Categories and Factors of Cost Overrun in Construction Projects: A Systematic Review

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ABSTRACT

Cost overruns represent a significant challenge in construction project management and often compromise project success. This study addresses gaps in previous research, particularly the lack of a unified classification of cost overrun factors. The aim is to provide a comprehensive, unbiased, and structured synthesis of existing research on the factors contributing to cost overruns in construction projects. It involves identifying, evaluating, and categorizing studies to answer predefined research questions related to cost overruns across various geographical contexts, project types, stakeholder perspectives, and project lifecycle phases. Through a Systematic Literature Review (SLR), the current study identifies and categorizes 99 factors into 10 distinct categories: 1) Execution, Resource, and Project Management Factors, 2) Design Factors, 3) Contractor Factors, 4) Consultant Factors, 5) Client Factors, 6) Financial Management Factors, 7) Bidding and Cost Estimation Factors 8) Contracts, Legal, and Regulatory Factors, 9) External Risks, Technology, and Sustainability Factors, and 10) Defects Liability Period (DLP) Operations and Maintenance Factors. Additionally, the present research examines both advanced and traditional methodologies for mitigating these overruns, emphasizing accurate cost estimation, risk management, and the use of advanced technologies, like Building Information Modeling (BIM), alongside strong financial and contract management. This paper synthesizes results from different global contexts to establish a solid foundation for future academic research and industry practices aimed at alleviating cost overruns in construction projects. It also promotes the development of customized frameworks that are specific to a country, a lifecycle phase, or a combination of conditions.

Keywords-cost overruns; construction management; stakeholder collaboration; project lifecycle; systematic literature review

I. INTRODUCTION

A construction project is defined by specific objectives, a set timeframe, and an allocated budget. Despite this seemingly straightforward concept, managing projects effectively throughout their lifecycle presents numerous challenges [1]. Historically, construction management focused primarily on design, materials, and construction methods. However, with the increasing complexity of modern projects, factors, such as stakeholder collaboration, resource management, risk planning, and financial integration have become vital [2]. In addition to these internal project complexities, evolving regulations, governance requirements, and client expectations for high-quality, sustainable, and timely outcomes further complicate project delivery. Although the traditional focus on time, cost, and quality remains central, new priorities, such as sustainability, health and safety, ethics, and digital integration, have emerged. Modern construction management must now adapt to these dynamics, employing advanced technologies and management techniques to meet these evolving demands [3]. One of the most significant challenges in modern construction management is controlling project costs. Despite advancements in management practices and technology, cost overruns remain a common and persistent issue across construction projects worldwide. These overruns can arise from various factors, including inaccurate initial estimates [4] and unforeseen complications during execution [5]. Identifying the key factors that contribute to cost overruns is critical for developing effective mitigation strategies [6].

A. Problem Definition

Cost overruns are a persistent challenge in construction management. The complexity of construction projects often leads to discrepancies between planned budgets and actual costs, resulting in delays and unexpected expenses. Over the past 70 years, the average cost overrun in construction projects has been about 28% [7]. While completing projects within budget is a primary goal, unforeseen cost overruns frequently impose financial strain and compromise project success [8]. A cost overrun occurs when a project's actual expenses exceed its initial budget, often due to unexpected circumstances [9]. In the construction industry, this issue is particularly common, with overruns ranging from 12% to 70% of the contract value [10]. Given the significant financial impact of these overruns, it is crucial to understand their root causes in order to develop effective mitigation strategies. Systematic research is essential to identify, categorize, and analyze the factors contributing to cost overruns, providing a foundation for more effective management practices and mitigation frameworks.

B. Literature Review

Existing research identifies several factors contributing to cost overruns, such as inaccurate cost estimation, project delays, and inefficiencies during execution [11]. These factors affect various phases of the project lifecycle, from initiation to execution, operation, and maintenance. Many studies have attempted to categorize these factors. For instance, authors in [12] classified 119 cost overrun factors in Jordanian construction projects into 11 categories [12], whereas another study in the UAE identified 83 factors but lacked a structured categorization system [13]. The inconsistent classification of these factors across studies complicates analysis and hinders the development of effective mitigation strategies, underscoring the need for a unified and standardized classification framework. Furthermore, many studies focus narrowly on specific aspects of cost overruns without considering broader contexts. For example, a research on UAE residential construction identified 12 cost overrun factors but did not address quality or design-related issues [14]. Other studies on high-rise buildings in India overlooked stakeholder perspectives [15]. Additionally, some research focused exclusively on the construction phase without specifying project types or locations, limiting the applicability of the findings across diverse construction settings [16]. Evidence also suggests that cost overrun factors differ between countries and types of construction projects [17]. To address these gaps, this research aims to develop a unified framework for categorizing the particular factors. By systematically reviewing the existing literature, the study seeks to standardize terminology and classifications, ensuring consistency for both research and practical applications. The final comprehensive analysis will consider project type, region, lifecycle phase, and stakeholder perspective, providing valuable insights for understanding and mitigating cost overruns.

II. RESEARCH METHODOLOGY

This study aims to build a conceptual foundation for future investigations of cost overruns from perspectives such as geographical regions, types of construction projects, lifecycle phases of construction, stakeholders' engagement, and tool and method evaluation. To achieve this, an SLR was conducted by integrating the Protocol, Search, Appraisal, Synthesis, Analysis, and Report (PSALSAR) steps [18] within the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [19]. This approach ensures a comprehensive and rigorous review process, enhancing the validity and reliability of the findings. Figure 1 presents the research methodology adopted in this study.

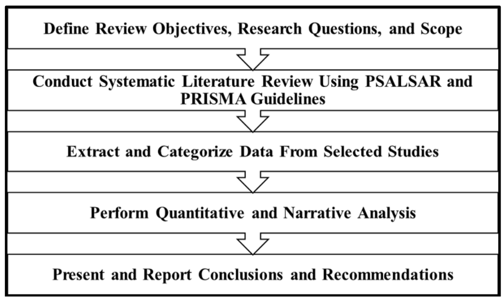

Fig. 1. Research methodology flowchart.

The initial stage involved delineating the research objectives, formulating the overarching research questions, and defining the scope. Following the identification process, a search strategy to identify and retrieve relevant literature, detailed in Section B, was developed. The authors conducted meticulous screening and selection of articles to ensure the quality and relevance of the selected studies. The PRISMA checklist was applied to guarantee transparency and reproducibility in the selection process. The inclusion criteria encompassed publication in peer-reviewed journals and relevance to construction cost overruns. Exclusion criteria were established to rule out studies that were not peer-reviewed, lacked relevance to the topic, or had insufficient methodological quality.

Relevant data were extracted from the selected studies, including study characteristics, methodologies, key findings, and identified factors contributing to cost overruns. The data were then sorted to establish connections and patterns. Subsequently, the extracted data were categorized according to various dimensions, such as the type of construction projects, geographical regions, stakeholder involvement, and lifecycle phases of construction projects. Thereafter, the quantitative, and narrative data analysis methods were performed. Quantitative analysis was conducted to categorize and describe the data, whereas narrative analysis was used to interpret and synthesize the findings, identify trends and gaps, and compare results across studies. Conclusions and recommendations were then derived from the findings. The final stage involved the systematic reporting of the study's findings, highlighting key findings and recommendations for practice and future research.

A. Research Questions

The current research aims to answer the following key questions:

1. Based on the literature, what are the primary categories and specific factors of cost overruns in construction projects?
2. What are the geographical and temporal trends in the literature on construction project cost overruns?
3. According to the literature, which types of construction projects are frequently subject to cost overruns?
4. According to the literature, which stakeholders frequently contribute to cost overruns in construction projects?
5. During which lifecycle phases of the construction projects are cost overruns most frequently discussed?
6. What are the primary research methodologies employed in studies focusing on cost overruns in construction projects?
7. What are the suggested mitigation strategies, action measures, and tools in the literature to address cost overruns in construction projects?
8. What gaps and limitations exist in the current studies on construction project cost overruns?

Table I outlines the research questions and their respective subsections. It highlights the subsection titles that provide detailed analysis and results, ensuring a clear connection between the research questions and their placement within the study.

TABLE I. MAPPING RESEARCH QUESTIONS TO RESEARCH OUTCOMES

Research Question No.	Corresponding Study Subsections
1	IV.A. Categories of Cost Overrun IV.B. Cost Overrun Factors
2	IV.C. Geographical Distribution
3	IV.D. Project Types
4	IV.E. Stakeholders Analysis
5	IV.F. Lifecycle Phases Analysis
6	IV.G. Factors Identification Techniques
7	IV.H. Mitigation Strategies
8	III.A. Examination of Earlier Papers

B. Research Strategy

The second stage of the research methodology involved a meticulous search that aligned with the research questions. ProQuest and Taylor and Francis Online were selected as the primary databases due to their relevance in construction management research, particularly for review papers addressing cost overruns in construction projects. Concurrently, the ScienceDirect database was employed to broaden the search, which encompasses scholarly journals, conference papers, proceedings, dissertations, and theses. The ProQuest database was utilized first to retrieve studies using a set of search parameters. Keywords such as "cost overrun" and "construction" were mandated to appear in the title of the studies. The temporal scope of the search was set from 2005 to 2023, with the inclusion criteria specifying full-text availability, English language, and source types limited to conference papers and proceedings, dissertations and theses, and scholarly journals. This search strategy yielded a total of 83 relevant studies. Further refinement of the search criteria to include the keyword "UAE" narrowed the results down to 21. A parallel search method was deployed in the Taylor and Francis Online database, adhering to the same criteria. This led to the identification of 18 relevant papers. Incorporating the keyword "UAE" reduced the count to five. Extending this advanced search methodology to the ScienceDirect database revealed 19 pertinent studies. However, the inclusion of "UAE" as a search term yielded no results, highlighting a potential research gap in this specific area.

The snowball sampling method was then utilized, in which the references from the initially identified articles were reviewed to find further relevant studies. This approach plays a crucial role in identifying seminal works and key studies in the field, which database-specific keyword searches may not capture. Initial search across various databases resulted in an extensive collection of 443 papers selected based on their title relevance to a comprehensive set of keywords and their synonyms, including "Cost," "Overrun," "Factors," "Construction," "UAE," "BIM," "Mitigation," "Building," "Life Cycle," "Design," "Bidding," "Execution," and "DLP."

The screening process, involving an initial skimming of titles and abstracts, led to the elimination of duplicates or papers irrelevant to the research scope. In addition, to ensure the highest standard of research quality, the search was confined to 11 databases: Academia.edu, ASCE Library, Emerald, Google Scholar, MDPI, ProQuest, ScienceDirect, Semantic Scholar, Springer Link, and Taylor and Francis Online. Studies not sourced from these databases were excluded. This refinement process reduced the selection to 144 papers. After reviewing the full texts, three studies were excluded because their research aims did not align with the primary focus of this research. Additionally, seven studies were excluded because they did not enumerate or discuss any factors related to cost overrun. Figure 2 summarizes the search strategy employed in this study.

The resultant 134 academic works included 12 review journal articles, 102 journal articles, 12 conference proceedings, two PhD theses, five MSc theses, and one diploma research. The 114 journal articles are distributed across 78 distinct journals. The five most frequently cited journals, demonstrating their prominence and significance in the realms of civil engineering and construction management, are: Buildings, cited nine times, International Journal of Construction Management, cited seven times, International Journal of Sustainable Construction Engineering and Technology, cited five times, Engineering, Construction, and Architectural Management, cited four times, and Construction Management and Economics, cited three times.

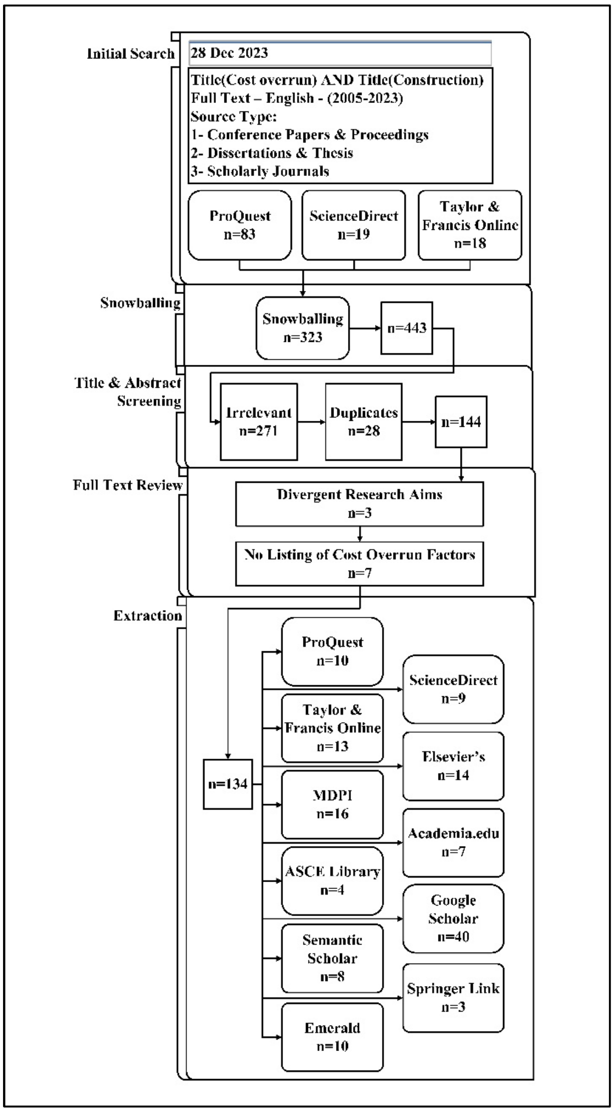

Fig. 2. PRISMA flowchart adopted as the search strategy of this study.

III. DATA ANALYSIS

The data for this analysis were gathered and organized into a structured database using Microsoft Excel. Key details were recorded, including the study title, author names, year of publication, primary objectives, and identified research gaps. Additionally, important aspects, such as the materials and methods used, geographical location, categorization of cost overrun factors, project lifecycle phases addressed, identification of responsible stakeholders, construction project type, and proposed mitigation strategies were systematically documented.

A. Examination of Earlier Papers

The initial phase of the analysis focused on earlier review papers, examining their methodologies to identify gaps in their review processes. This analysis is pivotal in establishing the necessity and direction of this paper. Table II details the distribution of these review papers.

TABLE II. PREVIOUS REVIEW PAPERS

Ref.	Database	Journal Name
[20]	Taylor and Francis Online	International Journal of Construction Management
[21]	MDPI	Infrastructures
[22]	ProQuest	Webology
[23]	Emerald	Engineering, Construction and Architectural Management
[24]	Google Scholar	Advance Researches in Civil Engineering
[25]	Google Scholar	International Journal of Sustainable Construction Engineering and Technology
[26]	Semantic Scholar	International Journal of New Innovations in Engineering and Technology
[27]	Academia.edu	International Research Journal of Engineering and Technology (IRJET)
[28]	Semantic Scholar	International Journal of Innovation, Management and Technology
[29]	Google Scholar	International Journal of Applied Engineering
[30]	Google Scholar	Journal of Civil Engineering Research
[31]	ProQuest	Australasian Journal of Construction Economics and Building

The comprehensive analysis of previous review papers reveals several gaps and areas where they may not fully align with the current research objectives. These gaps highlight the need for a more up-to-date, methodologically diverse, and practically oriented analysis of cost overrun factors and their mitigation strategies in construction management. The identified gaps are:

- Limited Database Scope: Studies, like [20], confined their literature search to only two databases, limiting the scope of their findings. The present research, with a broader database scope, aims to provide a more comprehensive understanding of cost overrun factors.
- Stakeholder Analysis: Previous studies lacked a thorough analysis of specific stakeholders predominantly contributing to cost overruns. The current research seeks to conduct a detailed examination of stakeholder roles and influences, crucial for understanding the dynamics of cost overrun scenarios.
- Phase-Specific Analysis: There is a need to explore how cost overruns manifest across different construction phases, such as design, bidding, or post-construction, which is vital for developing effective mitigation strategies.
- Diversity in Research Methodologies: Many reviews did not examine the research methodologies employed in the studies they reviewed. The current research intends to explore a wide array of methodologies, particularly those applicable to various types of construction projects.
- Mitigation Strategies: Studies, like [16, 17], did not extensively address mitigation strategies for cost overruns.

The present research aims to fill this gap by exploring specific mitigation strategies and tools.

- Global and Regional Trends: Some studies, such as [25], provided comparative analyses between developed and developing countries but did not emphasize the latest global and regional trends in construction management.
- Prioritization and Categorization of Factors: Research, like [19, 20], compiled extensive lists of cost overrun factors but did not prioritize or categorize these factors in terms of their impact, manageability, or frequency of occurrence.
- Innovative Approaches and Latest Trends: There is a gap in emphasizing the latest trends and methodologies in construction management, which is critical for understanding the current and future cost overrun dynamics.
- Context-Specific Analysis: Studies like [17], highlighted the need for context-specific analysis in construction management, considering the unique challenges in different geographical locations and project types.
- A Comprehensive Analysis of Delay Factors: A comprehensive analysis of delay factors and their mitigation strategies is necessary to complement studies on construction delays, such as [31].
- Practical Implications and Best Practices: There is a need for research that not only contributes to the academic literature, but also provides practical implications for improving project management practices, especially in developing targeted mitigation strategies, addressing specific challenges identified by stakeholders.

This research aims to fill in the gaps in the existing review literature and previous studies by looking at the causes of cost overruns and how to avoid them in a more thorough, up-to-date, and methodologically varied way.

B. *Categories and Factors of Cost Overruns*

Managing cost overruns in construction projects is a complex challenge. Although various studies have tried to identify and categorize the factors behind cost overruns, inconsistencies in classification have made it difficult to create a unified framework. This section highlights how different studies have categorized these elements, revealing the need for a standardized approach to better address cost overruns. For example, studies have classified "Shortage of Materials" differently, that is, as a "Non-Human Resource" [32], a "Material and Machinery Related Factor" [33], or a "Lack of Coordination" among contracting parties [34]. Similarly, some studies place "Unclear Details in Drawings" under "Design-Related Factors" [35], while others simply label it as "Incomplete Drawings and Specifications" without further categorization [36]. Through a comprehensive review of the literature, 4,424 distinct cost overrun factors were identified and distributed across 628 categories. Among the most significant studies, [27] identified 200 factors, while [37] identified 95 factors and grouped them into 20 categories. This observation highlights the inconsistent classifications and underscores the need for a more cohesive and structured framework to help address cost overruns effectively in future research and practical applications.

IV. RESEARCH OUTCOMES

This section explores various dimensions of cost overruns in construction projects, analyzing data from the literature through multiple lenses. It focuses on identifying key contributing factors and assessing trends across previous studies, including geographical distribution, project types, stakeholder involvement, lifecycle phases, and proposed mitigation strategies. By synthesizing this information, the research provides a comprehensive understanding of cost overruns while addressing gaps and uncovering patterns in earlier studies.

A. *Cost Overrun Categories*

Previous studies on cost overruns in construction projects often approached the issue from a limited perspective, for example, focusing on specific stakeholders, such as clients, contractors, or consultants, project lifecycle phases like design, execution, or operation, or areas within project management, such as risk or cost management, as outlined by the Project Management Institute (PMI). Although these approaches offer valuable insights, they fail to capture the full complexity of the factors contributing to cost overruns. These studies often overlook the interconnections between various aspects of construction management. Recognizing these limitations, this research presents a more comprehensive and multidimensional categorization addressing all critical aspects of construction project management. By integrating existing perspectives and introducing additional dimensions, such as environmental, social, sustainability, technology, and innovation factors, this approach provides a more holistic understanding of cost overrun factors.

To establish the final list of cost overrun factors and categories, a detailed review of the literature was undertaken. This process involved compiling relevant factors from various studies, grouping similar factors to avoid redundancies across categories, and performing multiple rounds of cross-checks and refinements. This effort resulted in the identification of 10 key categories that represent the diverse factors influencing cost overruns in construction projects. The primary categories identified are: 1) Execution, Resource, and Project Management Factors, 2) Design Factors, 3) Contractor Factors, 4) Consultant Factors, 5) Client Factors, 6) Financial Management Factors, 7) Bidding and Cost Estimation Factors, 8) Contracts, Legal, and Regulatory Factors, 9) External Risks, Technology, and Sustainability Factors, and 10) DLP Operations and Maintenance Factors. This refined classification system provides a structured foundation for analyzing the factors within each category. This categorization offers a clear and organized approach to understanding the diverse factors contributing to cost overruns in construction projects. By incorporating a wider range of perspectives, including modern dimensions, such as technology and sustainability, the framework provides a comprehensive perspective that overcomes the limitations of previous studies. Each of the 10 categories is essential for understanding the multifaceted nature of cost overruns.

1) Execution, Resource, and Project Management Factors

This category concentrates on the essential components of construction project management, guaranteeing optimal outcomes by aligning all aspects of execution, resource allocation, and project oversight, while emphasizing the need for a comprehensive approach for successful project completion. It integrates Project Management and Execution Factors, Resource Management, Procurement Management, and Communication and Information Management into a cohesive framework, ensuring that all aspects of project execution are well-coordinated and effectively managed.

Project Management and Execution Factors form the foundation of this category by focusing on the holistic management of construction projects. This includes planning, scheduling, execution, and addressing the psychological aspects of management. Effective leadership, strategic planning, and attention to team dynamics are essential, as they directly influence the overall performance and efficiency of construction projects. These elements are crucial for ensuring that the project remains aligned with its objectives, helping to prevent cost overruns and delay [38]. The need to manage timelines, address delays, ensure quality assurance, and handle challenges, such as poor planning and improper construction methods, further underscores the importance of these factors [3]. By establishing a strong foundation in project management, these factors lay the groundwork for successful project execution [39].

Building on this foundation, the factors of Resource Management, namely Manpower, Material, and Machinery, play a critical role in the efficient execution of construction projects. In order to minimize waste and maximize output, effective resource management optimizes the deployment and productivity of the aforementioned factors [40]. Manpower management necessitates not only strategic human resource allocation, but also a focus on workforce motivation and safety, which are critical for maintaining productivity and reducing the risk of delays [41]. Material management is substantial for ensuring timely procurement and efficient use of construction materials, which helps prevent shortages and logistical issues that could lead to cost overruns [42]. Maintaining equipment, ensuring its availability, and selecting the appropriate machinery for specific tasks are all critical for project efficiency [26]. These interdependent elements certify that the resources necessary for project success are available and effectively utilized.

Procurement management, which complements resource management, plays a crucial part in securing the external resources required for the project. This process focuses on obtaining goods, services, and work from external sources, with an emphasis on cost-effectiveness, quality, and timely delivery [43]. By strategically sourcing and selecting suppliers and subcontractors, procurement management ascertains that the project has access to the necessary materials and services required to meet project goals [44]. Effective procurement also involves managing the supply chain to prevent delays and cost overruns due to material shortages or logistical issues [45]. The importance of continuous monitoring and evaluation of suppliers and subcontractors further emphasizes the need for diligent procurement practices to avoid potential risks [46].

To tie all these elements together, Communication and Information Management plays a pivotal role in simplifying the flow of information and enhancing coordination among all stakeholders involved in the project [47]. Effective communication ensures that information is clear, accurate, and timely, reaching the appropriate parties to prevent misunderstandings and delays [48]. Information management, particularly in today's construction environment, often relies on digital tools, such as BIM, to integrate various types of project data into a shared digital space, supporting real-time collaboration [49]. Moreover, robust communication and information management systems are essential for effective risk management, enabling the proactive identification and resolution of potential issues that could impact project success [50]. Additionally, the prevalence of remote work arrangements highlights the need for reliable and efficient communication platforms, underscoring the importance of maintaining continuous and effective information flow [51].

2) Design and Technical Factors

This category encompasses the intricate and specialized aspects of engineering, architectural design, and the integration of various technical components. It focuses on the technical proficiency and design solutions essential for successful project execution. The technical complexities inherent in architectural and engineering design can often lead to challenges that impact project costs directly, underscoring the necessity for thorough planning and precision in this domain [52]. The initial design phase, which develops architectural and engineering plans, is a key aspect of this category. Since this phase sets the foundation for the entire project, errors or oversights during this stage can lead to costly modifications at a later stage. Moreover, the integration of various technical systems, such as electrical, plumbing, and HVAC, is a complex task that demands careful coordination and expert knowledge to ensure all systems function seamlessly together without necessitating expensive rework [53].

The significance of this category lies in its direct impact on the structural integrity, functionality, and aesthetic appeal of construction projects. It involves critical considerations, such as material selection, structural design, environmental sustainability, and adherence to building codes and standards. Each of these elements can have profound implications for the cost and execution of a project, with potential overruns often stemming from necessary adjustments or corrections that arise during the construction phase [54].

The role of technology, particularly BIM, is increasingly recognized in this category. BIM facilitates better design coordination, conflict detection, and project visualization, which can help reduce errors and subsequent cost overruns. BIM's capabilities allow for a more integrated approach to construction planning and management, proving essential in minimizing potential design-related issues that can affect project costs [21]. Value engineering, a systematic method to enhance project value through design reviews and optimization, guarantees the achievement of project objectives at the lowest possible cost without compromising quality or performance.

Technical and Design Factors are critical in determining the feasibility, safety, and success of construction projects. The focus of this category on technical intricacies and design excellence ensures that projects not only meet the desired specifications and functionality, but also adhere to budgetary constraints, thereby mitigating the risk of cost overruns. Factors, such as changes in specifications, ambiguous project designs, an incomplete design at the time of tender, inadequate review of drawings and other contract documents, and discrepancies between technical requirements and managerial expectations highlight the complexity of managing technical and design aspects in construction. Proper planning, effective communication, and the use of advanced technologies are vital to addressing these challenges and ensuring project success.

3) Contractor Factors

Contractor Factors in construction projects encompass the performance, expertise, and management capabilities of contractors, playing a pivotal role in the success and efficiency of construction projects. This category focuses on the selection and management of contractors, emphasizing the importance of their coordination and the impact of their performance on the overall project. The selection of competent contractors is crucial as it influences every aspect of project delivery, from resource allocation to the final execution and quality control [55]. The use of incompetent subcontractors can lead to significant delays and quality issues.

The effectiveness of contractors is measured not only by their technical expertise, but also by their capacity to manage resources effectively, adhere to schedules, and communicate efficiently with other stakeholders. Factors, such as the contractor track record, financial stability, and their capacity to handle the specific demands of a project, are key considerations [56]. For instance, failing to conduct a site visit during the bidding process can result in a lack of understanding of site conditions, leading to inadequate planning and unforeseen challenges during execution. Once selected, the management of contractors involves overseeing their work to ensure compliance with project specifications, timelines, and quality standards. Effective contractor management also includes fostering a collaborative environment where contractors, clients, and consultants work together toward common goals, which enhances project coherence and reduces misunderstandings and disputes [57].

The coordination aspect of contractor factors is crucial, especially in complex projects where multiple contractors may be involved. Coordinating their activities to avoid conflicts and ensure a seamless workflow is essential for maintaining project schedules and budgets. Moreover, the impact of contractor performance extends beyond the immediate scope of construction activities. It encompasses their ability to manage unforeseen challenges, respond to changes in project scope, and maintain safety standards. The contractor's performance directly affects project costs, timelines, and the overall quality of the finished construction [58]. Delays in providing shop drawings by contractors can slow down the project, as these drawings are necessary for the next steps in construction and fabrication processes. Addressing such issues can significantly reduce cost overruns in construction projects.

4) Consultant Factors

This category focuses on external advisors, their expertise, and the quality of their guidance, which is distinct from the direct management roles of contractors and project managers. Consultants in construction projects typically include architectural firms, engineering consultants, and specialized advisors. Their expertise is crucial in areas, such as design, compliance with regulations, sustainability, and project feasibility studies. One of the primary roles of the consultants is to provide expert advice that aids in making informed decisions. This includes offering alternative solutions, innovative approaches, and risk assessments. Consultants also play a vital role in bridging the gap between the client vision and the practical aspects of construction, ensuring that the project aligns with the client objectives while remaining feasible and compliant with regulations [59].

Consultants offer crucial support in areas, such as design optimization and compliance with local and international standards, which significantly affect the project's lifecycle and overall success [60]. For example, delays in providing design drawings or approving shop drawings by consultants can halt progress and cause scheduling conflicts, emphasizing the need for timely delivery of these documents and prompt approval processes. These professionals ensure that the project aligns with the latest industry standards and practices, which can prevent costly redesigns and modifications. Their strategic input is instrumental in steering projects toward efficiency and effectiveness, particularly in complex projects that require multifaceted expertise. Consultants' oversight of testing and acceptance criteria ensures that all project components meet the required standards before approving them for further stages. Not only does technical expertise measure the effectiveness of consultants, but also their ability to communicate effectively, coordinate with other stakeholders, and adapt to the evolving needs of the project. Their ability to foresee potential issues and provide proactive solutions can prevent costly mistakes and delays. The quality of consultancy can significantly impact the project's overall success, influencing aspects like design efficiency, cost-effectiveness, and regulatory compliance [61]. Furthermore, consultants are often responsible for quality control and assurance, ensuring that the project adheres to the highest standards of quality and safety. They also contribute to the project's sustainability by integrating environmentally friendly practices and materials [62]. Their support in ensuring that projects are well-designed, compliant, cost-effective, and sustainable plays a significant role in mitigating cost overruns and enhancing the overall quality of construction projects.

5) Client Factors

Client Factors in construction projects pertain to the influence of clients on the construction process, encompassing their decision-making processes, involvement, and requirements management. This category is crucial as clients are the driving force behind the project, and their actions and decisions have a significant impact on the project's direction, cost, and overall success [63]. Clients play a pivotal role from the project's inception. Their vision and requirements set the project’s objectives and scope. The clarity and stability of these requirements are essential, as frequent changes or unclear objectives can lead to scope creep, project delays, and cost overruns [64]. The client and the project team must effectively communicate requirements and expectations to ensure all parties align and the project goals are clear and attainable, which is crucial for its success.

The decision-making process relevant to the clients is another critical aspect. Timely and informed decisions are necessary to keep the project on track. Delays in decision-making can cause project delays, whereas hasty or uninformed decisions might lead to costly mistakes [65]. Client involvement in the project, through regular meetings and reviews, ensures that it aligns with their vision and expectations, which is crucial for maintaining momentum and avoiding unnecessary alterations that could derail progress.

Moreover, the financial aspect of the client factors is significant. The client's financial stability and promptness in funding and payments directly affect project cash flow and financial health. Delays or inconsistencies in payments can cause interruptions in the construction process and strain relationships with contractors and suppliers [66]. Clients also play a part in risk management, as their understanding and acceptance of project risks can influence project risk mitigation strategies [67]. Their willingness to engage in risk-sharing mechanisms can be crucial, especially in complex projects [68]. Proper risk management and contingency planning by the client can help reduce unforeseen issues that might arise during the construction phase.

6) Financial Management Factors

Financial Management Factors in construction projects cover the financial aspects, namely budgeting, cash flow management, and overall financial planning. This category is crucial for understanding how financial oversight and strategies impact the economic success of a project. It is distinct from cost estimation, which focuses more on predicting costs, as financial management involves the ongoing process of managing and allocating financial resources throughout the project lifecycle [37]. Factors, such as project administration cost increases, which often stem from changes in the project scope, management inefficiencies, or unexpected demands, are crucial considerations in financial management.

Financial planning involves a strategic approach to the project finances, encompassing risk management, investment decisions, and the securing of funding. It includes the assessment of financial risks and the implementation of strategies to alleviate these risks. Financial planning also involves certifying that the project delivers value for money and achieves its expected financial returns [69]. The opportunity costs, associated with choosing one investment or action over another, emphasize the need for strategic financial decisions to optimize resource allocation and manage potential financial implications.

Managing the financial aspects of construction projects is essential for reducing financial risks and ensuring that projects stay within budget, highlighting the need for accurate budgeting and proactive financial planning [45]. Effective financial management in construction projects starts with the development of a comprehensive and realistic budget. This budget must account for all potential expenses, including materials, labor, equipment, and contingency funds for unforeseen costs. The accuracy and thoroughness of this initial budget are critical for project financial health [38].

Cash flow management is another key aspect of this category. Construction projects typically involve large expenditures over a prolonged period and managing the inflow and outflow of funds is essential to maintaining financial stability. This includes timely invoicing, efficient payment processing, and the strategic timing of expenditures. Poor cash flow management can lead to project delays, halted work, or even project abandonment [70]. The factor of "Delayed Salary Payments to Staff by the Contractor" also falls under this category, as it affects the overall cash flow and morale of the workforce.

Financial management in construction also includes the monitoring and controlling of costs throughout the project. This involves regular financial reporting, reviewing expenditures against the budget, and taking corrective actions when necessary. Effective financial control helps to avoid cost overruns and ensures that the project remains financially viable, whereas a lack of proper cost management can lead to unanticipated expenses and budgetary issues, such as increasing resource costs. These rising costs need to be anticipated and managed within the project budget. Additionally, managers' lack of cost awareness can further exacerbate financial mismanagement, leading to uncontrolled expenses and inefficiencies.

The risk of insolvency is another substantial factor under financial management, relating to the financial stability and the ability of stakeholders to fulfill their financial obligations. This risk can lead to severe cost overruns if not managed properly. Similarly, statutory charges, such as those for planning and building permits, and insurance costs, including health insurance, are entailed in this category because they are essential financial expenses required for legal compliance and risk management.

7) Bidding and Cost Estimation Factors

In construction projects, the Bidding and Cost Estimation Factors category concentrates on the crucial early stages of project initiation, which establish the foundation for project financial success. This category encompasses the preparation of bid documents, the evaluation and selection of contractors, and the meticulous process of cost estimation, all of which are essential for setting a solid foundation for project execution.

The bidding process begins with the preparation of bid documents that detail the project specifications, scope of work, timelines, and terms and conditions. These documents should be carefully prepared to avoid misunderstandings, disputes, or cost overruns later in the project [71]. Moreover, the development of a fair and transparent bidding process is crucial. This process involves setting objective criteria for evaluating bids and ensuring a level playing field for all participants. The criteria may include price, contractor experience, project approach, technical capabilities, and past performance, which in combination enhance the credibility of the project and help in selecting the most suitable contractor [15]. The selection of contractors or suppliers marks the end of the bidding process. This decision is based on a comprehensive evaluation of all bids, considering the price, quality, reliability, and suitability of each bidder for the project. The selection process must be objective, transparent, and well-documented to ensure fairness and accountability throughout the project lifecycle [15].

The integration of Cost Estimation Factors within the bidding phase is equally important to accurate cost estimation for setting realistic budgets and evaluating bids. Cost estimation involves predicting the total costs of the project, including materials, labor, equipment, and overheads, thereby setting the financial foundation for the project. The accuracy of these estimates influences the evaluation of bids and helps identify any discrepancies between the selected bid and the consultant estimate, ensuring alignment and accuracy in project budgeting [72].

Cost Estimation Factors extend beyond the bidding phase, serving as a fundamental process that continues to influence project overall success. Accurate cost estimation is crucial for predicting the total expenses required to complete the project, including direct costs, such as materials and labor, as well as indirect costs, like administrative fees, overhead, and contingency funds. Underestimating costs can lead to budget shortfalls, whereas overestimating can affect project feasibility and competitiveness. The complexity of the project and the available information determine the cost estimation methodology, whether parametric, analogical, bottom-up, or based on historical data. People are increasingly using advanced methods like BIM to achieve more accurate and detailed cost estimations [73].

Additionally, it is crucial to consider risk and uncertainty in cost estimations. This involves identifying potential cost overrun factors and incorporating them into the estimate, either as contingencies or through probabilistic risk analysis. Managing these uncertainties effectively is crucial for creating a realistic and resilient budget [74]. Furthermore, the accuracy of early information and the continuous refinement of estimates as the project progresses are essential for maintaining the relevance and reliability of the project's financial planning [75].

8) Contracts, Legal and Regulatory Factors

Contracts, Legal, and Regulatory Factors involve understanding and complying with the legal standards and regulations that govern the construction industry. This category covers the legal framework within which construction projects operate as distinguished from the more practical aspects of project execution. It encompasses the legal considerations, contractual obligations, and regulatory compliance issues that are essential for the lawful and ethical completion of construction projects [76]. Factors, such as variations in construction projects and delays in the approval of design changes, fall under this category, as they involve contractual and regulatory processes that impact project timelines and costs. Understanding and navigating the legal landscape is crucial for construction projects. This includes being aware of and adhering to local, regional, and national building codes and standards, environmental regulations, labor laws, and safety standards. Non-compliance with these regulations can result in legal disputes, fines, and project delays, impacting the project's cost and reputation [77]. Issues, such as health and safety regulations, difficulties in obtaining work permits, and corruption among client representatives, are also significant considerations in this category.

Contract management is a key aspect of this category. Contracts in construction define the scope of work, roles and responsibilities, payment terms, and procedures for handling changes and disputes. Effective contract management ensures that all parties involved in the project understand their contractual obligations and rights. It also involves ensuring that contracts are fair, clear, and enforceable and that they adequately protect the interests of all parties involved [78]. Factors related to ambiguous contract terms, conflicts, disputes, and contractual claims are integral to effective contract management.

Another important element is the management of legal risks. This involves identifying potential legal issues that could arise during the course of the project and implementing strategies to mitigate these risks [79]. Legal risk management is essential to prevent disputes and litigation, which can be costly and time-consuming [80]. The approval process for design drawings, which often involves both clients and regulatory authorities, is a critical aspect of legal risk management. Regulatory compliance is also a substantial component. Construction projects must comply with a wide range of regulations, including zoning laws, environmental protection standards, and workplace safety regulations. Staying informed about relevant laws and regulations and ensuring compliance is essential for the smooth execution of the project [81]. Inadequate contract duration and delays in approval of design changes highlight the need for rigorous regulatory compliance and effective communication between project stakeholders.

9) External Risks, Technology and Sustainability Factors

The External Risks, Technology and Sustainability Factors category encompasses the critical external influences and technological advancements that significantly impact the success, efficiency, and sustainability of construction projects. This category highlights the intersection between external risks, such as environmental, political, and market factors, and the adoption of cutting-edge technologies and innovative practices that drive project success.

External Factors and Risks represent a broad range of elements that lie outside the direct control of the project team but have a profound impact on the project's schedule, financial plan, and overall success. Environmental risks, including natural disasters, such as floods, earthquakes, and severe weather conditions, can cause unexpected delays and damage, necessitating contingency plans and adaptive construction methods. Additionally, the geographical and environmental conditions of a site, namely soil quality, groundwater levels, and topography, can influence construction activities and lead to additional resources or changes in design [82].

Market conditions are another significant external factor. Fluctuations in material prices, changes in labor availability, and broader economic trends can all impact project costs and timelines. For example, a sudden increase in steel prices due to market dynamics can significantly raise construction costs, affecting project financial viability [83]. Moreover, dependency on imported materials and the fluctuation of resource prices introduce financial uncertainty, complicating project planning.

Political and regulatory factors also play a crucial part in shaping project outcomes. Changes in government policies, building codes, and regulatory requirements can lead to project delays or additional costs. For instance, new environmental regulations may necessitate changes in construction practices or materials, impacting both the budget and schedule [84]. Additionally, external organizational changes, such as slow responses from utility agencies or changes in project partners can disrupt project stability and continuity.

Labor strikes and other social disruptions represent another critical dimension of external risks. These disruptions directly affect manpower availability and productivity, leading to delays and increased costs. Work stoppages due to disputes or legal challenges can also halt progress, further complicating project timelines and budgets. Ethical concerns, such as bribery, corruption, and fraudulent practices can result in increased costs, project delays, and legal complications. Moreover, theft and vandalism on construction sites cause material losses, increased security costs, and potential project delays. Inaccurate site investigations further exacerbate these risks by leading to unforeseen conditions, like soil issues or environmental hazards that disrupt the construction process and escalate costs.

Technology and Innovation Factors are increasingly important in addressing some of these external risks and enhancing the overall productivity and sustainability of construction projects. The implementation of new technologies, ranging from advanced design and project management software, like BIM, to modern construction techniques, such as modular or prefabricated construction, offers numerous benefits. These technologies improve design accuracy and enhance stakeholder collaboration [85]. Furthermore, they streamline project management and reduce waste, contributing to more efficient construction processes [86].

Innovation in construction also involves the use of new materials and building techniques that offer better performance, sustainability, or cost-effectiveness. For instance, green building materials, energy-efficient systems, and smart building technologies contribute to creating more sustainable and livable environments [87]. The integration of digital tools and automation, such as drones for site surveying, artificial intelligence for project planning, and robotics in construction tasks, further enhances safety, precision, and productivity [88].

Despite the benefits, implementing new technologies and innovations also presents challenges. These include the need for skilled personnel, investment in new tools and training, and the management of change in established processes [89]. Moreover, the risk of technical obsolescence must be managed to ensure that the adopted technologies remain relevant and effective over time. Overcoming these challenges is essential for the successful integration of technology and innovation, which are critical for improving efficiency, quality, and sustainability in construction projects.

10) Operation and Maintenance During DLP Factors

This category concentrates on rectifying any arising defects during the post-construction phase. It is unique in its concentration on quality assurance and maintenance responsibilities after project completion, setting it apart from the construction and planning phases. The DLP is a critical time when contractors are responsible for addressing any issues that emerge in the completed construction project, ensuring that all aspects of the work meet the agreed-upon standards and specifications [90]. Typically, the DLP commences immediately upon the completion of the construction project and its transfer to the client. The duration of this period is usually defined in the contract and can vary depending on the project's size and complexity. The contractor must rectify any defects, shrinkages, or other faults in the work during this time, at their own cost. The focus is on ensuring that the building or infrastructure performs as intended and meets the quality standards set forth in the contract [91].

Effective management during the DLP involves systematic inspection and identification of defects, timely response to maintenance requests, and efficient rectification of any issues. This demands excellent communication between the client, contractors, and maintenance teams. Contractors must also handle these responsibilities with a well-organized approach, which includes a clear process for reporting issues, deploying maintenance teams, and ensuring repairs meet the required standards [92]. Another aspect of this category is the documentation and tracking of maintenance and repair work during the DLP. This ensures transparency and accountability, providing a record of the actions taken to address any defects. It also serves as a valuable resource for future maintenance work and can inform best practices in future projects [92].

B. Cost Overrun Factors

The undertaken extensive review initially identified a total of 4,424 factors pertinent to construction project management. These factors were meticulously analyzed, and instances of duplication were systematically excluded to ensure the uniqueness and relevance of each factor considered. Additionally, factors that were semantically similar or had overlapping meanings were consolidated to prevent redundancy. Subsequently, each factor underwent rigorous examination to determine whether it had been categorized by previous studies. This involved scrutinizing the categorization practices across various studies to identify inconsistencies in how similar factors were classified. It was observed that different studies often categorized similar factors under different headings, as previously noted.

After comprehensive analysis and careful consideration, the original list was narrowed down to 99 unique factors. These factors were then classified into 10 distinct categories, ensuring coherent and systematic organization. Figure 3 shows the number of factors listed under each category. For further reference, a comprehensive list of these categorized cost overrun factors can be found in the Appendix at the end of the paper. This refined categorization aims to enhance the clarity and applicability of the factors in addressing cost overruns in construction projects, thereby contributing to a more robust and unified framework in the field.

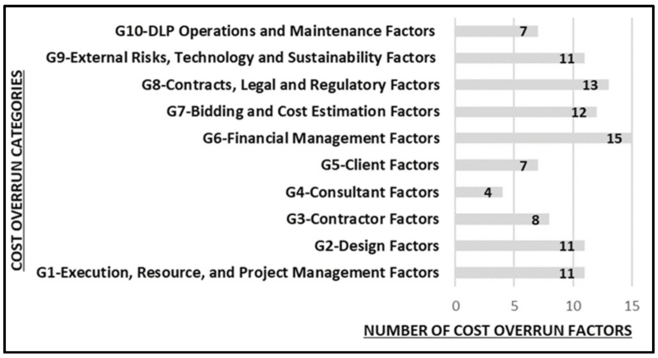

Fig. 3. Number of cost overrun factors under their categories.

C. Geographical Distribution

Previous studies have revealed a diverse geographical distribution of research on construction project management. Table III prominently features countries, like Malaysia, the UAE, Nigeria, and Iran, indicating significant research activity in these regions. These geographical spreads highlight a keen academic interest in understanding and addressing construction management issues across various economic and developmental contexts. Other regions also exhibit substantial scholarly attention, contributing to the global understanding of construction management practices. It is worth noting that 27 studies did not specify any country, suggesting a global perspective or a focus on generalized theories and models applicable across different contexts.

TABLE III. FREQUENCY OF COUNTRIES MENTIONED IN PREVIOUS STUDIES

Country	Mentioned
Malaysia	15
United Arab Emirates	13
Nigeria	11
Iran	10
Egypt - India	7
Australia – Ghana - Trinidad and Tobago	5
Indonesia - Saudi Arabia	4
Italy - Jordan - Norway - Oman - Qatar	3
China - South Korea - Sweden - Taiwan - Turkey	2
Bahrain - Canada - Chile - Colombia - Ethiopia - Hong Kong - Lebanon - Libya - Mauritania - Poland - Rwanda - UK - USA - Vietnam	1

The review of cost overruns in these countries reveals a variety of challenges and strategies for managing project costs. For instance, research in Malaysia and the UAE often emphasizes the integration of advanced technologies and management practices to decrease cost overruns, reflecting their rapid infrastructural development [84]. Studies in Nigeria and Iran emphasize the impact of political, economic, and regulatory factors on project costs, illustrating the complexities faced in these environments [93]. Research in India, as noted in [15], frequently addresses issues related to resource management and project delays, whereas studies in Egypt, as observed in [94], focus on historical data and the evolution of construction practices. This underscores the critical need for tailored strategies to manage construction costs effectively, considering the unique challenges and conditions of each region.

D. Project Types

The literature highlights those various types of construction projects that experience cost overruns in distinct ways, as outlined in Table IV. For example, building projects, such as residential developments, high-rise buildings, and public housing, are often prone to cost increases due to factors like design changes, unexpected site conditions, and delays in obtaining approvals [41]. Infrastructure projects, including roads, highways, and transportation systems, tend to face cost overruns caused by logistical challenges, environmental considerations, and the complexity of coordinating multiple stakeholders [93]. Large-scale public and mega construction projects, such as sporting facilities and public infrastructure, frequently encounter cost overruns due to their size, heightened public scrutiny, and the need to comply with stringent regulatory standards [94]. These findings underscore the importance of adopting tailored cost management strategies that account for the unique challenges of each project type, offering valuable guidance for industry professionals and policymakers seeking to improve financial outcomes in the construction sector.

TABLE IV. TYPE OF CONSTRUCTION PROJECT AS PREVIOUS STUDIES FOCUS

Type of Construction Project	Mentioned
Construction Projects	90
Public Projects	8
Public Projects (Buildings and Roads)	1
Buildings	8
Buildings (Residential)	7
Buildings (Public Sector Housing)	5
Buildings (High-rise)	4
Buildings [(Educational) - (Green and Conventional) - (Hospitals) - (Industrial)]	1 (Each)
Design and Build Projects	1
Infrastructure	5
Infrastructure (Roads)	5
Infrastructure (Transportation)	3
Infrastructure (Highway)	2
Infrastructure [(Mega-Transport)- (Rails)]	1 (Each)
Mega Construction Projects	3
Mega Construction Projects (Sporting Facilities)	1
Irrigation Projects	1

E. Stakeholders Analysis

Previous research on cost overruns in construction projects has frequently stressed the critical roles played by various stakeholders, particularly clients, consultants, and contractors. These stakeholders are integral to the planning, execution, and completion phases of construction projects, and their decisions and actions significantly influence project outcomes.

Contractors are the most frequently mentioned stakeholders, with 64 mentions, underscoring their direct involvement in day-to-day operations and their pivotal role in managing on-site activities, according to the analysis. The analysis prominently features consultants, such as project managers, designers, and engineers, with 61 mentions, highlighting their crucial role in project planning, design accuracy, and oversight. Clients, with 55 mentions, are essential for providing project funding, setting objectives, and making important decisions that impact the project's direction and scope. 21 mentions emphasize the influence of other stakeholders, including governmental authorities and decision-makers, on regulatory compliance and policy-related aspects of construction projects.

Recognizing the importance of stakeholder involvement in the study of cost overruns, the proposed new category framework places a dedicated emphasis on each of the three primary stakeholders: consultants, clients, and contractors. By creating separate categories for these key groups, the framework aims to provide a more detailed and structured analysis of how each stakeholder group contributes to and can reduce cost overruns. This approach not only recognizes the unique roles and responsibilities of each stakeholder, but also aids in pinpointing specific areas for improvement to boost project efficiency and financial performance. Table V compiles the frequency of mentions of each stakeholder group in the reviewed studies.

TABLE V. STAKEHOLDER GROUPS MENTIONED IN PREVIOUS STUDIES

Stakeholder Group	Mentioned
Contractors	64
Consultants (Including Project Managers, Designers, Engineers)	61
Clients	55
Not Specified	38
Others (Governmental Authorities, Suppliers, Decision-Makers, Planners, Bankers, etc.)	21

F. *Lifecycle Phase Analysis*

Table VI highlights the varying focus of previous studies across different phases of the project's lifecycle. Studies have referenced multiple lifecycle phases, sometimes using different terminology depending on the type of contract, for instance, Design-Bid-Build, regional practices, or project type. In some cases, studies combine phases based on organizational structures or stakeholder roles. For example, the pre-construction phase often includes both the planning and design stages, reflecting the integrated management approach to these early stages. The "Not Specified" category, which appears most frequently, suggests that many studies either address broad concepts relevant to all phases or do not specify a particular phase. Meanwhile, studies covering the "Full Lifecycle" and "Various Phases" demonstrate a more holistic approach, analyzing cost overruns throughout the entire project lifecycle. The literature prominently features key phases like the "Construction Phase" and "Pre-Construction Phase" due to their significant impact on cost management. Less frequently mentioned phases, such as the "Bidding Phase" and the "Initiation and Planning Phases," are still crucial in laying the groundwork for effective cost control. Future research should prioritize the bidding phase and the DLP to develop comprehensive strategies for managing cost overruns, given their limited attention.

These findings emphasize the importance of addressing cost overruns at each stage of the project's lifecycle to improve overall project success.

TABLE VI. LIFECYCLE PHASES MENTIONED IN PREVIOUS STUDIES

Lifecycle Phase	Mentioned
Not Specified	68
Various Phases (Including Multiple Phases, Planning, Design, and Execution Phases)	24
Construction Phase (Including Construction and Decoration Stages)	15
Pre-Construction Phase (Including Pre-Design, Planning, Pre-Construction and Construction Phases)	15
Full Lifecycle	10
Design Phase	7
Planning and Execution Phases	2
Front-End Phase (Including Significant Uncertainty and Multiple Government Levels)	2
Project Design and Engineering Cost Estimation, Contractor Selection, Project Execution, and Closeout	2
Bidding Phase	1
Design, Construction, and Operation Phases (DBB Process)	1
Initiation and Planning Phases	1
Pre-Study Phase, Pre-Project Phase, and Requirement for QA1 at the Earliest Stage of Project Development	1
Planning/Design Risks, Discrepancy Risks, Risks of Increased Production Costs, Inaccurate Cost Assessment	1

G. *Factor Identification Techniques*

Studies on cost overruns in construction projects have utilized a wide variety of research methods to uncover the underlying causes and contributing factors. One of the most used approaches is a mixed-method design, which combines quantitative surveys with qualitative interviews to offer a well-rounded analysis [28]. This method enables researchers to collect detailed insights from different stakeholders, including project managers, contractors, and consultants, providing a broader understanding of the issues. Quantitative surveys, often utilizing Likert-scale questionnaires and factor analysis, are popular for gathering data from large samples. This approach facilitates statistical analysis and helps identify trends and patterns related to cost overruns. Furthermore, comprehensive literature reviews are frequently conducted to synthesize existing knowledge, identify research gaps, and form the basis for future empirical studies and theoretical frameworks.

In recent years, researchers have employed more advanced techniques, such as Machine Learning (ML) models [95], data mining [96], and fuzzy inference models [97], to predict cost overruns, and analyze complex datasets. For instance, researchers have applied real-time Hidden Markov Models (HMM) and Dynamic Bayesian Networks (DBN) in their analysis [98], and have also combined Knowledge Discovery (KD) with data mining techniques [96]. Artificial Neural

Networks (ANN) are another valuable tool, particularly for improving the accuracy of cost predictions [99].

Other methodologies include the Delphi technique [100], exploratory factor analysis [101], and multi-attribute decision-making analysis [102]. For instance, some studies [22, 99] deployed the Delphi method to build consensus on the factors contributing to cost overruns. The application of fuzzy logic systems is another innovative methodology, as demonstrated in [104]. For instance, researchers have applied the Mamdani model as a fuzzy inference system in various cases [105]. The use of software tools, like Power BI, Excel, and SPSS, along with structured multi-stage research designs, enhances the robustness and reliability of findings. These diverse methodologies highlight the complexity of cost overruns in construction projects and emphasize the need for a multifaceted approach to effectively address and mitigate these challenges.

H. Mitigation Strategies

Mitigation strategies for construction project cost overruns, emphasize a multifaceted approach involving detailed planning, proactive management, and the use of technological tools [6]. A fundamental aspect of developing effective mitigation strategies is the thorough identification of cost overrun factors, which requires extensive study and analysis. Accurate identification of these factors paves the way for the development and implementation of targeted mitigation measures [106].

The literature highlights the development of detailed budgets and the use of accurate cost estimation methods as primary strategies to account for all potential expenses from the outset [107]. This includes regular progress monitoring and the implementation of change management processes to handle unexpected changes and keep projects on track. Effective communication among stakeholders and the use of advanced technology, such as BIM, are crucial for enhancing coordination, reducing errors, and improving overall project outcomes [48]. These tools help visualize potential issues early and allow for timely interventions [73].

Risk management is another critical area of focus in mitigating cost overruns. The literature emphasizes the early identification and assessment of potential risks through methods, such as the Delphi technique, sensitivity analysis, and predictive models, like HMM or DBN [68]. These approaches enable project managers to foresee potential challenges and develop strategies to address them before they escalate into significant cost overruns. Effective risk management entails not only identifying and analyzing risks but also implementing contingency plans and maintaining a risk register to monitor and control them throughout the project lifecycle [37].

Financial management and resource allocation are also essential components of reducing cost overruns. Frequently suggested strategies include ensuring timely payments from clients to contractors, maintaining financial stability, and implementing robust financial planning and control measures. Additionally, strategic labor management, which entails employing skilled workers and providing continuous training, is emphasized to enhance productivity and efficiency. Effective contract management, involving clear project goals, objectives, and flexible contract terms, is also crucial for adapting to changing project requirements without significant cost implications.

The choice of mitigation methodology, whether advanced or classic, plays a significant role in the effectiveness of these strategies. Advanced methodologies involve the integration of predictive models and real-time data analysis to forecast potential cost overruns and take corrective actions proactively. These include using support vector machine techniques, Bayesian network models, and other data-driven approaches to identify and manage risks dynamically. On the other hand, classic methodologies focus on monitoring and controlling each cost overrun factor individually, employing traditional project management tools and techniques. This involves rigorous planning, regular progress reviews, and employing best practices in project management to ensure that all aspects of the project are under control. The choice between advanced and classic mitigation methodologies will depend on the specific project context and the availability of resources.

V. CONCLUSION

The findings from this study highlight the critical need for a holistic and integrated approach to managing cost overruns in construction projects. The synthesis and categorization of 99 cost overrun factors into 10 distinct categories provides a comprehensive framework that allows stakeholders to systematically address the complex and interconnected causes of cost overruns. These categories cover essential areas, such as project management, technical and design factors, contractor and consultant performance, client involvement, financial management, cost estimation, and external risks.

The study also reveals that cost overruns are a global issue, with region-specific challenges that underscore the importance of localized strategies. Different regions experience unique patterns of cost overruns influenced by factors, such as economic conditions, regulatory frameworks, and cultural practices. The analysis emphasizes the significant roles played by contractors, consultants, and clients, each of whom influences different aspects of project execution and financial management. Contractors, with their hands-on role in daily operations, have a direct impact on cost control and operational efficiency. Consultants offer crucial supervision and guarantee the fulfillment of design and technical specifications. Clients, who drive project objectives and funding, play a crucial role in maintaining financial discipline and ensuring projects stay within budget.

The diversity of cost overrun patterns across different project types and phases of the project lifecycle calls for tailored strategies. For example, building, infrastructure, and mega-construction projects face unique challenges, requiring specific management approaches. Similarly, cost control strategies need to be adapted to different phases of the project lifecycle, from design and bidding through construction and post-completion.

Addressing cost overruns effectively requires a balanced integration of both advanced and traditional methodologies. Emerging technologies, such as Machine Learning (ML), data mining, and predictive analytics, offer valuable tools for proactive risk management and precise cost estimation. These advanced techniques allow project managers to anticipate potential cost overruns and take corrective actions in real time. Additionally, project managers frequently highlight BIM as a key tool for improving coordination, minimizing errors, and enhancing project outcomes. On the other hand, classic approaches like detailed planning, continuous monitoring, and efficient resource management remain essential. This involves accurate budgeting, optimal use of manpower, materials, and machinery, and ensuring clear and consistent communication among all stakeholders. Strong financial management, involving precise cost estimation and effective cash flow management, is critical to preventing budget overruns and ensuring timely project delivery.

VI. RECOMMENDATIONS FOR FUTURE RESEARCH

Future research should prioritize identifying cost overrun factors specific to different regions, countries, and building types. A localized approach will yield more precise insights, enabling the development of tailored strategies that address the unique challenges faced in various geographic and project contexts. For example, the factors driving cost overruns in high-rise residential buildings in densely populated urban areas may differ greatly from those affecting large-scale infrastructure projects in rural regions. By focusing on these specific contexts, researchers can formulate more effective and targeted mitigation strategies.

In addition, future studies should explore advanced methodologies for mitigating cost overruns, particularly using emerging technologies. Leveraging tools, such as ML, data analytics, and artificial intelligence, can help predict cost overruns and allow project managers to take proactive steps to prevent them. The integration of these technologies with BIM could further improve project planning, coordination, and execution, leading to more efficient cost control. Furthermore, exploring blockchain technology for secure and transparent contract management and payment processes presents a promising avenue for reducing financial risks and building trust among stakeholders.

APPENDIX

DETAILED LIST OF CATEGORIZED COST OVERRUN FACTORS

Factor Code	Description
G1	**Execution, Resource, and Project Management Factors**
G1.1.1	Inadequate risk management
G1.2.2	Ambiguous project scope and frequent changes
G1.3.3	Improper planning, scheduling, and delays
G1.4.4	Project management challenges in leadership, experience, and decision-making
G1.5.5	Improper construction methods or techniques
G1.6.6	Inadequate monitoring and control
G1.7.7	Inadequate quality assurance, control, and conformance management
G1.8.8	Challenges in site access and services cost, project scale, and managing multiple projects
G1.9.9	Inadequate resource management (manpower, material, and machinery)
G1.10.10	Poor procurement management and supplier issues
G1.11.11	Inadequate management of communication, coordination, and verbal instructions
G2	**Design Factors**
G2.1.12	Inadequate design process management and review
G2.2.13	Discrepancies between technical and managerial requirements
G2.3.14	Absence of contractor's involvement in the design stage.
G2.4.15	Ambiguities and mistakes in specifications and drawings
G2.5.16	Complexity and buildability of project design
G2.6.17	Design delays
G2.7.18	Incomplete design at the time of tender
G2.8.19	Insufficient data collection and survey before design
G2.9.20	Inadequate resources and experience in design development
G2.10.21	Lack of accuracy in geotechnical studies
G2.11.22	Value engineering
G3	**Contractor Factors**
G3.1.23	Subcontractor selection and competence issues
G3.2.24	Contractor not reviewing the design and making observations
G3.3.25	Contractor's work overload
G3.4.26	Delay in preparation of shop drawings and materials samples
G3.5.27	Contractor inexperience and performance deficiencies
G3.6.28	Poor managerial structure of construction companies
G3.7.29	The contractor does not carry out a field visit to the site during the bidding process
G3.8.30	The contractor's failure to observe HSE
G4	**Consultant Factors**
G4.1.31	Consultant delays in inspections, and approvals
G4.2.32	Consultant's rejection of submittals (shop drawings, equipment, and material samples)
G4.3.33	Inadequate consultant management and supervision
G4.4.34	Inflexibility (rigidity) of consultant
G5	**Client Factors**
G5.1.35	Change in specifications by the owner
G5.2.36	Delay to handover the site to the contractor
G5.3.37	Owner interference
G5.4.38	Poor definitions of requirement
G5.5.39	Slow decision-making and failure in required contractual actions by the client
G5.6.40	Unrealistic client expectations and timelines
G5.7.41	Work suspension by owner
G6	**Financial Management Factors**
G6.1.42	Over time work hours of supervising engineer are paid by the contractor.
G6.2.43	Delayed salary payments to staff by the contractor.
G6.3.44	Inadequate financial planning and overcommitment to inefficient strategies
G6.4.45	Impact of economic conditions and market changes
G6.5.46	Improper project forecasting and feasibility study
G6.6.47	Insurance cost
G6.7.48	Lack of sub-contractor capabilities in financial matters
G6.8.49	Negotiation and administrative costs: Costs for handling variations, claims, change orders.
G6.9.50	Owner liabilities, fund shortages, and payment delays
G6.10.51	Remeasurement of provisional sum
G6.11.52	Rework and its financial consequences
G6.12.53	Some tendering manoeuvres by contractors, such as front-loading of rates.
G6.13.54	Unavailability of incentives for contractor for finishing ahead of schedule or to reduce the cost.
G6.14.55	Statutory charges: Costs for planning and building permits.
G6.15.56	The increase of indirect costs due to extended contract duration
G7	**Bidding and Cost Estimation Factors**
G7.1.57	Inaccurate estimation and quantity take-off
G7.2.58	Discrepancies and poor bidding documents
G7.3.59	Insufficient bidding time for estimation and clarification
G7.4.60	Inadequate data and estimation methods
G7.5.61	Lack of value management and buildability consideration

G7.6.62	Delays from design to tender preparation and bidding
G7.7.63	Unreliable estimation practices: Underbidding and overcosting
G7.8.64	Limited competition and ineffective contractor pre-qualification
G7.9.65	Complicated and restrictive tendering conditions
G7.10.66	Difference between selected bid and the consultant's estimation
G7.11.67	Inadequate bid evaluation and ineffective award practices such as lowest bid
G7.12.68	Delays in costing variations and additional works
G8	**Contracts, Legal and Regulatory Factors**
G8.1.69	Health and safety, management and regulations
G8.2.70	Corruption, bribes, and ethical issues
G8.3.71	Changes to standard general conditions
G8.4.72	Poorly designed, unbalanced, and ambiguous contract conditions
G8.5.73	Contractual claims, disputes, and legal issues
G8.6.74	Frequent design and specification changes and delays in approvals
G8.7.75	Nonadherence to contract conditions
G8.8.76	Rejected and delayed change orders
G8.9.77	Termination of contracts due to pandemic challenges
G8.10.78	Unbalanced risk distribution between parties
G8.11.79	Variations in project scope
G8.12.80	Governmental policies
G8.13.81	Difficulties in obtaining work permits
G9	**External Risks, Technology and Sustainability Factors**
G9.1.82	Delays from third-parties and utility agencies
G9.2.83	Workforce, cultural, and social challenges
G9.3.84	Change of partners in the project organization
G9.4.85	Inadequate production of raw materials by the country
G9.5.86	Inflation and fluctuation of material and machine prices
G9.6.87	Poor weather or emergency conditions
G9.7.88	Site location and ground condition challenges
G9.8.89	Uncontrollable events: Pandemics, natural disasters, and political instability
G9.9.90	Local issues and community security concerns
G9.10.91	Environmental protection and sustainability challenges
G9.11.92	Technology risks and obsolescence
G10	**DLP Operations and Maintenance Factors**
G10.1.93	Commissioning and machine start-up activities
G10.2.94	Damaged parts
G10.3.95	Excessive bureaucracy in project-owner operation
G10.4.96	Lack of training personnel and management support to model construction operation
G10.5.97	Long period of the project "one year" maintenance period
G10.6.98	Machinery maintenance cost
G10.7.99	Risk of extraordinary maintenance

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