Chapter 3: Research Design and Methodology

3.1 Introduction

In this chapter, the blueprint of the research design and methodology used to conduct the research has been detailed out. It entails the outline of the research problem, methods used therein to reliably ascertain the data points, methods and instruments used for data collection, instruments design, data analysis and due validation of the same. Due care and in-depth analysis has been done to ascertain these methods and are revalidated, so that appropriate inference is drawn to address the research problem. The chapter will encompass the overview of the research framework adopted for the study and the relevant details including implementation, data analysis and inferences are covered in subsequent chapters.

This chapter is divided into three sections. Section 3.2 covers an overview of the research process while defining the research problem and objectives, and the research design and methodology adopted aligned to meet the research objectives. Section 3.3 covers the constructs for data collection, Instruments used for data collection and the way it is fieldwork is executed. Section 3.4 covers the statistical tools and techniques used for analysis, respectively, as well as their appropriateness in meeting the research objectives, respectively.

3.2 Overview of the Research Process

Research is a systematic process which consists of formulating the research problem, collecting the relevant facts and data, logically analyzing the facts and deriving information, inferences and conclusions (Rwegoshora, 2016). Research is a scientific process which needs to be undertaken in a structured manner (Sekaran & Bougie, 2016). Research process entails a series of logically ordered directional choices, running from problem formulation, design and execution of the study, analysis and interpretation (Ghauri & Gronhaug, 2005). This research work has been taken up accordingly following a systematic process.

The overall Research process followed includes logically deriving and defining the Research Problem, developing the Research objectives to address the

Research Problem, deciding upon the steps and studies required to meet the requirements to meet objectives, assessment of the data and information requirements involving the extent of data required, working out the methods for data collection, analyzing the data and arriving at a relevant conclusion and more so revalidating the analysis and inferences drawn from the data.

To arrive at the research problem, a systematic top-down approach has been followed narrowing down the research scope and objectives therein so that the research is specific and does not become too open-ended. The specific reason to restrict the research problem to logistics infrastructure only and that to specific to airports is to remain focused and have an in-depth study of the sector to strongly arrive at the solutions and framework which can be well emulated. Inferences have also been drawn from the study on highway projects to include practices in BOT (Build, Operate and Transfer) projects and draw similarities and extend the hypothesis to PPP projects.

Fig. 3. 1 below details out the approach followed to arrive at the research problem and research objectives.

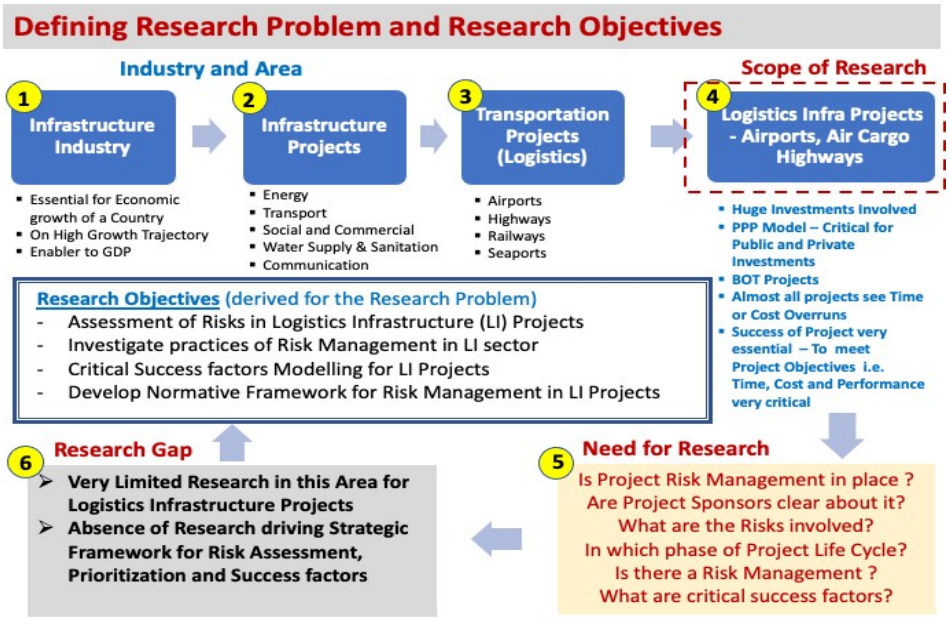

Fig. 3. 1 Framework for the research problem and research objectives

The research work progresses from providing a broad idea about the Infrastructure industry at extensive and more specific from India perspective while considering global references. It entails opportunities lying ahead in

Infrastructure development sector and contribution of the transportation infrastructure. This research study has been carried out keeping in view the practicality of adoption of the framework in practice and from the ease of implementation point of view while considering all the fundamentals in place with regards to risk management. There is a very limited research study in the field of logistics infrastructure. There is quite a good research work done on IT projects. However, risk management in logistics infrastructure has not been so much.

The transportation sector is the leading sector of the country, and there are enormous plans laid down by the government as part of the growth of this sector in India. Government has come up with the National Civil Aviation Policy (NCAP) to boost the aviation sector of the country and also a National Air Cargo Policy (NACP) to boost Air cargo multi-folds. All these growth opportunities are backed with adequate and efficient infrastructure development. Government has come with up with a unique model of Public-Private Partnership (PPP) model to attract the private sector to bring in speed, investment and quality to meet international standards. The aviation sector is on a growth trajectory, and new airports are getting developed, old airports are being expanded and modernized. Connectivity to the airports are enhanced and upgraded, and New trade corridors are getting developed. With all these developments, infrastructure projects in the logistics sector have to be taken up more efficiently while meeting the project success criteria of Time, Cost and Quality. Keeping in view, this background Research has been designed in such a way that it effectively responds to the research problem. Methods used to comprehend the subject, collect relevant data from the best sources available, use of data collection techniques, use of analytical tool and techniques both qualitatively and quantitatively is based on a very systematic and scientific approach to address the research needs.

The entire research work has been arranged into systematic process steps starting from the defining the Research Problem and Research objectives and then laying down the study requirements to conclude and a suggested Normative framework which can be used by project sponsors, project managers, the project team. The research design and methodology outline

encompassing data collection (source, type, and methodology), Data analysis/ statistical tools/ techniques employed and analysis/ outcome are shown in Fig. 3.2.

Fig. 3.2 lays down the outline of the research design and methodology outline providing the Research process adopted, the objective of each process step, the data and information requirement, Tools and Techniques and the outcome of that process step.

Research design has been developed to have all the process steps well integrated into the overall design and establish proper linkages among them. Further, care has been taken while developing the Research design to ensure that the results as an outcome of the Research work are valid and reliable.

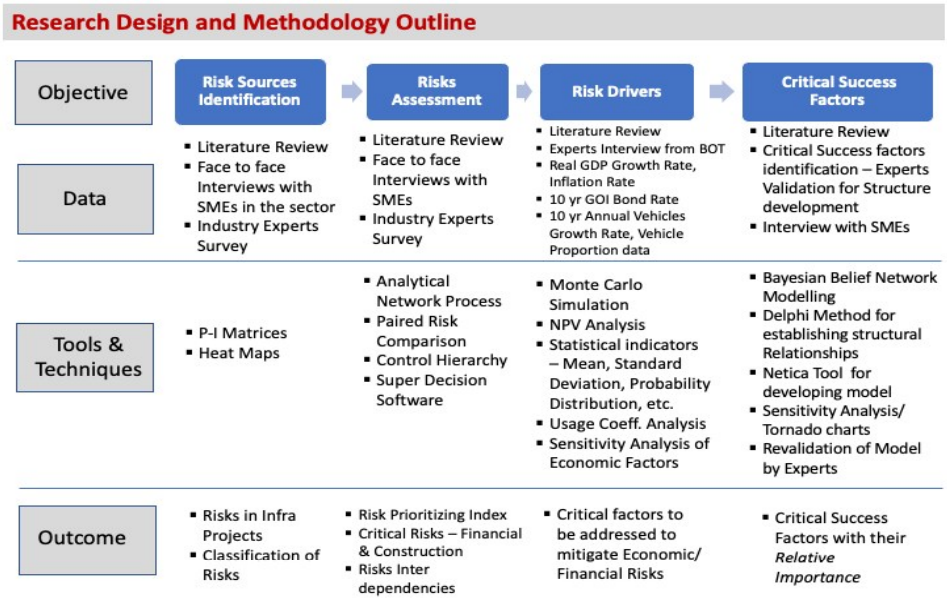

Fig. 3. 2 Research Design and Methodology Outline

The problem demands to identify and assess the risks sources, classification of these risks factors, prioritization of the risk factors, understand interdependencies, critical deflators and enablers.

An extensive literature review has been undertaken for identifying the academic developments and approaches undertaken in the field, followed by data collection through experts. As the research is very specific, subject matter experts who have been involved in the Infrastructure projects, logistics infrastructure development, airport development, cargo logistics park

development, etc. were interviewed through structured interview questions designed to cater to the requirements of the research problem and research objectives. This was followed by a research survey in the form of questionnaires filled in by the experts. While the research problem entails different aspects of Risk management, the research process was designed in such a manner to all the inputs required to arrive at a comprehensive framework. Accordingly, multiple questionnaire sets were designed, and inputs taken from Experts. Care has been taken to fill the data gaps of secondary data.

While the data was collected for different steps and stages of the research work, which is detailed out in subsequent sections, multiple tools and techniques were used to process and analyze the data. An exercise was carried out to assess the tools and techniques available, which will be relevant to analyze the data for the research problem and best suitable, appropriate techniques were arrived upon. This involved tools and techniques used by other researchers also and what are the benefits and challenges of the same, for all the data collected, comparative analysis of tools and techniques, e.g. AHP versus ANP as detailed out in subsequent sections.

As there is limited research available in the area which entails detailed study on risk management in logistics infrastructure projects, Research problem and set of objectives requires to undertake both qualitative and quantitative assessment of the Risks factor, with detailed analysis of these risk factors. Combination of quantitative and qualitative methods have been used. Quantitative methods including surveys with SMEs, project sponsors, project managers, etc. have been used to measure, rank, identify and categorize risks and to draw out inferences.

Different research designs used by various researchers are divided into three categories, according to Niglas, 2009, which include exploratory, descriptive, and experimental. There are different Research design concepts laid down by different researchers. The research design developed for this study is both considered those aspects, e.g. research design for exploratory research or descriptive research, at the same time it is also well considered the Research Outcome and the linkages to the research objectives are well established.

The fact that the risk management in logistics infrastructure projects has not been much dealt with in the past and the research has been mainly towards risk identification and assessment for projects majorly in IT sector or to say to infrastructure projects to a minimal extent. The conceptual studies therein represent a research methodology that describes the general concepts of Project risk management. Most papers propose a conceptual framework for managing infrastructure risks, followed by empirical research, which is by far less than the conceptual and exploratory researches (Mathew & Aundhe, 2011).

This study is based on research objectives leading to the development of a conceptual framework and resultant model. The intention is to carry out a quantitative, scientific examination of the normative comprehensive risk management model for logistics infrastructure projects in the Indian context. The coverage includes overall research methodology, research design, sampling strategy, measurement of constructs and design, research instrument and the statistical tools employed, i.e. the significant issue about the methodology of data analysis.

In order to prepare a comprehensive risk management normative framework for the Indian logistics infrastructure projects, a detailed study of the risk sources, risk factors assessment, resources and critical success factors incorporating financial modelling has been undertaken. The data has been collected through both primary (industry practitioners and experts using detailed interactions/ in-depth interviews, surveys etc.) and through secondary sources (including online databases, annual reports, third-party data providers, etc.).

Both qualitative and quantitative tools and statistical techniques have been used. The outcomes of these analysis/ models are 'Risk Prioritization Index' (RPI), critical prioritized risk factors, risk interdependencies, critical economic factors impacting the financials of logistics infrastructure projects under BOT model, risk enabling factors and thereupon linked and integrated into a 'Strategic Risk Management Framework' (SRMF) for logistics infrastructure projects in the Indian context. The architecture of research design and research methodology of this study has been built keeping the alignment with the

research objectives. The following section covers the description of the data collection and data analysis techniques used in this research.

3.3 Constructs for Data Collection

Data collection is the process of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes. The goal for all data collection is to capture quality evidence that then translates to rich data analysis and allows the building of a convincing and credible answer to questions that have been posted.

Extensive exercise has been undertaken to source the data for the research. This includes both secondary and primary data collection techniques. This included a literature review which formed the basis to carry out further data search and sourcing.

Both qualitative and quantitative data have been collected, keeping in view the requirements of the research objectives defined through primary and secondary sources. In-depth surveys with the experts, face to face interviews with experts, infrastructure project professionals, consultants in the field has been conducted. Primary data sources included surveys using a questionnaire, Delphi technique, in-depth interviews with industry and sector experts. An extensive literature review was conducted for all the aspects related to the research problem and objectives.

3.3.1 Survey Instruments

The survey instruments have been in the form of a structured questionnaire with respective constructs and indicators designed to elicit responses from higher management. The survey instrument is formulated based on an extensive literature survey as well as consultants in the infrastructure projects industry. The scale items are then amalgamated suitably in the form of questionnaires. The questionnaire is divided into two parts. Part A is preceded by a brief explanation and objectives of the study, contained unstructured questions and is open-ended in nature designed to ascertain information about the respondents such as name, significant products/ vehicle variants, number of employees. The covering note to the questionnaires, besides elucidating the

background, purpose and significance of the study, also stresses the fact that the response shall be confidential and that if the respondent so desired, the summary of results and recommendations will be sent to them.

Survey Questionnaires: Survey questionnaires were developed to seek inputs in a most reliable form. Questionnaires were designed keeping in view questionnaire design principles as prescribed to be able to be analyzed in a way to produce required results. The survey questionnaire was designed for seeking inputs on risk sources, risk factors, risk attributes. Questionnaires were sent to the experts in the field on email, courier, and also distributed by hand in hard copies.

Pre-Testing of Questionnaire

The survey instruments have been pre-tested in the following stage-wise manner:

The instrument has been examined for relevance and applicability by senior experts responsible for airport infrastructure development activities.

The instrument is then pre-tested for content validity, clarity and relevance by obtaining responses from 17 practitioners, including management consultants from the logistics infrastructure development sector. Based on the above, suitable modifications have been made to the questionnaire, and a partial pre-test was done involving a different set of respondents.

The final stage of the pre-testing of the questionnaire involved discussing it with a few members associated with this logistics infrastructure industry. Their suggestions, as relevant, have been incorporated in finalizing the questionnaires.

The finalized questionnaires, after the above-mentioned stage-wise pre-testing process, have been then transcribed into a form suitable for electronic means of transmission.

The survey questionnaire has been carried out to seek responses from the sample population. Survey method is widely used, especially when the aim is to collect a large number of responses as possible and is comparatively simple to administer and obtain responses (Hair et al., 2013).

3.3.2 In-depth interview with experts

In-depth interviews have been carried out to seek inputs and knowledge of the sector and practices followed and not followed on risk management in logistics infrastructure projects. To have a complete sample representation, experts from all the relevant fields about respective fields were taken, e.g. experts from commercial business, infrastructure development, project finance, legal, operations, commercial contracts, quality assurance, business integration, etc., have been included. The interview questionnaire has been systematically designed to conduct a face-to-face conversation with the respondent. Care has been taken to ensure all the relevant data points, and views are recorded in the right manner as has been told. Audio recordings have been made with the respondents' permission wherever possible.

3.3.3 Target population and sampling design

The target population for the data sourcing was experts from infrastructure industry involved in the development of infrastructure projects, airport development, highway projects, consultants working in the field, subject matter experts from the industry with relevant experience in risk management, infrastructure project development. The sampling design was done accordingly. The purpose to include consultants was to gain insights from their experience in the field while working solution for projects on time or to develop strategies for failed projects. Further, the sample was designed to keep experts from different levels which include project sponsor, project head, team head, project managers so that the sample is quite representative of all the hierarchy levels in project management.

Data Collection Field Work

The administration of the survey instrument was done in two stages. The first stage involved transmission through email and simultaneously posting it by regular post. Concurrently with the electronic means, the questionnaires have been mailed by post to the surveyed population along with a postage-paid envelope for returning the completed questionnaire. The respondents in the same city and approachable were handed over the survey questionnaire by hand as well. The mail survey, both by email and surface mail, has been

complemented by several randomly selected interviews where it has been felt that respondents may require intervention to facilitate the process of completing research instruments. The possibility of self-selection bias and false representation (Zikmund & Babin, 2007) was addressed by ensuring that each respondent fills in their business details. The details of responses received have also been covered at appropriate places in the subsequent chapters.

The in-depth interview was undertaken in an environment where there is least disturbance so that the respondent feels comfortable and is not disturbed with external factors.

The relevant details about the number of professionals approached, and their relevant details are covered in the subsequent chapters 4 to 8.

Data Analysis and Evaluation

Fig 3.2 enumerates the techniques employed for undertaking analysis and interpretation of the results concerning the objectives of the study. A healthy mix of both qualitative as well as quantitative statistical tools/ techniques has been employed in the research. Analytic Network Process (ANP), Monte Carlo simulation, Bayesian Belief Network (BBN) techniques have been used to arrive at the desired outcome effectively. In this study, construct reliability was ascertained at each stage and has been validated with proper indices and industry benchmarks. A brief overview of the ANP Process, BBN, etc. employed for the development of assessment of risks and risk enabling factors to meet the first research objective are discussed in the next section. A model has been developed to generate the heat maps based on the inputs provided by experts through structured questionnaires. Heat maps have been generated about the first risk objective for the assessment of risks in logistics infrastructure projects. This has been further assessed and analyzed using paired comparison technique, control hierarchy model with Analytic Network Process (ANP) for generating inter-relations between the risk drivers and prioritized risk factors as an outcome to second research objective related to risk assessment. The analysis and results were worked upon using Super Decision software. The work has been accepted in a leading journal for publication. To understand the impact of these prioritized risk factor, a model

has been developed to analyze the relationship and interdependencies with the impact of economic factors on the outcome of the project governed with these factors. Monte Carlo simulation has been used for this purpose and performing sensitivity analysis on the NPV of the projects. As there is not sufficient information available related to the airports, the analogy has been derived from the highway sector where both airports and highway infrastructure projects are awarded on BOT model in the Indian context. BBN model has been used analyze for the third research objective, i.e. to assess and derive the critical success factors and enabling factors for logistics infrastructure projects. All the major tools and techniques used and the constructs behind them are discussed in the following sub-sections to have a perspective around them.

P-I matrix simulation and Heat Maps

The risk depends upon the likelihood of its occurrence and the impact or severity which is associated with its occurrence. The likelihood of risk is based on the historical information of the risk, or it is based on the inputs received from Project personnel who have sufficient understanding of the occurrence of the risk-based on their experience in the field. This is generally measured in terms of Very High–5, High-4, Moderate-3, Low-2, Very Low-1. Similarly, in terms of severity from the occurrence of risk is measured in terms of Very High– 5, High-4, Moderate-3, Low-2, Very Low-1. A matrix is drawn, which visually depicts the results of Risk Probability, and Impact Assessment termed as P-I matrix. Risk Index or Risk Rating arrives with a product of Probability score and the Impact score

$$R = P \times I \qquad \text{--- (3.1)}$$

Where R= Risk Rating

P = Probability Score and

I = Impact Score

Risk having a high probability and high impact have serious consequence to the success of project objectives and have to be looked into with appropriate action at the right time while ascertaining the root of risks (Fouladgar et al., 2012).

Data for the probability and the impact score was collected from all the respondents in the form of the matrix for the identified risk factors and their corresponding attributes. A cumulative score was worked out considering the inputs from each respondent. Each attribute associated with its corresponding risk factor had a relative weightage factor. Cumulative probability and impact score for each risk factor were calculated using the weighted average mean.

A model has been developed to scientifically map and generate the Risk Heat Map (RHM) categorizing the risks from low probability to high probability and impact zones. The result drawn from this method is later compared with the other methods used in the study.

Analytic Network Process

ANP has been used for risk assessment for various kind of projects. In research by Boateng et al. (2017) considered the construction project risk and STEEP (Social, Technical, Economic, Environmental, Political). ANP is among the complex and advances Multi-Criteria Decision-Making (MCDM) methods. This method works between the network's elements by supporting the feedback and dependencies.

The techniques of MCDM are undertaken for measuring the degree of project's risk, and taking corrective or/and preventive actions which will lead to balancing or/and preventing the risks, permitting project managers in the implementation of response to risk plans for reducing, avoiding or/and accepting the risk of the projects. This technique considers the criteria for time, cost and quality, which represents the Project management's Iron Triangle (Atkinson, 1999).

AHP is a hierarchy-based model where the goal, criteria, sub-criteria and ultimately, alternatives are modelled in the top-down approach powered with the pair-wise comparison. AHP technique, however, has limitations where goal and criteria have interdependencies. In such cases, ANP is more reliable and provides desired decision-making support based on systematic and reliable analysis. In a hierarchy based AHP approach, the effect on the alternatives and criteria dependency and further criteria affects goal. AHP does not consider or

is not effective where criteria affect alternatives; the criterion has interdependencies and alternatives dependency on one another.

The main steps followed in ANP are:

First, the risk factors affecting the project are identified and are classified according to an objective criterion. All the factors are then arranged in a hierarchical tree structure with categories of risk in the intermediate level and lowest level having the factors of risk.

Each level elements are compared pair-wise from a scale of 1 to 9 about its standing in producing the under-consideration decisions. One denotes equally preferred, 3 is for moderately preferred, 5 for strongly preferred, seven denotes very strongly preferred 7 and 9 represents extremely preferred. If the manager feels that the importance lies in between the given preferences, he can use the middle values of 2, 4, 6 and 8. For example, if a factor is more than just strongly preferred but not so much as to be very strongly preferred, it can be rated as 6. These preferences are captured in the form of a comparison matrix.

The upper half values denote its reciprocal values that are diagonal of the matrix values. Hence, the stakeholders need to fill only the upper triangle of the matrix.

The consistency ratios of the resultant matrix are calculated, and this should be less than 0.1 as per consistency criteria suggested by Saaty (1989). If this does not happen, then the recollection of data is to be done until that turn out to be consistent.

Then the element's relative weights for every level about the adjacent upper-level elements are calculated as the normalized eigenvector components associates to the comparison matrix's largest eigenvalue.

The Super matrix is constructed. For obtaining priorities globally in a system having influences interdependently, columns are used for entering the local priority vectors. These local priority matrices are positioned as a segment in the Super matrix based on influence flow from cluster to cluster or within the cluster.

Monte Carlo simulation

Monte Carlo simulation is a useful technique to draw generalizations and generate random variables for modelling risk or uncertainty of a large array of systems (Raychaudhuri, 2008). Compared to other deterministic analysis, the Monte Carlo method provides a superior simulation of risk (Paskov & Traub, 1996). It gives a good insight of not only the expected outcome but also the probability of occurrence of that outcome. It is also possible to model correlated input variables (Iman & Conover, 1982). Monte Carlo method is applied to use the randomness to solve such problems that might be deterministic in nature.

In this research, financial risk assessment has been undertaken for logistics infrastructure projects in Build-Operate-Transfer (BOT) model. Monte Carlo simulation technique is used to gain insight from the correlated variables in BOT projects under study. Two types of parameters/ variables have been used in the model - Certain and Uncertain. The probability distribution (with predefined mean and standard deviation) is have been assigned to the uncertain variables accordingly, and then the relationship between the parameters and their effect on the NPV value is tested on the defined confidence interval. Multiple iterations are run upon the model to draw necessary inferences using Monte-Carlo Simulations.

Bayesian Belief Network (BBN)

The Bayesian Belief Network (BBN) model is a probability model that relates the cause and effect relationship to a set of variables and their relative dependence on the form of Directed Acyclic Graphs (DAGs). Bayesian networks are DAGs, whose nodes represent variables in a Bayesian sense. Nodes represent random variables with some probability distribution and direct edges represent causal relationships. The conditional probability table associates each node with the parent node. Using Bayes' theorem for conditional probability, the probability that a particular condition of a random variable will occur is more precise and can be predicted more accurately for a particular condition.

Quantitative tools in Risk Assessment (RA) commenced with decision tree analysis to select amongst the risk options vis-à-vis risk factor itself. One dimensional scenario analysis is also predictive in nature, though it is purely a qualitative approach. The Bayesian network technique is a comprehensive one in that it estimates multiple and inter-related dependence relationships and corrects for measurement errors during estimation. It is often used to analyses the causal relationship between entities. For example, the Bayesian network represents the probability relationships between risks and results / effects in the industry. In terms of outcome, the network can be used to quantify the presence of various risk factors. It can be used in two ways: 1) top-down, predictive modeling, and 2) bottom-up, diagnostic tool. That is, one cannot only convert from causes to consequences, but also calculate the various causes that lead to these effects. BBN is used for data and expert knowledge, especially in areas where there is uncertainty, which enables uncertainty to be clearly considered. For reason modeling, BBN is a good fit methodology. In this research, an attempt has been made to study the different levels of risk that enable factors in project goals.

Various authors (Campbell and Schofield, 2006) have identified relevant risk enabling factors by integrating success factors into major infrastructure projects, eliminating irrelevant risk factors that do not affect selected investigational variables, including risk associated with project sustainability and ethical code. Elaborate consultation was conducted with infrastructure project development professionals to get their feedback for shortlisting the factors.

The BBN Model generation is undertaken in two phases - structural study and other parameterization study. Structure learning was done by forming of the directed acyclic graph, variables identification and finding relationships among them by utilizing available data through secondary sources, including a literature review and taking inputs from Experts. The parameter study was undertaken to determine the probability distribution of each node assigned to the structure of the BBN. For the development of the structural model, six experts were interviewed using the Delphi method. The BBN model was developed using the Netica tool. The procedure followed consists of 2 steps.

First, ask the conditional probability for each parent of the node. Then combine these probabilities and get the conditional probabilities for all of the node's parents.

This chapter detailed out the Research design and methodology followed in carrying out research with details of what the data collected, means and methods data collection was structured and executed, data analysis and the tools/ techniques used to do this analysis to achieve the desired results aligned to the research objectives. The next chapter entails the identification of risk sources, the risk factors and associated or contributing factors in detail. It will also include assigning a probability of occurrence of the certain risk, and to what extent is the impact in case the risk occurs.