DEVELOPMENT OF RISK ANALYSIS MODEL IN PUBLIC PRIVATE PARTNERSHIP PROJECTS

PROJECT REPORT

Submitted by

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DECLARATION

I undersigned hereby declare that the project report, “Development of Risk Analysis Model in Public Private Partnership Projects”, submitted for partial fulfilment of the requirements for the award of the degree of Master of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under supervision of Dr. Anu V. Thomas. This submission represents my ideas in my own words and where ideas or words of others have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. I understand that any violation of the above will be cause for disciplinary action by the institute and/ or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

Place: Kollam

Date: 06/07/2022 FIZA FATHIMA

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CERTIFICATE

Certified that this report entitled '**DEVELOPMENT OF RISK ANALYSIS MODEL IN PUBLIC PRIVATE PARTNERSHIP PROJECTS**' is the report of project presented by **FIZA FATHIMA, TKM20CESC11** during **2021-2022** in partial fulfilment of the requirements for the award of the Degree of Master of Technology in Structural Engineering and Construction Management of the A P J Abdul Kalam Technological University.

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ABSTRACT

To fulfil the increasing demands of the public, Public Private Partnership (PPP) has been increasingly used to procure infrastructure projects. However, the risks involved in PPP projects are unique and dynamic due to large amount of investment and long concession period. This causes many challenges like cost overruns, time overruns and lower quality.

Risk management is a crucial part of PPP projects. It is important to accurately identify and evaluate the risks involved in PPP projects due to its immense application in the development of infrastructure. The present study deals with the prioritization and analysis of risks in PPP projects. 26 risk factors are categorized under 8 main risk heads identified from literature. Multiple-Criteria Decision Analysis (MCDMs) techniques like Analytical Hierarchy Process (AHP), Decision Making Trial and Evaluation Laboratory (DEMATEL) and Failure Mode and Effect Analysis (FMEA) are utilized for prioritizing, finding the stakeholder perception of the risk factors and determining the interrelationship between the main risk heads. The eight main risk heads identified are financial, legal, political, economic, operation and maintenance, construction, social and relationship risks. Social risk is identified as the most significant risk in all basis.

Risk remedial measures are also identified to mitigate the risks in PPP projects. Relative Importance Index (RII) is used to prioritize them. Finally, risk factors are modelled in Partial Least Square Structural Equation Modelling (PLS-SEM) to find their impact on PPP project performance. The study concluded that social, legal, financial and construction risks have significant negative impact on project performance. Effect of social and legal risks on economic risk and political risk on financial risk are also found significant.

Keywords: *Public Private Partnership Projects, Risk Management, Analytical Hierarchy Process (AHP), Decision Making Trial and Evaluation Laboratory (DEMATEL), Failure Mode and Effect Analysis (FMEA), Risk Factor, Stakeholder Perception, Risk Remedial Measures, Partial Least Square Structural Equation Modelling (PLS-SEM), Project Performance*

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ABBREVATIONS

AHP	:	Analytical Hierarchy Process
AVE	:	Average Variance Extracted
DBFOT	:	Design-Build-Finance-Operate and Transfer
DEMATEL	:	Decision Making Trial and Evaluation Laboratory
FMEA	:	Failure Mode and Effect Analysis
HTMT	:	Heterotrait-Monotrait
KCRIP	:	Kozhikode City Road Improvement Project
MCDM	:	Multiple Criteria Decision Making
PLS	:	Partial Least Square
PLS-SEM	:	Partial Least Square Structural Equation Modelling
PMBOK	:	Project Management Body of Knowledge
PPP	:	Public Private Partnership
RBS	:	Risk Breakdown Structure
RII	:	Relative Importance Index
RPN	:	Risk Priority Number
SPV	:	Special Purpose Vehicle
VIF	:	Variance Inflection Factor

CHAPTER 1
INTRODUCTION

1.1 GENERAL

Risk has become an indispensable part of everyday life. Risk is present everywhere and in every area of life. Construction projects, being highly variable and complex, are prone to various types of risks. All construction projects have unique goals, which are to be realized in terms of time, cost and quality. The failures to achieve these goals are often due to improper management of the risks.

The government sector has limited resources which makes it difficult to handle the growing demands of infrastructure for the country, on its own. Therefore, the Government needs to look into private participation for meeting the infrastructure demands. This is where Public Private Partnership Projects (PPP) come into play. This is a contractual partnership between the public and private sector agencies. They contribute to an increase in the number of services that can be provided within a given budget.

Risks involved in PPP projects are very significant. Large concession period, huge investments and complex technology make risk management an important element in PPP projects. The risk needs to be thoroughly analyzed, researched and managed to minimize disputes as well as cost and maximize the value for money. Quantitative analysis of risks in PPP projects provides a very clear picture of the most prominent risk groups (Gupta et al., 2013).

Identification of risk is the first move toward risk management. The present study includes the identification and prioritization of risk factors using Multiple-Criteria Decision-Making (MCDM) techniques. MCDMs used in the present study are Analytical Hierarchy Process (AHP), Failure Mode and Effect Analysis (FMEA) and Decision Making Trial and Evaluation Laboratory (DEMATEL). AHP ranks the risk factors, FMEA discovers the stakeholder perceptions of risk factors and DEMATEL approach determines the interrelationships between main risk heads (Kaushal et al., 2019; Sakthiganesh and Suchithra et al. 2017; Zheng et al., 2021)

Risk remedial measures are identified from PPP case studies in India (Compendium of case studies, Public Private Partnership projects in India). These risk remedial measures provide positive impact on the success of PPP project performance. A survey is conducted among the stakeholders to recognize the significance of the identified risk remedial measures in Kerala context.

A live PPP project in Kerala (Kozhikode City Road Improvement Project-Phase 1) is identified to validate the survey results. The impact of risk factors on PPP project performance are modelled using Partial Least Square Structural Equation Modelling (PLS-SEM).

1.2 SIGNIFICANCE OF THE STUDY

Stakeholders are not just shareholders. According to the PMBOK Guide, "A stakeholder is an individual, group, or organization who may affect, be affected by or perceive itself to be affected by a decision, activity, or outcome of a project". Identifying the risk source is crucial for reducing risk as well as ensuring proper PPP project implementation. However, it is difficult to track these sources as some risks are related to different stakeholders. There is a group of stakeholders with different interests in a PPP project and among these itself, the stakeholder group is not absolute. PPPs have multiple stakeholders and they bring different problems to the project. Hence, it is worthwhile to review their roles (Yang et al. 2020)

In PPP projects, stakeholders can be investors, government departments, project owners, contractors, legal agencies and end-users. There is a complex structure for stakeholders in PPP, which leads to unpredictable outcomes of the project. This is the reason for misalignment of project goals with that of various stakeholders, occasionally some are oppositional which leads to failure of PPP projects. Stakeholder opposition is mainly due to the gap between the expectations of various stakeholders and desired outcome of the project. Capturing and addressing risk perception according to each stakeholder is crucial for the success and sustainability of PPP (Park et al. 2020).

1.3 RESEARCH OBJECTIVES

The research objectives of the present study are given below:

- To discover the interdependencies of main risk heads using Decision Making Trial and Evaluation Laboratory (DEMATEL) approach
- To identify and prioritize critical risk factors in PPP projects using Analytical Hierarchy Process (AHP)
- To distinguish the priority of risks for various stakeholders using Failure Mode and Effect Analysis (FMEA)
- To identify the risk remedial measures to improve the project performance
- To propose a risk analysis model for PPP projects using Partial Least Square – Structural Equation Modelling (PLS-SEM)

1.4 SCOPE OF THE STUDY

The present study is limited to PPP projects in Kerala and considers only highway projects. The cost of construction of the projects contemplated in the study is greater than 5 crores. Decision Making Trial and Evaluation Laboratory (DEMATEL) approach is employed to find the interdependencies among the main risk heads. For prioritization and finding stakeholder perception of risk factors, Analytical Hierarchy Process (AHP) and Failure Mode and Effect Analysis (FMEA) techniques are used respectively. Also Partial Least Square – Structural Equation Modelling (PLS-SEM) is used to model the impact of risk factors to PPP project performance.

1.5 ORGANIZATION OF THE THESIS

The thesis is structured into six main chapters. Chapter one describes the background of the study, research significance, objectives and scope of the study

Chapter two reports the literature review of the risk factors, their analysis, risk remedial measures to mitigate the identified risk factors and modelling using PLS-SEM technique.

Chapter three discusses the research methodology. Data collection and analysis methods adopted for the study are described in this chapter. It discusses the questionnaire survey adopted to study the risk factors in PPP projects in Kerala.

Chapter four represents the findings of the questionnaire survey. It reports the interdependencies of main risk heads, ranking and stakeholder perceptions of risk factors using DEMATEL approach, AHP analysis and FMEA technique respectively. Significance of risk remedial measures in mitigating identified risk factors and validation of survey results from AHP and FMEA analyses using a live PPP project are also reported.

Chapter five reports the analysis of the model on risk factors impacting PPP project performance using the PLS-SEM technique.

Chapter six describes the major findings of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 PUBLIC PRIVATE PARTNERSHIP PROJECTS

The Department of Economic Affairs, India defines PPP as "An agreement between appropriate government or a statutory entity or a government owned entity on one side and a private entity on the other for the provision of public assets and/or public services, through investments being made and/or management being undertaken by the private entity for a specified period of time when there is well-defined allocation of risk between the private and the public entity and the private entity receives performance linked payments that conform to specified and pre-determined performance standards measurable by public entity or its representatives".

The key features of PPP projects are listed below:

- Accelerated infrastructure provision by allowing private sector financial participation
- Timely project implementation
- Reduced whole life cost
- Reduced government risk exposure by transferring such risks to private sector
- Improved service quality and innovation through the use of private sector expertise and performance incentives
- Effective management of public funds and reduced corruption by increase in accountability and transparency

A typical PPP structure consists of a number of parties like Government, project sponsor, project operator, financiers, suppliers, contractors, engineers, third parties and customers (Quium, 2011). A typical structure of a PPP project is shown in Figure 2.1 below. Special Purpose Vehicle (SPV) is a commercial venture and a key feature in most of the PPP projects. It is a legal entity that undertakes a project and negotiates contract agreements with other parties including the government. The project company and the lenders appoint Escrow

Agent for managing an account called an escrow account which is an account set up to hold funds accrued to the project company.

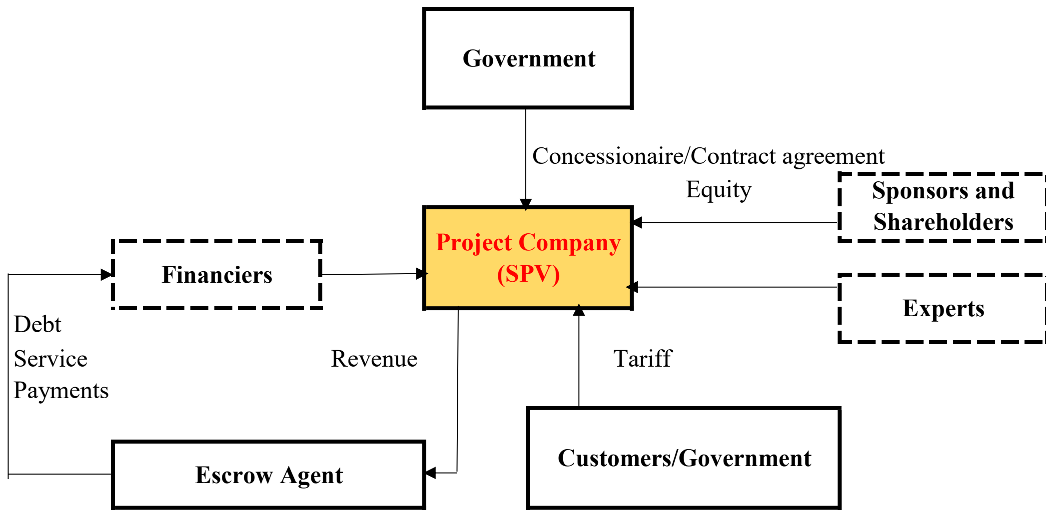

Figure 2.1 **Typical structure of a PPP project (Quium, 2011)**

2.2 RISK MANAGEMENT

The Project Management Body of Knowledge (PMBOK) Guide (2017) defines risk as "an uncertain event or condition that, if it occurs, has an effect on at least one project objective". These objectives can be scope, schedule, cost or quality. Risk may have a positive or negative impact on these objectives.

Risk management is a crucial part of project management. According to PMBOK Guide (2017), project risk management is defined as the "systematic process of identifying, analyzing and responding to project risks". It is mainly a four-stage process, consisting of risk identification, risk analysis, selection of risk management techniques and frequent monitoring of the management of risk consequences. (Peckiene et al., 2013).

Identification can be done through experience, internal history, external research and consulting with experts. There are various risk categories like financial, contractual, political, economic, force majeure etc. Identified risks have to be categorized into these major risk factors. After the identification, the risk has to be analyzed. Scope and factors affecting risk within the organization have to be determined. The severity and seriousness of the risk have to be understood. Later on, ranking and prioritization of the risks should be carried out. Then, effective treatment and mitigation of the risks using suitable risk management techniques are to be planned. Frequent updation on the management techniques is also necessary. Thereafter, it is to be made sure whether the implemented technique is effective or not, if not new strategies are to be found.

2.3 RISK FACTORS IN PPP PROJECTS

Risks associated with PPP projects cannot be underestimated due to large investments and the longer life of the project. Risk profile of PPP projects is entirely different from that of conventional projects. Numerous studies have been carried out to identify the risks in PPP projects.

Gupta et al. (2013) identified major risk factors of ongoing PPP highway projects in India. The root cause of high risks in PPP projects was the longer duration of the project. The construction phase was the riskiest phase of the project. Social, economic and legal risks were found to be crucial. The cumulative impact of risks and their variations over different phases of project life were analyzed. The study suggested setting up a Regulator in the upcoming projects which could inspect the rapidly changing socio-economic environment so as to resolve the issues unaddressed in the contractual agreement.

Valipour et al. (2015) prioritized and established relationships among risks in freeway PPP projects in Iran. Questionnaire surveys were distributed among experts to collect the data and Fuzzy Analytic Network Process (FANP) were applied to analyze the collected data. Financial, political and legal risks topped the priority lists of main risks whereas limited capital, improper design and change in the value of granted lands and termination of concession were significant among the sub-risk factors. A risk prioritization model was developed using FANP in view of helping the public and private sector to identify the source of risk before the implementation of the project.

Khodier and Mohamed (2013) conducted qualitative risk analysis based on Cairo Festival City, Egypt to recognize the key risks emerging from internal and external environment during the construction phase of infrastructure projects. A checklist technique was employed to obtain the key 50 risk factors among 157 identified risks. A Risk Breakdown Structure

(RBS) was drawn for infrastructure projects. The main risk categories in the RBS were technical risks, project management risks, financial risks, environmental risks, organizational risks and external risks. A risk register was created based on the survey results containing the key risks. The key risks were change in currency price, new tax rates, lack of fuel, unsecured roads, official changes, workers' strikes and fire risk. The paper suggested suitable risk response strategies for the identified main risks.

Khahro et al. (2021) designed a risk severity matrix for sustainable PPP projects in developing countries. The risk evaluation was carried out for PPP projects in Pakistan. A risk severity model was created to understand the intensity of each risk. The study recognized inflation, revenue risk from end user, foreign exchange fluctuations, country's political condition, law and order situation and corruption as the crucial risks in PPP. Evaluation results were compared with previous studies conducted in India, Egypt and China. Results of comparative analysis manifested that Indian PPP projects are strongly similar to Pakistani projects due to similarity in the region and governing systems, but, Chinese projects are weakly similar and Egyptian projects are distinct.

Ke et al. (2010) studied the risk allocation preferences of risks for PPP projects in China. The developed model would help the public and private sectors to attain equilibrium of distribution of risks which could reduce contractual disputes. The public sector entirely took the responsibility for only one risk (Expropriation and nationalization) out of 37 risks. Out of the 36 risks left, 12 were mostly allocated to the public sector, 14 were equally shared and 10 were mostly allocated to the private sector. Government's intervention and reliability, land acquisition, change in law and tax regulations, delay in approvals and permits were some of the risks mostly allocated to the public sector. Public and political opposition, tariff change, force majeure, improper contracts, environmental risk, payment risk, inflation and market demand change were some of the risks equally shared by both the parties. Construction and operation changes, operation cost overruns, time overruns, financial and technical risk were a few among the risks allocated to the private sector.

Jokar et al. (2021) prioritized risk factors in PPP projects using Fuzzy MCDMs. Economic and financial, operation, legal, political and government risks were top ranked main risks. Delay in project approvals and government intervention were the most and the least ranked sub risks. Risks of high financing costs, quality of performance and standards, lack of support infrastructure, risk of construction completion and cost overruns and time overruns due to contractual ambiguities were the top five impact risks. Risks of inappropriate change and estimation of market demand, force majeure, third party delay, unpredictable weather conditions and political/public opposition were the least impact risks.

The review of the risk factors helped to identify 97 factors having an impact on project performance. The detailed discussion on the risk factors is given in the next chapter.

2.4 ANALYSIS OF RISK FACTORS

Keshk et al. (2018) analyzed risk quantitatively as well as quantitatively. The qualitative assessment included risk probability assessment and evaluation of risk consequences. Risk probability was assessed using a common assessment scale (0.1 for “very low”, 0.3 for “low”, 0.5 for “moderate”, 0.7 for “high” and 0.9 for “very high”). Similarly, risk consequence was also evaluated using a common scale (0.1 for “low impact”, 0.2 for ‘moderate impact”, 0.4 for “high impact” and 0.8 for “very high impact”). Quantitative assessment was done by interviewing stakeholders to determine the quantitative assessment of risk in terms of cost, decision tree method and simulation by Monte-Carlo method.

Issa et al. (2021) examined the risk factors affecting the execution of roadway construction projects. The probability of occurrence and the impacts of risks on objective in terms of cost, time and quality are determined along with risk severity. Risk factors were analyzed based on Risk Probability Index (RPI), Impact Index (time, cost, quality) and Risk Factor Index (RFI). Interrelationships between risk factors were measured by correlation coefficient value.

Tamosaitiene et al. (2021) carried out qualitative and quantitative risk assessments. In qualitative risk assessment, the importance of each risk was determined in terms of probability of occurrence and the impact of risks on project objectives. Finally, a quantitative assessment was performed for prioritizing Critical Risk Factors (CRFs) using TOPSIS. Delphi survey technique was antedated of TOPSIS. TOPSIS provided rating of each risk based on Confidence Interval (CL) which was a number between one and zero. A rating of one means the risk significance could be high whereas a rating of zero means a risk with least priority.

Yuan et al. (2018) performed Confirmatory Factor Analysis (CFA) to investigate the significance of social risks in PPP road projects in China. A questionnaire survey was conducted to assess the relative significance of social risks using Likert scale. A conceptual model was developed for social risk factors and tested its consistency with the survey data obtained. The survey data followed normal distribution assumption to obtain logical results. The consistency was checked based on the values obtained for Goodness Fit Indices (Degree of freedom-Df; Comparative Fit Index-CFI; Normal Fit Index-NFI; Root Mean Square Error of Approximation-RMSEA). The consistency was accomplished as the indices were within the recommended limits.

Razi et al. (2019) proposed an empirical study of risk assessment for public road construction projects using the AHP technique. AHP application was simplified using the Expert Choice software. AHP analysis consisted of pair wise comparison, normalization and consistency analysis. Sensitivity analysis was performed to find the most sensitive project phase. The construction phase followed by the planning phase were found as the sensitive project phases. **Eskander (2018)** assessed risks influencing Arabian construction projects using AHP.

Mohanty et al. (2019) provided effective decision making for choosing the best location for project based on risk factors. The selection was performed using AHP. Project locations were ranked based on risk factors. **Almuhisen et al. (2021)** evaluated and analyzed Critical Success Factors (CSFs) and risk factors affecting the successful implementation of PPP projects in Jordan. **Askari et al. (2014)** used AHP to calculate the Significant Risks in Construction Projects (SRCP) based on the project's objectives. SRCP was determined using global risk weights and linguistic variables. Risks were categorized as very good (0.8 -1.0), good (0.6-0.8), moderate (0.4-0.6) and bad (0.0-0.4) based on SRCP value.

Jokar et al. (2021) developed a systematic model for risk assessment in PPP infrastructure projects in Malaysia using the risk management process suggested in PMBOK. Fuzzy MCDMs like Fuzzy AHP and Fuzzy-Technique for Order of Preference by Similarity to Ideal Solution (FTOPSIS) were utilized for qualitative and quantitative analysis for establishing the importance and prioritization of risks. Qualitative analysis was based on the relative importance of occurrence probability, impact severity and risk rate. Based on qualitative analysis, risks were classified into critical, precautionary and acceptable. FAHP was employed to carry out quantitative analysis.

Karamoozian et al. (2019) proposed a hybrid efficient approach for risk assessment in construction projects. DEMATEL-Analytical Network Process (ANP) model was developed for prioritization and finding interdependencies among the risk factors in construction projects. DEMATEL technique derived interdependencies among the risk factors and identified the risk factors with the highest relationship with others. Weights of the risk factors were calculated using ANP to know the priority.

Seker et al. (2017) evaluated occupational risks on construction sites using DEMATEL method. The method assessed causal factors of occupational hazards using cause-effect diagram. The sensitivity analysis was performed to validate the results. **Zheng et al. (2021)** used DEMATEL approach to understand the decisive causes of PPP project disputes in China. **Sakthiganesh and Suchithra (2017)** inspected project risks by means of FMEA. Risk Priority Number (RPN) was calculated as the product of rating given to occurrence, severity and detection**.**

Mohammadi and Tavakolan (2017) assessed risks of a subway construction project using FMEA. **Abdelgawad and Fayek (2012)** prioritized risks using both FMEA and AHP. Severity was calculated as the impact of risk in terms of cost, time and quality. **Wang et al. (2020)** constructed a social PPP project risk factor relationship network model using Social Network Analysis (SNA) to understand the risk factors and their complicated relationship. Index analysis was carried out to find the relationship between risks and their propagation mechanism.

2.5 RISK REMEDIAL MEASURES IN PPP PROJECTS

The infrastructure division of the Department of Economic Affairs, India, published a compendium of case studies of Public Private Partnership Projects in June 2015. The compendium presented case studies of selected PPP projects in India. Several methods are suggested to mitigate the risks experienced in PPP projects.

Tariff is the main source of return for the private sector. Determination of tariff in project preparation stage could prevent revenue risk and termination risk. It should be fair enough to the private party to get a reasonable profit. Obscurity in tariff leads to disputes among parties. One such example is Nhava Sheva Integrated Container Terminal project. In Latur Water Supply project, tariff was determined before the bidding process so that the bidders could quantify the measurable benefits from the project and hence the revenue risk was reduced.

One of the most challenging processes in the pre procurement stage of a PPP project is land acquisition. The provision of public land during the planning stage is a mitigation measure. This measure was taken in Grain Silo project in Ujjain which ensured a smooth implementation of the project. The state government, provided a Business Guarantee for the first 10 years. Penalties should be imposed on the government if the land is not provided within the due date provided in the contractual documents. This measure could effectively manage land acquisition risk, social risk, time and cost overruns.

The concessionaire needs to obtain clearances from numerous government departments and notify the progress of the project to various departments which will lead to time and cost overruns in developing the project. Government should provide a single interface interaction setup to prevent delays. Such a single interface system was created for Alandur Sewerage Project. The initiative was done by Alandur Municipality. The Delhi Gurgaon expressway faced significant delay as the project is located within two states, Delhi and Haryana. Lack of cooperation among the local government bodies also triggered approval risk as in the case of Karnataka Urban Water Supply Improvement project.

Financing innovations reduce the cost of funds and provide a new source of funding. This type of funding enables the concessionaire in repaying the loan taken for the project by accessing lower-cost funding. Financing methods like deep discount bonds with take-out financing and cumulative convertible preference shares were employed in Vadodara Halol Toll Road project. Attempt to public deposits was utilized in the Alandur Sewerage project.

Every infrastructure project will have some sort of social and environmental impact. Thus, it is imperative that PPPs should have an environmentally and socially responsive framework. This will also help to gain public support and ease the land acquisition process.

Introducing social and environmental safeguards in contractual documents will grow a positive approach of the public towards PPP projects as they are convinced with the fact that infrastructure projects could be developed in an environmentally and socially responsive manner. It is a best measure for environmental risk mitigation.

The operation phase of conventional projects is managed by the public sector. Since the operation phase in PPP projects is managed by the private sector, it is necessary to provide an operating environment for them or else revenue risk could be aroused. Clear determination of tariff before the bidding process provides optimal space for the private sector to function in the operation phase.

Proper public consultation during the development stage of the project yields public support for the project which will ease the land acquisition process. The public should be convinced of the benefits of the project before the commencement of the construction phase. Lack of public support may even lead to the termination of promising PPP projects. Stakeholder consultations could have avoided many agitation campaigns.

Active support from the government during the various phases of the project prevents political and social risk. This could even lead to the implementation of PPP projects in challenging areas. Government can even convince the public and gain their support for PPP implementation. Government can act as a mediator when a dispute arises between the concessionaire and the public.

A review of case studies helped in identifying seven risk remedial measures to mitigate the risks in PPP projects. Strong political will and public support, favourable operating environment, financing innovations, environmentally and socially responsive development framework, streamlining of approvals and clearances, handling of land acquisitions and clarity of determining tariff were the major measures implemented in the projects to mitigate risks.

2.6 STRUCTURAL EQUATION MODELLING

Hassan et al. (2019) examined the influence of project triple constraints (time, cost and quantity) on building projects in Malaysia. Project triple constraints were the independent variables and building projects were the dependent variable. The effects and relationship between time, cost and quality management towards building projects were investigated. IBM SPSS 22 and SmartPLS 3.2.4 were used for structural equation modelling. The study manifested a strong positive relationship among the project triple constraints on building projects.

Adeleke et al. (2015) integrated internal and external organizational factors, effective construction risk management and government policy into a single model. Effective construction risk management was the dependent variable, internal and external organizational factors were independent variables, and rules and regulations were the moderators of the relationship between the internal and external variables. This model enabled policymakers to enhance the projects and manage the risks effectively through rules and regulations by the government in Nigerian construction industry. The study was limited to assessing the reliability and validity of the instruments. So, only PLS-SEM measurement model was created. The results showed that instruments were reliable and valid.

Ndashimiye et al. (2021) assessed the influence of credit risk and operational risk on the financial performance of commercial banks in Rwanda. Credit risk and operational risk were the independent variables. Profitability was the dependent variable. The size and age of the bank were the control variables. The study concluded that credit risk influenced negatively and operational risks influenced positively profitability. Control variables like size and age of bank were insignificant to profitability.

Guzman et al. (2022) evaluated the relationship between five areas of Occupational Health and Safety (OHS) vulnerability measure and their effects on Workplace Safety (WS) in Oil and Gas industry. The five measures were Exposure to Workplace Hazard (EWH), Policies and Procedures in the Workplace (PPW), Perception on Health and Safety Culture in the Workplace (PHSCW), Self-Awareness in Health and Safety Procedures and Responsibilities (SAHSPR) and Preventive Measure for the Transmission of COVID 19 at the Workplace (PMTC19W). The five OHS measures were independent variables whereas WS was the dependent variable. The findings revealed that only PHSCW positively affected WS. All other hypotheses were insignificant.

From the literature it was found that SEM is similar but more powerful than regression analyses, it examines linear casual relationships among variables, while simultaneously accounting for measurement error.

2.7 SUMMARY

A number of studies have been conducted to identify the risk factors in PPP projects. Various MCDMs were employed to analyze the identified risks in a PPP project. However, no previous studies were initiated to find out the stakeholder perception regarding the risk factors. Past studies on modelling the impact of risk factors on PPP project performance using Partial Least Square Structural Equation Modelling (PLS-SEM) also do not exist.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The research methodology adopted to achieve the objectives of the study is discussed in this chapter and schematic diagram is shown in Figure 3.1 below. Extensive literature survey was conducted to identify 96 risk factors and 7 risk remedial measures which constituted the preliminary set. A pilot study was carried out to shortlist the risk factors and risk remedial measures. The final set included 26 risk factors and 7 risk remedial measures. A Risk Breakdown Structure (RBS) was produced with 26 risk factors categorized under 8 main risk heads.

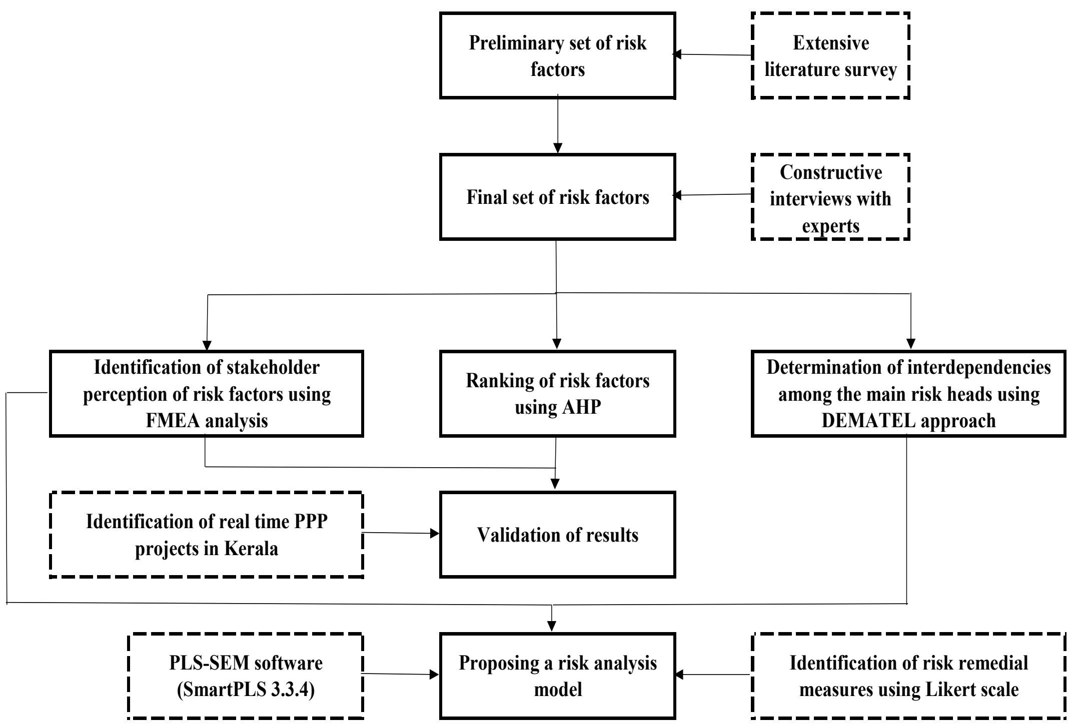

Figure 3.1 Flow chart of research methodology

Multiple-Criteria Decision-Making (MCDM) techniques like Analytical Hierarchy Process (AHP), Failure Mode and Effect Analysis (FMEA) and Decision Making Trial and Evaluation Laboratory (DEMATEL) were utilized for prioritizing and analyzing the risk factors. Relative Importance Index (RII) were employed to find the significance of risk remedial measures. Finally, the impact of risk factors to PPP project performance were modelled using Partial Least Square Structural Equation Modelling (PLS-SEM).

3.2 REVIEW OF LITERATURE

From the literature, a list of 97 risk factors and 7 risk remedial measures in PPP projects were identified. Table 3.1 and 3.2 show the preliminary list of risk factors and risk remedial measures respectively.

Table 3.1 Risk factors influencing project performance

Sl. No	Main risk heads	Risk factors
1	Financial Risks	Availability of funds
2		Type of funds
3		Need for land appraisal
4		Lack of demand/slow development of country
5		Invoice delays
6		Cash flow problems during construction
7		Improper budgeting & contingencies
8		Management strategy of client
9		Organization structure of client
10		Size of the project
11	Legal Risks	Law and order situation
12		Regulatory/Contractual risks
13		Improper design
14		Land acquisition risks
15		Lack of standard model for PPP agreements
16		Need for environmental approval
17		Ownership assets
18		Inadequate study and insufficient data
19		Failure to renew resolutions
20		Inappropriate competition for tenders
21		Insolvency of concession company
22		Third party tort liability
23		Legislation changes
24		Delay in project approvals/permits
25	Political Risks	Termination of agreement by Govt.
26		Attitude of Govt. towards foreign investors
27		Imposition of new tax
28		Increase in tax
29		Expropriation and nationalization of assets

Sl. No	Main risk heads	Risk factors
30	Political Risks	Political/public opposition
31		Influential political events
32		Lack of political support
33		Bribery and corruption
34		Wars and revolutions
35		Unstable government
36		Changes in industrial code of practices
37		Swings in public opinion
38		Government intervention
39		Change in legislation
40	Economic Risks	Poor financial market
41		Inflation rate volatility
42		Interest rate volatility
43		Financial closure risk
44		Exchange rate fluctuations
45		Compulsory purchase risks
46		Market competition(Uniqueness and Exclusiveness)
47		Inappropriate change and estimation in market
48		Tax rate
49		Revenue risk from end user
50		Change in energy cost
51	Operation and Maintenance Risks	Unexpected/unforeseen deterioration
52		Tolling technology
53		Design deficiency
54		Poor workmanship
55		Low quality during construction
56		Operation cost overruns
57		High maintenance cost
58		Project complexity
59		Lack of support infrastructure
60		Operator default
61		Quality of operation
62		Condition of facility
63		Residual assets risks
64		Low operating productivity
65		Frequency of maintenance
66		Risks regarding pricing of products/services
67		Residual value(after concession period)
68	Construction Risks	Change in the scope of work
69		Poor contract management
70		Nonperformance of subcontractors
71		Technology deficiency

Sl. No	Main risk heads	Risk factors
72	Construction Risks	Changing the design specifications
73		Construction completion risks
74		Protection of historical and heritage objects
75		Drop in labour productivity
76		Unproven engineering techniques
77		Site availability
78		Ground conditions
79		Cost overruns
80		Time overruns
81		Site safety
82		Labour disputes and strikes
83		Material/labour availability
84		Contractor failure
85		Material monopoly
86		Equipment quality
87		Supporting utilities risk
88	Social Risks	Social unrest problem
89		Environmental clearance
90		Poor public decision making process
91		Lack of tradition of private provision of public services
92	Relationship Risks	Organization and co-ordination risk
93		Inadequate experience in PPP/PFI
94		Inadequate distribution of responsibilities and risks
95		Differences in working method and know-how between partners
96		Lack of commitment from either partner
97		Inadequate distribution of authority in partnership

Table 3.2 List of risk remedial measures

Sl. No.	Risk Remedial Measures
1	Strong political will and public support
2	Favourable operating environment
3	Financing innovations
4	Environmentally and socially responsive development framework
5	Streamlining of approvals and clearances
6	Handling of land acquisitions
7	Clarity of determining tariff

A pilot study was executed to shortlist the preliminary list of risk factors and risk remedial measures. A total of six experts in PPP projects participated in the pilot study. The list of risk factors was modified whereas the list of risk remedial measures remained unchanged. Table 3.3 shows the final list of risk factors and risk remedial measures adopted in the study and the Risk Breakdown Structure (RBS) is shown in Figure 3.2.

Table 3.3 Final list of risk factors and risk remedial measures

Main risk heads	Risk factors	References
Financial Risks (FR)	Availability of funds (FR1)	[1],[3],[8],[9]
	Concessionaire event of default (FR2)	[2],[9],[12]
	Improper budgeting & contingencies (FR3)	[5],[10],[11]
Political Risks (PR)	Swings in political/public opinion(PR1)	[3],[4],[5]
	Government's intervention and reliability (PR2)	[9],[11],[12]
	Change in legislation (PR3)	[2],[3],[7],[9]
Economic Risks (ER)	Poor financial market (ER1)	[5],[7],[8]
	Inflation and interest rate volatility (ER2)	[7],[11],[12]
	Change in tax regulation (ER3)	[6],[8],[11]
	Exchange rate fluctuations (ER4)	[9],[10],[11]
Legal Risks (LR)	Regulatory/Contractual risks (LR1)	[5],[6],[9]
	Land acquisition risks (LR2)	[3],[7],[8],[10]
	Delay in project approvals/permits (LR3)	[1],[2],[5]
Social Risks (SR)	Social unrest (SR1)	[1],[2],[3]
	Environmental clearance (SR2)	[4],[5],[9]
Operation and Maintenance Risks (OMR)	Operation cost overruns (OMR1)	[1],[3],[8],[12]
	Maintenance cost overruns (OMR2)	[1],[3],[6],[11]
Construction Risks (CR)	Change in the scope of work , design specifications and technology (CR1)	[3],[7]
	Cost overruns (CR2)	[1],[3],[8],[12]
	Time overruns (CR3)	[1],[3],[6],[11]
	Site safety and external linkages (CR4)	[5],[7],[9]
	Availability of resources (CR5)	[9],[11]
Construction Risks (CR)	Availability and drop in productivity of resources (CR6)	[5],[6],[9]
Relationship Risks (RR)	Inadequate experience in PPP and lack of commitment (RR1)	[9],[12]
	Inadequate distribution of responsibilities and risks (RR2)	[5],[6],[7]
	Inadequate distribution of authority in partnership (RR3)	[5],[8],[12]

Risk Remedial Measures	References
Strong political will and public support (RM1)	[13]
Favourable operating environment (RM2)	[13]
Financing innovations (RM3)	[13]
Environmentally and socially responsive development framework (RM4)	[13]
Streamlining of approvals and clearances (RM5)	[13]
Handling of land acquisitions (RM6)	[13]
Clarity of determining tariff (RM7)	[13]

[1] Gupta et al. (2015); [2] Issa et al. (2021); [3] Jocker et al. (2021); [4] Karim et al. (2015); [5] Ke et al. (2010); [6] Khahro et al. (2021); [7] Khodier et al. (2014); [8] Khodier et al. (2019); [9] Valipour et al. (2015); [10] Kesh et al. (2018); [11] Szymanski et al. (2017); [12] Zhang et al. (2019); [13] Government of India

3.3 QUESTIONNAIRE SURVEY

A formal questionnaire survey was conducted to collect the responses of different stakeholders involved in PPP projects. The detailed questionnaire is provided in Appendix A. The questionnaire consisted of two parts. The first part was intended to collect the general information about the respondent's organization, designation, present location of work and work experience in PPP projects. The second part was designed to study the respondent's perceptions on the risks in PPP projects for highways in Kerala. The second part is again sub divided into four parts. Information sought in each of the parts are as follows:

- PART A: The respondents are asked to rate the relative importance of risk factors for AHP analysis
- PART B: The respondents are asked to rate the occurrence, severity and detection of each of the risk factors for FMEA analysis
- PART C: The respondents are asked to rate the effect of each of the main risk heads over the others for DEMATEL analysis
- PART D: The respondents are asked to rate the significance of each of the risk remedial measures using Likert scale

Questionnaire were conducted in two ways, online (via Email and LinkedIn) and one to one interviews. A total of 96 responses were received, out of which, 30 responses were received

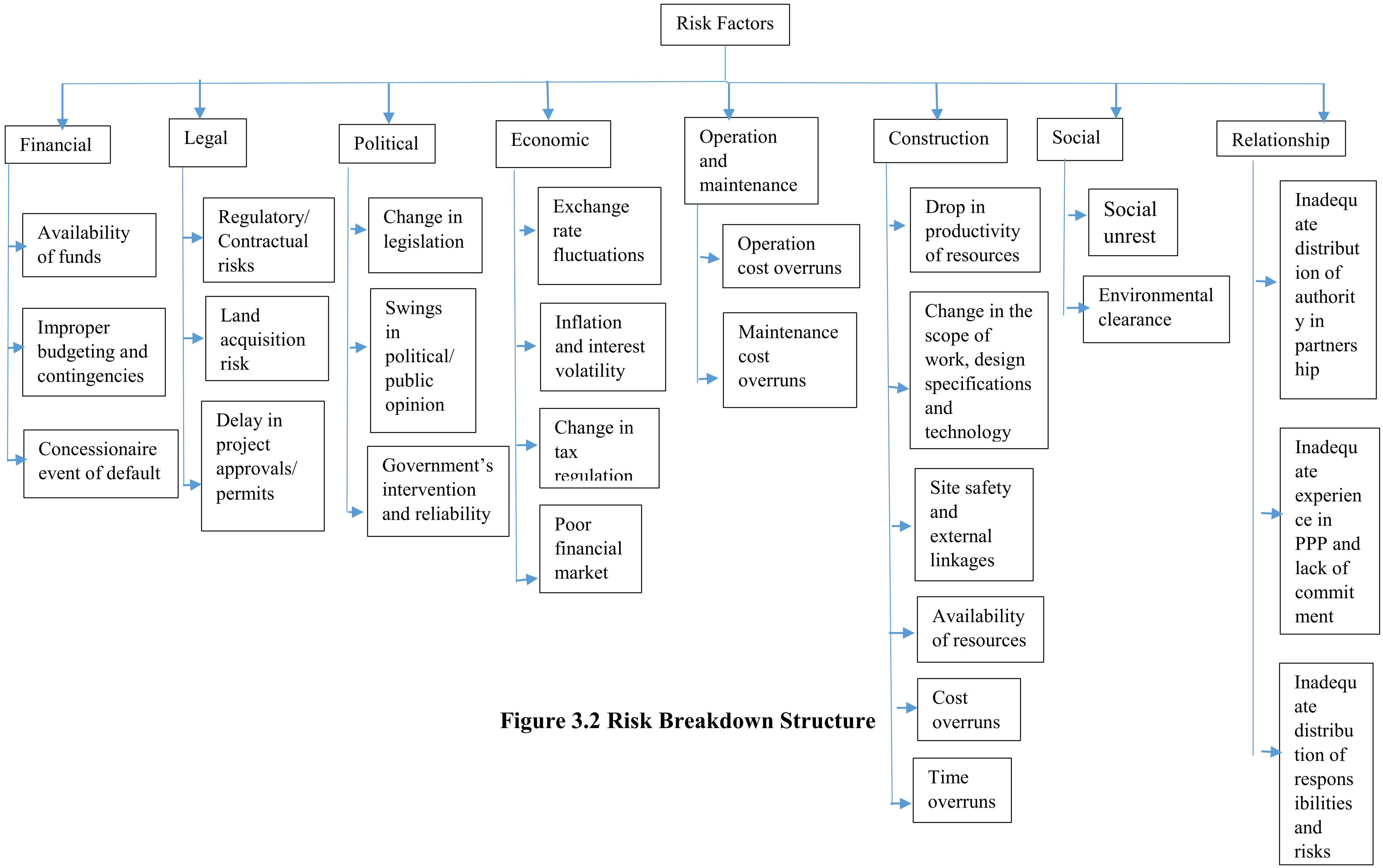

Figure 3.2 Risk Breakdown Structure

each from professionals working in public and private sector, 16 were received from users and 10 were received each from concessionaires and suppliers in Kerala.

3.4 ANALYSIS OF RISK FACTORS AND RISK REMEDIAL MEASURES

3.4.1 Analytical Hierarchy Process

The Analytical Hierarchy Process (AHP) was developed by Thomas L. Saaty in 1970s. The AHP is a method for organizing and analyzing complex decisions, using math and psychology. The AHP model is a tree diagram, consists of a goal at the top, a set of alternatives for reaching the goal at the lowest level, and a set of criteria connecting the alternatives to the goal. The goal in the present study is the project performance. As per Saaty, the first step of AHP is to formulate the decision problem in a hierarchy structure. The fundamental hierarchy structure includes three levels. The second step is to carry out pair-wise comparison where elements in each level are pair-wise compared with respect to their importance to the entire decision problem. After checking the consistency of the pair-wise comparison, the ranking of each element and the priority of alternatives can be computed. The hierarchy structure of AHP is given in Figure 3.3 below. (Mustafa and Bahar 1991)

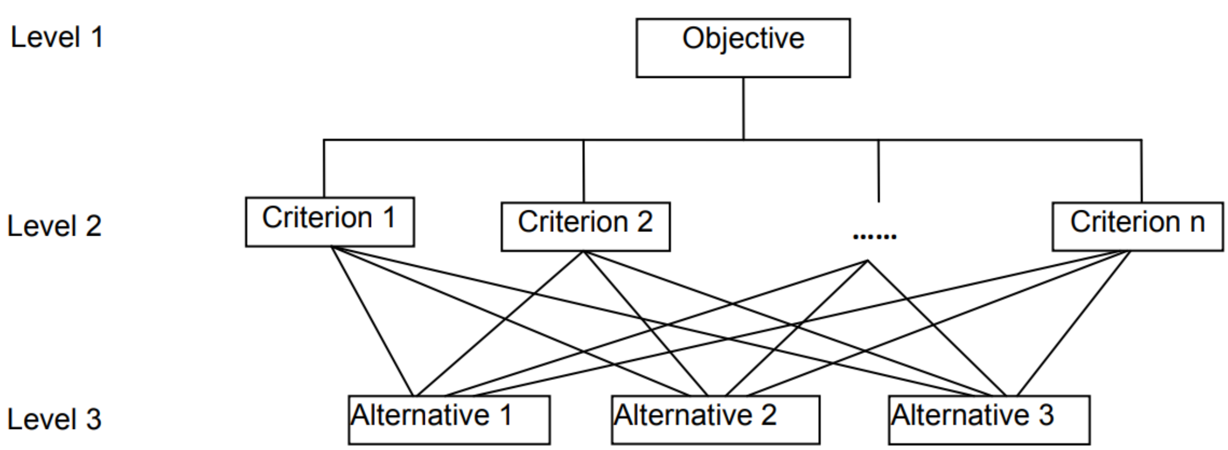

Figure 3.3 Hierarchy structure of AHP (Mustafa and Bahar, 1991)

3.4.2 Failure Mode and Effect Analysis

Begun in the 1940s by the US military, Failure Mode and Effect Analysis (FMEA) is a tool for identifying potential modes of failure in a system, evaluating the main causes, determining the impact of failures and formulating preventive measures (Mohammadi and Tavakolan, 2013). In this system, a Risk Priority Number (RPN) for each risk is calculated as the product of the probability of risk occurrence (O), severity (S) and detection (D). The 'O' rating refers to the frequency of the occurrence of a particular risk factor. The 'S' rating is used to represent the potential effects associated with the occurrence of a risk factor. The 'D' rating considers the likelihood of detection of a particular risk factor. The RPN represents the level of particular risk, i.e., a higher value of RPN means higher level of risk. FMEA technique treats O, S, and D as equally important.

3.4.3 Decision Making Trial and Evaluation Laboratory (DEMATEL)

The Decision making trial and evaluation laboratory (DEMATEL) technique was first developed by the Geneva Research Centre of the Battelle Memorial Institute to illustrate the causal relationships among various elements and determine the importance of each element in the system. It is a comprehensive method using causal relationship matrices or digraphs to establish a structural model and portray cause-effect relationships between systems components. The Decision-Making Trail and Evaluation Laboratory (DEMATEL) is used to analyze the casual relationships between different factors and employs diagrams to show the weight of each factor. This technique is very helpful in solving problems with factors having number of interrelationships.

3.4.4 Likert Scale

Rensis Likert, the inventor of Likert scale, defined it as a five (or seven) point scale which is used to allow the individual to express how much they agree or disagree with a particular statement. Thus, the range captures the intensity of their feelings for a given item. The ranking of the attributes was done using the Relative Importance Index (RII) method.

3.5 STRUCTURAL EQUATION MODELLING

Structural Equation Modelling (SEM) is a set of statistical techniques used to measure and analyze the relationships of observed and latent variables. Observed variables are those which are directly measured and latent variables are those which are not directly measured, but measured using observed variables. A structural equation model has two components, structural model (inner model) and measurement model (outer model). The structural model shows the relationship between the latent variables (constructs). The measurement model includes unidirectional predictive relationships between each latent variable and its associated observed variable. The two types of SEM approaches are Covariance-Based Structural Equation Modelling (CB-SEM) and the Partial Least Square Structural Equation Modelling (PLS-SEM) (Hair et al., 2014). This study, focuses on PLS-SEM approach.

3.6 SUMMARY

The various risk factors and risk remedial measures influencing PPP project performance in the context of Kerala were identified from the literature and subsequent pilot study was conducted among professionals in the construction industry. Questionnaire survey was conducted to gather the opinions of different stakeholders on the risk factors and risk remedial measures influencing PPP project performance in Kerala. The risk factors were classified into Financial Risks (FR), Political Risks (PR), Economic Risks (ER), Social and Legal Risks (SLR), Operation and Maintenance Risks (OMR) and Construction Risks (CR). Partial least square structural equation modelling (PLS-SEM) technique was used for modelling and evaluating the impact of risk factors on project performance and the interrelationships.

CHAPTER 4

ANALYSIS OF RISK FACTORS AND RISK REMEDIAL MEASURES

4.1 INTRODUCTION

Risk factors and risk remedial measures in PPP projects were prioritized and analyzed using responses obtained from questionnaire survey. The comprehensive questionnaire is given in Appendix. A total of 96 responses were received, out of which, 30 responses were received each from professionals working in the public and private sectors, 16 were received from end-users and 10 each were received from concessionaires and suppliers in Kerala. Table 4.1 show the list of projects considered in this survey.

Table 4.1 List of projects

Sl. No.	Name of the Project
1	Kozhikode City Road Improvement Project
2	Thiruvananthapuram City Road Improvement Project
3	Kannur City Road Improvement Project
4	Six-laning of Kozhikode bypass (Vengalam-Ramanattukara)
5	Four-laning of Walayar - Vadakkanchery
6	Six-laning of Vadakkanchery - Thrissur

4.2 DEMOGRAPHICS OF RESPONDENTS

Responses were received from stakeholders in 9 districts in Kerala. Figure 4.1 shows the city wise comparison of the respondent's present location of work. More than half (65%) of the responses were received from three districts, Thiruvananthapuram, Kozhikode and Ernakulum. Figure 4.2 shows the working experience of the respondents. More the half of the respondents had ample experience in the construction industry.

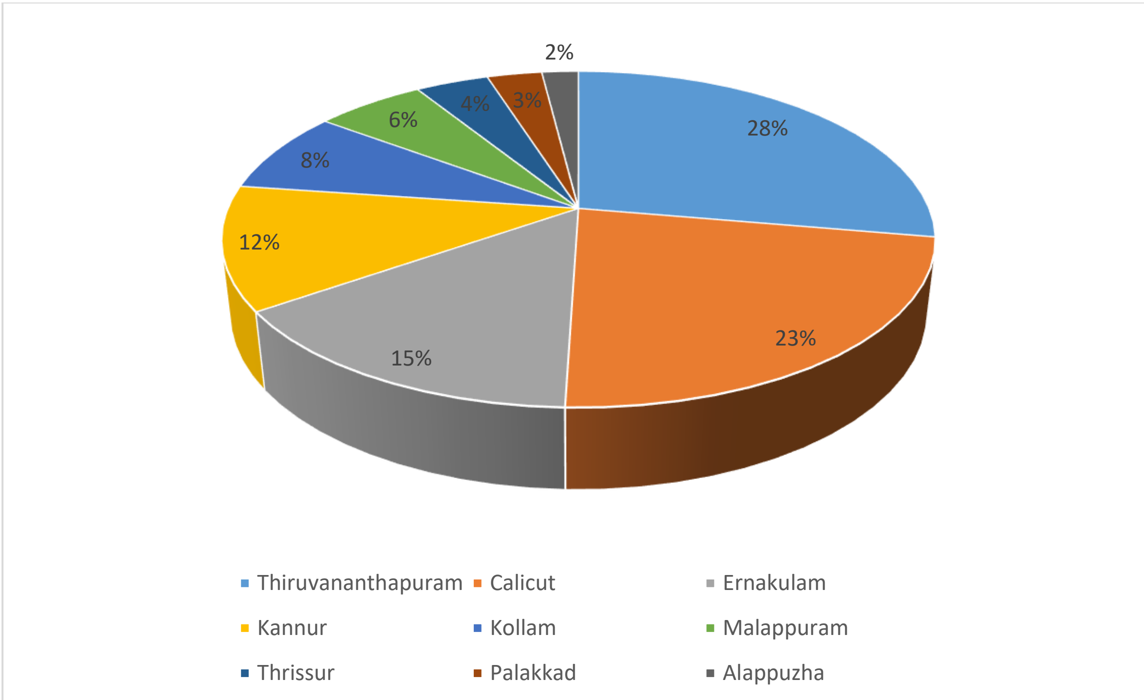

Figure 4.1 District wise composition of the respondent's present location of work

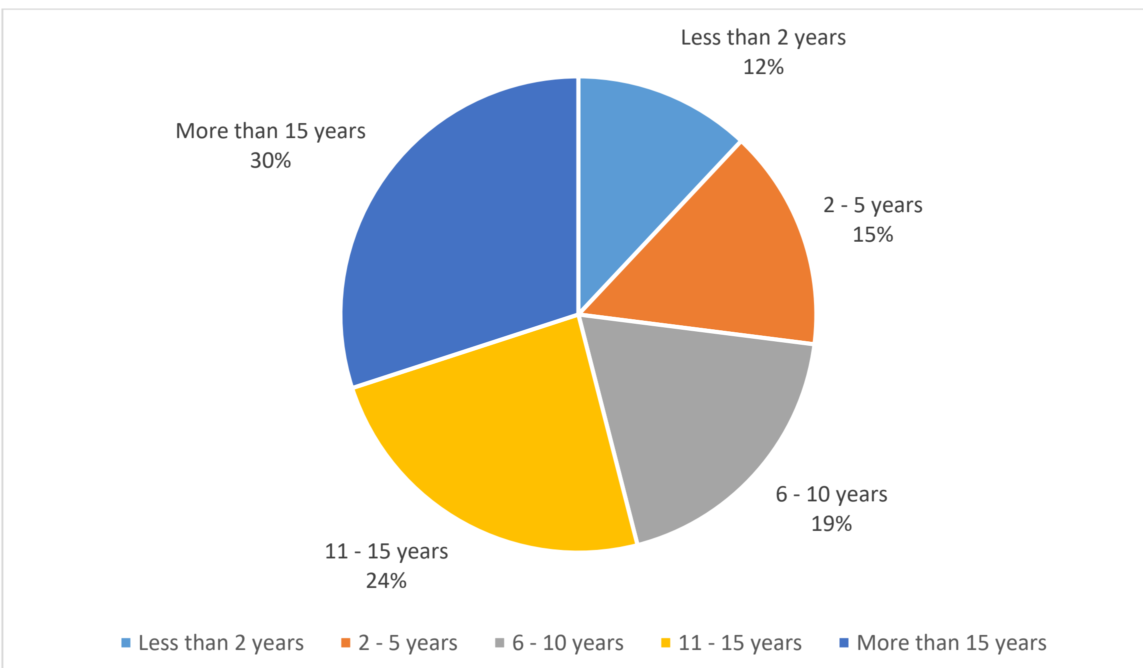

Figure 4.2 Experience of the respondents

Table 4.2 shows the profile of respondents. Information like the designation of respondents and the stakeholder category are summarized in this table.

Table 4.2 Profile of respondents

Stakeholder category	Designation
Concessionaire	Chairman
	Vice Chairman
	Director
	Chief Executive Officer
Client	General Manager
	Assistant Manager
	Executive Engineer
	Assistant Executive Engineer
	Assistant Engineer
	Project Engineer
Employees	Senior Manager
	Senior Project Engineer
	Project Auditor
	Senior Finance Executive
	Project Engineer
	Senior Finance Auditor
	Finance Executive
	Finance Auditor
	Contracts Engineer
	Project Manager
	Planning Engineer
	Site Engineer
	Project Coordinator
	Quality Assurance/Control Engineer
	Quantity Surveyor
	Structural Engineer
	Highway Design Engineer
	Procurement Engineer
	Project Estimator
Supplier	Deputy Manager
	Regional Head
	Quality Control Officer
	Marketing and Sales Manager
	Branch Manager

4.3 ANALYSIS OF MAIN RISK HEADS

Decision- Making Trial and Evaluation Laboratory (DEMATEL) method was used to define the interdependencies or relative intensity among the main risk heads. The procedure for DEMATEL analysis to find the cause and effect relationship between the main risk heads is given below (Zheng et al., 2021; Zhang et al., 2019; Sekerand and Zavadskar, 2017; Altuntas and Yilmaz, 2016).

Step 1: Define the evaluation scale:

Respondents are asked to indicate the direct influence that they believe each element exerts on each of the others in an integer scale ranging 0 to 4. The linguistic scale is given in Table 4.3 below.

Table 4.3 Linguistic Scale-DEMATEL (Zhang et al., 2019)

Linguistic variable	Influence score
No influence	0
Very low influence	1
Low influence	2
High influence	3
Very high influence	4

Step 2: Compute average initial direct-relation matrix (Z matrix)

Suppose in a problem that composes 'n' factors, binary relations and the degree of influence of criteria i to criteria j are investigated. All pairwise comparisons between the i^{th} criteria and the j^{th} criteria is denoted as a_{ij}. Each expert would produce an n x n matrix. Z matrix is given by Eq. 4.1 below. Table 4.4 shows the Z matrix for 32 responses.

$$\text{Z matrix} = z_{ij} = \frac{\sum_{n=1}^{m} a_{ij}^{n}}{m} \quad \text{where, m = total number of responses} \qquad (4.1)$$

Table 4.4 Average initial direct-relation matrix

Main risk heads	FR	LR	PR	ER	OMR	CR	SR	RR
FR	0.000	2.167	1.667	2.917	3.000	3.417	1.917	1.333
LR	2.250	0.000	1.667	2.167	2.250	2.500	2.083	1.500
PR	2.167	1.583	0.000	2.500	2.333	2.583	2.083	1.750
ER	3.083	1.750	1.917	0.000	2.667	2.583	1.750	1.250
OMR	3.083	2.500	2.250	3.083	0.000	3.250	2.083	1.583
CR	3.333	2.667	2.417	2.667	2.583	0.000	2.333	2.000
SR	1.750	1.583	2.000	1.750	2.000	2.417	0.000	1.833
RR	2.333	1.583	1.917	1.917	2.167	2.750	2.000	0.000

Step 3: Calculate the normalized direct-relation matrix (X matrix)

X matrix can be obtained by normalizing the average initial direct-relation matrix (Z matrix). Using the normalization factor ‘S’. The X matrix is given by Eq. 4.2 below. The initial influence which an element exerts and receives from another can be read from the Xth matrix. (Tzeng et al., 2007)

X matrix = $[x_{ij}]_{nxn}$, $0 \leq x_{ij} \leq 1$ (4.2)

$= S * Z$ where, $S = \frac{1}{\max 1 \leq i \leq n \sum_{j=1}^{n} z_{ij}}$; i, j = 1,2,….,n

Table 4.5 Normalized direct-relation matrix

Main risk heads	FR	LR	PR	ER	OMR	CR	SR	RR
FR	0.000	0.111	0.085	0.105	0.154	0.175	0.098	0.068
LR	0.115	0.000	0.085	0.111	0.115	0.128	0.107	0.077
PR	0.111	0.081	0.000	0.128	0.120	0.132	0.107	0.090
ER	0.158	0.090	0.098	0.000	0.137	0.132	0.090	0.064
OMR	0.158	0.128	0.115	0.158	0.000	0.167	0.107	0.081
CR	0.171	0.137	0.124	0.137	0.132	0.000	0.120	0.103
SR	0.090	0.081	0.103	0.090	0.103	0.124	0.000	0.094
RR	0.120	0.081	0.098	0.098	0.111	0.141	0.103	0.000

Table 4.5 shows the values of normalized direct-relation matrix. The largest of the row and column is 17.832 and 19.5 respectively and the highest value (19.5) is used in further calculations.

Step 4: Derive the total-relation matrix (T matrix)

A continuous decrease of the indirect effects of problems along the powers of the matrix X (X^2, X^3,….., X^{α}) guarantees convergent solutions to matrix inversion. The T matrix is given by Eq. 4.3 below. Table 4.6 shows the values of total-relation matrix.

$$\text{T matrix} = X(I-X)^{-1} \tag{4.3}$$

Table 4.6 Total-relation matrix

Main risk heads	**FR**	**LR**	**PR**	**ER**	**OMR**	**CR**	**SR**	**RR**
FR	0.525	0.515	0.485	0.063	0.506	0.703	0.627	0.398
LR	0.563	0.364	0.436	**0.836**	0.463	0.600	0.537	0.366
PR	**0.878**	0.453	0.371	0.567	0.477	0.622	0.558	0.388
ER	0.620	0.465	0.463	0.459	0.466	0.062	0.576	0.364
OMR	0.512	0.414	0.428	0.490	0.343	0.654	0.468	0.361
CR	0.707	0.056	0.054	0.653	0.554	0.564	0.646	0.451
SR	0.697	0.556	0.537	**0.868**	0.542	0.735	0.528	0.432
RR	0.576	0.446	0.454	0.534	0.467	0.620	0.542	0.300

Step 5: Produce a casual diagram

The sum of the values of each column and row in the total relation matrix are calculated. 'R' is the sum of rows and 'C' is the sum of columns of respective factors. The R and C values represent both the direct and indirect influences between factors. R_i value means the sum of influence dispatching from element i to the other elements. C_j means the sum of influence that element j receives from the other elements.

A casual diagram is produced by mapping the dataset of (Prominence, Relation). "Prominence" (horizontal axis) is made by adding R and C and "Relation" (vertical axis) is made by subtracting C from R. "Prominence" shows how important the criteria is, whereas "Relation" may divide the criteria into the cause and effect groups. When the relation value is positive, the criterion belongs to the cause group. If the relation value is negative, the criterion belongs to the effect group. Table 4.7 shows the Prominence and Relation values.

Along the horizontal axis of the cause effect diagram, the prominence of the factors increases. From the casual diagram (Figure 4.3), it can be inferred that Social Risks (SR) are the most prominent risk group closely followed by Financial Risks (FR). The horizontal axis separate the cause group risks and effect group risks. Figure 4.3 reveals that Relationship Risks (RR), Legal Risks (LR), Political Risks (PR) and Social Risks (SR) lies in cause group whereas Financial Risks (FR), Economic Risks (ER), Construction Risks (CR) and Operation & Maintenance Risks (OMR) lies in effect group.

Table 4.7 Prominence and Relation values

Main risk heads	R	C	R+C	R-C
FR	3.822	5.078	8.900	-1.256
LR	4.314	3.228	7.542	1.085
PR	4.165	3.269	7.434	0.896
ER	3.475	4.470	7.945	-0.995
OMR	3.670	3.818	7.488	-0.148
CR	3.685	4.560	8.245	-0.874
SR	4.895	4.482	9.377	0.413
RR	3.939	3.060	6.999	0.879

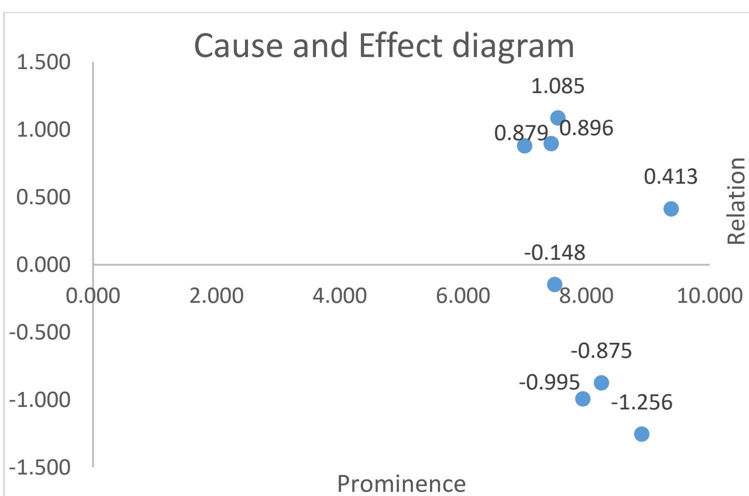

Figure 4.3 Cause and effect diagram

The cause group triggers the other risks. Legal Risks (LR) were the major cause group risks and hence legal risks should be given due consideration in the risk management process. Legal Risks (LR) had highest influence as PPPs are in nurturing stage in Kerala, and were affected by many uncertain factors like policies of the concessionaire, region regulations, new laws and so on (Zhang et al., 2019). Financial Risks (FR) and Construction Risks (CR) had high prominence value and low relation value implying that they were significant risks and easily affected by other risks.

In PLS-SEM, the results of DEMATEL approach were utilized to develop the hypothesis on the interrelationship of risk factors. Only critical influence values were considered in PLS modelling. Interrelationship of Legal Risks (LR) and Social Risks (SR) to Economic Risks (ER) and Political Risks (PR) to Financial Risks (FR) were taken as critical relations as their influence value was greater than 0.8 (Table 4.8).

In the process of formulating or amending laws, legislative departments do not seek and consider the opinions and interests of private sector. This leads to concessionaires not willing to fund PPP projects. Revenue leakage leads to failure in monetizing high value services appropriately, resulting in poor financial market. In addition, end-user may not be ready to use the infrastructure project due to change in markets from social and legal factors.

4.4 ANALYSIS OF RISK FACTORS

4.4.1 Analytical Hierarchy Process (AHP)

As the interdependencies among the main risk heads were established, the next step is to prioritize the main risk heads and risk factors. The steps employed to find the AHP weights of sub risk factors are given below (Askart et al., 2014; Jokar et al., 2021).

Step 1: Pair wise comparison

Respondents rate the relative importance of factors using the scale from 1 to 9. The linguistic scale is shown in Table 4.8. The pair wise comparison matrix is created by filling upper triangular matrix first. If the judgment value is on the left side of 1, actual judgment value is written on the upper triangular matrix. If the judgment value is on the right side of 1, reciprocal value is written on the upper triangular matrix. If the criteria in the column are preferred to the criteria in the row, then the inverse of the rating is given. To fill the lower triangular matrix, the reciprocal values of the upper diagonal are used. In pairwise comparison, the criteria in the row are being compared to the criteria in the columns. The pairwise comparison matrix is shown in Table 4.9.

Table 4.8 Linguistic scale-AHP (Saaty and Vargas, 1991)

Scale	Degree of preference
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance

Table 4.9 Pairwise comparison matrix

Main risk factors	FR	LR	PR	ER	OMR	CR	SR	RR
FR	1.000	3.149	2.639	2.051	2.502	1.588	1.925	3.274
LR	0.316	1.000	1.762	1.076	1.682	1.136	1.573	2.678
PR	0.379	0.568	1.000	1.404	1.130	0.820	0.802	1.298
ER	0.488	0.929	0.712	1.000	1.804	0.827	2.059	2.686
OMR	0.400	0.595	0.885	0.554	1.000	1.509	2.197	2.482
CR	0.630	0.880	1.220	1.209	0.663	1.000	3.259	2.569
SR	0.519	0.636	1.247	0.486	0.455	0.307	1.000	1.863
RR	0.305	0.373	0.770	0.372	0.403	0.389	0.537	1.000

Step2: Normalization

This step is to normalize the matrix by totaling the number in each column. Each entry in the column is divided by the column sum to yield its normalized score. The sum of each column is 1.

Step 3: Consistency analysis

The purpose of calculating the consistency ratio is to make sure that the original preference ratings are consistent. In practice, a value 0.1 or below is considered acceptable. Any higher value at any level indicates that the judgments warrant re-examination. The consistency ratio is below 0.1 for all the normalized matrices.

The AHP analysis is done using the aid of online software which directly gives the AHP weights and provides the pairwise comparison matrix.

Step 4: Developing AHP weights for each criterion

Averaging the values in each row of the normalized matrix yields the AHP weights. Table 4.10 shows the AHP weights and ranking of main risk heads.

Table 4.10 AHP weights and ranking of main risk heads

Main Risk Heads	AHP Weights	Rank
Social Risks	0.8073	1
Financial Risks	0.2441	2
Construction Risks	0.1394	3
Legal Risks	0.1375	4
Economic Risks	0.1290	5
Operation and Maintenance Risks	0.1163	6
Political Risks	0.0991	7
Relationship Risks	0.0534	8

Among the main risk heads, social risks and financial risks were ranked top. Social risks arise due to public opposition upon site selection and land acquisition, environmental pollution etc. Financial risks like insufficient funds will directly affect the construction as PPP projects require a large investment.

AHP weights of main risk heads were multiplied with the local AHP weights of risk factors to obtain the global AHP weights of risk factors.

Table 4.11 AHP weights and ranking of risk factors

Main Risk Heads	AHP Weights of Main Risk Heads	Risk Factors	Local AHP Weights of Risk Factors	Global AHP Weights of Risk Factors	Rank
Financial Risks	0.244	FR1	0.650	0.159	3
		FR2	0.106	0.026	16
		FR3	0.242	0.059	6
Legal Risks	0.137	LR1	0.179	0.030	12
		LR2	0.225	0.047	7
		LR3	0.595	0.082	5
Political Risks	0.099	PR1	0.435	0.036	10
		PR2	0.368	0.025	17
		PR3	0.195	0.043	8
Economic Risks	0.129	ER1	0.191	0.025	18
		ER2	0.366	0.019	21
		ER3	0.225	0.018	22
		ER4	0.215	0.028	14
Operation and Maintenance Risks	0.116	OMR1	0.772	0.090	4
		OMR2	0.227	0.024	19
Construction Risks	0.139	CR1	0.275	0.032	11
		CR2	0.236	0.029	13
		CR3	0.173	0.026	15
		CR4	0.035	0.011	26
		CR5	0.076	0.019	24
		CR6	0.103	0.038	9
Social Risks	0.807	SR1	0.535	0.432	1
		SR2	0.464	0.375	2
Relationship Risks	0.053	RR1	0.484	0.023	20
		RR2	0.277	0.014	23

There are two types of weights in AHP: global and local weights. Local AHP weights are obtained as a result of AHP analysis within each category. The sum of local weights of the total categories on the same hierarchy was 1.000. The value of global weight equaled the value of the local weight within each category multiplied by the value of local weight within each variable. The sum of global weights was also 1.000. AHP weights of main risk heads were multiplied with the local AHP weights of risk factors to obtain the global AHP weights of risk factors. For example, the value of the global weight for availability of funds. The ranking was arranged according to the order of the global weight. Table 4.11 shows the AHP weights and ranking of risk factors.

The top five risks obtained from AHP analysis were Social unrest (SR1), Environmental clearance (SR2), Availability of funds (FR1), Operation cost overruns (OMR1) and Delay in project approvals/permits (LR1).

4.4.2 Failure Mode and Effect Analysis (FMEA)

In AHP analysis, the risk factors were prioritized without taking into consideration the stakeholder perception on risk factors. FMEA analyzes the risk factors based on the perceptions of stakeholder on various risk factors. The survey responses for FMEA analysis is used in modelling the impact of risk factors on PPP project performance in PLS-SEM.

FMEA procedure employed for the present study is discussed below (Nazeri and Naderikia, 2017);

Step 1: Respondents are asked to rate the occurrence (O), severity (S) and detection (D) according to a linguistic scale. The linguistic scale used in the study is provided in Table 4.12.

4.12 Linguistic scale- FMEA

Occurrence	**Severity**	**Detection**	**Rating**
Linguistic phrase			
Very high	Extremely significant effect	No chance	5
High	Very significant effect	Low chance	4
Medium	Significant effect	Moderate chance	3
Low	Slight effect	High chance	2
Very low	No effect	Very high chance	1

Step 2: The mean responses are found by taking the average of the ratings from the respondents.

Table 4.13 FMEA ranking of risk factors

Code	Risk Factors	RPN	Rank
SR1	Social unrest	85.965	1
SR2	Environmental Clearance	82.634	2
FR1	Availability of funds	78.512	3
OMR1	Operations cost overruns	75.832	4
LR3	Delay in project approvals/permits	71.245	5
PR3	Change in legislation	66.356	6
LR2	Land acquisition risks	61.763	7
FR3	Improper budgeting and contingencies	58.451	8
PR1	Swings in political/public opinion	54.333	9
CR1	Change in the scope of work, design and specifications and technology	51.169	10
CR6	Drop in productivity of resources	49.168	11
LR1	Regulatory/contractual risks	45.258	12
ER3	Change in tax regulations	42.056	13
FR2	Concessionaire event of default	39.613	14
CR2	Cost overruns	35.111	15
CR3	Time overruns	33.523	16
PR2	Government's intervention and reliability	31.226	17
ER1	Poor financial market	29.197	18
OMR2	Maintenance cost overruns	27.891	19
RR1	Inadequate experience in PPP and lack of commitment	25.498	20
ER4	Exchange rate fluctuations	23.569	21
ER2	Inflation and interest rate volatility	21.555	22
CR5	Availability of resources	19.456	23
RR2	Inadequate distribution of responsibilities and risks	18.569	24
RR3	Inadequate distribution of authority in partnership	18.253	25
CR4	Site safety and external linkages	17.564	26

Step 3: The Risk Priority Number (RPN) is the FMEA weights of each risk calculated as the product of ratings of occurrence, severity and detection.

Perceptions of various stakeholders on risk factors was analyzed using FMEA analysis. General ranking of risk factors on FMEA analysis is shown in 4.13 including every stakeholder.

Social unrest (SR1), Environmental clearance (SR2), Availability of funds (FR1), Operation cost overruns (OMR1) and Delay in project approvals/permits (LR1) were the top five risk factors for general ranking.

Figure 4.4 shows the comparison of ranking FMEA analysis among various stakeholders. Social unrest (SR1), Environmental clearance (SR2), Change in legislation (PR3), Land acquisition risk (LR2) and Drop in productivity of resources (CR6) were the top five risk factors for end-user. For end user, the project should be free from social and environmental risks.

In the clients' point of view, Availability of funds (FR1), Regulatory/contractual risk (LR1), Social unrest (SR1), Operations cost overruns (OMR1) and Concessionaire event of default (FR2) were the top five risk factors. On-time funding of project is crucial for the smooth execution without time overrun. Client needs the project to complete within the stipulated time.

Delay in project approvals (LR3), Land acquisition risks (LR2), Time overruns (CR3), Change in legislation (PR3) and Change in tax regulations (ER3) were the top risks in employee's perspective. If project approvals are cleared timely and lands are acquired during the development stage, the employees can focus more on project than on running behind approvals and wait till the lands are acquired to start the construction of the project.

Delay in project approvals (LR3), Social unrest (SR1), Swings in political/public opinion (PR1), Change in tax regulations (ER3) and Change in legislation (PR3) were the top ranked risks as per concessionaire's outlook. Swings in political/public opinion affect the smooth execution of project. Strong support from government as well as public is mandatory for the same.

Availability of funds (FR1), Concessionaire event of default (FR2), Delay in project approvals (LR3), Change in legislation (PR3) and Change in tax regulations (ER3) were the top risks for supplier. Supplier needs the construction phase to run smoothly without delay from the part of concessionaire.

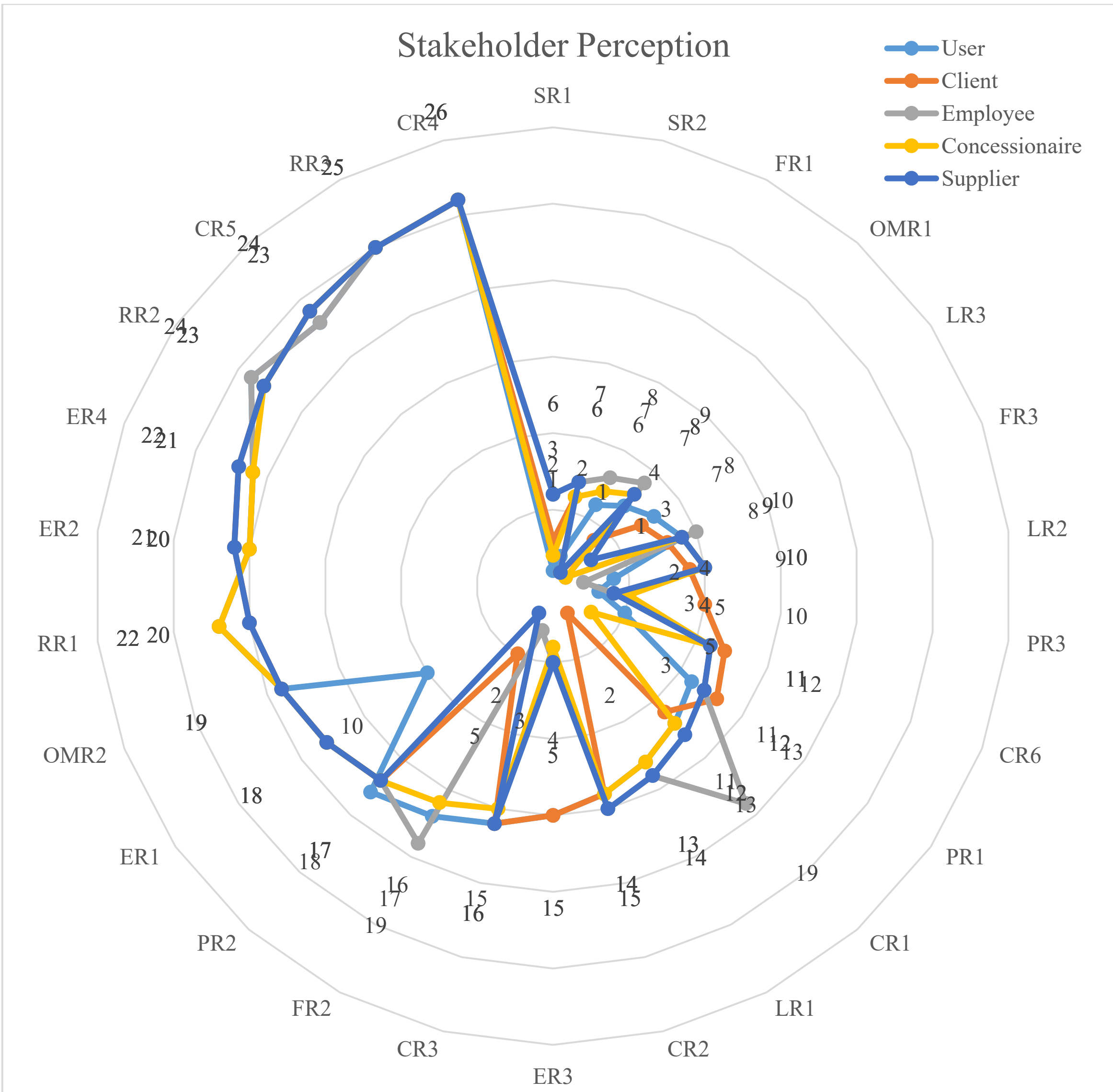

Figure 4.4 Comparison of ranking using FMEA analysis among various stakeholders

4.5 VALIDATION OF RESULTS

A live PPP project in Kerala was selected for validation the results. The survey was conducted with respondents who were involved in the Kozhikode City Road Improvement

Project (KCRIP) – Phase 1. The construction phase of the project was completed and it was under operation and maintenance phase. Phase 2 of the project was also under construction. The execution of the project, KCRIP was on the basis of Design-Build-Finance-Operate-Transfer (DBFOT) mode. Phase I included the development of 6 corridors of 22.251 km which was completed and opened for public.

The execution of the project was entrusted with M/s. Uralungal Labour Contractors Co-operative Society Calicut City Infrastructure Development Pvt. Ltd. (UCCIDPL) with a concession period of 15 years. Improvisation of 28 junctions, 15 signalized junctions, provision of 62 bus shelters and 39 bus bays, installation of 9 High mast Lights were the salient features of KCRIP.

Table 4.14 and Table 4.15 show the ranking of risk factors in PPP projects in Kerala and. case study respectively. Comparing the ranking of PPP projects by AHP analysis, FMEA analysis, occurrence rating and severity rating, it was seen that rankings were more or less same. Social unrest (SR1) and Environmental clearance (SR2) were the top two risks for all the analyses. Availability of funds (FR1) was the third ranked risk for all the analyses, except for severity rating. Considering the top five risks, the risk factors were same in all the analyses.

The trend was similar in the case of ranking of risk factors in case study compared to overall ranking. Social unrest (SR1) and Environmental clearance (SR2) were the top two risks for all the analyses. Availability of funds (FR1) was the third ranked risk for all the analyses, except for severity rating. Considering the top five risks, the risk factors were same in all the analyses.

Table 4.14 Ranking of risk factors in PPP projects in Kerala

Risk Factors	General (Kerala Projects)							
	AHP Analysis		FMEA Analysis		Ranking Based on Occurrence		Ranking Based on Severity	
	AHP Weights	Rank	RPN	Rank	RII	Rank	RII	Rank
SR1	0.432	1	85.965	1	0.812	1	0.787	1
SR2	0.375	2	82.634	2	0.795	2	0.765	2
FR1	0.159	3	78.512	3	0.788	3	0.731	5
OMR1	0.090	4	75.832	4	0.777	5	0.746	4
LR3	0.082	5	71.245	5	0.782	4	0.754	3
PR3	0.059	6	58.451	8	0.765	7	0.723	6
LR2	0.047	7	61.763	7	0.771	6	0.698	8
FR3	0.043	8	66.356	6	0.758	8	0.705	7
PR1	0.038	9	49.168	11	0.741	9	0.688	9
CR1	0.037	10	54.333	9	0.722	11	0.666	11
CR6	0.033	11	51.169	10	0.736	10	0.671	10
LR1	0.031	12	45.258	12	0.715	12	0.659	12
ER3	0.029	13	35.111	15	0.696	13	0.631	14
FR2	0.028	14	42.056	13	0.658	15	0.645	13
CR2	0.026	15	33.523	16	0.671	14	0.625	15
CR3	0.026	16	39.613	14	0.633	16	0.613	16
PR2	0.026	17	31.226	17	0.596	18	0.599	17
ER1	0.025	18	29.197	18	0.571	19	0.574	19
OMR2	0.025	19	27.891	19	0.557	20	0.582	18
RR1	0.024	20	25.498	20	0.613	17	0.561	20
ER4	0.019	21	21.555	22	0.532	21	0.549	21
ER2	0.017	22	23.569	21	0.517	23	0.533	22
CR5	0.015	23	18.569	24	0.526	22	0.508	24
RR2	0.014	24	19.456	23	0.502	24	0.514	23
RR3	0.013	25	18.253	25	0.496	25	0.491	25
CR4	0.011	26	17.564	26	0.482	26	0.478	26

Table 4.15 Ranking of risk factors in case study

Risk Factors	Kozhikode City Road Improvement Project-Phase 1							
	AHP Analysis		FMEA Analysis		Ranking Based on Occurrence		Ranking Based on Severity	
	AHP Weights	Rank	RPN	Rank	RII	Rank	RII	Rank
SR1	0.399	1	77.954	1	0.825	1	0.765	1
SR2	0.354	2	74.543	2	0.816	2	0.755	2
FR1	0.205	3	65.847	5	0.806	3	0.748	3
OMR1	0.198	4	71.933	3	0.800	4	0.735	5
LR3	0.178	5	68.584	4	0.795	5	0.741	4
FR3	0.154	7	63.286	6	0.789	6	0.725	7
LR2	0.136	8	61.298	7	0.777	8	0.725	8
PR3	0.166	6	56.222	9	0.784	7	0.723	9
CR6	0.115	9	51.369	10	0.771	9	0.731	6
PR1	0.102	10	47.234	11	0.768	10	0.719	10
CR1	0.098	11	58.794	8	0.761	12	0.711	12
LR1	0.087	12	39.548	14	0.765	11	0.715	11
CR2	0.077	14	33.698	16	0.755	13	0.708	13
ER3	0.065	15	36.215	15	0.746	14	0.704	14
CR3	0.082	13	41.589	13	0.732	15	0.698	15
FR2	0.058	16	44.895	12	0.729	18	0.694	16
PR2	0.045	17	30.258	17	0.721	16	0.688	18
ER1	0.036	19	27.431	18	0.716	17	0.672	19
OMR2	0.028	20	25.985	19	0.711	20	0.666	20
RR1	0.023	18	21.569	20	0.705	19	0.691	17
ER2	0.021	21	18.235	21	0.702	22	0.645	21
ER4	0.018	22	15.236	22	0.699	23	0.631	22
RR2	0.016	23	14.235	24	0.688	21	0.615	24
CR5	0.015	24	13.256	23	0.658	24	0.603	23
RR3	0.012	25	12.841	25	0.644	25	0.591	25
CR4	0.009	26	11.145	26	0.632	26	0.577	26

Figure 4.5 shows the comparison of ranking in PPP projects and case study. The variations in rankings of the risk factors was comparatively negligible in all the analyses. In all the comparison analyses, top 5 risks were same. From the study, it was clear that Social unrest (SR1), Environmental clearance (SR2), Availability of funds (FR1), Operation cost overruns (OMR1) and Delay in project approvals/permits (LR1) were the most critical risks in PPP projects in Kerala. The least significant risk was Sate safety and external linkages (CR4).

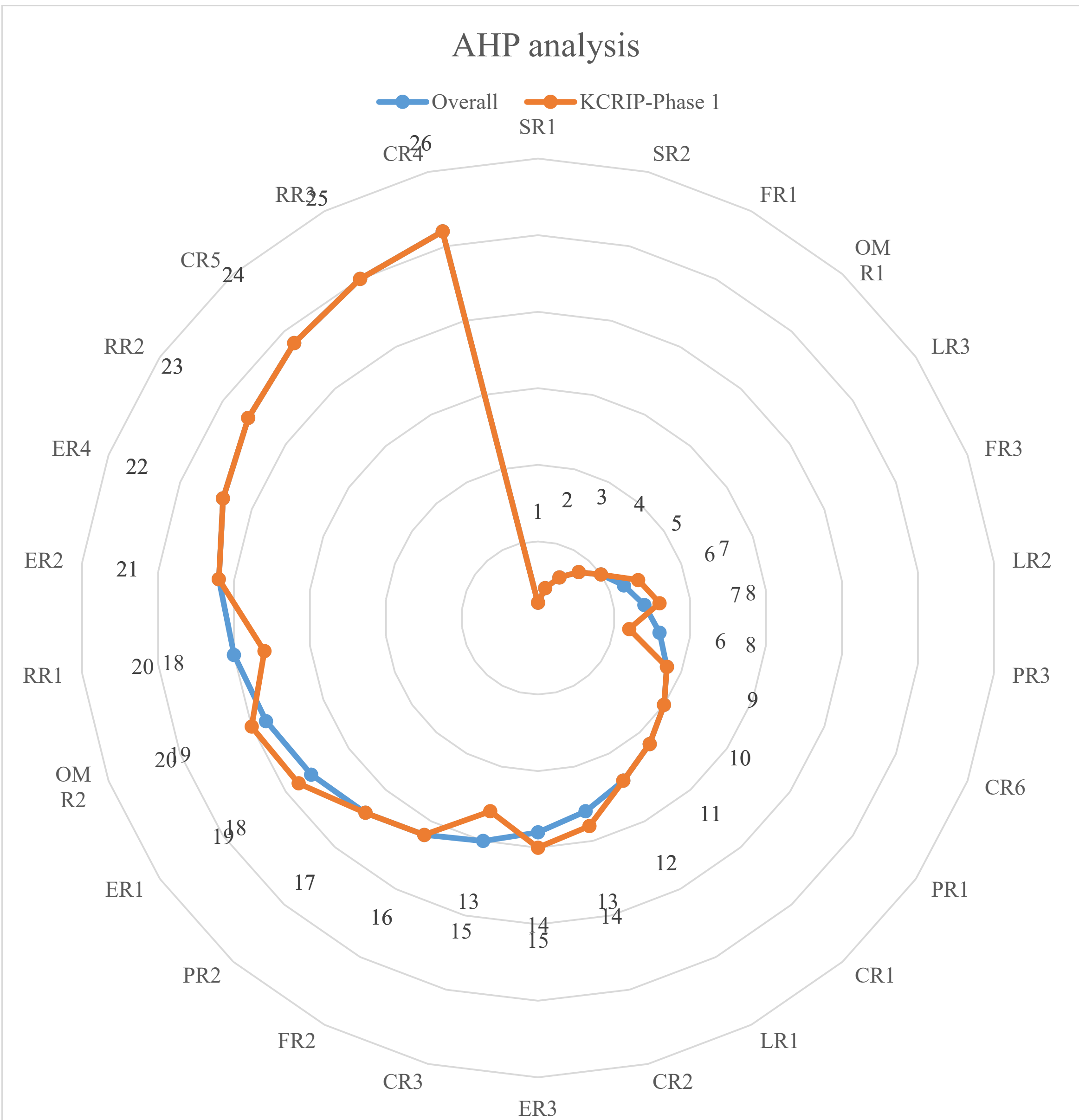

Figure 4.5 (a) Comparison of AHP analysis

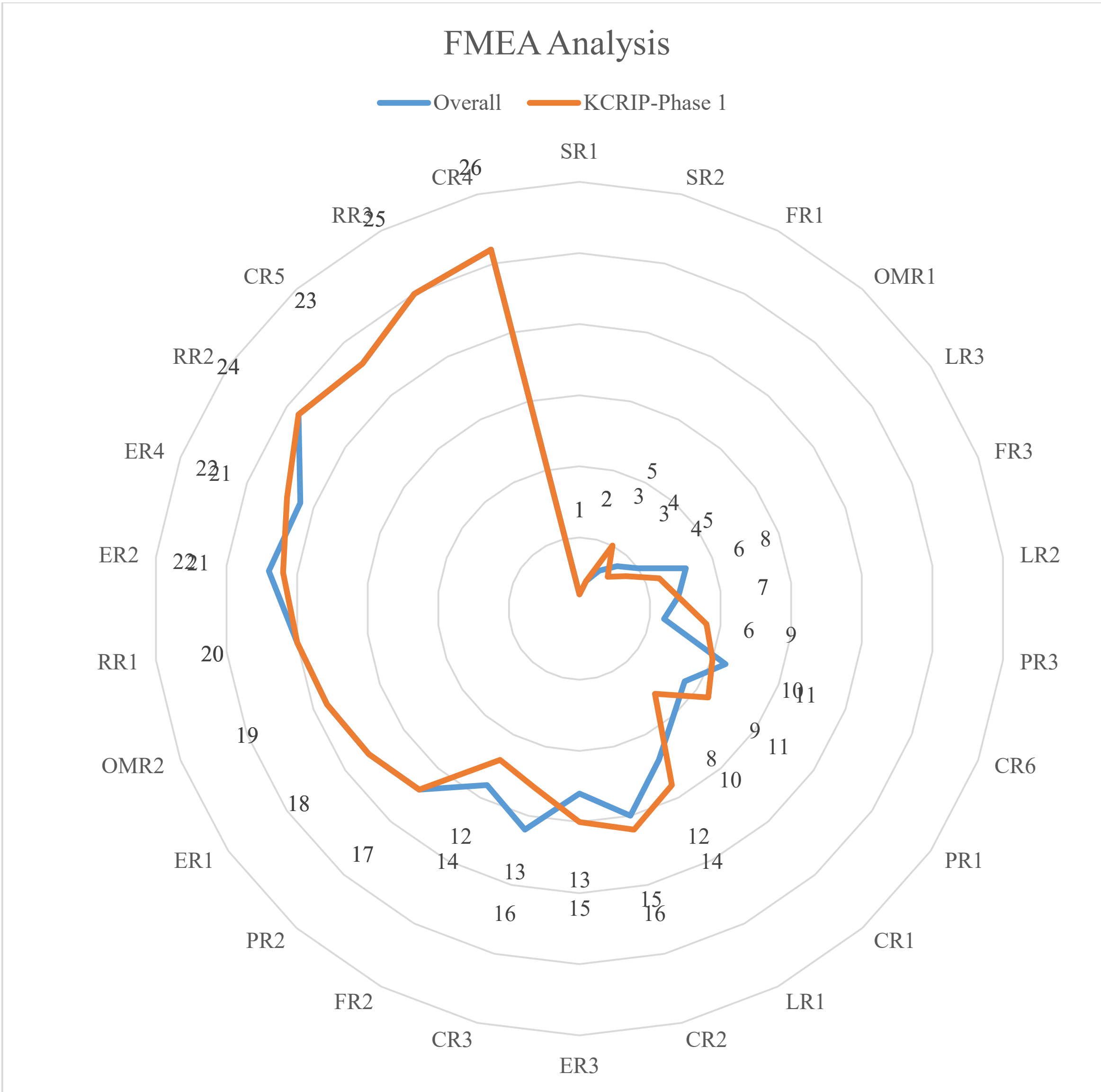

Figure 4.5 (b) Comparison of FMEA analysis

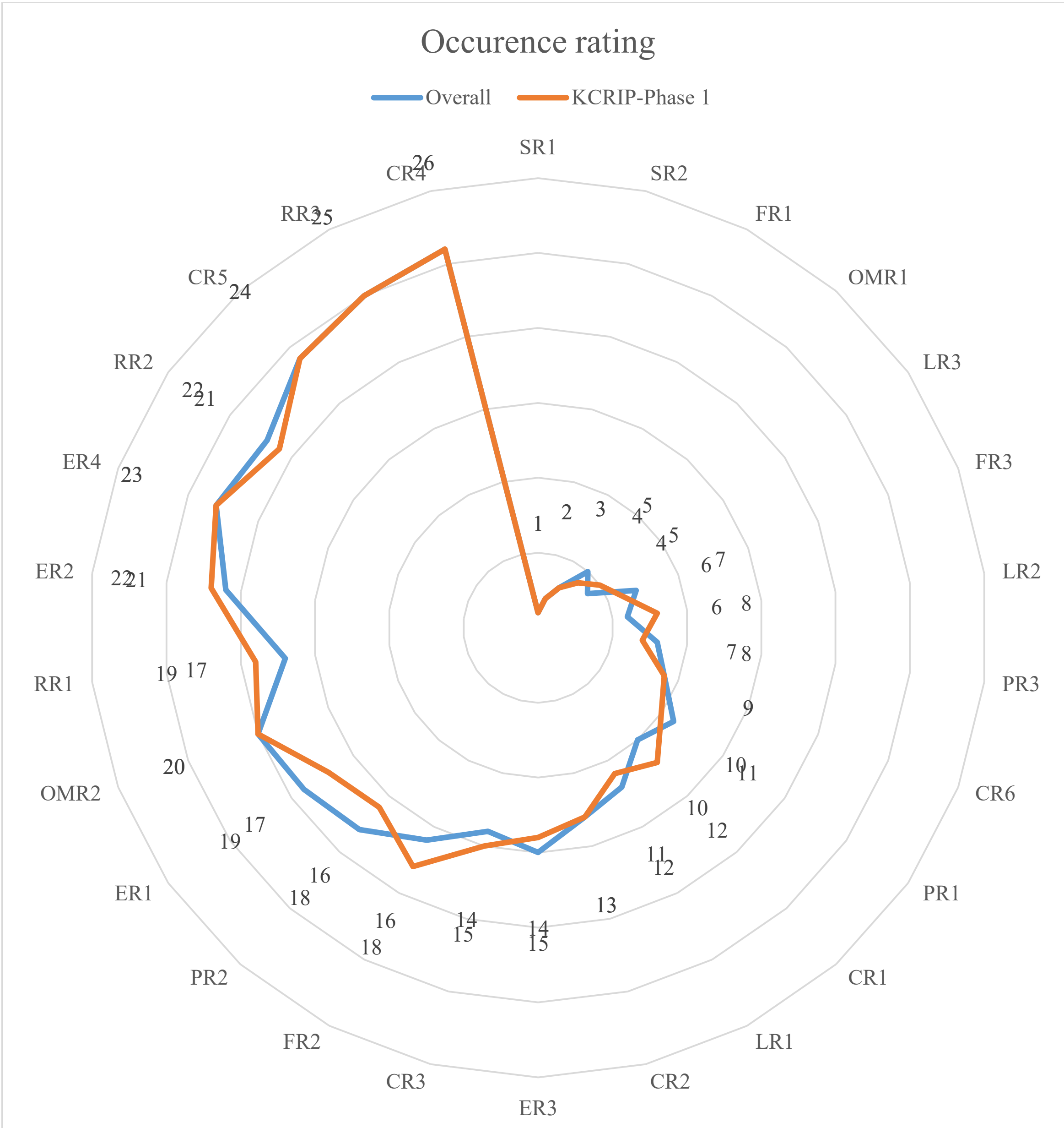

Figure 4.5 (c) Comparison of Occurrence rating

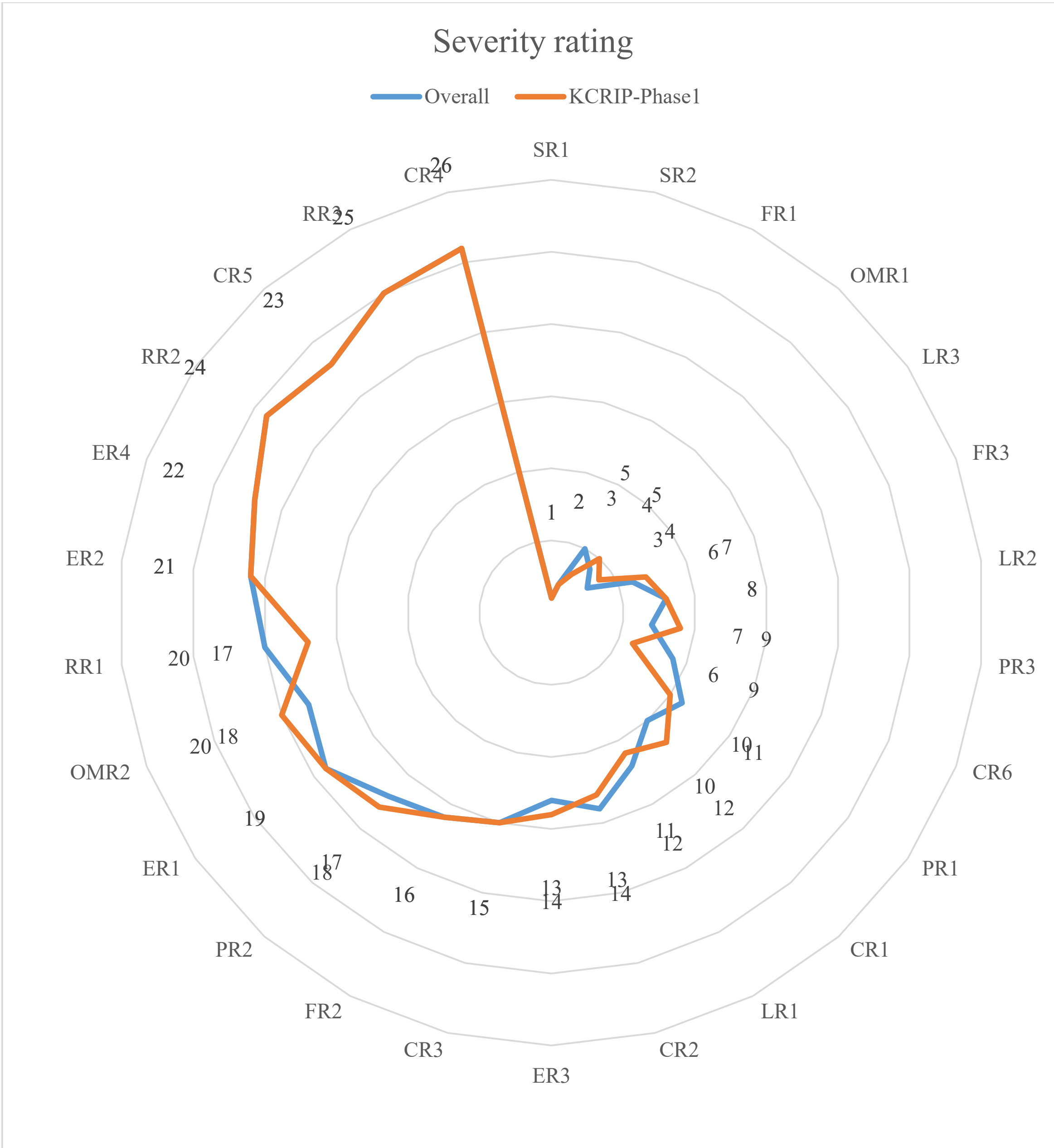

Figure 4.5 (d) Comparison of Severity rating

4.6 DISCUSSION ON RISK FACTORS

Social Risks (SR) were found to be the most significant risk from the analyses except in DEMATEL approach. Social risks were triggered mainly due to lack of effective Rehabilitation and Resettlement policy and social and environmental impact assessment. Opposition from stakeholders of the project added more disputes to the situation.

Construction projects affect the local environment of the project area and have significant impact on local population due to social and environmental risks. This created obstacles in project implementation due to public opposition leading to cost overruns and time overruns. Large scale projects had capability in displacing and affecting a large group of families. Effective communication with local population regarding the project before the project procurement stage ensures smooth functioning of the project. Social risks were mainly aroused due to the poor public consultation during the project development stage. In the case study of Vadodara Halol Toll Road, a significant benefit of the project was the extensive environment and social impact assessment undertaken during the development phase of the project (Chandrasekaran and Sreehari, 2021).

Financial Risks (FR) were the second most significant risk. PPP projects required large working capital. On-time funding is necessary for the smooth execution of the project. Non-availability of funds leads to cost and time overruns and difficulty of financing. This is mainly due to the absence of a well-organized financial framework. Financing innovations should be identified to overcome such situations.

Legal and Political risk were also significant. Delay in getting timely approvals and permits from local government lead to project time overruns and cost overruns. The concessionaire would find it difficult to execute the work within the stipulated time. This risk is not within the limit of concessionaire. Government should interfere in such situations to avoid further delay. Imposition of new laws or amendment of existing laws after the award of PPP project generated trouble for private party in the PPP arrangement. Land acquisition was a root cause of termination of many promising PPP projects. Proper public consultation and strong political support were mandatory to reduce such risks.

4.7 ANALYSIS OF RISK REMEDIAL MEASURES

A questionnaire survey was conducted to rank the risk remedial measures using Likert scale. A five point Likert scale was in this study to determine significance of each risk reduction measures. Relative Importance Index (RII) were computed as the mean score of responses obtained from survey. RII is given by Eq. 4.4 below (Yuan et al. (2018). Microsoft excel was used for analysis. Table 4.16 below shows the ranking of risk remedial measures based on RII.

$$RII = \frac{\sum W}{A \, X \, N} \qquad (4.4)$$

Where, W = weightage given by respondents to each risk remedial measure

A = highest weightage in the Likert scale

N = total number of respondents

Table 4.16 Ranking of risk remedial measures

Risk Remedial Measures	RII	Rank
Strong political will and public support	0.869	2
Favourable operating environment	0.755	6
Financing innovations	0.866	3
Environmentally and socially responsive development framework	0.879	1
Streamlining of approvals and clearances	0.836	4
Handling of land acquisitions	0.823	5
Clarity of determining tariff	0.645	7

From Table 4.16 it can be inferred that Environmentally and socially responsive development framework, Strong political will and public support and Financing innovations are the top three risk remedial measures based on RII. So, the stakeholders held the belief that many of the risks could be negated by the effect of Environmentally and socially responsive development framework. The risks that could be encountered include Social unrest (SR1), Environmental clearance (SR2), Land acquisition risk (LR2) and Swings in political/public opinion (PR1).

Strong political will and public support mitigates risks like Social unrest (SR1), Swings in political/public opinion (PR1), Land acquisition risk (LR2) and Government's intervention and reliability (PR2). Availability of funds (FR1) could be mitigated through Financing innovations. Delay in project approvals/permits (LR3), Cost overruns (CR2) and Time overruns (CR3) can be reduced by Streamlining of approvals and clearances. Proper Handling of land acquisitions reduce Social unrest (SR1), Land acquisition risk (LR2), Cost overruns (CR2) and Time overruns (CR3).

4.8 SUMMARY

The questionnaire survey conducted among the stakeholders of PPP projects were analyzed using FMEA, DEMATEL, AHP and RII. In DEMATEL analysis, the interrelationship between risk factors was determined. Relationship risks, Legal risks, Political risks and Social risks belonged to cause risk group whereas Financial risks, Economic risks, Construction risks and O & M risks belonged to effect risk group. In AHP analysis, Social risks and Financial risks were the significant risks among main risk heads. Social unrest and Site safety and external linkages were the most and least significant risks in AHP and FMEA analyses. The survey results were validated on a live PPP project in Kerala. The project chosen for validating the survey results was the KCRIP-Phase 1 project and the results of the studies were more or less similar and comparable. Risk remedial measures were analyzed using RII and Environmentally and socially responsive development framework was the highest rated measure. The survey responses obtained from DEMATEL approach, FMEA and Likert scale were directly used as the input of PLS-SEM software. Relationship Risks were omitted from further analysis as they were least significant risk category.

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CHAPTER 5

PARTIAL LEAST SQUARE STRUCTURAL EQUATION MODELLING

5.1 INTRODUCTION

This chapter discusses the modelling of risks in PPP projects. Risk factors in PPP projects were modelled using Partial Least Square Structural Equation Modelling (PLS-SEM) software, SmartPLS 3.3.4. Minimum sample size was determined using rule of thumb as 10 times the largest number of inner model paths directed at a particular construct in the inner model. (Hair et al., 2014, Barclay et al., 1995). Inner models or structural model were the models exhibiting the relationships between the constructs. Six number of arrows were directed at the construct project performance, which was the largest in the model (Figure 5.2) and hence as per the thumb rule, the minimum number of observations necessary to estimate the model is 60. 68 responses from the FMEA survey and RII analysis were used for the PLS-SEM analysis. The interrelationship between the risk factors were established from the results of DEMATEL analysis. Only critical relationship were considered for the study. The measurement and structural model were evaluated for the risk factors in PPP projects.

5.2 DEVELOPEMNT OF MODEL AND HYPOTHEIS

A research framework was formulated to evaluate the impact of risk factors on project performance. Figure 5.1 shows the proposed research framework.

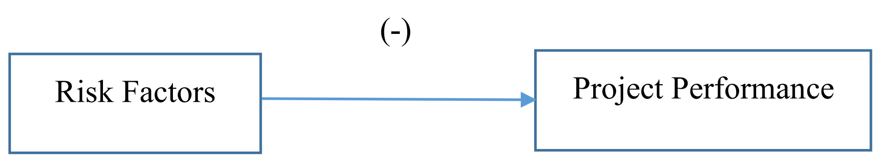

Figure 5.1 Research Framework

The risk factors were assigned a negative sign to project performance, indicating the negative impact of risk factors on project performance. The positive impact of the risk remedial measures on the project performance could negate the impact of risk factors. Table 5.1 shows the list of constructs and their respective indicators.

Table 5.1 List of constructs and their indicators

Constructs	Code	Indicators
Risk Factors		
Financial Risks (FR)	FR1	Availability of funds
	FR2	Concessionaire event of default
	FR3	Improper budgeting & contingencies
Political Risks (PR)	PR1	Swings in political/public opinion
	PR2	Government's intervention and reliability
	PR3	Change in legislation
Economic Risks (ER)	ER1	Poor financial market
	ER2	Inflation and interest rate volatility
	ER3	Change in tax regulation
	ER4	Exchange rate fluctuations
Social and Legal Risks (SLR)	LR1	Regulatory/Contractual risks
	LR2	Land acquisition risks
	LR3	Delay in project approvals/permits
	SR1	Social unrest
	SR2	Environmental clearance
Operation and Maintenance Risks (OMR)	OMR1	Operation cost overruns
	OMR2	Maintenance cost overruns
Construction Risks (CR)	CR1	Change in the scope of work , design specifications and technology
	CR2	Cost overruns
	CR3	Time overruns
	CR4	Site safety and external linkages
	CR5	Availability of resources
	CR6	Availability and drop in productivity of resources
Project Performance		
Risk remedial Measures	PP1	Strong political will and public support
	PP2	Favourable operating environment
	PP3	Financing innovations
	PP4	Environmentally and socially responsive development framework
	PP5	Streamlining of approvals and clearances
	PP6	Handling of land acquisitions
	PP7	Clarity of determining tariff

The 23 risk factors identified were classified into six constructs: Financial Risks (FR), Political Risks (PR), Economic Risks (ER), Social and Legal Risks (SLR), Operation and Maintenance Risks (OMR) and Construction Risks (CR). The indicators of project performance were the Risk remedial Measures identified.

The following hypotheses were proposed for the present study:

H1: Social and Legal Risks have a significant negative impact on Project Performance.

H2: Political Risks have a significant negative impact on Project Performance.

H3: Construction Risks have a significant negative impact on Project Performance.

H4: Financial Risks have a significant negative impact on Project Performance.

H5: Economic Risks have a significant negative impact on Project Performance.

H6: Operation and Maintenance Risks have a significant negative impact on Project Performance.

H7: Social and Legal Risks have a significant impact on Economic Risks.

H8: Political Risks have a significant impact on Financial Risks

H7 and H8 are developed based on the results obtained from DEMATEL analysis.

Table 5.2 shows the proposed research hypotheses

Table 5.2 Research Hypothesis

Item	**Path Hypothesis**			**Impact**
H1	Social and Legal Risk (SLR)	⇨	Project Performance (PP)	Significant Negative Impact
H2	Political Risk (PR)	⇨	Project Performance (PP)	Significant Negative Impact
H3	Construction Risk (CR)	⇨	Project Performance (PP)	Significant Negative Impact
H4	Financial Risk (FR)	⇨	Project Performance (PP)	Significant Negative Impact
H5	Economic Risk (ER)	⇨	Project Performance (PP)	Significant Negative Impact
H6	Operation and Maintenance Risk (OMR)	⇨	Project Performance (PP)	Significant Negative Impact
H7	Social and Legal Risk (SLR)	⇨	Economic Risk (ER)	Significant Impact
H8	Political Risk (PR)	⇨	Financial Risk (FR)	Significant Impact

The model considered in the study was reflective measurement model in which arrows point from the construct (latent variable) to the indicator (observed variable). Indicators in the study were presented as reflective measurements. Assessment of reflective measurement involved establishment of reliability and validity. The two types of validity established were convergent validity and discriminant validity. Convergent validity determined whether the indicators adequately represent their underlying constructs. Discriminant validity determined whether the constructs were different from each other. Reliability of the model determined the relationship between the constructs and their indicators. When measurement model was found valid and reliable, structural model was evaluated based on model's predictive accuracy, predictive relevance and path coefficients to determine the relationship between the constructs based on hypotheses developed.

5.3 PLS-SEM MODEL EVALUATION

5.3.1 Measurement model evaluation

Indicator variables were discarded either when their factor loading value was less than 0.6 or when they perform well to constructs other than their parent constructs in cross loadings. In this study, two indicators PR3 and CR6 were discarded from the analysis due to low factor loading (0.579 and 0.545 respectively) and they perform well to other constructs as well (Hair et al., (2014). Such deletion was acceptable in reflective measurement models as it would otherwise affect the evaluation of rest of the indicator variables.

Table 5.1 shows the results of convergent validity assessment with factor loading values. To establish convergent validity of constructs, values of Cronbach's Alpha and Composite Reliability should be greater than 0.7 for all constructs, rho_A values should be between values of Cronbach's Alpha and Composite Reliability and Average Variance Extracted (AVE) should be greater than 0.5 (Hair et al., 2019). AVE is the variance that can be extracted from the indicator to measure construct. Convergent validity was established as the values of all the indices were within the acceptable value.

Discriminant validity was established by Fornell and Larcker criterion, cross loadings, and HTMT ratio criterion. Table 5.4 shows the results of cross loadings. The results showed that indicator variables perform well to their parent construct than other constructs. Table 5.5 shows the correlation matrix of the constructs. The cross section of constructs were square

Table 5.3 Convergent validity assessment

Construct	Indicator	Factor loading	Cronbach's Alpha	Composite reliability	AVE
CR	CR1	0.749	0.815	0.837	0.656
	CR2	0.844			
	CR3	0.701			
	CR4	0.737			
	CR5	0.744			
ER	ER1	0.872	0.803	0.817	0.628
	ER2	0.841			
	ER3	0.814			
	ER4	0.839			
FR	FR1	0.864	0.707	0.836	0.631
	FR2	0.800			
	FR3	0.716			
OMR	OMR1	0.848	0.788	0.904	0.825
	OMR2	0.879			
PR	PR1	0.873	0.753	0.883	0.792
	PR2	0.871			
PP	RM1	0.753	0.911	0.930	0.646
	RM2	0.826			
	RM3	0.850			
	RM4	0.757			
	RM5	0.871			
	RM6	0.874			
	RM7	0.814			
SLR	LR1	0.776	0.837	0.885	0.709
	LR2	0.811			
	LR3	0.860			
	SR1	0.858			
	SR2	0.703			

root of their respective AVE (Table 5.3). The rest of the values in the column were the correlation values between the constructs. The square root of AVE should be higher than the correlations underneath i.e., for all other constructs. A more newer and advanced method for establishing Discriminant validity wae evaluating heterotrait-monotrait (HTMT) ratio of correlations (Henseler et al., 2015). HTMT check whether the relationships of the indicators within the same construct are stronger than those of the indicators across constructs measuring different phenomena. Table 5.6 shows the HTMT values. The threshold value for HTMT value was 0.85. Since all the values are within the threshold value, discriminant validity was established. Thus, the model was valid and reliable.

Table 5.4 Discriminant validity assessment: Cross Loadings

	CR	ER	FR	OMR	PR	PP	SLR
CR1	**0.749**	0.070	0.442	0.081	0.415	0.348	-0.022
CR2	**0.844**	0.099	0.674	0.180	0.684	0.612	0.035
CR3	**0.701**	0.005	0.337	0.081	0.565	0.434	-0.126
CR4	**0.737**	0.041	0.534	0.115	0.498	0.591	-0.007
CR5	**0.744**	0.039	0.631	0.143	0.616	0.408	-0.045
CR6	**0.545**	0.082	0.822	0.213	0.699	0.785	0.003
ER1	0.173	**0.872**	0.233	0.730	0.139	0.159	0.714
ER2	0.015	**0.841**	0.007	0.684	-0.040	-0.003	0.681
ER3	0.000	**0.814**	0.111	0.537	0.070	-0.015	0.622
ER4	0.044	**0.839**	0.074	0.583	0.028	0.087	0.664
FR1	0.588	0.216	**0.864**	0.229	0.668	0.449	0.129
FR2	0.484	0.054	**0.800**	0.107	0.581	0.555	0.077
FR3	0.528	0.027	**0.716**	0.100	0.500	0.455	-0.064
OMR1	0.027	0.733	0.109	**0.848**	0.088	0.060	0.656
OMR2	0.183	0.673	0.184	**0.879**	0.088	0.224	0.579
PR1	0.726	0.072	0.686	0.101	**0.873**	0.470	-0.024
PR2	0.571	0.033	0.599	0.067	**0.871**	0.569	-0.019
PR3	0.822	0.028	0.792	0.122	**0.579**	0.628	0.002
PP1	0.651	0.044	0.554	0.169	0.539	**0.753**	0.032
PP2	0.613	0.037	0.561	0.145	0.514	**0.826**	-0.012
PP3	0.409	-0.038	0.408	0.058	0.427	**0.850**	0.038
PP4	0.411	0.017	0.379	0.098	0.407	**0.757**	0.053
PP5	0.496	0.161	0.460	0.219	0.437	**0.871**	0.150
PP6	0.475	0.086	0.511	0.242	0.478	**0.874**	0.084
PP7	0.569	0.059	0.510	0.207	0.506	**0.814**	0.083
LR1	-0.021	0.661	0.080	0.713	-0.049	0.036	**0.776**
LR2	-0.014	0.659	0.085	0.491	0.009	0.086	**0.811**
LR3	-0.014	0.699	0.024	0.559	-0.012	0.040	**0.860**
SR1	-0.039	0.729	0.085	0.594	-0.006	0.095	**0.858**
SR2	-0.056	0.563	-0.014	0.335	-0.046	0.036	**0.703**

Table 5.5 Discriminant validity assessment: Correlation matrix

Construct	CR	ER	FR	OMR	PR	PP	SLR
CR	**0.794**						
ER	0.070	**0.842**					
FR	0.706	0.129	**0.890**				
OMR	0.165	0.753	0.185	**0.908**			
PR	0.744	0.061	0.737	0.097	**0.792**		
PP	0.659	0.068	0.612	0.208	0.596	**0.810**	
SLR	0.035	0.827	0.067	0.677	0.025	0.074	**0.804**

Table 5.6 Discriminant validity assessment: HTMT criterion

Construct	CR	ER	FR	OMR	PR	PP	SLR
CR							
ER	0.119						
FR	0.620	0.187					
OMR	0.186	0.092	0.296				
PR	0.781	0.109	0.055	0.154			
PP	0.713	0.122	0.747	0.221	0.742		
SLR	0.093	0.557	0.151	0.330	0.061	0.106	

Figure 5.2 shows the structural equation model of risk factors influencing PPP project performance.

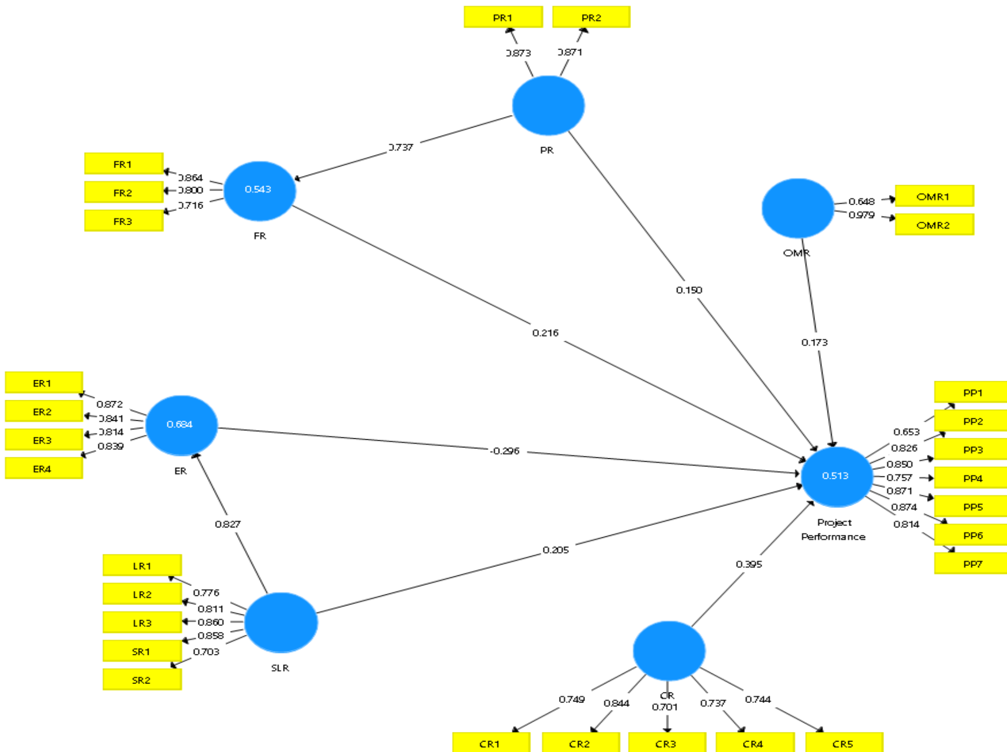

Figure 5.2 Structural equation model

5.3.2 Structural model evaluation

Structural model was assessed to find the relationship between constructs based on hypotheses developed. Multicollinearity was measured by Variance Inflation Factor (VIF), the value of which should be between 0.2 and 5. Table 5.7 shows the Variance Inflection Factor (VIF) tolerance values. Eight sets of constructs were evaluated where the sets to be evaluated are equal to the number of hypotheses. All VIF values were below the threshold of 3.3 (Hair et al., 2019). The results indicated that predictor(ER, FR and PP) was not correlated with other variables as VIF.

The model's R^2 was computed to quantify the variation in the endogenous constructs caused by exogenous constructs. The R^2 value was the measure of model's predictive power and represented the combined effect of the exogenous variables on the endogenous variable. The R^2 values of 0.75, 0.50, and 0.25 for endogenous constructs were considered substantial, moderate and weak respectively (Hair et al., 2017). A value greater than 0.1 for the R^2 values was considered acceptable. The value for ER was 0.684 which means the 68.4 % of change in ER could be attributed to SLR and PP. A satisfactory level of predictive capability was established.

Q^2 value predict the validity of the model. The Q^2 value should be greater than zero to stipulate predictive accuracy of the structural model for the particular endogenous construct. The results revealed that endogenous construct was within the acceptable limit for the predictive relevance test. Table 5.8 shows the R^2 and Q^2 values of the endogenous latent variable.

Table 5.7 Variance Inflection Factor (VIF) tolerance values

	Endogeneous Latent Variable		
Predictors	**ER**	**FR**	**PP**
CR			2.657
ER			3.079
FR			2.552
OMR			2.481
PR		1.000	2.832
PP			
SLR	1.000		2.380

Table 5.8 R^2 and Q^2 values of the endogenous latent variable

Endogenous Latent Variable	R^2	Q^2
ER	0.684	0.474
FR	0.543	0.338
PP	0.513	0.297

The structural model was assessed to test the research hypotheses. The hypotheses were confirmed by calculating path coefficients, t-value and p-value for each hypothesis. Table 5.9 shows the results of hypothesis testing for the model. For a hypothesis to be significant, path coefficient value should be greater than 0.200, t value should be greater than 1.96 (0.05 level) /2.57 (0.01 level) and p value should be less than 0.05. The results of the assessment are explained below:

• H1, H3 and H4 were statistically significant at the 0.05 level. Hence Social and Legal Risks, Construction Risks and Financial Risks had a significant negative impact on the PPP project performance.

• Hypotheses H2, H5 and H6 were rejected as they had low path coefficients with t-values below 1.96.

• H7 and H8 were statistically significant at the 0.01 level. Hence, Social and Legal Risks have a significant impact on the Economic Risks and Political Risks have a significant impact on the Financial Risks.

Table 5.9 Structural model evaluation

Path	Path Coefficient	t-value	p-value	Inference
SLR-PP (H1)	0.202	6.345	0.012	*Significant*
PR->PP(H2)	0.151	1.231	0.219	*Insignificant*
CR->PP (H3)	0.395	4.023	0.000	*Significant*
FR->PP(H4)	0.215	2.017	0.021	*Significant*
ER->PP (H5)	-0.299	1.818	0.070	*Insignificant*
OMR->PP (H6)	0.173	1.534	0.126	*Insignificant*
SLP->ER (H7)	0.827	21.821	0.000	*Significant*
PR->FR (H8)	0.737	14.328	0.000	*Significant*

5.4 SUMMARY

The proposed model was found to reliable and valid in PLS-SEM analysis. Hypothesis on the relationship between the factors were analyzed. Social and Legal Risks, Construction Risks and Financial Risks have a significant negative influence on PPP project performance. Economic Risks and Financial Risks are significantly influenced by the Social and Legal Risks and Political Risks respectively.

CHAPTER 6
CONCLUSION

The Public Private Partnerships (PPPs) have emerged as a very feasible, reliable, viable, and growing mode of creating infrastructure for developing countries like India. A questionnaire survey was conducted to prioritize the risk factors and risk remedial measures in PPP projects in Kerala. The responses from the survey were used to develop a model in PLS-SEM to evaluate the impact of risk factors on PPP project performance. The risk factors were classified into Social Risks, Financial Risks, Economic Risks, Political Risks, Operation and Maintenance Risks, Relationship Risks, Construction Risks and Legal Risks.

The major findings from the study are as follows:

- In DEMATEL analysis, the interdependencies of main risk heads were examined. Relationship risks, Legal risks, Political risks and Social risks belong to the cause group whereas Financial risks, Economic risks, Construction risks and Operation & Maintenance risks belong to the effect group. With respect to the influence relation, Social and Legal risks critically influence Economical risks and Political risks critically influence Financial risks.
- In AHP analysis, the risk factors were prioritized. Social risks, Financial risks and Construction risks have highest AHP weights in main risk heads category whereas Social unrest, Environmental Clearance, Availability of funds, Operations cost overruns and Delay in project approvals/permits are the top five risk factors.
- In FMEA analysis, stakeholder perception of the risk factors were identified. The following observations were made:
    - Availability of funds and Regulatory/contractual risks are the top two risk factors as per clients.
    - Delay in project approvals/permits and Land acquisition risks are the top two risk factors as per employees.
    - Delay in project approvals/permits and Social unrest are the top risk factors as per concessionaire.
    - Social unrest and Environmental clearance are the top risk factors as per end-user.

- ➢ Availability of funds and Concessionaire event of default are the top risk factors as per suppliers.

- Environmentally and socially responsive development framework, Strong political will and public support and Financing innovations are the top three risk remedial measures identified in the study.
- Kozhikode City Road Improvement Project-Phase 1 is selected for validating the survey results. The trend of overall ranking and rankings from case study is comparable

The important observations from the partial least square structural equation model are as follows:

- Social and Legal risks, Political risks and Financial risks have significant negative impact on project performance.
- Social and Legal risks have significant impact on Economic risks.
- Political risks have significant impact on Financial risks.

This study has identified the major risk heads and the significant risk factors that affect PPP project performance. A risk analysis model has also been developed to analyze the impact of the risk factors on project performance. The study would be helpful to the construction practitioners in understanding the various risk factors influencing PPP project performance and the impact of the factors on performance.

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APPENDIX

QUESTIONNAIRE ON RISK FACTORS IN PUBLIC PRIVATE PARTNERSHIP PROJECTS

Introduction

This questionnaire is aimed at identifying the risk factors and risk remedial measures associated with Public Private Partnership Projects.

We recognize that you are a professional with rich experience in construction industry. We request you to help us by filling the questionnaire. Please respond to each question honestly and accurately.

We assure you that the responses will be kept confidential and the responses/data will be used only for academic/research purposes.

For any queries/suggestions concerning the survey, please contact: Fiza Fathima, P. G. Scholar, Dept. of Civil Engineering, T. K. M. College of Engineering, Kollam.

Email: fiza.fathima.1998@gmail.com

Please fill in the blank or tick (✓) in the box

A. GENERAL INFORMATION

1. Your organization/Company name (optional): ______________________________

2. Organization turnover:

☐ < 5 crores ☐ 5 – 10 crores ☐ 11 – 25 crores

☐ 26 – 50 crores ☐ 51 – 100 crores ☐ > 100 crores

3. Respondent Designation: ______________________________

4. Experience in construction field:

☐ < 2 years ☐ 2 – 5 years ☐ 6 – 10 years

☐ 11 – 15 years ☐ >15 years

5. Experience in present position:

☐ < 2 years ☐ 2 – 5 years ☐ 6 – 10 years

☐ 11 – 15 years ☐ >15 years

6. Total no. of years you have been with the present firm:

☐ < 1 year ☐ 1 – 5 years ☐ 6 – 10 years

☐ 11 – 15 years ☐ >15 years

B. PROJECT INFORMATION:

7. Project name:

8. Project Location:

9. Estimated cost of the project:

10. Estimated duration of the project:

11. Actual cost of the project:

12. Actual duration of the project:

PART A

Using the scale from 1 to 9 (where 9 is extremely and 1 is equally important), please indicate the ***relative importance*** of options of column 1 with respect to options of column 2.

If Column 1 element is of more importance than Column 2					**Equally Important**	**If Column 2 element is of more importance than Column 1**				
Column 1	**Extremely**	**Very Strongly**	**Strongly**	**Moderately**		**Moderately**	**Strongly**	**Very Srongly**	**Extremely**	**Column 2**
Financial Risks										
Availability of funds	9	7	5	3	1	3	5	7	9	Improper budgeting and contingencies
Availability of funds	9	7	5	3	1	3	5	7	9	Concessionaire event of default
Improper budgeting and contingencies	9	7	5	3	1	3	5	7	9	Concessionaire event of default
Legal Risks										
Delay in project approvals/permits	9	7	5	3	1	3	5	7	9	Regulatory/Contractual risks
Delay in project approvals/permits	9	7	5	3	1	3	5	7	9	Land acquisition risks
Regulatory/Contractual risks	9	7	5	3	1	3	5	7	9	Land acquisition risks
Political Risks										
Change in legislation	9	7	5	3	1	3	5	7	9	Swings in political/public opinion
Change in legislation	9	7	5	3	1	3	5	7	9	Government's intervention and reliability
Swings in political/public opinion	9	7	5	3	1	3	5	7	9	Government's intervention and reliability

If Column 1 element is of more importance than Column 2					Equally Important	If Column 2 element is of more importance than Column 1				
Column 1	Extremely	Very Strongly	Strongly	Moderately	Equally Important	Moderately	Strongly	Very Strongly	Extremely	Column 2
Economic Risks										
Exchange rate fluctuations	9	7	5	3	1	3	5	7	9	Poor financial market
Exchange rate fluctuations	9	7	5	3	1	3	5	7	9	Inflation and interest rate volatility
Exchange rate fluctuations	9	7	5	3	1	3	5	7	9	Change in tax regulation
Poor financial market	9	7	5	3	1	3	5	7	9	Inflation and interest rate volatility
Poor financial market	9	7	5	3	1	3	5	7	9	Change in tax regulation
Inflation and interest rate volatility	9	7	5	3	1	3	5	7	9	Change in tax regulation
Operation and maintenance risks										
Operation cost overruns	9	7	5	3	1	3	5	7	9	Maintenance cost overruns
Construction Risks										
Drop in productivity of resources	9	7	5	3	1	3	5	7	9	Change in the scope of work , design specifications and technology
Drop in productivity of resources	9	7	5	3	1	3	5	7	9	Cost overruns
Drop in productivity of resources	9	7	5	3	1	3	5	7	9	Time overruns
Drop in productivity of resources	9	7	5	3	1	3	5	7	9	Site safety and external linkages
Drop in productivity of resources	9	7	5	3	1	3	5	7	9	Availability of resources

If Column 1 element is of more importance than Column 2					Equally Important	If Column 2 element is of more importance than Column 1				
Column 1	**Extremely**	**Very Strongly**	**Strongly**	**Moderately**		**Moderately**	**Strongly**	**Very Strongly**	**Extremely**	**Column 2**
Construction Risks										
Change in the scope of work , design specifications and technology	9	7	5	3	1	3	5	7	9	Cost overruns
Change in the scope of work , design specifications and technology	9	7	5	3	1	3	5	7	9	Time overruns
Change in the scope of work , design specifications and technology	9	7	5	3	1	3	5	7	9	Site safety and external linkages
Change in the scope of work , design specifications and technology	9	7	5	3	1	3	5	7	9	Availability of resources
Cost overruns	9	7	5	3	1	3	5	7	9	Time overruns
Cost overruns	9	7	5	3	1	3	5	7	9	Site safety and external linkages
Cost overruns	9	7	5	3	1	3	5	7	9	Availability of resources
Time overruns	9	7	5	3	1	3	5	7	9	Site safety and external linkages
Time overruns	9	7	5	3	1	3	5	7	9	Availability of resources
Site safety and external linkages	9	7	5	3	1	3	5	7	9	Availability of resources
Social Risks										
Social unrest	9	7	5	3	1	3	5	7	9	Environmental clearance

If Column 1 element is of more importance than Column 2					Equally Important	If Column 2 element is of more importance than Column 1				
Column 1	**Extremely**	**Very Strongly**	**Strongly**	**Moderately**		**Moderately**	**Strongly**	**Very Strongly**	**Extremely**	**Column 2**
Relationship Risks										
Inadequate experience in PPP and lack of commitment	9	7	5	3	1	3	5	7	9	Inadequate distribution of responsibilities and risks
Inadequate experience in PPP/PFI and lack of commitment	9	7	5	3	1	3	5	7	9	Inadequate distribution of authority in partnership
Inadequate distribution of responsibilities and risks	9	7	5	3	1	3	5	7	9	Inadequate distribution of authority in partnership

If Column 1 element is of more importance than Column 2					Equally Important	If Column 2 element is of more importance than Column 1				
Column 1	Extremely	Very Strongly	Strongly	Moderately		Moderately	Strongly	Very Strongly	Extremely	Column 2
Financial Risks	9	7	5	3	1	3	5	7	9	Legal Risks
	9	7	5	3	1	3	5	7	9	Political Risks
	9	7	5	3	1	3	5	7	9	Economic Risks
	9	7	5	3	1	3	5	7	9	Operation and Maintenance Risks
	9	7	5	3	1	3	5	7	9	Construction Risks
	9	7	5	3	1	3	5	7	9	Social Risks
	9	7	5	3	1	3	5	7	9	Relationship Risks
Legal Risks	9	7	5	3	1	3	5	7	9	Political Risks
	9	7	5	3	1	3	5	7	9	Economic Risks
	9	7	5	3	1	3	5	7	9	Operation and Maintenance Risks
	9	7	5	3	1	3	5	7	9	Construction Risks
	9	7	5	3	1	3	5	7	9	Social Risks
	9	7	5	3	1	3	5	7	9	Relationship Risks
Political Risks	9	7	5	3	1	3	5	7	9	Economic Risks
	9	7	5	3	1	3	5	7	9	Operation and Maintenance Risks
	9	7	5	3	1	3	5	7	9	Construction Risks
	9	7	5	3	1	3	5	7	9	Social Risks
	9	7	5	3	1	3	5	7	9	Relationship Risks
Economic Risks	9	7	5	3	1	3	5	7	9	Operation and Maintenance Risks
	9	7	5	3	1	3	5	7	9	Construction Risks
	9	7	5	3	1	3	5	7	9	Social Risks
	9	7	5	3	1	3	5	7	9	Relationship Risks
Operation and Maintenance Risks	9	7	5	3	1	3	5	7	9	Construction Risks
	9	7	5	3	1	3	5	7	9	Social Risks
	9	7	5	3	1	3	5	7	9	Relationship Risks
Construction Risks	9	7	5	3	1	3	5	7	9	Social Risks
	9	7	5	3	1	3	5	7	9	Relationship Risks
Social Risks	9	7	5	3	1	3	5	7	9	Relationship Risks

PART B

Kindly make an assessment of the effect of the risk factors given below.

(***Please tick the answer that best describes your views***)

Sl.No.	Risk Factors	**How well this risk factor can be detected?** *No chance of detection - 5* *Low chance of detection - 4* *Moderate chance of detection - 3* *High chance of detection - 2* *Almost certainty of detection - 1*				
1	Availability of funds	1	2	3	4	5
2	Concessionaire event of default	1	2	3	4	5
3	Improper budgeting & contingencies	1	2	3	4	5
4	Regulatory/Contractual risks	1	2	3	4	5
5	Land acquisition risks	1	2	3	4	5
6	Delay in project approvals/permits	1	2	3	4	5
7	Swings in political/public opinion	1	2	3	4	5
8	Government's intervention and reliability	1	2	3	4	5
9	Change in legislation	1	2	3	4	5
10	Poor financial market	1	2	3	4	5
11	Inflation and interest rate volatility	1	2	3	4	5
12	Change in tax regulation	1	2	3	4	5
13	Exchange rate fluctuations	1	2	3	4	5
14	Operation cost overruns	1	2	3	4	5
15	Maintenance cost overruns	1	2	3	4	5

Sl.No.	Risk Factors	**How well this risk factor can be detected?** *No chance of detection - 5* *Low chance of detection - 4* *Moderate chance of detection - 3* *High chance of detection - 2* *Almost certainty of detection - 1*				
16	Change in the scope of work , design specifications and technology	1	2	3	4	5
17	Cost overruns	1	2	3	4	5
18	Time overruns	1	2	3	4	5
19	Site safety and external linkages	1	2	3	4	5
20	Availability of resources	1	2	3	4	5
21	Availability and drop in productivity of resources	1	2	3	4	5
22	Social unrest	1	2	3	4	5
23	Environmental clearance	1	2	3	4	5
24	Inadequate experience in PPP and lack of commitment	1	2	3	4	5
25	Inadequate distribution of responsibilities and risks	1	2	3	4	5
26	Inadequate distribution of authority in partnership	1	2	3	4	5

Sl. No	Risk Factors	**How do you rank the effect of this factor in PPP projects?** *Extremely significant effect - 5* *Very significant effect-4* *Significant effect-3* *Slight effect-2* *No effect-1*					**Rate the occurrence of this factor based on your experience?**
1	Availability of funds	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
2	Concessionaire event of default	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
3	Improper budgeting & contingencies	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
4	Regulatory/Contractual risks	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
5	Land acquisition risks	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
6	Delay in project approvals/permits	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
7	Swings in political/public opinion	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
8	Government's intervention and reliability	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
9	Change in legislation	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
10	Poor financial market	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
11	Inflation and interest rate volatility	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
12	Change in tax regulation	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
13	Exchange rate fluctuations	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
14	Operation cost overruns	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
15	Maintenance cost overruns	1	2	3	4	5	*Very low /Low /Medium /High /Very High*

Sl. No	Risk Factors	**How do you rank the effect of this factor in PPP projects?** *Extremely significant effect - 5* *Very significant effect-4* *Significant effect-3* *Slight effect-2* *No effect-1*					**Rate the occurrence of this factor based on your experience?**
16	Change in the scope of work , design specifications and technology	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
17	Cost overruns	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
18	Time overruns	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
19	Site safety and external linkages	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
20	Availability of resources	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
21	Drop in productivity of resources	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
22	Social unrest	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
23	Environmental clearance	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
24	Inadequate experience in PPP and lack of commitment	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
25	Inadequate distribution of responsibilities and risks	1	2	3	4	5	*Very low /Low /Medium /High /Very High*
26	Inadequate distribution of authority in partnership	1	2	3	4	5	*Very low /Low /Medium /High /Very High*

PART C

Please rate the influence of each risk factor on all other according to the influence scores given below.

Linguistic Phrases	Influence Score
No influence	0
Very low influence	1
Low influence	2
High influence	3
Very high influence	4

Main risk heads	Financial risks	Legal risks	Political risks	Economic risks	Operations and maintenance risks	Construction risks	Social risks	Relation ship risks
Financial Risks								
Legal Risks								
Political Risks								
Economic Risks								
Operation and Maintenance Risks								
Construction Risks								
Social Risks								
Relationship Risks								

PART D

Kindly rate the significance of risk remedial measures to mitigate the risks

Sl. No	Risk Remedial Measures	How do you rank the effect of this factor in PPP projects? *Extremely significant effect - 5* *Very significant effect-4* *Significant effect-3* *Slight effect-2* *No effect-1*				
1	Strong political will and public support	1	2	3	4	5
2	Favourable operating environment	1	2	3	4	5
3	Financing innovations	1	2	3	4	5
4	Environmentally and socially responsive development framework	1	2	3	4	5
5	Streamlining of approvals and clearances	1	2	3	4	5
6	Handling of land acquisitions	1	2	3	4	5
7	Clarity of determining tariff	1	2	3	4	5

Thank you for your valuable time and effort in completing this survey

LIST OF PUBLICATIONS

International Conference

1. Fathima, F., and Thomas, A. V. (2022). "Analysis of Risk Factors for Public Private Partnership (PPP) Projects in Construction Industry using Analytical Hierarchy Process (AHP)." *Proceedings of the 2nd International Conference on Recent Trends in Engineering Technology Management 2022,* 62-63