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Improvement of transportation system through the Lean methodology application with the purpose of mitigating environmental impacts at the U.M. SUMMA GOLD CORPORATION
[Mejora del sistema de transporte a través de la aplicación de la metodología Lean con el propósito de mitigar los impactos ambientales en la U.M. SUMMA GOLD CORPORATION]

Pedro L. Rodriguez Avila [a], Jean F. Roman Barrios [*a], Victor M. Ruiz Rodriguez [a]

[a] Facultad de Ingeniería, Universidad Nacional de Trujillo. Av. Juan Pablo II s/n –Ciudad Universitaria, Trujillo, Perú.
jroman@unitru.edu.pe

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Resumen

El propósito de esta evaluación es determinar en qué medida la mejora del proceso de transporte basada en la metodología Lean reduce los impactos ambientales en la Unidad SUMMA GOLD. El principal foco de análisis de esta investigación es conocer, definir, medir y minimizar las causas de los errores generados en el proceso de transporte de materiales en una unidad minera, lo que a su vez identifica y reduce los impactos ambientales negativos. Esta evaluación se realiza utilizando el enfoque de la herramienta DMAIC (Definir, Medir, Analizar, Mejorar y Controlar), que ofrece una estructura sólida para la resolución de problemas y va de la mano con la metodología Lean Manufacturing. La aplicación de la metodología Lean y la propuesta de mejora de una herramienta tecnológica lograron incrementar el desempeño del transporte de cada área, de 19.95% a 31.32%, obteniendo como variación un 11% de mejora; Esto aumenta la cantidad de mineral producido en 3094 en promedio por viaje. También permite incrementar la tasa de reducción de costos en el uso de combustibles del 25% al 54.91%, obteniendo una mejora del 30% lo que se traduce en una reducción de 1.9 galones por hora con una disminución de costos de S/5,616.1.

Palabras clave: Impactos ambientales, DMAIC, Lean Manufacturing.

Abstract

The purpose of this evaluation is to determine to what extent the improvement of the transportation process based on the Lean methodology reduces environmental impacts at the SUMMA GOLD Unit. The main focus of the analysis of this research is to know, define, measure and minimize the causes of errors generated in the material transportation process in a mining unit, which in turn identifies and reduces negative environmental impacts. This evaluation is carried out using the approach of the DMAIC tool (Define, Measure, Analyze, Improve and Control), which offers a solid structure for problem solving and goes hand in hand with the Lean Manufacturing methodology. The application of the Lean methodology and the proposal to improve a technological tool managed to increase the transportation performance of each area, from 19.95% to 31.32%, obtaining as a variation 11% improvement; This increases the amount

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of ore produced by 3094 on average per trip. It also allows increasing the fuel use cost reduction rate from 25% to 54.91%, obtaining an improvement of 30% which translates into a reduction of 1.9 gallons per hour with a decrease in costs of S/5,616.1.

Keywords: Environmental impacts, DMAIC, Lean Manufacturing

1. Introduction

Currently, institutions worldwide recognize that the deterioration of the environment represents one of the main threats that affects the planet, endangering the survival of various species, including humans (Ambiente, 2021). The current trend towards environmental degradation highlights the importance of establishing monitoring of natural resources in order to identify areas that show critical conditions of deterioration (INRENA, 2018). Spatial analysis and monitoring of environmental deterioration conditions emerge as the most efficient option to understand these trends at different times and regions, while facilitating the development of strategies and actions aimed at reducing and reversing this problem (Perez and Mas, 2021).

Olivera and Mas (2022), indicate that among the environmental problems that generate negative effects on both a global and local scale, the greenhouse effect and climate change, the decrease and loss of biodiversity, ozone deterioration, and deforestation stand out. and the deterioration of soil quality. These have emerged as the most alarming concerns in recent times (AlcaldiaDeMedellin, 2023).

The Lean philosophy does not start from assumptions, but rather constantly seeks new ways to carry out tasks in a more efficient, adaptable, agile and profitable way (Hernández and Mas, 2020). It is recognized that mining operations carry significant benefits, such as economic growth, increased investments in the country and an increase in exports (Narrea, 2020). However, these benefits also come with considerably serious negative repercussions. Thus, the urgency of improving mining processes to minimize adverse environmental impacts has become an issue of great importance. (Echave and Mas, 2018).

In Peru, several mining companies have adopted their own approaches to improve their processes. For example, Volcán Compañía Minera S.A.A. has implemented the Deming Cycle with the goal of reducing costs and increasing income. Likewise, Minera Yanacocha S.R.L. has introduced the Mining Explorator Robot, streamlining operational tasks and cutting expenses (Sagástegui and Mas, 2020). However, although these models seek to improve efficiency and reduce costs to increase productivity, none of them focus on addressing the negative environmental impacts of their processes (Garcia and Mas, 2021).

In this analysis, it is intended to use lean approaches as a set of tools with the purpose of improving the transportation process and examining in detail the environmental impacts associated with each phase of said process (Salas and Mas, 2021). An innovative methodology called "Lean & Environment" will be used, which uses the value chain mapping technique to end and minimize critical waste and discover areas for improvement (Carbajal, 2019). By minimizing this waste, we aim to eliminate adverse effects on the environment. These phases are initially introduced with a clear focus on obtaining environmental benefits, as well as reducing costs and times (Rivera, 2016).

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2. Materials and Methods

2.1 Data collection

The mining unit located in Huamachuco, as shown in Figure 1, has a total of 7 Tippers with a total of 1565 trips. All documented journeys made by these vehicles were analyzed from November 1, 2023 to November 30 of the same year. The sample considered the trip data and documented routes of two dump trucks, specifically the T4C-934 and the T2W-866, as specified in Table 1.

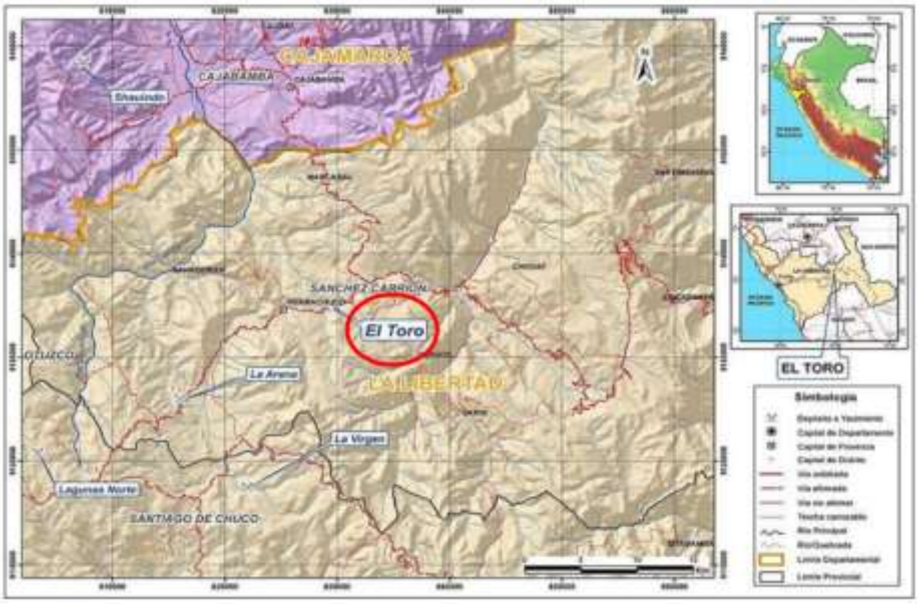

Figure 1. Location and access to the Summa Gold Corporation Mining Company.

Table 1. Number of trips made

Function	Dump truck T4C-934	Dump truck T2W-866
Plant mineral	52	59
Ore to tailings dam	78	79
Tailings to dump	85	95
Plant to be dismantled	89	80
Total	**304**	**313**

a. Surveys

To obtain a more detailed knowledge about the mining company, a tool was used that consists of 12 questions designed with the objective of deepening the understanding of employees' knowledge about the operation of the company, its safety protocols and their familiarity with the environmental issues in the area. Participants in the survey included 5 technicians, 5 supervisors, and 5 shift managers.

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Table 2. Questions from the survey conducted with company personnel

Item	Questions
1	An environmental management plan has been carried out in recent years
2	You know what the negative environmental impacts of your mining operations are.
3	There is adequate control of solid waste and polluting gases emitted by machinery.
4	The mine complies with the environmental laws indicated by the Ministry of the Environment
5	Are there delays in the transportation or delivery process due to incorrect documentation?
6	Are there delays in the loading process due to lack of properly trained personnel?
7	Is there correct management and control of the use of transport vehicles?
8	Is the root cause of a transportation problem quickly detected?
9	Is there adequate maintenance of heavy machinery?
10	Is mining equipment calculated according to the volumes extracted periodically?
11	Is the guide that regulates mining safety rules complied with?
12	Is there an adequately detailed record of the working hours of the machines?

b. Detection of environmental waste during operation in the mining area
Based on the results of the survey, three specific problems were found. Firstly, there is a lack of knowledge on the part of the workers regarding the environmental field of the mining company. Secondly, delays in transport procedures are detected, which could be the reason for the divergent opinions about the effective management of the company. For this reason, Table 3 was created, which shows that the mining unit is causing adverse environmental effects, primarily in the area of transportation.

Table 3. Identification of environmental waste in the mining unit

Process	Environmental Impact
Hauling and loading	- Noise is generated by the heavy machines used, especially when they start or are in operation. - Gases are emitted as a result of combustion in the engines of mining machinery. Gases are also released during the extraction process, such as carbon dioxide, carbon monoxide and methane. - Fertile soils are lost due to erosion, pollution, overgrazing and deforestation. - Fuel is wasted to power the machinery, which has economic and environmental impacts
Exploration	- The mining unit causes the destruction of natural spaces such as rivers and lakes. By excavating and extracting resources, vegetation is removed and the natural landscape is modified. - They also cause landslides and soil instability, when digging which weakens the structure of the ground, increasing the risk of subsidence and landslides
Exploitation	- The noise is generated by blasting. - Gases are emitted during blasting. For example, the combustion of coal releases carbon oxides, nitrogen oxides and sulfur oxides. Pyrometallurgical processes emit sulfur dioxide. - Suspended particles are released due to exploitation activities. - During exploitation, toxic aerosols are formed that contaminate the air.

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Infrastructure	- Destruction of fertile soils by excavating and removing top soil layers. - It also causes desertification, that is, loss of fertile soil, due to deforestation and erosion. - In addition, excavations and alteration of the water table destabilize the surrounding slopes. By extracting material and fluids from the subsoil, the structure and composition of the terrain is modified, making the slopes more prone to landslides and instability.

c. Data processing

In this phase, the activities carried out are quantified, detailing the total hours worked by the team and the total trips made by the team. Based on the sample, 2 dump trucks will be considered during the month of November 2023. Their hours worked, time per lap and observations that were found during data collection were considered. These data reveal that the rental cost for the T4C-934 and T2W-866 dump trucks is obtained by multiplying the hourly cost of the dump truck by the total accumulated hours, which results in S/. 33,525.80. To this calculation is added the General Sales Tax (IGV) of 18% on the total, equivalent to S/. 6,034.64, resulting in a total cost in soles for the rental of said dump trucks is S/. 39,560.44.

d. Analysis of data

The analysis of the route from the Mine to the Plant reveals an approximate initial trip duration of 151.9 minutes, followed by a decrease to 55 minutes, which represents a variation of 63.15%. Regarding the journey from the mine to the tailings dam, an initial time of 50 minutes per trip is recorded, with a subsequent reduction to 13.7 minutes, reflecting a variation of 70.2%. On the path from the plant to the clearing, an initial time of 67.2 minutes per lap is observed, which experiences a decrease to 28.9 minutes, resulting in a variation of 57%. Finally, the journey from the Tailings Plant to the Dump shows an initial time of 29.6 minutes per trip, which is reduced to 22.9 minutes, with a variation of 23%.

d.1 Pareto Diagram

The consumption costs by area in the mining unit under investigation are detailed, where three areas are identified that represent more than 81% of the total monthly consumption in the mining unit. Firstly, the area of "Mining Operations" stands out, covering all operations related exclusively to the extraction of mineral, reflecting 60.9% of the total consumption of the mining unit. Given its importance, this area includes both the management and planning of the mine, as well as the extraction and transfer phases of the mineral to the plant, along with complementary services.

Secondly, there is the general maintenance department of the mine, in charge of carrying out the inspection and maintenance tasks of all operational equipment in the mining complex. Thirdly, the scope of planning and projects is highlighted, which covers activities related to project management and development, such as the launch of camps, plant expansions, preparation of housing for personnel, development of platforms, community support, construction of temporary crushers, among others. These three areas constitute fundamental pillars in the mining company's cost structure, highlighting their relevance in the management and comprehensive development of the company.

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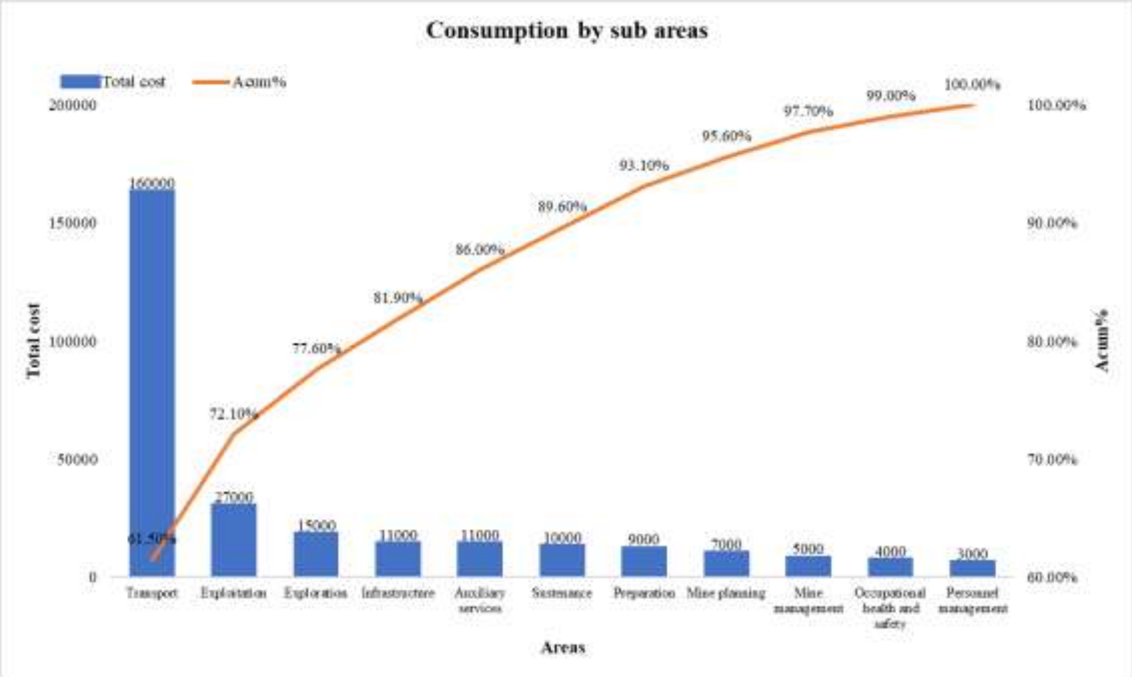

Figure 2. Pareto diagram where we detail the costs by area at the UM.

d.2 Ishikawa diagram

The potential reasons that generate harmful environmental impacts in a mining facility were addressed, detailing more specifically the causes of these adverse effects on the environment. It is made up of different categories: processes (Long mineral delivery times, poor plant design, Ineffective process management), machinery and equipment (Poor condition of machinery, presence of noisy equipment), labor (Lack of capacity, exposure to high sound pressures, lack of motivation, exhaustion, indiscipline, long delivery times), Method (Undocumented procedures, insufficient description, lack of standardization of processes), environment (High sound pressures, vibrations, traffic of vehicles inefficient, generation of dust particles, unevenness on the surface, lack of orientation by workers).

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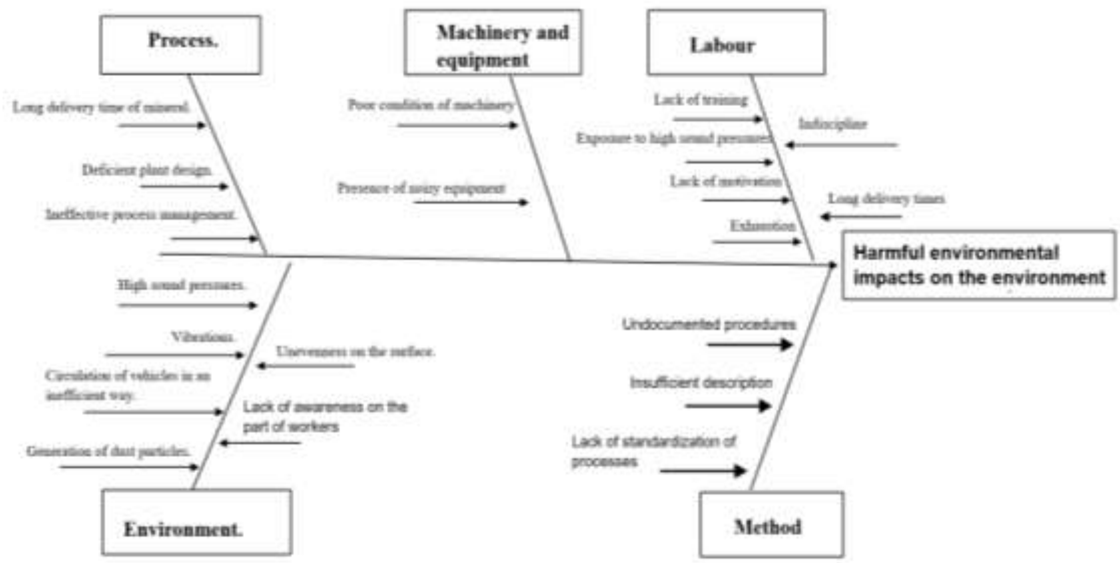

Figure 3. Ishikawa diagram

e. Improvement simulation

Using the ProModel simulation program, a comprehensive evaluation of the material transportation process in the mine was carried out. This simulation will provide a valuable tool to validate the optimization achieved in said process. The analysis covered the six locations where the loading and unloading operations of materials are carried out, also considering the operating environment and the participation of the seven dump truck drivers. The simulation will allow a comprehensive evaluation of the system's behavior in terms of efficiency, time and resources. This methodology will provide crucial data to support decision making and encourage constant improvement of the transportation process at the mine.

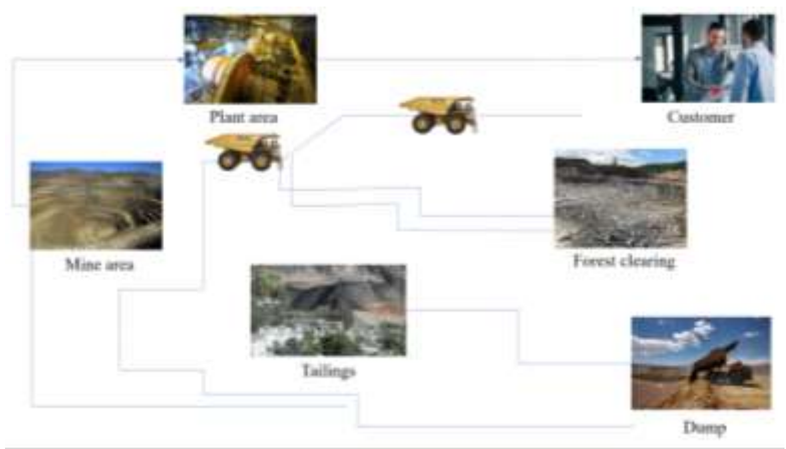

Figure 4. Improvement simulation in ProModel Software

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3. Results

Figure 5 presents the findings of the survey conducted among the 15 employees, which addressed aspects such as company performance, safety regulations, and understanding of environmental issues.

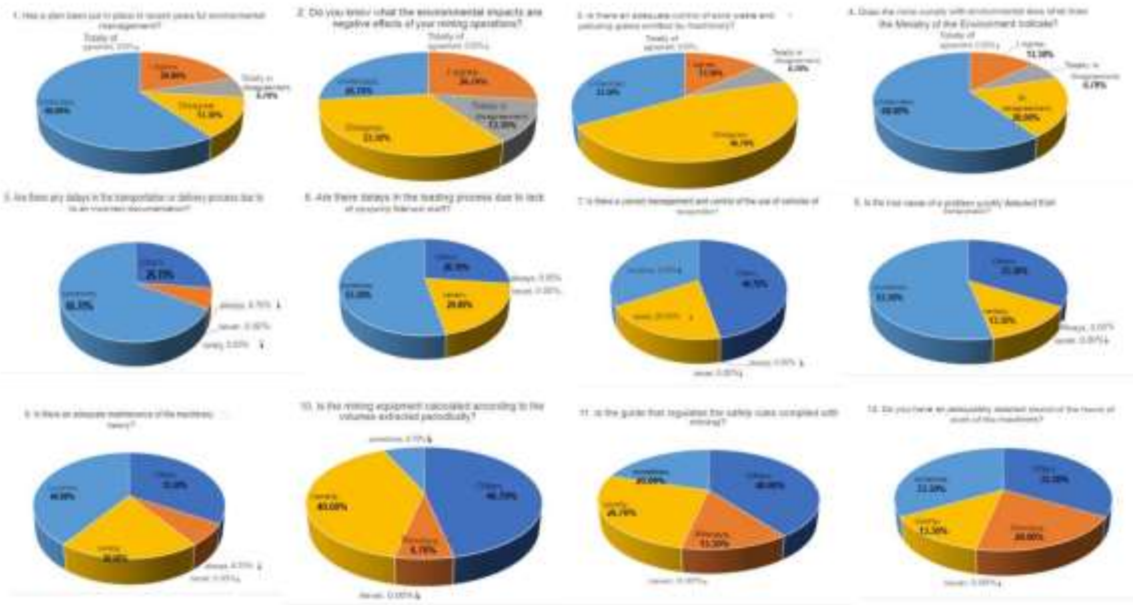

Figure 5. Survey results

Based on this final set of questions, it can be concluded that opinions on whether the company is currently managing processes adequately are undecided and divided.

In the validation process, the aim is to evaluate the hypotheses formulated during the research by comparing them with the tables corresponding to each variable. The significance level (α) is established, which indicates the margin of error associated with performing the test. In this context, it has been decided to use a confidence level of 96%, which is equivalent to a degree of significance α = 5.13%, representing 0.05 of the testing procedure.

Validation of normality involves the formulation of null and alternative hypotheses for each test, followed by parametric analysis with the corresponding normal distribution. The selection of the test is based on comparing the constant variable, involving a longitudinal analysis with two measures (pre and post), with the random variable that denotes a numerical percentage.

After examining both sets of data, it is determined that Student's T with related samples is the most appropriate test for this specific case, as illustrated in Figure 6.

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Study Population	Condition	Quantitative data		Qualitative data
		Test for Metrics	Non-parametric test	Non-parametric test
Two groups	Independent	T-student for independent samples	U-Mann Whitney	X^2 Homogeneity
	Matched	T-student for related samples	Wilcoxon	Mc. Nemar (dichotomous)
From more than two groups	Independent	ANOVA (Analysis of Variance)	Kruskal Wallis	X^2 Homogeneity
	Matched	ANOVA Repeated Measures	Friedman	Cochran (dichotomous)

Figure 6. Comparison of objectives between parametric and non-parametric statistics.
Source: Dr. Alberto Cáceres Huambo (2018).

- H0: A significant disparity will not be observed when reducing environmental impacts in the “Summa Gold” mining unit through the optimization of the transportation process through the application of the Lean methodology.
- H1: A significant disparity will be evident when reducing environmental impacts in the “Summa Gold” mining unit through the optimization of the transportation process through the application of the Lean methodology.

A table has been prepared that reflects the current efficiency, both in its current state without applying improvements, and with the suggested improvements, as the corresponding data is detailed in Table 4.

Table 4. Current efficiency level without improvements and improved

Operation	Percentage of current efficiency without applying improvements in the transportation process.	Percentage of current efficiency with the application of improvements in the transportation process.
Transportation of the mineral to the plant.	22.6	59.8
Movement of the mineral towards the tailings dam.	13.4	45.2
Transportation of tailings from the tailings dam to the dump.	12.2	38.9
Transfer from the plant to the clearing area.	18.8	31.3

To calculate these percentages, the hours worked by both dump trucks during the month of March were totaled, as well as the complete production per area during that same period. Then, a simulation was performed using SPSS software, generating the data presented in Table 5.

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Table 5. Descriptive statistical summary table 1

		Statistics	Error tip.
EF1	Mean	16.76	2.41
	Confidence margin for the mean at 95% (Minimum value).	9.07	
	Confidence margin for the mean at 95% (Maximum value).	24.43	
	Mean cut to 5%	16.69	
	Median	16.13	
	Variance	23.31	
	Typical deviation	4.83	
	Mínimum	12.20	
	Máximum	22.56	
EF2	Media	43.78	6.04
	Confidence margin for the mean at 95% (Minimum value).	24.55	
	Confidence margin for the mean at 95% (Maximum value).	63.00	
	Mean cut to 5%	43.59	
	Median	42.05	
	Variance	145.99	
	Typical deviation	12.08	
	Mínimum	31.25	
	Máximum	59.52	

Since the sample consists of 4 data and is less than 31, it was evaluated by implementing the Shapiro-Wilk test. This information is detailed in Table 6.

Table 6. First normality test

	Kolmogorov - Smirnov			Shapiro - Wilk		
	Estadística	Gl	Sig.	Estadística	Gl	Sig.
EF1	0.26	4	.	0.92	4	0.54
EF2	0.21	4	.	0.97	4	0.85

After confirming that it is a normal distribution, the next stage involves carrying out the Student's T-Test calculation, and the corresponding results are presented in Table 7.

Table 7. Efficiency test using Student's T test

	Discrepancias vinculadas.				
	Media	Desviación típica	Error tipo de la media	Margen de confianza para la media al 95%	
				Inferior	Superior
EF1 – EF2	-27.02	10.64	5.32	-43.95	-10.09

Based on the results obtained, which indicated a significance level of 0.015, it was determined to reject the null hypothesis (H0) and accept the alternative hypothesis (H1). This finding indicates the existence of a significant difference when improving the transportation process through the

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application of the Lean methodology. Therefore, it is expected that this improvement will lead to a significant reduction in environmental effects at the "Summa Gold" mining unit.

In Figure 7, the Route Diagram is used to examine all the average travel times of both dump trucks to all locations, since it is an ideal tool for this type of analysis. These data were analyzed in the context of the extraction of material from one of the three existing veins in the company.

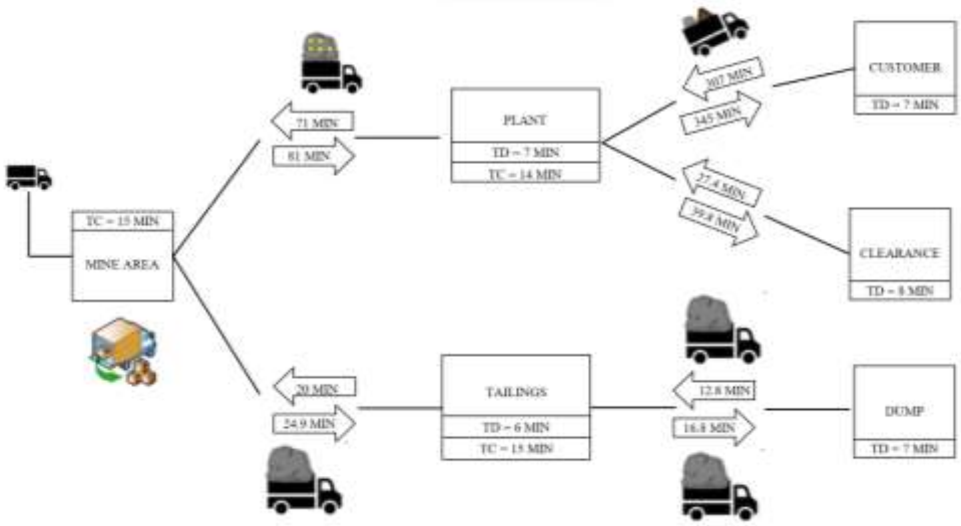

Figure 7. Current route diagram

Thanks to the proposals mentioned above, a significant improvement in the transportation process times per route is observed in Figure 8. The future path diagram aims to represent the situation of operations after the implementation of the proposals, using the FlexSim program. In this context, new times will be introduced to the system, allowing the optimal future condition to be visualized, based on the route sheets of two dump trucks and their productivity.

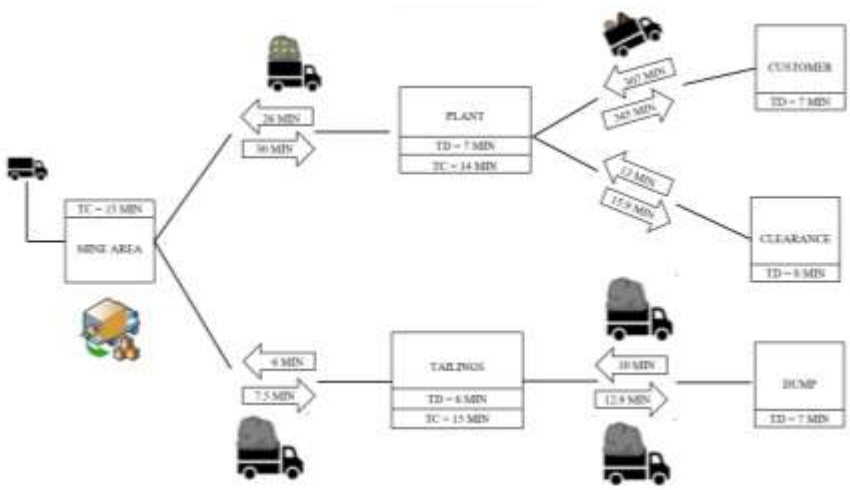

Figure 8. Improved route diagram

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Table 8 shows the variation of the current situation vs. the improved one.

Table 8. Current time vs improved time

Travel area	Total current time	Total improved time	Variation
Mine to Plant	2.53 hrs * 60 min/hrs = 152 min	0.93 hrs * 60 min/hrs = 56 min	63%
Mine to Tailings	0.75 hrs * 60 min/hrs = 44.9 min	0.225 hrs * 60 min/hrs = 13.5 min	70 %
Plant to Desmontera	1.12 hrs * 60 min/hrs = 67.2 min	0.48 hrs * 60 min/hrs = 28.9 min	57 %
Tailings to Dump	0.49 hrs * 60 min/hrs = 29.6 min	0.038 hrs * 60 min/hrs = 22.9 min	23 %

Table 8 presents the routes of the freight vehicles, along with the total times before and after the implementation of the improvements proposed in this research study.

Firstly, the trip from Mine to Plant initially showed an estimated time of 152 minutes, but with the proposed improvements, it was reduced to 56 minutes, representing a decrease of 63%. Regarding the route from Mina to Tailings, the initial time per trip was 44.9 minutes, and after the improvements, it was reduced to 13.5 minutes, with a variation of 70%. In the case of Planta to Desmontera, the initial total time was 67.2 minutes per lap, and with the improvements, it was reduced to 28.9 minutes, reflecting a variation of 57%. Finally, the trip from Tailings to Dump experienced a change from 29.6 minutes per trip to 22.9 minutes after the improvement, with a variation of 23%.

4. Conclusions

It is concluded that the Lean methodology focuses on eliminating waste, optimizing processes and seeking continuous improvements. Its application brings benefits such as cost reduction, operational efficiency and better quality. Foster a culture focused on innovation and customer satisfaction by eliminating activities that do not add value. This methodology is adaptable to various industries and areas, promoting operational excellence in different contexts.
It is determined that by implementing the Lean Methodology and the proposal for improvement through the Lean tool, transportation of the mineral to the plant increased by 37.2%, movement of the mineral to the tailings dam increased by 31.8%, transportation of tailings from the tailings dam to the dump increased by 26.7% and in the transfer from the plant to the clearing area increased by 12.5%.

By exercising control over the activities of the transportation process, it is possible to increase the reduction in fuel costs from 25.12% to 54.83%, thus generating an improvement of 31%. This improvement is reflected in a decrease of 1.85 gallons per hour and a decrease in costs of S/ 5,618.2

These increases in efficiency have culminated in an average of 3,094 additional units of ore transported per trip. This allows the company to generate more profits and fewer delays in production; as well as faster transportation by preventing trucks from expelling less proportioned gas and dust when traveling.

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References

AlcaldiaDeMedellin. (24 de Mayo de 2023). Problemas ambientales: qué son, relevancia y los 23 más graves que están afectando a nuestro planeta. Ciencia, Tecnología e Innovación, 22. https://www.medellin.gov.co/es/sala-de-prensa/noticias/problemas-ambientales-que-son-relevancia-y-los-23-mas-graves-que-estan-afectando-a-nuestro-planeta/

Ambiente (2021). Informe nacional sobre el estado del ambiente. Lima. https://sinia.minam.gob.pe/inea/wp-content/uploads/2021/07/INEA-2014-2019_red.pdf

Carbajal. (2019). Modelo Lean-Green en el proceso de producción dentro de la industria de. Lima. https://repositorioacademico.upc.edu.pe/bitstream/handle/10757/626171/CarbajalA_G.pdf?sequence=3&isAllowed=y

Echave y Mas. (2018). Minería y conflicto social. Consejo Latinoamericano de Ciencias Sociales. Lima.https://repositorio.iep.org.pe/bitstream/handle/IEP/639/huber_mineriayconflictosocial.pdf;jsessionid=898B5A7A917438B504282ECF9760C012?sequence=2

Garcia y Mas. (2021). Mejora del proceso de transporte basado en la metodología Lean para reducir los impactos ambientales en una mina ubicada en Pataz 2021. UNIVERSIDAD RICARDO PALMA, FACULTAD DE INGENIERÍA, Lima. https://hdl.handle.net/20.500.14138/5012

Hernández y Mas. (2020). Lean manufacturing Conceptos, técnicas e implantación. Madrid. https://www.researchgate.net/publication/313931573_Lean_Manufacturing_Conceptos_tecnicas_e_implantacion.

INRENA. (2018). Escenarios y estrategias para el manejo sostenible de los recursos naturales del Perú al 2030. San Isidro. https://archivo.cepal.org/pdfs/GuiaProspectiva/inrena2008.pdf

Narrea O. (2020). La minería como motor de desarrollo económico para el cumplinento de los objetivos de Desarrollo Sotenible 8,9,12 y 17. Lima. https://www.up.edu.pe/egp/Documentos/agenda_2030_la_mineria_como_motor_de_desarrollo_economico_para_el_cumplimiento_de_los_ods_89_12_y_17.pdf

Olivera y Mas. (2022). Impactos del cambio climático. Mexico. https://www.researchgate.net/publication/359074539_Impactos_del_cambio_climatico_una_vision_desde_Mexico.

Perez y Mas, J. (09 de Marzo de 2021). Environmental Degradation from Land-Cover and Use Change Processes from a Spatial Perspective in the State of Guanajuato, Mexico. https://www.scielo.org.mx/scielo.php?pid=S0188461120200003000006&script=sci_abstract&tlng=en

Rivera L. A. (2016). Estrategias de producción más limpia para el proceso de cromado en la empresa zinc. Bogota. https://repository.unilibre.edu.co/handle/10901/9491

Sagástegui y Mas. (2020). Calidad en las Empresas en el Sector Minería del Perú. Surco. https://tesis.pucp.edu.pe/repositorio/bitstream/handle/20.500.12404/18470/Calidad%20en%20las%20Empresas%20en%20el%20Sector%20Miner%C3%ADa%20del%20Per%C3%BA-SAGASTEGUI.pdf?sequence=1&isAllowed=y

Salas y Mas. (2021). Propuesta de implementación de herramientas Lean Office en el proceso de compras para disminuir los gastos administrativos de una empresa del sector financiero. Lima. http://hdl.handle.net/10757/658552