Identification of Factors Affecting the Overrun of Costs in Rural Road Projects: A Study Based on Sri Lanka

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Abstract: This study focused on identifying the main factors affecting cost overruns in rural road projects and ascertaining their various economic and social implications from policy perspectives. In addition to the secondary data, a structured questionnaire was used to collect primary data from the 30 senior engineers, and interviews were carried out with many stakeholders involved in these rural road development initiatives in Sri Lanka under the iROAD project. Multiple regression, correlation analysis, and rank agreement factor methods were used to identify and check the significance and ranking of the main factors affecting phases of contract procurement and the project implementation for cost overruns in rural road development. This study found positive relationships between the awarded contract value, the engineer's estimates, and the cost of km length, and altogether 43 factors were identified and ranked by looking at their importance under the five categories: technical, economic and financial, political and regulatory management, project resources, and project implementation environment. The methodology used and the policies derived from this study can be applied to other similar projects to ascertain the factors affecting cost overruns in rural road projects and to find policy recommendations to minimize this problem in any country, specifically for South Pacific countries, including Papua New Guinea.

Keywords: Cost Overrun, Rural Roads, Project Management, Cost Estimation, Economic Development, Sri Lanka.

1. Introduction

Sri Lanka owns a very well-spread-out road network of about 119,000 km, and the current road density of Sri Lanka is 1.7 km of roads per square kilometer, a very high number when compared to its regional peers. While the road network is enough to provide accessibility to the country's entire population across the urban centers and provinces, the rural road network is not in a good motorable condition. Since about 70% of Sri Lanka's population lives in rural and peri-urban areas, the road network needs to be developed to travel within less time with efficiency. Several regional road network development projects were proposed with the view of enhancing regional connectivity and efficiency of the transport system, which will, in turn, help people to save time for productive activities [1]. The integrated road investment program was established in 2014, thereby increasing the rural population's involvement in national economic and social development. First, this integrated road investment program (iROAD - Phase I) will improve around 3000 km of rural roads in the Southern, Sabaragamuwa, Central, North Central, and North-Western Provinces and Kalutara district through 42 civil works contracts. Under the second integrated program, 3,400 kilometers (km) of rural access roads and 340 km of national roads in Eastern, Northern, Uva, and Western Provinces will be rehabilitated and improved. Some packages are already commenced, and some are still in the pre-bidding stages. Asian Development Bank (ADB) funds this project through the Multi-Tranche Financing Facility. Under the iROAD phase I, a USD 800 million loan is allocated in 6 tranches, and the Sri Lankan government contributes over 106 USD million worth of funds, and altogether 906 USD million invested in these rural roads from 2014 to 2020. The main target is to achieve project goals within the estimated budget to ensure sufficient funds are available for the completion of the whole project.

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1.1 Research Questions

1. Why do the estimated costs of the projects increase during the contract period?
2. What are the factors that affect the cost overrun in rural road projects?
3. How can the cost overrun of rural road development projects affect the economy, and what is the impact on the contractors' business involved in the contract?
4. What are the reasons behind the termination of several packages and disputes between parties after cost overruns?
5. What are the policies and strategies to overcome or control this cost overrun situation?

1.2 Research Objectives

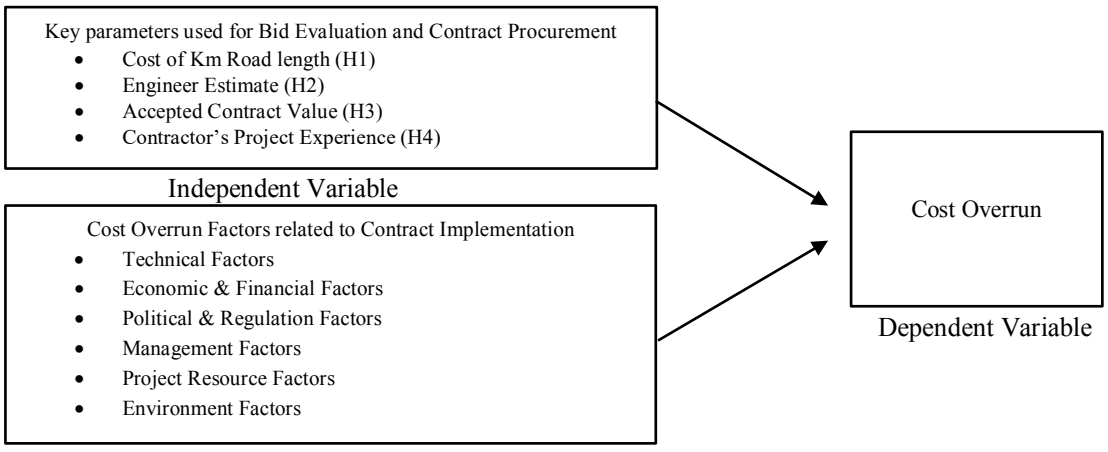
1. Identify the relationship between the cost overrun and the key parameters used in contract procurement and describe the current situation of cost overrun in rural road rehabilitation projects in Sri Lanka.
2. Identify the main factors causing cost overruns during the implementation of rural road projects in Sri Lanka.
3. Ascertain the impact of the cost overrun of rural road projects on the Sri Lankan economy and society.
4. To recommend policies and strategies to overcome the cost overrun of rural road projects to minimize economic loss to Sri Lanka.

2. Conceptual Framework and Methodology

2.1 Conceptual Framework of the Study

The development of the conceptual framework aimed to derive scientifically proven research hypotheses, and it facilitates the development of the operationalization table with all indicators and other relevant details. All these are developed based on the extensive surveyed of literature [2, 3, 4, 5, 6, 7, 8]. The main objective of the development of the conceptual framework is to show how the project's cost overrun (dependent variable) is influenced by the independent variables. The dependent variable is the cost to completion of the packages (possibility of cost overrun), which is hypothesized to be explained by the key parameters used for selecting bidders to the contracts, namely, cost of kilometer road length, engineer estimation, contractor's project experience, and accepted contract value of each package.
Figure 1 shows the conceptual framework, which illustrates the relationship of the dependent variable to the key parameters used to select bidders and other relevant factors such as technical, economic, and financial, political and regulatory, management, project resources, and the environment under the construction phase.

Fig.1 Conceptual Framework



Moreover, the study focused only on the effectiveness of the independent variable on the dependent variable. There are no measurements for the relationship between independent variables (key parameters in bid evaluation and contract procurement) and independent variables (contract implementation). This kind of mixed method was chosen to integrate quantitative data gathered directly from rural road projects and data collected through a structured questionnaire survey technique. This survey was conducted based on 43 factors identified from the literature review and grouped into six groups of factors according to their similarities in nature. This kind of mixed method is followed when there is a need to gather information from multiple perspectives of the research subject.

2.2 The Hypothesis of the Study

Hypotheses were developed to identify the impact of independent variables selected from key parameters in the evaluation criteria for selecting bidders to the contracts, namely, cost of kilometer road length, engineer estimation, contractor's project experience, and accepted contract value of each package. The null and alternative hypotheses are set as follows:

H_0 - There is no impact of independent variables on cost to completion (cost overrun).

H_1 - There is a positive relationship between the cost of kilometer road length and cost to completion (cost overrun).

H_2 - There is a positive relationship between engineer estimation and cost to completion (cost overrun).

H_3 - There is a positive relationship between accepted contract value and cost to completion (cost overrun). H_4 - There is a positive relationship between the contractor's project experience and cost to completion (cost overrun).

The impact and influence of other selected variables on the cost overrun of the rural road project in Sri Lanka were identified by including and distributing the questionnaire among engineers of i-ROAD program. The following operationalization table is prepared based on the rigorous literature survey and conceptual framework of the study to derive hypotheses.

Table. 1: Operationalization of Research Variables

Variable	Type of Variable	Indicator	Measurement	Type of Analysis
Cost of Km road length	Independent	The level of cost incurred for the km of roads.	Actual Value	Correlation
Accepted contract value	Independent	The amount of expected disbursement for a project.	Actual Value	Correlation /Regression
Contractor's project experience	Independent	The capability of the Contractor in similar kinds of projects.	Actual Value	Correlation /Regression
Engineer estimate	Independent	The level of accuracy of estimation at tendering.	Actual Value	Correlation /Regression
Technical factors	Independent	The level of impact by the technical matters.	Five-point Likert Scale	Descriptive /Rank agreement factor
Economic and financial factors	Independent	The level of impact by economic and financial matters.	Five-point Likert Scale	Descriptive /Rank agreement factor

Political and regulation factors	Independent	The level of impact by political and regulatory actions.	Five-point Likert Scale	Descriptive/Rank agreement factor
Management factors	Independent	The level of impact by managerial actions.	Five-point Likert Scale	Descriptive/Rank agreement factor
Environmental factors	Independent	The level of the impact by environmental factors.	Five-point Likert Scale	Descriptive/Rank agreement factor
Project resource factors	Independent	The level of impact by assigning project resources.	Five-point Likert Scale	Descriptive/Rank agreement factor
Cost to Completion	Dependent	Successfully completion of the project within the budget.	Scale	Correlation/Regression

Source: Authors

Collection of data through the various sources was conducted to fulfill four objectives in this study and to develop an extensive inventory of the research problems in the study; a detailed literature review was carried out from textbooks, journals, government publications, and publications by funding agencies and online resources. Primary and secondary data available in the iROAD Project are collected through the interview and directly from the database of iROAD. It is necessary to obtain an adequate data sample size that represents the target population very well. At least the sample size should be 10 % of the target population to get an accurate result [9]. It is challenging task in finding the cost overrun data for the following reasons.

a) Time consumed to generate cost overrun data (Calculation of cost to completion for initial BOQ).
b) There is no proper evidence for increasing the initial contact value until it has exceeded.
c) The officers involved in the cost estimation are hiding data on cost overrun due to government regulation, and check and balances.

On the other hand, this project is the first-ever rural road rehabilitation project implemented under the Road Development Authority (RDA) with foreign funds. The experience of cost overrun in a rural road project for RDA a new thing. The data were collected based on the availability within the project to identify the impact of cost overrun on a rural road project. To identify the current cost overrun situation, the amount of money needed to complete each project (cost to completion) will be analyzed with independent variables selected from key parameters in bid evaluation and contract procurement for determining the bidder for the contract packages. For that purpose, all the values for variables have been obtained and recorded in line with concerning contract packages. The contract packages are selected as the population, and its size is 42, and it is not a large size when it is compared to the target population in other studies. The engineers working under the integrated road investment program were selected as the data sample for the data collection to identify the reasons for cost overrun of rural road projects in Sri Lanka. According to [9], “the target population is the entire group a researcher is interested in; the group about which the researcher wishes to conclude.” The sample should be selected from at least 10% of the target population. The number of engineers working for the integrated road investment program is around 300 and 30 sample sizes were selected for the data collection with the representation of all the provinces and every group of experts for better overall results.

During the data collection period, most of the projects are completed in iROAD phase I and few contactors were demobilized. Therefore, finding participants was somewhat difficult, and the participants were selected according to availability and willingness to take part in this survey. This method is called convenience sampling, which is included in the non-probability (non-random) sampling method. The selected data collecting methods are observations and direct extracting from the document maintained in the Integrated Investment Program Offices. This method helps to collect data for analysis of relationship of key parameters in bid evaluation and contract procurement and cost overrun in the rural road projects. The analyzed results were used to identify the current situation of cost overrun in the project. This selection is the requirement to improve the accuracy of the result by using actual values obtained during the project procurement and the project implementation.

The current cost overrun situation is analyzed with respect to the independent variable selected from the contract procurement stage. The primary purpose of this analysis is to identify how much these measurable key parameters used for selecting bidder to the contract (contract procurement) impacting the cost overrun of rural road development projects. Multiple Linear Regression (MLR) model selected the following as independent variables; contractor's project experience (number of similar projects completed by the qualified bidder within the last ten years), km cost (award price divided by the total length of the project, Rs. Million/ km), accepted contract value (awarded value of the selected bidder at time of award), engineer estimate (Government estimate is the estimated total project value by the implementing agency, mainly RDA).

The primary data for 42 Contracts were collected and checked the applicability of these data for MLR estimation. The structured questionnaire was distributed and analyzed to find the factors which are mostly affected by cost overrun of rural road projects during the implementation stage. These factors were selected through the past literature and tabulated in a questionnaire form. Participants are requested to give weighed value for those factors according to the impact and frequency of happening. Then collected data in the questionnaire was analyzed using the Importance Index (I.I), Frequency Index (F.I) and Severity Index (S.I). The Severity Index formula (S.I) ranks factors of cost overruns by calculating the weighted indexes of the importance and frequency of cost overrun factors [8]. This methodology clearly mentions in appendix.

3. Data Analysis and Interpretation

This section analyzes and interpret results of statistical analysis and based on that findings and policy implications derived in substantive manner. One of the primary objective of this analysis is to identify the impact of variation of independent variables used for selecting bidder to the contract (procurement stage) for the cost overrun of rural road development projects**.** Primary data were directly collected from the Project Management Unit. Accordingly, 42 data set observations belong to 6 provinces relating to award prices (Accepted contract price), Government estimate (engineer estimation), and cost to completion, as listed in Table 2 below.

Table. 2 - Cost to Completion of Rural Road Packages

No	Package No.	Engineer Estimation (LKR Mn)	Accepted Contract Value (LKR Mn)	Km Cost (LKR Mn)	Cost to Completion (LKR Mn)	Predicted % of cost overrun (+/-)
1	G1	1,231.05	1,458.06	19.06	1550.06	6.31
2	G2	1,300.45	1,483.14	19.70	1,637.18	10.39
3	G3	1,459.50	1,733.44	19.94	1,909.32	10.15
4	H1	1,436.05	1,583.59	21.40	1,731.75	9.36
5	H2	1,070.88	1,210.33	18.46	1,430.47	18.19
6	H3	856.01	1,052.14	20.43	1,203.10	14.35

7	M1	2,132.12	2,315.35	21.86	2,735.92	18.16
8	M2	1,572.64	1,803.30	22.73	1,553.40	(13.86)
9	M3	1,078.41	1,207.60	20.19	1,188.07	(1.62)
10	KA1	1,390.40	1,756.28	18.25	1,727.77	(1.62)
11	KA2	1,460.00	1,923.67	20.71	1,777.44	(7.60)
12	KA3	1,627.70	2,096.87	22.01	1,950.32	(6.99)
13	MA1	1,260.14	1,622.37	16.65	1788.37	10.23
14	MA2	1,057.11	1,248.83	18.55	1,248.83	(0.00)
15	MA3	1,197.51	1,407.72	19.54	1,366.59	(2.92)
16	NE1	1,477.01	2,297.89	19.28	2,581.75	12.35
17	NE2	822.91	1,241.72	21.37	1,241.27	(0.04)
18	NE3	1,426.07	2,069.69	21.97	2,495.58	20.58
19	KE1	1,639.21	1,972.53	21.93	2002.35	1.51
20	KE2	1,431.01	1,817.00	18.29	2,102.50	15.71
21	KE3	1,236.18	1,632.46	19.27	1,855.51	13.66
22	R1	1,708.50	2,022.05	20.60	2,356.33	16.53
23	R2	1,782.03	2,383.99	19.43	2,465.37	3.41
24	R3	1,581.95	2,021.00	19.69	2,370.57	17.30
25	AP1	1,733.60	1,656.92	20.37	1,674.27	1.05
26	AP2	2,041.05	1,824.18	26.67	1,653.44	(9.36)
27	AP3	1,685.25	1,492.77	20.43	1,715.20	14.90
28	AP4	1,889.54	1,635.13	21.19	1,671.06	2.20
29	PO1	1,161.21	1,158.53	22.60	1,028.41	(11.23)
30	PO2	1,542.53	1,483.69	21.19	1,465.64	(1.22)
31	PO3	1,265.32	1,249.34	26.13	1,108.16	(11.30)
32	KU1	1,885.98	2,005.79	22.77	2,286.60	14.00
33	KU2	2,098.57	2,124.17	21.56	2,421.55	14.00
34	KU3	2,097.46	1,976.72	23.32	1989.56	0.65
35	KU4	2,110.87	2,091.17	22.22	2100.57	0.45
36	KU5	2,053.10	1,996.56	20.56	2000.26	0.19
37	PU1	1,677.57	1,706.32	18.15	1,688.80	(1.03)
38	PU2	1,483.27	1,463.92	19.93	1546.33	5.63
39	PU3	1,236.21	1,210.36	25.50	1321.31	9.17
40	KL1	1,931.21	1,912.47	20.54	2,107.57	10.20
41	KL2	1,976.36	1,811.35	22.21	1950.02	7.66
42	KL3	2,074.73	1,817.75	22.07	1889.23	4.48

Source: Progress report iROAD program, 2020

The multiple regression model is used to analyze the variation of a single variable (Dependent variable) based on the value of two or more variables. The variable used in this study can be categorized as follows. Independent variables are contractor's project experience (Number of similar projects completed by the qualified bidder within the last ten years), Km cost (Award price divided by the total length of the project; Rs. Million/ km), Accepted contract value; awarded value (Value of the selected bidder at time of award) and engineer estimate (Government estimate). Dependent variable is cost to completion of each package at the project completion.

The primary data for 42 contracts were collected and tabulated and checked the applicability of these data for Multiple Leaner Regression (MLR) with the above four assumptions. Accordingly, as per the result shown in Table 3 and 4, the data was analyzed in SPSS software to determine whether the above assumptions are correct for running the Multiple Leaner Regression Model. The simple correlation, tolerance value, variance increase factor (VIF), and condition index (CI) were examined in order to find the possibility of multiple relations between independent variables and the findings as shown in Table 3 and Table 4.

Table. 3 - Multiple Relation Coefficients

	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
Constant	306451054.84	286329889.77		1.070	.291					
Eng. Estimate	-.051	.127	-.043	-.399	.692	.646	-.065	-.023	.280	3.568
Project. Exp.	867595.821	4253592.756	.013	.204	.839	-.095	.034	.012	.734	1.362
Km Cost	-22.345	12.992	-.109	-1.720	.094	-.098	-.272	-.097	.801	1.248
Contr. Value	1.191	.122	.966	9.764	.000	.931	.849	.552	.326	3.065

Dependent Variable: Cost to Completion

When the simple correlations are examined, if the correlation coefficients are higher than the value of 0.8 or Variance Increase Factor (VIF) is equal or higher than 10, there is a multiple relation between variables. According to the results obtained for coefficient of variable in Table 4 all the values are less than 0.8 and Variance Increase factor values of all variables are less than 10. Therefore, in this case, there are no multiple relations between variables.

Table. 4 - Multiple Relation Condition Index Value

Model	Factor	Eigenvalue	Condition Index	Variance Proportions				
				Constant	Engineer Estimate	Project Experience	Km Cost	Contract Value
1	1	4.452	1.000	.00	.00	.01	.00	.00
	2	.497	2.993	.00	.00	.73	.00	.00
	3	.038	10.851	.04	.11	.00	.05	.07
	4	.010	21.263	.05	.55	.23	.09	.54
	5	.003	30.332	.91	.34	.03	.85	.39

Dependent Variable: Cost to Completion

If case Condition Index (CI) is higher than 30, it is regarded that there is multiple relations between variables [10]. Obviously, the CI values less than 30, and there are no multiple relations between variables. The data set used for Multiple Linear Regression satisfied the defined assumptions and accordingly, regression analysis was done. The scatter diagrams of the dependent variable - estimated cost to completion at the end of the project, against the independent variables were developed to understand the relationship of dependent variable with respect to changing the independent variable. The scatter diagrams show the correlation coefficient of accepted contract value and engineer estimates are as 0.931 and 0.646 which consequently says that cost overrun positively correlates with these two variables. Accordingly, if the contract value and the engineer estimate are high, there is a high possibility of increasing project cost. Since

km cost and project experience have -0.098 and -0.095 correlation coefficient values, respectively, cost overrun has a negative correlation with these two variables. Therefore, if the project has a higher value for km cost and the contractor has high project experience in large projects, increasing project cost is low. Hence, it was proved that the null hypothesis could not be accepted. The conclusion of the validity of the alternative hypothesis is as follows,

H_1 - There is a **positive relationship** between the Cost of Kilometer road length and Cost to Completion (Cost Overrun)

According to the Multiple Correlation factor, the coefficient has a negative value. Accordingly, the independent variable has a negative impact. If the project has a proper suitable value for per Km cost, Cost Overrun will not happen. Therefore, this hypothesis cannot be accepted.

H_2 - There is a **positive relationship** between Engineer Estimation and Cost to Completion (Cost Overrun). According to the Multiple Correlation factor, the coefficient has a positive value and accordingly, the independent variable has a positive impact. Therefore, this hypothesis can be accepted.

H_3 - There is a **positive relationship** between Accepted contract value and Cost to Completion (Cost Overrun). The Correlation coefficient for the Accepted Contract value is 0.931 and a positive value. As described above, the Accepted Contract value has a positive relationship to the Cost to Completion and increasing of the contract value will influence the increase of Cost Overrun. This explains that the alternative hypothesis can be accepted.

H_4 - There is a **positive relationship** between the Contractor's project experience and Cost to Completion (Cost Overrun). The Correlation coefficient for the Contractor's Project Experiences value is -0.095 and it is a negative value. As described above, the Contractor's Project Experiences have a positive relationship to the Cost to Completion and have the possibility of decreasing Cost Overrun when the Contractor has the high project experience. Then it can confirm the alternative hypothesis is wrong.

ANOVA statistic test results were used to find the reliability of predicting the dependent variable and the relatively most important independent variable that could influence the dependent variable. Table 5 shows the Multiple Linear Regression analysis results related to the cost to completion of 42 rural road packages.

Table. 5 - Multiple Linear Regression Analysis Results Related to Cost to Completion

Variable	B	Beta	t	Sig.	Corr. Partial	Corr. Part
(Constant)	306451054.8		1.070	0.291		
Contractor's Project Experience	867595.821	0.013	0.204	0.839	0.034	0.012
Engineer Estimate	-0.051	-0.043	-0.399	0.692	-0.065	-0.023
Km Cost	-22.345	-0.109	-1.720	0.094	-0.272	-0.097
Contract Value	1.191	0.966	9.764	0.000	0.849	0.552
R = 0.939	R^2 = 0.882	Adjusted R^2 = 0.869		$F_{(4,42)}$ = 68.974		P = 0.00

According to the table 4.4, P-Value is very small ($p=0 < 0.05$) and less than 0.05. That means the null hypothesis can be accepted. The regression results explain that the independent variables reliably predict the dependent variable. Therefore, contractor's project experience, engineer estimate, Km cost and accepted contract value, can be used to predict the possibility of happening of cost overrun reliably. In another way, by looking at the R-value and R^2 value, the reliability of the prediction of the dependent variable can be justified. R is the 'multiple correlation coefficient and R can be used to measure the quality

of the prediction of the dependent variable. In an examination of table 4.6, the degree of predicting the dependent variable was found R = 0.939. The model's degree of explaining the variance in the dependent variable was $R^2 = 0.882$ and it is also called as the coefficient of determination. If the value of R^2 is high and it says that there is a strong linear relationship and if the R^2 value is small, it is called a weak linear relationship. By looking above two coefficient values, R^2 is 88.2% of independent variables that predict the dependent variable. It may be said that there is a strong linear relationship and the developed model predicts the dependent variable very well. Since it was found that the relationship of the independent variable to the dependent variable next step is to determine the level of effect of the independent variable. The absolute value of Beta (β) indicates the importance of the independent variable for changing the dependent variable. The variable with the highest beta value is the relatively most important independent variable in the study. On examining the contribution made by the independent variable in the model in Table 4.4, it was found that in the current situation, awarded contract value (β = 0.966) is the most important independent variable to contribute to changing the dependent variable (cost to completion). Awarded contract value was followed by Km cost, Engineer Estimation, and Contractor's project experience. The result of regression analysis shows that the beta value of the engineer estimation and contractor's project experience are 0.043 and 0.013, respectively. The absolute value shown in the result is small and explains engineer estimation and contractor's project experience have a small contribution to the model.

The questionnaire survey results describe and identify the major causes of Cost Overrun in rural road projects during the project implementation. The weighted value for effectiveness of the factor to the Cost overrun (1 – not significant, 5 – very Significant) and the weighted value for the frequency of happening of the factor (1 – not frequently, 5 – most frequently) for each cost Overrun factor are separately extracted from the response.

The total number of responses (N) in the questionnaire survey was 30, and the analysis of the questionnaire was done by using the Importance Index (I.I), the frequency Index (F.I), and the Severity Index formula (S.I), then rank the Cost Overrun factors by calculating the weighted indexes of the importance and frequency of cost overrun factors [8].

4. Classification of Cost Overrun factors

The Cost Overrun factors are grouped into several subgroups according to their similarity to find which has the higher impact on the research problems. The main six groups are namely; technical, financial and economic, management, project resource, political and regulation, and Environment as mentioned in Table 6.

Table. 6 - Groups for Factors causing Cost Overrun from previous studies

Group	Sub Group	Description	Factors (out of 43 factors)
Technical	Design	Tendering & Construction design drawing related factors	1,5,11,14,20,21,33
	Construction	Poor technical performance, changers or discrepancies that may occur during the construction period and delay in handing over the site related factors	3,14,31,37,41
	Scope	Scope, additional work and variation orders related factors	8,22,34
	Site	Site condition and site organization-related factors	7,22,39
	Experience	Decision-making in the tendering process, experience and procurement-related factors.	2,3,13
Economic and Financial	Financial Contracts	Donor policy in bidding, experience in contracts and contracts management-related factors.	28,32
	Financial Policy	Investment decisions, funding allocation and Methods of financing and payments for completed works related factors.	9,15,28,37
	Internal	Contractor management, organizational variables, Project characteristics and Client characteristics related factors	4,10,19,28

	External	Fluctuation in the money exchange rate, domination of the construction industry by foreign firms and aids, government policies (laws and regulations) and economic Instability related factors.	15,40
Political and regulation	Political situation	Unsupportive governmental policies and Governmental control and regulations related factors	15,38
Management	Estimation Process	Inaccurate or poor estimation of Original Cost, Incorrect/inappropriate methods of cost estimation and Estimating process risk	2,12,16,30,35
	Planning	Inadequate project analysis, Improper planning and scheduling and Poor planning	2,6,13
	Monitoring and Controlling	Poor site management, Poor cost control, Complexity of organizational structure of a project, absence of construction cost data and Fraudulent practices and kickbacks	9,10,17,18
	Communication	Poor coordination among the project participants and Lack of leadership knowledge	13,23,38,42,43
Project Resources	Labour	Shortage of labor and Unqualified labor	14,26
	Material	Fluctuations in the cost of building materials, The shortage in construction materials in markets and Materials problem	4,8,24,25
	Equipment	High cost of machinery and Lack of equipment	
Environment	Location	Location-related factors	43
	Weather Condition	Unpredictable weather conditions and Unsuitable climate to work	29

Source: Structured Questionnaire Survey

5. Results and Analysis of the Study

Here, 43 Cost overrun factors were included in the spread sheet and the ranking was tabulated as following Table. 7.

Table. 7 - Ranking of Cost Overrun Factors

Rank	S.No	Cost Overrun Factor	I.I	F.I	S.I
1	22	Additional Works and Variations	0.873	0.767	0.670
2	12	Inaccurate Time and Cost estimates	0.847	0.707	0.598
3	24	Fluctuation of price of material	0.780	0.733	0.572
4	32	Contractual Claims Such as extension of time with cost claims	0.800	0.707	0.565
5	30	Change of estimated quantity	0.780	0.700	0.546
6	2	Unrealistic Contract duration	0.767	0.660	0.506
7	16	Inaccurate Site Investigation	0.793	0.613	0.487
8	1	Poor design and delays in Design	0.773	0.607	0.469
9	20	Incomplete and Inaccurate Design at the time of tender	0.753	0.607	0.457

10	39	Unforeseen Ground Conditions	0.780	0.553	0.432
11	13	Delay of Decision making	0.733	0.587	0.430
12	42	Disputes	0.720	0.587	0.422
13	6	Inadequate planning and scheduling	0.727	0.573	0.417
14	7	Poor Site Management and Supervision	0.720	0.573	0.413
15	29	Effect of Weather	0.700	0.580	0.406
16	35	Omission and the errors in the BOQ	0.707	0.553	0.391
17	43	Utility Shifting	0.687	0.547	0.375
18	27	Bureaucracy in tendering method	0.667	0.553	0.369
19	25	Shortage of Material	0.647	0.560	0.362
20	9	Cash flow and financial difficulties faced by Contractor	0.633	0.567	0.359
21	18	Poor Project Management of the Contractor	0.680	0.527	0.358
22	14	Reworks	0.707	0.500	0.353
23	5	Delay preparation and approval of Drawings	0.647	0.540	0.349
24	21	Mistake and errors of Completed Design Drawings	0.687	0.507	0.348
25	11	Frequent Design Change	0.720	0.460	0.331
26	4	Late delivery of materials and equipment	0.667	0.493	0.329
27	34	Change in the scope of the project	0.667	0.487	0.324
28	10	Poor financial Control on site	0.640	0.507	0.324
29	41	Delaying Handing over site to contractor	0.633	0.500	0.317
30	31	Delay in Inspection and approvals	0.613	0.507	0.311
31	17	Inadequate monitoring and Control	0.633	0.487	0.308
32	40	High inflation rate	0.607	0.500	0.303
33	15	Finance Difficulties of Employer	0.627	0.480	0.301
34	19	Poor Contract Management of the Employer	0.607	0.493	0.299
35	3	Lack of experience	0.587	0.460	0.270
36	33	Impractical and Complicated Design	0.600	0.413	0.248
37	23	Slow information flow between parties	0.520	0.467	0.243
38	26	High Cost of Labour	0.553	0.433	0.240
39	28	Number of Construction going on same time	0.520	0.460	0.239
40	37	Delay payment to supplier / subcontractor	0.493	0.453	0.224
41	8	Change in material specification	0.500	0.380	0.190
42	38	Employer interference	0.453	0.413	0.187
43	36	Obsolete or unsuitable construction methods	0.500	0.353	0.177

Source: Structured Questionnaire Survey

The result of the analysis of questionnaire survey data by frequency index method presents in Table 8. It shows additional work and variation as the number one rank for cost overrun factor in rural road projects and followed by inaccurate time and cost estimates, fluctuation of the price of the material. Contractual claims such as extension of time with cost claims, Change of estimated quantity, unrealistic contract duration, inaccurate site investigation, poor design and delays in design, incomplete and inaccurate design at the time of tender and unforeseen ground conditions respectively.

Table. 8 - Result of Classification of Cost Overrun Factors

Group	Sub Group	Average S.I.	Rank	Group Rank
Technical	Design	0.365	9	3
	Construction	0.286	16	
	Scope	0.395	6	
	Site	0.505	2	
	Experience	0.394	7	
Economic and Financial	Financial Contracts	0.467	3	4
	Financial Policy	0.281	17	

	Internal	0.298	14	
	External	0.302	13	
Political and regulation	Political situation	0.244	18	6
Management	Estimation Process	0.506	1	1
	Planning	0.451	4	
	Monitoring and Controlling	0.337	11	
	Communication	0.331	12	
Project Resources	Labour	0.297	15	5
	Material	0.363	10	
	Equipment	0.000	19	
Environment	Location	0.375	8	2
	Weather Condition	0.406	5	

Source: Structured Questionnaire Survey

The funding agency (ADB) only allows a 15% increment of total budget allocated for each contract package, which provides a cost overrun margin for the project implementation. This study proved that the major first five factors of cost overrun are additional works and variations, inaccurate time and cost estimates, fluctuation of price of material, contractual claims such as extension of time with cost claims, and change of estimated quantity. In practical situations, most of the time above five factors caused a big impact on the total value of every contract [11]. A separate analysis carried out for Anuradhapura district but due to space problem that aspects did not include in this paper.

6. Ascertain the Impact of Cost Overrun of Rural Road Projects

This section investigates the impacts of cost overrun on rural road projects in Sri Lanka under the following headings.

6.1 Impacts to the project and stakeholders of the project

When participants were asked to explain the potential impact of Cost Overruns on rural road projects in Sri Lanka and how it would affect funding, debt resettlement, contractor activism and the country's economy, they pointed out that in rural road projects, if the cost exceeds unable to control effectively, it can lead to some of the consequences listed below.

i. Insufficient funds were available at the end of the project.

Experts have identified that the high cost of these projects is one of the reasons why there is not enough money at the end of the project. However, estimates have been prepared at the tender stage, including 20% uncertainty for physical and price variability in contract execution.
When the cost is exceeded, the estimated budget for the completion of the project also increases, but the existing fund remains the same as previously allocated. Further increase in project cost may result in insufficient funding at the end of the project, leading to failure to meet project goals and objectives defined at the outset.

ii. This may result in insufficient allocations.

At the beginning of the year, the Government of Sri Lanka allocates funds from the annual budget for the projects implemented under the Ministry of Highways. Then all the projects were allocated separate funds at the beginning of the year. Ministry of Highways has decided to put individual allocations for each road included in the projects. Since the effect of cost overrun, monthly expenditure will be increased, but financial allocation cannot normally be changed once fixed and approved in the budget. This may result in

a lack of funding for the roads and projects implemented under the Ministry of Highways. Finally, the employer may not be able to pay the monthly bills to contractors due to insufficient government financial allocations despite having a foreign fund.

iii. Contractors expected performance might experience shortcomings due to Cost Overrun. Their planned cash flow may get affected and sometimes result in implementation failures.

Contractors' performance directly depends on their cash flow. If they can achieve projected cash flow without any delay, the contractor's expected performance can also be achieved. Since the project is undergoing cost overrun, it will increase the cost to completion of the project; therefore, the required monthly cash flow will also be increased with time. That means it takes more money to complete the work scheduled to be done in the project program. High expenditure and less return will lead to the contractor's unbalance cash flow. If the contractor fails to achieve the plan cash flow and the contractor's expected performance may experience shortcomings due to the unavailability of financial capacity to complete the ongoing works [12]. Increasing required cash flow and frequent unexpected adjustments for contractor's cash flow due to Cost Overrun would sometimes result in project implementation failure.

iv. Any failure or shortcomings in achieving project targets or goals would impact the country's economy because borrowings are planned and made based on the project goals and their return.

While the project undergoes cost overrun, it would result in sort coming in to achieve the project target and goals. Project targets are mainly improving the motorable condition, reducing the travel time, and properly disbursement of the fund. According to the project's current situation, some packages were terminated and couldn't achieve project targets and goals and couldn't achieve their return with respect to the expenditure of each contract.

v. Delay in Completion of Project and curtailment of the original scope.

While the project is undergoing cost overrun, the required monthly cash flow also will be higher than the original plan with the time. That means it takes more money to complete the works scheduled to be done in the project master program. The annual turnover and working capital of many contractors are not sufficient to afford the increasing financial requirement because they depend on the line of credit to comply with financial resources as per the bidding criterion 2.3.3 of Section 3 standard bidding document [12]. Suppose the Contractor fails to provide the additional financial support to complete the project. In that case, slow progress can be observed during the latter part of the contract or under the breakeven point because they cannot make a profit for their future projects. As a result of continued slow progress, the amount of outstanding work will be increased with time and a delay in the completion of the project can happen. In many cases, the employer has decided to reduce the original scope of the contract as it is unable to provide the required additional cash flow. Pruning the original scope could have several consequences, including the loss of contractors' profits, the inability to achieve the project objectives, and the government spending the extra money to complete the incomplete scope of those projects. Therefore, this directly affects the socio-economy of the country.

vi. Terminated Contracts and Problem

- About 10% of contracts in iROAD program had to be terminated. Including one contract in the southern province, three contracts in Sabaragamuwa Province, one contract in the Central Province, five contracts in the North Western Province, and two contracts in the Kalutara District, as contractors suspended the construction works halfway without completing the full scope included in the contracts. Most of the terminated contracts are the lowest bidder and they have low rates for bill items in BOQs.
- The main reason for poor performance seems to be that their cost for construction is more than the amount they recovered through bills. That means the cost of the construction is increasing with the

time. Most of the packages were terminated due to the poor financial capability of the companies. Some investigation has found that the termination is a result of the cost overrun of the project.

- The contractors, who have completed the work, also did that by incurring substantial financial losses.

- Once the contract was terminated, preparation estimates for balance work, retendering, and the final process take 6-8 months. There is no party to maintain partially completed/uncompleted roads during that period, and roads have become unmotorable.

Excess cost is a major cause of the consequences highlighted above, and the problem of cost overruns that cause economic problems needs to be explained and answered. The participants in the interview explained how it happened and how it could be a financial problem as follows.

Participants identified that failure to execute contracts due to cost overruns would directly affect the rural economy. For example, suppose contractors have to allocate more financial resources for construction and have the less financial capacity to pay for local labor and suppliers. In that case, it is challenging to make those payments when the cost is exceeded. Delaying payment by the Contractor or Employer may result in social problems and economic problems, lowering the local peoples' living standards.

Contractors may fall into a situation of bankruptcy when limits are exceeded. A situation like this could impact the construction industry, contributing reasonably to the economic growth of the country. Another thing is that the construction will be suspended because of the termination of contracts, which may cause obstruction for the mobility of vehicles on partially completed roads. It is not only obstruction for mobility but also takes another 5 to 6 months to procure another contractor to do the balance work. Further, indirect benefits such as earning income by providing temporary accommodations, supplying food and other small businesses will be disrupted due to the uncontrollable situation described above.

7. General Discussion, Findings and Policy Recommendations

This section presents the general discussion in summary, and discusses the policies and recommendations to overcome the current situation of cost overrun in rural road projects in Sri Lanka.

- Identify the relationship between the cost overrun and the key parameters used in contract procurement and describe the current situation of cost overrun in rural road projects in Sri Lanka

The result of the regression models developed using the data collected from the database in the integrated road investment program shows cost overrun with the variation of cost of km road length, the value of engineer estimate, contract award value and contractor's project experience. The relationship between the independent variables and the dependent variable is as follows.

- Awarded contract value – Positive correlation to the cost overrun.
- Engineer estimate value – Positive correlation to the cost overrun.
- Cost of Km road length – Negative correlation to the cost overrun.
- Contractor's project experience – Negative correlation to the cost overrun.

- Awarded Contract Value

According to the scattered diagram and multiple regression analysis, the correlation coefficient of the awarded contract value is 0.931. That value indicates the awarded contract value has a strong positive correlation to the cost overrun of rural road projects in Sri Lanka. If the awarded value of a contact is high, there is a higher possibility of having a high completion cost with cost overrun.

- Engineer Estimate Value

The correlation coefficient of the engineering estimate is 0.646, which reveals that the cost overrun is positively correlated with this variable and that the engineering estimate has a moderate positive correlation to the cost overrun. This means that if the project has a high engineering estimate, there is a reasonable potential for project costs to increase. Furthermore, the estimates show some deviations from the actual values according to the observations. If the contract value is high, the possibility of happening errors is also high. That may result in high deviation and happening cost overrun.

- Cost of Km Road Length

According to the regression result, the cost of km length has a -0.098 correlation coefficient value. That means it has a weak negative or inverse correlation when two variables tend to move in opposite sides and directions from one another, such that the other variable decreases when one increases. If the cost of km road length is high, having a cost overrun is less. Compared with the contribution of Engineer estimates and the contribution of awarded contract value, the contribution of the cost of km length is significantly less for cost overrun.

- Contractor's Project Experience

The contractor's project experience has a correlation coefficient of -0.095 and the Cost Overrun is negatively correlated with this variable. This means that if the contractor has a high level of project experience in rural road projects, he is less likely to increase project costs. Because the contractor's project experience negatively correlates with cost overruns, a contractor is less likely to exceed the cost of a project with high project experience. Since the correlation coefficient value is minimal, the effect is understood to be very small.

On examining the contribution made by the independent variable in the models in Table. 5, it was found that in the current situation, awarded contract value (β=0.966) is the most important independent variable to contribute to changing dependent variable (cost to completion). It was followed by Km cost, engineer estimation, and contractor's project experience. This regression analysis in Table .5 found that the beta value of the engineer estimation and contractor's project experience are 0.043 and 0.013, respectively. That indicates engineer estimation and contractor's project experience have a small contribution to the model.

Based on multiple regression analysis, the regression equation was developed as follows,

Cost Overrun = 306,451,054.8 + 0.966 (Awarded Contract Value) – 0.109 (Km Cost) – 0.043 (Engineer Estimate) + 0.013 (Contractor's Project Experience)

- Identify the main factors causing cost overrun during the implementation of rural road projects in Sri Lanka.

The detail analysis of the questionnaire data ranking of 43 number of costs overrun factors are tabulated in Table.6. They summarized in below Table.9 based on overall index value method.

Table. 9 – The Summary of the Main Cost Overrun Factors

Rank	Cost Overrun Factor	Overall Index Value
1	Additional Works and Variations	0.670
2	Inaccurate Time and Cost estimates	0.598
3	Fluctuation of price of material	0.572
4	Contractual Claims Such as extension of time with cost claims	0.565
5	Change of estimated quantity	0.546
6	Unrealistic Contract duration	0.506
7	Inaccurate Site Investigation	0.487
8	Poor design and delays in Design	0.469
9	Incomplete and Inaccurate Design at the time of tender	0.457
10	Unforeseen Ground Conditions	0.432

Source: Structured Questionnaire Survey

This Table 9 reveals to the reader the most influencing factor for Cost Overrun is additional work and variations in rural road contracts. Inaccurate time and cost estimates are ranked as the second factor and fluctuation in price of the material is the third influencing factor of the analysis result. Other seven factors will follow, as mentioned in this Table. 9.

The factors identified as the cost overrun for rural road development projects in Sri Lanka are very much related to the errors done in the quantity calculation and design drawings done by both the employer and the contractor. As this is the first large-scale rural road development project in Sri Lanka currently in operation (iROAD project), there was not a great deal of experience, resources, and data available, and this research was completed with constraints. Furthermore, there were not many completed contracts to collect the actual data, and the data used for the research were estimated according to the current cost completion pattern. Ideally, the research should be conducted for several years and should be more focused on the actual data, not the predicted or estimated ones. Many projects were temporarily halted due to COVID-19 and the recent economic crisis. Especially many foreign-funded road projects temporarily stopped, such as iROAD in Sri Lanka. This research can be extended to other types of roads and transport infrastructure projects such as railways, seaports, air ports, and city and utility construction. This cost overrun problem is normal to all public sector projects in many countries. Especially, speed highway construction cost overruns are unbelievable in Sri Lanka and many other emerging economies, but so far not any scientific study has been undertaken on this aspect except some people's assertions and perceptions are reported by the media.

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Appendix

The Table.7, 8 and 9 in the text (Pages 13, 14, 15 and 20) are derived through the following Rank Agreement Factor (RAF) method. The questionnaire was distributed and analyzed to find the factors which are mostly affected by cost overrun of rural road projects during the implementation stage. That factors were selected through the past literature and tabulated in a questionnaire form. Participants are requested to give weighed value for those factors according to the impact and frequency of happening. Then collected data in the questionnaire was analyzed and ranked by using Importance Index (I.I), Frequency Index (F.I) and Severity Index (S.I) formula. The ranked factors of cost overruns further analyzed by calculating the weighted indexes of the importance and frequency aspects of cost overrun factors [8].

The following equation is used to calculate I.I, F.I & S.I.

$$\text{Importance Index } (I.I) = \frac{\text{a}.n}{AN}$$

($0 \leq$ index ≤ 1),

$$\text{Frequency Index } (F.I) = \frac{\text{a}.n}{AN}$$

($0 \leq$ index ≤ 1),

$$\text{Severity Index } (S.I) = I.I\ X\ F.I$$

($0 \leq$ index ≤ 1),

Where,
a = constant that represents a weight assigned to the importance scale (ranges from 5 for extremely high impact to 1 for not significant impact).
b = constant representing a weight assigned to the frequency scale (ranges from 5 for extremely frequent to 1 for not at all frequent).
n = The frequency of each response
A = Highest weight (i.e., 5 in this case)
N = Total number of responses

Rank Agreement Factor (RAF) is used to quantify the degree of agreement in ranking between separate groups of participants. RAF denotes the average absolute differences in the rank of the factors defined as follows,

$$RAF = \left[\frac{\sum_{i=1}^{N}|R_{i1} - R_{i2}|}{N}\right]$$

Where,

$R_{i\,1}$ - For any two groups, rank of the i th item in Group 1
$R_{i\,1}$ – Rank of the i th item in Group 2
N – The number of items
j = N – i + 1.

With a maximum RAF:

$$RAF = \left[\frac{\sum_{i=1}^{N}|R_{i1} - R_{j2}|}{N}\right]$$

The Percentage Disagreement is defined as,

$$PD = \left[\frac{\sum_{i=1}^{N}|R_{i1} - R_{i2}|}{\sum_{i=1}^{N}|R_{i1} - R_{j2}|}\right] * 100$$

Then the Percentage Agreement is defined as,

$$PA = 100 - PD$$

A lower value of RAF will suggest higher agreement between any two groups, and when it becomes zero, it is called perfect agreement.