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"Innovative financing and government guarantee in advancing sustainable development goals in water sector: A systematic literature review"

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Abstract

This study investigates the role of innovative financing mechanisms, particularly government guarantees, in advancing the Sustainable Development Goals (SDGs) within the water sector through public–private partnerships (PPPs). Amid increasing water scarcity, aging infrastructure, and constrained public budgets, PPPs are increasingly recognized as vital instruments to mobilize private investment and enhance water service delivery. Employing a systematic literature review and bibliometric analysis using the Scopus database, the study analyzed 126 peer-reviewed journal articles through co-occurrence network analysis, thematic mapping, and citation analysis via the Bibliometrix R package. The findings reveal that government guarantees are essential in mitigating financial, political, and operational risks, thereby improving project bankability and investor confidence, particularly in developing economies. Case studies from Indonesia and China highlight the dual nature of such guarantees, which can enhance infrastructure viability when well-calibrated but also pose risks such as moral hazard and fiscal burden when poorly designed. The study concludes that strategically implemented guarantees can serve as effective policy tools to de-risk water sector investments and support the achievement of SDG 6 (Clean Water and Sanitation) and SDG 11 (Sustainable Cities and Communities). Practically, this research provides actionable insights for policymakers and stakeholders, emphasizing the need for transparent, fiscally responsible, and context-sensitive guarantee frameworks to ensure resilient, inclusive, and sustainable water infrastructure development.

Keywords: Developing economies, Government guarantees, Public sector financing, Public–private partnerships, Risk allocation, Sustainable development Goals, Water infrastructure financing, Water sectors.

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1. Introduction

The global urgency for sustainable water sector development stems from escalating water scarcity He et al. [1], rapid urbanization Irfeey et al. [2], deteriorating infrastructure [3] and constrained public finances [4]. Given water's critical role in public health, economic resilience, and social equity, its financial project management is a key policy priority [5]. Public-Private Partnerships (PPPs) have emerged as a pivotal strategy to mobilize investment and enhance service delivery [6]. This study employs bibliometric analysis, comprising co-occurrence network analysis, thematic mapping, and thematic analysis, to investigate collaborative investment strategies. It emphasizes the essential function of government guarantees in reducing financial, political, and operational risks and enabling effective PPP implementation.

The Manila Water Concession in the Philippines illustrates a successful PPP application [7]. Initiated in 1997, this privatization aimed to improve service efficiency and coverage [8]. The partnership significantly expanded access to urban and underserved populations, reducing service interruptions and improving customer satisfaction [9]. Transparent stakeholder engagement was central to aligning interests among the government, private entities, and local communities, fostering effective collaboration.

Conversely, the Cochabamba water privatization in Bolivia exemplifies PPP failure Wilk et al. [10]. Marked by sharp tariff increases, it incited widespread protests and public dissent [11]. The absence of adequate stakeholder engagement and sound financial structuring led to the termination of the partnership and re-nationalization of services [12]. This case underscores the necessity of context-sensitive planning, robust financial models, and transparent communication to mitigate risks and enhance PPP outcomes.

As water scarcity issues intensify due to climate change and population growth, governments are increasingly looking to innovative financing models, including PPPs, to bridge the funding gap required for infrastructure development [13]. The essential role of the private sector in water management can be magnified through collaborative models that emphasize shared responsibility and enhance accountability [14]. For instance, implementing robust monitoring and evaluation frameworks can help assess the efficiency and effectiveness of these partnerships in real time, allowing for corrective measures to be promptly instituted when required [15].

PPPs have emerged as a pivotal strategy for improving the performance and sustainability of water sector management. PPPs are increasingly recognized as viable mechanisms to enhance service delivery and promote efficient, sustainable management of water resources [16]. These partnerships enable risk-sharing, mobilize private investment, drive technological innovation, and improve operational efficiency, thereby enhancing sectoral outcomes [3, 17].

Despite their advantages, PPPs face several challenges. Political uncertainty, financial instability, and market volatility can compromise their viability and long-term sustainability [18]. External pressures such as climate change and population growth can also disrupt water demand and supply, potentially rendering projects financially unsound and shifting risk to private partners [19]. These complexities highlight the need for government intervention to reinforce PPP resilience.

Government guarantees are essential tools for mitigating these risks and attracting private investment. They may address financial uncertainties, operational shortfalls, or regulatory compliance [20]. A Minimum Revenue Guarantee (MRG), for example, ensures baseline cash flow during revenue deficits, supporting continued infrastructure investment and service delivery [21].

Such guarantees are particularly significant in developing regions where policy volatility, regulatory ambiguity, and corruption often deter private sector involvement [22]. By offering clear assurances, governments can enhance investor confidence and foster collaborative environments. Strategically deployed guarantees shape perceptions of PPPs and encourage broader private sector participation in water infrastructure [23].

Understanding the role of government guarantees in PPPs is essential for refining policy and implementation frameworks. Bibliometric analysis provides a systematic overview of the literature, enabling researchers to identify trends, key themes, and influential studies relevant to guarantees in water-sector PPPs [5]. It also highlights knowledge gaps and directs future inquiries [24]. Synthesizing insights from works such as Ameyaw and Chan [25] supports the development of adaptive and context-specific strategies.

Case studies from Chile and Australia illustrate how well-structured government guarantees can enhance PPP viability. In Chile, risk mitigation policies successfully attracted private investment, leading to improved service delivery and broader coverage [26]. These examples provide transferable lessons for nations developing sustainable PPP models.

In infrastructure development, particularly in the water sector, government guarantees play a crucial role in managing sector-specific risks [27]. Water infrastructure projects involve complex operations, high capital demands, and extended investment horizons, which elevate investor risk perceptions [28]. Guarantees enhance creditworthiness, improve project bankability, and secure better financing terms [29, 30], which are essential in a sector where revenues depend on regulatory stability, affordability, and long-term outcomes.

The failed Cochabamba PPP in Bolivia highlights the risks of inadequate stakeholder engagement. Public backlash over mismanaged privatization led to protests and contract termination [11, 31]. This case underscores the need for context-sensitive guarantees that reflect socio-economic realities and public expectations.

Government guarantees act as a strategic tool to support the achievement of the Sustainable Development Goals (SDGs), especially SDG 6 (Clean Water and Sanitation) and SDG 11 (Sustainable Cities and Communities) [32]. They serve as investment tools and mechanisms to embed financial resilience and environmental safeguards into water infrastructure, fostering long-term sustainability [3, 13].

Guarantees strengthen investor confidence and encourage private participation by reducing financial, political, and regulatory risks [33, 34]. Through bibliometric insights and empirical evidence, stakeholders can better understand how guarantees shape PPP success, contributing to improved service quality, health outcomes, and social equity [3, 26].

2. Materials and Methods

2.1. Data Sources and Collection

Bibliometric analysis is widely employed as a robust quantitative method to evaluate scientific output and map intellectual structures across disciplines [35]. It enables a comprehensive literature evaluation by examining document volume, authorship, collaboration networks, publication sources, funding bodies, reference patterns, and co-citation structures [36]. This approach offers objective indicators that enhance analytical rigor and reduce subjective bias in research evaluation.

Aligned with this methodology, the present study used the Scopus database, a globally recognized citation index developed by Grosseck et al. [37]. The search employed combinations of the keywords "water sector" and "public-private partnership." The first query ("water" AND "sector" AND "ppp") returned 258 documents (1999–2025). The second query ("water" AND "sector" AND "public-private" AND "partnership") yielded 576 documents (1987–2025). The third ("water" AND "sector" AND "public" AND "private" AND "partnership") retrieved 1,561 documents, while the fourth—adding "government" AND "guarantee"—resulted in 16 documents (2009–2025).

Due to the multidisciplinary nature of the results, filters were applied to ensure alignment with the study's objectives: (1) subject areas restricted to business, management, and accounting; (2) journal articles as the source type; and (3) English-language publications. These criteria ensured focus and academic rigor [38, 39].

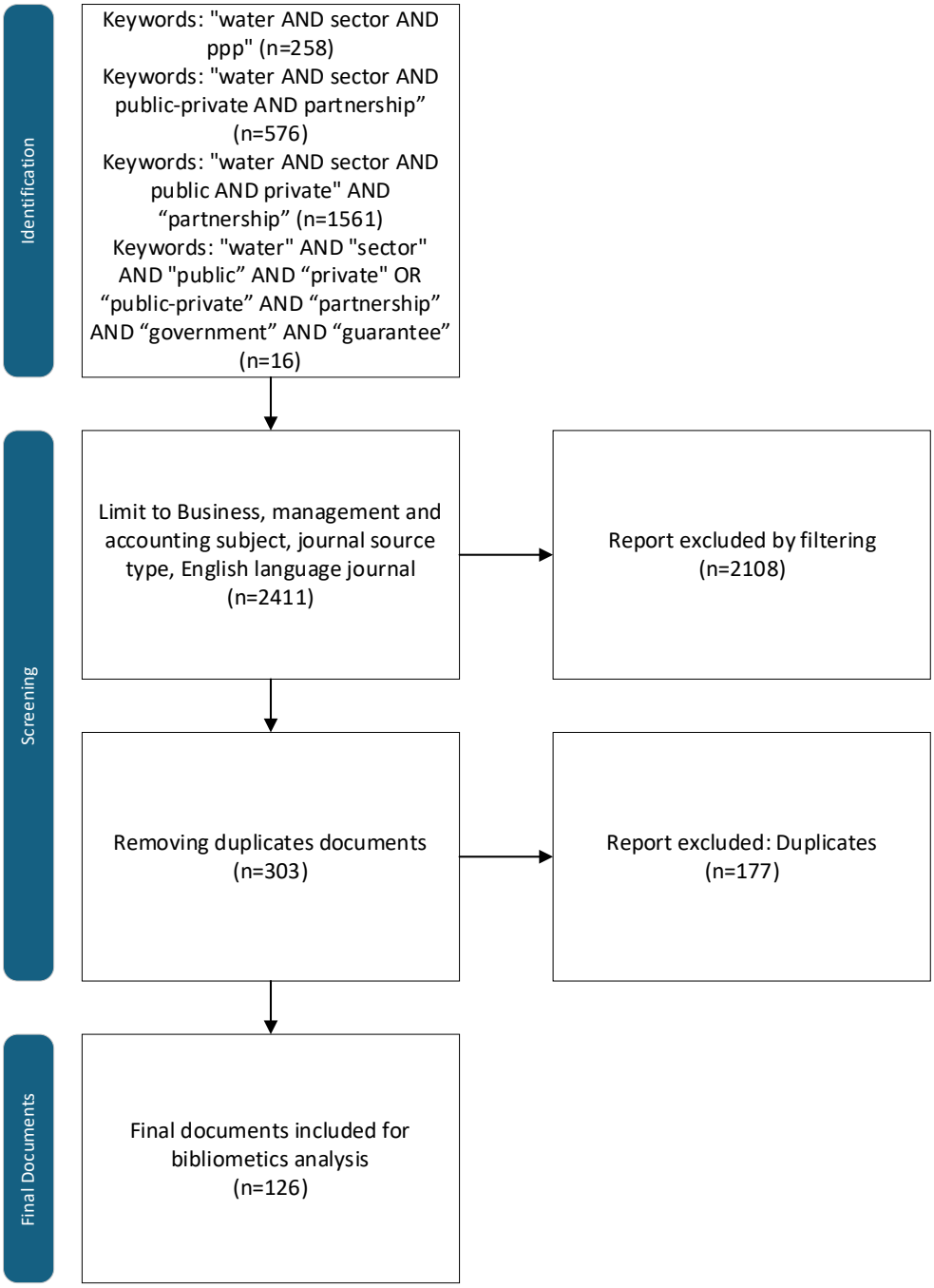

Figure 1.
PRISMA flow diagram for systematic narrative reviews.

Following the application of the specified filters, a total of 288 journal articles were initially identified for inclusion in the preliminary dataset. Subsequent data refinement using the *bibliometrix* software included the systematic removal of duplicate records. This process led to the exclusion of 168 duplicate entries, yielding a final curated dataset comprising 126 unique journal articles deemed suitable for further analysis.

2.2. Data Analysis

A subsequent bibliometric analysis was conducted using the bibliometrix package in RStudio, with the Biblioshiny interface Aria and Cuccurullo [40] employed explicitly. The CSV file retrieved from the Scopus search was processed to facilitate this analysis. Keywords from the retrieved documents were examined for their frequency, co-occurrence, and temporal distribution, thereby identifying prevailing research themes and emerging hotspots. As demonstrated in prior studies, keyword co-occurrence analysis has proven to be a valuable strategy for unveiling the conceptual and thematic architecture of academic disciplines [39].

3. Result

3.1. Descriptive Analysis

In total, 262 authors contributed to the 126 documents, which were disseminated across 78 distinct publication sources, reflecting a broad chronological scope of scholarly contributions. The annual publication growth rate was recorded at 9.46%, and a total of 355 unique author keywords were identified. Additionally, 30.16% of the documents involved international co-authorship, a trend further illustrated in the country collaboration map (Figure 2).

Figure 2.
General overview of the bibliometrix analysis of the keywords.

The annual scientific production from 2001 to 2024, as illustrated in the chart and corresponding dataset, reflects a gradual yet discernible upward trend in scholarly output within the specified domains of business, management, and accounting journals. During the initial period (2001–2008), the number of published articles remained low, ranging from zero to a maximum of two per year. However, beginning in 2009, there was a noticeable increase, with four articles published, followed by a peak of eight in 2010, marking the onset of more sustained academic attention to the topic.

The annual scientific production illustrated in Figure 3 demonstrates the temporal growth and fluctuations in scholarly output on public–private partnerships (PPPs) in the water sector from 2001 to 2010. In the early years, publication volume was minimal, with only one article each in 2001 and 2002, followed by a complete absence of publications from 2003 to 2005. This indicates a period of limited academic engagement with the topic, likely reflecting the nascency of the PPP framework within water governance discourse at the time.

A modest revival occurred in 2006, with one article published, followed by a gradual increase in 2007 (two articles) and 2008 (one article). The most notable growth occurred in 2009, when the number of articles increased to four, indicating a rising scholarly interest and greater institutional or policy emphasis on PPPs in water infrastructure.

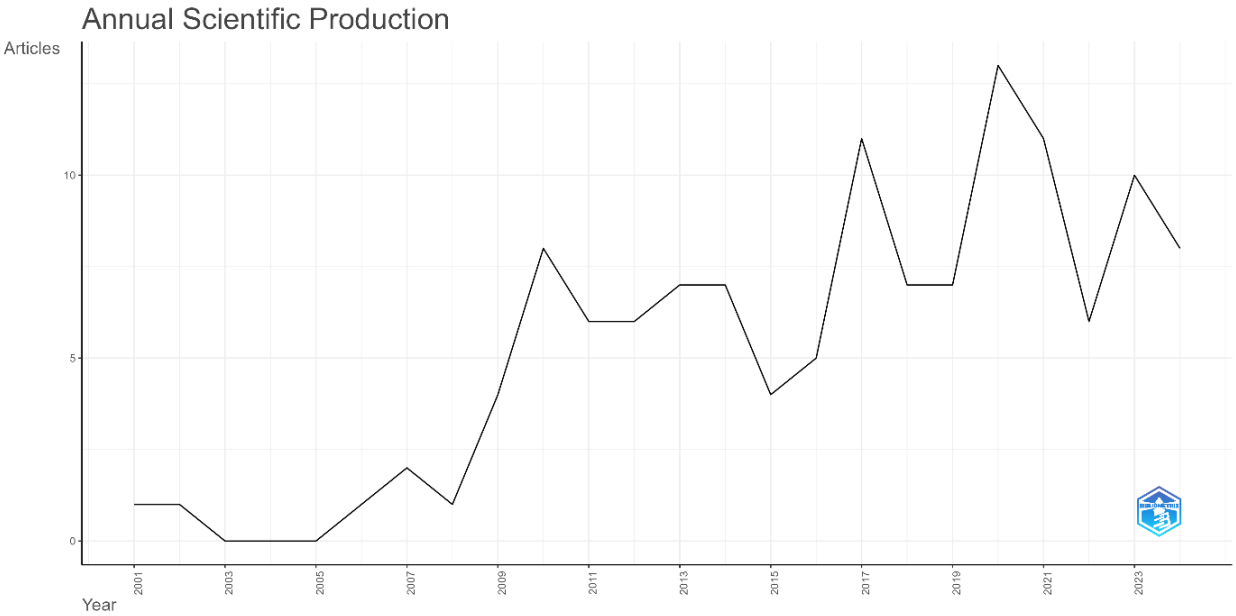

Figure 3.
Graph of scientific production growth.

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This upward trend culminated in 2010 with a peak of eight articles published, marking the first significant expansion of research activity in the field. This surge likely corresponds to the increasing global focus on sustainable development, infrastructure financing mechanisms, and the role of PPPs in tackling water service delivery challenges. Overall, this decade marks a foundational phase in establishing a research base that will become more mature and diversified in the years to come.

3.2. Source Description

Table 1 presents a comprehensive bibliometric analysis of key indicators to evaluate the productivity of journal sources in public–private partnership (PPP) research within the water sector. This assessment identifies the ten most productive journals based on output and scholarly influence.

Utilities Policy is the most prolific source, contributing 25% (12 articles) of the total publications. Classified in Bradford's Zone 1, it is a core journal with an h-index of 7, g-index of 12, and m-index of 0.5, reflecting consistent scholarly impact since 2012. The Journal of Construction Engineering and Management ranks second, accounting for 18.75% (9 articles), with a higher h-index of 9 and m-index of 0.563, signifying strong citation performance since 2010.

Other Zone 1 journals include Engineering, Construction and Architectural Management (5 articles) and four sources contributing four articles each (8.33%): International Journal of Project Management, International Journal of Strategic Property Management, and Journal of Facilities Management. These journals display moderate bibliometric indices (h-index 4–5); yet, their Zone 1 status highlights their relevance in governance, strategy, and facilities management.

The Journal of Cleaner Production, with three articles (6.25%), is significant for its early focus on sustainability in PPPs, dating back to 2007. Similarly, the Proceedings of the Institution of Civil Engineers: Management, Procurement and Law also published three articles, with a g-index of 3 and an m-index of 0.111, indicating a steady, moderate impact on the legal and procurement aspects of PPPs.

Table 1.
Top 10 most productive sources.

Sources	Number of Articles (%)	h-index	g-index	m-index	PY_start	Bradford Law	Predicate
Utilities Policy	12 (25.00%)	7	12	0.5	2012	Zone 1	Core
Journal of Construction Engineering and Management	9 (18.75%)	9	9	0.563	2010	Zone 1	Core
Engineering, Construction and Architectural Management	5 (10.42%)	4	5	0.333	2014	Zone 1	Core
International Journal of Project Management	4 (8.33%)	4	4	0.167	2002	Zone 1	Core
International Journal of Strategic Property Management	4 (8.33%)	4	4	0.267	2011	Zone 1	Core
Journal of Facilities Management	4 (8.33%)	4	4	0.286	2012	Zone 1	Core
Journal of Cleaner Production	3 (6.25%)	3	3	0.158	2007	Zone 1	Core
Proceedings of Institution of Civil Engineers: Management, Procurement and Law	3 (6.25%)	2	3	0.111	2008	Zone 1	Core
Competition and Regulation in Network Industries	2 (4.17%)	2	2	0.222	2017	Zone 2	Secondary
Construction Management and Economics	2 (4.17%)	2	2	0.118	2009	Zone 2	Secondary

In contrast, Zone 2 includes Competition and Regulation in Network Industries and Construction Management and Economics, each contributing 2 articles (4.17%). Though categorized as secondary sources, these journals offer valuable insights into regulatory frameworks and economic considerations underlying PPP arrangements. With h-indices of 2 and lower m-index scores (0.222 and 0.118, respectively), these journals occupy more specialized or emerging niches within the broader discourse.

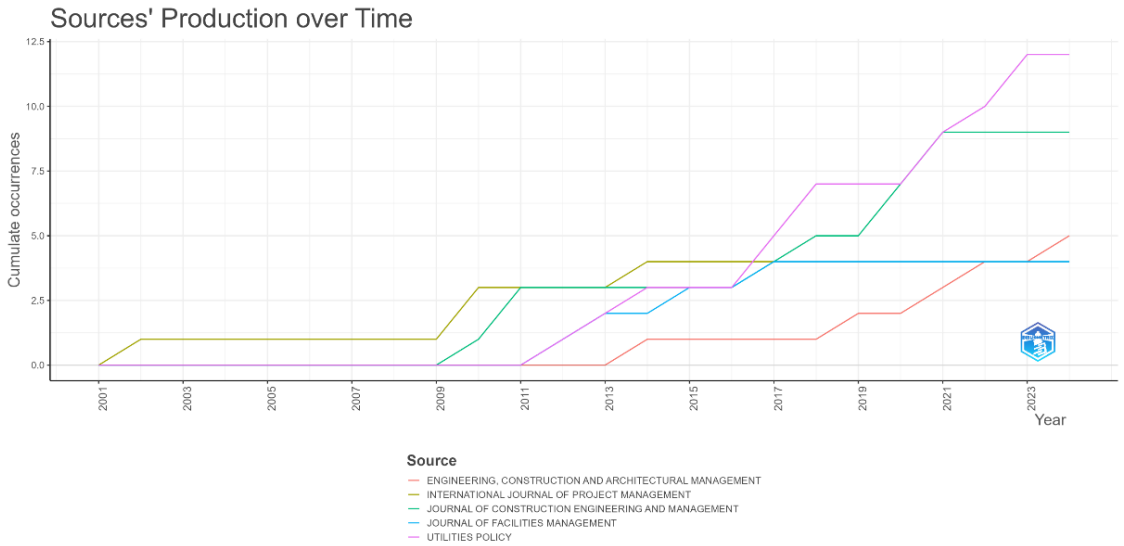

Figure 4.
Graph of core source's production over time.

Table 2 offers a comprehensive overview of the most frequently cited scholarly works on public–private partnerships (PPPs) in the water sector at the global level, providing critical insights into the intellectual foundation of this research area. The most frequently referenced document is authored by Grimsey and Lewis [41] present a rigorous evaluation of Public-Private Partnerships (PPPs) within the context of the United Kingdom's infrastructure policy. This work provides a detailed conceptual and empirical critique of the Private Finance Initiative (PFI), highlighting its implications for public sector accountability, fiscal transparency, and the pursuit of value for money. In second position is the study by Marques and Berg [42], which makes a notable contribution to the infrastructure service literature by developing a robust framework for risk allocation in PPP contracts, substantiated through empirical data from water utility projects in Portugal.

Next, Olusola Babatunde et al. [43] offer a valuable empirical exploration of critical success factors (CSFs) required for the success of PPPs in Nigeria's infrastructure development, particularly within Lagos State. Their findings fill a substantial void in the African PPP discourse by providing context-specific insights. Ameyaw and Chan [25] also investigate CSFs in the Nigerian context, affirming that PPPs are viable across various infrastructure domains, provided essential factors such as

institutional capacity and stakeholder coordination are adequately addressed. Choi et al. [44] contribute to the literature by analyzing differing risk perceptions among international investors in China's water PPP sector, shedding light on the dynamics influencing investor participation. Wibowo and Mohamed [45] explore similar themes in the Indonesian context, underscoring the challenges of risk distribution in environments marked by regulatory uncertainty. Shrestha et al. [46] extend this discussion by statistically validating the inefficiencies in risk allocation within China's PPP framework, offering a more data-driven perspective on an issue often discussed qualitatively.

Ameyaw and Chan [25] Enhance insights into public–private partnerships (PPPs) success through an empirical study of critical success factors (CSFs) in Ghana's construction industry, linking these factors to practical outcomes and recommending policy improvements. Jefferies et al. [47] further contribute by exploring relationship-based procurement in Australian project alliancing, highlighting key success elements such as integrated management and collaborative environments. Lastly, Liu and Cheah [48] introduce a novel real options analysis to address limitations of traditional evaluation methods like Discounted Cash Flow (DCF), advancing negotiation and decision-making processes in PPP and Private Finance Initiative (PFI) projects. Together, these studies emphasize effective risk allocation, performance-driven partnerships, and the transition from adversarial procurement approaches to collaborative models, forming a robust foundation for future research on adaptive and sustainable PPP frameworks.

Table 2.
Top 10 most globally cited documents.

Author	Title	Journal	Year of Publication	Total Citations (TC)	TC per Year
Grimsey and Lewis [23]	Evaluating the risks of public-private partnerships for infrastructure projects	International Journal of Project Management	2002	644	26.83
Marques and Berg [42]	Risks, Contracts, and Private-Sector Participation in Infrastructure	Journal of Construction Engineering and Management	2011	217	14.47
Brealey et al. [49]	Critical success factors in public-private partnership (PPP) on infrastructure delivery in Nigeria	Journal of Facilities Management	2012	146	10.43
Ameyaw and Chan [25]	Identifying public-private partnership (PPP) risks in managing water supply projects in Ghana	Journal of Facilities Management	2013	113	8.69
Choi et al. [44]	Risk perception analysis: Participation in China's water PPP market	International Journal of Project Management	2010	90	5.63
Wibowo and Mohamed [45]	Risk criticality and allocation in privatized water supply projects in Indonesia	International Journal of Project Management	2010	86	5.38
Shrestha et al. [46]	Risk Allocation Inefficiencies in Chinese PPP Water Projects	Journal of Construction Engineering and Management	2018	77	9.63
Ameyaw and Chan [25]	Risk allocation in public-private partnership water supply projects in Ghana	Construction Management and Economics	2015	72	6.55
Jefferies et al. [47]	Using a case study approach to identify critical success factors for alliance contracting	Engineering, Construction and Architectural Management	2014	63	5.25
Liu and Cheah [48]	Real option application in PPP/PFI project negotiation	Construction Management and Economics	2009	61	3.59

3.4. Trend Topics Description

Figure 5 illustrates the evolution of thematic priorities in the literature on public–private partnerships (PPPs) in the water sector over time. During the early stages of research between 2009 and 2011, scholarly focus was directed mainly toward technical and operational concerns, as reflected by the early appearance of terms such as *wastewater*, *internet protocols*, *private sectors*, and *water supply*. These studies, which often engaged with issues like non-revenue water, digital metering, and basic utility performance, were rooted in engineering and technological optimization. Despite their value in establishing foundational knowledge, their influence was primarily restricted to applied technical domains, with minimal engagement in governance, institutional design, or policy frameworks.

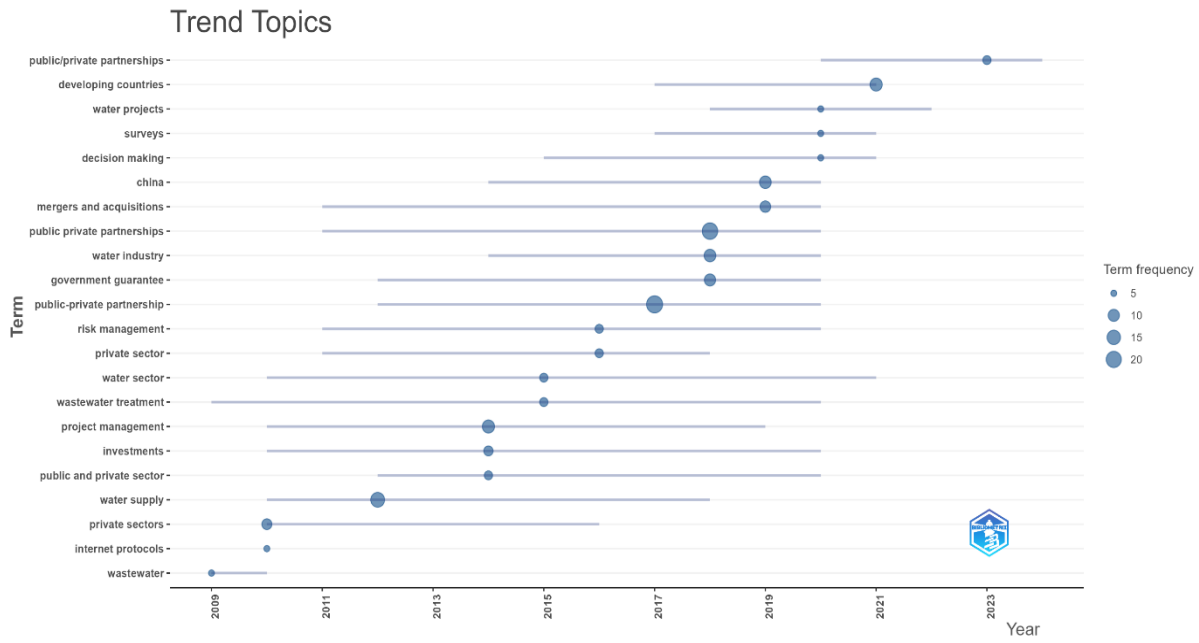

Figure 5.
Trend topics over time.

The period from 2012 to 2015 marked a pivotal shift towards institutional, managerial, and financial dimensions of public–private partnerships in the water sector. Terms such as *project management*, *investments*, *public and private sector*, and *public-private partnership* began to dominate the discourse, indicating a growing academic interest in how PPPs are structured, financed, and governed. During this phase, *government guarantee* also emerged as a critical theme, underscoring the importance of sovereign support mechanisms in de-risking infrastructure investments and enhancing private sector confidence. These developments align directly with your theoretical focus on agency and sociotechnical systems, highlighting how institutional arrangements and public risk-sharing mechanisms shape PPP outcomes.

Between 2015 and 2017, the literature deepened its engagement with themes of governance, risk, and institutional accountability. Keywords such as *risk management*, *water sector*, and *private sector* gained prominence, reflecting increased concern over contract enforcement, performance guarantees, and stakeholder alignment. This phase saw significant contributions from political economy and legal scholarship, particularly in evaluating the transparency and accountability mechanisms embedded in PPP frameworks. These studies provide important foundations for understanding stakeholder asymmetry and regulatory fragmentation key issues addressed in your research through the lens of agency theory.

From 2017 onward, the thematic focus broadened further, integrating terms like *public-private partnerships*, *mergers and acquisitions*, *surveys*, and *water industry*. This expansion of the discourse corresponds with the uptake of empirical and mixed-method research designs, particularly those involving stakeholder surveys and performance benchmarking. These methodologies provide valuable insight into how institutional actors interact across public and private boundaries precisely the type of communicative and relational inquiry that informs your use of Human-Machine Communication Theory. The concurrent rise of *government guarantees* during this time reaffirms the critical role of state-backed assurance in sustaining PPP viability amidst fiscal uncertainty.

A global perspective became more prominent between 2019 and 2021, with terms such as *developing countries*, *China*, and *water projects* featuring more frequently. This reflects a discernible shift in the literature toward the contextual adaptation of PPP models in diverse governance environments, especially in the Global South. These studies highlighted challenges such as limited regulatory oversight, institutional fragmentation, and the need for decentralized, participatory governance. These findings reinforce the relevance of your research, which critically examines how digital platforms, policy actors, and private entities interact in co-producing infrastructure governance within hybrid or transitional settings.

By 2023, *public/private partnerships* will reassert their centrality in the discourse, reflecting renewed scholarly interest in outcome-based evaluation, legitimacy, and transparency in PPP implementation. The increasing focus on post-pandemic recovery and the resilience of infrastructure partnerships has catalyzed a shift toward performance accountability and trust-building in institutional frameworks. These recent developments are directly aligned with the focus of this research, which explores the role of information systems, communicative structures, and AI-assisted decision-making environments in shaping contemporary water-sector PPPs.

The evolution of trend topics in this body of literature illustrates a dynamic transition from technical-operational issues toward more integrated analyses of governance, institutional trust, and digital communication. This study significantly contributes to this trajectory by highlighting the sociotechnical configurations and communicative interactions supporting successful water sector PPPs.

3.5. Network Analysis

3.5.1. Co-Occurrence Network Analysis

Network analysis using co-occurrence relationships effectively visualizes the structure of research fields and scholarly communication patterns. Frequently utilized in bibliometric studies, this method identifies connections among entities, such as keywords, authors, or institutions, by analyzing how frequently they appear together in academic documents. Figure 6 displays a keyword co-occurrence network map, supported by data from a co-word analysis presented in Table 3. This analysis classifies keywords by frequency and significance using centrality metrics such as betweenness, closeness, and PageRank, highlighting key thematic clusters and interdisciplinary connections within the research literature.

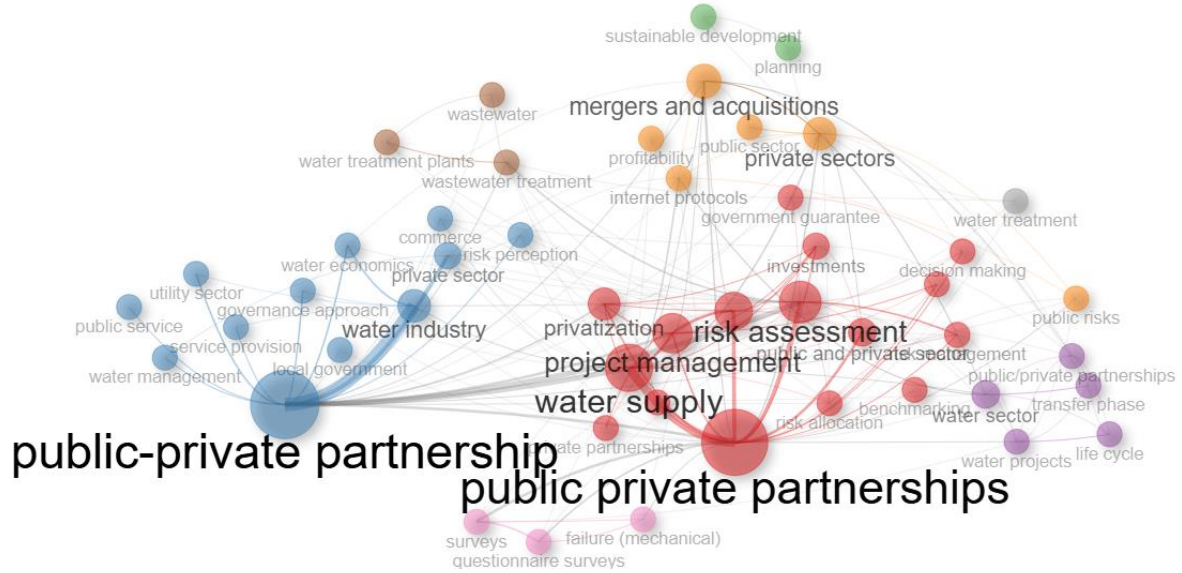

Figure 6.
Co-occurrence network map.

Cluster 1 forms the conceptual nucleus, with key terms such as public-private partnerships, water supply, project management, and risk assessment. The centrality of public-private partnerships illustrates their integrative function across diverse themes. The inclusion of developing countries and government guarantees further indicates a strong emphasis on PPP applications in low-resource settings and the critical role of sovereign instruments in risk mitigation and credit enhancement for infrastructure investment.

Table 3.
Co-occurrence network map.

Node	Cluster	Betweenness	Closeness	PageRank
Public private partnerships	1	316.908	0.015	0.091
Water supply	1	90.340	0.014	0.060
Developing countries	1	48.452	0.012	0.039
Project management	1	49.926	0.012	0.040
Government guarantee	1	4.432	0.010	0.013
Privatization	1	7.776	0.012	0.027
Risk assessment	1	77.466	0.013	0.050
Investments	1	5.028	0.011	0.021
Public and private sector	1	5.194	0.011	0.021
Risk management	1	2.705	0.011	0.018
Decision making	1	2.547	0.011	0.012
Infrastructure	1	0.107	0.010	0.011
Water infrastructure	1	0.000	0.010	0.010
Benchmarking	1	0.000	0.009	0.005
Private partnerships	1	0.000	0.009	0.009
Risk allocation	1	2.447	0.011	0.016
Public-private partnership	2	296.477	0.014	0.091
Water industry	2	11.865	0.011	0.031
Private sector	2	5.652	0.011	0.022
Governance approach	2	0.184	0.011	0.013
Local government	2	0.000	0.010	0.006
Risk perception	2	0.362	0.010	0.014
Utility sector	2	0.000	0.009	0.008
Water economics	2	0.000	0.009	0.011
Water management	2	0.000	0.009	0.007
Commerce	2	0.459	0.011	0.013
Public service	2	0.000	0.009	0.006
Service provision	2	0.000	0.009	0.007
Sustainable development	3	1.391	0.007	0.010
Planning	3	8.013	0.008	0.009
Public/private partnerships	4	13.271	0.010	0.018
Water sector	4	45.312	0.012	0.026
Water projects	4	25.468	0.011	0.021
Life cycle	4	0.000	0.008	0.011
Transfer phase	4	1.020	0.009	0.013
Mergers and acquisitions	5	65.407	0.012	0.035
Private sectors	5	88.252	0.012	0.035
Internet protocols	5	8.900	0.011	0.021
Profitability	5	0.000	0.009	0.008
Public risks	5	1.406	0.010	0.014
Public sector	5	0.000	0.008	0.007
Wastewater treatment	6	13.761	0.011	0.023
Wastewater	6	0.951	0.009	0.009
Water treatment plants	6	1.590	0.009	0.011
Surveys	7	2.303	0.010	0.018
Questionnaire surveys	7	0.194	0.010	0.016
Failure (mechanical)	7	0.000	0.010	0.012
Water treatment	8	38.434	0.010	0.012

Cluster 2 reflects a governance-centric orientation, led by the term public-private partnership, and supported by related concepts such as the water industry, the private sector, and the governance approach. These highlight the influence of institutional design, stakeholder dynamics, and administrative capability in shaping effective PPP implementation. Associated terms like risk perception, commerce, and the utility sector point to an expanding focus on regulatory behavior and the legitimacy of public service delivery.

Cluster 3, while more peripheral, introduces normative themes such as sustainable development and planning. Though less operationally central, these terms underscore the ongoing relevance of long-term policy goals and strategic foresight in guiding the PPP discourse within the water sector.

Clusters 4 and 5 broaden PPP research by incorporating practical and technological-financial dimensions. Cluster 4 addresses implementation issues across the PPP project life cycle, emphasizing terms like transfer phase and life cycle to highlight the growing interest in performance evaluation and contract oversight throughout infrastructure delivery.

Cluster 5 emphasizes the financial and technological roles of the private sector, with keywords such as mergers and acquisitions and internet protocols. This reflects the evolving participation of private entities as financiers, operators, and technological innovators. The mention of internet protocols suggests the growing integration of digital infrastructure, such as District Metering Areas (DMAs) and non-revenue water systems, into PPP frameworks, marking a convergence of engineering solutions and data-driven governance.

Clusters 6, 7, and 8 reflect specialized and methodological dimensions of PPP research. Cluster 6 centers on wastewater systems, highlighting technical issues in environmental infrastructure and urban sanitation through terms like wastewater treatment and water treatment plants. Cluster 7 emphasizes empirical methodologies, marked by keywords such as surveys and questionnaire surveys, pointing to the importance of stakeholder feedback and performance evaluation in assessing PPP outcomes.

Cluster 8, anchored by water treatment, illustrates a service delivery focus. While less central, it maintains relevance in connecting technical operations to broader governance frameworks. Collectively, these clusters reinforce the multidimensional character of PPP scholarship, encompassing institutional design, technological integration, and service performance.

3.5.2. Thematic Map Analysis

Thematic map analysis is a bibliometric method that systematically identifies, visualizes, and interprets primary research topics within extensive academic literature. It categorizes themes into basic (foundational), motor (influential and dynamic), niche (specialized), and emerging or declining (new or diminishing areas). Table 4 employs bibliometric indicators such as Callon's Centrality, Callon's Density, Rank Centrality, Rank Density, and Cluster Frequency to analyze global scholarly trends on public–private partnerships (PPPs) in the water sector, complementing Figure 7's thematic map. This structured approach aids scholars in comprehending intellectual frameworks and identifying critical research directions.

The Motor Themes quadrant represents the most mature and integrated domains. The dominant cluster here is centered on public-private partnerships, encompassing water supply and project management. This cluster exhibits the highest Callon Centrality (17.532) and Density (111.386), and a frequency of 205, reflecting its critical role in academic discourse. These metrics confirm the centrality of operational governance, project coordination, and infrastructure delivery as key foci in PPP literature, with strong resonance in sociotechnical and institutional frameworks.

Adjacent to this is the water industry cluster, also categorized under Motor Themes, comprising terms like utility sector and government approach. With a centrality of 4.939 and a density of 82.357, it demonstrates high structural cohesion and thematic relevance, especially in sectoral modernization and capacity-building discussions. Likewise, the developing countries cluster encompassing public/private partnerships and budget control registers significant academic engagement (centrality: 3.912; density: 77.778; frequency: 34), highlighting policy design and governance constraints in low- and middle-income contexts.

Table 4.
Thematic map cluster.

Cluster	Terms	Quadrant	Callon Centrality	Callon Density	Rank Centrality	Rank Density	Cluster Frequency
Public Service	• Public Service • Civil Engineering	Emerging Themes	0.5	50	3	1.5	5
Public-Private Partnership	• Public-Private Partnership • Public-Private Partnership • Water Supply	Motor Themes	17.532	111.386	10	10	205
Water Conservation	• Water Conservation	Emerging Themes	0	50	1	1.5	2
Government Guarantee	• Government Guarantee • Wastewater Treatment • Decision Making	Motor Themes	3.869	69.426	6	6	34
Sustainable Development	• Sustainable Development • Energy Efficiency • Dynamics	Emerging Themes	2.5	60.417	4	4	11
Water Industry	• Water Industry • Government Approach • Utility Sector	Motor Themes	4.939	82.357	9	8	44
Water Management	• Water Management • Sanitation • Water Use	Emerging Themes	0.458	58.333	2	3	8
Developing Countries	• Developing Countries • Public/Private Partnership • Budget Control	Motor Themes	3.912	77.778	7	7	34
Water Treatment	• Water Treatment • Public Sector • Profitability	Basic	4.326	62.857	8	5	22
Surveys	• Surveys • Questionnaire Surveys • Failure (Mechanical)	Niche Themes	2.554	98.194	5	9	18

The *Government Guarantee* cluster, although moderate in frequency (34), stands out as a strategically important motor theme. Its composition linking *government guarantee*, *wastewater treatment*, and *decision making* underscores increasing academic attention to fiscal risk management and contractual safeguards in PPP arrangements. The centrality (3.869) and density (69.426) metrics indicate its strong integration and internal development, suggesting that risk allocation, contingent liabilities, and state-backed guarantees are becoming essential considerations in water sector PPP design. This reflects a shift from purely operational concerns toward more institutional and outcome-based governance models.

In the Basic Themes quadrant, the water treatment cluster includes the public sector and profitability, with a centrality of 4.326 and a density of 62.857. Its classification as basic suggests that, while foundational, this domain has yet to evolve conceptually to the level of motor themes. These topics remain integral to environmental regulation, financial sustainability, and service equity but require deeper theoretical grounding.

Several themes fall within the Emerging or Declining quadrant. These include water conservation (centrality: 0; density: 50), public service (civil engineering), and water management (utility sector, sanitation). Their low centrality and density values and limited frequency indicate marginal but potentially ascendant areas of inquiry. These clusters are especially relevant to expanding discourses on decentralized infrastructure, regulatory reform, and engineering innovation in public utilities.

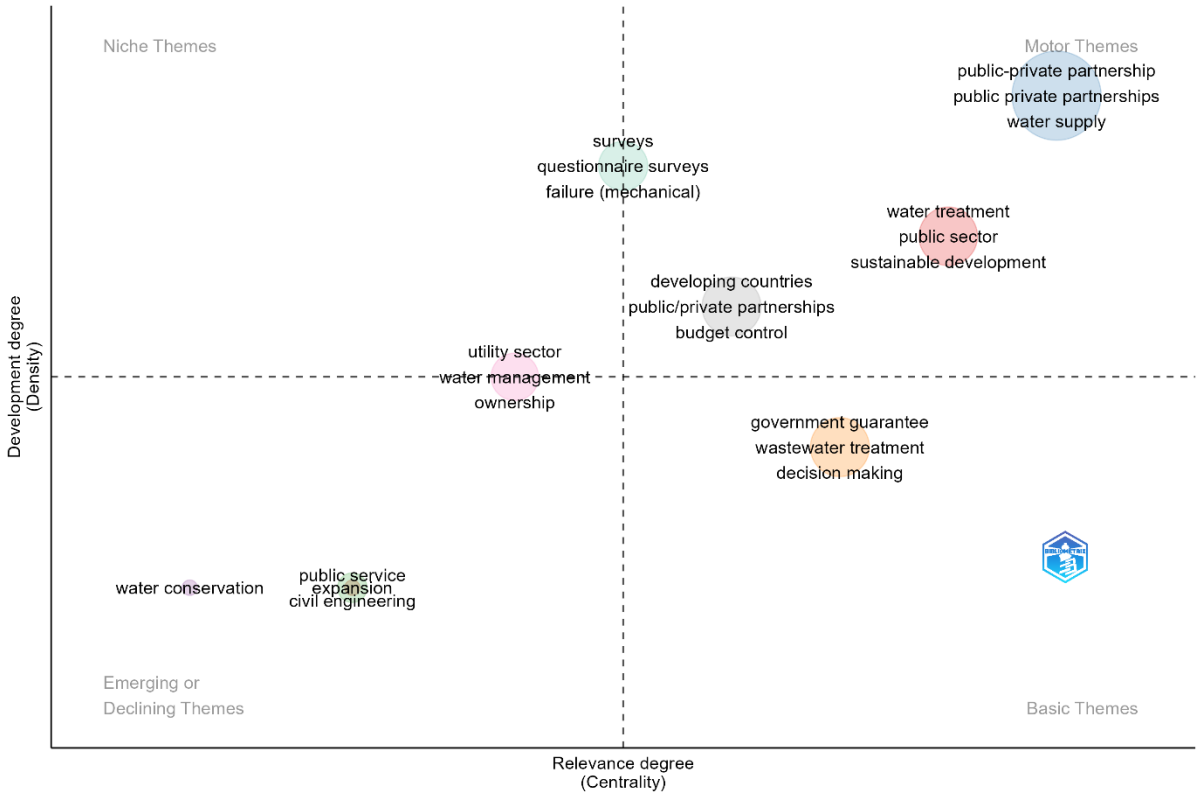

Figure 7.
Thematic map quadrant.

The Niche Themes quadrant contains the surveys cluster encompassing questionnaire surveys and failures (mechanical), which, despite modest centrality (2.554), exhibits high density (98.194), suggesting focused methodological advancement. This cluster underscores a deepening interest in empirical rigor, evaluation tools, and stakeholder analysis within PPP research.

The thematic distribution illustrates that research on PPPs in the water sector is heavily concentrated on implementation, managerial design, and policy frameworks, with emerging attention toward environmental sustainability, empirical evaluation, and governance in developing contexts.

3.5.3. Thematic Evolution Analysis

This study examines the evolution of scholarly themes related to public–private partnerships (PPPs) in the water sector from 2001 to 2024. Spanning over two decades, it provides a detailed depiction of shifts in academic attention. Figure 8 visually illustrates this thematic evolution, highlighting critical changes and emerging new areas such as water infrastructure, mechanical failures, and industry-specific concerns. This visualization underscores the maturation and interdisciplinary development of PPP discourse in water governance and offers insights for future research directions.

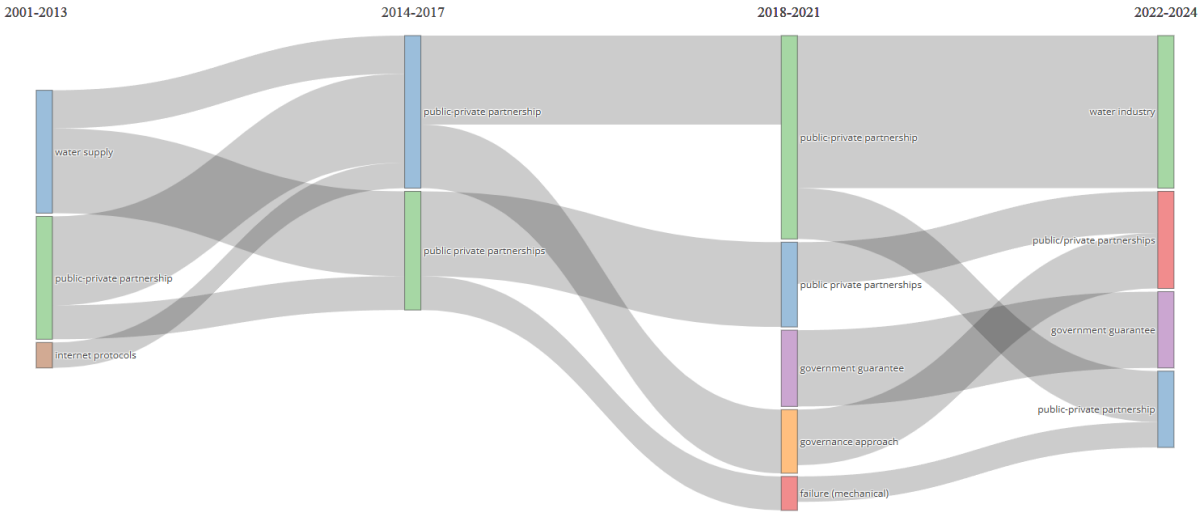

Figure 8.
Thematic evolution over time.

From 2001 to 2013, research predominantly concentrated on technical and operational aspects, using keywords like water supply, PPPs, and internet protocols. Studies during this phase emphasized infrastructure improvement and basic service delivery, with limited exploration of institutional or policy complexities.

Between 2014 and 2017, scholarly discussions underwent significant conceptual refinement, shifting attention to governance and administrative frameworks. Variations in terminology indicated an expanding dialogue around stakeholder roles, project management, and regulatory mechanisms. This period marked a noticeable increase in understanding partnership structures and assessing implementation effectiveness.

From 2018 to 2021, a crucial development was the emergence of "government guarantee" as a prominent theme. This shift reflected heightened scholarly interest in fiscal risk management, state-backed assurance mechanisms, and operational reliability. Discussions centered increasingly on mitigating investment risks and ensuring infrastructure performance, underscored by emerging concerns related to mechanical failures and service resilience.

In the most recent period (2022–2024), the centrality of government guarantees emphasizes financial accountability and sustainable infrastructure management within the water sector. The persistent emphasis on government guarantees underscores its critical role in aligning PPP projects with strategic objectives and institutional credibility. Concurrently, variations in PPP terminology suggest continued theoretical diversity and the ongoing necessity for definitional clarity.

The thematic progression indicates a shift from fundamental infrastructure concerns to sophisticated discussions on financial assurance, performance accountability, and sectoral integration. The sustained prominence of government guarantees points to ongoing scholarly and practical relevance, particularly in regulatory design and governance frameworks for effective PPP implementation in water management.

4. Discussion

The bibliometric analysis conducted in this study clearly underscores the water sector as a pivotal and enduring theme in public–private partnership (PPP) scholarship. Terms such as *"water sector," "water supply,"* and *"water industry"* appeared consistently throughout thematic clusters and temporal analyses, demonstrating the sector's central role in infrastructure discourse, particularly in relation to Sustainable Development Goal 6, which targets the availability and sustainable management of water and sanitation for all. The long-standing visibility of these terms within core bibliometric networks reflects a growing recognition that the water sector is a critical domain for achieving development outcomes and one of the most structurally complex and investment-constrained fields. In many developing countries, water infrastructure remains chronically underdeveloped due to a convergence of affordability constraints, political under-prioritization, and fragmented governance systems [50]. This is corroborated by global literature and local institutional observations, where unreliable revenue streams, high sunk costs, and low returns on investment repeatedly emerge as deterrents to private capital engagement [49, 51].

From a sociotechnical systems perspective, water infrastructure operates at the intersection of physical systems, institutional structures, and sociopolitical contexts. It encompasses a set of interdependent subsystems, including treatment plants, distribution networks, tariff regimes, and regulatory frameworks that must function cohesively to deliver reliable public services [52]. Failures in one domain often ripple across others; for example, inadequate regulatory enforcement may compromise technical performance, just as outdated physical systems may overwhelm administrative capacity [51, 53]. In this context, the state's responsibilities go beyond providing infrastructure to include sustaining institutional balance [54]. Government guarantees emerge here as institutional innovations that stabilize systemic coordination by mitigating financial and regulatory uncertainties [55]. Government guarantees also serve as enabling mechanisms that bridge technical risks (e.g., operational failures, demand variability) with governance gaps (e.g., weak enforcement, unclear accountability), thereby facilitating a more stable and predictable investment environment [56]. In essence, guarantees function not merely as fiscal incentives, but as *socio-institutional commitments* that strengthen the internal coherence of the sociotechnical system.

The significance of government guarantees is also evident when viewed through the lens of agency theory, which emphasizes the challenges of aligning interests between public principals and private agents under conditions of information asymmetry and incomplete contracts [35, 57]. Water-sector PPPs are particularly vulnerable to these agency problems given the long-term, capital-intensive nature of contracts and the essential nature of the services being delivered [14]. Governments often face challenges in specifying, monitoring, and enforcing complex contractual terms, while private agents may have incentives to reduce service quality or delay investments. Government guarantees can mitigate these risks by signaling credible public sector commitment, thereby lowering the perceived risk of contract renegotiation or expropriation [56]. Moreover, when guarantees are tied to performance benchmarks or contingent upon certain milestones, they serve a dual purpose: encouraging responsible agent behavior while preserving public sector oversight. As observed in recent thematic clusters, terms such as *"risk management," "risk allocation," "decision making,"* and *"public-private partnership"* frequently co-occur, reinforcing the idea that governance mechanisms are central to both theoretical and empirical investigations of PPP success.

These theoretical insights are borne out in empirical practice. Case studies from Indonesia provide tangible examples of how government guarantees and related instruments enhance PPP viability in the water sector. The Umbulan Drinking Water Supply System in East Java stands as a landmark case, marking Indonesia's first large-scale PPP in water infrastructure [58]. The project benefited from risk mitigation instruments provided by the Indonesia Infrastructure Guarantee Fund (IIGF), which enhanced project bankability and reduced perceived investment risks. These interventions were instrumental in overcoming multi-level governance challenges and building investor confidence in a project serving over 1.3 million people under a 25-year BOT scheme [59]. Similarly, the West Semarang Water Supply Project implemented a payment mechanism aimed at maintaining affordability for end-users, supported by government-funded intake construction and distribution

networks [58]. Although the project did not receive a VGF, its success is attributed to technical assistance, guarantees through IIGF, and local government leadership, which minimized political interference and streamlined coordination [60]. The Bandar Lampung project further illustrates how guarantees can de-risk projects at the subnational level, combining VGF funding (Rp259 billion), project development facility support, and capacity-building for local authorities [61]. In all three cases, the government guarantees balanced fiscal and operational risks, providing private investors with predictable returns while ensuring public sector accountability and service quality.

Quantitative evidence reinforces these findings. Regression analysis of the World Bank's PPI database reveals that government support, including guarantees, correlates with a statistically significant 0.66% increase in private investment flows to water-sector infrastructure [62]. Bibliometric network centrality values for *"government guarantee," "risk assessment," "investment,"* and *"project management"* further validate the thematic and conceptual centrality of guarantees in contemporary PPP research. These instruments do more than redistribute risk; they institutionalize confidence, align stakeholder incentives, and enable complex, capital-intensive projects to move from conceptualization to implementation, particularly in environments characterized by fiscal constraints and regulatory volatility.

The implications for research and policy are substantial. While guarantees are increasingly present in water PPPs, significant gaps remain in understanding their optimal design, scope, and enforceability. Future research should prioritize the development of frameworks that integrate CSFs with guarantee instruments. From a sociotechnical perspective, this means evaluating how guarantees influence the adaptability and resilience of water systems over time. From an agency theory standpoint, it necessitates closer scrutiny of how guarantee conditions affect contractor behavior, project outcomes, and institutional trust. As climate variability, urbanization, and demographic pressures intensify the demands on water systems, refined guarantee mechanisms will be essential to ensuring that PPPs are financially viable, socially equitable, and environmentally sustainable.

5. Conclusions

The growing urgency of sustainability in the water sector calls for practical solutions to address service coverage, quality, and resource allocation. Public–Private Partnerships (PPPs) have emerged as a key approach due to their potential for risk-sharing, attracting private investment, fostering innovation, and improving efficiency [1, 63]. However, PPPs often face political uncertainty, financial instability, and market fluctuations, which threaten their viability and long-term sustainability [64]. Addressing these challenges requires integrated frameworks involving stakeholder engagement, legal soundness, and continuous monitoring.

Strong legal and institutional foundations are vital. Government agencies must possess the structural capacity and expertise to manage public-private interactions effectively [13]. Without such capacity, PPPs risk inefficiency and mistrust. In contrast, institutional development and public education investments can enhance community participation and alignment with local priorities.

Bibliometric evidence confirms the central role of water in achieving the Sustainable Development Goals (SDGs), particularly SDG 6 and SDG 11, underscoring water's strategic importance for economic development, health, and [5, 13]. Scholarly interest in water-sector PPPs has evolved from infrastructure delivery to focus on governance, institutional design, and risk management.

Thematic mapping reveals "risk" and "government guarantee" as central constructs in the literature, emphasizing their conceptual and practical significance. The capital-intensive, politically sensitive nature of water projects—coupled with limited short-term returns—often deters private investment [65]. Further barriers such as regulatory uncertainty, revenue volatility, and weak institutions particularly affect developing economies [8, 10].

Government guarantees have become essential to mitigate these risks. Tools such as Minimum Revenue Guarantees (MRGs), Viability Gap Funding (VGF), exchange rate protection, and legal stabilization clauses help de-risk investments [20, 33]. Indonesian case studies show that such instruments, when coupled with strong institutions and political will can enhance project bankability [65]. The Umbulan, West Semarang, and Bandar Lampung projects exemplify successful application of guarantees.

However, inadequately structured guarantees may result in adverse consequences. Over-guaranteeing may distort risk allocation, strain public finances, and reduce efficiency, as seen in China, where excessive guarantees led to frequent renegotiations and unbalanced contracts [23, 33]. This underscores the need for balanced, transparent, and fiscally prudent guarantees that align private incentives with public goals.

The broader institutional context also shapes guarantee effectiveness. Political commitment, regulatory clarity, land acquisition processes, and inter-agency collaboration are all critical [22, 65]. In decentralized systems, local capacity limitations often constrain PPP implementation and scalability.

5.1. Future Research

The outcomes of this study emphasize the strategic importance of government guarantees in promoting sustainable public-private partnerships (PPPs) within the water sector, simultaneously highlighting critical avenues for further research. Initially, comparative analyses are necessary to assess the effectiveness of diverse guarantee instruments, such as exchange rate protections and performance-based subsidies, across various institutional and economic frameworks. Such investigations would facilitate the identification of context-sensitive best practices and contribute to improved investment results.

Beyond the initial project implementation phase, further research should assess the long-term impacts of guaranteed Public-Private Partnerships (PPPs), particularly regarding service continuity, affordability, and social equity. Additionally, attention must be given to the potential risks of over-guaranteeing, which can distort risk allocation and create fiscal

vulnerabilities. Investigating fiscal stress-testing methods and moral hazard mitigation strategies would inform more balanced guarantee frameworks.

Institutional capacity and governance also warrant deeper exploration. Studies should examine how political commitment, inter-agency coordination, and decentralization affect the implementation and oversight of guarantees. Moreover, research into integrating government guarantees with blended finance tools, such as green bonds, concessional loans, and climate funds, could provide valuable insights into structuring financially resilient and environmentally sustainable projects.

Finally, future work should emphasize stakeholder engagement and communicative governance. Transparent and participatory design of guarantee mechanisms, informed by cases of public resistance, is essential for fostering trust, legitimacy, and long-term success in PPP initiatives.

References

[1] C. He *et al.*, "Future global urban water scarcity and potential solutions," *Nature Communications*, vol. 12, no. 1, p. 4667, 2021. https://doi.org/10.1038/s41467-021-25026-3

[2] A. M. M. Irfeey, B. A. Alotaibi, M. M. Najim, and A. A. Shah, "Water valuation in urban settings for sustainable water management," *Water*, vol. 15, no. 17, p. 3105, 2023. https://doi.org/10.3390/w15173105

[3] Z. Nwokediegwu, A. Obaigbena, M. Majemite, O. Daraojimba, J. Oliha, and M. Dada, "Review of innovative approaches in water infrastructure: Sustainable desalination and public-private partnerships," *Int J Sci Res Arch*, vol. 11, no. 1, pp. 324-332, 2024. https://doi.org/10.30574/ijsra.2024.11.1.0072

[4] R. Ahlers and V. Merme, "Financialization, water governance, and uneven development," *Wiley Interdisciplinary Reviews: Water*, vol. 3, no. 6, pp. 766-774, 2016. https://doi.org/10.1002/wat2.1166

[5] S. Tariq and X. Zhang, "A critical analysis of water PPP failures in sub-Saharan Africa," *Engineering, Construction and Architectural Management*, vol. 29, no. 8, pp. 3157-3180, 2022. https://doi.org/10.1108/ECAM-01-2021-0084

[6] S. N. Chisika and C. Yeom, "Enhancing sustainable management of public natural forests through public private partnerships in Kenya," *Sage Open*, vol. 11, no. 4, p. 21582440211054490, 2021. https://doi.org/10.1177/21582440211054490

[7] M. Dumol, *The manila water concession*. Washington, D.C: World Bank, 2020.

[8] O. T. Seppälä, J. J. Hukka, and T. S. Katko, "Public-private partnerships in water and sewerage services: Privatization for profit or improvement of service and performance?," *Public Works Management & Policy*, vol. 6, no. 1, pp. 42-58, 2001. https://doi.org/10.1177/1087724X0161005

[9] V. C. Rivera Jr, "A concession success story: the private sector's role in water and sanitation in Manila | Proparco - Groupe Agence Française de Développement," Proparco," Retrieved: https://www.proparco.fr/en/article/concession-success-story-private-sectors-role-water-and-sanitation-manila, 2025.

[10] J. Wilk *et al.*, "Framing and blaming in the Cochabamba water agenda: Local, municipal and regional perspectives," *Water Policy*, vol. 19, no. 4, pp. 620-636, 2017. https://doi.org/10.2166/wp.2017.050

[11] A. Khalatbari, "A critique of neoliberal urbanization and its downsides on housing policies," 2024. https://doi.org/10.20944/preprints202404.0923.v1

[12] M. Toseef, A. S. Lodhi, and A. Nazir, "Science mapping of health sector kickbacks: A bibliometric analysis," *Health Sciences Journal*, vol. 2, no. 1, pp. 16-22, 2023. https://doi.org/10.59365/hsj.2(1).2023.56

[13] C. Ruiters and J. Amadi-Echendu, "Public–private partnerships as investment models for water infrastructure in South Africa," *Infrastructure Asset Management*, vol. 9, no. 4, pp. 180-193, 2022. https://doi.org/10.1680/jinam.21.00013

[14] M. Febiola, "Local private sector involvement in public–private partnerships for sustainable water and sanitation in Asia," *ADBI Policy Brief*, 2024. https://doi.org/10.56506/OOWF2834

[15] L. Su and Y. Cao, "Performance monitoring and evaluation of water environment treatment PPP projects with multi-source heterogeneous information," *Frontiers in Environmental Science*, vol. 10, p. 1024701, 2022. https://doi.org/10.3389/fenvs.2022.1024701

[16] T. Bovaird, "Public–private partnerships: from contested concepts to prevalent practice," *International review of administrative sciences*, vol. 70, no. 2, pp. 199-215, 2004. https://doi.org/10.1177/0020852304044250

[17] Y. H. Kwak, Y. Chih, and C. W. Ibbs, "Towards a comprehensive understanding of public private partnerships for infrastructure development," *California management review*, vol. 51, no. 2, pp. 51-78, 2009. https://doi.org/10.2307/41166480

[18] D. W. Brinkerhoff and J. M. Brinkerhoff, "Public–private partnerships: Perspectives on purposes, publicness, and good governance," *Public administration and development*, vol. 31, no. 1, pp. 2-14, 2011. https://doi.org/10.1002/pad.584

[19] M. G. Hiben, A. G. Awoke, and A. A. Ashenafi, "Future potable water supply demand projection under climate change and socioeconomic scenarios: A case of Gshba subbasin, Northern Ethiopia," *International Research Journal of Multidisciplinary Technovation*, vol. 6, no. 1, pp. 51-64, 2024. https://doi.org/10.54392/irjmt2415

[20] C. Cui, Y. Liu, A. Hope, and J. Wang, "Review of studies on the public–private partnerships (PPP) for infrastructure projects," *International journal of project management*, vol. 36, no. 5, pp. 773-794, 2018. https://doi.org/10.1016/j.ijproman.2018.03.004

[21] I. Akomea-Frimpong, X. Jin, and R. Osei-Kyei, "A holistic review of research studies on financial risk management in public–private partnership projects," *Engineering, construction and architectural management*, vol. 28, no. 9, pp. 2549-2569, 2021. https://doi.org/10.1108/ECAM-02-2020-0103

[22] G. T. Stewart, R. Kolluru, and M. Smith, "Leveraging public-private partnerships to improve community resilience in times of disaster," *International Journal of Physical Distribution & Logistics Management*, vol. 39, no. 5, pp. 343-364, 2009. https://doi.org/10.1108/09600030910973724

[23] D. Grimsey and M. K. Lewis, "Public private partnerships: The worldwide revolution in infrastructure provision and project finance," Edward Elgar Publishing. https://doi.org/10.4337/9781845423438, 2004.

[24] G. Citybabu and S. Yamini, "A state of the art of Lean Six Sigma in the Indian context–21st century: A bibliometric analysis," *The TQM Journal*, vol. 36, no. 7, pp. 2154-2192, 2023. https://doi.org/10.1108/TQM-12-2022-0357

[25] E. E. Ameyaw and A. P. Chan, "Risk ranking and analysis in PPP water supply infrastructure projects: An international survey of industry experts," *Facilities*, vol. 33, no. 7/8, pp. 428-453, 2015. https://doi.org/10.1108/F-12-2013-0091

[26] L. Zhong, A. P. Mol, and T. Fu, "Public-private partnerships in China's urban water sector," *Environmental Management*, vol. 41, pp. 863-877, 2008. https://doi.org/10.1007/s00267-008-9070-1
[27] M. Lee, X. Han, P. F. Quising, and M. L. Villaruel, "Hazard analysis on public-private partnership projects in developing Asia," *Journal of Infrastructure, Policy and Development*, vol. 4, no. 1, 200. https://doi.org/10.24294/jipd.v4i1.1165
[28] J. Mawejje, "Private sector participation in infrastructure in emerging market and developing economies: Evolution, constraints, and policies," *Global Policy*, vol. 15, no. 2, pp. 465-474, 2024. https://doi.org/10.1111/1758-5899.13375
[29] I. F. Machete and R. C. Marques, "Project risks influence on water supply and sanitation sector financing opportunities," *Water*, vol. 15, no. 12, p. 2295, 2023. https://doi.org/10.3390/w15122295
[30] H. Owolabi, L. Oyedele, H. Alaka, S. Ajayi, M. Bilal, and O. Akinade, "Risk mitigation in PFI/PPP project finance: A framework model for financiers' bankability criteria," *Built Environment Project and Asset Management*, vol. 10, no. 1, pp. 28-49, 2020. https://doi.org/10.1108/BEPAM-09-2018-0120
[31] Z. Le Squeren and J. Moore, "The political cycle of public-private contract renegotiations," in *In Academy of Management Proceedings (Vol. 2015, No. 1, p. 14612). Briarcliff Manor, NY 10510: Academy of Management. https://doi.org/10.5465/ambpp.2015.14612abstract*, 2015.
[32] K. A. Sanjo, A. A. Chinade, and A. Abdulsamad, "Water governance: challenges and prospects for the implementation of sustainable development goal six in Nigeria," *African Journal of Environmental Sciences and Renewable Energy*, vol. 14, no. 1, pp. 86-109, 2024. https://doi.org/10.62154/FKZ0PQ18
[33] Y. Xu, J. F. Yeung, A. P. Chan, D. W. Chan, S. Q. Wang, and Y. Ke, "Developing a risk assessment model for PPP projects in China—A fuzzy synthetic evaluation approach," *Automation in construction*, vol. 19, no. 7, pp. 929-943, 2010. https://doi.org/10.1016/j.autcon.2010.06.006
[34] P. Van Nguyen, H. D. X. Trieu, M. A. Do, and A. T. Nguyen, "Evaluating critical success factors in public – private partnership water supply infrastructure projects," presented at the SHS Web of Conferences, vol. 129. https://doi.org/10.1051/shsconf/202112909012, 2021.
[35] K. Madison, D. T. Holt, F. W. Kellermanns, and A. L. Ranft, "Viewing family firm behavior and governance through the lens of agency and stewardship theories," *Family Business Review*, vol. 29, no. 1, pp. 65-93, 2016. https://doi.org/10.1177/0894486515594292
[36] M. Menon, A. Katz, and M. C. Paretti, "A thematic and trend analysis of engineering education for sustainable development," in *ASEE Annual Conference and Exposition, Conference Proceedings. https://doi.org/10.18260/1-2--40876*, 2022.
[37] G. Grosseck, L. G. Țîru, and R. A. Bran, "Education for sustainable development: Evolution and perspectives: A bibliometric review of research, 1992–2018," *Sustainability*, vol. 11, no. 21, p. 6136, 2019. https://doi.org/10.3390/su11216136
[38] R. Raman, V. K. Nair, and P. Nedungadi, "Discrepancies in mapping sustainable development goal 3 (Good Health and Well-Being) research: a comparative analysis of scopus and dimensions databases," *Sustainability*, vol. 15, no. 23, p. 16413, 2023. https://doi.org/10.3390/su152316413
[39] U. R. de Oliveira, R. P. Menezes, and V. A. Fernandes, "A systematic literature review on corporate sustainability: contributions, barriers, innovations and future possibilities," *Environment, development and sustainability*, vol. 26, no. 2, pp. 3045-3079, 2024. https://doi.org/10.1007/s10668-023-02933-7
[40] M. Aria and C. Cuccurullo, "bibliometrix: An R-tool for comprehensive science mapping analysis," *Journal of informetrics*, vol. 11, no. 4, pp. 959-975, 2017. https://doi.org/10.1016/j.joi.2017.08.007
[41] D. Grimsey and M. K. Lewis, "Evaluating the risks of public private partnerships for infrastructure projects," *International journal of project management*, vol. 20, no. 2, pp. 107-118, 2002. https://doi.org/10.1016/S0263-7863(00)00040-5
[42] R. C. Marques and S. Berg, "Risks, contracts, and private-sector participation in infrastructure," *Journal of construction engineering and management*, vol. 137, no. 11, pp. 925-932, 2011. https://doi.org/10.1061/(asce)co.1943-7862.0000347
[43] S. Olusola Babatunde, A. Opawole, and O. Emmanuel Akinsiku, "Critical success factors in public-private partnership (PPP) on infrastructure delivery in Nigeria," *Journal of facilities management*, vol. 10, no. 3, pp. 212-225, 2012. https://doi.org/10.1108/14725961211246018
[44] J.-h. Choi, J. Chung, and D.-J. Lee, "Risk perception analysis: Participation in China's water PPP market," *International journal of project management*, vol. 28, no. 6, pp. 580-592, 2010. https://doi.org/10.1016/j.ijproman.2009.10.010
[45] A. Wibowo and S. Mohamed, "Risk criticality and allocation in privatised water supply projects in Indonesia," *International Journal of Project Management*, vol. 28, no. 5, pp. 504-513, 2010. https://doi.org/10.1016/j.ijproman.2009.08.003
[46] A. Shrestha, T.-K. Chan, A. A. Aibinu, C. Chen, and I. Martek, "Risk allocation inefficiencies in Chinese PPP water projects," *Journal of construction engineering and management*, vol. 144, no. 4, p. 04018013, 2018. https://doi.org/10.1061/(asce)co.1943-7862.0001457
[47] M. Jefferies, G. John Brewer, and T. Gajendran, "Using a case study approach to identify critical success factors for alliance contracting," *Engineering, Construction and Architectural Management*, vol. 21, no. 5, pp. 465-480, 2014. https://doi.org/10.1108/ECAM-01-2012-0007
[48] J. Liu and C. Y. Cheah, "Real option application in PPP/PFI project negotiation," *Construction management and economics*, vol. 27, no. 4, pp. 331-342, 2009. https://doi.org/10.1080/01446190902807071
[49] R. A. Brealey, I. A. Cooper, and M. A. Habib, "Cost of capital and valuation in the public and private sectors: Tax, risk and debt capacity," *Journal of Business finance & accounting*, vol. 47, no. 1-2, pp. 163-187, 2020. https://doi.org/10.1111/jbfa.12413
[50] D. Suhardiman, E. Karki, and R. C. Bastakoti, "Putting power and politics central in Nepal's water governance," *Development Policy Review*, vol. 39, no. 4, pp. 569-587, 2021. https://doi.org/10.1111/dpr.12519
[51] S. Frone and D. F. Frone, "Issues of efficiency for public-private partnerships in the water sector," *Stud. Sci. Res. Econ. Ed*, vol. 27, pp. 75-85, 2018. https://doi.org/10.29358/sceco.v0i27.413
[52] M. I. Dubaniowski and B. Stojadinović, "Agent-based framework for assessing systemic risk of interdependent sociotechnical and infrastructure systems," presented at the In 2022 6th International Conference on System Reliability and Safety (ICSRS) (pp. 196-201), 2022.
[53] S. Mvulirwenande, G. Alaerts, and U. Wehn de Montalvo, "From knowledge and capacity development to performance improvement in water supply: The importance of competence integration and use," *Water Policy*, vol. 15, no. S2, pp. 267-281, 2013. https://doi.org/10.2166/wp.2013.023

[54] F. Dakyaga, S. Schramm, J. M. Lupala, and D. L. Magembe-Mushi, "Charging the non-networked: Water pricing governance of the heterogeneous infrastructures beyond the utility network in Dar es Salaam," *Environment and Planning E: Nature and Space*, vol. 7, no. 4, pp. 1868-1892, 2024. https://doi.org/10.1177/25148486241238402

[55] C. Ruiters and M. P. Matji, "Water institutions and governance models for the funding, financing and management of water infrastructure in South Africa," *Water Sa*, vol. 41, no. 5, pp. 660-676, 2015. https://doi.org/10.4314/wsa.v41i5.09

[56] L. Wang, A. Shrestha, W. Zhang, and G. Wang, "Government guarantee decisions in PPP wastewater treatment expansion projects," *Water*, vol. 12, no. 12, p. 3352, 2020. https://doi.org/10.3390/w12123352

[57] T. A. Guerrero, "Water infrastructure: A terrain for studying nonhuman agency, power relations, and socioeconomic change," *Wiley Interdisciplinary Reviews: Water*, vol. 5, no. 5, 2018. https://doi.org/10.1002/WAT2.1298

[58] D. R. Parlindungan, R. Setiadi, and M. López, "Critical risk factors of ppp water supply project in Indonesia," *Development*, vol. 7, no. 1, pp. 21-32, 2022. https://doi.org/10.14710/IJPD.7.1.21-32

[59] J. Rahim and L. Budiati, "Online water quality monitoring: a case study in the umbulan drinking water supply system, East Java, Indonesia," *International Journal of Public Health Science*, vol. 13, no. 1, pp. 303-310, 2024. https://doi.org/10.11591/ijphs.v13i1.23174

[60] J. U. D. Hatmoko and R. Susanti, "Risk management of West Semarang water supply PPP project: Public sector perspective," *IPTEK Journal of Proceedings Series*, vol. 3, no. 1, pp. 48-54, 2017. https://doi.org/10.12962/j23546026.y2017i1.2191

[61] M. Mukhlis and R. Perdana, "A critical analysis of the challenges of collaborative governance in climate change adaptation policies in Bandar Lampung City, Indonesia," *Sustainability*, vol. 14, no. 7, p. 4077, 2022. https://doi.org/10.3390/su14074077

[62] W. Wu, "Infrastructure Investment and Finance in the Global South: Private Participation and Its Determinants," *Public Finance and Management*, vol. 23, no. 3, pp. 99-112, 2024. https://doi.org/10.1177/15239721241259573

[63] B. Li, A. Akintoye, P. J. Edwards, and C. Hardcastle, "Critical success factors for PPP/PFI projects in the UK construction industry," *Construction Management and Economics*, vol. 23, no. 5, 2005. https://doi.org/10.1080/01446190500041537

[64] K. Gassner, A. A. Popov, and N. Pushak, *Does private sector participation improve performance in electricity and water distribution?* World Bank Publications, 2009.

[65] F. Kacaribu, Y. M. Gultom, N. A. Desdiani, and S. Sabrina, "Government initiatives to unlock private participation in infrastructure: Lessons from Indonesia's public–private partnership in the water sector," Routledge. https://doi.org/10.4324/9781003228790-16, 2022, pp. 239-261.