Chapter 1: Introduction

1.1 Introduction to infrastructure industry and infrastructure projects

The infrastructure industry is one of the strongest and most efficient industries in the world. Infrastructure, rather than other industries or economic dimensions, has increased productivity, particularly in developing countries and is an important driver of global economic growth.

Infrastructure development is important for the development of the country, its various regions and the overall economy. The public infrastructure sector consists mainly of electricity, roads, telecommunications, railways, irrigation, water supply and sanitation, power projects, mining, ports, airports, storage facilities, oil and gas pipelines. The development of these facilities is significant and critical for the economic development of the country. More so these are essential for a country to grow and meet the needs of the countrymen at large.

With urbanization and increasing involvement of foreign investments, infrastructure industry in India has been experiencing rapid growth in its different sectors. India has taken a huge leap and is fast growing while competing with developed countries around the globe. The fast growth of the Indian economy in recent years has placed an increasing challenge on physical infrastructures, such as electricity, railways, roads, seaports, airports, irrigation, water supply, and sanitation systems.

There is a massive demand for infrastructure development in India. The World Bank estimates that an increase of 10 per cent in infrastructure assets directly increases GDP by up to 1 per cent (Ahsan, 2010). While energy sector production and demand gap impact the manufacturing and overall growth, transport sector demands huge investment and modernization in roads, airports, railways and seaports. While much development has been undertaken at metro airports in India, there is still a gap in capacity and airports are majorly saturated in India, which the Government is taking initiatives to address.

Government of India has a keen focus on infrastructure development in the country and has planned significant investments for the sector. India has plans

to spend US$1.4 trillion on its infrastructure in the next five years (Sitharaman, 2019), whereas it spent US$ 1.1 trillion in the last ten years (2008-17). This investment plan indicates that the next growth phase is set to come while keeping the recent COVID-19 impact. The Government has however decided to stall its significant plans for this year given COVID-19 outbreak. Nonetheless, barring COVID situation, there has been huge relief infusion by the Government. The private logistics sector plays a critical role in the development of infrastructure in the country. Private investment is also significant and plays a critical role in taking the country on a new growth path. As per IBEF infrastructure 2019 report, India has a demand of investment in the range of US$ 778 billion in infrastructure by 2022 and yearly private equity and other venture capital investments in India are expected to go over US$ 65 billion in 2025 (IBEF Infrastructure Report, 2019).

There has been a large amount of Foreign Direct Investment (FDI) attracted in India between the fiscal year 2001 to 2018 which is in the range of US$ 40 billion in the construction sector including housing, townships, built-up infrastructure development projects and activities (RBI Report, 2011). Increasing focus on infrastructure is further attracting FDI into India. Hence, infrastructure development is a crucial facilitator for the economic growth of a country.

1.1.1. Infrastructure projects

There has been a focus on infrastructure development in India with significant emphasis on construction, engineering, IT, entertainment, textiles, food, and utility with also large scale infrastructure ventures such as privatization of large metro airports in Delhi, Mumbai and Hyderabad (Kumar, 2017), the Delhi–Mumbai Industrial Corridor (Mukhopadhyay, 2018). The Government has worked with Japan and collaborated for financial and technical support.

The infrastructure industry in India is highly fragmented and has about 300,000 construction companies operating nationwide (Srivastava, 2011). Till November 2019, Projects that were under ‘Pre-construction Stage', or 'Under Construction' as on 1st April 2012, or 'Awarded' after that and with Project Cost >INR 50 crore are depicted in Fig. 1.1 with classification as Government

infrastructure Projects (Traditional mode), Government Infrastructure Projects under PPP mode and Private Sector Projects. 9245 number Projects were underway with a combined value of INR 68,28,908 crores in Communication, Energy, Social and Commercial Infrastructure, Transport Infrastructure, Water and Sanitation sector projects. With 3788 numbers Transport sector has the maximum number of Projects (InfrastructureIndia.gov.in – Database of Infrastructure projects in India, 2019).

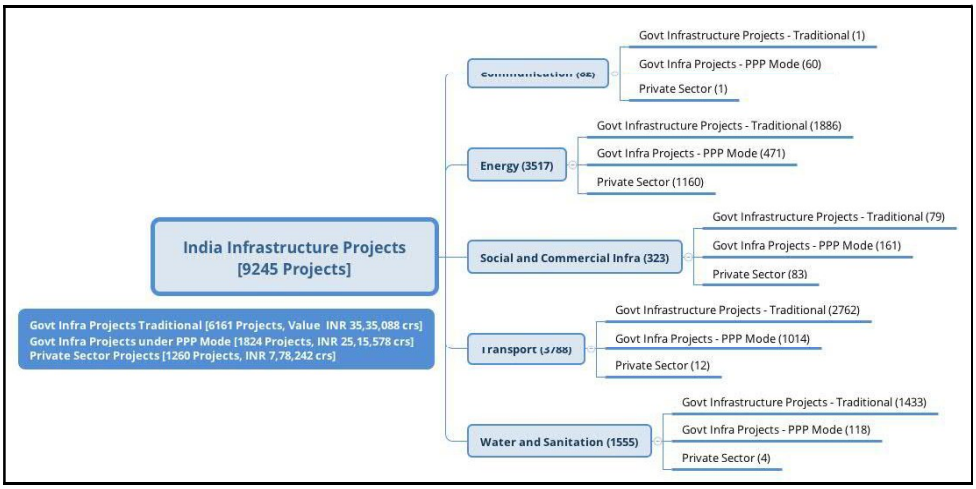

Fig. 1. 1 Infrastructure Projects undertaken in India as on 1st April 2012 (Ministry of Economic Affairs, GOI, 2019)

Over the last decade, with considerable involvement from the central and state governments in the transport sector, India's infrastructure development has been aided by numerous private investments from within and outside the country.

The Government of India has implemented several models for infrastructure development in India. In addition to the traditional model of public infrastructure development, the government has come up with a public-private partnership (PPP) model, under which the investment is made by a selected private company, where the project is owned, developed and jointly implemented by the public and private enterprise by. The private company will provide a return on investment in the project.

Under the PPP model, a public or state-owned corporation and a private sector for the benefit of the public with the investment and management of a private sector company for a specified period of time and for the provision of related

services. There is an agreement between the entity. There is considerable risk-sharing with the private company, and such a firm sets performance-related payments and meets pre-determined performance standards, which are measured by a public entity or its representative.

The PPP model has been very successfully adopted in many advanced countries and has been adopted in highways projects, airports, etc. in India. However, one of the critical issues confronting infrastructure and PPP projects in India is the delay in implementing and executing large-scale projects resulting in time and cost overruns. Also, there have many regulatory issues underlying the PPP model, where entities experience multiple issues at various stages of project implementation. There are several risks involved which if not appropriately addressed promptly may have a negative impact on the outcome of meeting project objectives.

1.1.2. Infrastructure Project Life Cycle or Project Phases

Risk assessment in different phases of the project life cycle is critical. As per PMIs' (Project Management Institute) 'Project Management Book of Knowledge, there are 5 phases in a project life cycle which is determined by the project team and the type of project. Project undergoes these phases and is characterized by a distinct set of activities or tasks taking a project from conception to conclusion. Projects are big and small depending upon the value and extent of volume with constraints like cost, time and resources.

With an increase in project complexity, it is always important to structure and define projects throughout the entire life cycle. Project life cycle phase includes – Project Initiation Phase, Planning Phase, Execution Phase, Project Monitoring and Controlling phase and Project closure phase, as indicated in Fig. 1.2 below.

Fig. 1. 2 Infrastructure Project Life Cycle Phases

Project Initiation phase – This involves the formal start of the project, commitments from project sponsors and other relevant stakeholders, feasibility

studies of the project, development of project charter, etc. (Besner & Hobbs, 2006) are undertaken in this phase. It is important to define proactive strategies with deeper and broader coverage of stakeholders. Stakeholder management is important to manage stakeholder interactions during the initiation phase (Buysse & Verbeke, 2003).

Project Planning phase – This involves the development of a comprehensive project planning and management plan, phasing plan, cost, scope, timelines, quality plan, resource estimation and planning, etc. Comprehensive planning for the development of a project is done in this phase with milestone charts, a plan for identifying and managing risks, risk mitigation approaches, and risk response planning (Zwikael, 2009).

Project Execution phase – This involves actual execution and development activities of the project adhering to the drawn-out plan. Execution phase includes numerous activities to execute the project and also carry out risk mitigation strategies. The execution phase is a crucial phase contributing significantly to the success or failure of the project. Project managers are required to keep their projects focused while supporting their organization's need to adapt to uncertainty in the business environment (Olsson, 2006).

Project Monitoring and Control phase – This coincides with execution phase which measures and monitor project performance and progression in terms of time, cost and quality, taking necessary corrective measures to keep the project on track, scope verification, quality of construction, etc. (Lee et al., 2008).

Project Closure phase – This phase is about project completion and closure. The project is officially completed, which includes a range of essential tasks such as delivering products, relieving resources, closing contracts, project closure reports, and more. Management is proposed according to the principles of project management, including risk management and concurrent engineering. The closure process and the governing body should assist in the practical evaluation of the closure and issuance of certificates (Fourie and Brent, 2006).

1.2 Risk management in infrastructure projects

The success of infrastructure project depends on timely execution within the allowable cost and with the required quality. There are three key objectives of a successful project – meeting timelines, maintaining the cost and maintaining the quality of the project. Unfortunately, the majority of the large infrastructure projects fail in keeping the balance of these three essential success pillars of the project. Identifying risks, prioritizing them and addressing risk resolutions becomes very important in any infrastructure project.

All mega projects involve huge investments of public and private money, which eventually comes from different taxes paid by the users. Infrastructure projects across sectors most of the time suffer significant delays or cost overrun, thus making the infrastructure projects unviable with an additional burden to the end-users (Bruzelius et al., 2002).

Why do projects fail? There are different theories and multiple factors which drive the success of a project. It continues from pre-conceptualization phase to conceptualization, to draw the feasibility, developing the execution plan, financing the project, executing the project, regulatory environment, etc. till the closure of the project. It also involves post-completion, i.e. the operationalization of the project say the returns are not as expected while conceptualizing the project, especially in PPP projects. Various factors in each phase contribute towards the success or failure of the project. Whether these factors are appropriately assessed, analyzed, and the risks involved addressed. To know the underlying risk is also as significant as mitigating it. Most of the time, project owners do not even know and only look for measures when it occurs and then it is too late. At least the controllable factors can be addressed on time, or the intensity of impact can be reduced. Hence, risk management involving risk identification, assessment and mitigation play a crucial and critical role in driving the success of any infrastructure project.

Almost all infrastructure projects are subject to various risks and more so perceived in developing countries as more vulnerable to risks as it involves financing. Project developers finance these projects with their equity, raising debts or other financing instruments with public funding. The risks involved in

the development of a project and consistent flow of revenue streams have to be seriously looked into. Although the project sponsors negotiate the project, it is the lender who plays a crucial role in project financing and thereby set risk standards.

The latest trend indicates that infrastructure projects development is majorly driven by investment funding provided by the private sector as compared to the traditional public sector financing pattern. Though a variety of funding initiatives and innovative solutions have come up, it had been a source to the most significant financial crisis over the past 80 years. With a focus on risk, as a result, it can be anticipated that in future, even more, stringent measures in both theoretical and practical approaches to risk management are required. Even though financing will attract more monitoring and control in various aspects of project appreciation, infrastructure development, and private sector participation is more to grow and will be in high demand.

The following sections address the major risks, how to manage these risks, and the issues that arise in each case. Some of these risks are prevalent in most investment projects. Are very important in infrastructure projects.

Risk assessment is an important step in the overall project implementation. However, this move is the most neglected activity to see that there is a greater focus on project implementation in the early stages of the project life cycle. If the risk is not recognized and adequately mitigated, it can have disastrous consequences for projects with high capital intensive investments.

Risks associated with infrastructure projects pose particular problems in implementation. Some risks may be known to any commercial enterprise and may be controlled by proven methods. However, other risks are specific to the infrastructure, for example, arising from interfaces with regulatory authorities and other government-owned entities. These risks can be brought to an acceptable level through a clear risk-sharing regime.

Type of risks may vary from project to project for different sectors and different business and economic environments. Risks can be prioritized using various tools, and the mitigation measures can be derived. Cost of risk mitigation measures may also vary for the risk mitigation measure and for not identifying the risk and addressing the mitigation at a later stage of the project.

1.3 Constructs of Logistics Infrastructure Projects Risk Management (LIPRM)

1.3.1 Definition of Risk

Different people have different definitions associated with risk. The Merriam Webster dictionary defines risk as "the possibility of loss or injury", risk management standards, guides, and methodologies define risk in many different ways. Some include the possibility of positive risks or opportunities; others do not. As per Project Management Institute, PMBOK 6th edition, '*Risk' is an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives* such as scope, schedule, cost, and quality, i.e. its notation is not every time negative, it can be positive as well. It is essential to properly assess the risks (financial, political and other risks) to ensure value for money and protect the public and end-users' interests. This becomes more crucial in PPP infrastructure projects and can only be achieved through optimal risk identification, assessment, allocation and management from a life cycle perspective. There needs to be balancing of interests between the Government or public and private partners as well as product end-users (Zou, Wang & Fang, 2008).

There is no project which is risk-free as there is an infinite number of events which can have an impact on the project objectives. A careful perusal of the definition given by PMBOK clarifies that risk involves uncertainty which may or may not occur. Further, it can be an issue or a problem, or it can be an opportunity as well as giving benefit. In any case, there needs to be a risk management plan to address the risks in the best possible manner.

1.3.2 Infrastructure Projects Risks

Infrastructure projects are subject to various types of risks during the project life cycle. The Risks can be internal to the organization which are generally controllable and external risks are those which may or may not be in the direct control.

Few common risks at a high level of risks associated with the project objectives

Cost Risk - Cost risk increases due to inaccurate cost estimation or other factors due to incorrect planning and project execution (Long et al., 2004). The

cost increase is defined as the final cost of the project compared to the estimated cost when deciding to proceed with the project. Some international project examples include heavy costs for tunnel projects, the Great Belt Link Tunnel (54% of the budget), the London Jubilee Line Metro Project (67% of the budget), Boston's Central Artery Tunnel (about 100% of the budget), and the tunnel (80% of the budget). All these are good and recognizable projects with well-recognized design and architectural success. Even in China, costly runs on complex mega-projects (such as Ayrton, Gialongdi, and Wanjiazai) are increasingly at risk because of unspecified geographical conditions (Reilly and Arrigoni, 2005).

Schedule Risk - It is related to project delays when it takes longer than expected. Schedule effects of project risks have been supplemented by conducting a case study using Monte Carlo simulations (Choudhury et al., 2014). Major research suggests that financial risk is an important factor affecting cost and schedule goals. Availability of funds with a relative importance index of over 85 is the highest-ranking factor that cannot be identified. The results of the Monte Carlo simulation were compared to the actual full-time and operational costs considered in the case study. In all cases, the actual completion date and cost are in the distribution of the Monte Carlo simulation, which suggests that risk analysis can help project managers manage costs and schedule risks (Choudhury et al., 2014).

Performance Risk - Not complying with specifications when producing a project. Depending on the factors affecting project objectives and the uncertainty that arises during project implementation, risk can be categorized into various forms, such as the impact of project governance structures on risk management in critical infrastructure projects (Guo et al., 2014).

Performance Risk – When the project produces results not consistent with the project specifications. Based on factors affecting the project objectives and the uncertainty arising during the project implementation, risk can be classified into various forms, such as effects of project governance structures on the management of risks in significant infrastructure projects, etc. (Guo et al., 2014).

Construction Risk - A risk and delay in execution due to defects and quality of construction equipment. Structural risks must be analyzed in order to verify their capabilities in construction site security systems and to create optimal trade-offs between minimizing security and reducing overall site costs (Said & El-Rays, 2010).

Contractual Risk - Risk of contract disputes, failure to comply with contractual obligations, inadequacy of contract terms, incorrect contract documentation and improper contract arrangements. Construction activities are dynamic and uncertain, and related risks are often involved in sustainable and construction projects. In large-scale infrastructure projects, in principle, the risk must be shared equally between the companies involved in the project through contractual arrangements. To avoid unforeseen risks and conflicts during construction, contractors should focus on local project characteristics and contracting practices, etc. (Chernigam and Yee, 1999).

Environmental Risk - The risk of environmental problems affecting project development, e.g. Changes in environmental clearance or environmental regulations or project impact on the environment. One consequence of misinformation is cost overruns, lack of profit and waste. Second, it examines the causes of misinformation, and political and economic performance explanations best describe the available evidence, designers, and promoters, who often misrepresent costs, revenue and risks, which positively show their projects, not their competition. This is the result of the survival of the 'un-fittest', which has been misrepresented as a result of subsequent failures. Finally, it introduces measures for the planning of infrastructure projects focusing on policy reforms and improved planning practices and changed governance structures, the latter showing that it is important (Flavazzar, 2007).

Financial Risk - Risk arising from lack of adequate funding and financing structure or hedging. Financial risks associated with infrastructure projects are critical and necessary to be mitigated by identifying parameters such as scope of project and the related costs; Risk is further evaluated by analyzing similar projects in India. Net Present Value (NPV) to the Risk Model tool can be considered using the Monte Carlo simulation, which takes into account the

probability distribution of different input parameters and the uncertainty associated with the NPV (Kumar, Jindal, & Velaga, 2018).

Force Majeure - Risk caused by events such as wars or natural disasters. Many share political, legal, and social risks, and force the most micro-level risks and lofty risks; It provides opportunities for investors to become more involved in infrastructure development (Kay, Wang & Chan, 2010).

Governance Risk - Risk associated with inappropriate governance of a project sponsor or board is compounded by ethics issues. Different project governance structures affect risk management. Comparative analysis provides a structural mechanism for identifying and mitigating project governance risks. Despite the different context, both projects rely on flexible contract terms to increase risk among project partners. While centralized, single-agent governance has been adopted in the form of project management (Guo et al., 2014).

Legal Risk - Risk arising from legal issues and litigation during project execution affecting project timelines and costs. The public and private sector must share legal and legislative risks, residual risk and relationship risk (Sastoke et al., 2016).

Market Risks – This risk includes changes in market environment, foreign currency, market demand and market indices. In the case of public procurement, the value of money must be achieved. For project sponsors, the characteristics of such programs depend on the lower equity, operating and capital costs of the project vehicle and the direct income of service debt finance provided by banks and other financiers (Grimsby & Lewis, 2002).

Operational Risk - The risk of operating equipment and operating costs exceeding the estimate. The importance of operational risk is to identify issues that affect its more effective identification and management (Allport & Ward, 2010).

Political Risk - Risk due to political interference in project development and development. Political risks are associated with the actions taken by host

governments, political groups, or individuals that have a negative impact on international governments or investment transactions (Sachs, Tiang & Wagner, 2008).

Regulatory Risks - Risk arising from changes to regulatory environment, regulations and applicable laws. There are huge gaps in understanding the various tools used to reduce regulatory risk. Ability Attendance and flexibility raises trade issues between freedom and responsibility. There are situations where policy flexibility is needed to reduce risk or increase the expected return on investment, both of which promote long-term investment (Jamison et al., 2005). Risks associated with external factors such as terrorism, job unrest, destruction, and civil war. It is important to develop a simple optimization-based model to support the decision-making process of identifying optimal solutions from different alternatives. The goal is to consider cost efficiency and security (external factors). Because there is a trade-off between these two objectives, formal empirical multi-object optimization techniques are needed to establish optimal Pareto solutions, which can then be used for decision-making purposes (Kim & Moon, 2008).

Technical Risks - Risks associated with project design and construction. When considering smart meters for advanced metering infrastructure (AMI) or water and power infrastructure, the primary role of policymakers is to investigate complex, interconnected and broader issues. Technical and non-technical alternatives for expansion purposes, cost-benefit (loss and mitigation) of infrastructure development and the impact of many stakeholders: customers, suppliers, retailers, competing market operators, competitive technology firms, etc. (McHenry, 2013).

Technology- Risk due to some technology going obsolete or change or wrong selection of technology. A system, method, and non-transitory computer-readable medium for modelling IT infrastructure risk factors. The non-transitory computer-readable medium having proper instructions, which when executed by a processor may cause the processor to generate risk matrices, where an external process of a customer of an IT supplier is mapped to an IT infrastructure element of the IT supplier and a business process of a client of

the customer is mapped to the external process of the customer, perform risk analysis using the plurality of matrices to determine a criticality value for the IT infrastructure element about the business process, and cause a presentation of the criticality value, etc. (Kay & Sahling, 2012).

1.3.3 Infrastructure Project Risks Sources and Consequences

Development of infrastructure projects is directly linked to the growth in GDP of a country. It is a crucial facilitator for economic growth and social development. However, major infrastructure projects have several problems of cost overruns, time delays, failed and stalled projects, funding issues and much more.

There are various factors responsible for project risks and if not adequately contained or mitigated have long term consequences. Primarily and most likely, there is a big issue of under management of risk in almost any stage of the project life cycle. There is a general tendency of giving low priority to risk management unless otherwise, it comes from the project sponsors themselves. As per industry estimate, there are direct value losses due to under management of risks to the tune of $1.5 trillion impacting GDP growth and other losses as well.

Lack of risk management strategy is another factor which directly impacts the risk factors to increase. Infrastructure projects require a robust strategy to correctly reflect the uncertainty and huge variety of risks these projects are exposed to over their life cycles. Risk is adjudged with its severity of impact and the probability of occurrence. In large projects, without a risk strategy, it is almost impossible to control the risks. Risks are generally managed to the extent lender is vigilant or has enforced certain checks and balances. If project sponsors are not serious about this, the probability of high impact from the risks is high as there is no mitigation measure planned.

Every phase in a project life cycle has risks involved. If the risks are not managed in time, it is likely to impact profoundly in the subsequent phases. Risk management is not to be seen as a ritual but as a compulsory and mandatory exercise which needs to be continuously monitored throughout the project life cycle. Inadequate risk assessment and risk allocation have far-

reaching damaging effects on project success. Large infrastructure projects will continue to become more significant and more complex, losses due to poorly managed risks will increase.

Infrastructure projects involve a large number of stakeholders entering and leaving the project during various phases of the project life cycle. The role and risks associated with each of them if not correctly ascertained may give rise to various impediments in the success of a project. This gives rise to risk interfaces and many cross-linkages which has to be addressed through proper risk management strategies. Another issue is that the risks of large infrastructure projects are not properly allocated to the best risk owners. They may have a superior ability to absorb risks. The risk mitigation measures when not deployed on time can be too late to undo the losses occurred (Van et al., 2015).

1.3.4 Infrastructure project risk drivers

Infrastructure projects are highly vulnerable to various risks at different stages of the project life cycle. This may include political, regulatory, financial, operations risks. The key driving factors in project risks include

- Sponsors and developers fail to plan proper execution and associated risks involved.
- Funding agencies deploy risk monitoring techniques to a limited level and loose confidence in project sponsors.
- Changes in regulations while not keeping up to the contractual commitments made.
- Lack of proper cost and time estimated for the execution of the Projects.
- Lack of viable funding options by the regulatory authorities to promote infrastructure development which results in limited options available with private sponsors.
- Poor Procurement planning and assessment results into time delays and cost overruns.
- Lack of life-cycle risk management approach.
- Gold plated projects or over-designed for the commercial opportunity.
- Lack of proper penalties in PPP model on cost and time overruns.

- Front-end planning to have proper conceptual design, procurement model, contracting model, project management model.
- Focus on optimal risk-ownership allocation.

1.3.5 Project Risk Management Framework (PRMF)

As mentioned in the above sections, it is essential to have risk identification, risk assessment and risk mitigation plan in place. Project Management Institute has suggested a project risk management process on what should be the process for risk assessment.

PMBOK's project risk management knowledge area contains seven processes:

1. Plan risk management
2. Identify risks
3. Perform qualitative risk analysis
4. Perform quantitative risk analysis
5. Plan risk responses
6. Implement risk responses
7. Monitor risks

Fig. 1. 3 Risk management process flow

The first step is, however, to have the project objectives clear in everyone's mind. Once the objectives are clear, the risk management plan has to be developed most effectively. With risk priorities clear to achieve project objectives, risks have to be identified, assessed, prioritized, and risk mitigation strategies need to be addressed in each of the project life cycle stages.

There needs to be proper front-end project planning with proper project risk profile to make use during execution coupled with aggressive monitoring, control and mitigation of the risks that may come during execution.

It is important to have a proper understanding of the risks and their mitigation strategies in the project and maintain the flexibility to respond to any changes in the project's life cycle. Assessing risks over the life cycle of a project is a powerful way to transform the dynamic and value chain into an eventual benefit for all involved.

1.4 Research Problem

Mega infrastructure projects involve huge investment and are subject to risks which may result in monetary losses due to delayed development or lack of resources (Haji-Kazemi et al., 2015). There has been researched in the areas of risk management in infrastructure projects, IT projects, etc. however, there is very limited research available in the field of logistics infrastructure.

There are also projects that are delivered on time and the costs to maintain the deadline can exceed many times. Why? Some projects succeed and some fail. Projects fail because of two external factors beyond the control of the project manager and the internal factors related to proper planning and management. Poor risk management, as a whole, is a major factor causing projects to collapse, and has become a major hindrance in many projects developed today (Beckers et al., 2013). The policy of managing infrastructure projects plays an important role in the economic growth of the country. Time and cost overruns Increased spending and revenue delays add additional burden to the economy. According to a recent study by Beckers (2013), managing large-scale projects could exceed $ 1.5 trillion over the next five years. 2010). The National Capital Bus Rapid Transit (BRT) project, the rise of the PPP projects and the highway projects that have been trapped during this time are clear examples of project failures. Whether developers and promoters take risk assessments at the outset of projects and perform them well when undertaking development work has a direct impact on project success.

The infrastructure industry is one of the most efficient and powerful industries in the world, contributing to economic growth worldwide. As a financial contributor, infrastructure has increased productivity compared to other industries, especially developing countries, and is a key component of global economic growth. Infrastructure is a rapidly growing sector with huge demand from customers and companies. The current global project in the pipeline is estimated to be around 9 trillion tr, one-third of which is in Asia (PWC Oxford Research, 2014). India is expected to spend $ 550 billion on large-scale projects over the next five years. Developed economies have significant infrastructure development plans. For example, the United Kingdom has identified infrastructure with more than 500 projects worth over $ 250 billion

(Ahsan, 2010). Infrastructure projects are high on governments' agendas under the 12th five-year plan, and the infrastructure development and investment pipeline are massive. The success of these high-value projects is of prime importance—infrastructure deficiency in a country presents one of the biggest obstacles to economic growth and social development worldwide. Many projects in the recent past have seen pre-mature closure and even closure after huge investments have been made. The success of infrastructure project depends on timely execution within the allowable cost and with the required quality. Unfortunately, the majority of the large infrastructure projects fail in keeping the right balance of these three essential pillars of any project. Identifying risks, prioritizing them and addressing risk resolutions becomes very important in any infrastructure project.

This research shall investigate the current risk management practices followed in the industry while planning and executing mega Infrastructure projects and evaluate the impact of various identified risks in such projects followed by the development of integrated risk management framework, which can be adopted to assess, prioritize and manage risks in logistic infrastructure projects both at strategy development and project execution stages. The research primarily focuses on logistics infrastructure projects, especially airports and road transport infrastructure in India.

1.5 Objectives of the Research

1. To investigate and identify risk factors involved in logistics infrastructure Projects
2. To prioritize identified risk factors and risk modelling
3. Modelling Critical Success Factors in logistics infrastructure projects
4. To develop a strategic Risk Management Normative (RMN) framework for managing risks in the logistics infrastructure sector.

1.6 Scope of the Research

The above research objectives shall be studied as part of this research restricted to risk management logistics infrastructure projects in the Indian context. Given the global constructs and practices related to the subject, the study shall endeavor to encompass complex facets of risk identification, assessment and

mitigation strategies applicable in the Indian context to develop a risk management framework.

1.7 Outline of the Thesis

This section describes the purpose of each chapter in this thesis.

Chapter 1: Introduction

This chapter introduces the topic of research and describes various parts of the research topic. The introductory chapter explains the relevance of the research problem in the context of developing a framework, research objectives, and methodology. This chapter outlines the basics, background and importance of the research problem as the basis for research work. This chapter also explains the outline of the thesis.

Chapter 2: Literature Review

In this chapter, an extensive review of the literature in the field of infrastructure projects risk management with a focus on logistics sector infrastructure projects looking into various facets of risk management practices worldwide and develop linkages to Indian context is undertaken in this chapter. The research gaps are also identified as proposing a research framework. The proposed framework is drawn based on an understanding of extant literature and later identified research gaps.

Chapter 3: Research Design and Methodology

In this chapter, the research approach and research design are explained which have been employed to carry out the research. This chapter explains the overview of the research process adopted during the study and various issues like survey instrument development, modification in the survey questionnaire, sampling frame, and data collection procedure and research techniques: Probability-Impact factor analysis, Analytic Network Process (ANP), and Bayesian Belief Network (BBN). The details concerning research design, methodology, data analysis, and discussion are discussed at appropriate places in the next three chapters, as different techniques are employed during different phases of this research.

Chapter 4: Risk Factor Assessment in Logistics Infrastructure Projects

In this chapter, a comprehensive assessment of risk attributes, risk factors, risk categories has been done. One hundred thirty-three (133) risk attributes (RA) have been identified which have been analyzed in terms of probability and impact for each of the project objective, i.e. time, cost and quality. These risk attributes have been consolidated for each of the twenty-nine (29) risk factors. Further, these 29 risk factors have been grouped into Nine (9) risk categories. Risk heat maps have been created to analyze the criticality of the risks, and results have been compared.

Chapter 5: Assessment for Risk of Logistics Infrastructure Projects using Analytic Network Process (ANP)

In this chapter, the next level of paired risk comparison has been done using the Analytic Network Process (ANP) technique. The analysis through ANP technique has revealed a comparison of various risks, their interdependencies, their relative ranking based on risk priority indices. This has revealed that financial and construction risks play a very important and critical for the success of infrastructure projects. Finally, the study present insights into risk implications with their relative importance that will rationalize the management's effort.

Chapter 6: Financial Risk Modeling of Infrastructure BOT Projects

This chapter provides a detailed evaluation and analysis of the financial risk identified as one of the critical risks in infrastructure projects. The research includes a study of ten highway projects as case studies, which were developed in India on BOT (Build, Operate and Transfer) model. A mathematical model has been developed calculating the Net Present Value (NPV) of these projects consisting of various volatile variables in the general economic environment of India. The chapter discusses the analysis in detail and comes up with recommendations to mitigate the financial risks arising due to these variables.

Chapter 7: Critical Success Factors Modelling for Infrastructure Projects Using Bayesian Belief Network

This chapter presents a conceptual research framework on risk assessment, which builds on the Bayesian Belief Network (BBN) model, which includes

risk factors for the Indian logistics infrastructure sector and provides a reasonable empirical idea of how risk factors lead to it. Project. Bayesian networks provide a very useful risk assessment tool, considering the advantages of quantitative and quantitative risk assessment techniques. The model is used to gauge the sensitivity of risk enabling factors on the relevant query variables related to the stipulated project objectives. The analysis resulted in the relative importance of various critical success factors in affecting project success.

Chapter 8: Development of Strategic Logistics Infrastructure Risk Management Normative framework

This chapter includes the development of a normative framework for logistics infrastructure projects risk management duly integrating the outcome and analysis of 4 level analysis of risk factors, impact intensity, critical success factors and enablers. The framework will provide an enhanced platform for risk assessment and mitigation measures in the logistics infrastructure development project.

Chapter 9: Conclusion and Future Scope of Research

This chapter includes a discussion on the contributions of the research. The limitations are also provided by identifying their theoretical and implementation limits. This chapter also discusses the future scope of research.

The next chapter lays down extensive literature review in terms of risk sources, risk categories, risk factors, risk key enablers, practices followed in various logistics infrastructure projects and will form a foundation for further research work conducted as part of this thesis.