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Construction Management in the Amazon: Analysis of Performance Indicators and Impacts of COVID-19

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SUMMARY
Management failures in public construction projects result in significant resource wastage and delays in social development goals. This research aims to evaluate the management of contracts for public school construction projects using cost, schedule, and scope performance indicators, as well as investigate the influence of the characteristics of the Amazon region and the COVID-19 pandemic on project execution. The methodology involved document analysis of selected samples, describing the projects, geographical locations, contractual changes, and statistical correlation tests. Subsequently, the study surveyed the consequences of the COVID-19 pandemic on the analyzed projects, along with an analysis of performance indicators. The results revealed that all projects experienced cost increases, with an average percentage of 24.36%. Regarding schedule extensions, 92.30% of the projects underwent contractual changes, with an average increase in time of 142.19%. Scope changes were present in all projects, with an average modification percentage of 61.84%. It is believed that this study contributes to a critical analysis of the management of public engineering projects, enabling the identification of problems and improvement opportunities.

KEYWORDS: Construction Management. Public Projects. Performance Indicators.

1 INTRODUCTION

Project Management Failures result in numerous setbacks for the Construction Industry. This scenario is particularly pronounced in the context of the Brazilian Amazon, where challenges are exacerbated by limited access and a shortage of skilled labor.

For instance, the Madeira-Mamoré railway, costing the equivalent of 1.2 billion reais and claiming the lives of approximately 10 thousand workers (MATIAS, 2012), stands as the second-largest project undertaken by the United States outside its territory, following only the Panama Canal (VAN DEURSEN, 2017). The lack of regional infrastructure, high maintenance costs, tropical climate diseases (such as malaria), and the decline of rubber production ultimately led to the definitive termination of the project (IPSEI, 2019).

A century later, similar challenges persist. Logistic hurdles and planning deficiencies are still prevalent in various projects in the region, resulting in resource wastage and delaying the anticipated social benefits upon project completion.

As highlighted by Pinheiro and Crivelaro (2018), the impact of major engineering projects on the country's development is substantial, given the crucial role of enhancing transportation, telecommunications, energy, health, and education services in improving national productivity and competitiveness. However, shortcomings in project management pose significant obstacles to this socio-economic advancement.

According to a study conducted by the Tribunal de Contas da União (TCU), Brazil currently has 8.6 thousand unfinished construction projects out of a total of 21 thousand (BRASIL, 2023). Among these, 3600 are educational facilities (kindergartens and schools), accounting for 12% of all projects launched since 2007 (ACCIOLY, 2022).

Brandstetter and Ribeiro (2020) evaluated contract amendments in public educational projects and found that half of the modifications stemmed from project flaws, followed by scope changes requested by users (20%), improvements for building maintenance (15%), and budget errors (11.7%). These shortcomings significantly affect project performance, particularly regarding the triple constraint (cost, schedule, and scope).

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Given the importance of the topic for construction management, this article aims to analyze the management of public projects using performance indicators based on the project management triangle (cost, schedule, and scope), as well as the effects of geographic location and the COVID-19 pandemic on school construction projects.

2 LITERATURA REVIEW

The term "project" has various literary meanings. Mattos (2019) explains that, in civil engineering, the term refers to the overall plan of a building or the set of information necessary for the execution of a work, such as structural, architectural, hydraulic, sanitary, and electrical projects.

In the public sector, the concept of a project is broader, encompassing the set of necessary and sufficient elements for the execution of the work, including graphic drawings, budgets, cost composition, physical-financial schedule, descriptive memorial, and calculation memory (BRASIL, 1993).

In both the public and private spheres, the managers' objective is the same: to achieve the success of the project. However, unexpected situations or those resulting from poor planning arise during contract management and have significant impacts on the final result. Failures caused by project deficiencies, budget errors, scope changes by clients, and slow decision-making were the most recurring reasons for failures in construction projects (BRANDSTETTER; RIBEIRO, 2020; D'ANGELO, 2022).

Another factor contributing to this inefficiency is the legislation governing public contracts. The old Brazilian standard for service procurement - Bidding and Contracts Law No. 8666/93 - in force until December 30, 2023, has gaps that lead to failures in projects since price overrides quality during the proposal evaluation (GOMES, 2007). The new Bidding Law - 14.133/21 - which came into force in April 2021 and will become exclusive in 2024, was designed to correct flaws in the contracting process and make Public Administration more efficient.

However, Timóteo (2021) points out that both the old and the new legislation were silent regarding the limits of deadline extensions for projects, focusing only on financial indicators and demonstrating the legislator's negligence regarding the completion time of services.

As if the failures resulting from the process itself were not enough, situations arise that go beyond the construction site environment, as was the case with the COVID-19 pandemic, which brought numerous adversities to the global population and builders in the years 2020 and 2021 (UNASUS, 2020).

In the public sector, these adversities caused by the COVID-19 pandemic led to work stoppages, reduced activity rates, implementation of unforeseen sanitary procedures, as well as abnormal adjustments in input values. These situations led to several requests for economic-financial rebalancing and deadline extensions for contracts (ESPÍRITO SANTO, 2021).

Raoufi and Fayek (2020) highlight that despite the mitigation measures of the pandemic's effects implemented by construction companies, such as monitoring health indicators, removing workers exposed to the COVID-19 virus, implementing hygiene devices, and using masks in the work environment, many projects suffered losses due to interruptions.

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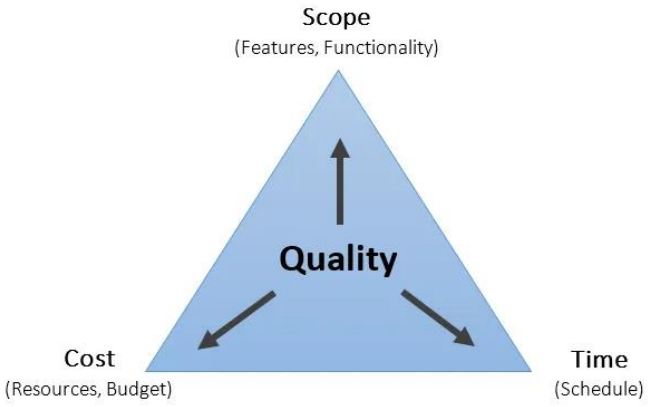
An alternative to mitigate these impacts would be the enhancement of construction project performance management tools. In this regard, Moradi et al. (2021) state that the best way to assess and control project performance is through defining metrics that allow for objective analysis of indicators.

According to Marzouk and Gaid (2018), analyzing project performance enables companies to focus efforts on the most deficient areas of the project, enabling the implementation of corrective actions and, consequently, improvement of performance indicators. Espinha (2019) mentions that Key Performance Indicators (KPIs) are project management tools that enable the control of organizational efficiency indices.

A study by Moradi et al. (2021) pointed out that the main KPIs used in civil construction projects worldwide are: Cost (45%); Quality (45%); Schedule (40%); Productivity (36%); Customer satisfaction (31%); Profitability (27%); and Environment (20%).

In this regard, a concept in project management stands out: the iron triangle. According to Louzada (2019), cost, schedule, and scope are closely linked in a project and are primarily responsible for the final product quality, as any change in one indicator significantly influences the others.

Figure 1 – Triple Constraints of Project Management.



Source: Polito (2015).

Through the analysis of performance indicators of educational construction projects, the aim is to identify the origins of project failures and opportunities for implementing improvements in the public works management process.

3 METHODOLOGY

The nature of this research is descriptive, and the case study method was adopted to achieve the proposed objectives. Descriptive research involves the collection and analysis of data without the interference of the researcher (BARROS; LEHFELD, 2007). Therefore, the methodology of this work included the following steps:

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a) Systematic Literature Review: A survey was conducted on topics related to the management of public works and the performance indicators used to evaluate the projects;

b) Non-probabilistic sampling technique was adopted, where the data were selected according to specific criteria:

1. Public educational construction projects;
2. Standardized projects;
3. Comprehensive record of contractual management;
4. Ease of obtaining data;

The theme of the research shaped the search criteria, focusing on public educational projects. Prioritization of standardized projects followed a preliminary analysis of available data, as criteria for comparison among similar objects were more reliable. Subsequently, the preference was for information available in computerized construction management systems, contrasting with data obtained in physical form, given the sluggishness in data collection, processing, and analysis. These requirements were crucial for selecting projects with reliable elements, as computerized systems ensure the availability of information promptly and the integrity of data, reducing the possibilities of manipulation.

Thus, thirteen works from the State Department of Education of Amazonas - SEDUC/AM - were chosen to be part of this study. These projects are part of the CETI - Full-Time Educational Center - implemented in twelve municipalities in the interior of the state and only one in the state capital (Manaus). Information about contract management is in the public domain and available on the state government's transparency portal.

c) Characterization of samples: identification of project components and significant divergences between them, as well as geographic particularities (location, distance to the central hub, transportation time of inputs), in order to recognize connections between flaws in the works and their spatial characteristics. The Spearman correlation statistical test was adopted at this stage;

d) Influence of the Covid-19 Pandemic: efforts were made to identify the impacts of the pandemic on the chosen samples and to segregate information from the final performance analysis, given that the sample elements were built between 2015 and 2022, with some projects completed before the start of the health crisis.

e) Establishment of performance indicators: during the documentary analysis of the projects, it was identified that only information regarding cost, schedule, and scope was documented. Therefore, the research focused on evaluating these aspects, based on the equations:

$$Cost = \frac{Planned\ Cost\ (R\$)}{Effective\ Cost\ (R\$)} \quad (1)$$

$$Time = \frac{Planned\ schedule\ (days)}{Effective\ Schedule\ (days)} \quad (2)$$

$$Scope = \frac{Planned\ Services\ (spreadsheet\ items)}{[Planned\ Services + Modified\ Services\ (spreadsheet\ items)]} \quad (3)$$

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Based on the results obtained, the profile of the analyzed public works was outlined. The product of the three indicators (CxTxS) was correlated with the management iron triangle, with a reference parameter for analysis being a value equal to 1.0, since the planned should be equal to the executed.

f) Analysis of the results: The interrelationships between geographic location and the main project failures, the evaluation of performance indicators, as well as the quantitative analysis of contractual changes were examined together and supported the conclusions drawn at the end of the research.

The realization of this research was preceded by a preliminary study on the proposed topic, the collection of relevant information on the management of the works through the Transparency Portal of the Government of the State of Amazonas, as well as visits to the Secretariat of Education of Amazonas to clarify doubts.

4 RESULTS

4.1 Characterizacion of samples

The construction of the Full-time Educational Centers (CETI) was carried out through a National Public Bidding process, based on standard projects provided by the Education Secretariat. The project consists of an educational block, a covered courtyard, a gymnasium, a swimming pool, a football field, a guardhouse, and a trash bin (Figure 2).

Figure 2 – CETI Standard Project.

Source: Amazonas (2022).

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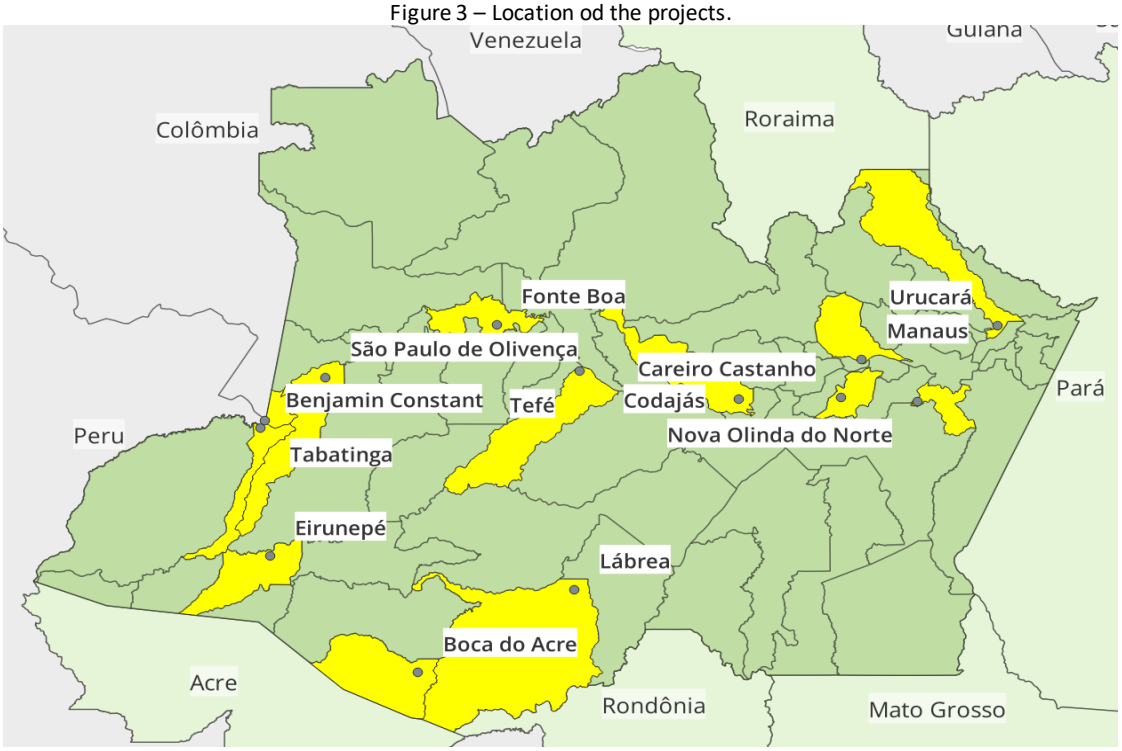
Initially, it is worth noting that the divergences among the thirteen projects are restricted to the external areas, given that the terrain was a determining factor for the differentiation of the quantities of complementary services, such as paving and landscaping.

The percentage variation of complementary services around the average reached 137.54% for the "asphalt coating" item in the project located in Nova Olinda do Norte and 161.94% for the "grass application" item in the municipality of Benjamin Constant.

It is important to emphasize that the above-mentioned project differences do not represent a significant portion of the project budget, since the aforementioned services do not belong to segment A of the ABC curve of services. Therefore, the degree of project complexity was similar, with no obstacle to comparison.

Regarding the geographical location of the projects, the availability of main transport modes in the region (river, land, and air), the distance (kilometers), and the travel time (hours/days) to the capital Manaus were investigated. The geographical position of the municipalities is indicated in Figure 3.

Figure 3 – Location od the projects.



Source: Author, 2023.

Following, a logistical overview of each project was presented (Table 1), highlighting the difficulty of access and raw material transportation, with emphasis on the municipality of Eirunepé, where travel varies from 15 to 30 days, depending on the direction of the journey (from the headwaters to the mouth of the Amazon River).

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Table 1 - Geographical information of the municipalities.

	Transport Mode			Route (km)			
Locality	Terrestrial	Aerial	Fluvial	Terrestrial	Fluvial	Total Distance	Travel Time
C. Castanho	x		x	112,1	11,9	124	2,7h
Lábrea	x		x	839,91	12,09	852	13h
N.O. Norte	x		x	148	42,3	134	5h
Urucará	x		x	339	39	378	7h
B. Constant			x		1119	1119	3 days/6 days
Tefé		x	x		643	643	2 days/1,5 day
Tabatinga		x	x		1106	1106	3 days/6 days
B. Acre *	x		x	220		220	3h
S. P. Olivença			x		1008	1008	3 days/6 days
Codajás			x		240	240	1 day/14,5h
Eirunepé		x	x		2417	2417	15 days/30 days
Fonte boa			x		880	880	3 days/2 days

Source: Author, 2023.

Afterward, the changes in contracts (cost and timeframe) for the thirteen analyzed projects were surveyed. The data was collected directly from the Transparency Portal of the State of Amazonas and is summarized in Table 2.

Table 2 - Summary of the amount of additive cost and time.

	Cost		Time	
Unit	Quantity	R$	Quantity	Days
Careiro Castanho	4	5.779.034,25	13	1710
Lábrea	4	2.621.144,87	9	960
Nova Olinda do Norte	3	2.592.804,09	10	994
Urucará	1	1.909.038,75	4	420
Benjamin Constant	2	2.694.356,27	9	909
Tefé	4	2.910.426,30	10	1248
Tabatinga	3	9.686.120,79	8	915
Boca do Acre	3	7.268.240,91	7	994
São Paulo de Olivença	2	3.193.831,09	7	707
Codajás	3	5.098.606,41	6	585
Eirunepé	3	8.143.066,99	5	700
Fonte Boa	2	6.443.953,32	8	795
Manaus	3	2.760.938,45	5	330

Source: Autor, 2023.

The information in Table 2 shows a concerning situation, as all projects had modifications in cost and timeframe. The average number of deadline extensions per contract

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was approximately 8 terms, totaling 867 days. Regarding the increases in cost, the average for the analyzed projects was 24.36%, just below the legal limit of 25% defined in Law 8.666/93.

Subsequently, a statistical analysis of Spearman's correlation (Table 3) was conducted between the contract changes (cost and timeframe) and the logistical information of the projects (distance and travel time).

Table 3 - Correlation between geographic location and additives.

Parameters	Correlation Coefficient (R)	
	Number of days added	Additive cost (millions)
Distance (Km)	0,304	0,357
Travel Time (h)	0,243	0,437

Source: Author, 2023.

It was observed that the correlation between the location of the project implementation and the increases in timeframe and cost had a dependency relationship ranging from moderate to weak, meaning that the geographical position was not a determining factor for the poor performance of the projects.

A similar result was obtained by Alvarenga et al. (2021), who analyzed the construction of higher education institutions in the five Brazilian regions, finding no evidence that projects launched in the Northern region (farther from the Brazilian economic center) necessarily had more delays than projects in other regions of Brazil.

4.2 Effects of the covid-19 pandemic

With the aim of identifying the influence of the COVID-19 pandemic on the public works contracts of CETI and making the analysis of project performance more equitable, a survey was conducted on government actions that influenced the development of the samples.

Over 150 state decrees addressing COVID-19 response measures were analyzed between March 16, 2020, and December 20, 2021. For the Construction Industry, government actions mainly involved restrictions on urban mobility and social distancing measures, commonly known as "lockdowns," regular monitoring of public health indicators, isolation of symptomatic workers, provision of hand hygiene equipment on construction sites, and implementation of distancing plans at work sites.

Public projects for the construction of school units were not included in the list of essential activities by the local government, resulting in numerous interruptions. Data from the Transparency Portal of the State of Amazonas revealed that during the aforementioned period, CETI projects experienced 168 days of complete work stoppage and 439 days of reduced work hours.

Subsequently, a new analysis of contractual deadline extensions was conducted, disregarding technical justifications that included the effects of the COVID-19 pandemic (Table

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4). The main justifications mentioned were stoppages, reduced work pace, difficulty in obtaining inputs, and the absence of symptomatic employees.

Table 4 - Summary of Deadline Extensions Disregarding the Effects of the Pandemic.

			Total		With Covid-19		Without Covid-19	
Start	Conclusion	Unit	Quant.	Days	Quant.	Days	Quant.	Days
2015	2021	Careiro Castanho	13	1710	6	450	7	1260
2016	2020	Lábrea	9	960	-	-	9	960
2016	2020	Nova Olinda do Norte	10	994	-	-	10	994
2017	2019	Urucará	4	420	-	-	4	420
2017	2020	Benjamin Constant	9	909	-	-	9	909
2017	2021	Tefé	10	1248	7	598	3	650
2018	2022	Tabatinga	8	915	4	581	4	334
2018	2022	Boca do Acre	7	994	4	724	3	270
2018	2021	São Paulo de Olivença	7	707	4	360	3	347
2019	2022	Codajás	6	585	6	585	0	0
2019	2022	Eirunepé	5	700	3	606	2	94
2019	2022	Fonte Boa	8	795	5	554	3	241
2020	2022	Manaus	5	330	3	210	2	120

Source: Author, 2023.

The works in Lábrea, Nova Olinda do Norte, Urucará, and Benjamin Constant did not undergo any changes, as they were initiated and completed before the onset of the COVID-19 pandemic in Amazonas (March 2020). After segregating the justifications, it was noted that the average number of days added to the contracts due to the pandemic was 519, a result 142.19% higher than the total time stipulated for the completion of the works (365 days).

Disregarding the effects of COVID-19, only the project developed in Codajás did not show any deadline extension, meaning that 92.3% of the sample data had their schedules altered, a parameter similar to that found by Santos (2015), as shown in Table 5.

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Table 5 - Percentage recurrence and intensity of contractual amendments.

Author	Country	Tipology	Frequency		Intensity	
			Time	Cost	Time	Cost
Arditi *et al* (1985)	Turquia	Education/Health/Safety	-	-	40%	-
Al-Momani (2000)	Jordânia	Health/Residential/Commercial/ Administrative	82%	-	-	-
Aibinu e Jagboro (2002)	Nigéria	Education/Health/Residential/Commercial/Infrastructure	-	-	-	17,3%
Hsieh *et al*. (2004)	Taiwan	Education/Health/Residential/Commercial/Infrastructure/Leisure	-	-	-	10 a 17%
Assaf e Al-Hejji (2006)	Arábia Saudita	Education/Health/Residential/Commercial/Leisure	70%	-	10 a 30%	-
Rasmussen (2013)	Brasil	Education/Health	84%	80%	201,20%	13,67%
Shehu *et al*. (2014)	Malásia	Education/Health/Residential/Commercial/Infrastructure/Leisure	-	55%	-	-
Santos (2015)	Brasil	Education/Health/Safety/Culture/Administrative	96%	72%	109%	16%
Casotte (2016)	Brasil	Education	-	-	100%	-
Corrêa e Shih (2019)	Brasil	Education	79%	100%	167%	22%
Brandstetter e Ribeiro (2020)	Brasil	Education	-	85,7%	-	-
D'Ângelo (2022)	Brasil	Education	83%	74,3%	-	-
Timóteo (2021)	Brasil	Education/Health	83,30%	83,30%	95,40%	12,40%
Alvarenga *et al* (2021)	Brasil	Education	69,05%	61,89%	92,03%	13,87%

Source: Adapted from Santos (2015).

During the analysis of the projects, no changes in contract values were observed under the justification of the pandemic, such as economic-financial rebalancing through revision. Only the adjustment, which is contractually provided and occurs annually, was noted. All projects showed increases in value, as evidenced in Table 2, but none were motivated by the pandemic.

The cost amendments studied in the literature were not similar to those found in the CETI project. The highest percentage of incidence was observed by Brandstetter and Ribeiro (2020), who identified value increases in 85.7% of the analyzed works, lower than the 100% obtained in the sample of this research. Regarding intensity, the average percentage observed in the CETI projects was 24.36%, much higher than that found by other researchers, who identified rates between 10 and 17.3%.

4.3 Performance indicators

In this phase, the analysis of performance indicators was conducted according to parameters described in the materials and methods section. The projects were listed in chronological order of execution, starting in 2015 with the Careiro Castanho project, up to the CETI Manaus project, which was initiated in 2020.

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By comparing the planned budget with the actual budget, excluding adjustment values, the cost indicator result was obtained (Table 6).

Table 6 – Cost indicator.

Unit	Planned	Addtive	Effective	Indicator
Careiro Castanho	R$ 13.989.533,67	R$ 5.779.034,25	R$ 19.768.567,92	0,71
Lábrea	R$ 15.098.214,91	R$ 2.621.144,87	R$ 17.719.359,78	0,85
Nova Olinda do Norte	R$ 15.006.170,77	R$ 2.592.804,09	R$ 17.598.974,86	0,85
Urucará	R$ 15.668.262,25	R$ 1.909.038,75	R$ 17.577.301,00	0,89
Benjamin Constant	R$ 16.337.175,18	R$ 2.694.356,27	R$ 19.031.531,45	0,86
Tefé	R$ 14.138.539,79	R$ 2.910.426,30	R$ 17.048.966,09	0,83
Tabatinga	R$ 20.500.000,00	R$ 9.686.120,79	R$ 30.186.120,79	0,68
Boca do Acre	R$ 17.331.520,50	R$ 7.268.240,91	R$ 24.599.761,41	0,70
São Paulo de Olivença	R$ 17.075.947,60	R$ 3.193.831,09	R$ 20.269.778,69	0,84
Codajás	R$ 14.242.036,74	R$ 5.098.606,41	R$ 19.340.643,15	0,74
Eirunepé	R$ 20.298.260,13	R$ 8.143.066,99	R$ 28.441.327,12	0,71
Fonte Boa	R$ 15.779.056,81	R$ 6.443.953,32	R$ 22.223.010,13	0,71
Manaus	R$ 17.927.734,58	R$ 2.760.938,45	R$ 20.688.673,03	0,87

Source: Author, 2023.

The project that showed the best performance in this regard was Urucará (0.89), while the venture with the worst result was Tabatinga (0.68). The values of the cost indicator fluctuated over the years, making it impossible to infer any improvement over time.

In this aspect, a failure in monitoring and controlling the projects can be observed, given that the implementation of standardized projects contributes to continuous improvement in the process. However, this did not happen, as the same increases persisted over 5 years for all projects, without improvements in the indicators.

Subsequently, a comparison was made between the initial deadline for the services and the actual one, disregarding the additional time due to the covid-19 pandemic (Table 7).

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Table 7 – Time Indicator (to be continued).

Unit	Planned	Addtive	Effective	Indicator
Careiro Castanho	365	1260	1625	0,22
Lábrea	365	960	1325	0,28
Nova Olinda do Norte	365	994	1359	0,27
Urucará	365	420	785	0,46
Benjamin Constant	365	909	1274	0,29
Tefé	365	650	1015	0,36
Tabatinga	365	334	699	0,52
Boca do Acre	365	270	635	0,57

Table 7 – Time indicator (conclusion).

São Paulo de Olivença	365	347	712	0,51
Codajás	365	0	365	1,00
Eirunepé	365	94	459	0,80
Fonte Boa	365	241	606	0,60
Manaus	365	120	485	0,75

Source: Author, 2023.

The project with the best performance was Codajás (1.00), as the planned deadline for the activities was met. On the other hand, the project with the worst performance was Careiro Castanho (0.22). The results shown in Table 7 allow us to conclude that there was a substantial improvement in the scope indicator, since the most recent projects have values close to 1.0.

Finally, the same comparison was made between planned and executed services with the scope indicator (Table 8).

Table 8 – Scope Indicator.

Unit	Planned Services Quant.	Modified Services		Indicator
		Planned	News	
Careiro Castanho	898	431	266	0,56
Lábrea	945	350	338	0,58
Nova Olinda do Norte	913	403	254	0,58
Urucará	1210	600	0	0,67
Benjamin Constant	908	360	263	0,59
Tefé	909	348	301	0,58
Tabatinga	1034	246	370	0,63
Boca do Acre	930	438	252	0,57
São Paulo de Olivença	970	260	112	0,72
Codajás	882	608	269	0,50
Eirunepé	1019	186	238	0,71
Fonte Boa	956	153	284	0,69
Manaus	970	125	196	0,75

Source: Author, 2023.

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The project with the fewest scope changes and, consequently, the best index was Manaus (0.75). On the other hand, the project with the highest volume of scope changes was Codajás (0.50). Therefore, a slight improvement in the scope indicator was observed throughout the program, mainly due to the additional services in the pedagogical block structure. This contractual change was repeated in all projects, even those that had not yet been launched.

After analyzing the aforementioned indicators, the information was triangulated from the perspective of the management iron triangle (Table 9).

Table 9 – Performance indicator (to be continued).

Unit	Indicator			CxTxS
	Cost	Time	Scope	
Careiro Castanho	0,71	0,22	0,56	0,09
Lábrea	0,85	0,28	0,58	0,14
Nova Olinda do Norte	0,85	0,27	0,58	0,13
Urucará	0,89	0,46	0,67	0,28

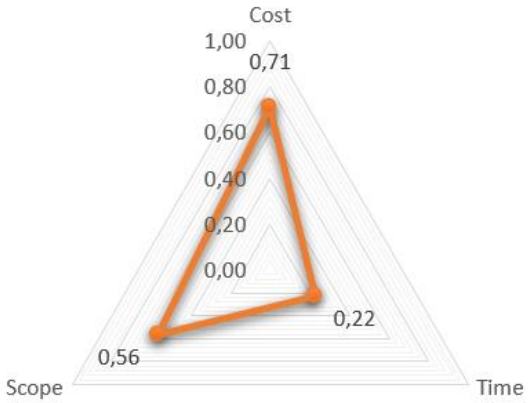
Table 9 - Performance indicator (conclusion).

Benjamin Constant	0,86	0,29	0,59	0,15
Tefé	0,83	0,36	0,58	0,17
Tabatinga	0,68	0,52	0,63	0,22
Boca do Acre	0,70	0,57	0,57	0,23
São Paulo de Olivença	0,84	0,51	0,72	0,31
Codajás	0,74	1,00	0,50	0,37
Eirunepé	0,71	0,80	0,71	0,40
Fonte Boa	0,71	0,60	0,69	0,29
Manaus	0,87	0,75	0,75	0,49

Source: Author.

The projects in Careiro Castanho, Lábrea, and Nova Olinda do Norte, launched in the initial phase of the CETI program, had the worst indices (0.09; 0.14; 0.13, respectively). Figure 4 allows visualization of the indicators of the Careiro Castanho project from the perspective of the iron triangle.

Figure 4 – Performance indicators of CETI Careiro Castanho.



Source: Author, 2023.

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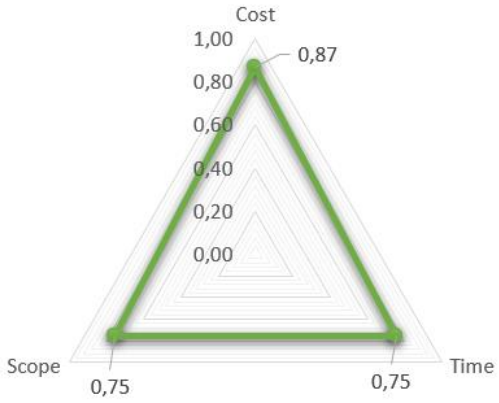
On the other hand, the works that showed the best performances, Manaus (0.49) and Eirunepé (0.40), were launched in the final years of the program, albeit far from the desirable benchmark (1.0). Figure 5 allows visualization of the performance indicators of the iron triangle, especially regarding the deadline, where improvements were more significant and drive overall performance growth.

Figure 5 – Performance indicators of CETI Manaus.



Source: Author, 2023.

A joint analysis of the three indicators revealed the effective improvement in project performance over the years, suggesting that some initial inconsistencies were addressed in subsequent projects, based on the concept of lessons learned and continuous improvement.

However, a flaw in the integration of project stages was also noted, particularly in the closing and planning phases. It can be inferred that the management team was aware of the shortcomings of the standard project, as there was a significant improvement in the timeframe indicator. However, these imperfections were not communicated to the planning team for correction; instead, they were addressed concurrently with execution, leading to inconsistencies that could have been avoided.

5 CONCLUSION

Based on the analysis of the performance of school projects in the Amazon region, it can be observed that the particularities of each municipality were described as non-influential factors in the final outcome of the project, as the correlation between contractual changes (timeframe and cost) and the geographical location of the project (distance and travel time to the central hub) ranged from weak to moderate (0.243 to 0.437). Therefore, it is concluded that geographical location was not a determining factor for the success or failure of the projects.

Despite the adoption of control and prevention measures for the COVID-19 pandemic at construction sites, activity shutdowns were significant. The interruptions in the normal workflow had a strong impact, particularly on contractual changes in timeframe, which showed an average increase of 519 days per project, 142.19% higher than planned.

On the other hand, the pandemic was not used as justification for any requests for increased cost or contract revision, suggesting that the contracted companies absorbed the

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extra costs associated with site protection and hygiene, as well as the shutdowns and worker absences.

The absence of a management model that prioritized integration between project phases highlighted various flaws, as imperfections identified during the execution phase were corrected throughout the process but were not passed on to the planning department as lessons learned.

The evaluation of performance indicators suggests a significant improvement in project execution time, primarily due to mastery of the standard project model. However, this performance was not reflected in the cost indicator, indicating avoidable flaws, especially in subsequent projects, since project standardization eliminated the unpredictability of implementing a new construction model.

As a recommendation for future studies, it is suggested to analyze renovation/reconstruction projects, expand to other construction groups (Special Structures; Infrastructure), and analyze the performance of projects adopting the BIM system in the development of basic and executive projects.

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