Hindawi
Advances in Civil Engineering
Volume 2021, Article ID 4991204, 15 pages
https://doi.org/10.1155/2021/4991204

Research Article

Analysis of Cost Overrun and Schedule Delays of Infrastructure Projects in Low Income Economies: Case Studies in Ethiopia

Solomon Melaku Belay ,[1] Seifu Tilahun,[1] Mitiku Yehualaw,[1] Jose Matos,[2] Helder Sousa ,[2] and Endalew Temesgen Workneh[3]

[1]*Faculty of Civil and Water Resource Engineering, Bahir Dar Institute of Technology, Bahir Dar, Ethiopia*
[2]*Department of Civil Engineering, University of Minho, Guimaraes, Portugal*
[3]*Construction Works Regulatory Authority, Addis Ababa, Ethiopia*

Correspondence should be addressed to Solomon Melaku Belay; solomon.melaku@bdu.edu.et

Received 18 September 2021; Revised 25 October 2021; Accepted 27 October 2021; Published 17 November 2021

Academic Editor: Heap-Yih (John) Chong

Today, several developing countries struggle to improve the cost and time performances of major infrastructure works due to various reasons. Cost overrun and delay are one of the major challenges being faced by the construction and infrastructure sector. Hence, the aim of this study is to explore the extent of cost overrun and schedule delays in building and road infrastructure projects across the Ethiopian construction industry. Primary data were collected through a structured questionnaire survey to evaluate the potential risks leading to those challenges. Various data analysis tools were employed, to investigate the critical causes of cost overrun and delays in infrastructure projects. The findings reveal that the minimum cost overrun for building construction projects is found to be 2%, whereas the maximum and average cost overruns are 248% and 35%, respectively. For road infrastructure projects, the minimum, maximum, and average cost overruns are found to be 1%, 61%, and 18%, respectively. Similarly, the minimum, maximum, and average delays recorded in building construction projects are 9%, 802%, and 143%, respectively, whereas, in road infrastructure projects, the minimum delay is found to be 3%, the maximum delay is 312%, and an average schedule delay of 110% is recorded. In addition, the top risk factors leading to cost overrun in infrastructure projects are inflation, inaccurate cost estimates, and variations, whereas the major risks causing schedule delays are variations, economic conditions, and escalation of material prices. Further, practical implications and key recommendations were provided to curb cost overrun and delay in infrastructure projects.

1. Introduction

The infrastructure and construction sector in the Sub-Saharan Africa region faces several problems and challenges ranging from quality work to severe budget constraints [1, 2]. These challenges could lead to several instances and disputes among parties across the project life cycle [3]. One of the most common challenges the construction industry is confronting cost overrun and schedule delays in various infrastructure projects. Consequently, these problems are often regarded as a very common phenomenon in the majority of projects across developing countries [4].

Prior studies highlighted the negative impacts of cost overrun and schedule delays in numerous developing countries, such as Tanzania [5], Pakistan [6], South Africa [7], Iran [8], and Malaysia and Ghana [9]. These studies explored the negative impacts of cost overrun and schedule delays on various stakeholders involving in construction projects including owners, contractors, and the practitioners' in general. For instance, to contractors, it amounts to profit lose due to inferior performance and defamation that could threaten the firm's chances of participating in further contracts, if at fault. To client/owner, both problems in infrastructure projects indicate increased budget over the initially agreed contract amount at the onset, resulting in bad investment return. To practitioners, cost overrun and schedule delay imply failure to deliver the required work as per the specification and could well tarnish their reputations and result in loss of confidence by the key business owners in general.

One of the most important features to consider to enhance the overall performance of construction projects in low income economies and particularly in the Ethiopian construction industry is by exploring the aspects of cost overrun and schedule delays using actual project data. Hence, the specific objectives of this study are threefold: (1) examine the extent of cost overrun and schedule delays in infrastructure projects; (2) investigate the risk factors leading to both challenges; and (3) provide comprehensive critical recommended actions and practical implications to curb the problems imposed by potential cost overrun and schedule delays in construction projects. The findings of this paper provide a vital science-based data to various stakeholders practicing in the Ethiopian construction sector and developing countries in general.

2. Literature Review

In public construction projects, evaluating performance of each activity throughout the project life cycle is vital for the successful delivery of infrastructures [10]. An infrastructure project is considered successful when it is completed in the allotted time, with agreed contract budget, and within the depicted specifications [11]. It is also important to denote that successful delivery of construction projects requires the utmost cooperation and coordination of project team across the project life cycle [12, 13].

In contrast, many construction projects in different regions fail to meet the success criteria due to various challenges, including low level of cost and time performances [14]. Previous studies highlighted a number of causes and risk factors leading to poor cost and time performances, including different aspects of cost overrun and schedule delays in both developing and developed nations. For instance, In Jordan, the top causes of cost overrun and delay are lack of experienced construction manager, lowest bidder selection, and funding shortage by owner [15]. In India, inadequate contractor's work and experience and also poor risk management and ignorance and poor communication and coordination with the participants of the construction project are considered as major causes of poor cost and time performance [16], whereas delay in progress payment by client, changing orders by client during construction, and poor site management are regarded as the top causes in Iran [17].

Consequently, its vital to investigate the key risk factors and causes of cost overruns and schedule delays from a country specific perspective and provide key practical recommendations and check lists to curb the underlying root causes and ensure success in public infrastructure projects.

2.1. Cost Overrun in Construction Projects

2.1. Cost Overrun in Construction Projects. In the context of construction projects, cost overruns can be expressed as the excess of actual project completion cost over contract budget amount [18]. Cost overrun is computed by the initial estimated cost, and total completion cost incurred during commissioning of the project. The difference between estimated and completion cost is termed as the magnitude of the cost overrun. In relation to this, cost overrun can be obtained by the positive difference between the completion cost of a construction project during commissioning and the contract amount agreed by the major parties during the contract signing and commencement of projects. The difference between agreed contract sum and final project cost can be expressed as [19]

$$\text{cost ratio (CR)} = \frac{\text{completion cost}}{\text{contract amount}}. \quad (1)$$

The ideal CR is 1.0, so, any value above this can be considered as a cost overrun.

This calculation can be converted to a percentage for ease of comparison

$$\text{Cost overrun} = \frac{\text{Completion Cost-Original Contract Cost}}{\text{Original Contract Cost}}. \quad (2)$$

It is important to denote that delivering a construction project within the planned contract budget is one of the main success criteria in construction projects.

2.2. Risk Factors Leading to Cost Overrun. Several factors affect the extent of cost overrun and schedule delays in the construction sector. These risk factors could be classified as factors related to consultant, contractor, design parameters, and information, factors related to market conditions (external factors), and factors related to project characteristics (Table 1).

2.3. Schedule Delay in Construction Projects. Construction delays are often a result of a mismanagement and can be seen as a risk for infrastructure projects, which if identified, analyzed, and managed in a systematic process of various phases of the project life cycle, could be managed, minimized, and mitigated [15]. Delay in construction project has a negative impact to key stakeholders in terms of growth in adversarial relationships, claims, litigation, arbitration, and cash-flow challenges [33]. A construction project may be regarded as a successful endeavor until it satisfies the cost, time, and quality limitations applied to it. However, it is not uncommon to see a construction project failing to achieve its goal within the specified cost, time, and quality. In order to counter the unforeseen delays beforehand the realm of "Project management" is resorted which helps mitigate the delays [37, 38].

2.4. Risks Leading to Schedule Delay in Construction Projects. Time overrun is any delay beyond the baseline construction schedule; time delay frequently occurs in all phases of a construction project and consequently increases the project total duration. Construction delays are usually caused by either the contractual parties such as client, contractor, and consultant or external factors that are beyond the control of

Table 1: Risk factors leading to cost overrun.

Category	Risks leading to cost overrun	Ref.
Client/owner	Type of client (public/private)	[3, 20, 21]
	Client's experience level	[8, 22]
	Client's initial brief (clear scope definition)	[20, 22]
	Effective communication between client and design team	[8, 23, 24]
	Client attitude towards changes (variations)	[25]
	Client's budget/cash-flow constraints	[7, 21, 25]
Consultant	Clear and detailed drawings and specification	[7, 22, 26]
	Competency and experience of the consulting firm	[20, 25]
	Availability of database for historical cost data	[21]
	Accuracy and reliability of cost related information	[22, 23]
	Project's team experience on project type	[9, 21]
	Completeness of cost information/estimation	[5, 14, 22]
	The estimating method used	[3]
	Level of involvement of the project manager	[9, 20]
	Quality of information and requirements between experts	[7, 22, 26]
	Time allowed for preparing cost estimates	[8]
	Risk sharing between the parties	[9, 20, 27]
Contractor	Clarity of project information before execution	[10, 28]
	Complexity of design and construction	[29]
	Clarity and quality of drawings before tendering	[3, 22, 30]
	Quality of information flow during execution	[9, 26, 31]]
	Availability of resources (labor, material, and equipment)	[32]
	Accuracy of bill of quantities	[8, 31]
	Method of construction and construction technique	[5, 7, 20]
	Type of project (residential, commercial)	[28, 33]
	Type of project structure (concrete, steel, masonry)	[26, 32]
	Project size and complexity	[33]
	Site conditions (topography, hot area, etc.)	[23]
	Site constrains (access, storage, electricity, etc.)	[21, 22, 30]
	Changes in project schedule, phasing requirements	[22, 31]
Contract administration	Financial status of the owner	[5, 32]
	Type of currency	[7, 9, 10]
	Method of payments and its approval period	[33]
	Delivery method and contractual arrangement	[14, 33]
	Advanced payment arrangement	[8, 34]
	Method of solving disputes	[9, 28, 29]
	Liquidated damage amount	[23]
	Amount and percentage of retention	[33, 34]
	Type and value of insurance	[3]
Project risks	Social aspects of the project (hot spots, near settlements)	[21, 29, 32]
	Segmentation (limitation of movement between areas)	[20, 33]
	Political situation of the country	[7]
	Expected natural forces (floods, storms)	[33, 35]
Market conditions (external factors)	Level of workmanship (productivity, performance)	[30, 35, 36]
	Market conditions/economic climate	[7, 14]
	Level of competition (number of competitors)	[33]
	Inflation (increase in unit cost of construction materials)	[20, 23, 26]
	Material availability (including raw materials)	[9, 22, 33]
	Labor availability and cost	[7, 23]
	Currency exchange fluctuation	[20]
	Impact of government regulations requirement	[14]
	Unforeseeable fluctuation in labor, materials prices	[10, 26, 27]
	Machinery (cost/availability/performance)	[21, 28]

the parties or force majeure. Table 2 illustrates the critical risks leading to delay in construction projects.

3. Methodology

This section is comprised of the overall research design, data collection, and analysis techniques used in the current study.

3.1. Data Collection. The primary data collection is collected using a structure questionnaire survey from various professionals in the Ethiopian construction sector. Along with the survey, primary historic cost and time data of various construction projects (building and road) have also been collected and used for this study. A mix of both qualitative and quantitative methodologies was employed to collect relevant data in numerous infrastructure projects. The combination of both suitable methods is suitable for data collection to answer the specific objectives as they provide an opportunity to get access to more data that could not helpful for scientific statistical analysis (Figure 1).

For the case of determining the extent of cost overrun and schedule delays, relevant project data including project documentation, archival records, survey, interviews, expert observations, participant observations, and physical artifacts were collected for both building and road projects across the Ethiopian construction sector. This in turn made the data collection complex because of the challenges to get historical data of completed projects from various sources. Each of the sources of data collection has its strengths and weaknesses while combining all the sources of the evidence is observed to provide better results instead of a single source of evidence. Recent studies also supported the use of multiple data collection and analysis tools for similar cost and time management studies [42–44].

Moreover, the current study employed various sources of data collection and analysis tools to validate for triangulation of the research techniques and therefore, the current study carefully considered and executed all possible data sources and project information to strengthen the analysis and provide relevant recommended actions, as well as comprehensive conclusion.

3.2. Sampling Design and Determination. Sampling is the selection of a subset (a statistical sample) of expert participants from within a certain statistical variable as a precondition to analyze the required data [13]. In this study, during the nature of the topic, a purposive sampling technique was employed to collect relevant data from experts working in various positions across the Ethiopian construction industry. Consequently, a total of 106 primary project data (both building and road projects) were collected to investigate the degree and severity of cost overrun and schedule delays in a larger scale.

Similarly, a total of 52 practitioners consisting of key stakeholders, including clients, contractors, consultants, and academia, participated to examine the critical risk factors leading to both problems in the Ethiopian construction industry. Similar studies also confirm that this sample size is adequate for analysis [45–47]. From the respondents, 2 have a PhD degree, 39 have MSc, and the remaining 13 have BSc degrees in civil engineering. Similarly, from the perspective of relevant experience in the construction industry, 6 respondents have more than 15 years of experience, whereas 5 respondents (11 to 15 years), 20 respondents (6 to 10 years), and 21 respondents have 0 to 5 years of experience in the construction industry.

3.3. Data Analysis. Data analysis is the process of analyzing, testing, and connecting a number of qualitative and/or quantitative data to address specific objectives and research questions [48]. For this study, the data collected from questionnaire survey is analyzed using popular statistical analysis tool, the Statistical Package for Social Science (SPSS), version 23. To ensure the consistency of the quantitative data and to make the interpretation of results more meaningful, several initial processes were undertaken. These processes include categorizing data, editing data, coding data, and creating data files. For this study different statistical tools are implemented, including Mean Score ranking, Chi-Square Technique, Kendall's Coefficient of Concordance, and Spearman's rank correlation.

3.4. Mean Score Ranking. Mean score (M) is one of the popular statistical methods that utilizes the average (mean) of a questionnaire survey response which were filled using a 5-point Likert's scale. As shown in equation (2), M is calculated by averaging all responses in an item.

$$M = \frac{\sum f \times S}{N} \quad (0 < M \leq 5), \tag{3}$$

where f is the frequency of responses, and S is the score given to each attribute by a respondent from 1 to 5.

w is weighting given to each factor by respondents ranging from 1 to 5, where 1 = number of respondents for very low important, 2 = number of respondents for low important, 3 = number of respondents for neutral, 4 = number of respondents for high important, and 5 = number of respondents for very high important. The M value ranges in $0 <$ Mean Score ≤ 1.

3.5. Chi-Square Test. The Chi-Square statistic is commonly used for testing relationships between categorical variables. The null hypothesis of the Chi-Square test is that no relationship exists on the categorical variables in the population; they are independent.

The Chi-Square statistic is adopted to evaluate Tests of Independence when using a crosstabulation (also known as a bivariate table). Crosstabulation presents the distributions of two categorical variables (stakeholders) simultaneously, with the intersections of the stakeholders appearing in the cells of the table. The Test of Independence assesses whether an association exists between the two stakeholders by comparing the observed pattern of responses in the cells to the pattern that would be expected if the variables were truly

Table 2: Risk factors leading to schedule delays in infrastructure projects.

Category	Risks leading to cost overrun	Ref.
Client/owner related	Unrealistic contract durations imposed by owner	[7, 39]
	Poorly defined scope	[9, 16]
	Client/owner interference	[22, 33, 39]
	Variations (design changes/extra work)	[38]
	Poor communication between project team	[37, 40]
	Slow decision making by owner	[33]
Consultant related	Delays in payments	[5, 41]
	Underestimation of project cost	[37, 40]
	Poor inspection or supervision	[15]
	Poor contract management	[40]
	Delay in preparation and approval of drawings	[5, 38]
	Waiting time for approval of tests and inspections	[33, 37]
	Lack of competency and experience of consultant	[9, 20, 33]
Contractor related	Poor site management	[28, 37]
	Financial problems/constraints	[5, 35, 37]
	Construction methods	[9, 33]
	Poor planning (materials and labor estimation)	[3, 15, 38]
	Poor communication and misunderstanding	[6, 17, 35]
	Subcontractors (lack of experience, etc.)	[7, 33]
	Inadequate experience and competency of contractor	[5, 35, 41]
Government related	Slow permits by government agencies	[9, 20]
	Bureaucracies in government agencies	[9]
	Political interference	[5, 7]
	Economic conditions (currencies, inflation)	[7, 25]
	Ineffective legislative regulations	[33]
Materials related	Shortage of construction materials	[5, 15]
	Escalation of material prices	[39]
	Delay of material delivery on-site	[28, 32, 33]
	Poor material procurement techniques	[7, 37]
	Low quality of materials	[9, 25, 35]
Contractual related	Major claims and disputes	[17]
	Inappropriate type of contract (procurement process)	[7, 9, 20]
	Poor collaboration between parties	[20, 33]

independent of each other. The calculation of the Chi-Square statistic is quite straightforward and intuitive:

$$x^2 = \sum \frac{(f_o - f_e)^2}{f_e}, \tag{4}$$

where f_o = the observed frequency (the observed counts in the cells) and f_e = the expected frequency if no relationship existed between the variables.

As depicted in the formula, the Chi-Square statistic is based on the difference between what is actually observed in the data and what would be expected if there was truly no relationship between the variables.

3.6. Kendall's Coefficient of Concordance. Kendall's coefficient of concordance, also known as Kendall's W, is a measure of agreement among different stakeholders. Assume there are m stakeholders rating k factors in rank order from 1 to k. Let r_{ij} = the rating stakeholder j given to factor i.

For each factor i, let $R_i = \sum_{j=1}^{m} r_{ij}$. Let $\overline{R}$ be the mean of the Ri and let R be the squared deviation, i.e.,

$$R = \sum_{i=1}^{k} (R_i - \overline{R}). \tag{5}$$

Kendall's W can be defined by

$$W = \frac{12R}{m^{2(k^3-k)}}. \tag{6}$$

3.7. Spearman's Rank Correlation. Spearman's rank correlation is the nonparametric version of the Pearson rank correlation. Spearman's correlation coefficient (ρ, also signified by r_s) measures the strength and direction of association between two ranked variables. Spearman's rank correlation can be computed using the following formula:

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}, \tag{7}$$

where ρ = Spearman rank correlation; d_i = the difference between the ranks of corresponding variables; n = number of observations.

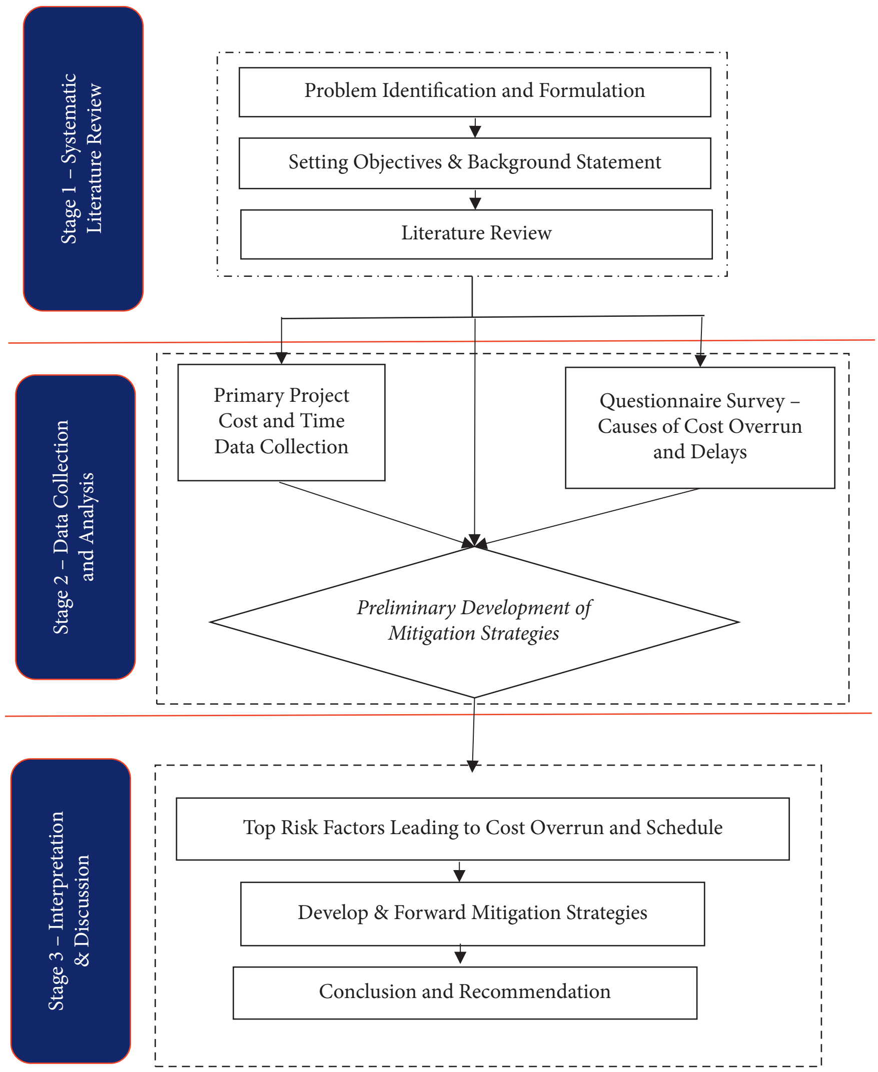

Figure 1: Research methodology flowchart.

4. Findings

This section describes the overall results obtained through various data collection methods and analyzed using statistical analysis tools.

4.1. Cost Overrun in Construction Projects

4.1.1. Building Projects. The first part of the analysis covers the cost data (contract amount and executed amount) of building construction projects collected throughout the country. The case studies involved for the analysis are illustrated in Table 3 below.

The first specific objective of this project work is to examine the extent of cost overrun and schedule delay in the Ethiopian building and road construction sectors. In this respect, for the cost overrun in building construction projects with contract amounts greater than 100 million, the minimum cost overrun for building projects is found to be 3% and the maximum amount is 71%. The result also reveals that the average cost overrun of these projects is found to be 26%. Similarly, the same computation has been done for contract amounts between 50 million and 100 million. In this case, the minimum cost overrun is found to be 4%, whereas the maximum cost overrun of 105% is recorded accordingly. Hence, the average cost overrun value will be 35%. Finally, for building construction projects with contract amounts <50 mil, the minimum, maximum, and average cost overruns are 2%, 42%, and 248%, respectively.

4.2. Road Infrastructure Projects. For the case of road projects, representative project data were collected mainly from the Ethiopian Road Authority (ERA). More so, additional road project data is also collected from Addis Ababa City Road Authority (ACRA), and the remaining data is collected using questionnaire survey from various contractors, clients, and consultants (Table 4).

For road construction projects, the minimum recorded cost overrun is 1% and the maximum cost overrun is found to be 61%. On average, the cost overrun for road projects is computed as 18%.

Table 3: Cost data for building construction projects.

Project	Contract amount	Cost overrun (%)
Medical faculty dormitory lot 2	498,310,069.60	16
Medical faculty dormitory building lot 1	496,173,245.40	8
Auditorium building	370,264,019.53	10
ICT building	335,260,766.15	37
Ethiopian institute of textile and fashion technology lot I	277,910,931.26	18
Sport academy	190,226,678.00	30
Medical faculty dormitory building lot 3 library and café	179,124,014.60	28
Gondar university expansion	150,382,372.74	71
BIT library building lot II	130,153,029.48	46
Awi zone administration office	120,607,551.16	6
Preclinical laboratory	116,022,883.93	43
EiTEX class room and clinic	115,433,696.00	16
Oromo public office building	106,031,742.33	3
Kombolcha city administration	99,259,111.12	6
Gondar university expansion lot II	98,592,813.82	47
ANRS trading industry development office in Gondar	91,188,136.36	29
Dormitory building for IOTEX lot 1	89718604.82	40
ANRS trading industry development office in Bahir Dar	89,002,144.52	27
Medical dormitory building	85,314,737.00	15
Medium industrial complex building	79,294,031.64	28
East Gojjam high court	78,841,316	79
Industry complex	77,393,169.15	23
Medium and higher industrial shade	77,393,155.16	85
Staff condominium lot II	76,980,110.79	105
Agricultural and science dormitory	74260442.7	54
IOT class room and laboratory	67942872.39	9
BIT class room and laboratory	66,783,018.96	4
Condominium phase II	56,642,580.71	20
Industry and urban development office	55,796,487.28	12
Debre Birhan industrial shade	55,796,487.28	17
Staff apartment II	50,995,495.00	25
Medical faculty staff apartment I	50,568,855.00	25
Bibugn primary hospital	47,446,951.37	7
Staff condominium lot I	44,015,747.96	16
AHWCE office	40,979,133.33	43
Debretabor administration office	40,154,960.66	54
Integrated land office (Amhara)	39,965,322.64	18
G+4 integrated land office in Gondar	39,965,322.64	25
Class rooms and lecture hall	32,850,712.29	42
OR center renovation	31,996,029.80	248
Wegeda secondary hospital	19,392,266.86	4
Gondar industry and urban development office	18,369,865.46	2
Students dormitory	12,491,518.24	28
ANRS education office Dessie	11,516,771.14	39
Store and office buildings	6,777,462.85	46

4.3. Schedule Delays in Construction Projects

4.3.1. Building Projects. The second specific objective of this project work is to compute the extent of schedule delays in both building and road construction projects. Similar to the previous computations, project contract and completion data were collected for building construction projects throughout the country. The time data for building projects with various contract amounts is shown in Table 5.

For infrastructure construction projects that have contract amounts greater than 100 million, the result illustrated that the minimum delay is 41%, whereas the maximum schedule delay is computed to be 327%. Finally, the average schedule delay is found to be 175%. In the case of building projects with contract amounts between 50 million and 100 million, the minimum project schedule is 11% and the maximum delay is 300%.

Moreover, the average schedule delay for these projects is found to be 114%. Further, the schedule delay for building projects with contract amounts less than 50 million ETB is computed as per the project time data presented in Table 5. From the computations, the minimum, maximum, and average schedule delays are 9%, 802%, and 153%, respectively. In general, after taking into account all building construction projects, the minimum, maximum, and average schedule delays are 9%, 802%, and 143%, respectively.

Table 4: Cost data for road projects in Ethiopia.

Projects	Project cost	Cost overrun (%)
Meri, Shashemene, Hawassa	197170297.92	17
Dedebit, Adiremet	810212552.61	17
Injibara, Chagni Pawi Junction, Fendika, Ayema	1337718925.93	10
Kibremengist, Shakiso	119673513.69	61
Koka, Adulala, Debrezeit	613165000.00	29
Hawassa Chuko (Mombasa, A.A Corridor)	965247145.48	25
Chenka, Dembidolo Road	648548842.21	4
Ayira, Chanka Road	669143993.90	1
Abi Adi, Fireweyni	819419501.06	7
South f6 junction, f4 junction	1399064061.64	5
Mekeranjo, Ayira	633534840.48	4
Jimma, Mizan	742938243.78	20
Dire Dawa, Melka Jebdu	470000000.00	8
Abunepetros square, Pastor	144440764.43	4.11
Dama Hotel, Hanamariam	54214003	26.47
Gotera, Wellosefer	30000000	8.17
Megenagna, Ayat	224055813.1	18.32
Megenagna, Meskel Square, Torhiloch lot 1 & lot 2	1162448901	4.49
Mekanisa roundabout, Addis	36554500.46	13.95
Meskel flower, Bole Rwanda	49587265.63	58.42
Shola Gebeya, Lemhotel, Anbessa Garage	109512767.9	32.69
Winget Aseco Bridge	154,485,787.41	17.25
Yekatit 12 square, Afenchober, Semen Hotel	36213579	50.04
Bedele, Metu Road Upgrading Project	610,019,298.35	16
Kombolcha, Burka	1,588,240,440.60	4
Tsegede Junction, Ketema Nigus	516,442,158.88	2

4.4. Schedule Delays in Road Projects. The data for road construction projects were collected mainly from the Ethiopian Road Authority (ERA), and additional data were collected in ACCRA, Amhara Roads Authority, Oromia Engineering Corporation, and others. The project time data are presented in Table 6 below.

For road construction projects, the overall computation is similar to that of the building projects. Hence, the minimum schedule delay is 3%, whereas the maximum delay is computed to be 312%. In addition, the average schedule delay for the road construction projects in Ethiopia is found to be 110%.

4.5. Risk Factors Leading to Cost Overrun

4.5.1. Mean Score Ranking. The first section of the analysis focuses on identifying the critical risks causing cost overrun in building and road construction projects. These risks could be arising from various aspects of the project life cycle. In this study, Mean Score ranking techniques have been employed to pinpoint the major risk factors leading to cost overrun in the Ethiopian construction sector. Table 7 presents the Mean Score analysis summary of cost overrun risk factors in the Ethiopian construction industry.

The result reveals that the top risks factors causing cost overrun in the building and road projects are inflation, inaccurate cost estimates, variations, unforeseeable fluctuation in material and labor prices, and availability of resources (labor, materials, and equipment).

4.6. Analysis of Agreement within the Rankings of Participant Groups. The levels of agreements or disagreements within the rankings of participants were analyzed using Kendall's coefficient of concordance (W). The range of values of Kendall's coefficient of concordance (W) is from 0 to 1. However, if the number of items that are going to be ranked is larger than 7, Chi-Square test will be used. W can be calculated using the following formula:

$$W = \frac{\sum_{i=1}^{n} (R1 - R2)^2}{n\left(n^2 - 1\right)/12}, \quad (8)$$

where n = number of items to be ranked; R = average of rank assigned to all items.

Similarly, the Chi-Square values with degree of freedom $(n - 1)$ is calculated as follows:

$$\varphi^2 = k(n - 1)W, \quad (9)$$

where k = number of respondents ranking the items; n = number of items to be ranked.

The rule is that if the Chi-Square values of risks leading to cost overrun are larger than the critical value reading from the Chi-Square significance level table and the given degrees of freedom (df) value, then the null hypothesis (Ho) will be rejected.

The null hypothesis (Ho) is as follows: *There is no relationship within the rankings of each participant groups.*

Kendall's coefficient of concordance (W) is computed to be 0.036 for all respondents. Significant values for all group of respondents is calculated to be 0.4 which is less

Table 5: Time data for building construction projects.

Projects	Project time		
	Contract duration (days)	Time elapsed (delay)	% delayed
Medical faculty dormitory lot 2	540	929	172
Medical faculty dormitory building lot 1	540	819	152
Auditorium building in Gondar	900	1321	147
ICT building	600	1604	267
EiTEX lot I	540	765	142
EiTEX lot II	540	697	129
Sport academy	540	872	161
Medical faculty dormitory building lot 3 library	475	593	125
Gondar university expansion	540	1768	327
BIT library building lot II	475	1535	323
Awi zone administration office	1080	655	61
Preclinical laboratory	540	1686	312
Ethiopia institute of textile & fashion class room	540	482	89
Oromo public office building	915	379	41
Gambela university project I	365	1,095	300
Gambela university project II	150	45	30.00
Ethio-ICT village	1,548	175	11.30
Kombolcha city administration	1080	280	26
Gondar university expansion lot II	480	1417	295
ANRS industry development office in Gondar	590	296	50
Dormitories, building for IOTEX lot 1	510	640	125
ANRS industry development office in Bahir Dar	590	470	80
Medical dormitory building	540	784	145
Medium industrial complex building	590	677	115
East Gojjam high court	730	634	87
Industry complex	590	553	94
Medium and higher industrial shade	655	220	34
Staff condominium lot II	540	641	119
Agricultural & science dormitory and class room	365	656	180
IOT class room and laboratory	365	409	112
BIT class room and laboratory	420	552	131
Condominium phase II	420	530	126
Debre Birhan industrial shade	655	120	18
Staff apartment (Bahir Dar)	540	651	121
Medical faculty staff apartment I	540	651	121
Bibugn primary hospital	387	116	30
Staff condominium lot I	540	641	119
AHWCE office	300	185	62
Debretabor administration office	730	400	55
Integrated land office (Amhara)	730	357	49
G+4 integrated land office in Gondar	655	567	87
Class rooms and lecture hall	270	880	326
OR center renovation	240	1041	434
Students kitchen (Dire Dawa University)	270	509	189
Wegeda Woreda secondary hospital	540	189	35
ANRS Burie industry park	150	13	9
Gondar industry and urban development office	655	120	18
University students dormitory	282	351	124
Students dormitory	282	351	124
ANRS education office Dessie	210	90	43
Store and office buildings	180	1444	802

than the allowable significance level (0.05 or 5%). Correspondingly, the Chi-Square values for all respondents is 4.046, respectively. From the Chi-Square table, the critical value of degree of freedom (df) = 4 and $p = 0.001$ is 13.28. Hence, since the calculated Chi-Square values of all group of respondents is lower than the critical value, it can be concluded that there is no relationship within rankings of each respondent group; and then the null hypothesis will be accepted.

4.7. Analysis of Agreement between Participant Groups. Spearman's rank correlation coefficient (r_s) was adopted to test the correlation between group of respondents on the sets

Table 6: Time data for road construction projects.

Road projects	Contract duration (days)	Time elapsed (delay)	Percentage (delay) (%)
Shekussen, Michola	365	499	137
Meri, Shashemene, Hawassa	770	924	120
Dedebit, Adiremet	1095	501	46
Injibara, Chagni Pawi Junction, Fendika, Ayema	913	721	79
Kibremengist, Shakiso	540	1035	192
Koka, Adulala, Debrezeit	730	330	45
Hawassa Chuko (Mombasa, A.A Corridor)	730	756	104
Chenka, Dembidolo Road	910	911	100
Ayira, Chanka Road	910	620	68
Abi Adi, Fireweyni	1095	799	73
South f6 junction, f4 junction	1095	34	3
Mekeranjo, Ayira	910	398	44
Jimma, Mizan	1036	1832	177
Dire Dawa - Melka Jebdu	548	377	69
Dolo Ojo Junction, Hargale	730	366	50
Winget, Aseco Bridge	330	718	217.58
Yekatit 12 square, Afenchober, Semen Hotel	365	965	264.38
Dama Hotel, Hanamariam	365	790	216.44
Megenagna, Meskel Square, Torhiloch lot 1 & lot 2	550	176	32.00
Meskel flower, Bole Rwanda	575	1,795	312.17
Shola Gebeya, Lemhotel, Anbessa Garage	575	657	114.26
Mekanisa roundabout, Addis	90	180	200.00
Abunepetros square, Pastuer	224	539	240.63
Megenagna, Ayat	420	289	68.81
Gotera, Wellosefer	180	45	25.00
Gelan, Insilale, L/Dadhi	1095	975	89
Sheno, Deneba	2036	65	3
Kula, Dereba, Semar	1300	460	35
Shambo town int. Asphalt	450	1156	257
Hinde Bridge	450	621	138
Kurbi, Giwe, Dado	925	2400	259
Hidi, Lola, Sololo	1095	120	11
Alge, Sachi, Mako, Degga	730	850	116
Yayo, Elemo	720	645	90
Gelila, Waja, Mender 10	1095	485	44
Bedele, Metu Road Upgrading Project	1,080.00	401.00	37
Kombolcha, Burka	1,095.00	187.00	17
Tsegede Junction, Ketema Nigus	730.00	554.00	76

of rankings. Normally, Spearman's rank correlation coefficient ranges from −1 to +1. The higher the positive/negative value of r_s, the stronger the positive/negative linear correlation (relationship). In contract, if $r_s = 0$, there is no linear relationship between two sets of rankings at all. The rule is that if r_s is statistically significant at a predetermined significance level (i.e., 5%), the null hypothesis (Ho) will be rejected.

The null hypothesis (Ho) in this is as follows: *There is no correlation between the sets of rankings among participant groups.*

r_s can be computed using the following formula:

$$r_s = \frac{6\sum d^2}{n\left(n^2 - 1\right)}, \tag{10}$$

where d = the difference between ranking of two groups in the same item; n = total number of responses for an item.

The r_s values for risks leading to cost overrun at the significant level of 0.05, (a) between clients and contractor group, (b) client and consultants, and (d) consultant and contractor, are 0.119, 0.699, and 0.119 respectively. Similarly, the significant levels for the pair between client and contractor, client and consultant, and consultant and contractor are 0.545, 0.051, and 0.545, respectively. All the calculated ρ values are greater than the threshold value 0.05. Hence, the null hypothesis will be accepted, which means that there is a no significant correlation between client and contractor group and client and consultant group on the overall ranking of risks leading to cost overrun in the Ethiopian public construction sector.

4.8. Risk Factors Leading to Schedule Delay

4.8.1. Mean Score Ranking. This section focuses on the critical risk factors leading to schedule delays in both building and road construction projects. These risks were initially collected using a systematic literature review and validated through content analysis before the main data collection. Consequently, the analysis is organized based on

Table 7: Critical risks leading to cost overrun in construction projects.

Critical risks leading to cost overrun	Mean score									
	Overall		Contractor		Consultant		Client		Academia	
	Mean score	Rank	Mean score	Rank	Mean score	Rank	Mean score	Rank	Mean score	Rank
Inflation	4.43	1	4.46	3	4.42	25	4.33	25	4.50	25
Inaccurate cost estimates	4.29	2	4.38	4	4.25	8	3.83	8	4.50	8
Variations	4.24	3	4.08	9	4.08	3	4.33	3	4.17	3
Unforeseeable fluctuation in material and labor prices	4.24	4	4.62	1	3.83	27	3.83	27	4.44	27
Availability of resources (labor, materials, and equipment)	4.14	5	4.08	11	3.50	14	3.50	14	4.11	14
Delay in decision making	4.10	6	3.92	12	3.92	4	3.33	4	4.17	4
Market conditions/economic climate	4.10	7	4.54	2	4.00	23	3.50	23	3.89	23
Political situation of the country	4.10	8	4.15	8	3.58	24	2.83	24	4.11	24
Delay in payment of completed works	3.95	9	4.15	6	3.42	2	3.00	2	4.33	2
Lack of coordination and communication between parties	3.95	10	3.85	13	4.17	5	3.50	5	4.28	5
Poor supervision and contract management	3.86	11	4.15	7	4.25	7	3.17	7	4.11	7
Clarity and accuracy of project information before execution	3.86	12	4.08	10	3.50	11	3.50	11	3.67	11
Financial status of client	3.81	13	3.69	18	3.67	1	3.83	1	4.06	1
Complexity of design and construction	3.81	14	3.15	25	3.50	12	3.83	12	3.61	12
Changes in project schedule and phasing requirements	3.80	15	3.62	20	3.92	17	3.83	17	4.17	17
Poor feasibility and project analysis	3.71	16	4.23	5	4.08	9	3.00	9	4.39	9
Level of workmanship (productivity and performance)	3.70	17	3.83	16	3.67	22	3.33	22	3.78	22
Competency and experience of consulting firm	3.57	18	3.85	14	3.17	6	3.50	6	3.83	6
Government regulations	3.48	19	3.23	24	3.42	26	3.33	26	3.61	26
Availability of machinery	3.48	20	3.77	17	3.00	28	2.33	28	3.44	28
Site constraints (access, storage, electricity)	3.43	21	3.54	21	3.33	16	3.17	16	3.17	16
Clear and detailed drawings and specification	3.38	22	3.62	19	3.42	10	3.50	10	3.61	10
Project delivery method and contractual arrangement	3.38	23	3.85	15	3.33	19	3.17	19	3.11	19
Quality of information flow during execution	3.29	24	3.46	22	3.50	13	3.17	13	3.61	13
Type of currency used	3.00	25	3.38	23	3.08	18	2.83	18	3.29	18
Advance payment arrangement	2.90	26	3.00	27	3.33	20	3.00	20	2.94	20
Type and value of insurance	2.71	27	2.85	28	3.25	21	3.33	21	2.72	21
Type of project (residential, commercial, industrial, etc.)	2.67	28	3.00	26	2.75	15	3.50	15	2.94	15

the perception of major stakeholders: overall, contractor, consultant, owner, and academia, as shown in Table 8.

The result reveals that the top risks factors causing delays in the building and road projects are variations (design changes/extra work), economic conditions (currency, inflation), escalation of material prices, shortage of construction materials, delay in payments, financial constraints, delay in preparation and approval of drawings, poor site management, and poor planning.

5. Discussion and Practical Implications

The aim of this study was to examine the extent of cost overrun and schedule delays, including the investigation of the critical causes of both challenges in low income countries using 52 respondents. Multiple data collection and analysis tools were deployed to provide key project data and practical implications for various stakeholders, including policy makers and the regulatory body.

The first section of the analysis reveals that an average cost overrun of 35% for building and 18% for road infrastructure projects were recorded throughout the Ethiopian construction industry. This is also evident in various developing and developed countries [3, 5, 39]. The present study also explored the extent of schedule delays in the Ethiopian infrastructure construction sector using first hand project information across the country. The case studies were analyzed after taking into account all building construction projects; and the average schedule delay of 143% is recorded. For road construction projects, the overall computation is similar to that of the building projects. Hence, the average schedule delay for these infrastructure projects in Ethiopia is found to be 110%.

Table 8: Critical risks leading to schedule delays in construction projects.

Critical risks leading to schedule delay	Mean score									
	Overall		Contractor		Consultant		Client		Academia	
	Mean score	Rank	Mean score	Rank	Mean score	Rank	Mean score	Rank	Mean score	Rank
Variations (design changes/extra work)	4.71	1	4.55	9	4.33	3	4.50	1	4.56	1
Economic conditions (currency, inflation)	4.48	2	4.92	1	4.75	1	4.67	3	4.50	2
Escalation of material prices	4.48	3	4.58	8	4.25	5	4.17	5	4.50	4
Shortage of construction materials	4.38	4	4.58	5	4.42	2	4.67	2	4.17	3
Delay in payments	4.33	5	4.25	3	3.83	9	3.50	21	4.22	5
Financial problems/constraints	4.33	6	4.67	14	4.08	17	3.50	22	4.17	17
Delay in preparation and approval of drawings	4.29	7	4.25	15	4.33	4	3.67	17	4.06	26
Poor site management	4.24	8	4.58	4	4.17	6	3.50	12	3.83	15
Poor planning (material and labor estimation)	4.24	9	4.67	6	4.17	7	3.83	23	4.00	29
Construction methods	4.14	10	4.33	2	3.83	12	3.50	4	4.06	6
Delay of material delivery on-site	4.14	11	4.75	12	3.92	18	4.50	24	4.11	9
Unrealistic contract durations imposed by owner	4.1	12	4.25	10	3.75	13	3.50	25	4.00	23
Underestimation of project cost	4.1	13	4.42	16	3.92	22	3.17	31	4.11	30
Poorly defined project scope	4.05	14	4.42	7	4.00	10	3.67	10	4.17	13
Slow decision making by owners	4.05	15	4.58	11	3.75	23	4.00	18	3.89	31
Poor communication between project team	4	16	4.08	19	3.92	14	4.17	6	3.94	7
Inadequate experience and competency of contractor	4	17	4.00	21	3.83	19	4.17	7	3.72	14
Lack of experience of consulting firm	3.95	18	3.83	25	4.17	8	3.33	28	3.56	32
Waiting time for approval of tests and inspections	3.86	19	3.83	13	4.00	11	3.50	8	3.78	10
Poor communication and misunderstandings	3.86	20	4.17	17	3.75	24	3.83	13	3.89	11
Bureaucracy in government agencies	3.86	21	4.33	22	3.58	27	4.17	26	4.17	22
Poor collaboration between major parties	3.86	22	4.00	26	3.67	32	3.00	32	3.94	27
Subcontractors (lack of experience, etc.)	3.76	23	4.09	18	3.67	20	3.67	14	3.61	8
Poor material procurement techniques	3.76	24	4.08	20	3.83	28	3.83	19	4.11	24
Owner interference	3.71	25	3.91	23	3.67	15	3.83	9	3.78	16
Poor inspection/supervision	3.71	26	3.75	24	3.75	25	3.50	15	4.11	18
Ineffective legislative regulations	3.71	27	3.67	29	3.67	29	4.17	27	3.94	20
Major claims and disputes	3.71	28	3.92	30	3.92	30	3.33	29	3.53	25
Inappropriate type of contract (procurement process)	3.67	29	3.83	27	3.67	31	3.33	30	3.78	28
Slow permits by government agencies	3.62	30	3.83	28	3.83	21	3.83	11	3.67	12
Political interference	3.62	31	3.67	31	3.75	26	4.00	16	3.56	19
Low quality of materials	3.48	32	3.33	32	3.92	16	3.67	20	3.72	21

Similarly, this paper explored the critical risk factors leading to cost overrun and schedule delays in Ethiopia. The result showed that variations (design changes/extra work) [Mean Score – 4.71] is the top risk factor contributing to schedule delays in both building and road construction projects. Variation in the construction industry is related to design changes and extra work that was not initially clustered in the first design. The result is in line with the findings of [39, 49].

The second top delay risk factor with a Mean Score of 4.48 is economic conditions (currency, inflation). The result is in line with similar studies conducted in Algeria and UAE [50, 51]. The construction sector is one of the major resource intensive industries that take up a huge amount of countries' budget for infrastructure construction [42]. Economic inflation and unexpected variations in prices of construction materials including equipment and fluctuations in foreign currency exchange rates disrupt the performance of infrastructure construction projects, which in turn leads to schedule delays and disputes among major construction parties [8, 40]. The remaining top risk factors causing schedule delays are escalation of material prices [Mean Score – 4.48], shortage of construction materials [Mean Score – 4.38], and delay in interim payments [Mean Score – 4.33]. These risk factors are all interrelated and need proper attention to alleviate the challenges caused by project delay, particularly in the planning, design, and construction stages of the project life cycle.

Further, the analysis covers risk factors leading to cost overrun in infrastructure projects. In this respect, the top risk factor leading to cost overrun in construction projects across the Ethiopian construction industry is found to be

Table 9: Critical recommended actions to reduce cost overrun and delay.

Stakeholder	Key recommended actions (checklists)
Client	(i) Client should allocate proper budget as per the cost estimation including contingency (ii) Owner should appoint a separate construction management consultant for quick decision making, particularly for major projects (iii) Scope of projects shall be adequately defined (iv) Reduce variations and change orders after comment of projects
Contractor	(i) Resource planning, including equipment and labor, should be done as per project milestone and duration (ii) Provide various capacity building trainings and motivation incentives for workers (iii) Develop proper work methodology to improve productivity of labors and equipment (iv) Develop project specific hierarchical structure to facilitate decision making between project team (v) Use appropriate innovations and technologies to improve performance of infrastructure projects
Consultant	(i) Provide complete design and cost estimation as per the requirement by owners (ii) Develop mechanisms to solve disputes between client and contractor (iii) Develop project specific strategies to monitor progress of projects and inspect key developments (iv) Approve interim payments and design changes in line with contract documents and specifications

inflation [Mean Score – 4.43]. Prior studies reported the negative impacts of inflation in the delivery and success of construction projects. For instance, Le-Hoai et al. in Vietnam elaborated that price inflation causes fluctuation of material and labor prices [52], whereas Abusafiya and Suliman discussed the effect of inflation and design change in const overrun and delays in Bahrain construction industry [47].

The second top risk factor is inaccurate cost estimates [Mean Score – 4.29]. Accurately estimating cost of infrastructure projects is critical for budgetary purposes. Consulting and design firms are responsible for estimating all the required costs immediately after completing all designs, before the preparation of tender documents. Omoush reported that inaccurate cost estimates can disrupt the overall performance of construction projects and ultimately create major court disputes between various project teams involving in infrastructure undertaking [53]. Similarly, the findings of this study also illustrated that variations [Mean Score – 4.24], unforeseeable fluctuation in material and labor prices [Mean Score – 4.24], and availability of resources (labor, materials, and equipment) [Mean Score – 4.14] greatly influence cost performance of infrastructure projects in the construction business environment. Table 9 presents the key recommended actions to improve cost overrun and reduce schedule delay in infrastructure projects.

6. Conclusion

The aim of this study was to examine the extent and risks leading to cost overrun and schedule delays in construction projects. Further, the study provided benchmarking key recommended actions (check lists) for major stakeholders to alleviate the critical risks imposed by project cost overrun and the associated schedule delays across various infrastructures in the Ethiopian construction market.

The results highlighted the degree of cost overrun and delay in both building and road infrastructure projects. In addition, the findings summarized the top key risk factors leading to cost overrun and schedule delays in construction projects. Further, this study for the first time contributed critical practical implications and checklists for key stakeholders to improve the overall cost and time performances of infrastructure projects in the Ethiopian construction sector.

The findings of this study will have meaningful positive impact for various practitioners and stakeholders in construction. Reducing and improving cost overruns and schedule delays is vital to ensure the success of infrastructure projects in any country. It is important to denote that both cost and time management are crucial project performance tools and indicators. The first step to devise important methodologies and steps for performance improvement is by exploring the extent of the problems and by identifying the root causes and critical risk factors leading to cost overrun and delay.

The study has a few limitations: (1) Although it might be beneficial to understand the impacts of both cost overrun and schedule delays in particular cases of different project types, this analysis does not consider the type of projects, such as residential, commercial, healthcare, and so on, and (2) it does not consider the contract amounts for road infrastructure projects, as the values are concentrated in similar amounts. Future studies could focus on investigating the relationship between cost overrun and schedule delays with project performance and success from the perspectives of small and medium sized enterprises to large corporations [54].

Data Availability

The data underlying the results presented in the study are available within the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

Acknowledgments

This project was funded by the Construction Works Regulatory Authority of Ethiopia (CWRA/LB/008/2013).

References

[1] S. Belay, J. Goedert, A. Woldesenbet, and S. Rokooei, "Enhancing BIM implementation in the Ethiopian public construction sector: an empirical study," *Cogent Engineering*, vol. 8, no. 1, pp. 1886476–1886527, 2021.

[2] E. L. C. Osabutey and Z. Jin, "Factors influencing technology and knowledge transfer: configurational recipes for Sub-Saharan Africa," *Journal of Business Research*, vol. 69, no. 11, pp. 5390–5395, 2016.

[3] J. S. Jongo, D. N. G. A. K. Tesha, R. Kasonga, J. J. Teyanga, and K. S. Lyimo, "Mitigation measures in dealing with delays and cost overrun in public building projects in dar-Es-salaam, Tanzania," *International Journal of Construction Engineering and Management*, vol. 8, no. 3, pp. 81–96, 2019.

[4] D. D. Ahiaga-Dagbui, P. E. D. Love, S. D. Smith, and F. Ackermann, "Toward a systemic view to cost overrun causation in infrastructure projects: a review and implications for research," *Project Management Journal*, vol. 48, no. 2, pp. 88–98, 2017.

[5] V. G. M. Luvara, S. Phoya, D. N. G. A. K. Tesha, and K. S. Lyimo, "Critical factors causing delay and cost overrun in public building projects in dar es salaam, Tanzania," *Indian Journal Research*, vol. 7, no. 7, 2018.

[6] A. Khan, M. Choudhary, S. Khushnood, and S. Masood, "Development of econometric models for cost & time overruns: an empirical study of major road construction projects in Pakistan," *University of Engineering Technology Taxila Technical Journal*, vol. 20, no. 4, p. 79, 2015.

[7] N. T. Adugna, *A Study of Causes of Delay and Cost Overrun in Office Construction Projects in the eThekwini Municipal Area*, pp. 1–136, Durban University of Technology, Durban, South Africa, 2015.

[8] R. Derakhshanalavijeh and J. M. C. Teixeira, "Cost overrun in construction projects in developing countries, Gas-Oil industry of Iran as a case study," *Journal of Civil Engineering and Management*, vol. 23, no. 1, pp. 125–136, 2016.

[9] R. K. Shah, "An exploration of causes for delay and cost overrun in construction projects: a case study of Australia, Malaysia & Ghana," *Journal of Advanced College of Engineering and Management*, vol. 2, 2016.

[10] I. Abdul Rahman, A. Hameed Mem, and A. Tarmizi Abd.-Karim, "Significant factors causing cost overruns in large construction projects in Malaysia," *Journal of Applied Sciences*, vol. 13, no. 2, pp. 286–293, 2013.

[11] S. Belay, J. Goedert, A. Woldesenbet, and S. Rokooei, "A hybrid delphi-AHP based analysis of construction project - specific success factors in emerging markets: the case of Ethiopia," *Cogent Engineering*, vol. 8, no. 1, pp. 1891701–1891723, 2021.

[12] Z. Alias, E. M. A. Zawawi, K. Yusof, and N. M. Aris, "Determining critical success factors of project management practice: a conceptual framework," *Procedia - Social and Behavioral Sciences*, vol. 153, pp. 61–69, 2014.

[13] M. M. Mukhtar, R. B. Amirudin, T. Sofield, and I. B. Mohamad, "Critical success factors for public housing projects in developing countries: a case study of Nigeria," *Environment, Development and Sustainability*, vol. 19, no. 5, pp. 2039–2067, 2017.

[14] E. G. Sinesilassie, S. Z. S. Tabish, and K. N. Jha, "Critical factors affecting cost performance: a case of Ethiopian public construction projects," *International Journal of Construction Management*, vol. 18, no. 2, pp. 108–119, 2018.

[15] T. Umar, "Causes of delay in construction projects in Oman," *Middle East Journal of Management*, vol. 5, no. 2, p. 121, 2018.

[16] K. Dinesh, "Causes and effects of delays in Indian construction projects," *International Research Journal of Engineering and Technology*, vol. 3, no. 4, pp. 1831–1837, 2016, Online]. Available: http://www.irjet.net.

[17] T. Pourrostam and A. Ismail, "Causes and effects of delay in Iranian construction projects," *International Journal of Engineering & Technology*, vol. 4, no. 5, pp. 598–601, 2012.

[18] M. Kesavan, R. Gobishanker, N. N. Gobidan, and P. B. G. Dissanayake, "Proper project planning in avoiding construction project delays," in *Proceedings of the 5th International Conference on Sustainable Built Environment*, pp. 256–265, Berlin, Germany, 2015.

[19] N. N. K. Nik Mohd Ainul Azman, A. Che Ahmad, M. Mohd Derus, and I. F. Mohd Kamar, "Determination of direct to indirect accident cost Ratio for railway construction project," *MATEC Web of Conferences*, vol. 266, Article ID 03009, 2019.

[20] Y. Frimpong, J. Oluwoye, and L. Crawford, "Causes of delay and cost overruns in construction of groundwater projects in a developing countries; Ghana as a case study," *International Journal of Project Management*, vol. 21, no. 5, pp. 321–326, 2003.

[21] G. A. Niazi and N. Painting, "Significant factors causing cost overruns in the construction industry in Afghanistan," *Procedia Engineering*, vol. 182, pp. 510–517, 2017.

[22] N. Al-Hazim, Z. A. Salem, and H. Ahmad, "Delay and cost overrun in infrastructure projects in Jordan," *Procedia Engineering*, vol. 182, pp. 18–24, 2017.

[23] Y. I. Park and T. C. Papadopoulou, "Causes of cost overruns in transport infrastructure projects in Asia," *Built Environment Project and Asset Management*, vol. 2, no. 2, pp. 195–216, 2012.

[24] A. H. Memon, I. A. Rahman, N. Y. Zainun, and A. T. A. Karim, "Web-based risk assessment technique for time and cost overrun (wrattco) - a framework," *Procedia - Social and Behavioral Sciences*, vol. 129, pp. 178–185, 2014.

[25] E. Sinesilassie, S. Tabish, and K. Jha, "Critical factors affecting schedule performance: a case of Ethiopian public construction projects - engineers' perspective," *Engineering Construction and Architectural Management*, vol. 22, no. 1, pp. 91–107, 2017.

[26] A. Shiferaw Belachew, "Causes of cost overrun in federal road projects of Ethiopia in case of southern district," *American Journal of Civil Engineering*, vol. 5, no. 1, p. 27, 2017.

[27] A. Hameed Memon, I. A. Rahman, M. R. Abdullah, A. Asmi, and A. Azis, "Factors affecting construction cost performance in project management projects: case of MARA large projects," *International Journal of Civil Engineering Built Environ.*vol. 1, no. 1, pp. 2289–6317, 2014.

[28] Z. Shehu, I. R. Endut, and A. Akintoye, "Factors contributing to project time and hence cost overrun in the Malaysian construction industry," *Journal of Financial Management of Property and Construction*, vol. 19, no. 1, pp. 55–75, 2014.

[29] T. A. Amri and M. Marey-Pérez, "Towards a sustainable construction industry: delays and cost overrun causes in construction projects of Oman," *Journal of Project Management*, vol. 5, pp. 87–102, 2020.

[30] A. Alhomidan, "Factors affecting cost overrun in road construction projects in Saudi arabia," *International Journal of Civil Environmental Engineering IJCEE-IJENS IJENS I J E N S*, vol. 13, no. 3, pp. 1–4, 2013.

[31] I. Mahamid and N. Dmaidi, "Risks leading to cost overrun in building construction from consultants' perspective,"

Organization, Technology & Management in Construction: An International Journal, vol. 5, no. 2, pp. 860–873, 2013.

[32] C. B. Venkateswaran, R. Murugasan, and R. Murugasan, "Time delay and cost overrun of road over bridge (ROB) construction projects in India," *Journal of Construction in Developing Countries*, vol. 22, no. 1, pp. 79–96, 2017.

[33] A. Enshassi, J. Al-Najjar, and M. Kumaraswamy, "Delays and cost overruns in the construction projects in the Gaza Strip," *Journal of Financial Management of Property and Construction*, vol. 14, no. 2, pp. 126–151, 2009.

[34] M. Aftab Hameed, R. Ismail Abdul, and A. Ade Asmi Abdul, "Preliminary study on causative factors leading to construction cost overrun," *Int. J. Sustain. Constr. Eng. Technol.*vol. 2, no. 1, pp. 57–71, 2011, [Online]. Available: http://penerbit.uthm.edu.my/ojs/index.php/IJSCET/article/viewFile/49/65.

[35] S. Ashwini Arun, "Effect of construction delays on project time overrun: Indian scenario," *International Journal of Renewable Energy Technology*, vol. 3, no. 1, pp. 543–547, 2014.

[36] A. Ade Asmi Abdul, M. Aftab Hameed, R. Ismail Abdul, and A. Ahmad Tarmizi, "Controlling cost overrun factors in construction projects in Malaysia," *Research Journal of Applied Sciences, Engineering and Technology*, vol. 5, no. 8, pp. 2621–2629, 2013.

[37] J.-B. Yang and P.-R. Wei, "Causes of delay in the planning and design phases for construction projects," *Journal of Architectural Engineering*, vol. 16, no. 2, pp. 80–83, 2010.

[38] J. Y. Altarawneh, V. Thiruchelvam, and B. Samadi, "Analysis of critical success factors influence on critical delays for water infrastructure construction projects in the abu dhabi emirate using PLS-SEM method," *International Business Research*, vol. 11, no. 2, p. 16, 2018.

[39] H. D. Wuala and A. D. Rarasati, "Causes of delays in construction project for developing Southeast Asia countries," *IOP Conference Series: Materials Science and Engineering*, vol. 830, no. 2, Article ID 022054, 2020.

[40] N. Serani, D. Tadele, and W. Bayeh, "The causes and effects of delay of building construction in Ethiopia, southern nation nationalities of people region in gurage zone (case of wolkite town)," *Civil and Environmental Research*, vol. 5790, pp. 12–21, 2020.

[41] T. Gebrehiwet and H. Luo, "Analysis of delay impact on construction project based on RII and correlation coefficient: empirical study," *Procedia Engineering*, vol. 196, pp. 366–374, 2017.

[42] M. S. B. A. Abd El-Karim, O. A. Mosa El Nawawy, and A. M. Abdel-Alim, "Identification and assessment of risk factors affecting construction projects," *HBRC Journal*, vol. 13, no. 2, pp. 202–216, 2017.

[43] M. M. Ghazal and A. Hammad, "Application of knowledge discovery in database (KDD) techniques in cost overrun of construction projects," *International Journal of Construction Management*, vol. 20, pp. 1–15, 2020.

[44] A. B. Senouci and S. A. Mubarak, "Multiobjective optimization model for scheduling of construction projects under extreme weather," *Journal of Civil Engineering and Management*, vol. 22, no. 3, pp. 373–381, 2016.

[45] S. A. Assaf and S. Al-Hejji, "Causes of delay in large construction projects," *International Journal of Project Management*, vol. 24, no. 4, pp. 349–357, 2006.

[46] C. Kaliba, M. Muya, and K. Mumba, "Cost escalation and schedule delays in road construction projects in Zambia," *International Journal of Project Management*, vol. 27, no. 5, pp. 522–531, 2009.

[47] H. A. M. Abusafiya and S. M. A. Suliman, "Causes and effects of cost overrun on construction project in Bahrain: part I (ranking of cost overrun factors and risk mapping)," *Modern Applied Science*, vol. 11, no. 7, p. 20, 2017.

[48] F. Afzal, S. Yunfei, M. Nazir, and S. M. Bhatti, "A review of artificial intelligence based risk assessment methods for capturing complexity-risk interdependencies," *International Journal of Managing Projects in Business*, vol. 14, no. 2, pp. 300–328, 2019.

[49] M. Khoshgoftar, A. H. A. Bakar, and O. Osman, "Causes of delays in Iranian construction projects," *International Journal of Construction Management*, vol. 10, no. 2, pp. 53–69, 2010.

[50] Z. Rachid, B. Toufik, and B. Mohammed, "Causes of schedule delays in construction projects in Algeria," *International Journal of Construction Management*, vol. 19, no. 5, pp. 371–381, 2019.

[51] A. S. Faridi and S. M. El-Sayegh, "Significant factors causing delay in the UAE construction industry," *Construction Management & Economics*, vol. 24, no. 11, pp. 1167–1176, 2006.

[52] L. Le-Hoai, Y. D. Lee, and J. Y. Lee, "Delay and cost overruns in Vietnam large construction projects: a comparison with other selected countries," *KSCE Journal of Civil Engineering*, vol. 12, no. 6, pp. 367–377, 2008.

[53] M. M. Omoush, "Assessing and prioritizing the critical success factors and delays of project management implementation: empirical evidence at construction projects in Jordan," *International Journal of Business and Management*, vol. 15, no. 10, p. 117, 2020.

[54] G. A. Bekr, "Identifying factors leading to cost overrun in construction projects in Jordan," *Journal of Construction Engineering, Technology & Management*, vol. 5, no. 3, pp. 25–33, 2015, [Online]. Available: http://www.stmjournals.com.