Research Paper **Open Access**

Anam Fatima*, Sajjad Mubin, Rehan Masood

Risk-based integrated performance assessment framework for public-private partnership infrastructure projects

DOI 10.2478/otmcj-2024-0018
Received: May 11, 2024; accepted: July 18, 2024

Abstract: Public-private partnerships (PPPs) play a pivotal role in global infrastructure development, significantly impacting economic growth. However, a notable research gap exists in addressing risk management adequately within the performance assessment of PPP projects, particularly in developing nations like Pakistan. This study aims to address this gap by developing an integrated performance assessment framework (IPAF) in order to fill the deficiency of structured risk management in PPP project evaluations. Therefore, the purpose of this study is to devise a systematic methodology for assessing PPP project performance, with a keen emphasis on robust risk management criteria. Employing a comprehensive approach, the methodology integrates 16 performance measures (PMs) aligned with key performance indicators (KPIs), covering the triple constraints of projects (cost, time and quality) during the project feasibility, execution and operation and maintenance phases of project life cycle. Additionally, it incorporates an analysis of 10 prominent risks, spanning financial, environmental, operational, construction, legal and governmental dimensions inherent to PPP projects. The IPAF not only identifies these risks but also offers calculated mitigation strategies to enhance overall project performance. Emphasising alignment with project objectives, stakeholder engagement and contextual factors, the framework aids decision-makers, project managers and policymakers in making informed decisions throughout the project lifecycle. Furthermore, this study contributes by providing a systematic approach to address the critical bond between risk management and project performance in PPP projects. By bridging this gap, the IPAF fosters enhanced project outcomes, thereby contributing to the advancement of infrastructure development practices in both developed and developing contexts.

Keywords: PPP life cycle, performance assessment, performance management, risk management, risk mitigation strategies, key performance indicators, performance measures

***Corresponding author: Anam Fatima,** Department of Architectural Engineering & Design, Faculty of Civil Engineering, University of Engineering and Technology, Lahore 54890, Pakistan, E-mail: anamfatima@uet.edu.pk
Sajjad Mubin, Department of Architectural Engineering & Design, Faculty of Civil Engineering, University of Engineering and Technology, Lahore 54890, Pakistan
Rehan Masood, Ako Delivery—Region Four: Construction Services Team, College of Engineering, Construction and Living Sciences, department of Construction, Otago Polytechnic, Te Pūkenga, Dunedin 9054, New Zealand

1 Introduction

Public-private partnership (PPP) projects have emerged as pivotal innovative procurement models in contemporary infrastructure development, playing a transformative role in the delivery of public services across various sectors. The significance of PPP projects lies in their capacity to address the growing demands for essential infrastructure, such as health, education and transportation, particularly in the face of increasing global population trends (Soomro and Zhang 2016). These collaborative ventures involve a strategic alliance between public and private entities to finance, construct and manage public facilities, transferring them to public-sector authorities after a predefined concession period (Brinkerhoff and Brinkerhoff 2011).

However, governments face challenges in financing the expanding infrastructure needs so PPPs represent a cooperative approach wherein private entities are invited to invest, construct, own and operate public facilities, contributing to the fulfilment of critical infrastructure needs (Kang et al. 2019). These projects offer an alternative means for governments to overcome financial constraints, especially in developing nations grappling with challenges related to national debts, limited budgets

and funding options (Yurdakul et al. 2022). PPP projects have demonstrated their ability to deliver higher value for money (VfM), offering advantageous returns on both cost and time invested (Yuan et al. 2012). The overarching significance of PPP projects lies in their ability to provide efficient, cost-effective solutions that bridge the gap between escalating infrastructure demands and constrained public resources (Borole 2022). By leveraging the expertise and resources of the private sector, PPP projects aim to optimise project outcomes, enhance service quality and promote sustainable development.

In the global or regional context, PPPs have become a prevalent and influential mechanism, reshaping the landscape of economic development. The global evolution of PPPs gained momentum in the 1970s and 1980s, marked by a shift towards involving private entities in infrastructure, construction and development projects (Chan et al. 2011). This paradigm shift was further fuelled by the Public Management Movement, emphasising the competition between private and public sectors in infrastructure development. In the past two decades, utilisation of PPPs has facilitated governments in enhancing the delivery of infrastructure projects, allowing for improved provision of public services (Pongsiri 2002). Globally, PPPs have proven to be instrumental in addressing the limitations of traditional government financing and delivery models. Their prevalence is particularly notable in mature markets such as Australia and the UK, where sophisticated PPP frameworks have been established, contributing to successful project delivery (Hodge 2004; Liang and Jia 2018; Ward et al. 2019; Nguyen et al. 2020; Berisha et al. 2022). Normative literature has documented numerous successes and occasional failures in PPPs. However, contemporary discourse surrounding PPPs has transcended ideological debates regarding their merits and drawbacks. Instead, the discussion now centres on structuring PPPs that aligns with public policy objectives (Hodge 2004; Yong 2010; Regan et al. 2011a, 2011b; Berisha et al. 2022). To harness the potential advantages offered by PPPs, they need to be structured to enhance performance while distributing costs and risks between the public and private sectors (Yong 2010). However, despite their experience in implementing PPPs, inadequate performance measures (PMs) have been pinpointed as a contributing factor to the challenges encountered during the delivery of projects such as the Latrobe Regional Hospital and Deer Park Women's Prison in Victoria, Australia, and Ashfield Prison in the United Kingdom (VAGO 2002; House of Commons Committee of Public Accounts 2003; Roth 2004). According to Yuan et al. (2009) the absence of effective PMs in PPPs acts as a trigger for producing below-optimum service quality of infrastructure. However, many PPP projects have not undergone a comprehensive form of *ex post* evaluation in terms of what has been delivered, and limited research has been undertaken to discuss how to comprehensively measure PPP infrastructure projects' performance (Hodge 2005; Hodge and Greve 2007; Yuan et al. 2009; Regan et al. 2011b). Measuring the performance of PPP projects is paramount for ensuring the success and sustainability of these collaborative initiatives (Love and Holt 2000; Kagioglou et al. 2001; Bassioni et al. 2004; Qureshi et al. 2009). The complexity of PPP projects, involving intricate contractual relationships between public and private entities, demands a systematic assessment to gauge their effectiveness. In addition, monitoring and evaluating performance constitute fundamental tasks within contract and project management, representing integral components of PPP policy across many nations (Chinyio and Gameson 2009; EIB 2012). Performance assessment serves as a diagnostic tool, shedding light on the strengths and weaknesses of a project, facilitating informed decision-making and promoting continuous improvement (Lusthaus 2002). The impact of PPPs on fiscal development is profound, offering accelerated infrastructure provision, timely project implementation, risk mitigation and improved service quality (Li and Wang 2023).

Implementing a robust performance assessment framework for PPP projects yields multifaceted benefits, enhancing accountability, risk management and overall project success (Yong 2010; Szemere et al. 2021). Effective risk management is another critical advantage of an integrated performance assessment framework (IPAF). Identifying, analysing and allocating risks play pivotal roles in PPP endeavours, especially given the limited obligation of private investors in design and construction, with the public sector bearing the brunt of financial and operational uncertainties (Nawaz et al. 2019; Sarvari et al. 2019). Extensive research has explored PPP risks, offering valuable perspectives on identifying and distributing these risks effectively (Wang et al. 2000a, 2000b; Grimsey and Lewis 2002; Thomas et al. 2003; Bing et al. 2005; Xu et al. 2010). By assessing and identifying risks systematically throughout the project lifecycle, stakeholders can implement mitigation strategies proactively (Valipour et al. 2018). This proactive approach minimises the likelihood of project disruptions, financial setbacks and legal disputes, thereby safeguarding the interests of both public and private participants (Floricel and Miller 2001).

Numerous researchers have outlined key elements vital for the successful implementation of PPP projects, emphasising the pivotal role of PMs (Hodge and Greve 2007; Yuan et al. 2009). According to Yong, stakeholders must prioritise performance measurement issues during project development to realise PPP benefits (Yong 2010). Performance measurement is crucial for achieving business success whether at the corporate or project level (Love and Holt 2000; Kagioglou et al. 2001). Monitoring and evaluating performance throughout the PPP life cycle are fundamental activities for contract and project management professionals, constituting an essential aspect of PPP policy in various countries (Chinyio and Gameson 2009; EIB 2012). Inadequate performance measurement in PPPs often leads to diminished infrastructure service quality (Liang and Wang 2019). However, despite the critical importance of performance measurement to project success, comprehensive assessments of many PPPs are still lacking (Regan et al. 2011b; Liu et al. 2015).

Given this context, this study reviews the literature on distinctive features and requisite evaluations of PPP projects, along with the broader domain of performance measurement in construction, it underscores the significance of achieving a balance between performance measurement and management processes. The study highlights the need for a comprehensive framework that not only assesses project performance but also integrates robust risk management strategies to mitigate uncertainties and enhance outcomes (Franco-Santos et al. 2012; Bititci 2015; Smith and Bititci 2017). It also aims to present an IPAF for evaluating PPP infrastructure projects, identifying clear and measurable critical risk factors associated with PPP projects and proposing effective mitigation techniques. This inclusive approach aims to evaluate the performance of PPP project management by furnishing stakeholders with insightful information on project performance and highlighting areas for improvement, fostering a more robust and nuanced understanding of project success. Furthermore, the study aims to contribute to the existing literature by exploring how the uncertain and volatile operating environment affects performance measurement and management in PPP projects (Nudurupati et al. 2021). By prioritising risk management within the Integrated assessment framework, the study seeks to offer insights into effectively managing the inherent complexities of PPP infrastructure projects (Smith and Bititci 2017; Bourne et al. 2018; Sardi et al. 2020).

2 Objectives and risk-based performance assessment in PPP infrastructure projects

Performance measurement in PPP projects encompasses efficiency, effectiveness and VfM (Lebas 1995; Akintoye et al. 2003; Grimsey and Lewis 2005; Solomon and Young 2007). VfM aims to balance cost and quality to meet user requirements (Office of Government Commerce 2002). While conventional assessments prioritise cost, incorporating time and quality dimensions allows for a more comprehensive evaluation (Henjewele et al. 2014). Neglecting stakeholder satisfaction and project phases may result in incomplete assessments (Liu et al. 2022). Various dimensions, including project quality, cost, duration, safety and environmental sustainability, significantly influence PPP performance (Lim and Mohamed 1999; Kumaraswamy and Zhang 2001; Yin 2009; Jin and Zhang 2011; Liu et al. 2015; Fellows and Liu 2021). Tailored assessment models acknowledge the multifaceted nature of PPP projects and advocate for nuanced approaches (Kumaraswamy and Zhang 2001; Cong and Ma 2018; Liang and Wang 2019; Esposito and Dicorato 2020). The incorporation of sustainable development goals (SDGs) underscores the increasing emphasis on sustainability within PPP initiatives.

Developing a performance assessment framework for PPP projects is imperative for several reasons. First, existing literature showcases various frameworks and models for evaluating PPP project performance, highlighting the diverse dimensions and criteria involved. However, their success hinges on effective performance assessment methodologies that account for inherent risks. Risk-based performance assessment in PPP projects is essential for identifying, managing and mitigating risks throughout the project lifecycle, ensuring optimal outcomes and value for stakeholders. For this purpose, this study aims to

a. Develop a systematic performance assessment framework for PPP projects, prioritising risk management in developing country contexts.
b. Integrate key PMs and risk mitigation strategies across the feasibility, execution and operation and maintenance phases of PPP projects.
c. Enable informed decision-making and enhance project outcomes through the structured application of the developed framework.

3 Research significance

Considering the studies and framework examples presented above, given Pakistan's status as a developing country, the need to establish a robust performance assessment framework for PPP projects takes on heightened significance. As Pakistan endeavours to accelerate its economic and infrastructure development, effective evaluation mechanisms become indispensable tools for ensuring accountability, transparency and efficient resource utilisation within PPP initiatives. Recent studies in Pakistan, such as (Ullah et al. 2016, 2018; Noor and Khalfan 2017; Javid 2019; Nawaz et al. 2019; Ahmad et al. 2022), underscore the importance of adapting global best practices to the local context and addressing the unique challenges faced by PPP projects in Pakistan. By forging an IPAF tailored to the unique socio-economic context of Pakistan, stakeholders can effectively monitor project progress, identify areas for improvement and mitigate risks inherent in PPP ventures. This framework not only fosters greater accountability among public and private entities but also facilitates evidence-based decision-making to optimise resource allocation and maximise the impact of infrastructure investments.

Moreover, the exploration of current gaps in the literature and the pursuit of future research avenues hold immense potential in advancing the understanding and practice of performance assessment in PPP projects within the Pakistani context. By addressing these gaps, researchers can contribute valuable insights that inform policy formulation, refine project management practices and ultimately enhance the efficacy and sustainability of PPP endeavours in driving socio-economic development across Pakistan. In essence, developing a robust performance assessment framework for PPP projects in Pakistan represents a pivotal step towards realising the country's developmental aspirations. Through concerted efforts to bridge existing knowledge gaps and innovate within the scope of performance assessment, Pakistan can chart a path towards more inclusive, resilient and prosperous infrastructure development outcomes.

4 Methodology

The study aims to provide valuable insights into the performance assessment of PPP projects in Pakistan through a rigorous research methodology, contributing to the advancement of knowledge in the field. The research methodology for this study is structured around a comprehensive understanding of research principles and methods (Ahmad et al. 2022). The research engages with various types of methodologies, with a primary focus on mixed-methods research incorporating qualitative and quantitative approaches as shown in Figure 1. The qualitative methodology is considered suitable for this research investigation as it enables thorough exploration and data collection to establish the grounded theory. This theory could certainly be confirmed through a quantitative approach using a larger dataset (Noor and Khalfan 2017). The methodology draws from the work of Jin and Zhang (2011) to identify qualitative PMs, Almarri and Abuhijleh (2017) for expert review, and data for the focus group interviews were gathered from the studies of Yin (2009) and Zhang et al. (2015), project documentation review from Saeed et al. (2018), and site observations from Trangkanont and Charoenngam (2014), methodologies previously employed in studies concerning performance evaluation frameworks for PPP projects.

The first stage of the research commenced with a comprehensive literature review aimed at identifying risk factors, key performance indicators (KPIs) and their corresponding PMs. Various academic sources, including journals, conferences and books, as well as non-academic materials like institutional reports and archives, were extensively consulted in this stage. Initially, KPIs were extracted from relevant studies conducted in developing countries (Liu et al. 2016; Noor and Khalfan 2017; Mazher et al. 2018; Ullah et al. 2018; Soomro et al. 2020; Ahmad et al. 2022). Subsequently, a meticulous review of 91 pertinent articles was conducted to augment the theoretical foundation. From these efforts, a total of 99 Risk Factors and 114 PMs were distilled from the literature, highlighting the extensive spectrum of PPP performance within the framework of the iron triangle concept (Liu et al. 2016). Questionnaires are designed based on insights from the literature review and undergo iterative refinement. A two-phase approach is employed, starting with a pilot survey to refine the questionnaire design to incorporate additional PMs that were not previously integrated, thereby enhancing the comprehensiveness of the framework, The pilot survey was digitally administered, offering considerable savings in time and costs when compared to traditional paper-based methods (Van Selm and Jankowski 2006) followed by the development of a main questionnaire for focussed interviews, where participants rated the significance of responses on a five-point scale, with '5' indicating extreme importance and '1' denoting insignificance. The relative importance of identified PMs and Risk factors were ranked using the relative importance index (RII) analysis method. The RII ranges from 0 to 1 and is used to rank factors based on their importance, with

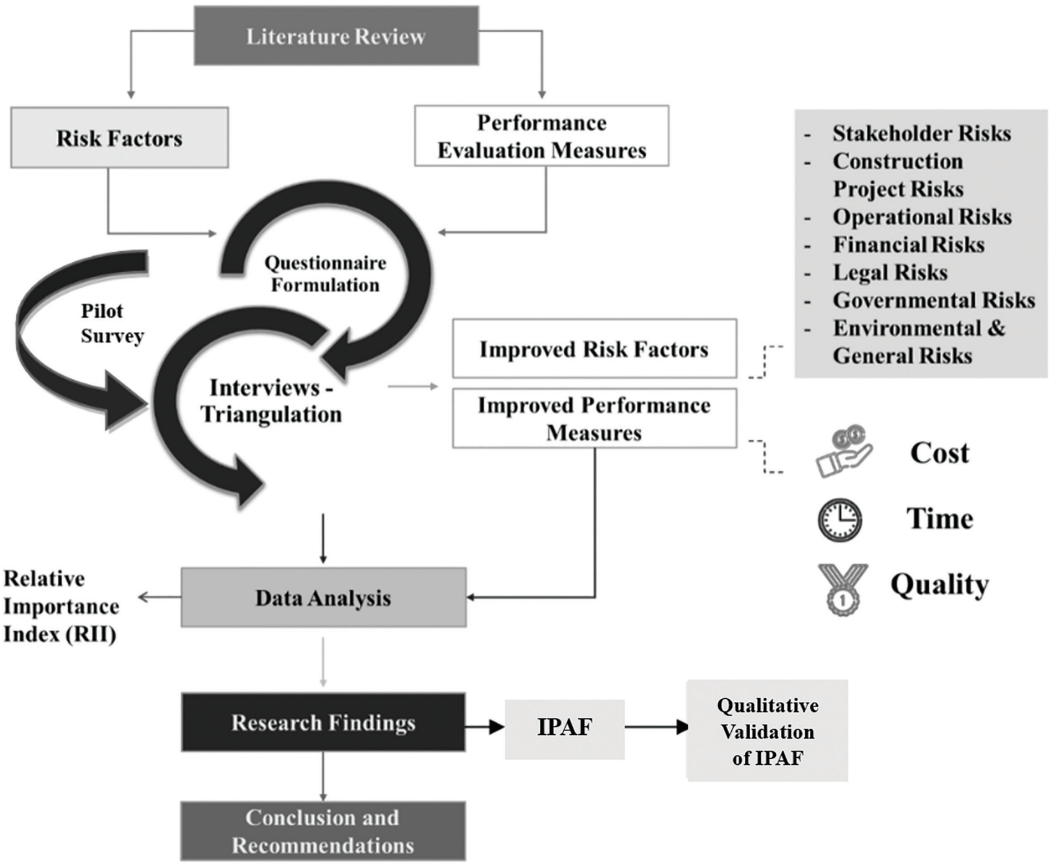

Fig. 1: Theoretical model of research methodology.

higher values indicating greater importance. An RII closer to 1 means that the factor is considered very important, while an RII closer to 0 indicates that the factor is less important. To calculate the relative importance of each item, the following formula was used (Masood et al. 2021)

$$RII = (\Sigma W)/(A \times N) \quad (1)$$

where,
W – weight of each factor (i.e. 1–5)
A – highest weight of factor (i.e. 5)
N – total number of participants.

The higher the likelihood of occurrence, the higher will be the RII Rating. After finding the RII, all the risk factors and PMs were ranked. The frequency of each point on the Likert scale for every risk factor and PM was determined using Statistical Package for Social Sciences (SPSS).

The sample size selection process for this qualitative research is contextual, based on the availability of participants and their level of experience in PPP projects. Baker and Edwards (2012) argue that there is no specific rule regarding the sample size for the number of interviews required in qualitative research, whereas Cresswell (2013) suggests a general rule of thumb for achieving data saturation. After conducting 10 interviews, it became evident that several risk and performance parameters presented similar responses from PPP experts, indicating a saturation point where no new information was gained. Consequently, only 10 interviews were conducted for this research.

The data collection methods involve an initial online questionnaire phase followed by focussed interviews, employing the triangulation method to ensure comprehensive data gathering. Triangulation enhances the validity and reliability of findings by integrating data from multiple sources and methods (Ahmad et al. 2022). To determine the internal consistency for sample reliability, Cronbach's alpha was calculated using the SPSS tool and found to be 0.896 which is >0.7 indicating that data is reliable for further analysis (Tavakol and Dennick 2011).

The second stage involves the analysis of gathered data, the focus of data collection centred around two main components: risk factors and PMs and collation specifically involve mapping risks to the PMs they directly influence (Noor and Khalfan 2017). Regarding risk factors, the categorisation process encompasses two main steps. First,

Tab. 1: Categorised critical risk factors

Stakeholder Risks		**Reference**	**Financial Risks**		**Reference**
SH1	Cultural differences between stakeholders	Ezatabadi et al. (2018)	F1	Financers Unwilling to take risks	Abd Karim (2011)
SH2	Communication Issues	Rasheed et al. (2022)	F2	Improper Risk Allocation	Koike and Hofert (2020)
SH3	Lack of leadership, authority, organisation and coordination	Ezatabadi et al. (2018)	F3	Delay in financial closure	Abd Karim (2011)
SH4	Lack of commitment by a private party	Abd Karim (2011)	F4	Delay in payment of annuity	
Construction Project Risks			F5	Delay in funding	Wang et al. (2020b)
CP1	Improper project feasibility study and planning	Sy et al. (2016)	F6	Concessionaire Change	Xu et al. (2010)
CP2	Incomplete Design	Rasheed et al. (2022)	F7	Change in project cost	Zou et al. (2008), Omoregie Aghimien et al. (2017)
CP3	Improper change order approval process	Chan et al. (2011)	F8	Minimum Revenue Guarantee	Zou et al. (2008)
CP4	Poor definition of scope and change in scope	Rasheed et al. (2022)	F9	Inflation and inaccurate estimate of market demand	Zou et al. (2008), Xu et al. (2010)
CP5	Inappropriate project specification	Wang et al. (2020a)	F10	Inadequate Insurance Coverage	Chan et al. (2015)
CP6	Inadequate Site Investigation	Chan et al. (2015)	F11	Improper Financial Model	Abd Karim (2011)
CP7	Losses to equipment and properties of contractors		**Legal Risks**		
CP8	Documentation Errors	Xu et al. (2015)	L1	Legal Proceedings	Soomro and Zhang (2015)
CP9	Accidents on sites and Injuries	Yuan et al. (2018)	L2	Contractual changes and ambiguities	
CP10	Unavailability of labour and material	Xu et al. (2010)	L3	Lack of federal, state and local permits	Abd Karim (2011)
CP11	Poor Workmanship	Rasheed et al. (2022)	**Governmental Risks**		
CP12	Third-Party Delay and Violation	Xu et al. (2010)	G1	Improper Regulatory Framework	Abd Karim (2011)
Operational Risks			G2	Inconsistency in governmental policies and regulations	
OP1	Low Operating Productivity	Abd Karim (2011)	G3	Lack of political support	Xu et al. (2010)
OP2	Lack of Public Acceptance of PPP Project	Zou et al. (2008)	G4	Change of Government	Zou et al. (2007)
OP3	Unsuitable Concession Period		**Environmental and General Risks**		
OP4	Unpredictable Revenue Generation		EG1	Act of God/Force Majeure Risks	Xu et al. (2010)
OP5	Poor O&M of Project	Qin et al. (2019)	EG2	Corruption	Zou et al. (2007)
OP6	Lack of Compliance of Contract	Rasheed et al. (2022)	EG3	Land Acquisition	Xu et al. (2010)

PPP, public-private partnership.

Tab. 2: KPIs and PMs in PPP projects.

Sr. No.	KPI	Code	PM	Research Question	Measurement	Reference
1.	KPI_1 Cost	PM-1	Construction Cost Variance	What is the disparity between the budgeted and actual construction expenses for the project?	Rupees	Soomro et al. (2020), Ullah et al. (2018) and Yuan et al. (2012)
2.		PM-2	Construction Cost	Was the construction cost optimised effectively?	Yes/No	Heale and Forbes (2013), Mazher et al. (2018) and Ying et al. (2024)
3.		PM-3	Viability of the Financial Model	Is the financial model considered to be feasible?	Yes/No	Guo et al. (2021), Jin et al. (2020) and Ke (2014)
4.		PM-4	VfM	What is the VfM for the project?	Rupees	Buyukyoran and Gundes (2018), Ingle et al. (2021) and Nguyen et al. (2018)
5.	KPI_2 Time	PM-5	Construction Time Variance	What distinguishes the allocated construction time from the actual construction time?	Days	Attarzadeh et al. (2017), Matraeva et al. (2016) and Yuan et al. (2012)
6.		PM-6	Project Completion and Delays	Was there any delay in completing the project?	Yes/No	Guo et al. (2021), Mladenovic et al. (2013)
7.		PM-7	Concession Period and Recovery	Was the concession period utilised optimally?	Yes/No	Malek and Gundaliya (2021), Yong Kim and Thuc (2021)
8.		PM-8	Defect Liability Period	What was the duration of the defect liability period for this project?	Years	Pilot Study
9.	KPI_3 Quality	PM-9	Quality Specified vs Actual Quality	Does the actual quality meet the listed standards?	Yes/No	Ahmadabadi and Heravi (2019), Guo et al. (2021), Osei-Kyei and Chan (2017) and Villalba-Romero and Liyanage (2016)
10.		PM-10	Health and Safety	Were the on-site health and safety provisions sufficiently provided?	Yes/No	Bao et al. (2018), Buertey and Asare (2014)
11.		PM-11	Defects and Problems	Were maintenance duties efficiently executed?	Yes/No	Mohamad et al. (2018), Radujković et al. (2010), Villalba-Romero et al. (2015) and Wang et al. (2020b)
12.		PM-12	Transparency	Were project issues and problems transparently communicated throughout?	Yes/No	Pilot Study
13.		PM-13	Effectiveness	Was the project compliant with the specified standards and objectives?	Yes/No	Pilot Study
14.		PM-14	Efficiency	Was the project executed efficiently?	Yes/No	Cong and Ma (2018)
15.		PM-15	Communication	Was the communication among stakeholders efficient and effective?	Yes/No	Pilot Study
16.		PM-16	Procurement	Were quality products and services procured as required?	Yes/No	Pilot Study

KPI, key performance indicator; PM, performance measure; PPP, public-private partnership; VfM, value for money.

an extensive literature review identifies and categorises risks into eleven distinct categories, including financial, contractual, political, construction and environmental risks, among others. Second, these risks are further segmented based on project phases, including feasibility, construction and operation and maintenance phases. A part of the questionnaire was used to validate and finalise the identified risk categories. The analysis of gathered data includes conducting the RII to measure the significance of both risk factors and PMs (Masood et al. 2021). Table 1 displays the 43 shortlisted risk factors along with their coding chosen for the RII test based on their relevance and occurrence. For the PMs, initially, a literature review compiles relevant PMs for PPP projects. A subsequent survey refines this list through interviews and analysis. The finalised set of 16 PMs out of 114, aligned with the key indicators, is detailed in Table 2, reflecting associations with cost, time and quality considerations. This iterative data collection and analysis process ensures the validity and reliability of the research findings.

In the third stage, the study formulates an IPAF for PPP projects based on 3 KPIs and 16 PMs derived from literature reviews and interviews, addressing the top 10 critical risk factors across various categories including stakeholder, construction project, financial, legal, governmental and environmental risks.

In stage four, the contents of the theoretical IPAF were reviewed by four PPP experts to assess their appropriateness and relevance to PPP projects across the region. This review functioned as an initial exploratory study to ensure alignment with the project's nature and the context of a developing country, precisely focussing on privately financed public sector infrastructure projects in Pakistan. The experts were selected based on their extensive involvement in PPP projects and their experience across various stages of project development. The panel, consisting of four experts, was carefully assembled to ensure a comprehensive evaluation process, each member brings distinct expertise to the table, ensuring that the number of participants is justified based on their relevant experience for the focussed group method (Masood et al. 2023). The first expert held the position of Deputy Director of Contracts (Works) at Punjab Road Road Authority (PRRA). The second expert served as Deputy Director of Engineering (Works) at PRRA. The third expert functioned as a Coordination Manager at LAFCO (Lahore – Sheikhupura – Faisalabad Dual Carriageway) and the fourth expert was the Assistant Manager of Evolutions at the Punjab PPP Authority. All experts possessed relevant qualifications in construction and brought over 10 years of experience in PPP projects, particularly related to highway infrastructure projects.

The consistency of expert responses was ensured through several steps. First, pilot testing of the questionnaire was conducted to resolve any issues and to ensure clarity, subsequently, focus group interviews were carried out to validate and clarify responses further (Yeong et al. 2018). By training participants, maintaining anonymity and randomising response options, we aimed to minimise bias and ensure reliable data (Hallowell and Gambatese 2010). Finally, thorough data analysis helped to identify and address any inconsistencies, thereby enhancing the credibility of our study.

5 Results and Discussion

The results highlight the nuanced approach required for performance measurement in construction projects, emphasising dimensions like cost, time and quality. Synthesising insights from literature reviews and interviews, the study uncovers the complexities of assessing project performance across diverse contexts. Through critical examination, the research contributes to ongoing discourse on effective performance measurement strategies.

The study utilised SPSS for data analysis for processing triangulated data collected through interviews (Lemon and Hayes 2020). Data, structured with a Likert scale, transitioned from qualitative to quantitative during interviews. SPSS performed frequency analysis, and spreadsheets computed the RII for risks, to find the top 10 risks, present in the PPP Industry of Pakistan out of 43 risks. Using the RII found for every risk, the bar chart in Figure 2 was constructed.

Table 3 outlines the top 10 risks as determined by the RII, shedding light on critical factors influencing project outcomes within the study's context. These risks span various categories, each identified by a unique ID. Financial Risk (F-9) emerges as the foremost concern, encompassing challenges related to inflation and inaccurate market demand estimates, which could significantly impact project finances. Environmental and General Risk (EG-1) follows closely, representing unpredictable events like Acts of God or Force Majeure, posing substantial threats to project continuity and progress. Operational Risk (OP-4) highlights the unpredictability of revenue generation, underscoring the importance of financial planning and sustainability measures. Meanwhile, Construction Project Risk (CP-1) underscores the significance of thorough feasibility studies and planning to mitigate potential challenges arising from improper project assessments. Governmental Risk (G-2) reflects the instability caused by inconsistencies in governmental policies

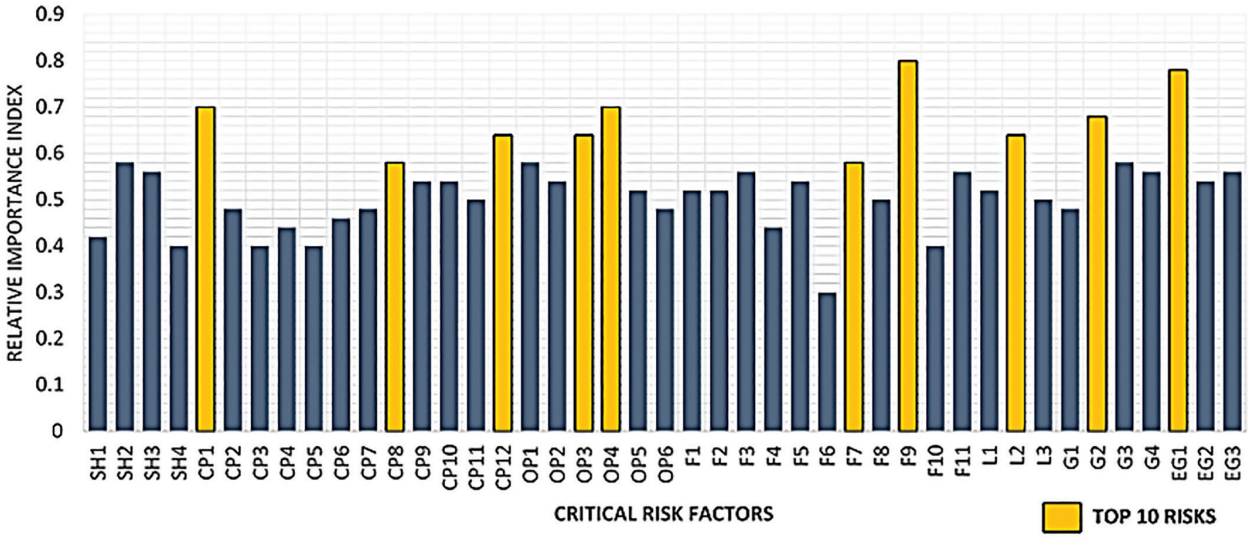

Fig 2: Analysis of top 10 risks in the PPP industry of Pakistan using RII technique. PPP, public-private partnership; RII, relative importance index.

Tab. 3: Top 10 risk ranking by RII

Rank	Risk Category	Risks	RII Value
1	F-9 Financial Risk	Inflation and inaccurate estimate of market demand	0.8
2	EG-1 Environmental and General Risk	Act of God/Force Majeure Risks	0.78
3	OP-4 Operational Risk	Unpredictable Revenue Generation	0.71
4	CP-1 Construction Project Risk	Improper project feasibility study and planning	0.7
5	G-2 Governmental Risk	Inconsistency in governmental policies and regulations	0.68
6	OP-3 Operational Risk	Unsuitable Concession Period	0.643
7	CP-12 Construction Project Risk	Third-Party Delay and Violation	0.642
8	L-2 Legal Risk	Contractual changes and ambiguities	0.64
9	F-7 Financial Risk	Change in project cost	0.581
10	CP-8 Construction Project Risk	Documentation Errors	0.58

RII, relative importance index.

and regulations, which could introduce uncertainty and hinder project execution. Moreover, Operational Risk (OP-3) addresses the suitability of concession periods critical for ensuring project viability and operational efficiency. Construction Project Risk (CP-12) identifies third-party delays and violations as potential impediments to project timelines and contractual agreements. Legal Risk (L-2) emphasises the importance of clear contractual terms to avoid legal complications and disputes stemming from contractual changes and ambiguities. Financial Risk (F-7) relates to fluctuations in project costs, necessitating budgetary flexibility and contingency planning to address unforeseen expenses. Finally, Construction Project Risk (CP-8) underscores the need for accurate documentation to prevent errors that could undermine project integrity and performance. Overall, these risks underscore the multifaceted challenges inherent in PPP projects, emphasising the importance of proactive risk management strategies to ensure successful project delivery and mitigate adverse impacts on project outcomes.

Furthermore, a total of 16 PMs were considered for 3 KPIs: cost, time and quality. Table 4 presents the ranking of PMs based on their RII, offering insights into key areas of focus for assessing project performance. The table categorises PMs according to their respective KPIs and assigns unique IDs to each measure. The top three PMs are respectively for KPI time, cost and quality. Under the KPI_1, PM-6 ranked first due to its importance and it highlights Project

Completion and Delays as a crucial metric for evaluating project timelines and adherence to schedules. Within the KPI_2 category, PM-3 ranked second, assesses the Viability of the Financial Model, emphasising the importance of financial sustainability and feasibility. KPI_3-related PMs include PM-9 which is ranked third, it evaluates Quality Specified vs Actual Quality, indicating the alignment between project specifications and actual outcomes. Lastly PM-15 (Communication) and PM-12 (Transparency) are ranked the lowest as it underscores the importance of safety protocols, effective communication and transparency in project operations. Overall, the table provides a comprehensive overview of performance metrics essential for evaluating PPP project outcomes and ensuring project success. All of these PMs were analysed through the RII technique as shown in Table 4. RII values ranked risks and PMs facilitated during the formulation of a PPP project performance assessment framework.

Key findings included top risk identification and PM ranking, reflecting extensive respondent experience in PPP projects. The analysis pinpointed prominent risk categories and PM importance, laying the groundwork for informed decision-making and risk mitigation strategies.

The performance measurement framework was developed based on the findings already discussed, categorising data according to its significance in PPP project performance measurement. Risks and PMs were organised based on their RII. The framework was structured across three levels: Level 1 – Risk Integration, Level 2 – Risk factors mapping with PMs and Level 3 – CPAF, integration of Risk with PMs in PPP Project Phases.

5.1 Level 1 – risk integration

At Level 1, the focus lies on understanding the relationship between risks. Risks can be either independent or dependent on each other, impacting mitigation strategies.

Based on the approach outlined by Utne et al. (2011), the risk interdependency diagram was developed, as depicted in Figure 3. This diagram illustrates the relationship between the top 10 risks, highlighting both independent and dependent risks.

A Risk Interdependency Diagram is a visual representation that illustrates the relationships between different risks within a system or project, it highlights how various risks interact with each other, showing dependencies and potential impacts (Tamimi 1989). This diagram helps stakeholders understand the complexity of risk scenarios and identify key areas for mitigation and management. The dotted line shows the risks that are independent of each other, while the solid line with an arrowhead shows the independent risk on its tail side and the dependent risk on the arrow side. The dependent risk is affected by the independent risks present at the tail end and thus can occur because of the independent risk. The mitigation strategy for the dependent risk can be the same as that applied to the risk that causes it (Tamimi 1989).

Tab. 4: PMs ranking by RII

Rank	KPIs	ID	Performance Measure (PMs)	RII Value
1	Time	PM-6	Project Completion and Delays	0.98
2	Cost	PM-3	Viability of the Financial Model	0.921
3	Quality	PM-9	Quality Specified vs Actual Quality	0.92
4	Cost	PM-2	Construction Cost	0.902
5	Cost	PM-5	Construction Time Variance	0.901
6	Quality	PM-14	Efficiency	0.90
7	Quality	PM-13	Effectiveness	0.88
8	Quality	PM-16	Procurement	0.86
9	Cost	PM-1	Construction Cost Variance	0.843
10	Quality	PM-11	Defects and Problems	0.841
11	Time	PM-7	Concession Period and Recovery	0.84
12	Cost	PM-4	VfM	0.822
13	Time	PM-8	Defect Liability	0.82
14	Quality	PM-10	Health and Safety	0.8
15	Quality	PM-15	Communication	0.68
16	Quality	PM-12	Transparency	0.66

KPI, key performance indicator; PM, performance measure; RII, relative importance index; VfM, value for money.

Figure 3 provides a visual representation of the interdependency among the top 10 risks, distinguishing between independent and dependent risks. Notably, OP-3 is reliant on a single risk, CP-1. CP-12 exhibits dependence on two risks, namely L-2 and G-2. F-7 demonstrates dependency on three risks: CP-12, F-9 and EG-1 while remaining independent of OP-4. Conversely, OP-4 depends on EG-1, OP-3, CP-1 and F-9, yet remains independent of F-7. Finally, CP-8, G-2, EG-1, L-2, F-9 and CP-1 are autonomous from all other risks, indicating their independent nature within the framework.

5.2 Level 2 – risk and PMs integration

Level 2 explores the connection between risks and the PMs they influence. As depicted in Appendix A, a detailed breakdown of the PMs aligned with KPIs and their associated risk factors along with integration solutions. Each KPI is accompanied by a set of PMs, and each PM is linked with specific risk factors that may impact its performance. For instance, under KPI_1 (Cost), PM-1 (Construction Cost Variance) is influenced by risks such as F-9 (Inflation and inaccurate estimate of market demand) and EG-1 (Act of God/Force Majeure). KPI_2 (Time) includes PM-5 (Construction Time Variance), which is affected by risks including EG-1 (Act of God/Force Majeure) and CP-12 (Third-Party Delay and Violation). Similarly, KPI_3 (Quality) includes PM-9 (Quality Specified vs Actual Quality), which is affected by risks including EG-1 (Act of God/Force Majeure) and CP-1 (Improper project feasibility study and planning).

Appendix A not only identifies the risks associated with specific KPIs and PMs but also provides comprehensive solutions for mitigating these risks, the solutions were

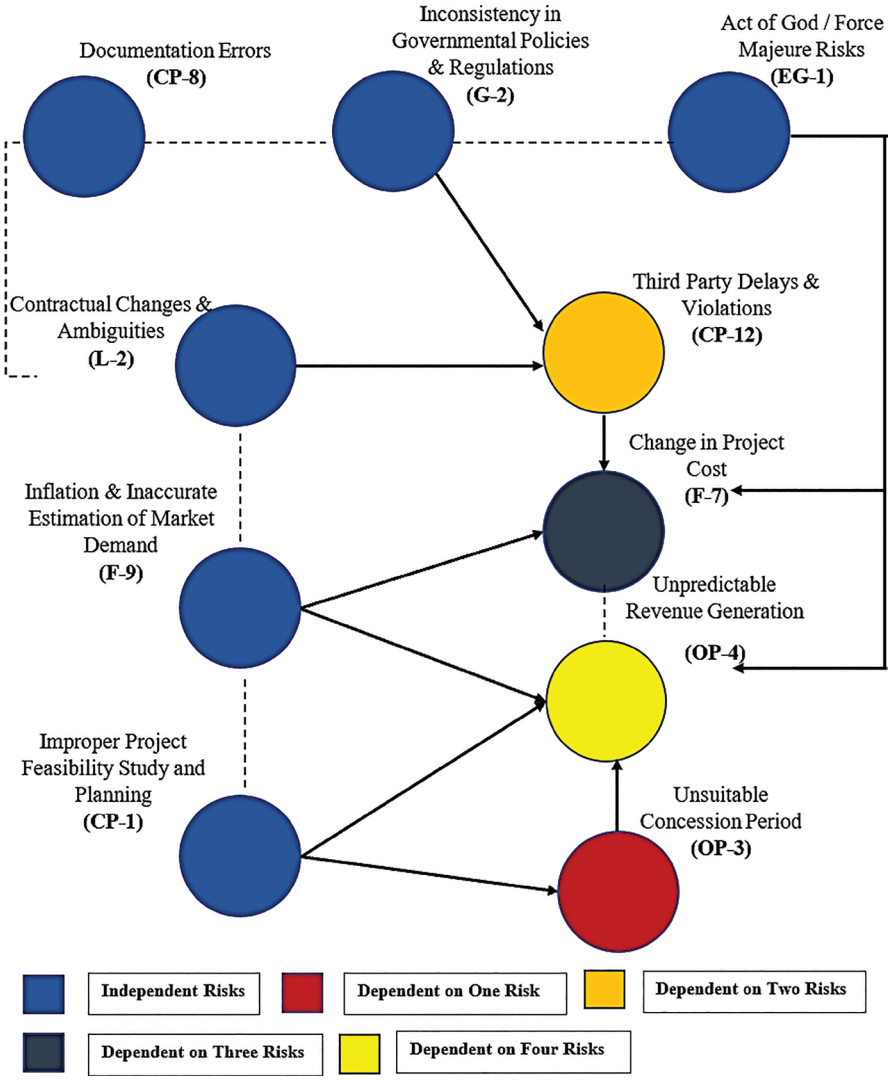

Fig 3: Risk interdependency diagram of top 10 risks.

extracted from literature and expert opinion. These solutions include conducting accurate market research, which allows project managers to better understand market dynamics and anticipate potential fluctuations in costs or demand. Furthermore, transferring risk through insurance coverage provides a safety net against unforeseen events such as Act of God occurrences, ensuring financial stability and minimising losses. Enforcing stringent safety measures on-site is another critical aspect highlighted in the appendix, as it reduces the likelihood of accidents and ensures compliance with regulatory standards. By implementing these suggested mitigation measures, project managers can significantly enhance their ability to execute projects with reduced risk exposure, ultimately contributing to successful project outcomes and stakeholder satisfaction.

5.3 Level 3 – IPAF

Level 3 of the research links risks and PMs with PPP project phases, offering a comprehensive framework for performance measurement as shown in Appendix A. Mitigation strategies are recommended for performance issues encountered across project stages. An influence diagram for each KPI (Cost, Time and Quality) illustrates their impact on project phases and suggests risk management techniques to mitigate negative effects as shown in Figure 4, and the details of each risk integrated with respective PMs are explained in Appendix A.

The conclusion of the study involves aligning risks and PMs with the various phases of PPP projects, resulting in an integrated performance measurement framework. This stage offers a structured approach to assess PPP project performance concerning risks and their management. Additionally, it provides recommendations for mitigating performance issues encountered throughout different project stages. The final framework represents when each PM should be evaluated within the project phases and advocates applying risk management strategies to address any identified issues. The phases considered in a PPP project include Phase-I (Inception), Phase-II (Feasibility, Planning and Design), Phase-III (Tendering and Bidding/Procurement), Phase-IV (Execution) and Phase-V (Operation and Maintenance). The framework provides recommendations for addressing performance issues encountered at various stages of PPP projects. For instance, during Phase II feasibility studies, attention should be given to PM-1, PM-3, PM-4, PM-9, PM-13 and PM-14. In Phase III, which involves tendering and bidding, PM-12 and PM-15 are particularly relevant. In Phase IV, encompassing execution, the focus should be on PM-10, PM-12, PM-15 and PM-16. Finally, during Phase V, the operation and maintenance phase, which is crucial, attention should be directed towards PM-2, PM-3, PM-4, PM-7, PM-9, PM-11, PM-13 and PM-14. This systematic approach ensures that performance issues are adequately addressed throughout the lifecycle of PPP projects. This multi-tiered framework provides a structured approach to evaluate and enhance PPP project performance, offering valuable insights for project management and stakeholders. With detailed analysis and integration of risks and PMs, the framework facilitates informed decision-making and effective risk mitigation strategies throughout the project lifecycle.

5.3.1 KPIs influence diagram

The relationships between risks, PMs and PPP project phases were developed from literature reviews and expert insights. The IPAF was informed by existing research and validated through input from experts in the field. Similarly, the influence diagrams for each KPI (Cost, Time and Quality) in Figure 4 were developed based on both literature findings and expert opinion to illustrate their impact on project phases and suggest risk management techniques.

5.3.1.1 KPI_1 influence diagram-cost

A cost influence diagram for KPI_1 was constructed to assess how risks impact various PMs across different phases of a PPP project, with Figure 4 elucidating these relationships. For instance, PM-1 focusses on Construction Cost Variance, and evaluates deviations between estimated and actual costs, crucial for financial performance evaluation, especially during the pre-feasibility, feasibility and execution stages. Among the top risks, F-9 (Inflation and Inaccurate Estimation of Market Demand) and EG-1 (Act of God/Force Majeure) significantly influence Construction Cost Variance, with suggested mitigation strategies including accurate estimation and risk transfer. Similarly, PM-2, addressing overall Construction Cost, is directly affected by risks like EG-1 and F-7 (Change in Project Cost), with mitigation strategies involving risk transfer and meticulous feasibility studies. PM-3, evaluating the Viability of the Financial Model, encounters risks such as OP-4 (Unpredictable Revenue Generation) and CP-1 (Improper Project Feasibility Studies and Planning), with mitigation strategies including revenue scenario planning and precise feasibility studies. Finally, PM-4, assessing VfM, faces similar risks, with strategies focussing on revenue

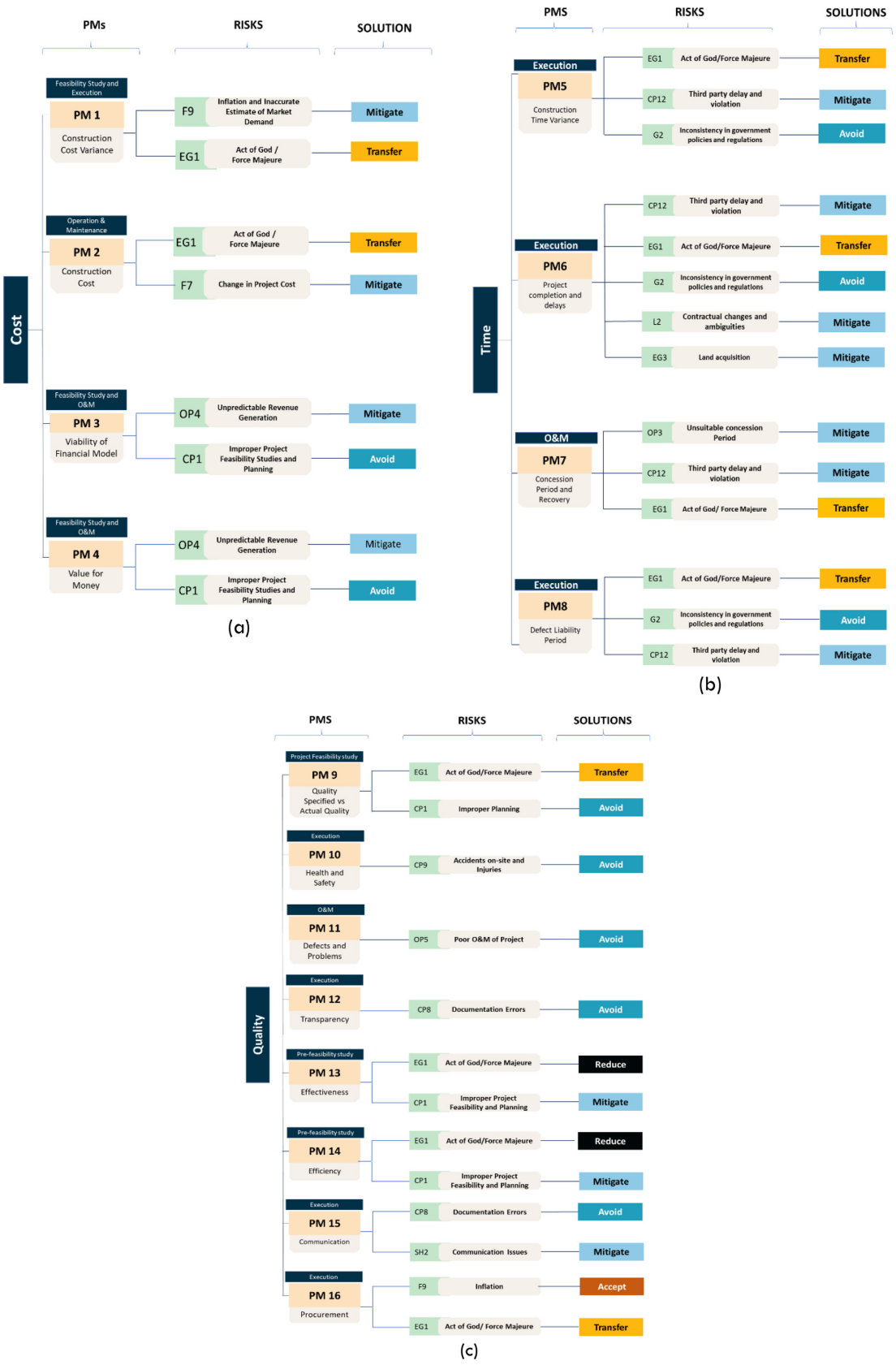

Fig 4: Influence diagram illustrating the impact of risks on PMs in PPP projects (integrating iron triangle). (A) Cost influence diagram, (B) Time influence diagram and (C) Quality influence diagram (right). PM, performance measure; PPP, public-private partnership.

estimation accuracy and rigorous feasibility studies. Implementing these strategies ensures optimal project performance and quality, maintaining a balance between benefits and costs across project stages, while addressing changing social and economic contexts.

5.3.1.2 KPI_2 influence diagram-time

A time influence diagram for KPI_2 was developed to assess how risks affect different performance metrics across various phases of a PPP project, as depicted in Figure 4, with a focus on evaluating Time-related KPIs. Most time-related issues occur during the project's execution phase, while the efficiency of the concession period is scrutinised during the operations phase. Primarily, the execution phase focusses on assessing PMs related to time, notably PM-5 Construction Time Variance, influenced by risks such as EG-1 Force Majeure, CP-12 Third Party Delays and Violation and G-2 Inconsistency in Governmental Policies and Regulations. These risks, occurring during execution, necessitate robust mitigation strategies. For instance, the transfer of Force Majeure risks to third parties like insurance companies mitigates delays, while negotiations mitigate third-party violations. Moreover, consistent governmental policies and clear contractual terms help avert delays caused by policy inconsistencies and contractual ambiguities. In the context of project completion and delays PM-6, risks including third-party delays, Force Majeure events and governmental policy inconsistencies impact project schedules and require similar mitigation efforts. Notably, addressing land acquisition challenges through compensation and pre-planning mitigates delays inherent to PPP projects. Additionally, during the concession period PM-7, risks like unsuitable concession periods, third-party delays and Force Majeure events require proactive measures such as clear communication, risk assessment and transferring risks to third parties to maintain project timelines. Finally, in managing the defect liability period PM-8, strategies like risk transfer, avoidance of policy inconsistencies and mitigation of third-party delays ensure efficient defect rectification within the stipulated timeframe, safeguarding project schedules and performance metrics across all phases.

5.3.1.3 KPI_3 influence diagram-quality

A quality influence diagram for KPI_3 has been devised to assess the impact of risks on various PMs throughout different phases of a PPP project, as depicted in Figure 4. PM-9, focussing on Quality Specified vs Actual Quality, emphasises the alignment between contractual standards and actual project outcomes, crucial for project success and stakeholder satisfaction. Misalignment between these two can jeopardise project success, stakeholder satisfaction and reputation. Risks such as CP-1 Improper Planning and EG-1 Act of God/Force Majeure can impede quality attainment, necessitating meticulous monitoring and control procedures during the operation phase to ensure adherence to set criteria. Mitigation strategies involve avoiding poor planning through thorough risk assessment and transferring force majeure risks to external parties. Another vital parameter is PM-10 Health and Safety, which highlights the importance of stringent adherence to health and safety standards throughout the execution phase to prevent accidents and injuries CP-9, thereby enhancing project productivity and reputation. The risk of on-site accidents and injuries underscores the need for robust safety protocols and training. An avoidance strategy involving strict safety procedures, training and routine inspections is recommended to mitigate this risk and maintain project quality. Furthermore, PM-11 Defects and Problems emphasises the significance of promptly identifying and rectifying flaws to minimise their negative impact on project performance and quality. Risks like OP-5 Ineffective operation and maintenance procedures pose a risk to quality, necessitating robust planning and implementation of O&M protocols. Avoidance strategies involving strong contractual requirements and qualified service providers can mitigate this risk and ensure ongoing quality and durability. PM-12 Transparency is critical for fostering stakeholder trust and accountability, thus improving project coordination and decision-making. Risks like CP-8 Documentation errors and communication issues can undermine transparency, highlighting the need for standardised templates, quality control measures and proactive communication strategies. Mitigation involves avoiding errors through standardised processes and mitigating communication issues through open dialogue and efficient project management techniques. PM-13, evaluating Effectiveness, underscores the importance of mitigating risks such as EG-1 Act of God/Force Majeure and CP-1 Improper Project Feasibility Study and Planning through early consideration and mitigation planning. PM-14, concerning Efficiency, emphasises cost-effectiveness and resource management, with risks mitigated through strategies like resilient design and thorough risk assessment. PM-15, addressing Communication, emphasises clarity and openness, with risks like CP-8 Documentation Error and SH-2 Communication Issues managed through standardised documentation and proactive communication strategies. Finally, PM-16, focussing on Procurement, highlights fair selection and VfM, with risks like F-9 Inflation and EG-1 Act of God/Force

Majeure managed through acceptance and transfer strategies, ensuring quality standards are upheld throughout the project lifecycle.

5.4 Expert review on CPAF

In the final stage of the research, the theoretical framework was scrutinised by four experts to ensure its appropriateness and alignment with the project context, especially considering the unique nature of public projects in Pakistan. The experts' extensive experience in PPP projects enabled them to assess the framework's relevance and applicability effectively.

The experts also meticulously evaluated the framework's alignment with the 2017 PPP Law, ensuring coherence and consistency with established legal and regulatory mandates (Malek & Gundaliya, 2021). This systematic alignment not only enhances the framework's practical relevance but also fosters transparency, accountability and regulatory compliance within the PPP ecosystem.

Their feedback and insights provided valuable qualitative validation, enhancing the framework's robustness and ensuring its suitability for assessing PPP project performance. This collaborative effort between experts with diverse backgrounds and expertise strengthened the framework's credibility and effectiveness in evaluating PPP projects in Pakistan.

6 Limitations and future scope of research

Despite the detailed methodology employed in this study, several limitations and opportunities for future research should be noted. First, though the RII is effective in ranking the factors, it may not fully capture the complexity of interdependent variables in PPP projects. Future studies could enhance understanding by integrating advanced statistical methods such as factor analysis or Garrett's ranking technique to explore factor interactions and dependencies. The study utilised a relatively small sample size, based on participant availability and expertise in PPP projects, enhancing external validity but may limit the generalisability of results. Future research should consider expanding the sample size and diversifying participant demographics and project contexts to improve broader applicability. Though the IPAF predominantly focusses on PPP projects in Pakistan it can be applicable in other developing countries as well, its applicability may vary across different project types and geographical contexts. Validation through case studies across diverse sectors and regions is essential. Future research could also refine the framework by adapting it to specific project characteristics and local regulatory environments, incorporating feedback loops for iterative improvement based on real-world applications. Finally, critiques and advancements in methodology, as highlighted by recent literature (Johnson and LeBreton 2004; Vibhute et al. 2023), underscore the ongoing need for methodological refinements in utilising RII and other quantitative approaches in risk management studies. Future studies should explore these refinements to deepen the understanding of risk factors and management practices in PPP projects. In conclusion, while the IPAF represents a significant advancement in PPP project assessment frameworks, addressing these limitations and exploring future research avenues will enhance its applicability, effectiveness and contribution to infrastructure development practices on a broader scale.

7 Conclusions

The conclusions drawn from this study underscore the critical role of PPPs as a developmental tool, particularly in challenging economic conditions like those in Pakistan. It emphasises the necessity for governments to raise awareness among policymakers, decision-makers and the public to ensure the success of PPP transactions. Monitoring and evaluation (M&E) of PPP projects emerge as vital components in delivering VfM, yet the existing literature lacks IPAFs both locally and globally. This study addresses this gap by introducing a systematic approach to assess PPP project performance, focussing on risk measurement across various project phases. Through a rigorous literature review, 99 critical risk factors were identified and 43 were selected for further analysis. These risks encompass stakeholder, construction, operation, financial, legal, governmental and environmental dimensions, aligning with three KPIs: cost, time and quality, supported by 16 PMs, which were shortlisted from 114 PMs, validated through expert opinion and applicable across different project phases and contexts. Structured interviews with experienced PPP industry professionals validated the significance of identified risks and PMs, highlighting key concerns such as inflation, force majeure events and project completion delays. Integrating these findings, a performance assessment framework was developed, emphasising the importance of assessing project phases, PMs and associated risks.

The proposed framework provides a structured approach for evaluating PPP project outcomes and success across various dimensions such as financial, environmental and social factors. It emphasises the importance of continuous M&E throughout the project lifecycle to ensure optimal performance. By explicitly linking risks to PMs, the framework enables stakeholders to develop effective risk mitigation strategies. In conclusion, the study underscores the significance of PPP performance evaluation in improving project outcomes, mitigating risks and promoting transparency and accountability in infrastructure development initiatives. The proposed IPAF will serve as a valuable tool for stakeholders navigating PPP implementations, fostering more effective and sustainable development efforts in Pakistan and beyond.

The IPAF for PPP projects applies to various stakeholders, including government agencies, private investors and project managers. To effectively utilise the IPAF, stakeholders must have access to comprehensive project data, encompassing financial records, stakeholder feedback and expert opinions to validate risks and PMs. Additionally, conducting a comprehensive literature review ensures alignment with global best practices, while understanding government policies and regulations provides essential context. The framework's effectiveness is further enhanced through meticulous project documentation, monitoring tools and active stakeholder engagement. By leveraging these resources, stakeholders can assess PPP project outcomes, pinpoint areas for improvement and make well-informed decisions to optimise project performance and achieve developmental objectives. It's worth noting that IPAF operates on a time-bound approach, where project evaluation occurs within predefined time intervals, such as quarterly or annually, ensuring ongoing assessment and improvement.

However, the study acknowledges limitations in the framework, such as its focus on water supply, sewerage, road and bridge construction projects. Future research opportunities include expanding case studies, contextualising the framework across different project types and countries and accommodating stakeholder-specific amendments for broader applicability. The proposed performance evaluation framework should undergo validation through case studies and practical implementations to assess its effectiveness and applicability. Continuous monitoring and adaptation of the framework are essential to align with evolving project requirements and changing circumstances. Establishing a standardised rating scale based on this framework would enhance comparability and evaluation consistency across PPP projects. Conducting thorough pre-feasibility studies is imperative to ensure cost-efficient PPP projects. Revenue generation projections must be meticulously examined, considering potential force majeure events and their impact on revenue streams. Mitigation strategies should be developed early in the project lifecycle to minimise cost overruns and ensure VfM for project stakeholders. Rigorous monitoring of time-based performance should occur during project execution and construction stages. Factors such as force majeure events, third-party delays and governmental policies should be accounted for during project planning, with appropriate mitigation strategies proposed to mitigate delays. Concession periods should be optimised considering revenue generation factors and potential disruptions. Quality assurance measures should be implemented during project execution and operation stages, focussing on identifying and rectifying defects and problems promptly. Indirect factors impacting project quality, including transparency, effectiveness, efficiency, stakeholder communication and procurement processes, should also be carefully evaluated. Risks affecting these aspects should be systematically addressed to uphold project quality standards.

References

Abd Karim, N. A. (2011). Risk allocation in public private partnership (PPP) project: A review on risk factors. *International Journal of Sustainable Construction Engineering Technology,* 2(2), 8-16.

Ahmad, Z., Mubin, S., Masood, R., Ullah, F., & Khalfan, M. (2022). Developing a performance evaluation framework for public private partnership projects. *Buildings,* 12(10), p. 1563. doi: 10.3390/buildings12101563

Ahmadabadi, A. A., & Heravi, G. (2019). The effect of critical success factors on project success in public-private partnership projects: A case study of highway projects in Iran. *Transport Policy,* 73, pp. 152-161. doi: 10.1016/j.tranpol.2018.07.004

Akintoye, A., Hardcastle, C., Beck, M., Chinyio, E., & Asenova, D. (2003). Achieving best value in private finance initiative project procurement. *Construction Management Economics,* 21(5), pp. 461-470. doi: 10.1080/0144619032000087285

Almarri, K., & Abuhijleh, B. (2017). A qualitative study for developing a framework for implementing public–private partnerships in developing countries. *Journal of Facilities Management,* 15(2), pp. 170-189. doi: 10.1108/JFM-07-2016-0031

Attarzadeh, M., Chua, D. K., Beer, M., & Abbott, E. L. (2017). Options-based negotiation management of PPP–BOT infrastructure projects. *Construction Management Economics,* 35(11–12), pp. 676-692. doi: 10.1080/01446193.2017.1325962

Baker, S. E., & Edwards, R. (2012). How many qualitative interviews is enough. Retrieved from United Kingdom: https://eprints.ncrm.ac.uk/id/eprint/2273/4/how_many_interviews.pdf

Bao, F., Chan, A. P., Chen, C., & Darko, A. (2018). Review of public–private partnership literature from a project lifecycle

perspective. *Journal of Infrastructure Systems,* 24(3), p. 04018008. doi: 10.1061/(ASCE)IS.1943-555X.0000424

Bassioni, H. A., Price, A. D., & Hassan, T. M. (2004). Performance measurement in construction. *Journal of Management in Engineering,* 20(2), pp. 42-50. doi: 10.1061/(ASCE)0742-597X(2004)20:2(42)

Berisha, A., Kruja, A., & Hysa, E. (2022). Perspective of critical factors toward successful public–private partnerships for emerging economies. *Administrative Sciences,* 12(4), p. 160. doi: 10.3390/admsci12040160

Bing, L., Akintoye, A., Edwards, P. J., & Hardcastle, C. (2005). The allocation of risk in PPP/PFI construction projects in the UK. *International Journal of Project Management,* 23(1), pp. 25-35. doi: 10.1016/j.ijproman.2004.04.006

Bititci, U. S. (2015). Managing Business Performance: The Science and the Art. Chichester, UK: John Wiley & Sons.

Borole, T. D. (2022). The Effectiveness of Public Private Partnerships in the Development of Road Infrastructure: The Case of Toll Concessions in South Africa. North-West University, South Africa.

Bourne, M., Franco-Santos, M., Micheli, P., & Pavlov, A. (2018). Performance measurement and management: A system of systems perspective. *International Journal of Production Research,* 56(8), pp. 2788-2799. doi: 10.1080/00207543.2017.1404159

Brinkerhoff, D. W., & Brinkerhoff, J. M. (2011). Public–private partnerships: Perspectives on purposes, publicness, and good governance. *Public Administration Development,* 31(1), pp. 2-14. doi: 10.1002/pad.584

Buertey, J. I. T., & Asare, S. K. (2014). Public private partnership in Ghana: A panacea to the infrastructural deficit. *International Journal of Construction Engineering Management,* 3, pp. 135-143.

Buyukyoran, F., & Gundes, S. (2018). Optimized real options-based approach for government guarantees in PPP toll road projects. *Construction Management Economics,* 36(4), pp. 203-216. doi: 10.1080/01446193.2017.1347267

Chan, A. P., Lam, P. T., Wen, Y., Ameyaw, E. E., Wang, S., & Ke, Y. (2015). Cross-sectional analysis of critical risk factors for PPP water projects in China. *Journal of Infrastructure Systems,* 21(1), p. 04014031. doi: 10.1061/(ASCE)IS.1943-555X.0000214

Chan, A. P., Yeung, J. F., Yu, C. C., Wang, S. Q., & Ke, Y. (2011). Empirical study of risk assessment and allocation of public-private partnership projects in China. *Journal of Management in Engineering,* 27(3), pp. 136-148. doi: 10.1061/(ASCE)ME.1943-5479.0000049

Chinyio, E., & Gameson, R. (2009). Private finance initiative in use. In: A. Akintoye & M. Beck (Eds.), *Policy, finance management for public private partnerships*. pp. 1-26. John Wiley & Sons.

Cong, X., & Ma, L. (2018). Performance evaluation of public-private partnership projects from the perspective of efficiency, economic, effectiveness, and equity: A study of residential renovation projects in China. *Sustainability,* 10(6), p. 1951. doi: 10.3390/su10061951

Cresswell, J. (2013). Qualitative inquiry & research design: Choosing among five approaches. (3rd ed.). United States of America: Sage.

EIB. (2012). *The Guide to Guidance: How to Prepare, Procure and Deliver PPP Projects*. Luxembourg, Belgium. Available at: https://ppp.worldbank.org/public-private-partnership/sites/ppp.worldbank.org/files/documents/EPEC_Guide%20to%20Guidance_EN.pdf.

Esposito, P., & Dicorato, S. L. (2020). Sustainable development, governance and performance measurement in public private partnerships (PPPs): A methodological proposal. *Sustainability,* 12(14), p. 5696. doi: 10.3390/su12145696

Ezatabadi, P. H., Mortazavi, M., & Rajabbeigi, H. (2018). Identifying and investigating variables affecting public private partnerships (PPP) in Iran by importance-performance analysis (IPA). Paper presented at the 11th International Project Management Conference, Iran. https://civilica.com/doc/620768/

Fellows, R. F., & Liu, A. M. (2021). *Research Methods for Construction*. Hoboken, New Jersey, USA: John Wiley & Sons.

Floricel, S., & Miller, R. (2001). Strategizing for anticipated risks and turbulence in large-scale engineering projects. *International Journal of Project Management,* 19(8), pp. 445-455. doi: 10.1016/S0263-7863(01)00047-3

Franco-Santos, M., Lucianetti, L., & Bourne, M. (2012). Contemporary performance measurement systems: A review of their consequences and a framework for research. *Management Accounting Research,* 23(2), pp. 79-119. doi: 10.1016/j.mar.2012.04.001

Grimsey, D., & Lewis, M. K. (2002). Evaluating the risks of public private partnerships for infrastructure projects. *International Journal of Project Management,* 20(2), pp. 107-118. doi: 10.1016/S0263-7863(00)00040-5

Grimsey, D., & Lewis, M. K. (2005). Are public private partnerships value for money? Evaluating alternative approaches and comparing academic and practitioner views. *Accounting Forum,* 29(4), 345-378.

Guo, K., Zhang, L., & Wang, T. (2021). Concession period optimisation in complex projects under uncertainty: A public–private partnership perspective. *Construction Management Economics,* 39(2), pp. 156-172. doi: 10.1080/01446193.2020.1849752

Hallowell, M. R., & Gambatese, J. A. (2010). Qualitative research: Application of the Delphi method to CEM research. *Journal of Construction Engineering Management,* 136(1), pp. 99-107. doi: 10.1061/(ASCE)CO.1943-7862.0000137

Heale, R., & Forbes, D. (2013). Understanding triangulation in research. *Evidence-Based Nursing,* 16(4), pp. 98-98. doi: 10.1136/eb-2013-101494

Henjewele, C., Sun, M., & Fewings, P. (2014). Comparative performance of healthcare and transport PFI projects: Empirical study on the influence of key factors. *International Journal of Project Management,* 32(1), pp. 77-87. doi: 10.1016/j.ijproman.2013.01.008

Hodge, G. (2005). Public–private partnerships: the Australasian experience with physical infrastructure. In: G. A. Hodge & C. Greve (Eds.), *The Challenge of Public–Private Partnerships: Learning from International Experience*. pp. 368. Edward Elgar.

Hodge, G. A., & Greve, C. (2007). Public–private partnerships: An international performance review. *Public Administration Review,* 67(3), pp. 545-558. doi: 10.1111/j.1540-6210.2007.00736.x

Hodge, G. A. (2004). The risky business of public–private partnerships. *Australian Journal of Public Administration,* 63(4), pp. 37-49. doi: 10.1111/j.1467-8500.2004.00400.x

House of Commons Committee of Public Accounts. (2003). *The Operational Performance of PFI Prisons*. London. Available at: https://publications.parliament.uk/pa/cm200203/cmselect/cmpubacc/904/904.pdf.

Ingle, P. V., Mahesh, G., & Deepak, M. D. (2021). Identifying the performance areas affecting the project performance for

Indian construction projects. *Journal of Engineering, Design Technology,* 19(1), pp. 1-20. doi: 10.1108/JEDT-01-2020-0027

Javid, M. (2019). Public and private infrastructure investment and economic growth in Pakistan: An aggregate and disaggregate analysis. *Sustainability,* 11(12), p. 3359. doi: 10.3390/su11123359

Jin, L., Zhang, Z., & Song, J. (2020). Profit allocation and subsidy mechanism for public–private partnership toll road projects. *Journal of Management in Engineering,* 36(3), p. 04020011. doi: 10.1061/(ASCE)ME.1943-5479.0000766

Jin, X.-H., & Zhang, G. (2011). Modelling optimal risk allocation in PPP projects using artificial neural networks. *International Journal of Project Management,* 29(5), pp. 591-603. doi: 10.1016/j.ijproman.2010.07.011

Johnson, J. W., & LeBreton, J. M. J. O. r. m. (2004). History and use of relative importance indices in organizational research. 7(3), pp. 238-257.

Kagioglou, M., Cooper, R., & Aouad, G. (2001). Performance management in construction: A conceptual framework. *Construction Management Economics,* 19(1), pp. 85-95. doi: 10.1080/01446190010003425

Kang, S., Mulaphong, D., Hwang, E., & Chang, C.-K. (2019). Public-private partnerships in developing countries: Factors for successful adoption and implementation. *International Journal of Public Sector Management,* 32(4), pp. 334-351. doi: 10.1108/IJPSM-01-2018-0001

Ke, Y. (2014). Is public–private partnership a panacea for infrastructure development? The case of Beijing National Stadium. *International Journal of Construction Management,* 14(2), pp. 90-100. doi: 10.1080/15623599.2014.899127

Koike, T., & Hofert, M. (2020). Markov chain Monte Carlo methods for estimating systemic risk allocations. *Risks,* 8(1), p. 6. doi: 10.3390/risks8010006

Kumaraswamy, M. M., & Zhang, X. Q. (2001). Governmental role in BOT-led infrastructure development. *International Journal of Project Management,* 19(4), pp. 195-205. doi: 10.1016/S0263-7863(99)00069-1

Lebas, M. J. (1995). Performance measurement and performance management. *International Journal of Production Economics,* 41(1–3), pp. 23-35. doi: 10.1016/0925-5273(95)00081-X

Lemon, L. L., & Hayes, J. (2020). Enhancing trustworthiness of qualitative findings: Using Leximancer for qualitative data analysis triangulation. *The Qualitative Report,* 25(3), pp. 604-614.

Li, Z., & Wang, H. (2023). Exploring risk factors affecting sustainable outcomes of global public–private partnership (PPP) projects: A stakeholder perspective. *Buildings,* 13(9), p. 2140. doi: 10.3390/buildings13092140

Liang, Y., & Jia, H. (2018). Key success indicators for PPP projects: Evidence from Hong Kong. *Journal of Advances in Civil Engineering,* 2018(1), p. 1-10.

Liang, Y., & Wang, H. (2019). Sustainable performance measurements for public–private partnership projects: Empirical evidence from China. *Sustainability,* 11(13), p. 3653. doi: 10.3390/su11133653

Lim, C., & Mohamed, M. Z. (1999). Criteria of project success: An exploratory re-examination. *International Journal of Project Management,* 17(4), pp. 243-248. doi: 10.1016/S0263-7863(98)00040-4

Liu, B., Lu, X., Hu, X., Li, L., & Li, Y. (2022). What's wrong with the public participation of urban regeneration project in China: A study from multiple stakeholders' perspectives. *Engineering, Construction Architectural Management,* 29(1), pp. 91-109. doi: 10.1108/ECAM-03-2020-0175

Liu, J., Love, P. E., Davis, P. R., Smith, J., & Regan, M. (2015). Conceptual framework for the performance measurement of public-private partnerships. *Journal of Infrastructure Systems,* 21(1), p. 04014023. doi: 10.1061/(ASCE)IS.1943-555X.0000210

Liu, J., Love, P. E., Smith, J., Matthews, J., & Sing, C.-P. (2016). Praxis of performance measurement in public-private partnerships: Moving beyond the iron triangle. *Journal of Management in Engineering,* 32(4), p. 04016004. doi: 10.1061/(ASCE)ME.1943-5479.0000433

Love, P. E., & Holt, G. D. (2000). Construction business performance measurement: The SPM alternative. *Business Process Management Journal,* 6(5), pp. 408-416. doi: 10.1108/14637150010352417

Lusthaus, C. (2002). Organizational Assessment: A Framework for Improving Performance. IDRC, Ottawa.

Malek, M., & Gundaliya, P. (2021). Value for money factors in Indian public-private partnership road projects: An exploratory approach. *Journal of Project Management,* 6(1), pp. 23-32. doi: 10.5267/j.jpm.2020.10.002

Masood, R., Lim, J. B., & Gonzalez, V. A. (2021). Performance of the supply chains for New Zealand prefabricated house-building. *Sustainable Cities Society,* 64, p. 102537. doi: 10.1016/j.scs.2020.102537

Masood, R., Roy, K., Gonzalez, V. A., Lim, J. B., & Nasir, A. R. (2023). Modeling relational performance of the supply chains for prefabricated housebuilding in New Zealand. *Smart Sustainable Built Environment*. Vol. ahead-of-print No. ahead-of-print. doi: 10.1108/SASBE-01-2023-0006

Matraeva, L. V., Konov, A. A., Belyak, A. V., Erokhin, S. G., & Vasyutina, E. S. (2016). Public private partnership in social sphere: Models review. *International Journal of Economics Financial Issues,* 6(8), pp. 127-136.

Mazher, K. M., Chan, A. P., Zahoor, H., Khan, M. I., & Ameyaw, E. E. (2018). Fuzzy integral–based risk-assessment approach for public–private partnership infrastructure projects. *Journal of Construction Engineering Management,* 144(12), p. 04018111. doi: 10.1061/(ASCE)CO.1943-7862.0001573

Mladenovic, G., Vajdic, N., Wündsch, B., & Temeljotov-Salaj, A. (2013). Use of key performance indicators for PPP transport projects to meet stakeholders' performance objectives. *Built Environment Project Asset Management,* 3(2), pp. 228-249. doi: 10.1108/BEPAM-05-2012-0026

Mohamad, R., Ismail, S., & Mohd Said, J. (2018). Performance indicators for public private partnership (PPP) projects in Malaysia. *Journal of Economic Administrative Sciences,* 34(2), pp. 137-152. doi: 10.1108/JEAS-04-2017-0018

Nawaz, A., Waqar, A., Shah, S. A. R., Sajid, M., & Khalid, M. I. (2019). An innovative framework for risk management in construction projects in developing countries: Evidence from Pakistan. *Risks,* 7(1), p. 24. doi: 10.3390/risks7010024

Nguyen, A., Mollik, A., & Chih, Y.-Y. (2018). Managing critical risks affecting the financial viability of public–private partnership projects: Case study of toll road projects in Vietnam. *Journal of*

Construction Engineering Management, 144(12), p. 05018014. doi: 10.1061/(ASCE)CO.1943-7862.0001571

Nguyen, T. C., Vu, T. N., Vo, D. H., & McAleer, M. (2020). Systematic risk at the industry level: A case study of Australia. *Risks,* 8(2), p. 36. doi: 10.3390/risks8020036

Noor, M. A., & Khalfan, M. (2017). Public private partnership in transport sector projects in Pakistan. *International Journal of Critical Infrastructures,* 13(1), pp. 70-92. doi: 10.1504/IJCIS.2017.083643

Nudurupati, S. S., Garengo, P., & Bititci, U. S. (2021). Impact of the changing business environment on performance measurement and management practices. *International Journal of Production Economics,* 232, p. 107942. doi: 10.1016/j.ijpe.2020.107942

Office of Government Commerce. (2002). *Green Public Private Partnerships – A Guidance Note on How to Include Environmental Considerations within PPPs and PFI Projects*. Norwich. Available at: https://www.thenbs.com/PublicationIndex/documents/details?Pub=OGC&DocID=266643

Omoregie Aghimien, D., Osanyinro, O., & Fadeke Adegbembo, T. (2017). Cost and time performance of traditional-, direct labour-and management-procured public projects in Ondo State, Nigeria. *J Organization, Technology Management in Construction: An International Journal, 9*(1), pp. 1593-1603. doi: 10.1515/otmcj-2016-0022

Osei-Kyei, R., & Chan, A. P. (2017). Risk assessment in public-private partnership infrastructure projects: Empirical comparison between Ghana and Hong Kong. *Construction Innovation,* 17(2), pp. 204-223. doi: 10.1108/CI-08-2016-0043

Pongsiri, N. (2002). Regulation and public-private partnerships. *International Journal of Public Sector Management,* 15(6), pp. 487-495. doi: 10.1108/09513550210439634

Qin, Y., Ding, X., & Chen, C. (2019). Contract realization of risk allocation plan for PPP Municipal infrastructure projects in China: A case study. *Paper presented at the IOP Conference Series: Earth and Environmental Science,* Dalian, China.

Qureshi, T. M., Warraich, A. S., & Hijazi, S. T. (2009). Significance of project management performance assessment (PMPA) model. *International Journal of Project Management,* 27(4), pp. 378-388. doi: 10.1016/j.ijproman.2008.05.001

Radujković, M., Vukomanović, M., & Dunović, I. B. (2010). Application of key performance indicators in South-Eastern European construction. *Journal of Civil Engineering Management,* 16(4), pp. 521-530.

Rasheed, N., Shahzad, W., Khalfan, M., & Rotimi, J. O. B. (2022). Risk identification, assessment, and allocation in PPP projects: A systematic review. *Buildings,* 12(8), p. 1109. doi: 10.3390/buildings12081109

Regan, M., Smith, J., & Love, P. (2011a). Impact of the capital market collapse on public-private partnership infrastructure projects. *Journal of Construction Engineering Management,* 137(1), pp. 6-16. doi: 10.1061/(ASCE)CO.1943-7862.0000245

Regan, M., Smith, J., & Love, P. (2011b). Infrastructure procurement: Learning from private–public partnership experiences 'down under'. *Environment and Planning C: Government and Policy,* 29(2), pp. 363-378. doi: 10.1068/c10122b

Roth, L. (2004). *Privatisation of Prisons*. Available at: https://apo.org.au/node/4371

Saeed, A. M., Duffield, C., & Hui, F. K. P. (2018). An enhanced framework for assessing the operational performance of public-private partnership school projects. *Built Environment Project Asset Management,* 8(2), pp. 194-214. doi: 10.1108/BEPAM-07-2017-0041

Sardi, A., Sorano, E., Ferraris, A., & Garengo, P. (2020). Evolutionary paths of performance measurement and management system: The longitudinal case study of a leading SME. *Measuring Business Excellence,* 24(4), pp. 495-510. doi: 10.1108/MBE-01-2020-0016

Sarvari, H., Valipour, A., Yahya, N., Noor, N. M., Beer, M., & Banaitiene, N. (2019). Approaches to risk identification in public–private partnership projects: Malaysian private partners' overview. *Administrative Sciences, 9*(1), p. 17. doi: 10.3390/admsci9010017

Smith, M., & Bititci, U. S. (2017). Interplay between performance measurement and management, employee engagement and performance. *International Journal of Operations Production Management,* 37(9), pp. 1207-1228. doi: 10.1108/IJOPM-06-2015-0313

Solomon, P. J., & Young, R. R. (2007). *Performance-Based Earned Value*. Citeseer: Wiley-IEEE.

Soomro, M. A., & Zhang, X. (2015). Roles of private-sector partners in transportation public-private partnership failures. *Journal of Management in Engineering,* 31(4), p. 04014056. doi: 10.1061/(ASCE)ME.1943-5479.0000263

Soomro, M. A., & Zhang, X. (2016). Evaluation of the functions of public sector partners in transportation public-private partnerships failures. *Journal of Management in Engineering,* 32(1), p. 04015027. doi: 10.1061/(ASCE)ME.1943-5479.0000387

Soomro, M. A., Li, Y., & Han, Y. (2020). Socioeconomic and political issues in transportation public–private partnership failures. *IEEE Transactions on Engineering Management,* 69(5), pp. 2073-2087. doi: 10.1109/TEM.2020.2997361

Sy, D. T., Likhitruangsilp, V., Onishi, M., & Nguyen, P. T. (2016). Impacts of risk factors on the performance of public-private partnership transportation projects in Vietnam. *ASEAN Engineering Journal,* 5(1), pp. 49-71. doi: 10.11113/aej.v5.15471

Szemere, T. P., Garai-Fodor, M., & Csiszárik-Kocsir, ÁJ. R. (2021). Risk approach – Risk hierarchy or construction investment risks in the light of interim empiric primary research conclusions. *Risks,* 9(5), p. 84. doi: 10.3390/risks9050084

Tamimi, S. T. (1989). An influence diagramming based risk analysis system. University of Colorado at Boulder.

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *J International Journal of Medical Education,* 2, p. 53.

Thomas, A., Kalidindi, S. N., & Ananthanarayanan, K. (2003). Risk perception analysis of BOT road project participants in India. *Construction Management Economics,* 21(4), pp. 393-407. doi: 10.1080/0144619032000064127

Trangkanont, S., & Charoenngam, C. (2014). Critical failure factors of public-private partnership low-cost housing program in Thailand. *Engineering, Construction Architectural Management,* 21(4), pp. 421-443. doi: 10.1108/ECAM-04-2012-0038

Ullah, F., Ayub, B., Siddiqui, S. Q., & Thaheem, M. J. (2016). A review of public-private partnership: Critical factors of concession period. *Journal of Financial Management of Property Construction Management,* 21(3), pp. 269-300.

Ullah, F., Thaheem, M. J., Sepasgozar, S. M., & Forcada, N. (2018). System dynamics model to determine concession period of PPP infrastructure projects: Overarching effects of critical

success factors. *Journal of Legal Affairs Dispute Resolution in Engineering Construction Management,* 10(4), p. 04518022. doi: 10.1061/(ASCE)LA.1943-4170.0000280

Utne, I. B., Hokstad, P., & Vatn, J. (2011). A method for risk modeling of interdependencies in critical infrastructures. *Reliability Engineering System Safety,* 96(6), pp. 671-678. doi: 10.1016/j.ress.2010.12.006

VAGO. (2002). *Report on Public Sector Agencies*. Melbourne, Australia. Available at: https://www.audit.vic.gov.au/report/report-public-sector-agencies-results-special-reviews-and-other-studies?section=

Valipour, A., Sarvari, H., & Tamošaitiene, J. (2018). Risk assessment in PPP projects by applying different MCDM methods and comparative results analysis. *Administrative Sciences,* 8(4), p. 80. doi: 10.3390/admsci8040080

Van Selm, M., & Jankowski, N. W. (2006). Conducting online surveys. *Quality Quantity,* 40, pp. 435-456. doi: 10.1007/s11135-005-8081-8

Vibhute, S. M., Baviskar, N., Salunke, A. D., & Gajbhar, V. (2023). Economic Importance Index: A New Approach To Quantify And Identify Critical Delay Factors in Construction Projects. *JETIR*, 10(11), 69-73.

Villalba-Romero, F., & Liyanage, C. (2016). Evaluating success in PPP road projects in Europe: A comparison of performance measurement approaches. *Transportation Research Procedia,* 14, pp. 372-381. doi: 10.1016/j.trpro.2016.05.089

Villalba-Romero, F., Liyanage, C., & Roumboutsos, A. (2015). Sustainable PPPs: A comparative approach for road infrastructure. *Case Studies on Transport Policy,* 3(2), pp. 243-250. doi: 10.1016/j.cstp.2015.04.005

Wang, S. Q., Tiong, R. L., Ting, S., & Ashley, D. (2000a). Evaluation and management of foreign exchange and revenue risks in China's BOT projects. *Construction Management Economics,* 18(2), pp. 197-207. doi: 10.1080/014461900370672

Wang, S. Q., Tiong, R. L., Ting, S., & Ashley, D. (2000b). Evaluation and management of political risks in China's BOT projects. *Journal of Construction Engineering Management,* 126(3), pp. 242-250. doi: 10.1061/(ASCE)0733-9364(2000)126:3(242)

Wang, Y., Wang, Y., Wu, X., & Li, J. (2020a). Exploring the risk factors of infrastructure PPP projects for sustainable delivery: A social network perspective. *Sustainability,* 12(10), p. 4152. doi: 10.3390/su12104152

Wang, N., Ma, M., & Liu, Y. (2020b). The whole lifecycle management efficiency of the public sector in PPP infrastructure projects. *Sustainability,* 12(7), p. 3049. doi: 10.3390/su12073049

Ward, J., Dimitriou, H. T., Field, B. G., & Dean, M. (2019). The planning and appraisal of mega transport infrastructure projects delivered by public–private partnerships: The case for the use of policy-led multi-criteria analysis. *J Organization, Technology Management in Construction: An International Journal,* 11(1), pp. 1992-2008. doi: 10.2478/otmcj-2019-0007

Xu, Y., Chan, A. P., & Yeung, J. F. (2010). Developing a fuzzy risk allocation model for PPP projects in China. *Journal of Construction Engineering Management,* 136(8), pp. 894-903. doi: 10.1061/(ASCE)CO.1943-7862.0000189

Xu, Y., Chan, A. P., Xia, B., Qian, Q. K., Liu, Y., & Peng, Y. (2015). Critical risk factors affecting the implementation of PPP waste-to-energy projects in China. *Applied Energy,* 158, pp. 403-411. doi: 10.1016/j.apenergy.2015.08.043

Yeong, M. L., Ismail, R., Ismail, N. H., & Hamzah, M. I. (2018). Interview protocol refinement: Fine-tuning qualitative research interview questions for multi-racial populations in Malaysia. *The Qualitative Report,* 23(11), pp. 2700-2713.

Yin, R. K. (2009). *Case Study Research: Design and Methods*, Vol. 5. Sage, Thousand Oaks.

Ying, G., Mat Isa, C. M., Ab Rani, N. I., & Mustaffa, N. K. (2024). Proposed development of an integrated framework for public–private partnership and value for money evaluation system of urban rail transit in China. In: Hashim, U. R., et al. (eds.), *Green Infrastructure: Materials and Sustainable Management*. Springer, Singapore, pp. 303-315.

Yong, H. K. (2010). Public-Private Partnerships Policy and Practice: A Reference Guide. Commonwealth Secretariat, London.

Yong Kim, S., & Thuc, L. D. (2021). Life cycle performance measurement in public–private partnership infrastructure projects. *Journal of Infrastructure Systems,* 27(4), p. 06021001. doi: 10.1061/(ASCE)IS.1943-555X.0000639

Yuan, J., Li, W., Guo, J., Zhao, X., & Skibniewski, M. J. (2018). Social risk factors of transportation PPP projects in China: A sustainable development perspective. *International Journal of Environmental Research Public Health,* 15(7), p. 1323. doi: 10.3390/ijerph15071323

Yuan, J., Wang, C., Skibniewski, M. J., & Li, Q. (2012). Developing key performance indicators for public-private partnership projects: Questionnaire survey and analysis. *Journal of Management in Engineering,* 28(3), pp. 252-264. doi: 10.1061/(ASCE)ME.1943-5479.0000113

Yuan, J., Zeng, A. Y., Skibniewski, M. J., & Li, Q. (2009). Selection of performance objectives and key performance indicators in public–private partnership projects to achieve value for money. *Construction Management Economics,* 27(3), pp. 253-270. doi: 10.1080/01446190902748705

Yurdakul, H., Kamaşak, R., & Öztürk, T. Y. (2022). Macroeconomic drivers of public private partnership (PPP) projects in low income and developing countries: A panel data analysis. *Borsa Istanbul Review,* 22(1), pp. 37-46. doi: 10.1016/j.bir.2021.01.002

Zhang, J., Zou, W., & Kumaraswamy, M. (2015). Developing public private people partnership (4P) for post disaster infrastructure procurement. *International Journal of Disaster Resilience in the Built Environment,* 6(4), pp. 468-484. doi: 10.1108/IJDRBE-06-2014-0040

Zou, P. X., Wang, S., & Fang, D. (2008). A life-cycle risk management framework for PPP infrastructure projects. *Journal of Financial Management of Property Construction Innovation,* 13(2), pp. 123-142. doi: 10.1108/13664380810898131

Zou, P. X., Zhang, G., & Wang, J. (2007). Understanding the key risks in construction projects in China. *International Journal of Project Management,* 25(6), pp. 601-614. doi: 10.1016/j.ijproman.2007.03.001

Appendix A: Level 2 – Risk Factors and PMs Integration

SR.	KPIs	PMs	Risk Factors	Risk Factors and PMs Integration	Solutions for Risks
1.	KPI1 Cost	PM-1 Construction Cost Variance	F-9: Inflation and inaccurate estimate of market demand	Inflation and Inaccurate Estimation: Improper estimations of inflation and market conditions can result in the construction cost at various stages varying from the estimated costs.	Mitigate – Conduct accurate market research and update budgets periodically.
			EG-1: Act of God/Force Majeure	Act of God/Force Majeure: Unexpected phenomena such as floods, earthquakes, pandemics and so on may cause economic strain in the market, resulting in increased prices of resources.	Transfer – Obtain insurance coverage and enforce safety measures at the construction site.
2.		PM-2 Construction Cost	EG-1: Act of God/Force Majeure	Act of God/Force Majeure: Unexpected phenomena such as floods, earthquakes, pandemics and so on may cause economic strain in the market, resulting in increased prices of resources and ultimately impacting the overall final cost of the project which may be more than that of similar PPP projects.	Transfer – Transfer risk to third parties through insurance.
			F-7: Change in Project Cost	Change in Project Cost: A change in the cost of a project at any phase may have a huge impact on the overall cost of the project.	Mitigate – Conduct comprehensive feasibility studies and adhere to project standards to minimise cost variations.
3.		PM-3 Viability of the Financial Model	OP-4: Unpredictable Revenue Generation	Revenue Generation: If unpredictable then the financial model may not be viable.	Mitigate – Strategies revenue scenarios during feasibility studies and propose efficient VGF Models.
			CP-1: Improper project feasibility study and planning	Feasibility Study and Planning: If not properly done then it may affect the profitability and financial viability of the project.	Avoid – Allocate adequate time and resources to ensure precise feasibility studies and planning.
4.		PM-4 VfM	OP-4: Unpredictable Revenue Generation	Revenue Generation: If unpredictable then the end – product gained may not provide financial benefit to the client, which decreases the VfM of the project.	Mitigate – Estimate revenue with consideration of various factors to maintain project value.
			CP-1: Improper project feasibility study and planning	Feasibility Study and Planning: If not properly done then the final project handed over to the client may not be feasible, resulting in reduced profitability and VfM.	Avoid – Conduct meticulous feasibility studies to ensure quality and cost balance throughout the project lifecycle.
5.	KPI2 Time	PM-5 Construction Time Variance	EG-1: Act of God/Force Majeure	Act of God/Force Majeure: Unexpected phenomena such as floods, earthquakes, pandemics and so on may halt or delay the project, resulting in the actual completion time varying from the estimated time.	Transfer – Transfer force majeure risks to third parties for timely resolution.
			CP-12: Third-Party Delay and Violation	Third-Party Delays and Violation: Issues caused by third parties such as NGOs, environmental bodies and so on may cause time variation.	Mitigate- Address third-party delays through negotiation and pre-contract agreements.
			G-2: Inconsistency in governmental policies and regulations	Inconsistency in Governmental Policies and Regulations: Constantly changing policies and laws regarding PPP Projects, may affect the scheduled tasks and cause delays.	Avoid- Secure political risk insurance to mitigate regulatory inconsistencies.

(*Continued*)

Appendix A: Continued

SR.	KPIs	PMs	Risk Factors	Risk Factors and PMs Integration	Solutions for Risks
6.		PM-6 Project Completion and Delays	CP-12: Third-Party Delay and Violation	Third-Party Delays and Violation: Issues caused by third parties such as NGOs, environmental bodies and so on may shut down the project or cause delays at various stages.	Mitigate-Establish clear communication channels with external entities.
			EG-1: Act of God/Force Majeure	Act of God/Force Majeure: Unexpected phenomena such as floods, earthquakes, pandemics and so on may completely stop or delay the project by causing irrefutable damages.	Transfer – Transfer force majeure risks to third parties.
			G-2: Inconsistency in governmental policies and regulations	Inconsistency in Governmental Policies and Regulations: Constantly changing policies and laws, including issues such as changes in government, may delay its construction and completion.	Avoid – Use governmental policies to maximise voluntary compliance.
			L-2: Contractual Changes and Ambiguities	Contractual Changes and Ambiguities: Due to contract changes, the scope and other parameters of the project may be redefined. Moreover, contract issues can lead to legal proceedings which may cause the project completion to be delayed.	Mitigate – Concretely define contract terms to prevent ambiguity.
			EG-3: Land Acquisition	Land Acquisition: Legal issues related to land acquisition for the PPP Project may cause project delays. These issues are mostly caused when public land is to be bought for construction.	Mitigate – Provide prompt compensation for affected parties.
7.		PM-7 Concession Period and Recovery	OP-3: Unsuitable Concession Period	Unsuitable Concession Period: If the concession period is not appropriate for revenue generation, it may affect the performance of a project concerning its concession period.	Mitigate-Set concession period with consideration of risks.
			CP-12: Third-Party Delay and Violation	Third-Party Delays and Violation: Issues caused by third parties such as NGOs, environmental bodies and so on may cause stay orders or other legal issues that can impact the concession period, by stopping the operation of the project.	Mitigate – Proactively manage and coordinate with external entities.
			EG-1: Act of God/Force Majeure	Act of God/Force Majeure: Unexpected phenomena such as floods, earthquakes, pandemics and so on may impact the generation of revenue, thus requiring an increase in the concession period.	Transfer – Transfer force majeure risks to third parties.
8.		PM-8 Defect Liability Period	EG-1: Act of God/Force Majeure	Act of God/Force Majeure: Unexpected phenomena such as floods, earthquakes, pandemics and so on may delay the defect liability period and thus affect the scheduled defect repair work and ultimately the handover of the PPP Project.	Transfer – Allocate responsibility for force majeure events in contracts.
			G-2: Inconsistency in governmental policies and regulations	Inconsistency in Governmental Policies and Regulations: Changing PPP Policies and political situations, may cause the project to halt during its defect liability period thus ultimately affecting the performance of a project for its defect liability period.	Avoid – Improve coordination and communication among government entities.
			CP-12: Third–Party Delays and Violation	Third-Party Delays and Violations: Third – parties such as NGOs and regulating bodies may intervene and cause delays during the defect liability period.	Mitigate – Take proactive steps to minimise impact of third-party delays.

(*Continued*)

Appendix A: Continued

SR.	KPIs	PMs	Risk Factors	Risk Factors and PMs Integration	Solutions for Risks
9.	KPI3 Quality	PM-9 Quality Specified vs Actual Quality	EG-1: Act of God/Force Majeure	Act of God/Force Majeure: Unexpected phenomena such as floods, earthquakes, pandemics and so on may cause damages on-site which ultimately affect the quality of the project.	Transfer – Utilise insurance policies or contractual agreements to transfer the risk of Act of God events to external parties.
			CP-1: Improper project feasibility study and planning	Improper Planning: If a project is not properly planned during the initial stages, it may lead to quality issues later on, which may deviate from the promised level of quality.	Avoid – Thorough project planning, stakeholder engagement and risk assessment to ensure quality control procedures.
10.		PM-10 Health and Safety	CP-9: Accidents on-site and Injuries	Accidents On-site and Injuries: If the number of accidents and injuries that happened on–site is more, then it affects the Health and Safety performance of the project. Such issues indicate that proper safety provisions were not undertaken on-site.	Avoid – Implement strict safety procedures, provide thorough training and conduct routine site inspections.
11.		PM-11 Defects and Problems	OP-5: Poor O&M of Project	Poor O&M of Project: If a PPP project is not properly maintained during its O&M period, it may lead to defects and problem issues after handover.	Avoid – Establish strong O&M protocols, select qualified service providers and conduct routine inspections.
12.		PM-12 Transparency	CP-8: Documentation Errors	Documentation Error: If documents are not properly maintained and are altered to change cost, schedule, or quality issues, it can lead to transparency problems and ultimately affect the quality of the project, as issues cannot be immediately communicated to relevant bodies due to lack of paperwork.	Avoid – Use standardised templates, stringent quality control and review systems for accurate documentation.
13.		PM-13 Effectiveness	EG-1: Act of God/Force Majeure	Act of God/Force Majeure: Unexpected phenomenon such as floods, earthquakes, pandemics and so on may cause damages on-site which ultimately affect the ability of the project to meet the required standards and goals.	Reduce – Implement early risk identification, contingency planning, resilient design practices and obtain insurance coverage.
			CP-1: Improper Project Feasibility and Planning	Improper Project Feasibility and Planning If a project is not properly planned during the initial stages, it may lead to quality issues later on. Moreover, if a proper feasibility study is not done, it can lead to reduced profitability of a PPP Project which is a major goal for all parties involved.	Mitigate – Conduct thorough risk assessments, engage experienced consultants and incorporate stakeholder input for realistic objectives.
14.		PM-14 Efficiency	EG-1: Act of God/Force Majeure	Act of God/Force Majeure: Unexpected phenomena such as floods, earthquakes, pandemics and so on may cause damages on-site which ultimately affect the quality of the project and thus make the project inefficient.	Reduce- Implement early risk identification, contingency planning and resilient design practices.
			CP-1: Improper Project Feasibility and Planning	Improper Planning: If the project is not properly planned during the initial stages, it may lead to quality issues later on and improper feasibility study impacts revenue generation which leads to inefficiency concerning both quality and cost.	Mitigate – Conduct thorough risk assessments, engage experienced consultants and adapt plans to ensure realistic objectives.

(*Continued*)

Appendix A: Continued

SR.	KPIs	PMs	Risk Factors	Risk Factors and PMs Integration	Solutions for Risks
15.		PM-15 Communication	CP-8: Documentation Errors	Documentation Errors: If documents are not properly maintained or are altered by a third party, it can lead to communication issues between stakeholders.	Avoid – Implement standardised documentation processes, conduct quality checks and encourage accurate information sharing.
			SH-2: Communication Issues	Communication Issues: Experience, work ethic, ambiguities, contract disputes and so on can cause communication issues and may cause an increase in change orders, which can hinder the quality of the project during the execution phase.	Mitigate – Foster open communication, stakeholder engagement and efficient project management for improved understanding.
16.		PM-16 Procurement	F-9: Inflation and inaccurate estimate of market demand	Inflation: An increase in inflation can cause budget constraints which may cause the procuring bodies to compromise on quality to maintain project costs.	Accept – Proactive monitoring of cost fluctuations, transparent price adjustment negotiations and contract clauses for inflation.
			EG-1: Act of God/Force Majeure	Act of God/Force Majeure: Unexpected phenomena such as floods, earthquakes, pandemics and so on can put economic constraints on services and goods, resulting in increased prices. Procuring bodies may have to compromise on quality to maintain project costs.	Transfer – Utilise expertise, resilient design and budget adjustments to mitigate the impact of force majeure events.

KPI, key performance indicator; PPP, public-private partnership; VfM, value for money.