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Fuzzy Analysis of Financial Risk Management Strategies for Sustainable Public–Private Partnership Infrastructure Projects in Ghana

Isaac Akomea-Frimpong *, Xiaohua Jin and Robert Osei-Kyei

School of Engineering, Design and Built Environment, Western Sydney University, Sydney, NSW 2747, Australia; xiaohua.jin@westernsydney.edu.au (X.J.); r.osei-kyei@westernsydney.edu.au (R.O.-K.)
* Correspondence: 90943718@westernsydney.edu.au

Abstract: Public–private partnership (PPP) is a prominent tool for sustainable infrastructure development. However, the positive contributions of PPPs toward the attainment of sustainable, climate resilience and zero-carbon infrastructure projects are hampered by poor financial risk management. This problem is more prevalent in developing countries like Ghana where private investment inflow has plummeted due to the COVID-19 recession and poor project performance. Thus, this study aims to assess the key financial risk management strategies in ensuring sustainable PPP infrastructure projects in Ghana. The study utilised primary data from PPP practitioners in Ghana solicited through survey questionnaires. Factor analysis, mean scores and fuzzy synthetic analysis are the data analysis techniques for this study. The results revealed that sustainable and green funding models, effective cost-reduction initiatives, a competent team with committed leadership and emerging technologies and regulations constitute the key strategies for managing the financial risks of sustainable PPP infrastructure projects. Although future studies must expand the scope of data gathering, the findings of the study enrich the theoretical understanding of financial risks in sustainable investments in PPP infrastructures. Relevant remedies that will aid the development of practical financial risk management guidelines are also provided in this study for PPP practitioners.

Keywords: financial risks; fuzzy synthetic evaluation; PPP infrastructure projects; sustainability; surveys

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1. Introduction

Achieving sustainable infrastructure development has been proven to be contending especially for developing economies. Developing nations such as Ghana are confronted with short-lived and poorly maintained public-sponsored infrastructure projects together with huge infrastructure deficits [1,2]. These limitations put a cap on the progress towards the attainment of sustainable development. The challenge is demonstrated in trafficked and congested transport networks, dilapidated school buildings, hospitals and recreational centres and polluted water supplies, among others [3,4]. In Ghana, the developmental challenges have been worsened by rapid urbanization and a high population growth rate [4]. The ever-increasing population demands eco-friendly and sustainable facilities and projects to meet the basic needs of life. However, the financial support from the Government of Ghana (GoG) is not enough to build and operate infrastructures for all the citizenry due to insufficient budgetary funds [5,6]. The recent COVID-19 recession and banking crisis in the country have negatively impacted the flow of private investment into sustainable and environmentally conscious development projects [7]. Projects such as the extension of the Accra–Tema Motorway, the development of eco-recreational parks, the Ghana–Burkina Railway Interconnectivity Project, the installation of a liquid waste treatment plant in Kotoku, the Sogakope–Lome Transboundary Water Supply Project and construction of the Atuabo Natural Gas Processing Plant have been financed through public–private partnership arrangements [8,9].

Nevertheless, these eco-friendly PPP projects have recorded monumental financial challenges. Scholarly works on financial challenges in Ghana together with projects and institutional reports from the Ministry of Finance, Ghana, the World Bank, and the African Development Bank position financial risks as the topmost obstacle to the successful execution of sustainability-inspired and climate-friendly PPP projects. Financial risks such as rising costs of materials, operating the facilities, maintenance, and energy consumption, as well as lower-than-expected revenue from these projects, pose threatening risks to the projects and financial investment returns for private financiers. Therefore, it is necessary that effective and sustainable financial measures are implemented to mitigate these negative consequences [10,11]. This study aims to analyse the financial risk management strategies for sustainable and eco-friendly PPP infrastructure projects in Ghana. The major significance of this article is twofold. The results provide relevant guiding measures on financial risks to assist PPP project managers and practitioners. The study could be an integral part of the strategies designed to improve organisational and project management processes and limit financial losses for sustainable infrastructure development in future studies. The rest of the study presents a literature review, the methodology, the results from the data analysis and the conclusions.

2. Literature Review

2.1. Sustainable Public–Private Partnership Infrastructure Projects

Sustainable infrastructure development has become a well-embraced concept in environmentally conscious and social inclusion matters [1]. It requires a degree of environmental, social and economic improvement to ensure the well-being of future generations [12]. Sustainable infrastructure development is embedded in all 17 of the United Nations' Sustainable Development Goals (SDGs) [13]. However, Villalba-Romero et al. [14] explained that a sustainable infrastructure development agenda could not achieved without the strong support of private financiers who play paramount roles in shifting hitherto government-sponsored projects to public–private partnership (PPP) infrastructure projects. Current and future PPP infrastructure development involves the inclusion of environmental and social impact assessments of the projects, together with net-zero and climate-friendly targets [15]. Similarly, the policies and programs of sustainability when renovating and improving the lifespan of existing PPP-built infrastructures are aimed at meeting the social needs of society and preserving environmental resources [16]. There is also a growing global recognition of the need to consider the integration of sustainability and eco-friendly designs into infrastructure projects delivered through public–private partnerships (PPPs) [17]. The successful implementation of sustainable measures in infrastructural projects is considered an important strategy for attaining sustainability [18].

2.2. Financial Risks in Sustainable PPP Infrastructure Projects

Prior to and during the COVID-19 pandemic, financial risk has been recognised as a topical issue among PPP practitioners and financiers [19]. Financial risk is rated as a significant influencer of poor PPP infrastructure performance [20]. Financial risks encompass all the cashflow challenges related to PPP infrastructure development [21]. They include rising loan interest charges, difficulty in soliciting funds to build and maintain PPP projects, additional construction budgeted costs, bloated operation and maintenance expenditure, low revenue from the project, poor investment returns to financiers and high market risks that emanate from unfavourable macroeconomic conditions. Akomea-Frimpong et al. [22] identified fifty-four (54) topmost financial risks in relation to PPP projects. Among these 54 financial risks, financial charges associated with contractual loans were prominent, followed by construction costs, inflation and operation expenses. Osei-Kyei et al.'s study [23] revealed the existence of a shortage of funds to complete PPP projects in developing economies. Zhang et al. [24], Xenidis and Angelides [25] and Yun et al. [26] analysed the key variables that influence the financial viability of PPP projects using the creditworthiness of bond capital, the financial expertise of the project team and general prevailing economic conditions. The studies explored special-purpose vehicles that undertook a comparative analysis of a project's financial success. The economic constraints of PPPs were analysed with both non-financial and economic models in transport, schools, hospitals and playgrounds under PPP arrangements. Prominent influencing factors that result in financial difficulties are regulation-related with strict terms and caps on the amount that can be contracted and spent on PPPs [27,28]. The coronavirus pandemic also triggered lockdowns and compulsory restrictions, putting a strain on the usage of PPP infrastructures that were already in operation [29]. It prompted a revenue (cash inflow) crisis, with PPP infrastructure operations closing with piling debts. However, the multi-dimensional perspectives on measures to reduce the financial losses of PPP infrastructure projects remain unexplored.

3. Research Methodology

3.1. Questionnaire Survey Data

The starting point in designing the survey questionnaire was the search for appropriate variables to be included in the survey. So, a review of the existing literature was conducted using the terms "financial risk management strategies" and "sustainable and eco-friendly public–private partnership projects". Scholarly literature from Web of Science, EBSCOhost, Scopus, and Google Scholar were retrieved and thoroughly analysed to extract data for the content of the survey questionnaire. These bibliographic databases are prominent tools for searching and extracting the relevant literature for academic research in the architecture, engineering, and construction research fields. After a thorough review of the articles retrieved with more emphasis on Ghana, forty-one (41) financial risk management strategies (FRMSs) were extracted from the literature. The 41 FRMSs were given to five experts (two senior academics and three practitioners who are knowledgeable in PPP projects) through pilot testing. The feedback received from the experts assisted in making changes to the variables for application in the PPP project setting of Ghana. Some of the 41 variables were either deleted or merged with other variables, reducing the number to twenty-three, as shown in Table 1 on a 5-point Likert scale. The two sections included in the survey questionnaire were the profiles of respondents (Section 1) and financial risk management strategies (Section 2). The variables (statements) in Section 2 were the items demonstrated in Table 1.

The participants targeted to respond to the statements in the surveys were practitioners and experts on PPP projects in Ghana. To participate in this study, a respondent must have taken a significant part in the construction and operation of at least one of the 30 PPP projects in the country [1]. Purposively, the selected respondents (participants) were encouraged to nominate or recommend colleagues to be involved in the data collection process. In summary, a total of 403 targeted participants were compiled with personal and career profiles. Emails were sent to all 403 targeted participants, but only 334 responded to participate in the survey. Qualtrics links containing the survey questionnaire were sent to the participants via email. Upon receiving all the responses, a thorough preliminary data check and cleaning indicated that 287 participants responded to all the questions in the survey. The deletion of 47 responses ensued because a maximum of two questions were answered in Section 1, leaving Section 2 unanswered. The 287 responses were analysed. The sufficiency of these responses (287 surveys) is supported by prior statistical models on the adequacy of sample size by Tijani et al. [30], Sunindijo and Kamardeen [31], Kotrlik and Higgins [32] and Cochran [33]. The mathematical equation to demonstrate this is shown as follows:

$$N = \frac{t^2 \times s^2}{d^2}.$$

N refers to the sample size, t is the significance level at 0.05 (5%) with a critical value of 1.96, s represents the estimated variance of deviation within the 5-point Likert scale and d represents the points or scales on the Likert scale multiplied by a margin of error. Therefore, the expected sample size from this mathematical equation is supposed to be:

$$N = \frac{1.96^2 \times 1^2}{(5 \times 0.05)^2} = 61.$$

The results from the mathematical formula of 61 respondents is lower than the accepted sample size of this study of 287 responses, confirming the sufficiency of the dataset. Table 2 demonstrates the description of the respondents.

3.2. Analysis of Data

Statistically, the dataset's reliability was tested to ascertain the internal consistency of the data within the SPSS statistical software 29 (Statistical Package for the Social Sciences). With the aid of Cronbach's alpha (CA), a 0.872 CA score was realised for the reliability test, a reflection of the internal consistency of the multiple items in the questionnaire [34]. Further, the Shapiro–Wilk test was conducted to establish the nature of the normality of the datasets [35]. The outcomes of the analysis show p-values of less than 0.000, an indication of the non-normal distribution of the dataset [36]. This result set the stage for the usage of the non-parametric data analysis techniques of the Kruskal–Wallis test together with the Mann–Whitney U test [37,38]. These non-parametric statistical tools assisted in establishing the differences in the views of the participants of this study [39]. The two statistical techniques are commonly utilised to assess the significant differences in non-parametric datasets [40]. Three categories of data were analysed to determine the differences and criticality of the different groups in the 287 datasets: PPP practitioners, PPP project types and PPP sectors.

Further, exploratory factor analysis (EFA) was used to extract principal factors from the 287 datasets. EFA explores the causal relationships between the latent variables and the measured items acting as common factor models [41]. In EFA, the fundamental tests to determine the reliability and validity of the model include the Kaiser–Meyer–Olkin (KMO) test, which measures the sampling adequacy of the dataset. The significance of the correlation matrix in the EFA analysis is established by Bartlett's sphericity test. Communalities within the EFA analysis indicate the sum of loadings of the variance explained by a variable (or factor), with the rotation results showcasing the minimisation of variables to retain significant financial risk management variables.

Lastly, the data are analysed using the fuzzy synthetic evaluation method. Linguistically, fuzzy logic theory rectifies the anomalies in complicated reasoning and vague terms that appear in subjective views on a subject into a more objective set of outcomes [42]. With fuzzy analysis, subjective opinions can be operationalised and computed to ascertain the desired results for decision making. Fuzzy synthetic evaluation (FSE) promotes the evaluation of diverse responses for decision making based on different sets of ranking criteria [43]. Previous studies such as those of Nguyen and Macchion [42] and Kukah et al. [44] mentioned that FSE is appropriate for the analysis of diverse factors (or criteria) in different fields. Within the construction project management literature, Xu et al. [45], Wuni, Shen and Osei-Kyei [35] and Ekanayake et al. [46] stated that FSE establishes weights and membership functions that ensure objective analysis of matters associated with the management of construction firms and projects. Additionally, Owusu-Manu et al. [47] and Osei-Kyei et al. [48] recounted the appropriateness of FSEs in choosing the critical factors in multi-criteria decision-making scenarios. The FSE in this study is modelled as follows:

Step one: Establish the principal groups from the exploratory factor analysis, $PCFR = \{f_1, f_2, f_i, \ldots f_m\}$.

Step two: Set a grading alternative, $Gt = \{gt_1, gt_2, gt_3, \ldots gt_e\}$, where gt_1 = Strongly disagree, gt_2 = Disagree, gt_3 = Neutral, gt_4 = Agree and gt_5 = Strongly agree.

Step three: Determine the weightings (W_i) of each of the financial risk management strategies and the principal groups using their mean scores.

Table 1. Financial risk management strategies (FRMSs) of sustainable PPP infrastructure projects.

S/N	FRMSs	References
FRMS1	Effective cost management strategies for sustainable and climate-friendly projects	Osei-Kyei and Chan [11]
FRMS2	Access to enough capital to support sustainable projects	Anarfo, Agoba and Abebreseh [9]
FRMS3	Sound corporate governance structures to meet economic sustainability targets	Kwofie et al. [49]
FRMS4	Strategic green financing alliance	Akomea-Frimpong, Jin and Osei-Kyei [22]
FRMS5	Stabilisation of the macroeconomic indicators to foster sustainable projects	Konadu-Agyemang [50]
FRMS6	Timely and independent audit review of project transactions	Osei-Kyei and Chan [39]
FRMS7	Adopting hedging strategies such as options, swaps, futures and forward	Aladağ and Işik [20]
FRMS8	Timely financial reports supervised by a project committee	Babatunde et al. [51]
FRMS9	Strong financial support from the community towards eco-friendly projects	Owusu-Antwi, Antwi, Ashong and Owusu-Peprah [8]
FRMS10	Thorough assessment of pre-construction stage fees and costs	Effah, Chan and Owusu-Manu [10]
FRMS11	Involve professional financial consultants in the financial valuation of the projects	Asante and Mills [52]
FRMS12	Roll out consistent and effective financial monitoring controls	Aladağ and Işik [20]
FRMS13	Carefully planned measures to cover financial uncertainties and climate crisis	Akomea-Frimpong, Jin and Osei-Kyei [22]
FRMS14	Resilient commitment from top management towards inclusive financial practices	Aldrete et al. [53]
FRMS15	Clear and specific financial goals of the project are set from the start of the project	Babatunde et al. [54]
FRMS16	Risk-based tariff pricing to trigger sustained inflow of revenues and green finance	Badu et al. [55]
FRMS17	Social needs and concerns of project users included in toll charges.	Eyiah-Botwe et al. [56], Owusu, Chan and Shan [37]
FRMS18	Promotion of innovative technologies for financial risk management	Akomea-Frimpong, Jin and Osei-Kyei [22]
FRMS19	The presence of strong private consortium attracted enough funds for the project	Konadu-Agyemang [50]
FRMS20	Affordable insurance coverage to manage financial shocks	Osei-Kyei and Chan [11]
FRMS21	Enough funding for recycling of construction wastes and carbon emissions	Eyiah-Botwe, Aigbavboa and Thwala [56]
FRMS22	Strong political support to investigate and manage misuse of project funds	Ghana [57],
FRMS23	Availability of comprehensive financial regulations	Ghana [57], Luo et al. [58]

Step four: Construct the fuzzy evaluation matrix from the principal groups:

$$R_i = \begin{bmatrix} X_{11} & X_{12} & X_{13} & X_{14} & X_{15} \\ X_{21} & X_{22} & X_{23} & X_{24} & X_{25} \\ X_{31} & X_{32} & X_{33} & X_{34} & X_{35} \\ \dots & \dots & \dots & \dots & \dots \\ X_{m1} & X_{m2} & X_{m3} & \dots & X_{mt} \end{bmatrix},$$

where R_i is the fuzzy evaluation matrix.

Step five: Undertake the fuzzy synthetic evaluation:

$$D_i = W_i \bullet R_i$$

where D_i *represents the FSE* value, W_i *is the weightings function*, R_i *represents the* membership functions of the principal groups *and "•" is the fuzzy composite operator*. Therefore,

$$D_i = \{wt_1,\ wt_2,\ wt_3, \dots wt_m\} \bullet \begin{bmatrix} X_{11} & X_{12} & X_{13} & X_{14} & X_{15} \\ X_{21} & X_{22} & X_{23} & X_{24} & X_{25} \\ X_{31} & X_{32} & X_{33} & X_{34} & X_{35} \\ \dots & \dots & \dots & \dots & \dots \\ X_{m1} & X_{m2} & X_{m3} & \dots & X_{mt} \end{bmatrix}.$$

Step six: Calculate both *criticality indexes* of the entire dataset and each *principal (group) factor* using the following equation:

$$\mathrm{K} = \sum_{\mathrm{i}=1}^{5} \mathrm{D} \times \mathrm{G},$$

where $G = (1, 2, 3, 4, 5)$, which are the grading alternatives.

Table 2. Basic information of respondents.

Profile	Category	Frequency	Percent (%)
Education status	Diploma	20	6.97
	Undergraduate	165	57.49
	Masters	89	31.01
	PhD	13	4.53
	Total	287	100.00
Years of working on PPPs	From 0–5 years	93	32.40
	6–10 years	127	44.25
	11–15 years	42	14.63
	More than 15 years	25	8.71
	Total	287	100.00
Participation in PPP projects	1 to 2 projects	149	51.92
	3 to 4 projects	101	35.19
	Either 5 or more projects	37	12.89
	Total	287	100.00
PPP sector	Private	153	53.31
	Public	134	46.69
	Total	287	100.00
PPP project type	Social projects	87	30.31
	Economic projects	122	42.51
	Environmental projects	78	27.18
	Total	287	100.00
PPP practitioner (title)	Project manager	72	25.09
	Quantity surveyor	69	24.04
	Risk manager	81	28.22
	Account (finance) manager	65	22.65
	Total	287	100.00

4. Results

4.1. Mean Scoring Analysis

In this section, the mitigating strategies for financial risks to increase the financial outcomes of sustainable and eco-friendly PPP projects are analysed. The criticality threshold varies in past studies, including values of 2.5, 3, 4 and 4.5 [59]. In this analysis, the minimum mean of 3.0 was adopted based on the outcomes of the dataset and the importance of the FRMSs in comparison with research such as that conducted by Babatunde, Opawole and Akinsiku [54] and Tang and Shen [60]. From Tables 3–5, it is noticeable that almost all means of the FRMSs range from 3 to 5. These ratings provided by the respondents presuppose these critical financial risk management strategies for sustainable infrastructures in Ghana. Consequently, to assess the difference in perceptions held by the two main parties involved in PPP projects, i.e., public, and private sectors, when it came to the ranking of the 23 identified FRMSs, the Mann–Whitney U test (at 5% level of significance) was performed. The null hypothesis posited no difference in the perceptions of both sectors on FRMSs. Table 3 of the test results indicates statistically significant values for all the identified FRMs. It shows the two sectors related to PPP projects in Ghana hold different views about management strategies on financial risks to enhance sustainable infrastructures in the country within PPP arrangements. Tables 4 and 5 tested the differences in perspectives of four groups of PPP practitioners in Ghana and three groups of PPP project types using the Kruskal–Wallis test. The aim was to depict the statistically significant differences between the various groupings with results indicating statistical significance at a *p*-value of 0.050. Substantially, the null hypothesis that there are no differences in the views of practitioners on FRMSs for sustainable and eco-friendly PPP projects in Ghana is rejected. This indicates that there are real differences in the perception of practitioners on the FRMSs. The expansive results in Table 5 highlight the differing perspectives of participants on the financial risk management measures by project types: social, economic, and environmental PPP projects. The analysis was set on the null hypothesis that a project type will not trigger the adoption of a particular FRMS. However, the outputs of the Kruskal–Wallis test analysis give a different result, where nineteen of the FRMSs recorded significant values of less than 5% [16].

Table 3. Analysis of the dataset of PPP sectors.

Financial Risk Management Strategies			PPP Sectors				Mann–Whitney U Test		
			Public Sector		Private Sector		U-Stat.	*p*-Value	Level of Sig.
	Overall MS	Rank	MS	SD	MS	SD			
FRMS1	4.68	1	4.75	0.55	4.60	0.80	8.334	0.000	Significant
FRMS2	4.61	2	4.64	0.65	4.58	0.83	5.712	0.000	Significant
FRMS3	4.58	3	4.57	0.71	4.58	0.87	15.234	0.000	Significant
FRMS4	4.54	4	4.51	0.83	4.57	0.80	6.732	0.000	Significant
FRMS5	4.51	5	4.49	0.97	4.53	0.89	4.042	0.000	Significant
FRMS7	4.50	6	4.49	0.95	4.51	0.89	0.073	0.000	Significant
FRMS9	4.46	7	4.42	0.97	4.49	0.79	9.321	0.000	Significant
FRMS12	4.45	8	4.41	0.95	4.49	0.86	4.795	0.000	Significant
FRMS15	4.45	9	4.41	0.91	4.48	0.85	12.842	0.000	Significant
FRMS17	4.44	10	4.41	0.83	4.46	0.87	11.115	0.000	Significant
FRMS19	4.40	11	4.41	0.93	4.39	0.88	14.123	0.000	Significant
FRMS20	4.38	12	4.39	0.96	4.37	0.94	7.322	0.000	Significant
FRMS22	4.33	13	4.35	0.97	4.30	1.02	12.619	0.000	Significant
FRMS23	4.19	14	4.28	0.99	4.09	1.13	4.211	0.000	Significant
FRMS10	3.79	15	3.49	1.40	4.08	0.15	6.231	0.000	Significant
FRMS11	3.65	16	3.25	1.37	4.05	1.10	7.432	0.000	Significant
FRMS13	3.62	17	3.21	1.46	4.03	1.24	19.432	0.000	Significant
FRMS14	3.48	18	3.17	1.38	3.78	1.28	12.232	0.000	Significant
FRMS16	3.44	19	3.13	1.43	3.75	0.36	14.422	0.000	Significant
FRMS18	3.41	20	3.09	0.04	3.73	1.36	3.562	0.000	Significant
FRMS21	3.35	21	3.02	1.45	3.67	1.37	11.424	0.000	Significant
FRMS6	3.24	22	2.80	1.43	2.88	1.37	16.331	0.000	Significant
FRMS8	3.16	23	2.59	1.35	2.53	1.36	19.321	0.000	Significant

Table 4. Critical analysis of the dataset of PPP practitioners.

			Perspectives of PPP Practitioners								Kruskal–Wallis Test		
			Project Managers		Quantity Surveyors		Risk Managers		Account/Finance Officers		F-Stat.	*p*-Value	Level of Significance
Financial Risk Management Strategies	Overall MS	Rank	MS	SD	MS	SD	MS	SD	MS	SD			
FRMS1	4.84	1	4.70	0.74	4.75	0.62	4.91	0.19	4.98	0.10	16.392	0.000	Significant
FRMS2	4.73	2	4.63	0.91	4.64	0.64	4.77	1.15	4.86	1.22	23.302	0.000	Significant
FRMS3	4.61	3	4.62	0.84	4.64	0.67	4.45	1.18	4.71	1.28	12.520	0.000	Significant
FRMS4	4.50	4	4.61	0.67	4.62	0.77	4.22	1.19	4.55	1.18	6.382	0.000	Significant
FRMS5	4.36	5	4.59	0.85	4.60	0.71	4.01	0.26	4.25	1.26	11.450	0.000	Significant
FRMS7	4.23	6	4.57	0.96	4.60	0.64	3.88	1.25	3.85	0.43	7.894	0.000	Significant
FRMS9	4.11	7	4.54	0.93	4.58	0.70	3.88	1.29	3.43	1.40	22.410	0.000	Significant
FRMS12	4.03	8	4.51	0.96	4.55	0.68	3.63	1.43	3.42	1.42	0.093	0.541	Insignificant
FRMS15	4.00	9	4.51	0.73	4.50	0.78	3.58	1.35	3.39	1.40	3.431	0.000	Significant
FRMS17	3.98	10	4.50	0.92	4.47	0.77	3.57	1.38	3.36	1.43	5.921	0.000	Significant
FRMS19	3.95	11	4.45	0.85	4.46	0.78	3.54	1.44	3.36	1.47	18.321	0.000	Significant
FRMS20	3.85	12	4.45	0.74	4.07	1.24	3.52	0.47	3.35	1.44	2.932	0.000	Significant
FRMS22	3.84	13	4.43	0.78	4.06	1.29	3.51	1.47	3.35	1.39	10.832	0.000	Significant
FRMS23	3.79	14	4.41	0.84	3.92	1.27	3.50	1.44	3.34	0.48	0.432	0.343	Insignificant
FRMS10	3.58	15	3.64	1.40	3.90	1.42	3.46	1.45	3.32	1.38	8.732	0.000	Significant
FRMS11	3.56	16	3.58	1.38	3.90	1.43	3.46	1.40	3.31	1.46	4.921	0.000	Significant
FRMS13	3.54	17	3.54	0.43	3.88	1.38	3.43	0.46	3.29	1.44	12.032	0.000	Significant
FRMS14	3.49	18	3.48	1.43	3.78	1.44	3.43	1.37	3.28	1.47	13.320	0.000	Significant
FRMS16	3.44	19	3.46	1.48	3.73	1.40	3.30	1.36	3.26	1.11	5.321	0.000	Significant
FRMS18	3.36	20	3.43	0.64	3.49	1.39	3.28	1.40	3.25	1.40	14.321	0.000	Significant
FRMS21	3.23	21	3.25	1.42	3.16	1.42	3.27	1.43	3.24	1.43	12.342	0.000	Significant
FRMS6	3.14	22	2.82	1.35	2.67	0.05	2.85	0.42	2.61	0.56	3.453	0.000	Significant
FRMS8	3.09	23	2.57	1.37	2.53	1.32	2.59	0.02	2.52	1.50	2.342	0.000	Significant

Table 5. Critical analysis of PPP project type data.

			PPP Project Type						Kruskal–Wallis Test		
			Economic Projects		Social Projects		Environmental Projects		F-Stat.	*p*-Value	Level of Sig.
Financial Risk Management Strategies	Overall MS	Rank	MS	SD	MS	SD	MS	SD			
FRMS1	4.64	1	4.95	0.62	4.59	0.85	4.81	0.14	13.481	0.000	Significant
FRMS2	4.57	2	4.74	0.64	4.58	0.87	4.39	1.44	7.452	0.000	Significant
FRMS3	4.53	3	4.64	0.67	4.57	0.80	4.38	1.41	6.431	0.000	Significant
FRMS4	4.50	4	4.62	0.77	4.53	0.89	4.37	1.21	5.324	0.000	Significant
FRMS5	4.24	5	4.62	0.84	3.78	1.28	4.34	1.38	19.432	0.000	Significant
FRMS7	4.00	6	4.60	0.71	3.67	1.37	4.31	1.38	15.911	0.000	Significant
FRMS9	3.86	7	4.60	0.64	3.48	1.39	3.73	1.47	7.421	0.000	Significant
FRMS12	3.77	8	4.58	0.70	3.46	1.45	3.49	1.36	6.452	0.000	Significant
FRMS15	3.76	9	4.55	0.68	3.45	1.42	3.28	1.44	0.004	0.732	Insignificant
FRMS17	3.73	10	4.50	0.78	3.43	1.40	3.27	1.37	6.463	0.000	Significant
FRMS19	3.72	11	4.47	0.77	3.43	1.46	3.27	1.39	8.432	0.000	Significant
FRMS20	3.72	12	4.46	0.78	3.43	1.44	3.27	1.43	14.657	0.000	Significant
FRMS22	3.69	13	4.45	0.74	3.36	1.43	3.27	1.39	9.224	0.000	Significant
FRMS23	3.66	14	4.41	0.84	3.35	0.72	3.25	1.43	5.711	0.000	Significant
FRMS10	3.53	15	4.06	1.29	3.31	1.44	3.23	1.38	6.963	0.000	Significant
FRMS11	3.47	16	3.90	1.42	3.31	1.46	3.23	1.45	0.043	0.472	Insignificant
FRMS13	3.47	17	3.90	1.43	3.3	1.36	3.21	1.42	1.156	0.149	Insignificant
FRMS14	3.45	18	3.88	1.38	3.29	1.33	3.20	0.34	6.432	0.000	Significant
FRMS16	3.41	19	3.78	1.44	3.28	1.40	3.19	1.38	5.82	0.000	Significant
FRMS18	3.39	20	3.73	1.40	3.28	1.45	3.18	0.34	11.345	0.000	Significant
FRMS21	3.32	21	3.38	0.08	3.27	1.44	3.15	1.38	8.562	0.000	Significant
FRMS6	3.26	22	2.59	1.39	2.87	0.23	2.81	1.47	0.015	0.532	Insignificant
FRMS8	3.12	23	2.56	1.42	2.44	1.43	2.64	0.03	16.421	0.000	Significant

4.2. Factor Analysis

To examine the underlying relationships of the twenty-three (23) FRMSs, the exploratory factor analysis (EFA) technique was employed. Previously, studies such as those of Muhammad and Johar [61] and Rachmawati et al. [62] have adopted EFA to assess the relationships between variables and given vivid explanations of the complex phenomena surrounding the variables in PPP research. Zhang [63] also argued that EFA is useful for condensing bulky data into abridged versions. Preliminary statistical tests were performed before conducting the EFA for the FRMSs (Chan et al., 2010). The KMO score was established from the analysis as 0.884, greater than the recommended threshold value of 0.60 used in the existing literature [64]. The Bartlett's test of sphericity results included a chi-square value of 9268.672 with a significance level = 0.000, demonstrating the suitability of the survey data for the appropriate analysis of the 23 FRMSs in the FA [65,66]. Following these tests of the dataset, the extraction of the groups with principal component analysis (PCA) using a varimax rotation was undertaken, and the outcome of the four-factor solution is shown in Table 6. Comparatively, varimax rotation, as an orthogonal rotation method, maximises the variance distributed among the variables with a more discrete representation of the data by providing an enhanced correlation of the variables with their principal components [67]. Table 6 shows the four-factor components producing eigenvalues more than 1.0 and explains 74.96% of the variances in the datasets. The factor loadings of the variables indicate the portion a variable contributes to a principal component [34]. With the factor loadings and the eigenvalues of the groups, it can be seen that all 23 FRMSs belong to a principal group, with factor loadings more than 0.7, the required threshold [68].

Table 6. Results of the exploratory factor analysis.

S/N	Principal Groups of the FRMSs	Factor Loadings	Eigenvalues	VE	CVE
FRMSG1	**Sustainable funding for the project**		5.162	30.134	30.134
FRMS2	Access to enough capital to support sustainable projects	0.934			
FRMS4	Strategic green financing alliance	0.892			
FRMS9	Strong financial support from the community towards eco-friendly projects	0.871			
FRMS5	Stabilisation of the macroeconomic indicators to foster sustainable projects	0.821			
FRMS16	Risk-based tariff pricing to trigger sustained inflow of revenues and green finance	0.799			
FRMS19	The presence of strong private consortium attracted enough funds for the project	0.757			
FRMS21	Enough funding for recycling of construction wastes and carbon emissions	0.742			
FRMS17	Social needs and concerns of project users included in toll charges	0.721			
FRMSG2	**Cost-reduction initiatives**		2.656	21.551	51.685
FRMS1	Effective cost management strategies for sustainable and climate-friendly projects	0.907			
FRMS12	Roll out consistent and effective financial monitoring controls	0.881			
FRMS7	Adopting hedging strategies such as options, swaps, futures and forward	0.875			
FRMS10	Thorough assessment of pre-construction stage fees and costs	0.841			
FRMS22	Strong political support to investigate and manage misuse of project funds	0.802			
FRMS20	Affordable insurance coverage to manage financial shocks	0.784			
FRMS13	Carefully planned measures to cover financial uncertainties and climate crisis	0.732			
FRMSG3	**Competent team with committed leadership**		1.804	14.192	65.877
FRMS15	Clear and specific financial goals of the project are set from the start of the project	0.845			
FRMS14	Resilient commitment from top management towards inclusive financial practices	0.817			
FRMS11	Involve professional financial consultants in the financial valuation of the projects	0.783			
FRMS6	Timely and independent audit review of project transactions	0.804			
FRMS8	Timely financial reports supervised by a project committee	0.755			
FRMSG4	**Innovative technologies and regulations**		1.019	9.082	74.959
FRMS23	Availability of comprehensive financial regulations	0.837			
FRMS18	Promotion of innovative technologies for financial risk management	0.792			
FRMS3	Sound corporate governance structures to meet economic sustainability targets	0.763			

Note: VE—variance explained, CVE—cumulative variance explained.

4.3. Fuzzy Synthetic Evaluation

From the results in Section 4.2 (factor analysis), the levels of fuzzy synthetic evaluation (FSE) can be drawn to further analyse the dataset on FRMSs. The FSE involves the multi-factor and multi-level approach; starting from the third level, the criticality of each of the items (FRMSs) in the four principal components (FRMSGs) is assessed [69,70]. This is followed by the second-level analysis, which determines the criticality of the principal components (FRMSGs). Finally, it is at the first level that the overall financial risk management strategies index is computed, flowing from levels two and three. To summarise the evaluation of the FSE as presented in Section 3.2, the following steps are applied:

(a) Determine the weightings of the FRMSs and FRMSGs

Studies such as those by Chang et al. [71] and Aghimien, Aigbavboa, Edwards, Mahamadu, Olomolaiye, Nash and Onyia [69] mentioned that the overall outcomes of the FSE analysis is dependent on the weights assigned to each of the FRMSs and FRMSGs. To compute the weightings, there are different types of techniques available in the existing literature such as the mean normalisation method, the analytic hierarchy process, the point allocation system, the judgement method and unit weighting [72,73]. In this analysis, the mean scoring approach (using the overall mean criticality scores) is adopted due to its ability to transform and strengthen the stability of test data and the model [45,74]. The weightings of the FRMSGs and FRMSs are determined as follows:

$$W_i = \frac{MCS_i}{\sum_{i=1}^{5} MCS_I}, 0 < w_i < 1, \text{ and } \sum_{i=1}^{n} w_i = 1.$$

w_i represents the weighting function of each of the FRMSs and the FRMSGs, whiles MCS_i demonstrates the mean criticality score of each of the variables. i shows the scores on the 5-point Likert scale, which is the grading scale. In summary, the weighting function is given as follows:

$$w_i = \{w_1, w_2,\ w_3,\ w_4 \ldots\ldots\ldots\ldots, w_n\}.$$

For instance, in Table 7, the mean score of FRMS2 is 4.73, and it is part of FRMSG1, which has a total mean criticality score of 32.30. Therefore, the weighting of FRMS2 was determined as follows:

$$wt_{CFR18} = \frac{4.73}{4.73+4.50+4.11+4.36+3.44+3.95+3.23+3.98} = \frac{4.73}{32.30} = 0.146.$$

Similarly, the same calculation was performed for all of the FRMSs, as shown in Table 7. The weightings form the basis of the determination of the membership functions. The computation undertaken for the FRMSGs include the following:

$$wt_{FRMSG1} = \frac{32.30}{32.20+27.91+17.31+11.76} = \frac{32.30}{89.28} = 0.362.$$
$$wt_{FRMSG2} = \frac{27.91}{32.20+27.91+17.31+11.76} = \frac{27.91}{89.28} = 0.313.$$
$$wt_{FRMSG3} = \frac{17.31}{32.20+27.91+17.31+11.76} = \frac{17.31}{89.28} = 0.194.$$
$$wt_{FRMSG4} = \frac{32.30}{32.20+27.91+17.31+11.76} = \frac{17.31}{89.28} = 0.132.$$

(b) Membership functions of the FRMSs and FRMSGs

The source of the membership functions (MFs) of the FRMSs is the percentage of the overall responses to the questionnaire survey dataset. As mentioned in Section 3.1, the Likert scale of the financial risk management strategies was set as follows: Strongly disagree (1), SiD; Disagree (2), Di; Neutral (3), Ne; Agree (4), Ag; and Strongly Agree (5), SiA. Therefore, to determine the MF of FRMS4 (strategic green financing alliance), the responses of a 2.40% rating for "Strongly disagree", 6.60% for "Disagree", 30.70% for "Neutral", 38.30% for "Agree" and 22.00% for "Strongly agree" from the 287 datasets were used. Therefore, the MF of FRMS4 is computed as follows:

$$MF_{CFR18} = \frac{0.024}{SiD(1)} + \frac{0.066}{Di(2)} + \frac{0.307}{Ne(3)} + \frac{0.383}{Ag(4)} + \frac{0.220}{SiA(5)},$$

Table 7. Weightings of FRMSs and FRMSGs.

S/N	Principal Groups of FRMSs	Mean Scores of the FRMS	Weightings of the FRMS	Mean Score of the FRMSG	Weightings of the FRMSG
FRMSG1	**Sustainable funding for the project**			**32.300**	**0.362**
FRMS2	Access to enough capital to support sustainable projects	4.73	0.146		
FRMS4	Strategic green financing alliance	4.50	0.139		
FRMS9	Strong financial support from the community towards eco-friendly projects	4.11	0.127		
FRMS5	Stabilisation of the macroeconomic indicators to foster sustainable projects	4.36	0.135		
FRMS16	Risk-based tariff pricing to trigger sustained inflow of revenues and green finance	3.44	0.107		
FRMS19	The presence of strong private consortium attracted enough funds for the project	3.95	0.122		
FRMS21	Enough funding for recycling of construction wastes and carbon emissions	3.23	0.100		
FRMS17	Social needs and concerns of project users included in toll charges	3.98	0.123		
FRMSG2	**Cost-reduction initiatives**			**27.910**	**0.313**
FRMS1	Effective cost management strategies for sustainable and climate-friendly projects	4.84	0.173		
FRMS12	Roll out consistent and effective financial monitoring controls	4.03	0.144		
FRMS7	Adopting hedging strategies such as options, swaps, futures and forward	4.23	0.152		
FRMS10	Thorough assessment of pre-construction stage fees and costs	3.58	0.128		
FRMS22	Strong political support to investigate and manage misuse of project funds	3.84	0.138		
FRMS20	Affordable insurance coverage to manage financial shocks	3.85	0.138		
FRMS13	Carefully planned measures to cover financial uncertainties and climate crisis	3.54	0.127		
FRMSG3	**Competent team with committed leadership**			**17.310**	**0.194**
FRMS15	Clear and specific financial goals of the project are set from the start of the project	4.00	0.231		
FRMS14	Resilient commitment from top management towards inclusive financial practices	3.49	0.202		
FRMS11	Involve professional financial consultants in the financial valuation of the projects	3.56	0.206		
FRMS6	Timely and independent audit review of project transactions	3.17	0.183		
FRMS8	Timely financial reports supervised by a project committee	3.09	0.179		
FRMSG4	**Innovative technologies and regulations**			**11.760**	**0.132**
FRMS23	Availability of comprehensive financial regulations	3.79	0.322		
FRMS18	Promotion of innovative technologies for financial risk management	3.36	0.286		
FRMS3	Sound corporate governance structures to meet economic sustainability targets	4.61	0.392		
	Total			**89.280**	

giving a membership function for FRMS4 of (0.024, 0.066, 0.307, 0.383, 0.220). The rest of the MFs of the FRMSs are calculated using the same approach. Further, the MFs of the FRMSGs (level 2) are obtained from the MFs of the FRMSs (level 3) and their weightings. This establishes the fuzzy evaluation matrix, which is the combination of the membership functions of FRMSs and the weightings, expressed as follows:

$$D_i = W_i \bullet R_i$$

where D_i represents the FSE evaluation matrix, W_i is the weightings function, R_i is the fuzzy evaluation matrix and "•" is the fuzzy composite operator. Based on this explanation, the membership functions of the FRMSGs can be computed as follows:

$$D_i = \{w_1, w_2, w_i, \ldots w_m\} \bullet \begin{bmatrix} X_{11} & X_{12} & X_{13} & X_{14} & X_{15} \\ X_{21} & X_{22} & X_{23} & X_{24} & X_{25} \\ X_{31} & X_{32} & X_{33} & X_{34} & X_{35} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ X_{m1} & X_{m2} & X_{m3} & \ldots & X_{mt} \end{bmatrix}.$$

FRMSG1 had weights of $wt_{FRMSG4} = \{0.322, 0.286, 0.392\}$ and a membership function of FRMSG4 of

$$R_{FRMSG4} = \begin{bmatrix} 0.010 & 0.042 & 0.244 & 0.348 & 0.355 \\ 0.035 & 0.094 & 0.105 & 0.453 & 0.314 \\ 0.000 & 0.042 & 0.087 & 0.244 & 0.627 \end{bmatrix}.$$

Thus, the fuzzy evaluation matrix for FRMSG4 is

$$D_{FRMSG4} = \{0.322, 0.286, 0.392\} \bullet \begin{bmatrix} 0.010 & 0.042 & 0.244 & 0.348 & 0.355 \\ 0.035 & 0.094 & 0.105 & 0.453 & 0.314 \\ 0.000 & 0.042 & 0.087 & 0.244 & 0.627 \end{bmatrix} = (0.013, 0.057, 0.143, 0.337, 0.0450).$$

The same approach is applied to compute the fuzzy matrixes for FRMSG1, FRMSG2 and FRMSG3, as demonstrated in Table 8.

(c) The criticality indexes of the principal groups and the entire dataset

The combination of the fuzzy matrixes and the grade alternatives are set from the overall outcomes of the financial risk management strategies on the Likert scale from 1 to 5. In view of this, the criticality indices of the FRMSs are set as follows:

$$FRMSG_{index} = \sum_{i=1}^{5} (D_I \times G_i),$$

where $G_i = (1, 2, 3, 4, 5)$ is the range of the Likert scale concerning the total effectiveness of the financial risk management strategies and D_i is the fuzzy evaluation matrix. Consequently, the critical factor groups were computed as follows:

$$FRMSG1 = (0.031, 0.097, 0.265, 0.374, 0.232) \times (1, 2, 3, 4, 5) = (0.031 \times 1 + 0.097 \times 2 + 0.265 \times 3 + 0.374 \times 4 + 0.232 \times 5) = \mathbf{3.679}.$$
$$FRMSG2 = (0.023, 0.048, 0.208, 0.362, 0.359) \times (1, 2, 3, 4, 5) = (0.023 \times 1 + 0.048 \times 2 + 0.208 \times 3 + 0.362 \times 4 + 0.359 \times 5) = \mathbf{3.985}.$$
$$FRMSG3 = (0.020, 0.076, 0.131, 0.373, 0.400) \times (1, 2, 3, 4, 5) = (0.020 \times 1 + 0.076 \times 2 + 0.131 \times 3 + 0.373 \times 4 + 0.400 \times 5) = \mathbf{4.058}.$$
$$FRMSG4 = (0.013, 0.057, 0.143, 0.337, 0.450) \times (1, 2, 3, 4, 5) = (0.013 \times 1 + 0.057 \times 2 + 0.143 \times 3 + 0.337 \times 4 + 0.450 \times 5) = \mathbf{4.154}.$$

Table 8. Membership functions (MFs) of FRMSs and FRMSGs.

S/N	Principal Groupings of FRMSs and FRMSGs	Weightings	MF of FRMS (Level 3)	MF of FRMSG (Level 2)
FRMSG1	**Sustainable funding for the project**			(0.031, 0.097, 0.265, 0.374, 0.232)
FRMS2	Access to enough capital to support sustainable projects	0.146	(0.000, 0.010, 0.233, 05.44, 0.213)	
FRMS4	Strategic green financing alliance	0.139	(0.024, 0.066, 0.307, 05.83, 0.220)	
FRMS9	Strong financial support from the community towards eco-friendly projects	0.127	(0.077, 0.118, 0.174, 05.31, 0.300)	
FRMS5	Stabilisation of the macroeconomic indicators to foster sustainable projects	0.135	(0.017, 0.059, 0.282, 05.75, 0.366)	
FRMS16	Risk-based tariff pricing to trigger sustained inflow of revenues and green finance	0.107	(0.031, 0.132, 0.314, 05.07, 0.216)	
FRMS19	The presence of strong private consortium attracted enough funds for the project	0.122	(0.007, 0.195, 0.348, 05.18, 0.031)	
FRMS21	Enough funding for recycling of construction wastes and carbon emissions	0.100	(0.035, 0.094, 0.105, 05.04, 0.362)	
FRMS17	Social needs and concerns of project users included in toll charges	0.123	(0.066, 0.129, 0.334, 05.07, 0.164)	
FRMSG2	**Cost-reduction initiatives**			(0.023, 0.048, 0.208, 0.362, 0.359)
FRMS1	Effective cost management strategies for sustainable and climate-friendly projects	0.173	(0.014, 0.063, 0.589, 0.314, 0.021)	
FRMS12	Roll out consistent and effective financial monitoring controls	0.144	(0.045, 0.059, 0.087, 0.418, 0.390)	
FRMS7	Adopting hedging strategies such as options, swaps, futures and forward	0.152	(0.035, 0.052, 0.098, 0.348, 0.467)	
FRMS10	Thorough assessment of pre-construction stage fees and costs	0.128	(0.010, 0.028, 0.157, 0.240, 0.564)	
FRMS22	Strong political support to investigate and manage misuse of project funds	0.138	(0.007, 0.028, 0.070, 0.418, 0.477)	
FRMS20	Affordable insurance coverage to manage financial shocks	0.138	(0.035, 0.066, 0.080, 0.418, 0.401)	
FRMS13	Carefully planned measures to cover financial uncertainties and climate crisis	0.127	(0.014, 0.035, 0.296, 0.383, 0.272)	
FRMSG3	**Competent team with committed leadership**			(0.020, 0.076, 0.131, 0.373, 0.400)
FRMS15	Clear and specific financial goals of the project are set from the start of the project	0.231	(0.049, 0.167, 0.199, 0.251, 0.334)	
FRMS14	Resilient commitment from top management towards inclusive financial practices	0.202	(0.031, 0.045, 0.195, 0.310, 0.418)	
FRMS11	Involve professional financial consultants in the financial valuation of the projects	0.206	(0.010, 0.031, 0.070, 0.679, 0.209)	
FRMS6	Timely and independent audit review of project transactions	0.183	(0.000, 0.059, 0.105, 0.279, 0.557)	
FRMS8	Timely financial reports supervised by a project committee	0.179	(0.000, 0.059, 0.070, 0.348, 0.523)	
FRMSG4	**Innovative technologies and regulations**			(0.013, 0.057, 0.143, 0.337, 0.450)
FRMS23	Availability of comprehensive financial regulations	0.322	(0.010, 0.042, 0.244, 0.348, 0.355)	
FRMS18	Promotion of innovative technologies for financial risk management	0.286	(0.035, 0.094, 0.105, 0.453, 0.314)	
FRMS3	Sound corporate governance structures to meet economic sustainability targets	0.392	(0.000, 0.042, 0.087, 0.244, 0.627)	

The overall index of the FRMS was determined with the fuzzy matrixes of FRMSGs and the sum weightings. First, the fuzzy evaluation matrix is computed from Table 7. The FRMSGs have weightings of $W_{\text{overallFRMSGi}} = (0.362, 0.313, 0.194, 0.132)$ and the fuzzy matrixes from the table are

$$R_{\text{OverallFRMSGi}} = \begin{bmatrix} 0.031 & 0.097 & 0.265 & 0.374 & 0.232 \\ 0.023 & 0.048 & 0.208 & 0.362 & 0.359 \\ 0.020 & 0.076 & 0.131 & 0.373 & 0.400 \\ 0.013 & 0.057 & 0.143 & 0.337 & 0.450 \end{bmatrix}.$$

Therefore, the overall financial risk management strategies matrix is computed as follows:

$$D_{\text{overallPCFR}} = W_{\text{overallPCFR}} \bullet R_{\text{overallPCFR}}.$$

$$D_{\text{overallPCFR}} = (0.362, 0.313, 0.194, 0.132) \times \begin{bmatrix} 0.031 & 0.097 & 0.265 & 0.374 & 0.232 \\ 0.023 & 0.048 & 0.208 & 0.362 & 0.359 \\ 0.020 & 0.076 & 0.131 & 0.373 & 0.400 \\ 0.013 & 0.057 & 0.143 & 0.337 & 0.450 \end{bmatrix} = (0.024, 0.072, 0.205, 0.365, 0.333).$$

Then, the overall financial risk management strategies index is calculated as follows:

$$\text{OverallFRMS}_{\text{index}} = (0.024, 0.072, 0.205, 0.365, 0.333) \times (1, 2, 3, 4, 5) = (0.024 \times 1) + (0.072 \times 2) + (0.205 \times 3) + (0.365 \times 4) + (0.333 \times 5) = \mathbf{3.911}$$

5. Discussion

The results from the above fuzzy synthetic analysis show an overall criticality index of 3.911 for the datasets, indicating the role the financial risk management strategies play in ensuring the sustainability of PPP infrastructures in Ghana, even in the face of the country's economic crisis. In addition, the findings indicate four principal groupings of the financial risk management strategies with criticality scores above 3.0, the threshold set for this analysis. A further demonstration of the relevance of these strategies is presented in this study for practice and project policies. The FRMSs have a cumulative variance of 74.96% (see Table 6) with factor loadings of the FRMSs (>0.7) [75,76]. The principal groupings are explained as follows:

Component 1: Sustainable funding for the project (FRMSG1)

This principal group of the FRMSs explains 30.134 per cent of the principal components generated by the eigenvectors with a critical score of 3.68 from the fuzzy synthetic analysis. In agreement with the findings of Debela [68], the basis of curtailing financial risks on sustainable and climate funding is to support resilient PPP projects. The requirement to attain this goal is through strategic financial alliance. This alliance consists of a collaboration between local financial institutions in Ghana, international financiers, and a consortium of investors. In recent decades, project funding through PPP arrangements has embraced private investments to support the paltry national budget for construction projects in Ghana. Some parties of the finance alliance were triggered by arrangements instituted by the Bretton Woods institutions as part of structural adjustment programs (SAPs) to reform and develop the country's infrastructures [50,77]. Other strategic alliances that were deliberately entered into by the Ghanaian government with international donor agencies and private financiers to accelerate the development of the country must be guided by a policy framework [10]. Even though these strategic alliances bring in financial support, downsides resulting from the non-involvement of stakeholders during critical decision-making processes in such financing arrangements to construct and maintain PPP infrastructures in every region of Ghana could result in numerous unsolicited misunderstandings and conflicts among all concerned parties, i.e., the public and project parties [55].

Some disputes and legal actions taken to challenge the investment of private investors and rogue nations have led to public uproar and the non-achievement of targets set for certain projects. Thus, as a means of ensuring openness and transparency through high levels of accessibility, parties involved in the project, particularly public departments, and agencies, need to liaise with all other concerned stakeholders when critical matters resulting in decisions are to be discussed. These issues might resort to financial contracts that tend to influence the tariffs, pricing, and conditions of service provisions of the project [78]. Moreover, in situations where private financiers form a consortium to finance the project, there must be clear regulations and documentation to guide the financiers [79]. Several private institutions within Ghana and investors in the capital market should agree to jointly supervise the funding of projects in the country with the facilitation ensured by the government. Unlike in loan syndication, a consortium allows banks and investors to pull together a large amount of capital to fund a PPP project [80]. Effective consortium policies in Ghana should be guided by national financial regulation guidelines to handle large or too risky funds of projects. Instituting a wide coverage of insurance also contributes substantially to ensuring the sustainability and success of the project. Any of the projects constructed using a PPP arrangement should be covered including property, fire and health insurance policies for both infrastructure and human beings (construction workers and users of the project). The process of purchasing an insurance policy for the project must be unbiased and non-discriminatory, and even more so, the premiums and claims should be reported to the appropriate stakeholders of the project [81]. As another means to enhance transparency in the insurance policies, it is becoming a necessity for project stakeholders to be clear on mutual insurance rewards and specifically detail the duties of the partners within the partnership pact. Insurance coverages go a long way to reduce accidental claims from the project [82].

Component 2: Cost-reduction initiatives (FRMSG2)

In Table 7, 21.55% is the proportion of the explained variance on FRMSs for PPPs in Ghana attributed to this factor component. The position of this principal group is third with a criticality score of 3.985. This outcome supports the outputs of Aladağ and Işik [20], who posited that establishing effective cost-reduction strategies and efficient revenue mobilisation positively influenced the financial outcomes of climate-friendly PPP projects. Carbonara et al. [83] mentioned the need for clear cost-reduction strategies while fulfilling the societal pact of the project to serve the community at a lesser to no profit. This singular step aids in achieving the financial targets of the project by clarifying communication to minimise negative perceptions and conflicts. Further, Ke et al. [84] also stated that it is important that project managers assume broad consultation of the tariffs of PPP projects in Ghana with the users, so charges and fees do not become a surprise amount to be dealt with for the users. Quick and adequate information sharing leads to understanding, and there stands a chance of increasing the demand and access to the project if users understand the details of the charges expected from them [85]. Information sharing and consultation with users of the project are also key in avoiding undue agitation from pressure groups who are likely to give the project a bad name and draw people away from using the project in Ghana, which could, in the long run, affect the revenue targets of the project negatively [86]. Ideally, using financial software boosts information sharing and management of the financial transactions of the project. Within the financial software of CostX, the cost of the project can be monitored consistently with the revenue outcomes during the operational stage of the project. In addition, financial software packages and reporting guidelines suitable for sustainable zero-carbon PPP projects need to be adopted to enhance the transparency of financial data on the infrastructure projects by key allied parties [87]. Providing comprehensive project policies and reports inclusive of measures on financial risks to the partners and even the public, in general, minimises the challenges of the poor demand for sustainable PPP projects in Ghana. With technology in use, the records on the project cost sharing together with revenue disbursement is facilitated with the assistance of financial experts. The project's financial policies should capture the cost of smart technologies and software for financial risk management. Ensuring that efficiency and a large quantum of revenue from the project are retained necessitates thorough and fact-based revenue risk evaluation and the suitable allocation of revenue risks among stakeholders [88]. In the early phases of the projects, investment appraisal software needs to be comprehensively used to review, identify, and project all sources with a high potential of revenue risks that could derail the financial rewards of the project [89].

Component 3: Competent team with committed leadership (FRMSG3)

This crucial factor component accounts for 14.192% of the variance explained in Table 7. The results of Demirag et al.'s [90] study correspond with good leadership and component people-centred measures to assess and control financial deficits recorded on sustainable infrastructures under the PPP contracts in Ghana. Employing qualified and competent people with the sole aim of reducing overall project costs and boosting returns of capital investment minimises financial risks [58,63]. Aldrete, Bujanda and Valdez [53] reiterate that the role of competent personnel in the success of sustainable PPP projects cannot be overemphasised. Thus, the focus of robust financial risk management must be on the level of expertise and training of the people managing the financial risks. First, stakeholders, especially project managers and construction workers, who are the centre of reporting losses, must be trained to know the constituents of these financial reports and measures to improve upon the outcomes across all sectors of the PPP market [51]. Also, competent quantity surveyors, financial consultants, project cost managers and auditors should be the priority of the top management of the project to prevent the project from incurring avoidable costs. The extent of commitment and expertise exhibited by these experts has an influence on the net revenue [91]. At the pre-construction stage of the project, loopholes in the procurement contract and potential corrupt practices could be detected with pre-design controllable practices to minimise the expected costs during the entire lifespan of the project. However, the personal financial interests of the experts must be checked when such competent people are engaged to avoid role conflicts and misapplication of the project funds [92]. Furthermore, a strong partnership must be built among stakeholders, and measures must be implemented to manage stakeholder conflicts [93]. These complex financial relationships between the stakeholders should be guided within the confines of financial management policies on PPP projects. Lasting financial alliances should be encouraged to create a consortium of financers for a project and similar projects in the future [94].

Component 4: Innovative technologies and regulations (FRMSG4)

The outcome of the EFA of this fourth component shows a variance of 9.08%, and it occupies the first position of the fuzzy synthetic analysis. This establishes this component as the key financial risk-controlling strategy for sustainable PPP project development in Ghana. Financial regulations provide the step-by-step method needed for the implementation of financial controls to minimise the financial risks of PPP projects specified clearly in the legal books [76]. These measures encompass relevant steps of action taken in planning, monitoring, and providing feedback to appropriate authorities through a sound financial system to mitigate cost overruns, which are determined by an industry practice or legal framework [95]. The attainment of risk maturity on financial transactions of the projects requires a sound legal process regarding the structures and systems to upgrade the financial success of the project. Recently, the Ghanaian government passed the Public–Private Partnership Act, 2020 [57]. However, the bureaucratic and complex processes of reporting the financial transactions on PPP projects together with unclear legal provisions were found in the regulations [96]. Thus, there is a need for a review of the current regulations to account for adequate legal backing in managing expenses and income generated in operating the project. The financial systems of PPP projects in the country must be reviewed and integrated into national governance processes, where competent experts can supervise and give timely reports to top state officials and key private financiers about the progress of the project. Also, it is necessary that the project governance committee understand the legal processes involved in securing capital from financiers of the project (private investors and financial institutions) and maintain a sound financial management of the project's funds [49]. Yun et al. [97] mentioned that the stimulation of clear financial regulations mitigates financial losses. Consequently, a comprehensive and accessible regulatory framework must embody a broad-based viewpoint of stakeholders on PPP contracts. A change in financial laws on accessing capital, sharing of financial risks and investment returns needs to be spelled out clearly within national- and project-level policies. Moreover, contracts on PPP projects are secured and yield greater financial success when there are well-established regulations, including exclusion clauses, contingency provisions, fixed-price supplies, performance-based payments, and quality standards for sustainable PPP project development [54,98]. Also, stringent regulations on minimum revenue guarantee (MRG) provide private investors with the confidence to make available capital investments for similar projects [99]. The role of the state at this crucial point is to boost and secure private financial alliances for similar PPP infrastructure projects in the future [100]. Favourable pricing policies on user tariffs must embrace the broad consultations of stakeholders and market forces to take into consideration the standard of living of Ghanaians in the project [85]. Such regulations on tariffs should be monitored and supervised by state officials, the project's team members, such as quantity surveyors, and professional project finance experts continuously through the project's lifecycle to reduce overall project costs.

6. Practical and Research Implications of the Study

In the recent past, Ghana has experienced challenges with its economic outlook, together with budgetary shortages, as reported by the Ministry of Finance and the Bank of Ghana. Moreover, the economic advances of the country have taken a large hit due to the COVID-19 economic recession, affecting the funding of PPP projects [52,101]. Thus, the results of this study are important to understand and equip project managers with the tools to devise measures to attract funding and manage financial risks in these challenging times. Learning from the consequences of the pandemic and past funding challenges to infrastructure projects in the country, project managers and key stakeholders can institute project-based financial policies and budgets to either minimise or lower current project account deficits, stimulate favourable investment outcomes and promote inclusive financial management solutions that consider fluctuations in the exchange rate, interest charges and inflation rates [102]. With increasing focus on net-zero, climate resilience and sustainability-based financial risk management measures, this study provides key measures to meet economic sustainability targets. Further, the relevance of this study is in the mitigation of shortages of funds and the establishment of a guiding practice framework to support the construction and management of PPP projects in Ghana through comprehensive project and policy guidelines. It was revealed in this study that Ghana lacks a policy document on financial risk management and has no comprehensive legislation on financial regulations in PPP project transactions. Therefore, the findings of this study will inform actionable policy guidance from the Ministry of Finance and other related government agencies with private financiers. The long-term focus of the policy document and the legislation is to improve financial risk management frameworks to promote sustainable PPP projects in Ghana. In addition, the study is important to multiple partners who take active part in PPP financing and development in Ghana to help them understand the project's financial reporting systems and governance structures. Effective project finance risk management policies coupled with investment successes increase the confidence investors have in PPP projects and will increase private investments in Ghana's public project development.

Future studies should use this study as a guide to delve deeper into the risks to the economic sustainability of PPP projects in similar developing countries that share key developmental features with Ghana. In addition, the financial management of PPP infrastructures in Ghana can be facilitated by solutions from researchers using innovative technological software to develop a project-focused financial risk management framework to guide PPP projects. The advancement of health and safety technology-based financial assessment and management is important in understanding the challenges of construction workers. Drawing lessons from this work, studies must investigate financial risk management measures to manage climate change, nature-based solutions, social inclusion and the environmentally inspired risks of PPP infrastructure initiation, development, and management.

7. Conclusions and Limitations

This study identified, assessed, and established the financial risk management strategies (FRMSs) for sustainable PPP project development. It undertook a questionnaire survey of knowledgeable and experienced PPP experts in the Ghanaian economy. The data analysis was conducted using non-parametric tests (Kruskal–Wallis and Mann–Whitney U) in addition to factor analysis and fuzzy synthetic evaluation to analyse the differences between PPP practitioners, sectors, and project types. Statistically, the results showed no significant differences between the views of the various groups on mitigation strategies for the financial risks of PPPs. The study also evaluated the criticality of the principal components of the FRMSs using exploratory factor analysis and fuzzy synthetic evaluation methods. The findings include the promotion of sustainable funding, effective cost-reduction strategies, and the inclusion of competent team members, together with good leadership, who are focused on ensuring the sustainable development of PPP projects. Also, the study established emerging technologies and regulations and strong financial alliances towards climate-resilient PPP projects.

Despite these relevant findings aimed at mitigating financial risks for sustainable infrastructures like schools, roads, and hospitals in PPP contracts for Ghana's socio-economic development, the study has some limitations that must be addressed. Limited categories of analysis were investigated in this study: project type, sector, and practitioner. Further studies must expand the scope to include, but not be limited to, analysis of project size, capital investment, project settings and external stakeholders to attain a more multi-dimensional framework to countermeasure financial risks. With a limited sample size of responses from PPP practitioners in Ghana, the generalizability of the application of the findings is affected. Thus, caution must be exercised in the applications of the findings of the study, taking into consideration the project setting and economic environment. Future studies must seek to utilise a larger sample size inclusive of policymakers and users of PPP infrastructure projects. Also, further studies must employ mixed methodologies to address the shortfalls in this study.

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