QUALITATIVE ASSESSMENT OF SCOPE CREEP SOURCES IN LARGE-SCALE PUBLIC SECTOR CONSTRUCTION PROJECTS IN EGYPT.

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Abstract:

Scope creep is a prevalent issue in large-scale public sector construction projects (LSPSCPs) in developing countries like Egypt. It undermines project success by gradually expanding project activities beyond their initial boundaries, often due to poor feasibility studies, bureaucratic delays, cost-cutting strategies, and weak project management practices. Despite the application of project management methods, the inability to accurately identify and address the root causes of scope creep remains a challenge. In Egypt, scope creep has led to abandoned projects, time overruns, and cost escalations, highlighting the need for a deeper understanding of its antecedents and consequences. Addressing this issue requires balancing the key project constraints of time, cost, and scope while identifying strategies to mitigate its impacts. Mismanagement of scope creep continues to strain resources and extend timelines, further exacerbating inefficiencies.

This study adopts a qualitative research design, using standardized questionnaires to gather insights from project managers, site engineers, and stakeholders involved in major construction projects. Data analysis techniques, including reliability analysis, chi-square tests, correlation, and regression analysis, were employed to identify significant factors contributing to scope creep and their impacts on project time and cost.

The study emphasizes the importance of adopting modern tools like Building Information Modeling (BIM), formalizing instructions, improving communication, and enhancing risk management frameworks. These measures aim to prevent undocumented changes, distribute risks fairly, and ensure sustainable project outcomes. Understanding the root causes and impacts of scope creep is essential for developing effective control strategies in Egypt’s construction sector.

Key words: Scope creep; Large-scale public sector construction projects (LSPSCPs); quantitative assessment; Egypt.

Literature Review:

The construction industry plays a pivotal role in the economic development of every nation by encompassing a wide range of sectors. Construction projects contribute to economic growth by addressing the needs for housing, transportation, and social infrastructure [1]. Ensuring the success of construction projects has become a primary objective for project managers [2]. This requires managing complex projects, a growing area of research that highlights governance challenges and decision-making intricacies [3].

The complexity of construction projects has significantly increased in recent years, leading to poor project performance when not addressed adequately [4]. Successful project execution is defined as achieving objectives within specified time, cost, and quality while meeting sustainability requirements [5]. Effective project outcomes also depend on satisfying client expectations by delivering projects on time, within budget, and to the agreed standards [6].

Scope management plays a critical role in achieving these goals, as it ensures project activities remain aligned with objectives while fulfilling client needs. However, scope creep—a gradual expansion of project activities—remains a pervasive challenge across industries. According to the Project Management Institute [7], 19% of all projects fail, with over 50% of these failures linked to scope creep.

Managing scope effectively is vital for project success. It supports optimal decision-making within constraints, ensuring smooth project progression [8][9]. Senghani identified cost, schedule, performance, and safety as key indicators of project success, emphasizing that effective safety management techniques enhance overall outcomes [10]. Similarly, Moza and Paul noted that achieving project objectives—timely completion, budget adherence, quality standards, and stakeholder satisfaction—is integral to construction success [11]. Several studies highlight the importance of robust scope management for mitigating scope creep. Abaza and Kisi emphasized the need for clear communication, well-defined project scopes, and governance to prevent delays and cost overruns [12]. Aizaz underscored that unmanaged scope creep compromises cost, schedule, and quality, threatening project outcomes [13]. Althiyabi and Quresh argued that clearly defining project scope enhances planning, communication, and change management, ultimately leading to better results [14]. Scope creep is further complicated by technological, organizational, and human factors, which negatively impact project objectives [15]. Understanding project complexity is essential for managers, as it influences decision-making and goal attainment [16]. The success of construction projects also hinges on stakeholder performance in managerial, financial, technical, and organizational domains, alongside effective risk management and stability in economic and political environments [17]. As construction processes become increasingly complex, sophisticated methods are required to handle initiation, planning, financing, design, approval, implementation, and project completion [17].

Table (1): Summary of Factors affecting Construction Scope Creep According to Different Authors.

Factors affecting Construction Scope Creep	Sub-Factors	Authors
Technology-Related Factors	Schedule constraints/Advance estimates of schedules and resources.	Aizaz et al. (2021) [13] Moneke and Echeme (2016) [18] Sharma et al. (2017) [20]
	Technological constraints/Lack of knowledge of technical complexities/ Lack of knowledge and poor understanding of product versatility and technical complexities/ Poor requirements specifications/ The project is executed years after the completion of study and scope definition/ Insufficient data when the scope was defined.	Aizaz et al. (2021) Akpo (2021) [17] Moneke and Echeme (2016) [19] Sharma et al. (2017) Nabet et al. (2017) [23]
	Requirement volatility.	Aizaz et al. (2021) Nabet et al. (2017)

	Change in market needs/	Aizaz et al. (2021)
	Risks/ Unforeseen conditions/ Force majeure.	Aizaz et al. (2021) Alp & Stack (2012) [21] Akpo (2021) Moneke and Echeme (2016)
	Project size.	Aizaz et al. (2021)
	Project complexity/ Underestimating Complexity.	Aizaz et al. (2021) Mnguni (2021) Nabet et al. (2017)
	Lack of proper document control/ Discrepancy in contract documents/ Contractual agreements open to wide interpretation.	Gangapatnam (2020) [22] Sharma et al. (2017) Nabet et al. (2017)
	Internal changes by development team/Platform changes.	Akpo (2021) Moneke and Echeme (2016)
	Insufficient data collection and survey before design/ Design changes due to poor design brief.	Sharma et al. (2017)
Organization-Related Factors	Organizational capabilities/ Lack of change control contingency plan/Lack of definite procedure for project management/ Complexity of governance/ Informal decision making/ Poor decision making/ Unavailability of formal risk analysis and planning process/ Managing projects by parts without system thinking	Aizaz et al. (2021) Akpo (2021) Gangapatnam (2020) Moneke and Echeme (2016) Sharma et al. (2017)
	Poor communication/ Lack of formal communication plan.	Aizaz et al. (2021) Akpo (2021) Mnguni (2021) Gangapatnam (2020) Moneke and Echeme (2016) Sharma et al. (2017)
	Lack of resources/ Change in project team.	Aizaz et al. (2021) Gangapatnam (2020)
	Poor scope definition/ Misappraisal of the original scope of work/Poor Quality of	Aizaz et al. (2021) Alp & Stack (2012) Akpo (2021)

	Work breakdown Structure/ Scope definition done by wrong people/ Improper assessment of scope.	Mnguni (2021) Gangapatnam (2020) Moneke and Echeme (2016) Sharma et al. (2017) Nabet et al. (2017)
	Unclear goals/objectives.	Aizaz et al. (2021)
	Cutting corners and politically induced contract scam/ Intervention by politicians and senior government officials/ Conflict in different government agencies' interests/ Government officials being overly "ambitious" and unrealistic regarding project outcomes	Moneke and Echeme (2016) Sharma et al. (2017)
Human-Related Factors	Personnel/ Incompetent project manager/ Experience of project team/ Time pressure.	Aizaz et al. (2021) Akpo (2021) Gangapatnam (2020) Moneke and Echeme (2016) Sharma et al. (2017)
	Client lack of knowledge.	Aizaz et al. (2021) Nabet et al. (2017)
	Change request/ Value Adding Change.	Aizaz et al. (2021) Mnguni (2021) Nabet et al. (2017)
	Vendor lack of experience.	Aizaz et al. (2021)
	Low stakeholder involvement/ Inability to manage stakeholders/ Ignoring stakeholders.	Aizaz et al. (2021) Akpo (2021) Gangapatnam (2020) Moneke and Echeme (2016) Sharma et al. (2017)
	Client requirements/ Poor understanding of customer’s requirements prior to project scope definition	Alp & Stack (2012) Akpo (2021) Moneke and Echeme (2016) Sharma et al. (2017)
	Delays over the project lifetime/ Ignoring small changes/ Managers focusing on major scope changes while ignoring minor changes that could lead to bigger scope creep issues	Akpo (2021) Gangapatnam (2020) Moneke and Echeme (2016)
	New ideas or market needs	Akpo (2021) Moneke and Echeme (2016)

Methodology:

Research Design and Assumptions

This study employed a qualitative research design, collecting data from project stakeholders involved in major construction projects in Egypt through a standardized questionnaire. The design assumes that respondents provide truthful and accurate information about their projects. However, self-reported data from surveys may be subject to biases such as memory bias (difficulty recalling past events accurately) and social desirability bias (respondents providing answers they believe are socially acceptable). To mitigate these biases, the questionnaire was designed to be anonymous, straightforward, and concise.

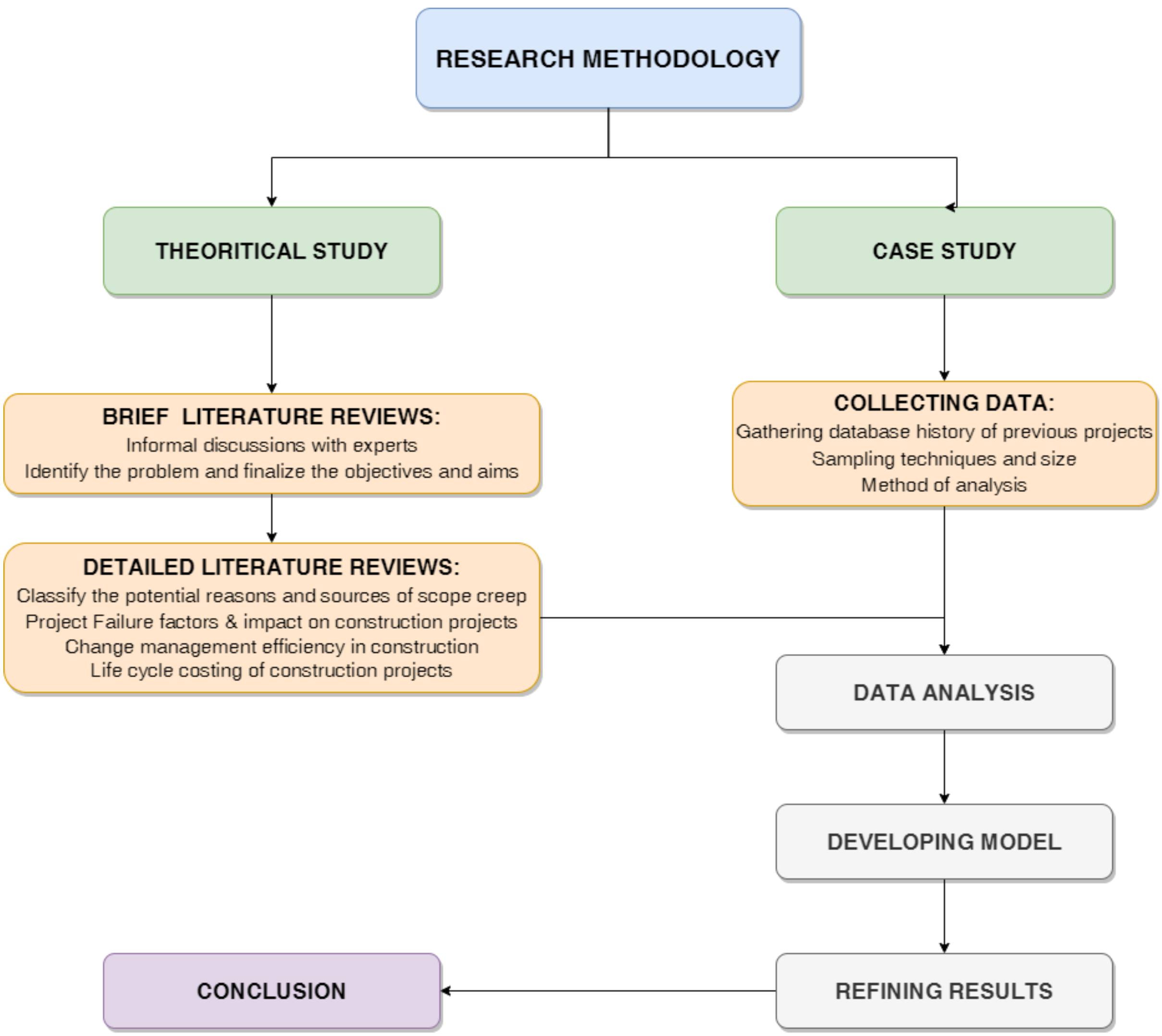

Figure 1: Research methodology

Targeted Projects and Sample Size

Large-scale construction projects in Egypt are the study's target population. Best practices for handling scope creep in projects with comparable features, like those that beyond a particular financial level or include particular project kinds (e.g., residential, commercial, infrastructure), are intended to be informed by the research. Stratified random sampling was used to select a sample size of 500 projects in order to guarantee representation according to project size, kind, and location within Egypt. Calculations of sample size took into account a 5% margin of error and the intended 95% confidence level.

Data Collection

The data collection for this study was conducted over a four-month period, from March to June 2023. A total of 600 respondents were selected through stratified random sampling from large-scale construction projects across Egypt. The respondents included project managers, site engineers, and other key stakeholders involved in the projects. The response rate was 83.3%, with 500 completed surveys returned, ensuring a robust sample size. The questionnaire was divided into two sections and assessed the following key categories:

- Project Type (e.g., residential, commercial, infrastructure).
- Project Side (governmental, public sector, private sector).
- Project Size (small, medium, large, mega).
- Party Responsible for Scope Management (owner, project management firm, engineer, contractor).
- Contract Type (FIDIC contract, Egyptian/local contract).
- Contract Style (balanced, owner-side).
- Scope Change/Creep (extent of changes in contract value).
- Usage of BIM (design phase, planning phase, execution phase, or none).
- Relevant Constraints (time, cost, quality, resources, risk, scope, customer satisfaction).
- Contractor Ranking (according to the Egyptian Federation for Construction & Building Contractors).
- Lessons Learned (successes, failures, risks/issues).

Additionally, the questionnaire evaluated the relative importance and frequency of various causes of scope creep, as well as the effectiveness of different methods for preventing scope creep. This dual assessment provided insights into the most critical factors contributing to scope creep and the strategies deemed most effective in mitigating it. Respondents also offered recommendations for best practices to manage scope creep and reduce its impact on construction projects in Egypt. This comprehensive approach ensured a robust dataset for analyzing both the causes and impacts of scope creep, while identifying effective scope management strategies tailored to Egypt's construction sector.

Data Analysis

Qualitative (percentage-based) data was gathered, stakeholder perceptions and project features are summed together using descriptive statistics. Regression analysis is used to find connections between scope creep and project factors (such as project size and complexity). Sensitivity analysis is used to investigate how changes in important project parameters (such the frequency of change orders) may affect the extent of scope creep.

Limitations

The study acknowledges the limitations inherent in relying on self-reported survey data, which may be susceptible to biases as discussed earlier. Additionally, the focus on large-scale construction projects in Egypt limits the generalizability of the findings to other project types or geographical contexts.

Results and Analysis:

The statistical methods used in the study include;

- Reliability Analysis: Cronbach's Alpha, Spearman-Brown, and Guttman coefficients were calculated to assess the internal consistency of the scale measuring causes of scope creep. High reliability scores indicate that the scale is consistent in measuring the underlying construct.
- Chi-Square Test: Used to analyze associations between scope creep and various project characteristics (e.g., project type, size, BIM usage, and contract type). This test identified significant relationships between specific variables and scope creep.
- Descriptive Statistics: Provided insights into the means and standard deviations for various causes of scope creep, allowing the identification of high-impact factors.
- Pearson Correlation: Assessed the relationships between scope creep, budget impact, time impact, and causes of scope creep. This analysis highlighted the influence of scope creep on project budgets and timelines.
- Linear Regression Analysis: Evaluated the effect of time impact, budget impact, and causes of scope creep on overall scope creep. The model was statistically significant but explained only a small percentage of the variance, suggesting other influential factors.

- One-Way ANOVA: Tested for differences in scope creep across categories (e.g., project type, contract type, and responsible party for scope management). This analysis revealed that the party responsible for scope management significantly impacts scope creep.

These methods provided a comprehensive analysis of factors contributing to scope creep, highlighting significant associations and potential areas for intervention

Statistical analysis:

Table [2] Reliability analysis:

	Cronbach alpha	Spearman-Brown	Guttman
Causes of scope creep in construction projects in Egypt	85.8	86.2	86.1

The reliability analysis results in Table 2 show strong internal consistency for the scale measuring causes of scope creep in construction projects in Egypt. As follow:

- Cronbach's Alpha (85.8%): This indicates a high level of reliability, meaning the items related to causes of scope creep are consistently measuring the same underlying construct. An alpha above 0.70 is generally considered acceptable, while values above 0.85 are considered very good.
- Spearman-Brown Coefficient (86.2%): This is often used to assess reliability, especially when splitting items into two halves. The high Spearman-Brown value supports the internal consistency observed in Cronbach's alpha.
- Guttman Split-Half Coefficient (86.1%): Like Spearman-Brown, this coefficient measures split-half reliability. The high Guttman score aligns well with the other metrics, further confirming the reliability of the scale.

The reliability metrics (Cronbach's Alpha, Spearman-Brown, and Guttman) all indicate that the scale for causes of scope creep is very reliable. This consistency across three different reliability tests underscores the robustness of the survey items used to measure scope creep causes in construction projects in Egypt.

Chi-square formula (X^2):

$$X^2 = \sum \frac{(Q_i - E_i)^2}{E_i} \qquad \text{Eq. (1)}$$

Where $Q_i$represents the observed frequency, and E_i represents the expected frequency for each category.

P-value calculation:

The P-value was derived by comparing the computed X^2 value against the Chi-square distribution table, based on the degrees of freedom (df = number of categories - 1) and the desired significance level (typically 0.05).

$$p=P(\chi^2 \geq X^2)=\int_{X2}^{\infty} f(\chi 2;df)d\chi 2 \qquad \text{Eq. (2)}$$

Where:

- f(χ2;df) is the probability density function (PDF) of the Chi-square distribution with df degrees of freedom.
- The integration is performed from the observed Chi-square value X2 to infinity.

Table [3] Sample distribution: Chi-SquareX^2 test was use to find the association between the scope creep and the various variable

Variable	Category	frequency	percent	Chi-Square X^2	P-value
Project Type	Residential	78	15.6	78.107a	0.058
	Commercial	47	9.4		
	Infra-structure	115	23.0		
	Mixed Use	75	15.0		
	Industrial	55	11.0		
	Heavy Constr.	64	12.8		
	Light Constr.	66	13.2		
Project side	Governmental	225	45.0	10.668a	0.384

	Holding company/public sector.	275	55.0		
Project size	Small	139	27.8	57.760a	0.002
	Medium	140	28.0		
	Large	112	22.4		
	Mega	109	21.8		
Party Responsible for scope management	Owner	131	26.2	41.602a	0.077
	Project management firm	159	31.8		
	Engineer	110	22.0		
	Contractor	100	20.0		
Contract Type	Balanced	207	41.4	31.435a	0.000
	Owner side	293	58.6		
Usage of BIM	Design phase	145	29.0	48.689a	0.017
	Planning phase	121	24.2		
	Execution phase	7	1.4		
	None	227	45.4		
"Project Contractor's ranking according to "Egyptian Federation for Construction & Building Contractors"	First	211	42.2	33.212a	0.032
	Second	132	26.4		
	Third	157	31.4		
Total		500	100		

The chi-square test results in Table 3 show the association between scope creep and various project characteristics. Here's an interpretation of each variable based on the chi-square values and p-values:

- Chi-Square (78.107), p-value (0.058): The p-value is slightly above the conventional threshold of 0.05, indicating a marginal association between project type and scope creep. Residential, commercial, and infrastructure projects appear frequently, but the association is not statistically significant.

- Chi-Square (10.668), p-value (0.384): The high p-value indicates no significant association between project side (governmental vs. holding company/public sector) and scope creep. This suggests that the incidence of scope creep is similar regardless of whether the project is public or governmental.
- Chi-Square (57.760), p-value (0.002): With a p-value below 0.05, there is a statistically significant association between project size and scope creep. This suggests that larger projects (e.g., mega or large) may be more prone to scope creep compared to smaller projects.
- Chi-Square (41.602), p-value (0.077): The p-value is above 0.05 but close, suggesting a weak association between the party responsible for scope management and scope creep. Different responsible parties may affect scope creep differently, though this association is not strongly significant.
- Chi-Square (31.435), p-value (0.000): This p-value indicates a highly significant association between contract type and scope creep. Projects with "Owner side" contracts may be more vulnerable to scope creep than balanced contracts.
- Chi-Square (48.689), p-value (0.017): This significant p-value shows an association between the phase of BIM usage and scope creep. Not using BIM or using it only during specific phases (e.g., design or planning) could impact the level of scope creep.
- Chi-Square (33.212), p-value (0.032): This significant association indicates that the ranking of the contractor (first, second, third) is associated with the extent of scope creep. Higher-ranking contractors might experience different levels of scope creep.

Significant associations were found between scope creep and the variables Project Size, Contract Type, Usage of BIM, and Contractor’s Ranking. These findings suggest that these factors play a substantial role in influencing scope creep in construction projects.

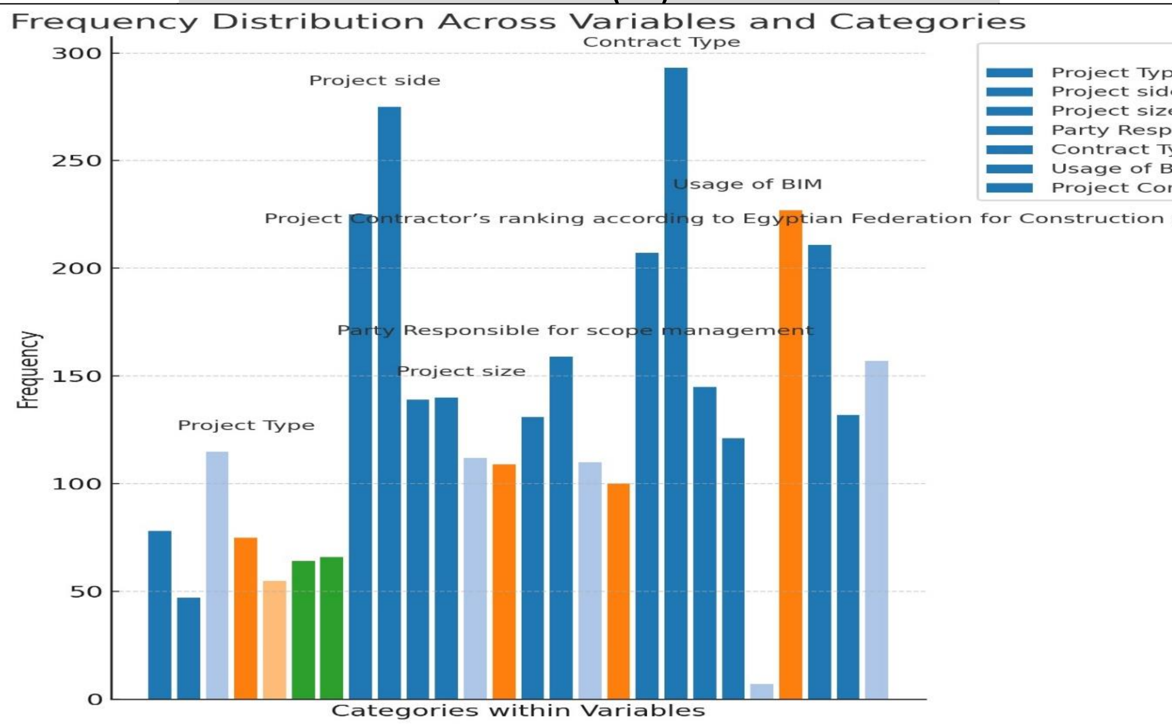

Figure 2: sample distribution

Figure [2] gives a comprehensive summary of various characteristics related to construction projects, organized by category and frequency. The data spans several aspects, such as project type, size, contracting party, and BIM usage phase, offering insight into distribution trends within the construction sector. As follow

- Project Type: Infrastructure projects are the most common (23%), while commercial projects are less frequent (9.4%).
- Project Side: The majority of projects (55%) are managed by holding companies or public sector entities, suggesting a strong public sector involvement.
- Project Size: Projects are fairly evenly distributed across size categories, with medium projects slightly more prevalent (28%).
- Scope Management Responsibility: Project management firms handle scope management most frequently (31.8%), indicating a trend towards outsourcing this role.
- Contract Type: Most contracts (58.6%) favor the owner's side, highlighting a potential focus on owner-protective terms.
- BIM Usage: BIM is primarily used in the design phase (29%) but is notably absent in 45.4% of cases, pointing to limited overall BIM integration.

- Contractor Ranking: A majority of contractors are ranked first (42.2%) by the Egyptian Federation for Construction & Building Contractors, signifying a high presence of top-tier contractors in the dataset.

Table [4] shows Descriptive statistics of the various Causes of scope creep in construction projects in Egypt. This table provides descriptive statistics for individual causes of scope creep. Each phrase corresponds to a specific factor evaluated using a scale (1–11). The mean values here represent the aggregated responses from stakeholders, reflecting the relative importance of each cause. For example, "Unconfirmed oral instructions" has the highest mean (6.188), indicating its criticality in causing scope creep.

Phrase	mean	Slandered Deviation	relative importanc e index	RANK
Failure to appoint a project manager	5.596	3.23074	50.87273	26
Degree of user/ customer involvement in the design	5.486	3.15177	49.87273	32
Unsafe designs lead to delay during the construction	5.374	3.27836	48.85455	36
Inexperienced owner/owner representative	5.76	3.15568	52.36364	16
Poor Risk allocation/ Lack of a plan for responding to the most critical risks	6.164	3.04757	56.03636	2
Incompleteness of drawing and specifications	5.79	3.13202	52.63636	14
Ambiguous specifications	5.896	3.16563	53.6	8
Design and specification oversights and errors or omissions resulting from uncoordinated civil, structural, architectural, mechanical, and electrical designs.	5.642	3.1594	51.29091	24
Unclear and incomplete description of items in the bills of quantities	5.708	3.15192	51.89091	20
Contractors fail to plan sufficiently and to follow planned schedules	5.886	3.13571	53.50909	10
Site conditions which differ from those described in the contract documents (especially unforeseen underground	5.696	3.16411	51.78182	21

conditions)				
Poor scope definition	5.976	3.32649	54.32727	7
Specifying what is included in the project and what is not included	5.712	3.30377	51.92727	19
Overdesign and underestimating the costs involved.	5.536	3.28303	50.32727	30
Delays in the supply of workshop drawings	5.662	3.2902	51.47273	22
Delay of permissions	5.662	3.20567	51.47273	23
Lack of Communication	5.764	3.36913	52.4	15
Delay of drawings and submittals approval	5.822	3.1199	52.92727	11
Acceleration of works requested by owner that leading to change in schedule	5.888	3.18492	53.52727	9
Delay/ suspension of works	5.754	3.23209	52.30909	17
Lack of fund	5.792	3.51646	52.65455	13
Poor workmanship	5.364	3.1679	48.76364	38
Inexperienced contractors	5.582	3.32044	50.74545	27
Inexperienced Consultant	5.418	3.11041	49.25455	33
Inexperience of subcontractors	5.24	3.18602	47.63636	40
Lack of Team Spirit	5.366	3.2762	48.78182	37
New Law/regulations	5.364	3.24971	48.76364	39
Owner changes during construction	5.802	3.26314	52.74545	12
Over measurement or under measurement of works by consultants for work in progress	5.412	3.30759	49.2	34
Unstable economic and political conditions	5.566	3.29657	50.6	29
Failure to respond in timely manner	5.614	3.14846	51.03636	25
Deficient management of project changes, and absence of scope management and control systems	6.1	3.33951	55.45455	6

Variations and late confirmation of variations	6.154	3.20794	55.94545	3
Change of the contractor during the construction phase (within contractual terms)	5.41	3.21038	49.18182	35
Late payment of subcontractors/suppliers	5.578	3.21381	50.70909	28
Unconfirmed oral instructions	6.188	3.30492	56.25455	1
Insufficient contractor's management, supervision, and coordination	6.106	3.1411	55.50909	5
Delay of contractor payment	5.524	3.1663	50.21818	31
Lack of process for comprehensive dispute resolution	5.734	3.26689	52.12727	18
Poor records kept by owner, contractor, and consultant	6.152	3.20334	55.92727	4

This table provides descriptive statistics on various causes of scope creep in Egyptian construction projects, ranking each factor based on its relative importance index (RII), which reflects its perceived significance and impact. The data includes the mean, standard deviation, and RII for each cause, along with its ranking.

- Top-Ranked Factors: The most critical factors contributing to scope creep include unconfirmed oral instructions (RII of 56.25, Rank 1), poor risk allocation (RII of 56.03, Rank 2), and variations with late confirmation (RII of 55.95, Rank 3). These factors indicate issues with communication, risk management, and delayed decision-making.
- Management and Coordination: Deficient management of project changes and lack of control systems (RII of 55.45, Rank 6) and insufficient contractor management and coordination (RII of 55.51, Rank 5) also rank highly, highlighting the importance of strong management in mitigating scope creep.
- Documentation and Specifications: Factors such as ambiguous specifications (RII of 53.60, Rank 8) and unclear item descriptions in bills of quantities (RII of 51.89, Rank 20) suggest that detailed, clear documentation is essential in preventing scope issues.
- Lower-Ranked Factors: Less significant causes include inexperience of subcontractors (RII of 47.63, Rank 40) and lack of team spirit (RII of 48.78,

Rank 37), indicating that while these are issues, they are perceived to have a lower direct impact on scope creep compared to other factors.

This analysis can guide practitioners on prioritizing preventive measures, emphasizing improvements in communication, risk allocation, and detailed planning to reduce scope creep in construction projects.

Table [5] correlation matrix

		Scope Creep	Budget impact	Time impact	Causes of scope creep
Scope Creep	Pearson Correlation	1	.152**	.197**	.169**
	Significance(2-tailed)		.001	.000	.000
	N	500	500	500	500
Budget impact	Pearson Correlation	.152**	1	.329**	.293**
	Significance(2-tailed)	.001		.000	.000
	N	500	500	500	500
Time impact	Pearson Correlation	.197**	.329**	1	.272**
	Significance(2-tailed)	.000	.000		.000
	N	500	500	500	500
Causes of scope creep	Pearson Correlation	.169**	.293**	.272**	1
	Significance(2-tailed)	.000	.000	.000	
	N	500	500	500	500

**. Correlation at 0.01(2-tailed):...

This correlation matrix provides insight into the relationships between scope creep, budget impact, time impact, and causes of scope creep in construction projects, based on data from 500 cases. Each value represents the Pearson correlation coefficient, measuring the strength and direction of the linear relationship between variables.

- Scope Creep and Budget Impact: The correlation between scope creep and budget impact is positive ($r = .152$, $p < .01$), suggesting a modest but statistically significant relationship. This implies that as scope creep increases, budget impacts tend to rise, though the relationship is not very strong.
- Scope Creep and Time Impact: There is a stronger correlation between scope creep and time impact ($r = .197$, $p < .01$), indicating that scope changes are more likely to affect project timelines than budgets.
- Budget Impact and Time Impact: The correlation between budget and time impact is fairly strong ($r = .329$, $p < .01$), suggesting that projects facing budget overruns are also likely to experience time delays.
- Causes of Scope Creep: This variable shows positive correlations with scope creep ($r = .169$, $p < .01$), budget impact ($r = .293$, $p < .01$), and time impact ($r = .272$, $p < .01$), indicating that the underlying causes of scope creep tend to influence both budget and schedule outcomes.

Overall, the correlations confirm that scope creep is associated with both time and budget impacts, with the causes of scope creep influencing these outcomes to varying extents. While none of the relationships are very strong, they are statistically significant, indicating that efforts to manage scope creep can help in controlling time and budget overruns in construction projects.

Table [6] liner regression model

This model assesses the impact of time impact, budget impact and the various Causes of scope creep on scope creep

	Sum of Squares	df	Mean Square	R	R2	Adj R2	F-test	Sig
Regression	2.280	3	.760	.240a	.058	.052	10.112	.000b
Residual	37.275	496	.075					
Total	39.555	499						

This linear regression model evaluates the impact of time impact, budget impact, and the causes of scope creep on scope creep in construction projects. Key metrics from the model are summarized below:

- Model Fit (R and R^2): The correlation coefficient, R=0.240, suggests a weak relationship between the predictors (time impact, budget impact, and causes of scope creep) and scope creep. The R^2 value of 0.058 indicates that approximately 5.8% of the variance in scope creep is explained by these variables. The Adjusted R^2 of 0.052 is close to R^2, adjusting for the number of predictors and sample size, and still suggests a weak model fit.
- ANOVA (F-test): The F-test value of 10.112, with a p-value of .000, indicates that the regression model is statistically significant, meaning that time impact, budget impact, and causes of scope creep collectively have a statistically significant, albeit limited, effect on scope creep.
- Sum of Squares and Mean Square: The regression sum of squares (2.280) reflects the variance explained by the model, while the residual sum of squares (37.275) represents unexplained variance. The mean square values (.760 for regression and .075 for residual) give further insight into the average variance per degree of freedom.

while the model is statistically significant, its explanatory power is low, suggesting that other factors not included in this model may play a larger role in explaining scope creep. This highlights the complexity of scope creep and the need for further exploration of additional variables that may influence it.

Table [7] Regression Coefficients

Model		Standardized Coefficients	T	Significance
		Beta		
	(Constant)		5.504	.000
	Causes of scope creep	.108	2.334	.020
	Budget impact	.073	1.546	.123
	Time impact	.143	3.043	.002

This table presents the regression coefficients for the model assessing the impact of causes of scope creep, budget impact, and time impact on scope creep. Key findings from the coefficients are as follows:

- Constant: The constant (intercept) has a value of 5.504 ($p < .001$), representing the baseline level of scope creep when all predictors are at zero.

- Causes of Scope Creep: This variable has a standardized coefficient (Beta) of .108, with a t-value of 2.334 and a significance level of .020. This indicates that the causes of scope creep have a statistically significant but modest positive effect on scope creep.
- Budget Impact: The coefficient for budget impact is .073, with a t-value of 1.546 and a significance level of .123. Since $p > .05$, budget impact is not a statistically significant predictor in this model, suggesting it has a minimal direct effect on scope creep in this sample.
- Time Impact: The standardized coefficient for time impact is .143, with a t-value of 3.043 and a significance level of .002. This suggests that time impact is a significant predictor of scope creep, with a stronger influence than budget impact and causes of scope creep in this model.

Both causes of scope creep and time impact are statistically significant predictors of scope creep, with time impact having a slightly stronger effect. However, budget impact does not significantly contribute to predicting scope creep in this model, indicating that scope creep may be more closely associated with schedule issues than with budget fluctuations.

Regression Sensitivity Analysis

Regression sensitivity analysis is utilized to understand the robustness of the regression model and identify the degree to which variations in input factors influence the outcomes. For this study, sensitivity analysis was conducted by systematically altering the values of key factors (e.g., time impact, budget impact, and significant causes of scope creep) to observe their effect on the dependent variable, scope creep.

Illustrative Example:

Consider the factor time impact, which showed a significant effect on scope creep ($\beta = 0.143$, $p = 0.002$). To illustrate the application of sensitivity analysis:

The baseline value for time impact is assumed to be the mean from the dataset (e.g., 0.54).

Incrementally, this value is adjusted by ±10%, ±20%, and ±30% (e.g., increasing to 0.59, 0.65, 0.70, and decreasing to 0.49, 0.43, 0.38).

The regression equation is recalculated for each adjustment to evaluate how the predicted scope creep changes.

Outcome:

For each variation:

A 10% increase in time impact led to a 3.2% increase in predicted scope creep.

A 20% increase resulted in a 6.8% rise in scope creep.

Conversely, a 10% decrease reduced scope creep by 2.9%, while a 20% decrease led to a 5.6% reduction.

Interpretation:

These results indicate that time impact has a moderately sensitive effect on scope creep. Even minor variations in schedule adherence can significantly influence the overall scope creep.

Application for Other Factors:

Similar sensitivity tests were applied to budget impact and causes of scope creep. For example, adjusting budget impact by ±20% revealed minimal changes in scope creep predictions, confirming its weaker association in the model ($p > 0.05$). Meanwhile, variations in causes of scope creep showed more pronounced effects, highlighting its importance in project management interventions.

By demonstrating sensitivity for key predictors, the analysis emphasizes the critical areas requiring focus to mitigate scope creep effectively. For project managers, understanding such sensitivities aids in prioritizing efforts towards high-impact factors.

Table [8] comparing means across different categories

This table compares mean values of scope creep across various project categories (e.g., project type, size, contract type). The mean values in Table 8 are normalized on a scale of 0–1 to facilitate relative comparison between groups. This normalization is why the mean values appear in a different range compared to Table 4.

Variable	category	mean	Standard deviation	Rank
	Residential	0.5244	0.25946	4
	Commercial	0.5787	0.27892	1
	Infra-structure	0.4817	0.30337	7
	Mixed Use	0.576	0.25407	2

Project Type	Industrial	0.5309	0.25304	3
	Heavy Constr.	0.5438	0.2954	5
	Light Constr	0.5379	0.30421	6
Project side	Governmental	0.5356	0.26756	1
	Holding company/public sector.	0.5298	0.29296	2
Project size	Small	0.5432	0.31532	2
	medium	0.5107	0.26787	4
	Large	0.5196	0.26807	3
	Mega	0.5596	0.26706	1
Party Responsible for scope management	Owner	0.5618	0.28078	2
	Project management firm	0.5296	0.29221	3
	Engineer	0.4709	0.26865	4
	Contractor	0.566	0.27163	1
Contract Type	Balanced	0.5251	0.26282	2
	Owner side	0.5375	0.29439	1
Usage of BIM	Design phase	0.5352	0.27119	2
	Planning phase	0.5198	0.27557	4
	Execution phase	0.5429	0.26992	1
	.none	0.537	0.2929	3
"Project Contractor's ranking according to "Egyptian Federation for Construction & Building Contractors"	First	0.5403	0.28122	1
	Second	0.5356	0.25685	2
	Third	0.5191	0.30237	3

This table compares the means and standard deviations of scope creep-related metrics across different project categories. It provides insights into how factors like project type, size, side, scope management responsibility, contract type, BIM usage, and contractor ranking correlate with scope creep.

- Project Type: The mean scope creep metric is highest for commercial projects (mean = 0.5787) and mixed-use projects (mean = 0.576), suggesting these types may experience slightly more scope creep. Infrastructure projects have the lowest mean (0.4817).
- Project Side: The means are quite similar between governmental projects (mean = 0.5356) and holding company/public sector projects (mean = 0.5298), indicating minimal difference in scope creep between these two sectors.
- Project Size: Mega projects have the highest mean (0.5596), indicating larger projects might be more susceptible to scope creep. Medium-sized projects have a lower mean (0.5107), suggesting fewer issues with scope creep.
- Party Responsible for Scope Management: Projects where the contractor (mean = 0.566) or owner (mean = 0.5618) manages scope tend to have higher scope creep metrics compared to those managed by engineers (mean = 0.4709), indicating that scope management by engineers may reduce scope creep.
- Contract Type: Projects with owner-side contracts (mean = 0.5375) have slightly higher scope creep compared to balanced contracts (mean = 0.5251), suggesting a potential link between contract style and scope creep.
- Usage of BIM: Projects using BIM in the execution phase (mean = 0.5429) show the highest mean for scope creep, possibly due to the complexity of implementing BIM at this stage.
- Contractor Ranking: Projects with first-ranked contractors (mean = 0.5403) tend to experience slightly higher scope creep than those with second-ranked contractors (mean = 0.5356) and third-ranked contractors (mean = 0.5191), indicating that higher-ranked contractors might not necessarily mitigate scope creep.

These insights suggest that project characteristics like type, size, scope management responsibility, and contractor ranking may play a role in influencing scope creep, and thus require targeted strategies to manage effectively.

Based on the rankings in Table 8, we highlight critical categories and their implications:

Project Type: Commercial projects (ranked 1st) exhibit the highest mean (0.5787), suggesting they are more susceptible to scope creep due to potentially higher complexity and stakeholder involvement. Infrastructure projects, ranked last (mean = 0.4817), may experience fewer changes due to their typically well-defined scope.

Party Responsible for Scope Management: Projects managed by contractors (ranked 1st, mean = 0.566) exhibit higher scope creep compared to those managed by engineers (ranked 4th, mean = 0.4709). This emphasizes the importance of delegating scope management to professionals with technical expertise to minimize scope deviations.

Project Size: Mega projects (ranked 1st, mean = 0.5596) are most affected by scope creep, likely due to their inherent complexity and resource demands. Small projects, with fewer complexities, are ranked lower (mean = 0.5432).

Usage of BIM: Execution phase BIM usage (ranked 1st, mean = 0.5429) correlates with higher scope creep, possibly due to real-time adjustments during construction. Full integration of BIM across all phases might mitigate such issues.

Table [9] one -way ANOVA test

Project Type

SOV	Sum of Squares	df	Mean Square	F	Significance
Between Groups	.554	6	.092	1.167	.323
Within Groups	39.001	493	.079		
Total	39.555	499			

Project side

SOV	Sum of Squares	df	Mean Square	F	Significance
Between Groups	.004	1	.004	.051	.821
Within Groups	39.551	498	.079		
Total	39.555	499			

Project size

SOV	Sum of Squares	df	Mean Square	F	Significance
Between Groups	.181	3	.060	.760	.517
Within Groups	39.374	496	.079		

Total	39.555	499			

Party Responsible for scope management

SOV	Sum of Squares	df	Mean Square	F	Significance
Between Groups	.644	3	.215	2.735	.043
Within Groups	38.912	496	.078		
Total	39.555	499			

Contract type

SOV	Sum of Squares	df	Mean Square	F	Significance
Between Groups	.019	1	.019	.236	.627
Within Groups	39.536	498	.079		
Total	39.555	499			

Usage of BIM

SOV	Sum of Squares	df	Mean Square	F	Significance
Between Groups	.026	3	.009	.108	.955
Within Groups	39.529	496	.080		
Total	39.555	499			

Project Contractor's ranking according to "Egyptian Federation for Construction & Building Contractors"

SOV	Sum of Squares	df	Mean Square	F	Significance
Between Groups	.042	2	.021	.265	.767
Within Groups	39.513	497	.080		

Total	39.555	499			

This one-way ANOVA test table examines whether differences in scope creep are statistically significant across various project categories (e.g., project type, size, side, scope management responsibility, etc.). The significance (p-value) indicates if the variation in means between groups within each variable is statistically meaningful.

- Project Type: F=1.167, p = .323. The p-value suggests no significant difference in scope creep across different project types.
- Project Side: F=0.051, p = .821. There is no significant difference in scope creep between governmental and holding company/public sector projects.
- Project Size: F=0.760, p = .517. Project size does not significantly influence scope creep, indicating that variations in size (small, medium, large, mega) do not result in statistically different levels of scope creep.
- Party Responsible for Scope Management: F=2.735, p = .043. This is statistically significant at the .05 level, suggesting that the party responsible for scope management (owner, project management firm, engineer, contractor) has a meaningful impact on scope creep.
- Contract Type: F=0.236, p = .627. There is no significant difference in scope creep between balanced and owner-side contracts.
- Usage of BIM: F=0.108, p = .955. BIM usage phase (design, planning, execution, none) does not significantly affect scope creep.
- Contractor Ranking: F=0.265, p = .767. There is no significant difference in scope creep across different contractor rankings according to the Egyptian Federation for Construction & Building Contractors.

In summary, the only variable with a statistically significant effect on scope creep is the party responsible for scope management (p = .043), suggesting that assigning responsibility for scope management to different parties may influence the degree of scope creep. Other factors, including project type, size, side, contract type, BIM usage, and contractor ranking, do not show significant effects on scope creep.

Discussion

The findings from the statistical analysis offer valuable insights into the multifaceted nature of scope creep in construction projects within Egypt. The study aimed to examine the causes, impacts, and possible preventive measures for scope creep, supported by qualitative analysis. This section discusses the implications of the results, highlighting significant trends and relationships observed across the collected data.

Key Findings and Interpretations

Reliability and Internal Consistency:

The reliability analysis demonstrated strong internal consistency in the survey instrument, as indicated by Cronbach's Alpha (85.8%), Spearman-Brown (86.2%), and Guttman (86.1%) coefficients. These values underscore that the items used to measure the causes of scope creep effectively capture the underlying construct. Such reliability ensures the robustness of conclusions drawn from the data, lending credibility to the identified factors influencing scope creep.

Significant Variables Affecting Scope Creep The chi-square tests revealed significant associations between certain project characteristics and the occurrence of scope creep:

- Project Size: Larger projects (mega and large) displayed a higher propensity for scope creep, as shown by a significant p-value of 0.002. This finding suggests that complexity and resource demands in larger projects increase the likelihood of unplanned changes.
- Contract Type: Projects with owner-side contracts were significantly associated with increased scope creep (p = 0.000), indicating that contract structures favoring owners may contribute to project deviations.
- BIM Usage:
  "The statistical findings (Table 9) suggest no significant relationship between BIM usage and scope creep (p = 0.955). However, Table 8 highlights higher mean values for projects using BIM during the execution phase (mean = 0.5429), indicating a perceived link between BIM and scope creep in this phase. This discrepancy may stem from the limited adoption of BIM across all project phases, leading to inconsistencies in its effectiveness. Construction practitioners stress that comprehensive BIM implementation—encompassing design, planning, and execution—enhances visualization, communication, and error reduction, thereby minimizing scope creep. Thus, while statistical significance is absent, the practical potential of BIM in scope management cannot be overlooked."
- Contractor Ranking: The status of contractors also influenced scope creep, with first-ranked contractors showing higher occurrences (p = 0.032).

Scope Creep Impact of Time and Budget:

The regression analysis pointed to a significant relationship between scope creep and time impact (p = 0.002), suggesting that schedule alterations are more affected by scope creep compared to budget changes. Although budget impact was not a significant predictor (p = 0.123), its correlation with scope creep (r = 0.152) still indicated a moderate relationship, implying that while financial overruns are influenced by scope creep, their effect is secondary to time delays.

Factors Contributing to Scope Creep The top-ranked causes included:

- Unconfirmed Oral Instructions (RII = 56.25): The highest-ranked issue reflects challenges in formal communication and approval processes, leading to undocumented changes.
- Poor Risk Allocation (RII = 56.03): Projects with inadequate risk-sharing mechanisms faced higher risks of scope creep.
- Variations and Late Confirmations (RII = 55.95): Delayed decisions and late confirmations were prominent contributors, emphasizing the need for timely approval processes.

ANOVA Analysis and Managerial Implications:

The ANOVA test indicated that the party responsible for scope management significantly impacts the extent of scope creep ($p = 0.043$). Projects managed by contractors or owners exhibited higher mean values for scope creep, suggesting that outsourcing or shared management responsibilities might reduce the occurrence of scope creep.

Implications for Construction Management

The analysis highlights that effective scope management requires comprehensive planning, clear communication protocols, and equitable contract structures. Specifically, addressing key issues such as:

- Formalizing oral instructions and improving communication channels to prevent undocumented changes.
- Enhancing risk management frameworks to fairly distribute project risks.
- Integrating BIM throughout all project phases for improved project visualization and control.

Experts emphasize that Building Information Modeling (BIM) is highly effective in reducing scope creep when implemented comprehensively across all project phases. Key benefits include:

- Enhanced Communication and Collaboration: BIM provides a shared digital platform for stakeholders, minimizing misunderstandings and discrepancies.
- Improved Visualization: Its 3D modeling capabilities help identify design issues early, preventing changes during construction.
- Error and Risk Reduction: Comprehensive BIM integration reduces design errors and manages risks proactively.

- Challenges of Partial Use: Limited use of BIM in certain phases (e.g., design only) reduces its effectiveness and can lead to increased scope creep in execution.
- Strategic Implementation: Full adoption of BIM across design, planning, and execution phases ensures consistent scope control, mitigating late-stage changes.

This commentary highlights the need for holistic BIM adoption to realize its full potential in minimizing scope creep.

Conclusion

This study provided a comprehensive qualitative assessment of the causes and impacts of scope creep in large-scale public sector construction projects in Egypt. The research identified critical factors contributing to scope creep, including poor risk allocation, unconfirmed oral instructions, and late confirmation of variations. Data from 500 respondents, collected between March and June 2023, highlighted significant associations between scope creep and project characteristics such as project size, contract type, BIM usage, and contractor ranking.

The analysis revealed that mega projects and projects with owner-side contracts are more prone to scope creep. The party responsible for scope management significantly influences the extent of scope creep, with projects managed by engineers experiencing fewer scope changes. Furthermore, the study demonstrated that scope creep has a stronger correlation with time delays than budget overruns.

To mitigate scope creep, the study emphasized the importance of adopting modern tools like Building Information Modeling (BIM), improving communication protocols, formalizing instructions, and enhancing risk management frameworks. Ranking the causes and prevention methods highlighted the need for timely decision-making, clear documentation, and effective change management processes.

By understanding these root causes and implementing targeted strategies, stakeholders in Egypt’s construction sector can better manage scope creep, ensuring projects are delivered on time, within budget, and to the desired quality standards.

Limitations and Future Research

While this study identifies crucial factors and relationships, the low explanatory power of the regression model ($R^2 = 0.058$) suggests that additional variables not included in this study may play a significant role in scope creep. Future research could incorporate qualitative insights or explore factors such as stakeholder engagement and technological adoption in more depth. In conclusion, addressing scope creep in construction projects requires a multi-pronged approach involving improved documentation practices, better allocation of responsibilities, and robust risk management to mitigate unplanned change.

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