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Street Lighting Quality using Lean Six Sigma

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Abstract

The present work seeks to increase the level of illuminance in the district of Santiago de Surco, which is below the minimum required by regulations. The methodology used is Lean Six Sigma, which begins with the “Define” phase, where data collection was carried out in the five selected Surco zones, it was determined that zones 2 and 3, Jr. Combate de Iquique and Jr. Almirante Grau, respectively, are the ones with the lowest lux. In the next phase, "Measure", it was validated that these areas have a lux level lower than the average, which according to regulations should be between 5 and 10 lux, identifying that only 47% of the light poles in these areas comply with the rule. In the "Analyze" phase, the focus was on identifying possible causes that could affect the quality of street lighting. These are the height of the pole, the condition of the lighthouse, and the type of light. Thanks to the development of a mathematical equation, in the improve and control phases, the potential to increase the average illuminance level has been identified, going from an average of 3,107 to 5,370 lux. The projected benefits are estimated at an environmental impact of 1,402.33 TCO2 and an annual economic impact of $34,800.00.

Keywords
Public lighting, Lean Six Sigma, DMAIC, Quality Management, and Energy Efficiency

1. Introduction
This research work focuses on the analysis of the public lighting service in the different areas of the district of Santiago de Surco in Peru, recognizing the importance of the lighting of parks and avenues as a crucial role in the safety and welfare of the community.“While official requirements differ around the world the main principles for good street lighting are the same; high quality illumination that ensures clear visibility and road safety” (LEDiL n.d.), For this reason, here in Peru, there is the Norma Técnica DGE “Alumbrado de Vías Públicas en Zonas de Concesión de Distribución”, which establishes standards to guarantee adequate conditions in terms of luminosity and visibility (Ministerio de Energía y Minas 2002). This standard was approved by Supreme Decree No. 020-97-EM, which establishes the guidelines for the quality control of electrical services, including public lighting (Decreto Supremo N° 020-97-EM 1997).

The “Defensoría del Pueblo” in Peru, is an autonomous constitutional body that oversees the rights of citizens (La República 2021). According to a report by la Defensoría del Pueblo (2015), this district was among those that registered a high number of citizen complaints about poor street lighting. We noticed that, despite this situation, the authorities had addressed the problems of the other districts with the exception of Santiago de Surco. Therefore, we decided to focus the research on this district to evaluate if there has been any improvement in this aspect up to the present date.

In Peru, Luz del Sur S.A.A is the company in charge of distributing energy in more than 60 districts of Metropolitan Lima, including the district of Santiago de Surco, which is the focus of study for this research, this company is in charge of correct maintenance and operation in the different concession areas seeking to improve the quality of life of its clients (Luz del Sur 2023). For this reason, this work is mainly directed at this company in its capacity as responsible for the public lighting service in Santiago de Surco, evaluating its efficiency and compliance with the DGE Technical Standard to identify areas for improvement and propose solutions that benefit the community.

2. Literature Review

In the Santiago de Surco district, significant problems have been identified in the quality of public lighting. To better understand the roots of these problems, we turn to the analysis carried out by the National University of Callao about the Evaluation of the quality of public lighting in the concession of Enel S.A.A, a company in charge of distributing energy to 50 districts of Lima, where mentions a set of common deficiencies used for the supervision procedure of public lighting units, which are divided into categories ranging from non-working lamps to interference caused by trees (Nemesio 2018). In addition, the information provided by OSINERGMIN, Supervisory Body for Investment in Energy and Mining in Peru, offers us a guide on the five most frequent problems in public lighting and the channels available to report these failures to the corresponding authorities (OSINERGMIN 2014). In applying this knowledge to the avenues we are studying, we have decided that it is essential to consider six specific factors: lighthouse condition, pastoral condition, light type, tree interference, pole height, and distance between poles, for an accurate evaluation of the situation.

In this context, it is important to highlight that despite the differences in terms of energy efficiency, light quality and durability, sodium and mercury lamps are frequently used in public lighting, especially in developing countries, due to its lowest initial cost. However, both technologies pose environmental challenges due to the presence of elements such as sodium and mercury, which can be harmful to health and the environment (Alcívar et al. 2023). An example that reflects this situation is the case of La Ciudad de la Paz in Bolivia, which had this type of lighting; However, it had low public lighting, and it was found that by replacing mercury and sodium lights with LEDs, great benefits were obtained in terms of costs and environmental impact (Miranda 2020).

To understand how these factors impact street lighting illuminance, we have decided to apply a linear regression analysis. This statistical technique is ideal for the study, since we work with a continuous dependent variable: lux levels. Linear regression allows us to analyze the quantitative relationship between independent variables, such as the state of the headlights, the condition of the poles, and tree interference with the dependent variable, lux levels (Peláez 2016). A study that carried out this method was that of Garabito (2023) in which the high consumption of electrical energy of people in their homes in the district of San Martín de Porres Peru was presented as a problem, identifying the most statistically significant causes that affect To solve the problem, it was possible to obtain a mathematical equation that allows establishing the optimal conditions to obtain the formula that reduces this energy consumption, resulting in reduced costs for electrical energy service and a positive environmental impact.

To measure the quality of public lighting we base it on the average illuminance (lux). LampHQ (n.d.) tells us that illuminance is used to establish the light that is generated in a certain area. Likewise, as the lux value increases, the surface receives more light, therefore, we will have a brighter surface (Santos 2024). In this study, to measure the illuminance of the poles of the chosen avenues we used the luxmeter, a measuring instrument that measures the average illuminance in units of Lux. In this way, one can accurately evaluate how each factor affects the overall effectiveness of the lighting on the avenues being investigated. This rigorous approach forms the basis of the conclusions and guides us in formulating specific recommendations to improve the quality of street lighting.

3. Research Model

Lean Six Sigma is a methodology that provides the tools to improve the process. In this way, the defects that may be found are reduced and thus the quality of the service or product can be improved (ASQ n.d.). That is why the DMAIC methodology will be used, it has 5 phases, which are: Define, Measure, Analyze, Improve and Control. Each phase plays a vital role in the objective of optimizing the lighting of the selected avenues, with the purpose of raising lux levels in accordance with the Norma Técnica DGE "Alumbrado de Vías Públicas en Zonas de Concesión de Distribución" (Ministerio de Energía y Minas 2002). The Define phase allows us to clearly establish the objectives and scope of the project.

Measurement helps us quantify the current state of lighting. In the Analysis phase, we examine the causes of the detected deficiencies. Improvement focuses on implementing solutions to increase lux levels, and finally, the Control phase ensures that the changes made are sustainable in the long term (JURAN 2024).

3.1 Define

To delimit, we selected the district of Santiago de Surco for the research because, according to a report by Defensoría del Pueblo (2015), this district was among those registering a high number of citizen complaints about poor street lighting.

Santiago de Surco is one of the largest districts in Lima, which makes it difficult to cover the entire territory in a single study. So we will focus on the avenues that delimit the district, with this, a representative sample of the district's public lighting can be obtained. The main avenues are those that we will mention in Table 1, which are shown below:

Table 1. Number of Public Lighting Poles by Zone in Santiago de Surco

Zone	Avenue	N° Light poles
1	Av. Paseo de la Castellana	13
2	Jr. Combate de Iquique	12
3	Jr. Almirante Miguel Grau	5
4	Jr. Paseo de la República	4
5	Jr. Combate Angamos	16

Once the number of public lighting poles per zone in Santiago de Surco was selected, we proceeded to carry out a set of measurements with the help of a lux meter in the selected zones and light poles. The analysis was based by the Norma Técnica DGE "Alumbrado de Vías Públicas en Zonas de Concesión de Distribución", which establishes the minimum illuminance level, measured in lux, for each zone. According to this standard, which we will detail later in the Measure phase, public lighting in the different areas must range between 5 and 10 lux (Ministerio de Energía y Minas 2002).

To identify which areas have the lowest illuminance levels, we performed an analysis of variance (Anova). This statistical analysis is appropriate given that we were comparing more than three areas. The Anova test is a statistical tool that allows us to determine if there are significant differences between the means of the groups under study. In this case, the groups correspond to the different areas of the Santiago de Surco district.

Medias

Factor	N	Media	Desv.Est.	IC de 95%
Zona 1	13	5.128	3.535	(3.735; 6.521)
Zona 2	12	3.231	1.706	(1.781; 4.681)
Zona 3	5	3.528	1.928	(1.282; 5.774)
Zona 4	4	4.415	0.437	(1.904; 6.926)
Zona 5	16	3.602	2.344	(2.346; 4.858)

Desv.Est. agrupada = 2.49378

Figure 1. The lux averages of the 5 zones of the district of Santiago de Surco

As can be seen in Figure 1, of the five selected zones of the Santiago de Surco district, those with the lowest median in terms of illuminance are Zones 2 and 3, corresponding to Jr. Combate de Iquique and Jr. Almirante Grau , respectively. These areas are at the lower limit of the minimum allowed by Norma Técnica DGE "Alumbrado de Vías

Públicas en Zonas de Concesión de Distribución", which establishes an illuminance level of at least 5 lux in "Calzada oscura"(Figure 2).

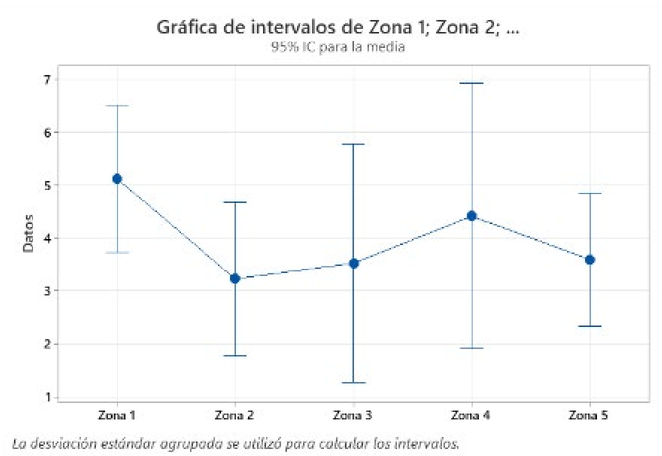

Figure 2. Interval Plot of the 5 zones of the district of Santiago de Surco

It can be concluded that Zones 2 and 3 are those with the lowest illuminance levels, with an average of 3,231 lux and 3,528 lux, respectively. The choice of Zones 2 and 3 for a more detailed study is justified for several reasons. First, these areas may be experiencing a deficiency in public lighting, which could have implications for the safety and quality of life of residents. Also, by focusing on areas with the lowest average illuminance, we can identify the underlying causes of this situation and effectively propose solutions and improvements. Therefore, Zones 2 and 3 will be the focus of the investigation.

4. Data Collection

4.1 Measure

To obtain a more precise understanding of the quality of public lighting in the selected avenues, we conducted in-person surveys of people living in Zones 2 and 3, which have the lowest levels of illuminance. After carrying out the surveys in these areas, there were several complaints regarding the level of illuminance, measured in lux, which confirms that it is representing a problem in these areas.

To ensure the precision and relevance of the measurements that will be carried out later in the Improve Phase, we rely on the Norma Técnica "DGE Alumbrado de Vías Públicas en Zonas de Concesión de Distribución" (Ministerio de Energía y Minas, 2002) shown in Figure 3. This standard provides clear guidelines on the appropriate average illuminance level (lux), depending on the type of lighting and roadway. For the research, Zones 2 and 3 are classified as Type IV lighting and "Calzada oscura" with respect to Average Illuminance (lux).

Tipo de alumbrado	Luminancia media revestimiento seco	Iluminancia media (lux)		Indice de control de deslumbramiento
	(cd/m2)	Calzada clara	Calzada oscura	(G)
I	1,5 – 2,0	15 – 20	30 – 40	≥ 6
II	1,0 – 2,0	10 – 20	20 – 40	5 - 6
III	0,5 – 1,0	5 – 10	10 – 20	5 - 6
IV		2 – 5	5 – 10	4 - 5
V		1 – 3	2 – 6	4 - 5

Figure 3. Luminance, illuminance and glare control index levels (Ministerio de Energía y Minas 2002, p. 7)

Once the illuminance level, measured in lux, has been established in the Santiago de Surco district, the first step in validating the problem is to carry out a normality analysis of the collected sample. This analysis is crucial to validate whether the illuminance level (lux) follows a normal distribution.
If the study variable follows a normal distribution, parametric statistics will be used. In this way, we propose the following hypothesis tests:

Null Hypothesis (Ho): Mean illuminance level (Lux), follows a normal distribution.
Alternative Hypothesis (Ha): Mean illuminance level (Lux), doesn't follow a normal distribution.

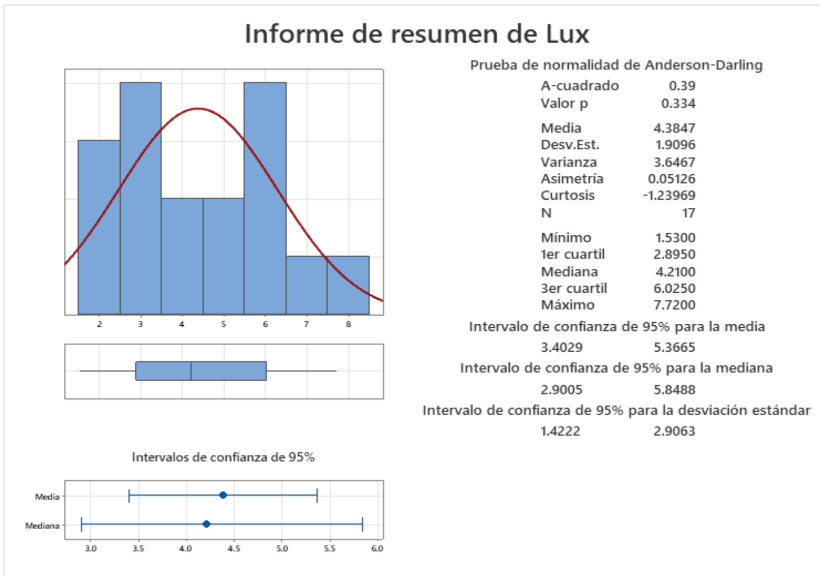

Figure 4. Normality test for lux level (Y) on light poles in the district of Santiago de Surco

The normality analysis shown in Figure 4 was performed with a confidence level of 95%. Based on this, a p-value greater than 0.05 was obtained, so we did not reject the alternative hypothesis and accepted the null hypothesis, which means that the mean illuminance level (Lux) follows a normal distribution.

We are now moving towards the implementation of the one sample (1T) test, with the objective of verifying if the data collected is below the established standard. According to the Norma Técnica DGE "Alumbrado de Vías Públicas en Zonas de Concesión de Distribución" (Ministerio de Energía y Minas 2002), a minimum of 5 lux is required for Type IV lighting, which is the case of zones 2 and 3 that we are analyzing. The hypotheses for this test are the following:

Null Hypothesis (Ho): The mean illuminance (lux) in zones 2 and 3 is equal to or greater than 5 lux.
Alternative Hypothesis (Ha): The mean illuminance (lux) in zones 2 and 3 is less than 5 lux.

Once the hypotheses were stated, the one sample test (1T) was carried out with the help of the Minitab statistical software, obtaining the following results:

Prueba

Hipótesis nula $H_0: \mu = 5$
Hipótesis alterna $H_1: \mu \neq 5$

Valor T	Valor p
-4.15	0.001

Figure 5. One-sample t-test for average illumination level (Lux)

As can be seen in Figure 5, a p-value of 0.000 (less than 0.05) was obtained, which is why we reject the null hypothesis that tells us that the average lux level is equal to 5 lux. Based on this, there is evidence that in the district of Santiago de Surco, on Jr. Combate de Iquique and Jr. Almirante Grau avenues, they have a lux level lower than the required average.

5. Results and Discussion

5.1 Analyze

5.1.1 Identification of possible causes

After verifying that two areas in the district of Santiago de Surco have lighting levels well below those stipulated in the Technical Standard, a significant problem was identified. To determine the possible causes affecting the quality of public lighting in the district, a 6M Ishikawa Diagram was implemented, which includes Measurement, Material, Labor, Method, Environment and Machinery. This analysis made it possible to identify a series of potential factors that could be contributing to the lighting deficiency. The following are the possible causes identified.

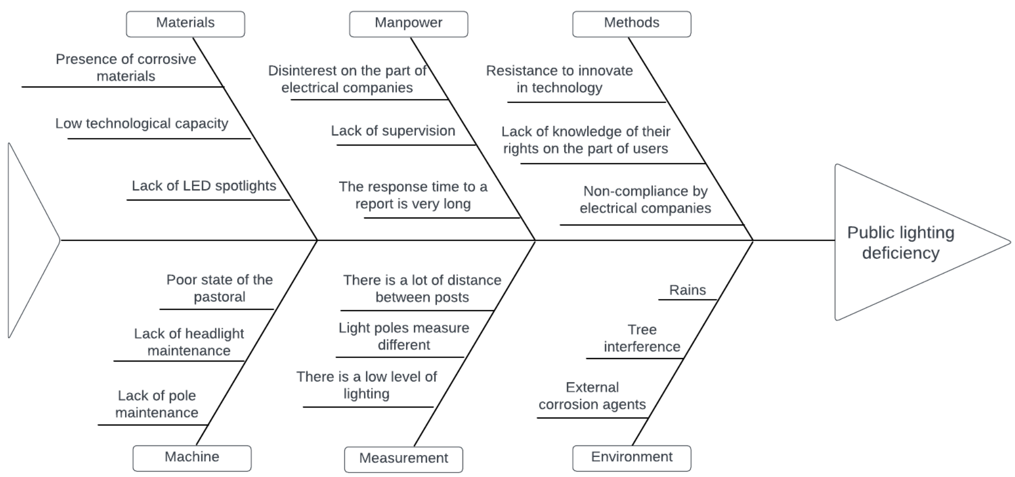

Figure 6. Ishikawa Diagram of possible causes affecting the quality of street lighting

There is a wide variety of possible causes as shown in Figure 6. Table 2 below shows the 6 causes chosen for the investigation along with their unit of measurement and a brief description of them.

Table 2. Possible causes of the deficiency in public lighting

N°	Cause	Unit of Measurement	Description
1	Tree interference	YES/NO	If the presence of a tree that interferes with the post is observed, it will be “YES”, otherwise “NO”.
2	Light type	SODIUM/ MERCURY	There are two types of light on the avenues of the Santiago de Surco district: “SODIUM” has a characteristic yellow light while “MERCURY” has a whiter or bluish light.
3	Lighthouse status	GOOD/BAD	It is considered “GOOD” when the headlight is physically in good condition, while “BAD” is considered when the headlight is broken or clouded due to aging or dirt.

4	Pole height	Meters	We measure the height of the post with an application.
5	Distance between light poles	Meters	We measure the distance between light poles by counting steps.
6	Pastoral condition	GOOD/BAD	It's considered "GOOD" when the pastoral does not have any physical damage, on the other hand it is considered "BAD" when it is broken or is poorly oriented.

5.2 Improve

5.2.1 Linear Regression Analysis

In order to have a mathematical equation of the problem, we have decided to carry out a linear regression with these 6 factors, from which the least significant variables were eliminated, since they had a p value greater than 0.05, managing to be left with 3 significant factors that They are: X1: Lighthouse status; X2: Light type and X3: Height of the light pole (m). In addition, an R2 of around 90% was obtained. Table 3 below shows the regression equation that gives us the relationship between the Y variable (average illuminance measured in lux) with the 3 X variables (significant causes).

Table 3. Regression equation for the 3 most significant causes in non-coded units

Lighthouse status	**Light type**	**Lux**
GOOD	MERCURY	0.56 + 0.337 Height of the light pole (m)
GOOD	SODIUM	2.01 + 0.337 Height of the light pole (m)
BAD	MERCURY	-1.078 + 0.337 Height of the light pole (m)
BAD	SODIUM	0.37 + 0.337 Height of the light pole (m)

5.2.2 Application of the regression equation

Table 4 shows the application of the equation for the 3 most significant causes, making changes to the initial values to achieve an increase in lux, which is reflected in the Adjusted Lux with respect to the Initial Lux.

Table 4. Test results for each of the significant causes

N°	**X1**	**X1(A)**	**X2**	**X2(A)**	**X3**	**X3(A)**	**Initial Lux**	**Ajusted Lux**
1	GOOD	GOOD	MER	SOD	7.7	9.1	3.20	5.08
2	GOOD	GOOD	SOD	SOD	9.1	10.1	4.21	5.41
3	BAD	GOOD	MER	MER	10	12	2.10	4.6
4	BAD	GOOD	SOD	SOD	10.1	13	2.92	6.39

Once the results are obtained for the four light poles, we see that the percentage increase in lighting is 42% on average (Table 5).

Table 5. Test results for each of the significant causes comparing the initial lux with the adjusted lux

N°	Initial	Ajusted	Increase
1	3.20	5.08	37.01%
2	4.21	5.41	22.18%
3	2.10	4.6	54.35%
4	2.92	6.39	54.30%

5.3 Control

5.3.1 Increase in average illuminance (lux)

During the control phase, it was validated that the average illuminance in lux increased when analyzing the potential of the project with respect to the initial lux values of the light poles. In addition, the IMR control graph was carried out to validate that both the average illuminance in lux and the moving range of lux are under statistical control.

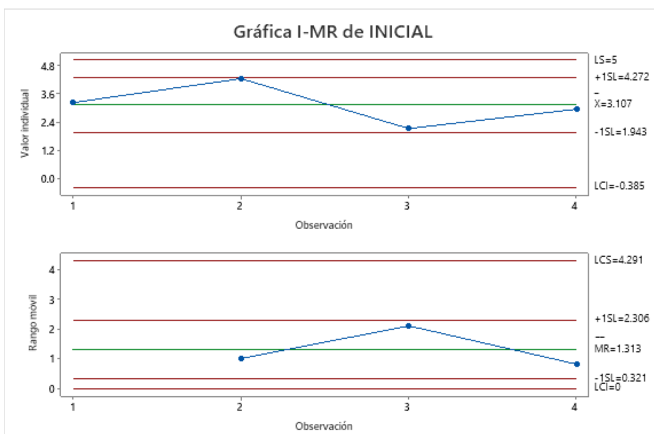

Figure 7. IMR graph for average illuminance (lux) before implementing the project

As can be seen in Figure 7, the average illuminance of the light poles had an average of 3,107 lux before implementing the project. Furthermore, it is observed that these measurements are under statistical control based on the upper (4,272 lux) and lower (1,943 lux) control limits. On the other hand, it is observed that in the moving range of the data it was under statistical control based on the upper and lower control limits.

After that, the IMR graph was also made for the measurements in adjusted lux in order to validate that the average of the mean illuminance increases by implementing small adjustments in the independent variables.

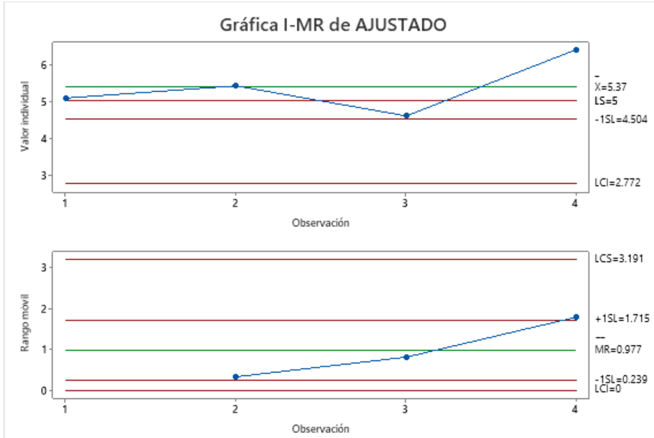

Figure 8. IMR graph for average illuminance (lux) after implementing the project

As shown in Figure 8, the average illuminance of the light poles has increased to an average of 5.37 lux, after applying the proposed improvements. However, it is noted that these measurements exceed the upper limit (5 lux), indicating that the process is not under statistical control. However, this is not a problem, since the objective is to raise the lux level until it reaches the minimum required by the standard, which is 5 lux.

5.3.2 Comparison of initial lux with adjusted lux

We performed a 2T statistical test to compare before and after the improvement, expecting the p value to be less than 0.05 at a 95% confidence level. Taking into account that we have previously performed the normality test on the data and subsequently the equality of variances test, confirming that the distributions are normal and the variances equal. The 2T test is used to see if there is a significant difference between the lux measurement before the project and after the improvements.

Null Hypothesis (Ho): The mean illuminance (lux) are the same before and after the project.
Alternative Hypothesis (Ha): The mean illuminance (lux) aren't the same before and after the project.

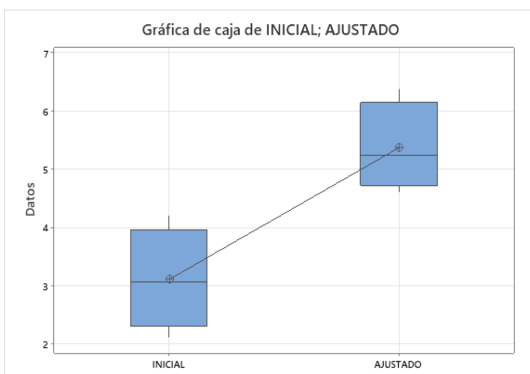

Figure 9. Boxplot of individual values of initial and adjusted lux

We see in Figure 9, it is observed that there is a great difference between the averages compared to the initial and the adjusted one after the implemented improvement, since the R2 came out around 10%, achieving an improvement in lighting around 73%.

5. Results and Discussion

5.1 Proposed Improvements

At first, three solution proposals were proposed to address the problem of low lighting in the Santiago de Surco district: Change the condition of the lighthouse, increase the height of the pole by 1.8 m on average and replace the type of lighting in mercury to sodium. However, it is crucial to evaluate the environmental impact in terms of energy efficiency.

For this, we did a detailed analysis of the Watts emitted by each type of light (Mercury, sodium and LED), with the objective of determining which of these options reduces environmental pollution and is in line with our proposed statistically supported solution. This approach will allow us to ensure that not only the issue of low street lighting is addressed, but that environmental sustainability is also promoted in the district.

According to Alcívar et al. (2023), the monthly electrical consumption of Mercury light is 54 Kwh, that of Sodium is 43.2 Kwh and that of LED light is 28.8 Kwh. From these data, it is inferred that LED light is the most efficient option in terms of electrical consumption, emitting a lower amount of Watts. When considering carbon footprint reduction, it is important to note that LED light offers a significant advantage over Mercury and Sodium options. Although it had initially been proposed to change from Mercury to Sodium to increase the illumination of the poles, it must be taken into account that Sodium light in terms of environmental pollution is higher compared to LED light. In addition, LED light not only consumes less energy monthly, but also provides equal or superior lighting compared to the other two types of light, which are Mercury and Sodium.

Therefore, it is proposed to make a detailed comparison of the energy savings that would be achieved by changing all the poles in Santiago de Surco to LED lighting. This change would not only contribute to reducing the carbon footprint, but would also allow for more efficient and sustainable lighting for the citizens of said district.

5.2 Environmental impact of the Santiago de Surco district

To calculate the environmental impact for the district of Santiago de Surco, the first thing that was done was to calculate the amount of Watts that would be saved by changing from Mercury and Sodium to LED, resulting in a saving of 14.40 Kwh and 25. 20 Kwh, respectively. Afterwards, the number of poles that exist in said district was calculated, to do so, we obtained a proportion. According to a report by OSINERGMIN (2018), Lima has 622,990 public lighting poles, of which 98.4% are operational, totaling 613,022 poles. Although Lima covers 35,892.49 km², this study considers that all operational posts are located in Metropolitan Lima, which has 2,829 km².

Santiago de Surco has an area of 52 km², so it must have around 11,304 light poles. Some poles, between mercury and sodium lights, since LED lights have not yet been implemented. According to a ratio of 5 to 12, based on the number of poles delineated at the beginning of the study, it is estimated that there are 3,325 mercury poles and 7,979 sodium poles in the district.

With these data, the environmental impact was calculated taking into account that the average monthly electrical savings of each pole from changing from mercury light to LED is 14.4 Kwh, and that for each Kwh saved, 0.000046 Ton of CO2 is no longer emitted. Based on this, it was estimated that the monthly energy savings for the mercury poles is 47,875.57 Kwh, which means stopping the emission of 29.21 tons of CO2 into the environment, the annualized savings are estimated at 574,506.88 Kwh of energy and 350.56 tons of CO2 would be stopped annually. And the same analysis is carried out for sodium posts as shown in Table 6.

Table 6. Environmental impact of changing light from mercury and sodium to LED

Light Type	Average per capita savings (KWh)	N° Poles	Monthly savings (KWh)	Annual savings (KWh)	Monthly environmental impact (Ton CO2 equivalente)	Annual environmental impact (Ton CO2 equivalente)
Mercury	14,40	3.325	47.875,57	574.506,88	29,21	350,56
Sodium	25,20	7.979	201.077,41	2.412.928,88	87,64	1.051,67

5.3 Carbon offset benefits

Carbon credits are essentially trading permits that represent the elimination or prevention of the emission of one metric ton of carbon dioxide or other equivalent greenhouse gases. According to a technical note issued by the Ministry of Economy and Finance - MEF of Peru (2023), the social price of carbon has been established at US $7.17 for each ton of CO2 emitted in Peru. This measure allows the costs and benefits associated with reducing or increasing greenhouse gas emissions to be taken into account in economic evaluations. However, the IMF proposes a minimum price of US$25 per ton of carbon, in order to meet the goal of keeping global warming below 2 degrees (Chateau et al. 2022). Therefore, it will be this price that we will consider for the calculations.

Based on this information, it is estimated in Table 7 that the monthly benefit from changing from mercury to LED in Santiago de Surco is $725, which means an annual benefit of $8,700 and the same analysis applies to sodium lights.

Table 7. Project benefit from carbon credits

Light Type	Monthly savings of Ton CO2 equivalent	N° Carbon Credits	Carbon Selling Price	Monthly Benefit	Annual Benefit
Mercury	29,21	29	$25,00	$725,00	$8.700,00
Sodium	87,64	87	$25,00	$2.175,00	$26.100,00

6.Conclusion

The project "Quality of Public Lighting using Lean Six Sigma" in Surco, Lima, Peru, managed to increase the average illuminance of light poles from 3.107 to 5.37 lux, meeting the minimum level required by the standard. Likewise, in order to reach the goal defined in the project, results were obtained for each of the 5 phases. In the define phase, it was determined that the problem is low lighting on Jirón Combate de Iquique and Jirón Combate de Angamos avenues in the Santiago de Surco district. Then, in the Measure phase, it was statistically obtained that the measurements of the Lux of the posts that were measured on average is 3.107 which is below the minimum which is between 5 - 10 lux, according to the Standard, classifying them according to the type of footwear. and collector. In the analyze phase, six possible causes were identified, and after statistical tests, the significant ones were: the condition of the lighthouse, the type of light and the height of the pole.

For the improve phase, a regression analysis was carried out, eliminating three less significant factors, which are: distance between posts (m), tree interference and pastoral condition, obtaining a mathematical equation with an R2 around 90%, which It allows us to establish the ideal conditions so that the illuminance level in lux improves.

Finally, in the control phase, the comparison of the lighting before and after the project is carried out. The improvement is evident because higher lighting levels and less variation in the lighting of all the posts are obtained at the ideal Lux. However, a greater environmental impact is evident, so in the last part it is proposed to change to LED lights, evidencing the savings in tons of CO2 eq that will be emitted annually, thanks to this comprehensive approach it will allow optimizing lighting and will contribute to the improvement general public lighting and the quality of life of citizens.

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