

Building bridges: Unraveling the missing links between Public-Private Partnerships and sustainable development

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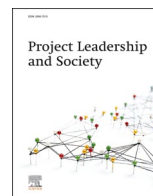
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Review

Building bridges: Unraveling the missing links between Public-Private Partnerships and sustainable development

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ABSTRACT

Although there is increasing agreement that Public-Private Partnerships (PPPs) contribute significantly to sustainable development, the intersection between the PPP body of knowledge and sustainability remains underdeveloped. This study adopts the Sustainability Development Goals (SDGs) and their sustainable targets as means to assess the intensity of the link between the PPP literature and sustainability. Findings show that the thematic keywords in the PPP literature are multidimensionally related to sustainability through 16 out of the 17 SDGs. However, the intensity of this relationship is heterogenous: while eleven SDGs were related to less than 5% of the topics, only four SDGs (i.e., 8, 9, 16, and 17) demonstrated a strong relationship with PPPs, representing 51 out of the 169 sustainability targets. Moreover, 19 sustainability targets within these four SDGs were found to be the most representative according to their connection with the studied PPP topics, underlining high interdependencies between the PPP field and the three sustainability dimensions (society, environment, and economy). Overall, this study establishes a foundation for future studies on sustainability in PPPs by proposing three research avenues associated with social, environmental, and economic perspectives: (1) exposing the life-cycle relations between sources of payment, financing conditions, and costs of PPPs. (2) examining the most relevant challenges in achieving social legitimacy of PPP programs in developing countries. (3) providing a multidimensional empirical analysis of the effectiveness of environmental assessment tools for PPP projects.

1. Introduction

Public-Private Partnerships (PPPs) have gained preponderance among project delivery methods, as they are useful instruments for developing large-scale projects worldwide (Grimsey and Lewis, 2004). The size of these projects also brings increasing complexity, forcing stakeholders to face unprecedented socio-technical challenges (Frischmann, 2012; Harvey et al., 2016). As socio-technical systems, PPPs are closely related to the concept of sustainability because of their ability to provide essential infrastructure and, simultaneously, the potential to generate harmful impacts at the economic, environmental, and social levels (Thacker et al., 2019).

Sustainability and PPPs have been analyzed by countless papers, but the intersection between both fields is an incipient research avenue that needs to be strengthened. Despite the relevance of PPPs for sustainability, previous research has not analyzed the PPP body of knowledge thoroughly to uncover the inherent relationships between this field and sustainable development. In contrast, researchers in the project management field have analyzed the PPP literature mostly from a general

perspective, identifying the main research topics, authors, research methods, institutions, and countries where the papers have been written (Cui et al., 2018; Tang et al., 2010; Zhang et al., 2016).

For instance, most PPP bibliographic studies and literature reviews identify financial aspects as the most influential topics in the PPP body of knowledge (Cui et al., 2018; Tang et al., 2010; Zhang et al., 2016a). However, they do so by considering such themes as specific areas in the PPP field without thoroughly analyzing their interrelationships with other topics relevant to sustainability (e.g., social stakeholders and environmental considerations). Thanks to such investigations, significant findings are now available to researchers worldwide; however, there is little evidence of comprehensive analyses of the PPP literature focused on providing cohesive and integrated depictions of sustainability contributions. This gap is more evident considering the comprehensive literature focused on the intersection between sustainability and project management (Huemann and Silvius, 2017; Sabini et al., 2019; Silvius and Schipper, 2020).

To start filling this gap, this study aims to analyze the relationships between PPP-related research and the achievement of specific SDGs and

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the intensity of these relationships. This provides the platform for identifying the specific research avenues for addressing sustainability in PPPs. This study contributes to the PPP literature by identifying (1) the PPP topics that drive sustainability through the lens of the SDGs, (2) the intensity between PPP and each SDG through the sustainable targets, and (3) the research epicenters for strengthening specific SDGs in the PPP field. This study contributes twofold: Firstly, public sector practitioners may use the findings of this study to purposely design PPP policies that incentivize specific SDGs depending on the specific sustainability needs of each country. Secondly, academics and practitioners may consider the geographic epicenters identified to purposely establish international cooperation networks that promote the transfer of theoretical and practical lessons useful to leverage the implementation of these SDGs.

This paper includes multiple sections. After introducing the theoretical problem and objectives of the study, the conceptual points of departure are presented. Then, the four-stage research methodology and validation are described. Next, a discussion of the main drivers and enablers of sustainability in the PPP literature is provided. The manuscript concludes by presenting the most relevant conclusions, future research streams, and limitations.

2. Points of departure

2.1. The concepts of PPP and sustainability

PPPs embody a project delivery method that integrates the complementary skills of private and public partners (Tang et al., 2010; Zhang et al., 2016). The former contributes with innovative, technical, and managerial strengths; the latter provides a social- and local-based perspective, and accountability, allowing an effective procurement method for a variety of services and infrastructure types (Carbonara et al., 2014; Loosemore and Cheung, 2015). This integration occurs across multiple lifecycle phases including long-term inter-organizational relationships between various participants and is affected by uncertainty and bounded rationality (Bing et al., 2005; Hartmann et al., 2014).

On the other hand, the literature does not provide a standard definition of the concept of sustainability. Although the number of sustainability-related investigations linked to infrastructure development has increased in recent decades (Kivilä et al., 2017; Koppenjan, 2015), researchers have not reached a consensus regarding the sustainability within infrastructure or management fields (Hueskes et al., 2017; Sabini et al., 2019). Most scholars agree that sustainability refers to all the efforts directed toward satisfying the present generation's requirements without undermining future generations to meet their requirements (World Commission on Environment and Development, 1987). Sustainability aims for balancing social, environmental, and economic perspectives on development and performance, summarized in the Triple Bottom Line perspective (Huemann and Silvius, 2017; Sabini et al., 2019; Silvius and Schipper, 2020). These dimensions, in turn, encompass multiple notions and goals related to "people", "planet", and "profit" as the basis of multiple sets of metrics for measuring and evaluating a project's sustainability performance (Kivilä et al., 2017; Silvius et al., 2017).

2.2. The relationship between sustainability and PPPs

Although PPPs and sustainability are intrinsically connected, their relationship is complex (Kivilä et al., 2017). On one side, public-private initiatives are valuable instruments to facilitate infrastructure provision by incorporating private capital into project delivery (Carbonara et al., 2014; Xu et al., 2012). On the other hand, PPPs contribute to incentivizing a lifecycle perspective in which public authorities, infrastructure developers, and equity investors work in conjunction to meet societies' needs (Hueskes et al., 2017; Mota and Moreira, 2015; Verweij, 2015). Therefore, this vision requires that government agencies clearly define

infrastructure project outcomes and that the private sector focuses on building infrastructure assets and ensuring adequate service-based conditions (Bing et al., 2005; Zhang et al., 2016). Because of that, multiple authors have argued that PPP development is a suitable means to improve infrastructure systems in any jurisdiction worldwide, and at the same time, accomplish economic, social, and environmental sustainability (Hueskes et al., 2017; Kivilä et al., 2017).

Despite their potential benefits, PPPs may also endanger sustainability. Project management literature suggests that one of the main hurdles to achieving sustainability through PPPs is related to the lack of external control over the role played by the private sector in these transactions (Kivilä et al., 2017). If government agencies are not able to effectively exert effective external control on the private sector's actions, infrastructure projects delivered through PPP schemes may become legal monopolies in which investors and developers pursue their self-interest rather than the general social welfare (Yescombe and Farquharson, 2018). These opportunistic behaviors hinder the accomplishment of multiple sustainability goals because private actors may behave opportunistically to improve their financial returns regardless of social, environmental, and economic necessities (Hueskes et al., 2017).

Clearly, the concept of infrastructure development lies at the center of the relationship between PPPs and sustainability. Although public-private initiatives are vehicles to enhance infrastructure systems, they may not necessarily do so by incorporating sustainability-related perspectives unless the public sector exerts effective control (Kivilä et al., 2017). Some scholars report how the implementation of PPPs has improved the provision of essential infrastructure-based public services globally. However, other researchers highlight multiple PPP-related controversies associated with a lack of socio-political legitimacy, negative environmental impacts in the long term, and excessive economic returns given to the private sector (Hueskes et al., 2017). In this sense, the evidence regarding successfully integrating the concepts of sustainability and PPPs remains inconclusive. As a result, there is a clear need to examine how to harmonize the implementation of these two concepts to improve infrastructure systems worldwide.

2.3. PPPs and SDGs

The United Nations countries embraced 17 SDGs to respond to the pervasive issues that endanger sustainability in 2015 to simultaneously guarantee prosperity, protect the environment, and finish poverty by 2030 (Sabini and Alderman, 2021; United Nations, 2016). These SDGs have been adopted by academics, project managers, and the public sector decision-makers worldwide to address sustainability in a joint effort involving a wide array of stakeholders (Sabini and Alderman, 2021). This multi-stakeholder approach is significantly close to the intended objectives of PPPs understood as collaborative partnerships between governments and private companies for providing long-term infrastructure and services (Biygautane et al., 2019; El-Gohary et al., 2006; Verweij, 2015).

PPPs are closely related to SDGs, given that public-private agreements facilitate the supply of critical services, such as transportation, education, water, healthcare, sewage, energy, and communication. Thacker et al. (2019) identified the influence of infrastructure development across all the 17 SDGs. According to them, all the sustainable targets related to SDG3 (i.e., good health and well-being for people), SDG6 (i.e., clean water and sanitation), SDG7 (i.e., affordable, and clean energy), SDG9 (i.e., industry, innovation, and infrastructure), and SDG11 (i.e., sustainable cities and communities) are affected by infrastructure projects. In this sense, PPPs play a crucial role in achieving high levels of sustainable development because of directly influence processes associated with accomplishing SDG3, SDG9, and SDG11 (Gundogdu, 2019; Thacker et al., 2019).

Moreover, PPPs also affect indirectly other SDGs because the supply of critical infrastructure and services allows markets to connect, boosts mobility, and generates jobs (Berrone et al., 2019). In this sense, the

overall accomplishment of all SDGs is indirectly influenced by PPP development because of the management issues, excessive costs of proper monitoring, stifled innovations, and significant cost of capital associated with these long-term initiatives (Ottaviani and De Marco, 2021; Thacker et al., 2019).

3. Research methodology

This study intends to gain insight into the complex interrelations between PPP topics and the concept of sustainability to elucidate the most significant research directions for sustainability in PPPs. Due to the lack of consensus regarding how to define sustainability, this manuscript adopts the SDGs as means to explore sustainability and its relationship to PPPs, which aims for unraveling the fundamental research avenues required for addressing sustainability in PPPs. To do so, a four-stage approach was conducted by combining techniques related to systematic coding process and content analysis following the recommendations of Braun and Clarke (2013) and Bazeley and Jackson (2013).

The four-stage approach is presented in Fig. 1. In stage 1, the scope of each SDG (and their sustainable targets) was identified in conjunction with their main relationships with PPPs. Stage 2 was developed to retrieve the keywords representing the main topics and infrastructure types in the PPP literature. Stage 3 was conducted for pairing the main PPP thematic keywords in the literature with the 17 SDGs based on the textual or no textual relationship of these PPP topics with the SDGs. In stage 4, a filtering process was conducted to remove from the analysis the SDGs least related to PPPs. The resulting SDGs were disaggregated according to their sustainability targets to pair them with the PPP thematic keywords.

3.1. Stage 1: coding process of SDGs and sustainable targets

In this stage, a systematic coding process of the SDGs was conducted to identify the scope of each SDG and its relationship with PPPs. To do so, each SDG was examined through its constitutive targets, as these are specific objectives within every general goal (i.e., there are between five and nineteen targets per SDG with a total of 169 specific objectives).

This was achieved by considering that the sustainable targets were presented in 2017 in a United Nations resolution by disaggregating each SDG based on either their means of implementation or outcomes (Thacker et al., 2019).

3.2. Stage 2: retrieving and filtering PPP thematic keywords

This study retrieved the thematic keywords of the PPP literature obtained from Castelblanco et al., (2021), which coded 139 thematic keywords from the PPP literature published in the last 20 years (Castelblanco, Guevara, Mesa, et al., 2021). These PPP thematic keywords represented the most relevant topics, the research methodologies, the infrastructure type, and, for case studies papers, the country or region of the study. Once the keywords were retrieved, a screening process was developed for excluding keywords unrelated to SDGs or sustainable targets. This process resulted in the removal of 58 keywords focused on specific research methodologies (e.g., stochastic model, game theory, qualitative analysis, system dynamics) and countries/regions that cannot be related to any specific SDG or sustainable target directly. As a result, 81 PPP thematic keywords which focused on the most relevant topics and infrastructure types remained.

3.3. Stage 3: pairing PPP thematic keywords and SDGs

This pairing process analyzed the potential relationship of each PPP thematic keyword with the SDGs. The pairing process considered whether there were textual or non-textual relationships between PPP thematic keywords and SDGs. A textual relationship was established in case a PPP keyword was found to be explicitly associated with an SDG or its related targets. For instance, SDG 7 (i.e., ensure access to modern, reliable, and affordable energy services) was directly related to the keyword “power infrastructure”. Conversely, a non-textual relationship of the PPP thematic keywords with the SDGs was established if, despite the absence of a literal connection, the relationship between any SDG and any PPP keyword was clearly supported by clear and logical reasoning. For example, SDG 11 (i.e., make human settlements and cities resilient, safe, and inclusive) is indirectly related to the keyword “traffic

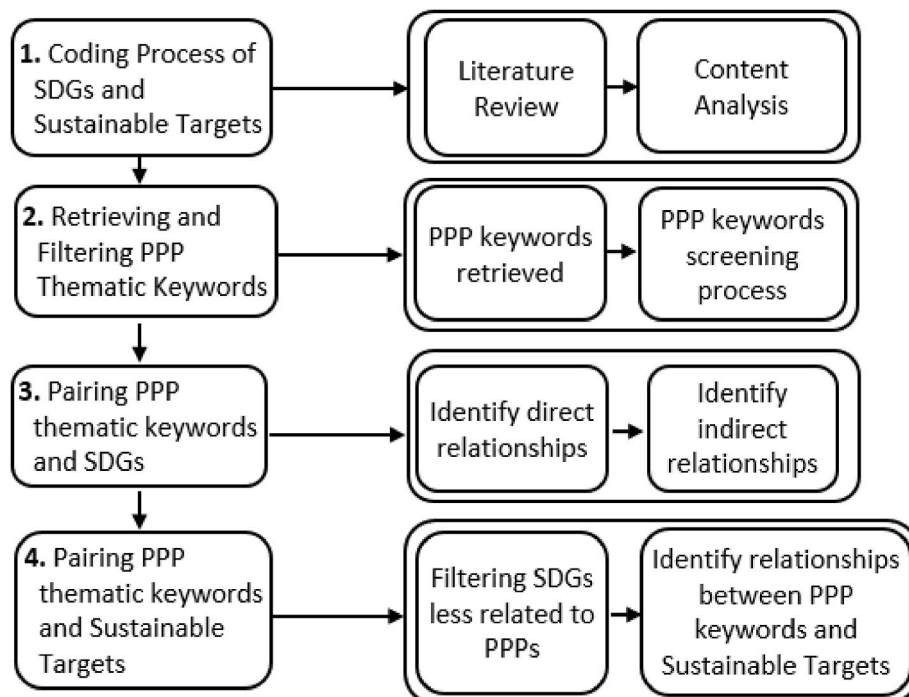


Fig. 1. Research methodology.

management”.

A reference matrix R_{ij} was developed by representing the SDGs as columns (i.e., SDG $_j$) and the PPP thematic keywords gathered by Castelblanco et al., (2021) as rows (i.e., P $_i$), as shown in Fig. 2. The relations between the SDGs and the PPP thematic keywords are denoted by W_{ij} . Consequently, if the PPP thematic keyword i was related to the SDG j , then $W_{ij} = 1$, otherwise $W_{ij} = 0$. The pairing process between PPP thematic keywords and SDGs resulted in an 81×17 matrix.

3.4. Stage 4: pairing PPP thematic keywords and sustainable targets

Once the pairing process between PPP thematic keywords and SDGs concluded, a filtering process was conducted to sharpen the analysis of the most significant relations between the PPP topics and SDGs. Consequently, the SDGs related to less than 10% of the PPP topics were removed. Then the resulting SDGs were disaggregated according to their targets. After that, a second pairing process between PPP thematic keywords and sustainability targets was developed. This pairing process resulted in a second reference matrix by representing the PPP thematic keywords sustainability targets as columns (i.e., P $_j$) and the sustainability targets as rows (i.e., SDG $_i$), as shown in Fig. 3. The pairing process between PPP thematic keywords and the sustainable targets resulted in a 51×81 matrix.

3.5. Validation

The strategy for grouping the keywords and developing the networks was conducted through a systematic stage-by-stage approach, completing an internal validation process to reach reliability and replicability. This validation process was focused on establishing an accurate and reliable coding process, relating the PPP thematic keywords with the SDG. This goal was accomplished using a structured grouping strategy derived from sound literature that demonstrates the relationship between the keyword and the SDG(s).

Additionally, two different analysts independently developed the process by reviewing the thematic keywords to pair them with one or multiple SDGs to validate the coding process. Then, agreement on the pairing between both analysts was computed through Cohen’s kappa based on equation (1) (Mchugh, 2012):.

$$\kappa = \frac{F_0 - F_C}{N - F_C} \tag{1}$$

In this equation, the term F_0 represents the number of judgments for which the analysts agree; F_C is the amount of judgments on which agreement is expected by chance; and N corresponds to the total amount of judgments made by each analyst.

The initial κ ranged between 0.7 and 1 among the SDGs. For the cases in which there was any disagreement among both analysts, a discussion regarding the discrepancies was made, which allowed for improving the κ to a range between 0.85 and 1. For the specific remaining disputes after the second round of discussion, both analysts discussed the discrepancies until reaching consensus (i.e., $\kappa = 1$).

4. Findings

4.1. Relationship between SDGs & keywords

Based on the targets that constitute each SDG, the relationships between SDGs and PPPs (Methodological Stage 1) are presented in Table 1. For building the table, the SDGs constituted an initial list of 17 codes containing their respective sustainable targets. Then, a content analysis of the literature on PPPs and SDGs was conducted through the lens of the 17 codes. In Table 1, illustrative references are shown to emphasize that multiple scholars have highlighted the potential relationships between SDGs and PPPs.

The general analysis of the literature that incorporates the interaction between the PPP topics and each SDG is incipient and its distribution is heterogeneous. In this regard, less than 10% of the papers analyzed incorporated any consideration related to SDGs 12, 14, 15, and 16, which are related mainly to the remaining environmental and institutional gaps associated with the large size of these projects.

Once the SDGs were unbundled into their targets and their relationships with PPPs were established, the PPP thematic keywords identified by Castelblanco et al. (2021) were codified and organized alphabetically (Methodological Stage 2). The PPP thematic keywords shown in Table 2 constituted the most significant topics and infrastructure types published in the last 20 years.

In respect to the Methodological Stage 3, the reference matrix R_{ij} was developed to depict interactions between each SDG and PPP thematic keywords. Due to space limitations, matrix R_{ij} is shown in the Supplemental Material section as Tables S–I. Based on the reference matrix, the number of keywords related to each of the SDGs is presented in the Supplemental Material section as Figure S–I. In general, the PPP thematic keywords demonstrated being multidimensionally related to sustainability because of their relations with most of the SDGs. In effect, 16 out of the 17 SDGs demonstrated being related to PPPs and only one SDG demonstrated being unrelated to PPPs (i.e., SDG 5 – Gender equality).

4.2. SDGs and PPPs: most frequent relationships

Despite the multidimensional relations between PPPs and sustainability, the intensity of these relations is heterogeneous. Accordingly, four SDGs (i.e., 8, 9, 16, and 17) demonstrated being the most frequently connected with PPP topics, each related to more than 10% of the PPP topics analyzed. These SDGs are associated with economic growth (SDG 8), industry and infrastructure (SDG 9), peace/justice and strong institutions (SDG 16), and partnerships for the goals (SDG 17). For these four SDGs, sustainable targets were retrieved to estimate the extent to which PPP themes influence the concept of sustainability. These four SDGs include 30% (51 out of the 169) of the total targets, which reflects their specific preponderance for overall sustainability. The 51 targets are shown in the Supplemental Material section Tables S–V.

Once the sustainability targets were retrieved for the four aforementioned SDGs, the pairing process between the PPP thematic keywords and sustainability targets (Methodological Stage 4) was

	SDG 1	...	SDG j	...	SDG 17
Keyword 1	1	1	1	...	0
...	1	1	0	...	1
Keyword i	0	0	0	...	1
...	1	0	1	...	0
Keyword 81	0	0	1	...	1

Fig. 2. Illustrative example of the R_{ij} matrix.

	Keyword 1 ...	Keyword j ...	Keyword 81
Sustainability Target 1	1	1	0
...	1	1	1
Sustainability Target i	0	0	1
...	1	0	0
Sustainability Target n	0	0	1

Fig. 3. Illustrative example of the 2nd Reference Matrix.

conducted. Based on that, the number of PPP thematic keywords related to each sustainability target is shown in the Supplemental Material Figure S-II; 42 out of the 51 sustainable targets analyzed were found to relate to at least one of the 81 PPP terms. This interaction pattern demonstrates how infrastructure PPPs are specially related to sustainable targets. Accordingly, Table 3 presents the PPP thematic keywords with the highest number of connections with the sustainable targets analyzed. Additionally, the definition for each ranked keyword is shown in the Supplemental Material section Table S-VI. Corresponding reference matrices of the sustainable targets for each SDG are shown in the Supplemental Material section in Tables S-II, S-III, and S-IV.

Despite this comprehensive relation between PPP and sustainability targets within SDGs 8, 9, 16, and 17; the strength of the specific connections demonstrated heterogeneity. Overall, 23 out of the 42 targets were related to less than 10% of the PPP thematic keywords. The remaining 19 sustainability targets were shown to be the most representative according to their match with PPP topics (i.e., more than 10% of the keywords), as depicted in the Supplemental Material section Figure S-II.

5. Discussion

5.1. Major bridges between PPPs and sustainability

Four SDGs (i.e., 8, 9, 16, and 17) act as major bridges between PPP topics and sustainability, which means that the research connecting PPP research and sustainability is inherently attracted to these sustainable goals.

In this context, the bridge between PPPs and SDG 8 is founded mainly on one single pillar (i.e., sustainable target 8.2 – economic productivity). In effect, due to the magnitude of PPPs (i.e., a substantial amount of capital expenditure is required for a typical project), these projects usually contribute significantly to national GDPs by promoting industrial production efforts (i.e., because of the equipment and raw material required), stimulating employment (i.e., due to the huge amount of personnel needed), and improving the financial sector (i.e., because of the significant debt leverage necessitated). Moreover, economic development and production are significantly boosted by long-term services associated with specific infrastructure types shown in Tables 2 and 3, such as port (P54) and urban (P80) infrastructures. The relevance of economic development and production derived from these PPP infrastructure types has been especially inquired about in Asian jurisdictions such as China, India, Singapore, and Hong Kong, (Cheung and Chan, 2011; Mahalingam, 2010; Panayides et al., 2015).

The bridge between PPPs and SDG 9 is focused on two significant features for infrastructure, resilience and environmental performance. This bridge is founded on three pillars: sustainability targets 9.1 (quality infrastructure), 9.4 (resource-use efficiency and environmentally sound technologies for infrastructure), and 9.a (sustainable infrastructure in developing countries), as shown in Supplemental Material Fig. S-II. Based on these pillars, PPPs should seek to incorporate the concepts of sustainability and resilience, as the implementation of these two notions contributes to improving overall infrastructure performance beyond economic and financial indicators (i.e., P42, P45, P76). This approach is

especially relevant for facing urban challenges associated with demographic growth and potential future disasters and extreme events. These may be more significantly difficult to face for developing countries (P25), as such jurisdictions are traditionally characterized by having a lack of resilient infrastructures and deficient urban development processes, which results in higher vulnerability to extreme events such as hurricanes, earthquakes, tsunamis, and alterations in climatic conditions. However, the research epicenter of these topics has been clustered mostly in European developed countries that have been the traditional leaders in sustainability implementation (e.g., Netherlands, Ireland, the UK, France, and Italy) (Akbiyikli et al., 2012; Dupont et al., 2015; Hueskes et al., 2017; Sheppard and Beck, 2016).

SDG 16 is a bridge motivated by overcoming two main constraints for the sustainability contribution of PPPs: lack of legitimacy and lack of public sector capacity. These constraints are reflected in the pillars identified in Supplemental Material Fig. S-II, namely, sustainable targets 16.5 (reduce corruption), 16.6 (accountable institutions), 16.7 (participatory decision-making), 16.8 (participation of developing countries in the global governance), 16.10 (public access to information), 16.a (building capacity in developing countries). In this context, building capacity remains one of the most significant public sector constraints for PPPs in developing countries (P25, P35, P43); and the incorporation of successful centralized PPP units and further supporting organizations is essential for allowing a proper enabling field for PPPs. In line with this, results show that for addressing PPP legitimacy (P41), governments are required to enable the successful participation of multiple private companies leveraged by competitive procurement (P59), public support (i.e., government guarantees), and social engagement.

SDG 17 is a sustainable bridge built on eight pillars (sustainable targets 17.1, 17.3, 17.5, 17.7, 17.9, 17.16, 17.18, 17.19) that support the relevance of the economic, environmental, and social dimensions previously highlighted. This requires balancing trade-offs between multiple stakeholders in terms of PPP governance (P34), and it is particularly important in contexts with weak institutional frameworks (P25). Balancing private and public sector interests requires institutions and contracting authorities to uphold clear perspectives and directions, as these are specifically relevant when renegotiations or contract modifications are required across settings in which investment promotion (17.5) needs to be maintained. In line with that, the public sector should build PPP-enabling capacities (sustainable targets 17.9 and 17.18) to gain social support by protecting both the public and PPP users from exploitation (i.e., preventing excessive tariffs and ensuring service quality and environmental compliance); thus, reinforcing sustainable targets 17.16 (multi-stakeholder partnerships), 17.7 (environmentally sound technologies), and 17.19 (sustainable development progress measures). On the other hand, the private sector should be also protected through the implementation of measures associated with cost-recovering tariffs and government prosecution of non-paying users; as these are key mechanisms for improving tax and revenue collection (17.1) and attracting additional international financial sources (17.3).

Despite the relevance of SDGs 16 and 17 for developing countries, the research epicenter of the PPP research linked to both SDGs has been clustered mostly around developed countries in three blocks: former British Commonwealth territories (i.e., the UK, Singapore, Scotland,

Table 1
SDGs and their relationship with PPPs.

Code	SDGs	References	No. of Sustainable Targets
1	End poverty and all its forms everywhere	[1], [2], [3], [7], [25], [26], [34]	7
2	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	[1], [2], [3], [7], [9], [10], [11]	8
3	Ensure healthy lives and promote well-being for all at all ages	[1], [2], [3], [4], [7], [12], [13], [14], [15], [28]	13
4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities	[1], [2], [3], [7], [16], [17]	10
5	Achieve gender equality and empower all women and girls	[1], [2], [3], [7]	9
6	Ensure availability and sustainable management of water and sanitation for all	[1], [2], [3], [4], [7], [9], [10], [11], [27]	8
7	Ensure Access to affordable, reliable, sustainable, and modern energy for all	[1], [2], [3], [4], [7], [9], [10], [11]	5
8	Promote sustained, inclusive, and sustainable economic growth, employment, and decent work	[1], [2], [3], [5], [6], [7], [20], [21], [22], [23], [24], [25], [26], [30], [31], [32], [33], [34], [35], [36], [37], [38]	12
9	Build resilient infrastructure, promote inclusive and sustainable industrialization/innovation	[1], [2], [3], [4], [7], [20], [21], [22], [23], [24], [25], [26], [28], [30], [31], [32], [34]	8
10	Reduce inequality within and among countries	[1], [2], [3], [7], [9], [11], [34]	10
11	Make cities and human settlements inclusive, safe, resilient, and sustainable	[1], [2], [3], [4], [5], [7], [18], [19]	10
12	Ensure sustainable consumption and production patterns	[2], [3], [7]	11
13	Take urgent action to combat climate change and its impacts	[2], [3], [5], [6], [7], [8], [9], [11]	5
14	Sustainably use the oceans, seas, and marine resources for sustainable development	[2], [3], [7]	10
15	Protect, restore, and promote sustainable use of terrestrial ecosystems	[2], [3], [7]	12
16	Build effective, accountable, and inclusive institutions at all levels	[2], [3], [7]	12
17	Strengthen the means of implementing the Global Partnership for sustainable development	[2], [3], [5], [6], [7]	19

Note: [1] (Gundogdu, 2019), [2] (Thacker et al., 2019), [3] (Berrone et al., 2019), [4] (Castelblanco, Guevara and Mendez-Gonzalez, 2021), [5] (Anwar et al., 2021), [6] (Chunling et al., 2021), [7] (Maslova, 2020), [8] (Rojas et al., 2020), [9] (Plummer Braeckman et al., 2020), [10] (Propersi and Gundes, 2006), [11] (Nsefu et al., 2021), [12] (De Marco and Mangano, 2013), [13] (Torchia et al., 2015), [14] (Cruz and Marques, 2013), [15] (Wright et al., 2019), [16] (Saeed et al., 2018), [17] (Hartwell et al., 2019), [18] (Reeves, 2013), [19] (Van Gestel et al., 2012), [20] (Grimsey and Lewis, 2004), [21] (Damjanovic et al., 2016), [22] (Higham et al., 2017), [23] (Reeves et al., 2017), [24] (Yescombe, 2014), [25] (Hueskes et al., 2017), [26] (Koppenjan and Enserink, 2009), [27] (Koppenjan, 2015), [28] (Ruiz and Guevara, 2020), [29] (Vazquez et al., 2013), [30] (Wang et al., 2018), [31] (Wojewnik-Filipkowska & Węgrzyn, 2019), [32] (Yescombe and Farquharson, 2018), [33] (Guevara and Garvin, 2017), [34] (Castelblanco, Guevara and Salazar, 2022), [35] (Marcellino et al., 2022b), [36] (Castelblanco, Guevara and Mendez-Gonzalez, 2022b), [37]

(Marcellino et al., 2022a), [38] (Castelblanco, Guevara and Mendez-Gonzalez, 2022a).

Canada, Australia, New Zealand, Ireland, India) (Agyenim-Boateng et al., 2017; Andon, 2016; Hwang et al., 2013; Reeves, 2013; Regan et al., 2011), East-Asian jurisdictions (i.e., Taiwan, Hong Kong, China) (Chen and Hubbard, 2012; Tserng et al., 2012; Zhang et al., 2016b), and European countries (i.e., Norway, Belgium, Netherlands, and Portugal) (Hueskes et al., 2017; Kort and Klijn, 2013; Schepper et al., 2014; Soliño and Santos, 2010).

5.2. Minor bridges between PPPs and sustainability

The heterogeneity in the intensity of the relationship between PPPs and sustainability is reflected in the fact that 11 out of the 17 SDGs were related to less than 5% of the PPP topics, as shown in Supplemental Material Figure S–I. These SDGs act less concurred bridges between PPP topics and sustainability. An analysis of the patterns in the relationship between PPP topics and SDGs demonstrated that there are common components among multiple of these sustainable bridges.

Non-financial determinants (P45) are a common component for linking PPPs and SDGs 1 and 2. *Non-financial determinants* such as the unemployment rate constitute a meaningful connection between PPPs and the eradication of poverty (SDG 1 – targets 1.1 and 1.2) and hunger (SDG 2 – targets 2.1 and 2.2). Given that PPP infrastructure projects are characterized as large-scale initiatives, each of them requires thousands of employees across procurement, construction, and operation phases (Thacker et al., 2019). Jobs offered during the long lifecycle of PPPs constitute a meaningful enabler for eradicating poverty and hunger. Research on this PPP topic has been worldwide distributed and led by studies from the US, the UK, Portugal, Hong Kong, Indonesia, and Australia (Chan et al., 2010; Mota and Moreira, 2015).

Specific PPP infrastructure sectors constitute a common component for some of these minor bridges (i.e., SDGs 3, 4, 6, 7, 11, 12, 13, 14, and 15). *Healthcare Infrastructure* (P36) is a key link for promoting health (SDG 3 – target 3.8) and addressing challenges of the healthcare system such as limited public capabilities, fast disease transmission across multiple countries, complex social issues, and scarce financial funds (Torchia et al., 2015). For ensuring education (SDG 4 – targets 4.3 and 4. a), the *Education* (P26) infrastructure sector is essential for upgrading education facilities (Saeed et al., 2018). Interestingly, healthcare and education PPP infrastructure have been specially advanced in the PPP literature by former Commonwealth countries (i.e., the UK, Australia, New Zealand, Canada, and Ireland). *Urban Infrastructure* (P80) sector -which includes water supply initiatives, wastewater treatment PPPs, and housing projects-contributes simultaneously to the sustainable management of water (SDG 6 – targets 6.1 and 6.3), inclusive cities (SDG 11 – targets 11.1, and 11.3), the reduction of marine pollution (SDG 14 – target 14.1), and the protection of freshwater ecosystems (SDG 15 – target). In turn, the role of *Power Infrastructure* (P55) in the PPP literature is key for ensuring energy (SDG 7 – targets 7.1 and 7.2) and sustainable patterns by implementing waste-to-energy PPP projects (SDG 12 – target 12–5) and taking action to combat climate changes through renewable energy PPPs (SDG 13 – target 13.1). Both urban and power infrastructure have been PPP topics led by Asian developing countries (i.e., China, Iran, and Turkey) having some of the most populated cities in the world and an increasing need for additional energy (Ameyaw and Chan, 2015; Schaufelberger and Wipadapisut, 2003; Shrestha et al., 2017).

Similarly, the PPP literature has devoted a significant contribution to facilitating financing mechanisms for *developing countries* (P25) as a meaningful constituent for SDG 10 (target 10.b). Developing countries have conducted significant research on PPPs in Africa (e.g., Egypt, Ghana, Nigeria, and South Africa) (Askar and Gab-Allah, 2002; Babatunde et al., 2015; Kwofie et al., 2019); Asia (e.g., Bangladesh, China, India, Iran, and Turkey) (Attarzadeh et al., 2017; Mahalingam, 2010);

Table 2
PPP thematic keywords.

Id	Thematic Keyword	Id	Thematic Keyword	Id	Thematic Keyword
P1	Accountability	P28	Evaluation stage	P55	Power infrastructure
P2	Administrative benefits	P29	Expropriation	P56	PPP implementation
P3	Agency	P30	Facilities management	P57	Pre-contract phase
P4	Airport infrastructure	P31	Finance-related factors	P58	Spatial dynamics
P5	Asset	P32	Franchising	P59	Procurement-related factors
P6	Behavioral dynamics	P33	Social theory	P60	Product differentiation
P7	Capacity choice	P34	Governance	P61	Property rights
P8	Collaborative process	P35	Public sector management	P62	Infrastructure stock
P9	Compensation model	P36	Healthcare infrastructure	P63	Quality
P10	Interorganizational networks	P37	Infrastructure development	P64	Rail infrastructure
P11	Cultural factors	P38	Land value	P65	Regulation
P12	Concession	P39	PPP scheme	P66	Relational management
P13	Conflicts	P40	Learning process	P67	Risk management
P14	Construction phase	P41	Legitimacy	P68	Road infrastructure
P15	Concessionaire	P42	Multidimensional impacts	P69	Satisfaction
P16	Contract management	P43	Project constraints	P70	Secondary market
P17	Contract performance	P44	Natural resources	P71	Service levels
P18	Coordination processes	P45	Non-financial determinants	P72	Smart city
P19	Corporate structure	P46	Operation phase	P73	Social infrastructure
P20	Corruption	P47	Organizational attributes	P74	Stakeholder management
P21	Costs	P48	Outsourcing	P75	Subsidy
P22	Country factors	P49	Pavement design parameters	P76	Sustainability
P23	Delivery systems	P50	Penalties	P77	Traffic management
P24	Developed countries	P51	Per-capita income	P78	Transfer management
P25	Developing countries	P52	Planning	P79	Tunnel infrastructure
P26	Education system	P53	Policy	P80	Urban infrastructure
P27	maintenance	P54	Port infrastructure	P81	Welfare

Table 3

Top 20 PPP Thematic Keywords according to their relationship with specific Sustainable Targets.

Rank	Code	Sustainable Targets	Total
1	P42	[8.1, 8.2, 8.5, 8.10, 8b], [9.1, 9.4, 9.a], [16.6, 16.a], [17.1, 17.3, 17.4, 17.9, 17.18]	15
2	P43	[-],[9.1,9.4],[16.5,16.6,16.10],[17.2,17.3,17.4,17.5,17.9,17.13,17.16,17.17,17.18]	14
3	P45	[-],[9.1, 9.4, 9.a],[16.6,16.7,16.8,16.10,16.a],[17.7,17.9,17.16,17.17,17.18,17.19]	14
4	P63	[-],[9.1,9.4,9.5,9.6],[16.7,16.8,16.10,16.a],[17.6,17.7,17.9,17.18,17.19]	13
5	P25	[8a],[9.5, 9.6, 9.7],[16a],[17.1, 17.2, 17.3, 17.4, 17.9, 17.16, 17.18]	12
6	P54	[8.1, 8.2, 8.3, 8.a], [9.1, 9.4, 9.a], [-], [17.1, 17.5, 17.11, 17.13]	11
7	P41	[-],[16.5,16.6,16.7,16.8,16.10,16.a],[17.1, 17.3, 17.9,17.18]	10
8	P59	[-],[16.5,16.6,16.7,16.8,16.10,16.a],[17.1,17.9,17.14,17.18]	10
9	P76	[8.2], [9.1, 9.4, 9.6], [-], [17.1, 17.4, 17.7, 17.9, 17.18, 17.19]	10
10	P32	[8.10],[9.1, 9.4, 9.6],[17.1, 17.3, 17.5, 17.16, 17.17]	9
11	P40	[-], [9.1, 9.a],[16.6, 16.7, 16.8,16.10,16.a],[17.9,17.18]	9
12	P47	[8.4],[16.5,16.6,16.10,16.a],[17.9,17.16,17.17,17.18]	9
13	P53	[-],[16.5,16.6,16.7,16.8,16.10],[17.1,17.5,17.9,17.18]	9
14	P80	[8.2, 8.3, 8.4], [9.1, 9.4, 9.a], [-], [17.6, 17.7, 17.19]	9
15	P12	[-],[9.1, 9.4, 9.6],[17.1,17.3,17.5,17.16,17.17]	8
16	P34	[-],[16.5,16.6,16.7,16.8,16.10,16.a],[17.9,17.18]	8
17	P35	[-],[16.5,16.6,16.7,16.8,16.10,16.a],[17.9,17.18]	8
18	P39	[-], [9.1,9.4,9.a], [-], [17.1,17.3,17.5,17.16,17.17]	8
19	P56	[-], [9.1,9.4,9.a], [-], [17.1,17.3,17.5,17.16,17.17]	8
20	P72	[8.2, 8.3, 8.4], [9.1, 9.a], [-], [17.6, 17.7, 17.19]	8

Europe (e.g., Bosnia Herzegovina, Serbia, Bulgaria, Poland, Romania, and Macedonia) (Carpintero, 2010); and America (e.g., Brazil, Colombia, Chile, and Mexico) in order to advance the successful implementation of PPPs (Carpintero and Gomez-Ibanez, 2011; Castelblanco, Guevara, Mesa, et al., 2022; Castelblanco and Guevara, 2020; de Castro Silva e Neto et al., 2019).

6. Theoretical and practical contributions

This study offers multiple contributions to academics and practitioners in the PPP field:

First, although academics have conducted incipient research on the link between sustainability and PPPs through the SDGs (Berrone et al., 2019; Maslova, 2020), this study assesses the intensity of the link between PPP research and each of the SDGs. Second, the public sector practitioners may use the findings of this study to purposely design PPP

policies that incentivize specific SDGs depending on the specific sustainability needs of each country. Third, this study also contributes to the sustainability-PPP field by identifying the research epicenters for specific SDGs. In this regard, PPP research contributing to SDGs 3, 4, 16 and 17 has been led by former British Commonwealth territories while the PPP studies related to SDGs 6, 7, 8, 11, 12, 13, 14, and 15 have been mostly developed in Asian developing countries. Consequently, academics and practitioners may consider these epicenters to purposely establish international cooperation networks that promote the transfer of theoretical and practical lessons useful to leverage the implementation of these SDGs.

7. Conclusion

Multiple analyses on literature reviews have been developed in the PPP field to date. However, the intrinsic relationship between general research topics and sustainability has not been explored yet. This study aims to be a pioneer to fill this gap by exposing these relationships that are bridged by the achievement of specific SDGs.

The conducted analysis shows that the relationship between PPP topics and sustainability is multidimensional and is mediated by 16 out of the 17 SDGs. However, the intensity of these relations is heterogeneous and four SDGs (i.e., 8, 9, 16, and 17) act as critical bridges, representing 51 out of the 169 sustainability targets. The importance of such SDGs (and their associated targets) implies that their multiple interdependencies with the PPP body of knowledge can be examined through economic, social, and environmental perspectives.

The preponderance of the SDGs and sustainable targets that were analyzed demonstrates how these can act as reference points for gaining a deeper understanding of sustainability within the PPP body of knowledge. In this context, the economic, social, and environmental dimensions of sustainability expose three lines of research that are essential not only to strengthen PPP development but specifically to counterbalance current inhibitors opposing sustainability.

The first avenue relies on the economic dimension of sustainability and its close connection to SDGs 8 and 17, which is mediated mainly by sustainable targets 8.2, 17.1, 17.3, and 17.5. These relationships highlight the relevance of obtaining sufficient economic benefits for public agencies and suitable financial performance levels for private partners. Based on that, the economic sustainability of PPPs relies significantly on addressing potential multi-dimensional impacts (P42) and social legitimacy issues (P41) across project life cycles. In this sense, uncertainties associated with debt-related conditions, construction expenditures, and operation costs in PPP projects can potentially threaten the private sector's financial expectations and jeopardize projects' bankability.

In this context, the economic sustainability of PPPs depends on the private sector's financial performance considering the occurrence of financial and non-financial uncertainties (P45). Private partners must comprehensively understand the financial implications of diverse and complex scenarios for PPPs to prioritize suitable strategies for optimizing revenues and expenditures across projects' life-cycle phases. Furthermore, the private sector's decision-makers must be aware of the systemic relations between sources of payment (e.g., user fees and availability payments), financing variables (e.g., interest rates and repayment periods), and investment parameters (e.g., CAPEX and OPEX), in conjunction with their implications for PPP life-cycle costs. This understanding is essential to avoid governance-related difficulties (P34) such as renegotiations, which may increase public subsidies or operational periods, affecting public institutional frameworks across jurisdictions in both industrialized and developing countries (P25).

The second avenue is linked to the social dimension of sustainability and is closely related to SDGs 16 and 17 through sustainable targets 16.5, 16.6, 16.7, 16.8, 16.10, 16.a, 17.9, 17.16, and 17.18. These sustainable targets expose that PPP performance relies significantly on public institutions and their relationships with society, especially in developing countries. The public sector requires the enhancement of

specific attributes associated with possessing the sufficient capacity for PPP development and having public entities to limit corruption practices (P35 and P47). This helps to foster the involvement of key international stakeholders such as debt providers and sponsors, which are essential for developing meaningful long-term PPP programs. Simultaneously, the success of PPPs also requires proper social involvement and perception derived from public accountability, public access to information, and participatory decision-making. In this regard, the development of social legitimacy is a prerequisite for the social sustainability of PPPs. Consequently, understanding the social dimension of sustainability (P76) in PPPs is necessary to redirect the discussion towards social legitimacy challenges (P41) and how to address them, especially in complex economic scenarios such as user-pay PPPs in developing countries (P25).

The third avenue relies on the environmental dimension of sustainability and is closely related to SDGs 9 and 17 mediated by sustainable targets 9.1, 9.4, 9.a, 17.7, and 17.19. These sustainable targets highlight that the development of sustainable infrastructure, industry, and services (P76) requires an understanding of the complex implications of PPPs for the environment's socio-economic, cultural, biological, and physical-chemical components. The magnitude of the likely environmental consequences of the construction and operation of PPP projects must be addressed with suitable mechanisms to assess and prevent such impacts (P42). PPPs require assessment tools to promote sustainable development within the project's decision-making processes starting at the early life-cycle phases (P59). However, current environmental assessment tools require significant efforts to improve the establishment of baseline conditions, prospective impacts, and significant impacts. Moreover, the effectiveness of these tools remains unclear, especially in complex urban mega-projects (P80). Although substantial efforts have been dedicated to defining the effectiveness of these assessments theoretically, there is still missing research oriented toward providing decision-makers with a multidimensional assessment of the effectiveness of these processes in PPP mega-projects.

Overall, despite its results and contributions, this study is limited in diverse ways. First, the scope of this study was focused on identifying general connections between sustainability and PPP rather than causalities. Further research can focus on identifying causalities, which can be useful for methodologies for analyzing complex relations such as System Dynamics. Second, this study used a qualitative approach to identify the relationship between PPP thematic keywords and SDGs/sustainable targets. Future research may complement this approach by adopting quantitative or semi-quantitative approaches. Clearly, the PPP-sustainability body of knowledge is an incipient research field that requires further devotion to research efforts to address multiple challenges in the next few years.

Declaration of competing interest

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

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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