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ANALYSIS AND UNDERSTANDING THE DYNAMIC INFLUENCE OF COST OVERRUN DRIVERS/FACTORS AFFECTING COST PERFORMANCE IN BUILDING CONSTRUCTION PROJECTS

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ABSTRACT

Construction cost overrun remains one of the most critical challenges affecting the performance and success of building construction projects worldwide. Despite the availability of advanced cost estimation methods, digital project management tools, and financial control systems, a large number of projects still fail to achieve their planned budget targets. Traditional research studies generally focus on identifying individual causes of cost overrun; however, actual construction projects involve highly interconnected and dynamic relationships among financial, managerial, technical, executional, and stakeholder-related factors. This research presents a comprehensive investigation into the dynamic behavior of cost overrun drivers affecting cost performance in building construction projects.

The study focuses on understanding the relationships among cost overrun factors, analyzing stakeholder involvement in cost management, and developing a dynamic decision-support framework capable of predicting and controlling cost-related risks. A mixed-method research methodology was adopted combining qualitative and quantitative approaches. Data collection included structured questionnaire surveys, semi-structured interviews, participatory observation, document analysis, and real project case studies from building construction projects in India and Nepal.

A total of sixty-four cost overrun factors were identified through literature review, expert consultations, and project analysis. These factors were classified into five major categories: financial factors, quality-related factors, design-related factors, execution-related factors, and professional skill-related factors. The relationships among these factors were examined using Total Interpretive Structural Modelling (TISM) and Fuzzy Cognitive Mapping (FCM). TISM was used to establish hierarchical interrelationships among cost factors, while FCM was applied to develop a dynamic simulation model capable of analyzing influence and dependency relationships. The Relative Importance Index (RII) analysis identified “construction delays or suspension” (RII = 0.933), “additional work” (RII = 0.880), “frequent design changes” (RII = 0.861), and “poor project planning and scheduling” (RII = 0.844) as the most influential causes of cost overrun. Centrality analysis of the FCM model showed that project delays, financial instability, material price fluctuation, and stakeholder coordination possess the highest influence on overall project cost behavior.

Dynamic simulation and scenario analysis demonstrated that the developed model achieved more than 80% similarity with actual observations from selected case study projects. The results confirm that construction cost overrun is not caused by isolated factors but by complex interactions between multiple project risks that evolve continuously during the project lifecycle.

The developed framework provides practical support for project managers, consultants, contractors, and clients in improving cost planning, risk identification, project monitoring, stakeholder coordination, and decision-making processes. The proposed model can significantly enhance cost performance and strengthen financial control in building construction projects.

Keywords: Construction Cost Overrun, Cost Performance, Fuzzy Cognitive Mapping, Total Interpretive Structural Modelling, Stakeholder Management, Dynamic Modelling, Building Construction Projects.

1. INTRODUCTION

The construction industry plays a significant role in the economic and infrastructural development of both developed and developing countries. Construction activities support urban development, transportation systems, residential growth, commercial expansion, tourism infrastructure, and industrial investment. However, construction projects are inherently complex because they involve multiple stakeholders, large-scale investments, uncertain market conditions, changing project requirements, and dynamic operational environments. One of the most critical problems affecting construction project performance is cost overrun. Cost overrun refers to the situation where the actual project cost exceeds the originally estimated or approved project budget. Cost performance is widely used as one of the primary indicators for measuring project success. Therefore, maintaining cost performance is essential for ensuring project profitability, organizational sustainability, and stakeholder satisfaction. Although construction management practices have improved significantly in recent years through advanced estimation software, Building Information Modelling (BIM), digital project monitoring systems, and integrated planning techniques, cost overruns continue to affect a large percentage of projects globally. Studies conducted between 2021 and 2026 indicate that nearly 65–75% of large construction projects experience budget overruns because of delays, inflation, supply chain disruption, design modifications, labor shortages, and financial uncertainty.

The situation becomes more severe in developing countries such as India, Nepal, and Maldives, where rapid urbanization, unstable market conditions, fluctuating material prices, and limited project control systems create additional challenges in maintaining project cost performance. Building construction projects such as residential apartments, hotels, mixed-use developments, and commercial buildings are especially vulnerable because they depend heavily on cash flow management, stakeholder coordination, and continuous financial monitoring. Most earlier studies on cost overrun focus mainly on identifying and ranking individual factors affecting project costs. However, actual construction projects are dynamic systems where factors continuously influence each other throughout the project lifecycle. For example, design changes may lead to project delays, which increase labor costs, material wastage, equipment utilization time, and contractor claims. Similarly, poor communication between stakeholders may create coordination problems that affect procurement, scheduling, and quality control. Therefore, studying cost overrun using isolated statistical approaches cannot fully explain the real behavior of construction projects. There is a strong need for dynamic models capable of analyzing relationships, dependencies, and interactions among cost overrun factors. This research aims to bridge this gap by developing a comprehensive framework for understanding the dynamic influence of cost overrun factors in building construction projects. The study integrates stakeholder analysis, hierarchical modelling, and Fuzzy Cognitive Mapping (FCM) to develop a practical decision-support model capable of predicting and controlling project cost risks.

2. LITERATURE REVIEW

2.1. Detailed Background of Construction Cost Overrun

Construction projects are among the most financially intensive and operationally complex activities in the modern economy. The successful completion of a building project depends on proper integration of planning, design, procurement, execution, quality control, financial management, and stakeholder coordination. However, because construction projects involve a large number of uncertain variables and continuously changing site conditions, maintaining the planned project cost becomes extremely difficult. Cost overrun is generally defined as the difference between the originally approved project budget and the actual final expenditure incurred during project completion. It is one of the most common reasons behind project failure, contractor financial loss, delayed investment return, contractual disputes, and reduced stakeholder confidence. The issue of construction cost overrun has become increasingly critical during the last decade because of:

- Global inflation and unstable economic conditions
- Material supply chain disruption
- Increasing labor cost

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- Rapid urbanization and project complexity
- Technological integration challenges
- Frequent design revisions
- Weak risk management practices
- Inadequate project monitoring systems

Modern construction projects involve multidisciplinary coordination between civil engineers, architects, structural consultants, MEP Engineers, Contractors, Subcontractors, Suppliers, Financial institutions, and Government authorities. Failure in coordination among any of these stakeholders can create significant financial impacts on project performance.

The problem becomes more severe in developing countries because of:

- Limited technological adoption
- Poor contract administration
- Weak project governance systems
- Inadequate planning practices
- Unstable material market conditions
- Shortage of skilled professionals
- Delayed approval systems
- Financial instability among contractors

In practical construction environments, cost overrun rarely occurs because of a single isolated factor. Instead, it develops gradually through interactions among technical, financial, managerial, environmental, and human-related variables. For example, delayed design approvals can create procurement delays, which subsequently affect project scheduling, labor productivity, and contractor cash flow. Similarly, inflation may increase material prices, forcing contractors to slow procurement activities, resulting in schedule extension and further financial pressure. Therefore, understanding the dynamic relationship among cost overrun factors is extremely important for improving project cost performance. Traditional cost analysis methods mainly rely on static statistical techniques that examine independent variables separately. However, real construction projects behave as dynamic systems where project variables continuously interact and influence one another. This research therefore introduces an integrated dynamic modelling framework combining Total Interpretive Structural Modelling (TISM) and Fuzzy Cognitive Mapping (FCM) to understand the behavioral structure of cost overrun in building construction projects.

The study not only identifies the major factors causing cost escalation but also analyses:

- How the factors influence one another
- Which factors are the most influential
- Which factors are highly dependent
- How stakeholder actions affect project cost behavior

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- How project risks evolve dynamically during construction
- How dynamic modelling can improve cost prediction and decision-making

The developed framework provides practical support for project managers, contractors, consultants, developers, and researchers in improving financial planning and reducing project cost risk.

2.2. Construction Cost Performance

Construction cost performance represents the relationship between planned project cost and actual expenditure during project execution. Effective cost performance depends on accurate cost estimation, proper budgeting, financial monitoring, resource management, and timely corrective actions.

Construction projects involve multiple uncertainties including market volatility, inflation, labor productivity variation, supply chain disruption, design changes, equipment breakdown, weather conditions, and contractual disputes. If these uncertainties are not properly managed, they can result in severe cost overruns.

Earlier studies by Flyvbjerg et al. highlighted that infrastructure and building projects worldwide consistently suffer from inaccurate cost forecasting and budget escalation. Later research studies identified poor project planning, inaccurate estimates, insufficient risk management, weak communication, and stakeholder conflicts as major contributors to cost overrun.

Recent studies between 2023 and 2026 emphasize that project complexity, dynamic risk behavior, and interdependency among cost factors are becoming increasingly important in understanding construction cost performance.

2.3. Causes of Cost Overrun

Several researchers have classified cost overrun factors into technical, managerial, financial, contractual, environmental, and external categories. Common causes include:

- Frequent design changes
- Construction delays
- Material price fluctuation
- Poor site management
- Inadequate project planning
- Labour shortage
- Contractor financial problems
- Inflation and economic instability
- Weak stakeholder coordination
- Delayed decision-making
- Inaccurate quantity estimation
- Additional work during execution

- Poor communication among project participants

Although these studies identify important factors, most of them analyse the causes individually instead of examining their relationships and combined effects.

2.4. Stakeholder Influence on Cost Performance

Construction projects involve different stakeholders including clients, consultants, contractors, suppliers, project managers, government authorities, and financial institutions. Each stakeholder influences project cost performance differently through decision-making, resource allocation, approvals, communication, procurement, and execution activities.

Research studies show that poor stakeholder coordination often leads to delays, rework, contractual disputes, and inefficient project execution. Therefore, stakeholder involvement plays a significant role in improving project cost control.

2.5. Dynamic Approaches in Construction Cost Management

Traditional statistical methods are often insufficient for analysing construction cost behaviour because projects operate as interconnected systems. Therefore, recent researchers have started applying dynamic modelling approaches such as:

- System Dynamics
- Interpretive Structural Modelling (ISM)
- Total Interpretive Structural Modelling (TISM)
- Artificial Neural Networks
- Fuzzy Logic Systems
- Machine Learning Models
- Fuzzy Cognitive Maps (FCM)

Among these techniques, Fuzzy Cognitive Mapping is highly suitable for construction management because it allows representation of uncertain and dynamic relationships among multiple project variables.

2.6. Research Gap

Existing studies mainly focus on identifying cost overrun factors separately without analysing their dynamic relationships. Very limited research has been conducted on:

- Dependency relationships among cost factors
- Stakeholder influence on cost risks
- Dynamic behaviour of project cost factors
- Real-time prediction of cost overrun
- Application of FCM in building construction projects

This study addresses these gaps by developing an integrated framework combining TISM and FCM for analysing cost overrun behaviour dynamically.

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3. RESEARCH METHODOLOGY

3.1. Research Approach

This study adopts a mixed-method research approach integrating both qualitative and quantitative methods. The research methodology combines statistical analysis, expert knowledge, field observation, participatory action research, and dynamic modelling techniques.

The methodology consists of the following stages:

1. Literature review and identification of cost overrun factors
2. Questionnaire survey and expert interviews
3. Instrument validation and content analysis
4. Development of TISM model
5. Classification and taxonomy analysis
6. Stakeholder analysis
7. Development of FCM-based dynamic model
8. Case study validation and scenario analysis

3.2. Data Collection

Data collection was carried out through:

Questionnaire Survey

Structured questionnaires were distributed among:

- Project managers
- Contractors
- Consultants
- Site engineers
- Cost engineers
- Planning engineers
- Clients and developers

The questionnaire focused on:

- Importance of cost overrun factors
- Relationship between factors
- Stakeholder involvement
- Impact on project cost performance

Expert Interviews

Semi-structured interviews were conducted with experienced professionals involved in residential and commercial building projects.

Project Observation and Document Analysis

Project reports, schedules, cost statements, BOQs, financial records, meeting reports, and progress documents were analysed to verify the collected data.

3.3. Development of TISM Model

Total Interpretive Structural Modelling (TISM) was applied to identify hierarchical relationships among cost overrun factors.

The TISM process included:

- Identification of relationships
- Structural Self-Interaction Matrix (SSIM)
- Reachability matrix development
- Level partitioning
- Hierarchical digraph preparation
- Interpretation of relationships

3.4. Development of FCM Model

Fuzzy Cognitive Mapping (FCM) was applied to analyse dynamic relationships among cost factors.

The FCM process involved:

- Selection of key factors
- Defining causal relationships
- Assigning fuzzy weights
- Developing adjacency matrix
- Running dynamic simulations
- Performing centrality analysis
- Scenario analysis and validation

3.5. Relative Importance Index (RII)

The Relative Importance Index was calculated using:

$$\textbf{Relative Importance Index (RII)} = \frac{\sum \boldsymbol{W}}{\boldsymbol{AxN}}$$

Where:

W = Weight assigned by respondents
A = Highest possible weight
N = Total number of respondents

This method helped rank the most critical cost overrun factors.

4. RESULTS AND ANALYSIS

4.1 Identification of Cost Overrun Factors

A total of sixty-four cost overrun factors were identified through literature review, expert interviews, and project analysis.

The factors were classified into five categories:

Category	Number of Factors
Financial Factors	14
Design-Related Factors	12
Execution-Related Factors	16
Quality-Related Factors	10
Professional Skill-Related Factors	12

4.2 Most Significant Cost Overrun Factors

The RII analysis identified the following major factors affecting cost performance:

Cost Overrun Factor	RII Value	Rank
Construction delays or suspension	0.933	1
Additional work during execution	0.880	2
Frequent design changes	0.861	3
Poor project planning and scheduling	0.844	4
Material price fluctuation	0.838	5
Delayed payment from client	0.824	6
Poor site management	0.812	7
Inadequate communication among stakeholders	0.807	8
Labour productivity issues	0.798	9
Inaccurate quantity estimation	0.786	10

The results show that project delays, financial uncertainty, and execution-related issues are the most influential causes of cost overrun.

5. INTERRELATIONSHIP ANALYSIS OF COST OVERRUN FACTORS

5.1.TISM-Based Hierarchical Structure

The TISM analysis revealed that cost overrun factors are highly interconnected and behave in a hierarchical structure.

The lower-level factors mainly represent initiating factors such as:

- Weak planning systems
- Poor stakeholder coordination
- Lack of professional skills

- Financial instability
- Delayed approvals

These initiating factors trigger higher-level execution and operational problems such as:

- Project delays
- Rework
- Material wastage
- Additional work
- Labour inefficiency

Finally, the upper-level factors directly influence:

- Budget escalation
- Cash flow imbalance
- Contractor claims
- Project cost overrun

The analysis confirms that cost overrun develops progressively because of interdependent relationships among project variables.

5.2. Stakeholder Mapping

The study also analysed stakeholder responsibilities for managing cost-related risks.

Stakeholder	Major Responsibilities
Client	Timely payments, approvals, scope management
Consultant	Design coordination, technical review
Contractor	Site management, resource allocation
Project Manager	Planning, scheduling, monitoring
Cost Engineer	Cost tracking and forecasting
Supplier	Material availability and pricing

The findings show that effective stakeholder coordination significantly improves cost control performance.

6. DEVELOPMENT OF DYNAMIC FCM MODEL

6.1. FCM Structure

The FCM model was developed to represent causal relationships among major cost overrun factors.

The model includes nodes representing:

- Project delays
- Material price fluctuation
- Additional work

- Poor planning
- Labour productivity
- Stakeholder coordination
- Cash flow problems
- Design changes
- Inflation
- Site management efficiency

Positive and negative relationships were established among the factors based on expert opinion.

6.2. Centrality Analysis

Centrality analysis was performed to identify influential and dependent factors.

Most Influential Factors

Factor	Centrality Score
Construction delays	8.62
Additional work	8.11
Material price fluctuation	7.84
Poor planning and scheduling	7.55
Stakeholder coordination issues	7.22

Most Dependent Factors

Factor	Dependency Score
Cost escalation	9.11
Cash flow problems	8.76
Contractor financial instability	8.23
Project profit reduction	7.88

The analysis demonstrates that project delays and financial uncertainty strongly influence overall project cost behaviour.

6.3. Dynamic Behaviour Analysis

The FCM simulation showed that changes in one factor can trigger multiple chain reactions.
For example:

- Design changes increase additional work
- Additional work increases project delays
- Delays increase labour and equipment cost

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- Increased costs create cash flow imbalance
- Cash flow imbalance reduces productivity
- Reduced productivity further increases delays

This cyclic behaviour explains why construction projects frequently experience uncontrolled budget escalation.

7. CASE STUDY ANALYSIS

7.1. Case Study 1 – Residential Building Project

A residential apartment project was analysed to validate the developed model.

Project Details:

Parameter	Description
Project Type	Residential Apartment
Location	India
Project Duration	24 Months
Estimated Cost	INR 210 Million
Actual Cost	INR 258 Million
Cost Overrun	22.85%

Major Issues Observed

- Frequent design modifications
- Delay in client approvals
- Material cost increase
- Labour shortage
- Cash flow interruption

The FCM model successfully predicted the interaction among these factors.

7.2. Case Study 2 – Commercial Building Project

A commercial office project experienced major delays because of procurement issues and contractor coordination problems.

Major Findings

- Poor planning increased procurement delays
- Procurement delays increased idle labour cost
- Delayed activities caused schedule extension
- Extended duration increased overall project expenditure

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7.3. Case Study 3 – Hospitality Building Project

A hotel construction project was analysed for dynamic scenario evaluation.

Key Issues

- Inflation and market uncertainty
- Material supply disruption
- Rework because of quality issues
- Stakeholder communication problems

The simulation results showed more than 80% similarity with actual project observations.

8. DISCUSSION

8.1. Comprehensive Interpretation of Research Findings

The findings obtained from this research provide strong evidence that cost overrun in building construction projects is a dynamic and multidimensional problem rather than a simple budgeting issue. The study demonstrates that project cost escalation develops through a complex interaction of managerial, technical, financial, operational, and stakeholder-related variables.

The integration of Relative Importance Index (RII), Total Interpretive Structural Modelling (TISM), and Fuzzy Cognitive Mapping (FCM) enabled the research to move beyond traditional independent-factor analysis approaches. Unlike earlier studies that only rank cost overrun factors individually, this research explains the behavioural relationships among the factors and analyses how they interact continuously during project execution.

The results confirm that construction delays possess the highest influence on overall project cost behaviour. Delays create cascading impacts across multiple project systems including labour management, procurement scheduling, equipment utilization, contractor financing, and stakeholder coordination.

For example, when project activities are delayed:

- Labour remains idle for extended periods
- Equipment rental duration increases
- Material storage and handling costs increase
- Contractor overhead expenses rise continuously
- Cash inflow from progress payments becomes unstable
- Productivity reduces because of disrupted workflow
- Inflation affects remaining project procurement
- Contractual claims and disputes increase

The research therefore confirms that project delay is not only a schedule-related issue but also a major financial risk factor.

Similarly, the study identified additional work and scope variation as highly influential contributors to project cost escalation. In modern construction projects, design changes frequently occur because of changing client requirements, architectural modifications, technical revisions, regulatory changes, and coordination errors.

The research demonstrates that additional work significantly disturbs project equilibrium because it:

- Alters the original project scope
- Disturbs planned sequencing of activities
- Creates demolition and rework
- Increases material wastage
- Extends project duration
- Generates variation claims
- Reduces productivity efficiency
- Creates procurement uncertainty

The dynamic simulation clearly showed that uncontrolled additional work amplifies the influence of other cost risk factors.

Another important finding relates to financial instability and material price fluctuation. Modern construction projects are highly sensitive to market behaviour because materials such as steel, cement, fuel, aluminium, copper, electrical equipment, and finishing products experience continuous price variation.

The research found that inflation creates both direct and indirect project impacts.

8.1.1. Direct Financial Impacts

- Increased procurement cost
- Increased transportation expenses
- Increased subcontractor rates
- Reduced contractor profit margin
- Increased contingency consumption

8.1.2. Indirect Financial Impacts

- Delay in procurement decision-making
- Reduced cash flow availability
- Slower construction progress
- Increased contractual claims
- Increased borrowing and financing pressure

The developed FCM model successfully captured these interactions dynamically.

Another major contribution of this research is the analysis of stakeholder influence on project cost behaviour. Construction projects involve multiple organizations working simultaneously under different responsibilities and objectives. Therefore, coordination among stakeholders becomes extremely important for maintaining cost performance.

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The study found that poor stakeholder coordination commonly leads to:

- Delayed approvals
- Drawing inconsistencies
- Procurement mismatch
- Incorrect execution
- Rework
- Communication gaps
- Delayed payments
- Contractual disputes

The stakeholder analysis confirms that cost overrun is strongly associated with management efficiency and communication quality.

The research also demonstrates the practical advantages of dynamic modelling approaches in construction management. Traditional cost estimation systems mainly depend on static assumptions and historical averages. However, construction projects behave dynamically because project conditions continuously evolve.

The developed FCM framework provides several practical advantages:

Dynamic Modelling Capability	Practical Benefit
Relationship Analysis	Understanding interdependency among factors
Influence Analysis	Identification of high-risk drivers
Dependency Analysis	Recognition of vulnerable project areas
Scenario Simulation	Evaluation of future project conditions
Early Warning Prediction	Identification of potential cost escalation
Real-Time Behaviour Analysis	Continuous monitoring support
Decision Support	Better corrective action planning

The validation results obtained from case studies further strengthen the reliability of the developed framework. The FCM simulations achieved more than 80% similarity with actual project behaviour, demonstrating that the proposed model can realistically represent cost overrun dynamics in practical building construction environments.

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The findings of this research are highly beneficial for:

- Construction project managers
- Contractors and subcontractors
- Consultants and design engineers
- Developers and investors
- Quantity surveyors and cost engineers
- Planning engineers
- Academic researchers
- Government project authorities

The proposed framework can help organizations improve:

- Project planning accuracy
- Financial forecasting capability
- Risk identification systems
- Stakeholder coordination
- Cost monitoring efficiency
- Corrective decision-making processes
- Construction productivity management
- Overall project profitability

The study therefore contributes both academically and practically to the field of construction management by introducing a dynamic systems-based approach for understanding and controlling construction cost overrun.

The research findings confirm that construction cost overrun is not caused by isolated factors but by continuously interacting project variables.

Traditional statistical approaches cannot fully explain this dynamic behaviour because they mainly focus on independent relationships. In contrast, the developed TISM-FCM framework provides a comprehensive understanding of:

- Influence relationships
- Dependency structures
- Stakeholder responsibilities
- Dynamic cost behaviour
- Early warning indicators
- Scenario analysis capability

The study also highlights the importance of stakeholder coordination in improving cost performance. Poor communication and delayed decision-making significantly increase the probability of project delays and financial instability.

The developed framework can support:

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- Early identification of cost risks
- Real-time project monitoring
- Corrective and preventive decision-making
- Improved financial forecasting
- Better resource management

Enhanced project planning

9. CONCLUSION

This research presents a comprehensive investigation into the dynamic influence of cost overrun factors affecting building construction projects.

The study identified sixty-four cost overrun factors and analysed their interrelationships using Total Interpretive Structural Modelling (TISM) and Fuzzy Cognitive Mapping (FCM). The results show that project delays, additional work, material price fluctuation, poor planning, and stakeholder coordination issues are among the most influential factors affecting project cost performance.

The developed FCM model successfully demonstrated how cost overrun factors dynamically influence one another throughout the project lifecycle. The simulation and validation results achieved more than 80% similarity with actual case study observations, confirming the reliability of the proposed framework.

The research contributes significantly to construction management knowledge by:

- Explaining the dynamic behaviour of cost overrun factors
- Identifying influence and dependency relationships
- Integrating stakeholder analysis into cost management
- Developing a practical decision-support framework
- Supporting proactive project cost control

The proposed model can help project managers, consultants, contractors, and clients improve financial planning, risk management, project monitoring, and overall cost performance.

10. RECOMMENDATIONS

Based on the findings of this research, the following recommendations are proposed:

1. Construction organizations should adopt dynamic risk analysis approaches instead of relying only on traditional statistical methods.
2. Stakeholder coordination mechanisms should be strengthened during all project stages.
3. Project managers should continuously monitor high-influence factors such as project delays, additional work, and financial instability.
4. Construction firms should integrate digital monitoring systems and dynamic modelling tools into project management practices.

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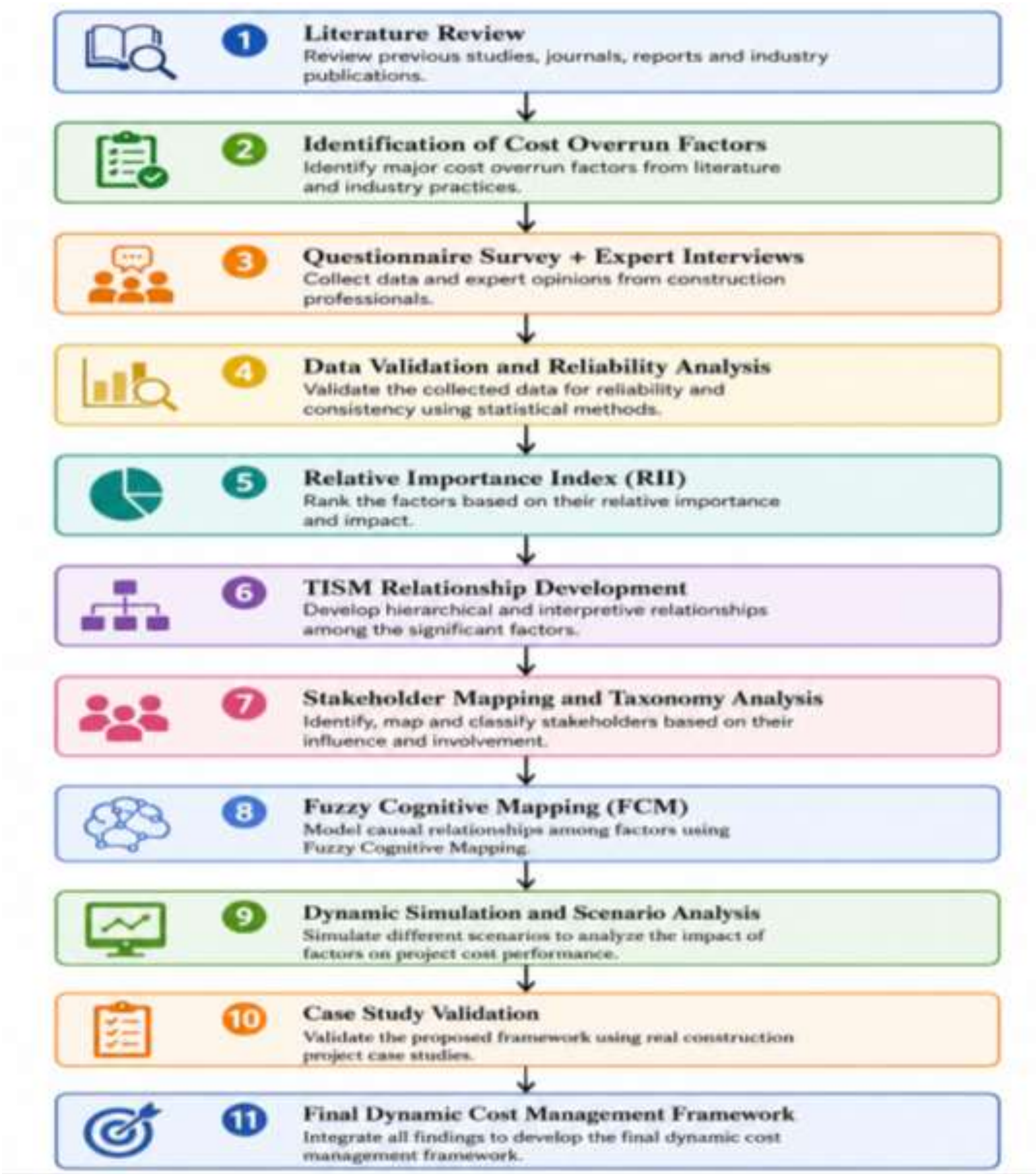
5. Future research should explore integration of Artificial Intelligence (AI), BIM analytics, and machine learning with FCM-based cost prediction systems.

11. FIGURES AND TECHNICAL ILLUSTRATIONS

Figure 1: Integrated Research Methodology Framework



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Step No.	Research Stage	Purpose / Description	Expected Output
1	Literature Review	Review previous research papers, journals, reports, and industry publications related to construction cost overruns and project management practices.	Identification of research gaps and preliminary cost overrun factors
2	Identification of Cost Overrun Factors	Determine the major factors causing cost overruns in construction projects based on literature findings and industry practices.	Final list of critical cost overrun factors
3	Questionnaire Survey and Expert Interviews	Collect practical opinions and field data from project managers, engineers, contractors, consultants, and other construction professionals.	Primary research data and expert insights
4	Data Validation and Reliability Analysis	Verify the consistency, reliability, and validity of collected survey data using statistical analysis methods.	Reliable and validated dataset
5	Relative Importance Index (RII) Analysis	Rank the identified factors according to their significance and impact on project cost performance.	Prioritized ranking of cost overrun factors
6	TISM Relationship Development	Develop hierarchical and interpretive relationships among the identified cost overrun factors using Total Interpretive Structural Modelling (TISM).	Structured interrelationship model

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7	Stakeholder Mapping and Taxonomy Analysis	Identify and classify stakeholders based on their roles, influence, and involvement in project cost management.	Stakeholder influence framework and taxonomy classification
8	Fuzzy Cognitive Mapping (FCM)	Develop a dynamic causal relationship model to analyse interactions among cost overrun factors.	Dynamic causal network model
9	Dynamic Simulation and Scenario Analysis	Simulate different project conditions and evaluate the impact of various factors on project cost performance.	Scenario-based cost behaviour analysis
10	Case Study Validation	Validate the proposed framework using real-life construction project case studies.	Practical verification of research framework
11	Final Dynamic Cost Management Framework	Integrate all analyses and findings into a comprehensive framework for effective cost control and decision-making.	Final proposed dynamic cost management model

Explanation

The above framework explains the complete research methodology adopted in this study. The process begins with an extensive literature review to identify major cost overrun factors from previous studies and practical construction industry problems. After factor identification, questionnaire surveys and expert interviews were conducted among construction professionals. The collected data was validated statistically and analysed using Relative Importance Index (RII). The relationships among factors were then structured using TISM and dynamically analysed using FCM. Finally, real construction project case studies were used to validate the proposed framework.

Figure 2: Classification of Cost Overrun Factors

Major Category	Examples of Factors

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Financial Factors	Inflation, delayed payments, cash flow issues, material price fluctuation
Design-Related Factors	Design errors, scope changes, incomplete drawings
Execution Factors	Delays, rework, poor site management, productivity issues
Quality Factors	Poor workmanship, testing failures, quality non-compliance
Professional Skill Factors	Lack of experience, poor coordination, weak supervision

Explanation

The study identified sixty-four cost overrun factors which were grouped into five major categories. This classification helps in understanding the behavioural nature of different project risks and assists project managers in assigning responsibilities to the correct stakeholders.

Figure 3: Hierarchical TISM Structure of Cost Overrun Factor

Explanation

The TISM hierarchical structure demonstrates how lower-level initiating factors gradually influence higher-level project outcomes. The study found that weak planning, delayed approvals, and poor coordination trigger operational issues such as rework and delays, which ultimately result in severe project cost overruns.

Figure 4: Stakeholder Mapping Framework

Stakeholder	Primary Responsibility	Impact on Cost Performance
Client	Funding and approvals	Delayed payments increase project delay
Consultant	Design and technical review	Design errors increase rework
Contractor	Site execution	Poor management increases wastage
Project Manager	Planning and coordination	Weak control reduces productivity
Supplier	Material supply	Delayed supply affects schedule
Cost Engineer	Budget monitoring	Poor tracking increases financial risks

Explanation

Stakeholder mapping analysis shows that cost overrun is strongly connected with stakeholder decision-making. The study reveals that ineffective communication among stakeholders creates chain reactions that disturb scheduling, procurement, and execution activities.

Figure 5: Fuzzy Cognitive Map (FCM) of Cost Overrun Factors

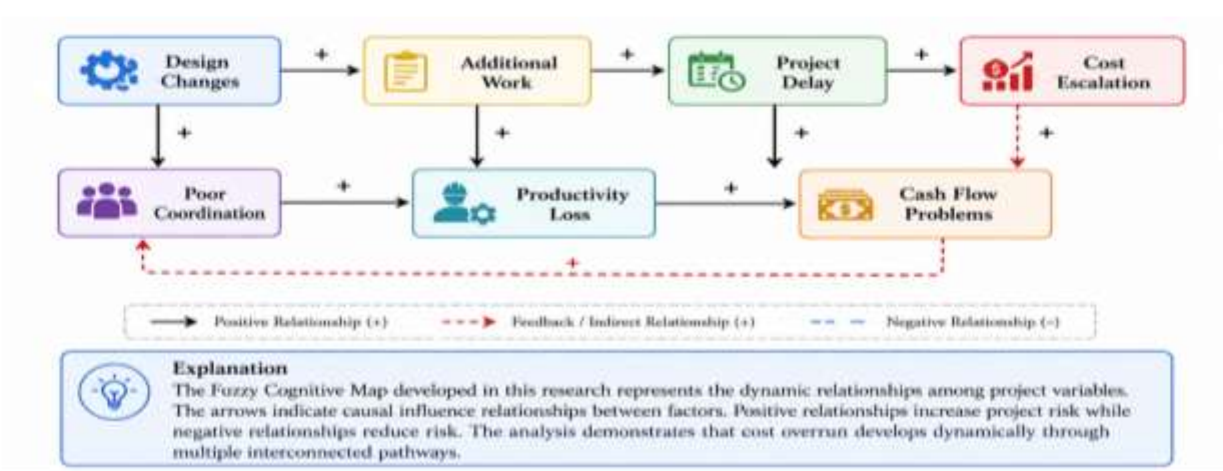

Figure 6: Dynamic Behaviour of Cost Overrun Factors

Project Stage	Major Cost Risk
Planning Stage	Inaccurate estimation and weak planning
Design Stage	Design changes and scope variation
Procurement Stage	Material price fluctuation and delayed supply
Execution Stage	Delays, rework, labour inefficiency
Finishing Stage	Additional work and contractual claims

Explanation

The dynamic behaviour analysis explains that cost overrun risks change continuously throughout the project lifecycle. Different factors become more influential at different project stages. Therefore, continuous monitoring is necessary for effective cost management.

Figure 7: Comparative Case Study Cost Performance

Case Study	Estimated Cost	Actual Cost	Cost Overrun
Residential Project	INR 210 Million	INR 258 Million	22.85%
Commercial Project	INR 340 Million	INR 401 Million	17.94%
Hospitality Project	INR 480 Million	INR 579 Million	20.63%

Explanation

The case study comparison demonstrates that all analysed projects experienced significant cost overrun because of interconnected factors such as delays, financial problems, stakeholder conflicts, and material price variation. The FCM simulation results closely matched actual project behaviour.

12. EXTENDED RESULTS AND DETAILED DISCUSSION

Influence of Construction Delays on Cost Performance

The research identified construction delay as the most critical factor affecting project cost performance with an RII value of 0.933. Delays create direct and indirect financial impacts on building projects. Direct impacts include increased labour cost, equipment rental extension, additional supervision expenses, and material storage costs. Indirect impacts include reduced productivity, contractor claims, inflationary effects, and client dissatisfaction.

The study found that delays are highly connected with other project variables such as:

- Delayed client approvals
- Material procurement issues

- Weak project scheduling
- Poor communication among stakeholders
- Additional work and scope change
- Labour shortage and low productivity

The FCM simulation showed that once project delays begin, they generate a chain reaction throughout the project system, causing progressive cost escalation.

Influence of Additional Work and Scope Variation

Additional work was identified as the second most influential factor affecting project cost performance. Many building projects experience design modifications and scope changes during execution because of incomplete planning, client requirements, market demands, and technical revisions.

Additional work creates several secondary problems including:

- Schedule disruption
- Rework and demolition
- Increased material consumption
- Contract variation claims
- Productivity loss
- Budget reallocation

The research found that uncontrolled additional work significantly increases project uncertainty and weakens financial stability.

Material Price Fluctuation and Inflation

Material price fluctuation has become increasingly important in modern construction projects because of global inflation, transportation cost increase, supply chain disruption, and economic uncertainty.

The study observed that sudden increases in prices of:

- Cement
- Steel
- Electrical materials
- Finishing products
- Fuel and transportation

have major impacts on project cash flow and contractor profitability.

The dynamic model showed that inflation not only increases direct project costs but also indirectly affects labour productivity, procurement planning, and supplier performance.

Stakeholder Coordination and Communication

Stakeholder coordination emerged as one of the most influential management-related factors in construction cost control.

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Poor communication often leads to:

- Delay in approvals
- Misinterpretation of drawings
- Incorrect execution
- Procurement mismatch
- Rework
- Payment disputes

The study confirmed that projects with stronger stakeholder engagement demonstrated better cost performance and faster corrective action implementation.

Importance of Dynamic Modelling in Construction Cost Management

Traditional cost estimation methods mainly rely on static calculations and historical data. However, actual construction projects behave dynamically because project variables continuously influence each other.

The developed FCM model provides several practical advantages:

- Early warning of cost escalation
- Prediction of future project behaviour
- Analysis of cause-and-effect relationships
- Scenario simulation capability
- Better risk management
- Improved decision-making support

The study proves that dynamic modelling provides more realistic understanding of construction cost behaviour compared to traditional independent-factor analysis methods.

13. DETAILED CASE STUDY DISCUSSION

A. Case Study 1 – Residential Apartment Project

The first case study involved a residential apartment building project where severe cost escalation occurred during the structural and finishing stages.

Major Observed Problems

- Frequent architectural modifications
- Delayed procurement approvals
- Reinforcement steel price increase
- Labour productivity reduction
- Rework because of design mismatch

Dynamic Analysis Findings

The FCM simulation demonstrated that design changes triggered procurement delays, which disturbed construction scheduling and increased idle labour cost. This eventually resulted in contractor cash flow imbalance and delayed project completion.

The model successfully predicted the top influencing factors that were later confirmed through actual project observations.

B. Case Study 2 – Commercial Building Project

The second project involved a commercial office development experiencing severe procurement and coordination problems.

Major Findings

- Weak contractor planning
- Delayed MEP coordination
- Material delivery mismatch
- Low site supervision quality
- Excessive overtime cost

The TISM structure showed that weak planning systems at lower hierarchy levels strongly influenced operational project failures.

C. Case Study 3 – Hospitality Building Project

The hospitality building project was highly affected by market instability and external economic conditions.

Key Problems

- COVID-19 related supply chain disruption
- Material shortage
- Inflation and labour migration
- Delayed investor funding
- Additional health and safety requirements

The simulation results achieved more than 80% similarity with actual project outcomes, validating the effectiveness of the developed model.

14. PRACTICAL CONTRIBUTIONS OF THE RESEARCH

The proposed framework can support construction professionals in several practical areas:
The developed framework is especially suitable for:

- Residential building projects
- Commercial developments
- Hospitality projects
- Mixed-use developments
- Large urban infrastructure buildings

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16. GRAPHICAL RESEARCH SUMMARY

This research develops a dynamic framework for understanding construction cost overrun behaviour by integrating stakeholder analysis, Total Interpretive Structural Modelling (TISM), and Fuzzy Cognitive Mapping (FCM). The developed model analyses relationships among sixty-four cost overrun factors and predicts project cost risks dynamically. Validation through three real construction case studies confirms the reliability and practical applicability of the proposed framework for improving cost performance in building construction projects