The Effects of Governance Practices on the Performance of the Sri Lankan Public Sector Development Projects

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Abstract

The use of Project Governance Practices (PGPs) is increasingly taking a substantial stage in developing economies, particularly in a newly industrializing nation like Sri Lanka where public sector development projects have been implemented to expedite the nation's growth and prosperity. As it is essential to lay a transparent and tangible foundation for an effective public sector that can be sustained, the paper focuses on the significance of PGPs in enhancing the performance of the Sri Lankan public sector development initiatives. Structuring, normalizing, facilitating, and post-conflict-sensitive variables were used to measure the PGPs, whereas financial and non-financial performance measures were employed to evaluate the project performance. The researcher conducted direct observations and administered a comprehensive Likert-scaled questionnaire to 518 project administrators involved in various Sri Lankan public sector development projects, specifically focusing on projects related to irrigation, roads and highways, water and sanitation, and other infrastructure developmental projects. The data was analyzed using the structural equation modeling through the AMOS software. The results showed that PGPs created a considerable improvement in project performance, which increased support for expanding economic prosperity through balanced development strategies and sustainability-based policy formation.

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1. Introduction

Project governance is an overall framework for ensuring that all stakeholders benefit from the work conducted in a specific project, program, or even portfolio (Waseem et al., 2022). It caters for the projects to operate smoothly within the budgetary limits in order to ensure the attainment of timely deliverables while satisfying all stakeholder requirements (Khan et al., 2021). There are specific components concentrated under this framework, such as project governance scope, roles and responsibilities, stakeholder engagement and communication, meetings, reporting, risk and issue management, assurance, project management control processes, etc. (Khan et al., 2019). These components will influence the creation, implementation, monitoring, and control of the governance framework in all aspects of project operation. In the Sri Lankan scenario, the progress of most public sector development projects is failing behind schedule, or is poor. Previous literature indicates that there are hidden governing and controlling issues in initiating, planning, implementing, monitoring, and controlling project financial, physical, and technical performance that connect with its current practices (Zhao et al., 2021), so that the project's financial and non-financial performance in the public sector is not satisfactory.

Public sector development projects are crucial for accelerating government development strategies and delivering community well-being (Brunet, 2019; Ahola et al., 2014). Project Governance Practices (PGPs) play a significant role in optimal project performance (Kodithuwakku, 2022; Gunawardana et al., 2021; Gunawardana & Karunasena, 2016). Issues like approval, standardization, financial planning, quality assurance, procurement delay, and post-conflict sensitive issues can impact project performance, similar to disaster management and climate change (Jayasundara et al., 2013). However, policies, regulations, functions, processes, procedures, and responsibilities may vary across countries, potentially impacting PGPs and Public Sector Development Projects' (PSDPs) performance (Khan et al., 2019).

This study examines the impact of Public Governance Principles (PGPs) on project performance of PSDPs in Sri Lanka, focusing on financial performance and non-financial performance. It develops a structural equation model to show the association between PGPs and project performance, which can be applied for future planning. Sri Lanka's development strategy is accelerating, and previous studies (Kodithuwakku, 2022; Gunawardana et al., 2021; Gamlath & Nanthagopan, 2017; Gunawardana & Karunasena, 2016; Jayasundara et al., 2013) have focused on controlling governing issues and challenges faced by public sector projects.

2. Literature Review

Project governance is an important debatable discipline in project literature and organizations have used this approach to meet organizational objectives (Khan et al., 2019; Biesenthal & Wilden, 2014). Nevertheless, this study focuses on the effect of PGPs on project performance as doing so is more applicable in the Sri Lankan context. This section discusses the literature pertaining to the research objectives on project initiation, project planning, project implementation, project monitoring and evaluation, and project closing (Project Management Institute, 2021) and highlights the existing gaps in objectives and questions of interest for the present study. The above underpinnings focus on the derivational path for identifying which types or categories of practices that need to be explored for the project's governance. In this context, the project governance scenario in the public sector has been a progressively useful tool in implementing many public programs and their activities (Gamlath & Nanthagopan, 2017).

Project governance is crucial for the success of public sector development projects. Scholars have defined it as the framework for decision-making processes, emphasizing clear roles, responsibilities, and decision-making processes (Turner & Keegan, 2001). Effective governance practices, such as stakeholder involvement, strategic alignment, and performance measurement, are critical for project success. Too & Weaver (2018); Joslin and Muller (2015) emphasize the role of governance in mitigating risks and enhancing project performance. Ahola et al. (2014) emphasize the importance of stakeholder involvement, risk management, and performance measurement in public-sector infrastructure projects. Budzier and Flyvbjerg (2018) emphasize the relationship between governance and cost performance in megaprojects, emphasizing the importance of realistic project planning, accurate cost estimation, and transparency. These findings provide valuable insights into the importance of project governance in achieving successful outcomes in public sector development projects.

Studies show a positive relationship between effective project governance practices and improved public sector development project performance (Gunawardana et al, 2021). Better governance practices, including transparency, accountability, and stakeholder participation, are linked to better project outcomes. As Musawir et al. (2020) emphasized, strong governance practices, such as stakeholder engagement, realistic cost estimation, and clear risk management, lead to better cost and schedule performance. Effective governance mechanisms, such as efficient decision-making processes and robust institutional frameworks, also contribute to project success. The overall trend suggests the importance of good governance for project success (Brunet, 2019; Brunet & Aubry, 2016).

Project governance practices significantly impact project performance, ensuring successful delivery of outcomes and satisfying stakeholders (Joslin & Muller, 2016). Studies have shown a positive relationship between effective governance practices and project success, with factors like stakeholder engagement, decision-making processes, and risk management which significantly influence the project outcomes (Liu & Walker, 1998). In construction projects, good governance practices, including stakeholder involvement, project planning, and communication, positively impacted performance. In public sector building projects, good governance practices, including stakeholder involvement, monitoring, and control mechanisms, were associated with improved performance (Haq et al., 2018; Mbachu & Nkado, 2016; Pardo-del-Val et al., 2012).

Scholars consistently support the notion that effective project governance practices positively impact project performance in public sector development projects (Judgev & Müller, 2005; Osei-Kyei & Chan, 2015; Muller & Lecocurve, 2014). As Khan et al. (2019) emphasized, this relationship is mediated by financial performance, and projects with well-defined governance structures and processes achieve higher financial performance and overall project success. Effective governance practices, such as clear project objectives, stakeholder engagement, and transparent decision-making processes, contribute to improved financial performance and overall project success. However, more recent research is needed to supplement these findings.

The use of project governance practices has an impact on project success and the use of such practices provides strategic and progressive benefits to the organization or project through the project management process (Bos-de Vos et al., 2022; Patanakul et al., 2010). Lawani and Moore (2016) found that the application of project management is still at a primary stage except for a few performances within a few industrial applications. In this case, Gamlath and Nanthagopan (2017); Pulmanis (2016); Lawani and Moore (2016) has emphasized that plans for implementing project management in a developing country should take into consideration the economic, cultural, political, and administrative factors, etc. The authors (Scheepers et al., 2022; Rmit.edu.ac., 2022; Nanthagopan et al., 2016; Jeyakanthan & Jayawardane, 2012; Pulmanis, 2014; Rwelamila & Purushottam, 2012) have explored that the essence of understanding and use of project management practices are the key requirements for improving the management capabilities of public sector organizations and their projects and their successful completion.

Even though the lack of knowledge of PGPs, insufficient time for better understanding and practicability, inadequate personal qualifications, low level of project management competence, and identification of a lack of appropriate organizational structure (Pulmanis, 2014) are the major deficiencies as categorically seen for the operationalization of PGPs in the achievement of best project performance in public sector projects, Therefore, in the Sri Lankan context, it applies

specific common methodological guidance to evaluate the possible benefits of infrastructure, but still, there is a need for improvement, although they have not always been practically used in government authorities' project evaluations. PSDPs in Sri Lanka and the initiation of such projects generally bear the notion that projects are inherently risky due to long policymaking horizons and complex interfaces.

Considering the Project Management Institute (2017), the implementation of a project is a cyclical process to achieve specific outcomes while sustaining a long-term vision through a predetermined logical framework. First, project initiation is a pre-thought deterministic view of one generation to the next. It states that something can be converted into a real-world exposure or never be reached (Project Management Institute, 2021). As emphasized by the project leaders, they initiate projects in response to factors acting upon their projects, thereby fulfilling regulatory, legal, or social requirements; satisfying stakeholders' requests or needs; implementing or changing business and technological strategies; and creating and improving products, processes, and services (Rmit.edu.au., 2022; Perera, n.d.). Due to these considerations, project management practices are used in initiating a particular project, which will require a structured response, which should involve an assessment of such practices in thematic as well as quantitative nature and complying with strategic objectives in a framework, institutional roles and responsibilities, resource base, and assessment of needs (Nanthagopan et al., 2016). As far as the theoretical and empirical coincidences go, the different countries, organizations, researchers, related experts, and the people who engage in practice have used processual strategies in order to identify and frame up the project governance (Giron et al., 2014; Adinyira et al., 2012). According to the origins of project governance, the empirical literature with the above underpinnings (Brunet, 2019; Aaltonen & Sivonen, 2009; Klakegg, 2009; Ruuska et al., 2009; Bredillet, 2008) emphasizes the importance of developing existing, new, or improved processes, systems, methods, and uses of legitimized conduct (Miller & Stawicki, 2008) in nature, as such processual and strategic corresponds through learning and practice to the project implementation. Explorative spirituality in these contextual humanities in project management and governance has been envisioned through the proper identification of proper uses of legitimate formations, frameworks, systems, and methodologies to explore and understand the Project Governance (PG) practices and project performance so that a clear framework on project governance can be developed for conceptualizing, preparing, moderating, and user-friending project implementation, thereby sustaining the project output in this context (Musawir et al., 2017; Breese et al., 2015; Ahola et al., 2014).

Assessing post-conflict settings for development is crucial, as shortcomings include inadequate government and non-government training, investment support, construction materials, administrative technical capacities, bureaucratic processes, uncompetitive quality, low return on investment, and a lack of risk reduction policies

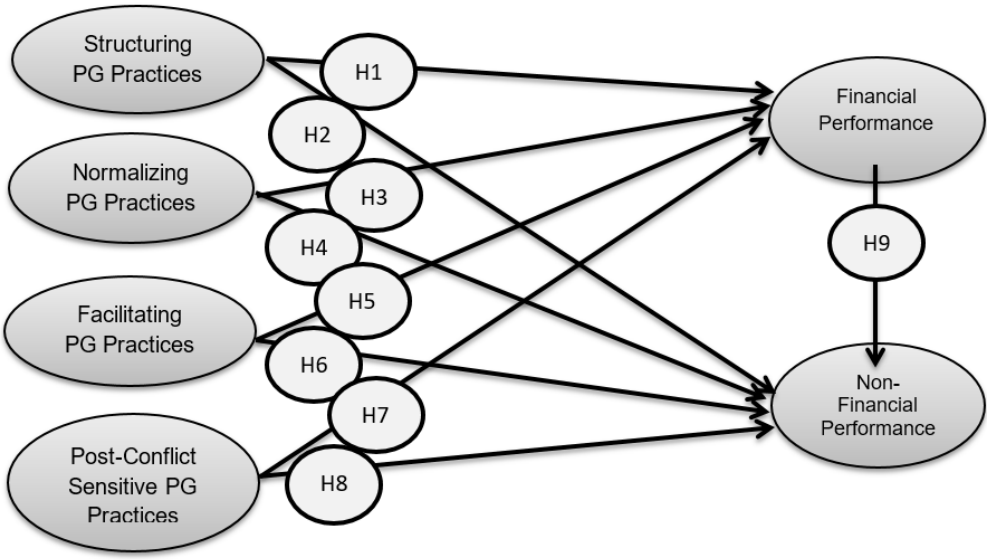
(Musawir et al., 2020). To implement appropriate project governance, identify post-conflict environment impact factors, determine key performance indicators, assess critical success factors, and adopt the best strategy for project performance. Role players must understand political reality, protect cultural property, and engage in capacity building to ensure a stable environment for successful reconstruction (Zaman et al., 2022). A well-defined systematic assessment methodology is essential for project governors and role players to guide the planning process and end results of the development process (Zaman et al., 2022; Haq et al., 2019).

According to the empirical evidence on the PG scenario with integrating the exploratory interviews conducted to verify its applicability for project governance into the context of Sri Lankan PSDPs, structuring PGPs covers practices; approval, cost-benefit analysis, government standards, methodologies, and guidelines, international standards, methodologies, and guidelines, national procurement path and memorandum of understandings. Normalizing PGPs cover action plans, fund disbursement, quality assurance, resource delivery, funders' concurrence, stakeholder negotiations, project completion, and statutory audit practice. Facilitating PGPs covers on-site monitoring and evaluation (M&E), off-site M&E, funders' M&E, stakeholders' M&E, and dispute resolution. Post-conflict sensitive PGPs cover lessons learned, structural PG framework, framework agreement, conditional agreement, human resource management for conflict-affected region, and grievance redress mechanism, etc. The effects of these practices will subsequently influence directly, positively, and significantly to the project performance of PSDPs in Sri Lanka (Jayasundara et al., 2013).

3. Conceptual Framework and Hypotheses Development

Based on the sketched summary of the literature, Figure 1 shows the conceptual framework that was derived to be presented by deducing the empirical interrelationships as therein.

Figure 01: Conceptual model for assessing the effects of PGPs on project Performance of Sri Lankan Public Sector Development Projects (SLPSDPs)



Source: Based on literature review

According to the above conceptual framework, this study measured the performance of PSDPs, which were categorized into two indicators: financial performance (FP) and non-financial performance (NFP) as dependent variables. Independent variables are the PGPs: structuring, normalizing, facilitating, and post-conflict-sensitive practices. The measurement model shows the casual, direct relationships between PGPs and project performance. Also, there is a casual direct relationship between financial performance and non-financial performance as well. In addition, the model shows the casual indirect relationship between PGPs and NFP through the mediatory effect of FP. Based on the particularly designed conceptual interrelationships, the following consequent hypotheses were formulated with the support of a significant contribution and with the aid of literature evidence.

Table 01: Hypotheses Development

Hypotheses No.	**Name of Hypothesis**	**Evidence of Literature**
H_1	Structuring PG Practices positively influence Financial Performance	Jayasundara et al. (2013); Brunet (2019)
H_2	Structuring PG Practices positively influence Non-Financial Performance	Brunet (2019)

H_{2a}	Structuring PG Practices positively influence Non-Financial Performance through Mediatory Effect on Financial Performance	Brunet (2019); Ahola et al. (2014); Kelly (2010)
H_3	Normalizing PG Practices positively influence Financial Performance	Department of Project Management and Monitoring, Sri Lanka (2021); Joslin and Muller (2016); Biesenthal and Wilden (2014); Miller and Hobbs (2005)
H_4	Normalizing PG Practices positively influences Non-Financial Performance	Department of Project Management and Monitoring, Sri Lanka (2021)
H_{4a}	Normalizing PG Practices positively influences Non-Financial Performance through Mediatory Effect of Financial Performance	Brunet and Aubry (2016); Biesenthal and Wilden (2014); Joslin and Muller (2016); Miller and Hobbs (2005)
H_5	Facilitating PG Practices positively influences Financial Performance	Sri Lanka Development Update Protecting the Poor and Vulnerable in a Time of Crisis (2022); Miller and Hobbs (2005); Wrobel et al. (2021); Pulmanis (2016); Pulmanis (2014);
H_6	Facilitating PG Practices positively influences Non-Financial Performance	Miller and Hobbs (2005)
H_{6a}	Facilitating PG Practices Positively influences Non-Financial Performance through Mediatory Effect of Financial Performance	Department of Project Management and Monitoring, Sri Lanka (2021)
H_7	Post-Conflict Sensitive PG practices positively influence Financial Performance	Sakalasuriya (2020); Tabassi et al. (2016); Muller et al. (2012)
H_8	Post-Conflict Sensitive PG practices positively influence Non-Financial Performance	Al-Chaar and Calfas (2019)
H_{8a}	Post-Conflict Sensitive PG Practices positively influence	Al-Chaar and Calfas (2019)

	Non-Financial Performance through Mediatory Effect on Financial Performance	
H_9	Financial Performance positively influences Non-Financial Performance	Athukorala et al., (2017)

Source: Literature review and exploratory case study's findings, (2023)

After deriving the above-mentioned 13 hypotheses, the researchers are to derive other hypotheses to emphasize the significance of project governance to the project's performance based on the results of the path coefficients of the structural model to be formulated based on the survey findings of this study. There are four latent variables in PG practices: structuring, normalizing, facilitating, and post-conflict-sensitive PG practices. By deriving hypothesis no. 09, empirical evidence and survey findings contribute to the projects' financial and non-financial performance according to the weight of significance to be obtained from the data analysis in the present study. Therefore, exploratory case study findings with the abovementioned empirical evidence propose that there is a substantial association between project governance practices and project performance as it relates to the SLPSDPs and their optimal performance for contributing to the country's development and sustainability (Athukorala et al., 2017).

4. Research Methodology

This study utilized a sample survey strategy to collect data on 1500 infrastructure development projects completed under the Government's treasury funds from 2011 to 2020. The population consisted of various construction and infrastructure-related projects, with 647 projects (68.25% of the population) being selected. A stratified random sampling technique was employed to select a proportionate sample, allowing for a randomized probabilistic sample and generalizing research findings. The researcher contacted 647 top-level project administrators, with 518 consenting to participate in the survey. The data was then collected and analyzed using univariate, bivariate and multivariate data analysis tools to ensure data distribution and descriptive measures. The researchers confirmed the normality threshold for each variable, and performed Exploratory Factor Analysis (EFA) to explore the appropriateness of selected items of the dimensions of PGPs and project performance measures (Koyuncu & Kilic, 2019; Yong & Pearce, 2013; Tabachnick & Fidell, 2013; Hair et al., 2010) and performed Confirmatory Factor Analysis (CFA) to confirm the best items (Koyuncu & Kilic, 2019; Brown, 2015). The study confirmed 24 items of PGPs based on four dimensions: "structuring," "normalizing," "facilitating," and

"post-conflict sensitive." Performance was measured using financial performance and non-financial performance measures. The study applied Structural Equation Modeling (SEM) to evaluate the effect of PGPs on the project performance of PSDPs in Sri Lanka. SEM is an analytical method used to examine multiple relationships between sets of variables, and it helps identify the hypothetical relationship between latent variables (Malkanthi, 2015). The structural relationship can be graphically represented to provide a clear understanding of the model's fit with the theoretical stances in the study. SEM also permits estimating the model fit with dependent variables and their variations, and aids in estimating and testing casual relationships among items (Zhao et al., 2021). Previous literature suggests an adequate sample size of 100 to 150 for conducting SEM (Tabachinick & Fidell, 2013), and more than 200 as a rule of thumb (Zhao et al., 2021). However, this study exceeded the evidential thumbs, meeting the minimum requirements to analyze the data through SEM to achieve the objectives set out in the study.

5. Analysis and Discussion

5.1. Convergent Validity and Reliability Test

The items of the questionnaire tested the convergent validity, reliability, and discriminant validity. As Hair et al. (2010) suggest, the rule of thumb for the convergent validity of the items associated with any latent constructs should have a loading factor that is more than or equal to a cutoff value of 0.5. Table 02 shows the convergent validity of all the items, indicating that the measurements for the convergent validity are confirmed as each item has a value higher than 0.5. The reliability of items was assessed by using Composite Reliability (CR) and Average Variance Explained (AVE), indicating that all items are supported as CR for each item has reached the excess of the suggested cutoff value of 0.6 and all AVE values are above the suggested cutoff value of 0.5 (Zhao et al, 2021).

Table 02: Results of the Convergent Validity Test

Construct	**No. of Items**	**Standardized Factor Loadings**		**Average Variance Extracted**	**Composite Reliability**
		Min.	**Max**		
Structuring PG Practices	4/6	0.791	0.877	0.700	0.903
Normalizing PG Practices	5/8	0.783	0.911	0.749	0.937

Facilitating PG Practices	4/5	0.771	0.888	0.687	0.897
Post Conflict Sensitive PG Practices	4/6	0.760	0.874	0.665	0.888
Financial Performance	3/5	0.833	0.860	0.709	0.880
Non-financial Performance	4/5	0.837	0.929	0.706	0.905

Source: Survey Data, (2023)

Furthermore, Table 03 shows the reliability and validity tests for the confirmed items for the measurement model and the structural model. The value for the KMO indicator is more than or equal to the cutoff value of 0.5; factor loading should be more than or equal to 0.6; Eigenvalue should be higher than 1; and Cronbach's Alpha should be equal to or higher than 0.7 for the reliability or validity of the variables (Zhao et al., 2021). Furthermore, all the values on reliability, validity, and sample adequacy have a value higher than the threshold values.

Table 03: Results of the Reliability and Validity Test

Construct	**No. of Items**	**Cronbach's Alpha**	**KMO Measure of Sampling Adequacy**	**Bartlett's Test of Sphericity Approx. Chi-Square (df)**	**P-Value**	**Extraction Sums of Squared Loadings**	
						Total	**% of Var.**
Structuring PG Practices	4/6	0.902	0.828	1323.333 (6)	0.000	3.099	77.469
Normalizing PG Practices	5/8	0.937	0.878	2273.868 (10	0.000	3.992	79.836
Facilitating PG Practices	4/5	0.897	0.818	1278.997 (6)	0.000	3.062	76.543
Post Conflict Sensitive PG Practices	4/6	0.887	0.828	1149.807 (6)	0.000	2.988	74.704
Financial Performance	3/5	0.877	0.744	822.311 (3)	0.000	2.420	80.680
Non-financial Performance	4/5	0.901	0.823	1392.772 (6)	0.000	3.104	77.609

Source: Survey Data, (2023)

5.2. Goodness of Fit

The goodness of fit is a test for confirming fitness to construct a measurement model that supports the final structural model through SEM. As shown in Table 04, the CMIN/DF index shows the minimum discrepancy per degree of freedom equaling 2.419 and the Goodness of Fit Index (GFI) equaling 0.889. The Normed Fit Index equals 0.862 and the Comparative Fit Index (CFI) equals 0.913, presenting that the model as indicated suggests an overall good fit for the measurement model in this study. Moreover, the Adjusted Good Fit Index (AGFI) indicates a value of 0.855 within the threshold limit. The Root Mean Square Residuals (PMR) and Root Mean Square Error of Approximation (RMSEA) indicate values of 0.083 and 0.067. Overall, these indexed values show that there is no decline in the fit indexes of the constrained model with a shred of satisfactory evidence for metric invariance (Zhao et al., 2021).

Table 04: Results of the Goodness of Fit of the Measurement Model

The Goodness of Fit Index		**Observed Value**	**Accepted value**
Absolute fit indices	CMIN/DF	2.986	< 3
	GFI	0.896	0 – 1
	AGFI	0.868	0 – 1
	RMR	0.051	< 0.1
	RMSEA	0.062	< 0.1
Incremental fit indices	TLI	0.938	0 – 1
	CFI	0.947	0 – 1
	RFI	0.910	0 – 1
	NFI	0.923	0 – 1
Parsimony fit indices	PGFI	0.708	0 – 1
	PRATIO	0.859	0 – 1
	PNFI	0.792	0 – 1
	PCFI	0.813	0 – 1

Source: Survey Data, (2023)

5.3. Discriminant Validity Test

After testing the convergent validity and the goodness of fit of the measurement model, the discriminant validity test was conducted to ensure the greater ability of the

square root of AVE for each variable than the inter-squared correlations. Table 5 compares the squared inter-construct correlation estimates with the AVE for all constructs. Table 05 also declares that the diagonal values (in bold) are the AVE for all constructs and the sub-diagonal values are the squared inter-construct correlation estimates among constructs. According to the AVE values in the table, the discriminant validity between underlying constructs as suggested, exists in this model, and all AVE values of each construct are higher than the squared correlations between the specified construct and other constructs.

Table 05: Comparisons of Squared Inter-correlations with AVE

	Structuring Practices	**Normalizing Practices**	**Facilitating Practices**	**Post-Conflict Sensitive Practices**	**Financial Performance**	**Non-Financial Performance**
Structuring PG Practices	**0.837**					
Normalizing PG Practices	0.129	**0.865**				
Facilitating PG Practices	0.209	0.166	**0.829**			
Post Conflict Sensitive PG Practices	0.209	0.224	0.144	**0.816**		
Financial Performance	0.391	0.280	0.343	0.431	**0.842**	
Non- Financial Performance	0.327	0.210	0.185	0.225	0.419	**0.840**

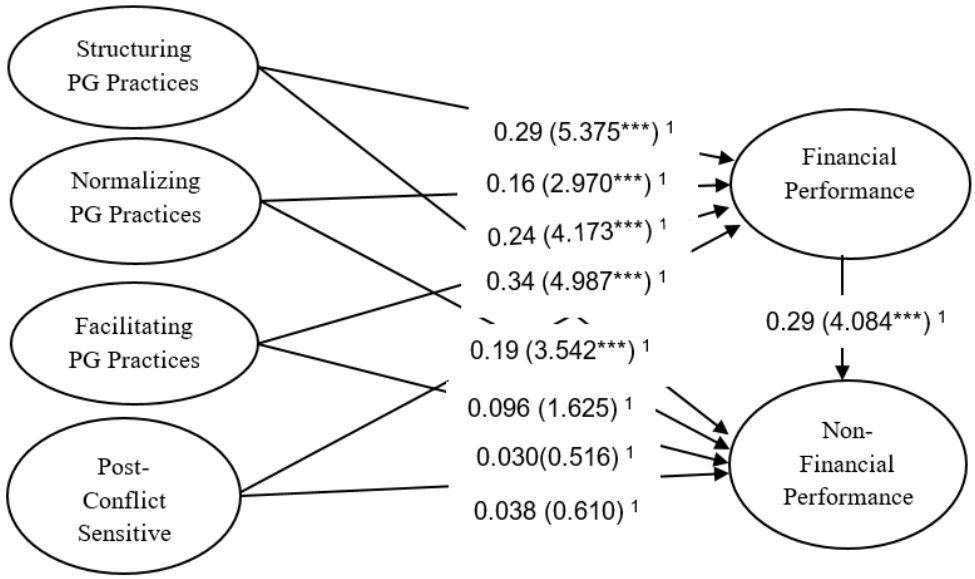
Source: Results obtained from Data Analysi,s (2023)

5.4. Model Development through Path Analysis

Path analysis is a general linear model compared to the multiple regressions model in that it allows measuring the effects of independent variables on dependent variables (Zhao et al., 2021). The results from the path analysis are obtained at two levels: with or without moderating effects on financial performance in this study. There are three models available in this path model. Out of these three models, the first two are

designed to measure the direct effects of PGPs on financial performance and non-financial performance respectively. The third model is designed to measure the indirect effects of PGPs on non-financial performance, through a mediatory effect of financial performance. Figure 02 shows empirical results based on the constructed structural model.

Figure 02: Results of the Empirical Model designed (Deduced from the Model developed by Zhao et al., 2021)



$H2_a$: SP → FLP → NFLP	0.082 (3.042***)[1]	Indirect
$H4_a$: NP → FLP → NFLP	0.046 (2.313***)[1]	Indirect
$H6_a$: FP → FLP → NFLP	0.069 (2.846***)[1]	Indirect
$H8_a$: PCSP → FLP → NFLP	0.096 (3.125***)[1]	Indirect

Source: Developed through Data Analysis, (2023)

[1] Standardized Path Coefficient (Critical Ratio)

***, ** and * denote the significance of the hypothesis at 1%, 5% and 10% respectively

The public sector project is implemented, managed, and monitored over a sequential path from its commencement to its end in accordance with the project governance mandate. Structuring, normalization, facilitation, and post-conflict sensitive PG practices can all be combined through this sequential path (Sakalasuriya, 2020; Athukorala et al., 2017). The empirical and exploratory case study findings showed that PG practices directly, positively, and significantly affected financial performance as well as non-financial performance, indicating that 77% (approximately) of the hypothetical paths (direct and indirect) have been derived from the structural model.

Balance 23% of hypothetical paths on PG practices were positively affected but not significantly affected on financial performance as well as non-financial performance. Finally, these findings were reached using the information gathered from the chosen sample of SLPSDPs. Even though exploratory case study findings and empirical evidence indicate that PG practice adaptation is strongly and significantly connected with both financial and non-financial success, directly and indirectly, these findings point to the necessity of systematic adoption and use of PG practices as well as the fact that project stakeholders are primarily aware of the outputs of sustainable development projects that would be made available to the public through integrated project governance.

Table 06 shows the interpretation of the casual direct and indirect effects between exogenous and endogenous variables, with and without mediating variables.

Table 06: Results of the Path Coefficients of the Structural Model

Path	Path Coefficients	Standardized Path Coefficients	Critical Ratio (P-Value)	Decision
Model 1: Financial Performance (Direct Effect)				
H1: SPrac → FP (Direct Effect)	0.215 (0.040)	0.285	5.3750 (0.001)***	Supportive
H3: NPrac → FP (Direct Effect)	0.110 (0.037)	0.160	2.9730 (0.004)***	Supportive
H5: FPrac → FP (Direct Effect)	0.217 (0.052)	0.241	4.1731 (0.001)***	Supportive
H7: PCSPrac → FP (Direct Effect)	0.369 (0.074)	0.335	4.9865 (0.001)***	Supportive
Model 2: Non-Financial Performance (Direct Effect)				
H2: SPrac → NFP (Direct Effect)	0.170 (0.048)	0.191	3.5417 (0.001)***	Supportive
H4: NPrac → NFP (Direct Effect)	0.078 (0.048)	0.096	1.6250 (0.101)	Not Supportive

H6: FPrac → NFP (Direct Effect)	0.032 (0.062)	0.030	0.5161 (0.608)	Not Supportive
H8: PCSPrac → NFP (Direct Effect)	0.050 (0.082)	0.038	0.6098 (0.539)	Not Supportive
H9: FP→ NFP (Direct Effect)	0.339 (0.083)	0.287	4.0843 (0.001)***	Supportive
Model 3: Non-Financial Performance (Indirect Effect)				
H2a: SPrac → FP→NFP (Indirect Effect)	0.073 (0.024)	0.082	3.0417 (0.001)***	Supportive
H4a: NPrac → FP→NFP (Indirect Effect)	0.037 (0.016)	0.046	2.3125 (0.004)***	Supportive
H6a FPrac → FP→NFP (Indirect Effect)	0.074 (0.026)	0.069	2.8462 (0.001)***	Supportive
H8a: PCSPrac → FP→NFP (Indirect Effect)	0.125 (0.040)	0.096	3.1250 (0.001)***	Supportive

Source: Survey Data, (2023)

In the above table on the results of the path coefficients of the structural model, the hypotheses on the effects of PGPs on financial and non-financial performance are shown under three direct and indirect models (Model1: Financial Performance (Direct Effect); Model 2: Non-Financial Performance (Direct Effect); Model 3: Non-Financial Performance – Indirect Effect). First, under Model 1, all hypotheses (H_1, H_3 H_5, and H_7) recorded direct positive significant effects, indicating that the structuring, normalizing, facilitating, and post-conflict sensitive PG practices have directly, positively, and significantly affected financial performance (0.29, 0.16, 0.24, and 0.34) at a 1% significance level. Second, the hypothesis (H_3) recorded a direct positive significant effect, indicating that structuring PG practices has directly, positively, and significantly affected non-financial performance (0.19) at a 1% significance level, whereas, normalizing, facilitating, and post-conflict-sensitive PG

practices recorded direct positive but insignificant effects on non-financial performance (H_4 H_6 and H_8). Third, the hypotheses ($H_{2a,}$ $H_{4a,}$ $H_{6a,}$ and H_{8a}) recorded indirect positive significant effects on non-financial performance, indicating that the structuring, normalizing, facilitating, and post-conflict sensitive PG practices have indirectly, positively, and significantly affected non-financial performance (0.08, 0.05, 0.07, and 0.10) through a mediatory effect of financial performance at a 1% significance level. Fourth, the hypothesis (H_9) recorded a direct, positive, and significant effect on non-financial performance, indicating that financial performance has directly, positively, and significantly affected non-financial performance (0.29) at a 1% significant level. Finally, out of 13 model hypotheses, 10 hypotheses (77%) recorded both direct and indirect positive effects significantly, and 3 hypotheses (23%) recorded direct positive but insignificant effects with non-financial performance.

5.5. Discussion on Findings

Findings revealed that the effects of all PG practices [structuring, normalizing, facilitating, and post-conflict sensitive] have a direct, positive, and significant influence on financial performance. Most literature evidences that project activities should first be conceptualized, regularized, approved, and authenticated in order to be compulsorily adopted in the project governance process and lead to optimal project performance for public sector development projects. Therefore, these findings are highly consistent with the previous literature (Gunawardana et al., 2021; Sakalasuriya, 2020; Brunet, 2019; Khan et al., 2019; Brunet & Aubry, 2016; Gunawardhane & Karunasena, 2016). Also, the same previous literature convinced the researcher that structuring PG practices has a direct, positive, and significant impact on non-financial performance as well. However, the findings revealed that (except structuring PG practices), normalizing, facilitating, and post-conflict-sensitive PG practices have a direct, positive, and insignificant impact on non-financial performance. But the previous literature (Kodithuwakku, 2022; Gunawardana et al., 2021; Sakalasuriya, 2020; Musawir et al., 2020; Brunet, 2019; Khan et al., 2019; Misawir et al., 2017; Brunet & Aubry, 2016; Gunawardhane & Karunasena, 2016; Miller & Hobbs, 2005) has evidenced that these practices are highly adoptable when performing optimal public sector project performance. Therefore, the findings are much more consistent with the previous literature than the recorded findings which relate to the Sri Lankan context. The results also confirmed that the financial performance of the public sector development projects have a direct, favorable, and significant impact on the non-financial performance of the projects because the government places exceptional importance on the financial performance when allocating budgetary financial allocations to the projects based on the most

satisfactory fulfilment of the non-financial performance. Moreover, the findings revealed the effects of all PG practices on public sector development in Sri Lanka. Therefore, the findings are highly consistent with the previous literature (Kodithuwakku, 2022; Khan et al., 2019). Consequently, all PG practices [structuring, normalizing, facilitating, and post-conflict sensitive] have indirectly, positively, and significantly influenced non-financial performance (Gunawardana et al., 2021) through a mediatory effect on financial performance, as these are highly concentrated on considering the accelerative development of a country through a public sector development project mode. Finally, all previous literature findings are greatly influenced by the need to achieve optimal project performance for the sustainable development in Sri Lanka.

6. Conclusion and Recommendations

6.1. Conclusion

The objective of this study is to investigate the effects of Governance Practices on the Performance of Public Sector Development Projects (PSDPs) in Sri Lanka. The analytical findings revealed that approximately 77% of direct effects demonstrated a positive and significant relationship between PGPs and project performance, indicating that PGPs have a considerable impact. On the other hand, around 23% of direct effects were positive but not statistically significant, suggesting a less pronounced influence of PGPs on project performance, in the context of public sector development projects in Sri Lanka. The results indicate that PSDPs in Sri Lanka adopt an integrated approach to achieve predetermined objectives, incorporating, constituting, regularizing, and facilitating practices. They also embrace a novelistic, post-conflict sensitive approach, aligning with the country's development strategies and maintaining a balanced perspective. The study successfully achieved its first objective, which was to establish a strong relationship between all dimensions of PGPs and project performance, particularly in developing countries like Sri Lanka. By establishing these associations, an empirical model was constructed to illustrate the connections between PGPs and project performance, in the Sri Lankan and other developmental public sector contexts. The study employed a case study approach and engaged project governance experts to identify research gaps. It also drew on empirical research conducted in the American, European, and African contexts by researchers outside of Sri Lanka. The findings highlight the variation in project governance practices and categorization depending on the country, project, or region. However, a balanced project governance strategy was found to enhance public sector project performance and usher in a new era of project governance. The study acknowledges the presence of potential hidden factors that may impact project

performance. Sri Lanka has made significant progress in overcoming its historical project governance and control issues by adopting conventional development methods. This study contributes to the field by introducing new indicators and expanding the three-factor model of PGPs (structuring, normalizing, and facilitating) to a four-factor model, which includes a post-conflict setting. This empirical model strengthens the understanding of the relationships between the four aforementioned PG variables and the project performance, of PSDPs in Sri Lanka, reinforcing the country's transition to modern development practices.

6.2. Implications through Contribution of the Study

This study highlights the importance of project governance in implementing public sector development projects. Governments in both developed and developing countries aim to accelerate the achievement of development objectives, while communities support these efforts. Project governance is crucial for ensuring the legitimacy of processes and fulfilling the objectives of a project. By implementing practice-based project governance, projects achieve financial and non-financial performance, benefiting all stakeholders. This approach also leads to the development of new discipline methodologies, leadership positions, knowledge bases, and capacities for project governance. The study suggests using professional project management experts and consultative forums to develop a checklist to capture new findings and determine the impact of project governance practices on performance. This process allows governors to accurately measure the impact of project governance practices and improve performance. The research findings will also attract researchers, professionals, and policymakers to present their research and knowledge potential, fostering outreach engagement opportunities for the wider community. The study's conclusions serve as a roadmap for scholarly and professional works that focus on governance-based project management techniques, addressing public sector development concerns while balancing academic, research, and community engagement philosophies.

7. Limitations and Further Research

This study focuses on the Sri Lankan public sector development projects, aiming to reduce poor project performance and failures. It aims to maintain a balanced development strategy and optimize project governance practices. However, the study's limitations include its focus on public sector projects and its limited generalization. Further research is needed to identify factors affecting project performance and address the knowledge gap, guiding future researchers in improving

project governance practices and performance. The results will be valuable in future research and public sector development projects.

References

Aaltonen, K., & Sivonen, R. (2009). Response strategies to stakeholder pressures in global projects. *International Journal of Project Management, 27(2),* 131–141. https://doi.org/10.1016/j.ijproman.2008.09.007

Adinyira, E., Botchway, E., & Kwofie, T. E. (2012). Determining critical project success criteria for public housing building projects (PHBPS) in Ghana. *Engineering Management Research*, *1*(2). https://doi.org/10.5539/emr.v1n2p122

Ahola, T., Ruuska, I., Artto, K., & Kujala, J. (2014). What is project governance and what are its origins? *International Journal of Project Management*, *32(8),* 1321–1332. https://doi.org/10.1016/j.ijproman.2013.09.005

Al-Chaar, G., & Calfas, G. (2019). A systematic methodology for pre-reconstruction planning in post-conflict scenarios. *The Open Construction and Building Technology Journal*, *13(1),* 301–307. https://doi.org/10.2174/1874836801913010301

Athukorala, P. C., Ginting, E., Hill, H., & Kumar, U. (2017). The Sri Lankan economy charting a new course. https://www.adb.org/sites/default/files/publication/373316/sri-lankan-economy.pdf

Biesenthal, C., & Wilden, R. (2014). Multi-level project governance: Trends and opportunities. *International Journal of Project Management*, *32*(8), 1291–1308. https://doi.org/10.1016/j.ijproman.2014.06.005

Bos-de Vos, M., Deken, F., & Kleinsmann, M. (2022). Navigating multiple contexts to integrate system transformation programs. *International Journal of Project Management*, 40(3), 290–311. https://doi.org/10.1016/j.ijproman.2022.03.003

Bredillet, C. N. (2008). Learning and acting in project situations through a meta-method (MAP) a case study: Contextual and situational approach for project management governance in management education. *International Journal of Project Management*, *26*(3), 238–250. https://doi.org/10.1016/j.ijproman.2008.01.002

Breese, R., Jenner, S., Serra, C. E. M., & Thorp, J. (2015). Benefits management: Lost or found in translation. *International Journal of Project Management, 33(7),* 1438–1451. https://doi.org/10.1016/j.ijproman.2015.06.004

Brown, T. A. (2015). Confirmatory factor analysis for applied research. *The Guilford Press.*

Brunet, M. (2019). Governance-as-practice for major public infrastructure projects: A case of multilevel project governing. *International Journal of Project Management*, *37*(2), 283–297. https://doi.org/10.1016/j.ijproman.2018.02.007

Brunet, M., & Aubry, M. (2016). The three dimensions of a governance framework for major public projects. *International Journal of Project Management*, *34*(8), 1596–1607. https://doi.org/10.1016/j.ijproman.2016.09.004

Budzier, A., & Flyvbjerg, B. (2018). Double Whammy-How ICT projects are fooled by randomness and screwed by political intent. *Journal of Information Technology*, *33*(2), 91-100.

Department of Project Management and Monitoring, Sri Lanka (2021). Annual performance report of the year 2021. https://www.treasury.gov.lk/api/file/8b086f94-fbbd-4e0d-b400d04ffbd05416 , pp.1–123

Gamlath, G.R.M., & Nanthagopan, Y. (2017). Development aspects of public sector development projects: Impact factors for project efficiency. *Vavuniya Campus International Research Symposium -2017*, Vavuniya, Sri Lanka.

Giron, K., Yan, L., Zhao, Y., & Sohail, M. T. (2014). Research on metallurgical project design and practices: Case study CCTEC Co. Ltd. *American Journal of Industrial and Business Management*, *04*(07), 345–354. https://doi.org/10.4236/ajibm.2014.47042

Gunawardana, K.A. P., & Karunasena, G. (2016). Gaps in public procurement process in Sri Lankan Construction Industry. *The 5th World Construction Symposium 2016: Greening Environment, Eco Innovations & Entrepreneurship*, 29-31 July 2016, Colombo, Sri Lanka

Gunawardana, K. A. P., Sandanayake, Y. G., Karunasena, G. I., & Jayawickrama, T. S. (2021). Problems and related causes of public procurement process to achieve sustainability in developing countries. *Proceedings of the 9th World Construction Symposium 2021 on Reshaping Construction: Strategic, Structural and Cultural Transformations towards the "next Normal."* https://doi.org/10.31705/wcs.2021.40

Hair, J.F., Black, W.C., Babin, B.J. and Anderson, R.E. (2010). Multivariate Data Analysis. Pearson College Division

Haq, S. U., Liang, C., Gu, D., Du, J. T., & Zhao, S. (2018). Project governance, project performance, and the mediating role of project quality and project management risk: An agency theory perspective. *Engineering Management Journal*, *30*(4), 274–292. https://doi.org/10.1080/10429247.2018.1503038

Haq, S. U., Gu, D., Liang, C., & Abdullah, I. (2019). Project governance mechanisms and the performance of software development projects: Moderating role of

requirements risk. *International Journal of Project Management*, *37*(4), 533–548. https://doi.org/10.1016/j.ijproman.2019.02.008

Jayasundara, C., Jayawickrama, V. and Sivagananathan, A. (2013). Effectiveness of project management tools used in the Sri Lankan public sector. *Sri Lankan Journal of Management*, *18*(3) & (4), 138-164.

Jeyakanthan, J., & Jayawardane, A. K. W. (2012). Mitigating delays in donor funded road projects in Sri Lanka. *Engineer: Journal of the Institution of Engineers, Sri Lanka*, *45*(1), 65. https://doi.org/10.4038/engineer.v45i1.6950

Joslin, R., & Muller, R. (2015). Relationships between a project management methodology and project success in different project governance contexts. *International Journal of Project Management*, *33*(6), 1377-1392.

Joslin, R., & Muller, R. (2016). The relationship between project governance and project success. International Journal of Project Management, 34(4), 613–626. https://doi.org/10.1016/j.ijproman.2016.01.008

Judgev, K., & Muller, R., (2005). A retrospective look at our evolving understanding of project success. *Project. Management. Journal. 36*(4), 19–31

Kelly, E. V. (2010). Governance rules! The principles of effective project governance. Paper presented at PMI Global Congress 2010 - North America, Washington, DC. Newtown Square, PA: Project Management Institute

Khan, A., Waris, M., Ismail, I., Sajid, M. R., Ali, Z., Ullah, M., & Hussain, A. (2019). Investigating the practices of project governance in public sector infrastructure program in Pakistan. *Advances in Civil Engineering*, *2019*, 1–11. https://doi.org/10.1155/2019/7436592

Khan, A., Waris, M., Panigrahi, S., Sajid, M. R., & Rana, F. (2021). Improving the performance of public sector infrastructure projects: Role of project governance and stakeholder management. *Journal of Management in Engineering*, *37*(2), 04020112. https://doi.org/10.1061/(asce)me.1943-5479.0000886

Klakegg, O. J. (2009). Pursuing relevance and sustainability. International Journal of Managing Projects in Business, 2(4), 499–518. https://doi.org/10.1108/17538370910991115

Kodithuwakku, R. (2022). Incorporating sustainable procurement practices in the construction industry in Sri Lanka: Benefits and challenges. *PM World Journal*, *XI*, 2330–4480. https://pmworldlibrary.net/wp-content/uploads/2022/10/pmwj122-Oct2022-Halwatura-Kodithuwakku-sustainable-procurement-in-sri-lanka-construction-industry.pdf

Koyuncu, İ., & Kiliç, A. F. (2019). The use of exploratory and confirmatory factor analyses: A document analysis. *TED EĞİTİM ve BİLİM*. https://doi.org/10.15390/eb.2019.7665

Lawani, A., & Moore, D. (2016). Project management practices in government organizations of developing countries: A systematic review. *The International Journal of Business & Management*, *4*(9). http://internationaljournalcorner.com/index.php/theijbm/article/view/127096

Liu, A. M. M., & Walker, A. (1998). Evaluation of project outcomes. Construction Management and Economics, 16(2), 209–219. https://doi.org/10.1080/014461998372493

Malkanthi, G. D. D. K. (2015). *A study of the modification of individual learner variables*. Repository.kln.ac.lk. http://repository.kln.ac.lk/handle/123456789/11894

Mbachu, J., & Nkado, R. (2006). Conceptual framework for assessment of client needs and satisfaction in the building development process. *Construction Management and Economics*, *24*(1), 31–44. https://doi.org/10.1080/01446190500126866

Miller, R., & Hobbs, B. (2005). Governance regimes for large complex projects. *Project Management Journal*, *36*(3), 42–50. https://doi.org/10.1177/875697280503600305

Miller, R., & Stawicki, J. (2008). A framework for building successful project organization. *Project Perspective, 29*, 68-72.

Muller, R., Andersen, E. S., Kvalnes, O., Shao, J., Sankaran, S., & Turner, J. R. (2012). The interrelationship of governance, trust, and ethics in temporary organizations. Paper presented at PMI® Research and Education Conference, Limerick, Munster, Ireland. Newtown Square, PA: Project Management Institute.

Muller, R., & Lecoeuvre, L. (2014). Operationalizing governance categories of projects. International. *Journal of Project Management, 32*(8), 1346–1357.

Musawir, A. ul, Abd-Karim, S. B., & Mohd-Danuri, M. S. (2020). Project governance and its role in enabling organizational strategy implementation: A systematic literature review. *International Journal of Project Management, 38(1), 1–16.* https://doi.org/10.1016/j.ijproman.2019.09.007

Musawir, A. ul., Serra, C. E. M., Zwikael, O., & Ali, I. (2017). Project governance, benefit management, and project success: Towards a framework for supporting organizational strategy implementation. *International Journal of Project Management, 35(8), 1658–1672.*

https://doi.org/10.1016/j.ijproman.2017.07.007Nanthagopan, Y., Williams, N. L., & Page, S. (2016). Understanding the nature of Project Management capacity in Sri Lankan non-governmental organisations (NGOs): A Resource Based Perspective. *International Journal of Project Management*, *34*(8), 1608–1624. https://doi.org/10.1016/j.ijproman.2016.09.003

Osei-Kyei, R., & Chan, A. P. C. (2015). Review of studies on the critical success factors for public–private partnership (PPP) projects from 1990 to 2013. *International Journal of Project Management*, *33*(6), 1335–1346. https://doi.org/10.1016/j.ijproman.2015.02.008

Pardo-del-Val, M., Martínez-Fuentes, C., & Roig-Dobón, S. (2012). Participative management and its influence on organizational change. *Management Decision*, *50*(10), 1843–1860. https://doi.org/10.1108/00251741211279639

Patanakul, P., Iewwongcharoen, B., & Milosevic, D. (2010). An empirical study on the use of project management tools and techniques across project life-cycle and their impact on project success. *Journal of General Management, 35*(3), 41–66. https://doi.org/10.1177/030630701003500304

Perera, G. (n.d.). Causes and effects of delays in capital construction projects at the state universities in Sri Lanka section 4(iii). Retrieved November 3, 2022, from https://www.researchpublishers.org/pdf/16/Causes-and-Effects-of-Delays-in-Capital-Construction-Projects-at-the-State-Universities-in-Sri-Lanka-by-Galpottage-Damith-Dhakshana-Perera.pdf

Project Management Institute (2017). PMBOK-6th ed-2017 - PDF Drive. https://www.pdfdrive.com/pmbok-6th-ed-2017-e158040583.html

Project Management Institute (2021). A guide to the project management body of knowledge (PMBOK® Guide) – Seventh Edition and The Standard for Project Management. Project Management Institute.

Pulmanis, A., (2014). Public sector project management application and sustainability problems, case of EU member state – Latvia. *PM World Journal 3*(11).

Pulmanis, A., (2016). Emerging need for improvement of project management practice in state enterprises, *PM World Journal, 5*(3), 01-12.

Rmit.edu.au. (2022). https://researchrepository.rmit.edu.au/esploro/outputs/doctoral/Investigating-project-management-practices-in-public-sector-organisations-of-a-less-developed-country/9921861557701341

Ruuska, I., Artto, K., Aaltonen, K., & Lehtonen, P. (2009). Dimensions of distance in a project network: Exploring Olkiluoto 3 nuclear power plant project. *International Journal of Project Management, 27*(2), 142–153. https://doi.org/10.1016/j.ijproman.2008.09.003

Rwelamila, P. D., & Purushottam, N. (2012). Project management trilogy challenges in Africa-where to from here? *Project Management Journal, 43*(4), 5–13. https://doi.org/10.1002/pmj.21278

Sakalasuriya, M.M. (2020). A framework to analyse the consequences of post conflict reconstruction intervention; The case of road infrastructure in Sri Lanka. Doctoral thesis, University of Huddersfield. http://eprints.hud.ac.uk/

Scheepers, H., McLoughlin, S., & Wijesinghe, R. (2022). Aligning stakeholders perceptions of project performance: The contribution of Business Realization Management. *International Journal of Project Management*. https://doi.org/10.1016/j.ijproman.2022.03.002

Sri Lanka Development Update Protecting the Poor and Vulnerable in a Time of Crisis, (2022). https://thedocs.worldbank.org/en/doc/6c87e47ca3f08a4b13e67f79aec8fa3b-0310062022/original/Sri-Lanka-Development-Update-October-2022-final.pdf.

Tabachnick, B.G., & Fidell, L.S. (2013). Using multivariate statistics: Pearson. 6th ed. Harlow: Pearson Education Limited.

Tabassi, A. A., Roufechaei, K. M., Ramli, M., Bakar, A. H. A., Ismail, R., & Pakir, A. H. K. (2016). Leadership competences of sustainable construction project managers. *Journal of Cleaner Production, 124*, 339–349. https://doi.org/10.1016/j.jclepro.2016.02.076

Too, E. G., & Weaver, P. (2018). The management of project management: A conceptual framework for project governance. *International Journal of Project Management*, *32*(8), 1382–1394. https://doi.org/10.1016/j.ijproman.2013.07.006

Turner, J.R., & Keegan, A. (2001). The versatile project-based organization: Governance and operational control. *European Management Journal, 19*(3), 260-271.

Waseem, M., Iqbal, S., & Khan, K. (2022). Impact of project governance on project success, with mediating role of organizational support and project team cohesion. *Journal of Facilities Management*. https://doi.org/10.1108/jfm-03-2022-0023

Wrobel, A. E., Johansen, M. K., Jørgensen, M. S., & Cash, P. (2021). Facilitating creativity: Shaping team processes. *Creativity and Innovation Management, 30*(4), 742–762. https://doi.org/10.1111/caim.12465

Yong, A. G., & Pearce, S. C. A. (2013). Beginner's guide to factor analysis: Focusing on exploratory factor

Zaman, U., Khan, M. N., Raza, S. H., & Farías, P. (2022). Fall seven times, stand up eight: Linking project management innovation, project governance, and high-performance work practices to project success. Frontiers in Psychology, 13.

Zhao, Y., Diunugala, H. P., & Mombeuil, C. (2021). Factors affecting household solid waste generation and management in Sri Lanka: an empirical study. *Environmental Monitoring and Assessment, 193*(12). https://doi.org/10.1007/s10661-021-09633-7