily applied by policymakers as an evaluation criterion at the decision-making stages. Further, this study reveals the immensely beneficial robustness of the work of Elinor Ostrom in the comprehension of rules. It shows that Ostrom's set of rules advances past a straightforward utilization of rules by enabling us to draw out certain effects of a set of rules into taxonomies suitable for sustainable PPP assessment.

In addition, our study has connotations for decision makers. Given the transdisciplinary nature of sustainable PPPs, which account for diverse objectives that are frequently connected, and the composite characteristics of PPPs—with different institutional structures, which tend to be knotty and lengthy and demand diverse actors—public authorities, most times, grapple to measure the ingrained and wide benefit of sustainable PPPs. Our

rule settings offer a prospect that creates an initial assessment of sustainability value across the planning stages.

In particular, it is paramount to accentuate that the rule settings on sustainable PPPs aim to support, not replicate, extant assessment instruments that are more concentrated on PPPs' financial efficiency or value for money. There exist established evaluation frameworks that rely on multiplex economic frameworks that furnish the standardization of the economic effects but neglect environmental and social goals. The rule settings aim at offering approximate and causal assessment criteria for sustainable PPP planning, which is also easier to apply compared to intricate models. However, the rule settings should be understood as a complementary tool to boost both the value and effect of the contemporary procedures of monitoring PPP planning in particular, especially regarding environmental and social sustainability.

Last, our study has importance, especially for those that take part in schedules connected to PPP project design. The simple way in which rule settings are linked to specific environmental and social sustainability strategies would enable PPPs not only to enlarge their pragmatic contribution to sustainability but also to go further by achieving a higher standard of quality and acceptance. We maintain that the core merit of our assessment tool lies in its institutional dimension and the spread of the dimensions, which touches a broad area of traverse outputs. With six dimensions of sustainability outcome principles that account for environmental and social aspects and fourteen steering strategies that cover a broad span of issues (PPPs' contribution to clean air, biodiversity, energy, material and design, participation and co-creation, health and safety, and labor and human rights, among many others), an opportunity for a comprehensive evaluation of sustainable PPPs is established.

We considered our rule settings as the first effort upon a parsimonious approach toward sustainable PPPs evaluation at the planning stages. The rule settings provide awareness of the diverse strategies, gaps, and deficiencies involved in integrating environmental and social sustainability principles into the PPP social processes. The steering strategies within the rule settings are applicable instruments for policymakers to rearrange public-private infrastructure project planning. Nonetheless, evaluation criteria obtained through the literature review need to be subjected to further study to enhance their applicability for practitioners.

In addition, while we employed a strict and transparent perspective to select the 32 papers, our procedure used to select the articles introduced some restraints that can be corrected in later studies. First, the analysis of environmental and social sustainability considerations is comprehensive but not exhaustive regarding the number of indicators that are utilized to measure particular components. Second, not all of the indicators found in the 754 articles initially selected applied to infrastructure PPP projects. Third, restraints of the research included the possibility of proclivity in the rules' taxonomic considerations. To limit this, relevant pieces of the literature were consulted to keep sensible cohesion in rationality; the concepts contrived have been developed for a logical judgment.

Nonetheless, countries, where PPP is habitually an innate choice for infrastructure projects can take advantage of the discoveries in this study. This is because the application of the identified steering strategies in countries with hierarchical control systems and different socio-political realities could be onerous. Subsequent studies can ameliorate this limitation. Researchers are challenged to further test and refine the rule settings using meta-analyses and case studies.

In subsequent research efforts, scholars need to understand if PPP has the requisite and adequate rules to go from capability to reality and whether it can go from being a remote problem solver to a methodical and comprehensive player that is futuristic in addressing urban unsustainability. Furthermore, it is principal to control what clears the way or constrains the institutional design of PPPs toward sustainability. What are the institutional environments that constrain sustainable PPP legal frameworks? Finally, future research is recommended to further elaborate upon the gaps and deficiencies found while

confronting a systematic literature review with a reductionist analytical model. Hence, the IAD framework must be on the research agenda if we are to understand and improve the sustainability of PPP legal frameworks.

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