

Risk Management Framework for Navigating the Pre-Construction Phase of Data Centres in Kerala

Milan Denny, Kranti Kumar Myneni



Abstract: Building a data centre is a complex process, and the pre-construction phase is crucial in ensuring the project's success. With Kerala emerging as a promising terminus for digital infrastructure, initiatives like the Kerala State Data Centre (KSDC), the Kerala Genome Data Centre (KGDC), and private sector plans highlight the state's potential. This paper aims to establish a structured framework for identifying, assessing, and prioritising risks during the pre-construction phase of data centre projects, with a focus on Kerala. The study examines various risks, including regulatory hurdles, site conditions, financial constraints, coordination challenges, and environmental factors. By assessing the likelihood and potential impact of these risks, the framework provides actionable insights to guide stakeholders in making informed decisions. Kerala's unique conditions, such as frequent monsoons, are considered alongside its strengths in disaster management and advancements in resilient construction practices. This research emphasizes the importance of proactive risk management during the early stages of data center development. It highlights how such an approach can reduce uncertainties, streamline project execution, and maintain quality standards. The findings aim to equip stakeholders with the tools to navigate challenges effectively, ensuring that Kerala remains a competitive and reliable choice for data centre investments.

Keywords: Data Centre, Information Technology, Internet of Things, Risk Assessment, Risk Matrix, UPS

Abbreviations:

KSDC: Kerala State Data Centre

KGDC: Kerala Genome Data Centre

IT: Information Technology

MEIT: Ministry of Electronics and Information Technology

STPI: Software Technological Park of India

EIA: Environmental Impact Assessment

IoT: Internet of Things

I. INTRODUCTION

Data centres trace their roots back to the early days of computing when computers were housed in specialized computing centres with specific operational requirements. The term 'data centre' gained prominence in the 1990s, with evolving features and defined operational standards that have

Shaped the modern data centre landscape. Historically, the development of data centres has progressed smoothly, evolving from IT departments or computer-building research [1]. Over time, data centre facilities have witnessed advancements in environmental controls, including temperature and humidity regulation through sophisticated air conditioning systems, to ensure optimal equipment performance. The architecture of modern data centres has been shaped by the need for high availability, scalability, and energy efficiency, driving innovations in cooling and power management. In the 21st century, contemporary data centres emphasize energy efficiency, incorporating sustainable practices, green technologies, and advanced cooling mechanisms to enhance operational efficiency and environmental sustainability, classifying themselves into four tiers (by Uptime Institute), namely:

- A. Tier I: Basic Capacity – Offers basic infrastructure with a single path for power and cooling, suitable for small operations with up to 28.8 hours of annual downtime.
- B. Tier II: Redundant Capacity—This option provides partial redundancy with some backup components, resulting in an average of 22 hours of downtime per year. It is ideal for businesses needing moderate reliability.
- C. Tier III: Concurrently Maintainable—Provides dual power paths, allowing maintenance without service interruption and achieving only 1.6 hours of annual downtime. It is suitable for enterprises needing high availability.
- D. Tier IV: Fault Tolerant—This system is fully fault-tolerant with 2N+1 redundancy, ensuring maximum uptime with just 26 minutes of downtime per year, ideal for mission-critical operations.

With the digital revolution, data centres have become essential infrastructure supporting various industries, from IT services to finance and healthcare. India has emerged as a prominent player in the global data centre market in recent years, driven by its growing digital economy, favourable government policies, and rapidly increasing data consumption. The demand for construction is increasing with the rise in population. Data centres are high energy consumers, both for power and the extraction of the heat dissipated from IT equipment. According to industry reports, the Indian data centre market is projected to witness significant growth over the next decade, driven by digital transformation initiatives, cloud adoption, and increased investment in Information Technology (IT) infrastructure.

India's strategic location, relatively low operating costs, and robust government support, such as the Data Centre Policy draft introduced by the Ministry of Electronics and Information Technology (MeitY), have further accelerated interest from global data centre

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operators. This push is also fueled by the 'Digital India' initiative, which emphasizes creating digital infrastructure to empower citizens. However, establishing a data centre in India is a complex and risk-intensive endeavour, particularly during the pre-construction phase. Challenges such as land acquisition, regulatory compliance, environmental clearances, and technical considerations make conducting a thorough risk assessment imperative to enhance project viability and operational efficiency. Data centre infrastructures provide a lens for understanding the rise of resilience thinking and grasping the pragmatism and promise of resilience as an approach [3].

The Kerala State Data Centre (KSDC), under the Software Technological Park of India (STPI), has expanded significantly since 2021, increasing its area in the state capital with plans to add more in Kochi. Complementing this is the ambitious Kerala Genome Data Centre (KGDC) initiative at the Digital University, which focuses on managing and analysing large genomic datasets. With an initial investment of Rs . 150 crores for hardware and software, and a total of Rs . 300 crores planned over the next four years. Reliance Group has proposed a Tier-IV data centre in the private sector in the state capital, pending government approval. This facility would enhance Kerala's reputation as a reliable, high-performance data infrastructure centre. These developments showcase the state's potential to attract investments and cement its role in India's growing data economy.

II. METHODOLOGY

The research begins with a thorough and focused literature review to explore the current state of knowledge on the pre-construction phase of data centres. This stage involves identifying and analysing the primary challenges faced in this phase, which include technical, financial, and regulatory hurdles. Additionally, the review studies the legal frameworks, standards, and specifications that govern data centre construction, particularly in the Indian context. Special attention is given to identifying risks during this phase, such as delays, cost overruns, and inadequate planning. This step lays the foundation for understanding the gaps in existing research and industry practices, which in turn form the basis for the subsequent steps.

Building on the findings from the literature review, the next step is to identify underexplored or inadequately addressed areas within the domain of pre-construction risk management for data centres. The focus here is on highlighting gaps that pertain to risk identification, assessment, and mitigation strategies. With these gaps in mind, specific research questions are formulated. These questions aim to address key issues such as the categorization of risks, their prioritization based on severity and likelihood, and the strategies employed for their mitigation. This step ensures that the research

remains focused on addressing critical areas with practical implications.

The third phase involves systematically collecting data from the reviewed literature. This includes compiling a comprehensive list of risk factors relevant to data centre pre-construction and categorising them based on their frequency of occurrence and significance. Commonly encountered challenges, such as delays due to permitting issues, supply chain disruptions, and design coordination errors, are documented alongside the mitigation strategies employed in previous projects. By mapping these challenges and strategy, this step creates a database of recurring patterns that informs the subsequent phases of the research. To complement the literature-based findings, a detailed questionnaire was designed for interviews with specialists in the data centre industry. The questionnaire is developed to probe all categories of risks identified in the literature review and explore their practical implications. Specific areas of focus include the strategies employed for risk mitigation and management, best practices observed in the field, and insights into emerging trends and innovations in data centre development. The questionnaire also aims to understand the future trajectory of the industry, including how upcoming advancements, such as green data centres and modular construction, may influence the pre-construction process. Once the interviews (3 Project Management Consultants) are conducted, the responses are subjected to qualitative analysis (Delphi technique). The feedback from experts is categorized to align with the risk factors identified in the literature review, creating a cohesive framework for analysis. This step ensures the study integrates practical, real-world insights with theoretical knowledge. The qualitative data is cross-referenced with findings from the literature review to validate and refine the understanding of risk factors, their interdependencies, and their potential mitigation strategies. This data triangulation adds robustness to the research findings, ensuring that the conclusions drawn are reliable.

The culmination of the research involves creating a risk matrix model (ISO 31000:2018) and a detailed risk document. In this step, the identified risks are organised based on their impact on cost (c), schedule (s), resources (r), and other factors (o), as well as their likelihood of occurrence, potential impact, and overall consequence. By prioritising risks according to these criteria, the matrix provides a clear and actionable framework for managing risks in the pre-construction phase of data centres. Furthermore, the risks are assigned to specific phases within the pre-construction process, enabling stakeholders to address them proactively. The data collected by the risk investigation should be identified, analyzed, evaluated, and countermeasures proposed [2]. The risk document includes tailored mitigation strategies designed to reduce or eliminate the impact of these risks.

Table-I: Risk Management Framework Model Referred from ISO 31000

	L1	L2	L3	L4	L5	Occurrence Lvl	Likelihood
P1	1	2	3	4	5	P1	20%
P2	2	4	6	8	10	P2	40%
P3	3	6	9	12	15	P3	60%
P4	4	8	12	16	20	P4	80%
P5	5	10	15	20	25	P5	100%

The final phase of the methodology is dedicated to assessing the future trends and scope of data centres in India. This step involves analysing how advancements such as green data centres, edge computing, and modular construction will likely influence the risk landscape and overall development of data centres.

III. ANALYSIS

A. Classification of Risks & Their Mitigation Strategies

Data centre projects require meticulous planning to manage various interconnected risks that impact feasibility, execution, and long-term functionality. They differ

significantly from standard construction projects due to their unique operational requirements [4], such as high-power availability, cooling efficiency, and data security. General risks in data centre construction include delays due to supply chain disruptions, cost escalations, technical failures, and environmental challenges. Specific to the Indian context, risks are further compounded by regulatory challenges, diverse climatic conditions, and infrastructural constraints. Effective risk management in construction projects necessitates the integration of intelligent systems to identify, assess, and mitigate potential issues proactively. A few of them are:

Table-II: Identified Risks and Their Mitigation Strategies

Risks Identified	Mitigation Strategies
Limited availability of skilled labour and resources	Pre-book skilled labour in advance and plan for on-site training. Develop resource scheduling software to optimise labour and materials.
Integration issues with advanced construction technologies	Conduct thorough technology compatibility testing. Provide training for key project members on new technologies.
Project delays due to political unrest in certain regions	Conduct a comprehensive political risk assessment before site selection. Implement contingency planning for critical project phases to ensure continuity and minimise disruptions.
Water scarcity issues are impacting cooling requirements	Install water recycling systems to reduce water dependency. Use alternative cooling technologies, such as air cooling.
Risk of power outages due to unstable utility supply	Incorporate multiple backup power systems. Collaborate with local power providers for priority services.
Unanticipated cost escalations in raw materials	Implement cost-control measures, including bulk purchasing and negotiated rates. Conduct regular market analysis to anticipate price trends.
Risk of flooding due to improper site location	Utilize flood risk mapping and avoid high-risk areas. Design and construct flood-resistant foundation systems.
Stakeholder conflicts are causing project delays.	Establish clear communication channels among stakeholders. Define roles and responsibilities in stakeholder agreements.
Potential fire hazards in material storage areas	Enforce fire safety protocols and use fire-resistant materials. Designate and label specific storage areas for flammable materials.
Contractual disputes due to unclear responsibilities	Establish clear roles and responsibilities in contracts. Schedule regular contract review meetings with all stakeholders.
Integration issues with construction management software	Provide training for software use and select compatible tools. Conduct pilot tests before full-scale implementation of new software.
Soil stability issues in data centre foundations	Conduct comprehensive soil tests and adapt foundation designs accordingly. Engage geotechnical engineers to review and assess soil data.
Environmental impact due to site selection	Conduct an Environmental Impact Assessment (EIA) early in the planning phase to choose low-risk sites. Implement sustainable construction practices to minimize ecological footprint.
Supply chain disruptions are impacting materials.	Diversify suppliers and maintain buffer stocks for critical materials. Use predictive analytics to anticipate and mitigate potential disruptions.
Delays due to regulatory and approval processes	Develop a regulatory compliance checklist and involve local consultants. Regularly update stakeholders on regulatory changes to ensure project plans are adjusted accordingly.

B. Forecasting of Future Trends and Scope of Data Centers in Kerala

With the rapid expansion of digital technologies, such as cloud computing, artificial intelligence, and IoT, Kerala is uniquely positioned to lead this global transformation. As traditional tech hubs in India become saturated, the state offers a fresh, competitive edge with its unique blend of natural resources, infrastructure, and skilled talent. One of Kerala's most significant advantages is its location. With

submarine cable landing stations providing high-speed global connectivity, the state can easily support data-intensive applications. However, large-scale energy projects often face challenges such as stakeholder fragmentation, cost overruns, and inflated expectations, which must be carefully managed to ensure successful implementation. Additionally, Kerala's strong focus on renewable energy, particularly solar and hydropower, makes it a sustainable choice for companies

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looking to reduce their environmental impact. This aligns perfectly with the growing demand for eco-friendly operations in the tech industry. The state's educated workforce, supported by engineering colleges and IT institutes, adds to its appeal as a destination for building and

maintaining high-performance data centres. Managing large-scale data operations necessitates careful consideration of legal aspects, including data protection, privacy, and compliance with international standards.

IV. RESULT

Table-III: Risks and their Impact Level for Data Centres in the Pre-Construction Stage in Kerala

Sl. No	Risk Description	C	S	R	O	Occurrence Lvl (P)	Consequence Lvl (L)	Prob. of Occurrence
Regulatory Compliance								
1	Delays due to regulatory and approval processes (EIA, DCR, SIDCO, SERC, Water from ULBs)	X	X			P4	L5	20
2	Environmental impact due to site selection	X	X	X		P2	L3	6
Site Conditions and Feasibility								
3	Soil stability issues in data centre foundations	X	X			P4	L3	12
4	Water scarcity issues are impacting cooling requirements	X		X		P4	L2	8
5	Risk of flooding due to improper site location	X	X	X		P4	L5	20
6	Structural risks due to landslides	X	X	X		P3	L4	12
7	High humidity level risks affecting site viability	X	X			P3	L3	9
Financial Risks								
8	Increase in land cost	X	X			P5	L3	15
9	Importing of equipment (Customs Act, 1962)	X	X	X		P5	L2	10
Stakeholders and Coordination Risks								
10	Unclear project requirements	X	X			P3	L2	6
11	Stakeholder conflicts are causing project delays	X	X			P3	L4	12
12	Contractual disputes due to unclear responsibilities		X			P2	L4	8
Project Commissioning								
13	Lack of standardized commissioning procedures		X			P3	L4	12
14	Delayed commissioning due to dependencies on others	X	X			P2	L4	8
Logistical and Supply Chain Risks								
15	Supply chain disruptions are impacting materials	X	X	X		P3	L4	12
16	Increased transportation costs due to fuel price volatility	X	X	X		P4	L2	8
17	Delays in customs clearance for imported materials	X	X	X		P4	L3	12
18	Limited availability of specific construction equipment	X	X	X		P2	L3	6
Technology and Infrastructure Risks								
19	Site security vulnerabilities impacting asset safety	X	X	X		P3	L3	9
20	Unstable power supply impacting operations	X	X			P3	L4	12
Health, Safety and Environmental Risks								
21	Potential fire hazards in material storage areas	X	X	X		P3	L5	15
22	Delays during the handling of heavy machinery	X	X	X		P2	L2	4
23	Environmental impact due to site selection	X	X	X		P2	L4	8

V. CONCLUSION

The risk management framework developed in this research offers a systematic and structured approach to assessing and quantifying risks during the pre-construction phase of data centre projects. By enabling clients to anticipate potential challenges effectively, it empowers them to make informed decisions that align with their strategic objectives. A core feature of the framework is its ability to analyse the occurrence and consequence levels of risks. Providing a range of probabilities and impacts for each identified risk equips stakeholders with the tools to evaluate whether continuing with a project aligns with their risk appetite. The findings underscore the importance of a robust pre-construction strategy, as risks such as equipment failure, design discrepancies, and adverse site conditions can significantly impact project timelines and success. There is a need for the adoption of new and innovative construction methodologies in the sector to introduce improvements for the delivery of this essential infrastructure [5]. Addressing these risks early in the project lifecycle improves schedule adherence and minimizes unforeseen costs and resource strain.

Geographically, Kerala presents unique risks, such as monsoons and flooding, which could impact data centre

development. However, advancements in resilient construction techniques and the state's established reputation for effective disaster management mitigate many of these challenges. These factors contribute to Kerala's viability as a location for critical infrastructure, demonstrating how informed planning and strategic mitigation can transform potential liabilities into manageable concerns. Furthermore, expanding the framework to encompass the construction and operational phases would ensure a comprehensive risk management strategy that addresses challenges throughout the data centre's entire lifecycle.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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Milan Denny is a detail-oriented professional with a background in architecture from NIT Calicut and a specialisation in Building Engineering and Management from SPA Vijayawada. He has trained at leading firms like Savills, gaining expertise in construction management and technical due diligence. His experience spans project planning, execution, and quality control in mid-rise and commercial developments. A keen observer and writer, he has also published articles on architectural discourse with *Rethinking The Future*. Passionate about efficiency and innovation in construction, Milan is committed to integrating design with practical implementation to create better-built environments.



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