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Social Impact Assessment in La Oroya, Peru Applying the Grey Clustering Method

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Abstract*: The social conflict presented in the city of La Oroya, of a national government issue type, is considered by the Ombudsman's Office as a latent social conflict during the month of April 2019; therefore, analyses, agreements, meetings and dialogue tables are presented, which allow subjective evaluations of the problematic reality, complicating the correct decision making. For which, the application of the Grey Clustering method is proposed to quantify the social impact presented in the city of La Oroya; the surveys were conducted on Sunday, June 2, 2019, containing 08 questions (same number of criteria to evaluate) that were answered by 20 settlers, such answers were evaluated with the Grey Clustering method obtaining as a result that the social impact in the city of La Oroya is of normal level.

Keywords* : Environmental pollution, Grey clustering, Social impact assessment.

I. INTRODUCTION

In 1997, in Peru, President Alberto Fujimori privatized the metallurgical complex; it was then that U.S. billionaire Ira Rennert, owner of the transnational Renco group, acquired the complex and established the company Doe Run Perú, which operates in Cobriza and La Oroya [1], and it was also then that he was charged with implementing an environmental adjustment program, request that he did not execute [2]. After extending its Environmental Adjustment and Management Program in 2006 [1], in July 2009, the Ministry of Energy and Mines (MEM) warns that it will close the La Oroya complex if Doe Run does not present a viable proposal to get out of the financial crisis it is going through; a month later the company becomes insolvent and goes into restructuring [3].

One of the immediate consequences of this state decision was that the workers agreed to suspend their work for a period of 90 days and receive only 63% of their salary in order to pressure the government to extend by 30 months the deadline given to the company to execute the Environmental Adjustment and Management Program [4]. In response, Congress extends by 30 months the deadline for Doe Run to conclude its EAMP, which expired in October 2012 [5].

Mobilizations, roadblocks, sacrificial marches, regional strikes and different measures were conducted by the (ex)-workers of the company, local social organizations and the community in general to demand from the State a renewal of the license for the activities of the company Doe Run; having in one of these, the death of a citizen in a road blockade in 2015 and dozens of wounded as consequences from the beginning of this confrontation of interests [6].

On this matter, the representative of the labor creditors of Doe Run Peru reminded the Peruvian population, in an interview this year, the economic losses that the State has suffered as a consequence of a decade since the cessation of activities, calculating a total of US$ 5,500 million [7]; not to mention the loss of 3500 workers that the company had on the payroll as well as another 6000 whose work depended indirectly on the metallurgical complex [1].

On the other hand, it is important to remember that it is not only the Peruvian State that refuses the activities of the metallurgical company, but also half of the population, since the industrial activity of the metallurgical complex carried out by the company Doe Run Peru has made the city of La Oroya to be considered among the ten most polluted cities in the world, according to the Blacksmith Institute, also reporting high rates of soil contamination as well as the fact that 99.1% of children in the city of La Oroya have high blood lead averages, 33.6 ug/dl (micrograms per deciliter), surpassing the World Health Organization's maximum permissible limits of 10 ug/dl, which is more than the triple allowed [1].

In addition, it is estimated that when it was in operation 1,070 cubic meters of smoke were produced daily, containing 15 different metals to the environment [8]. The main emission was through the chimneys, as well as the existence of fugitive sources of smoke through the ventilation ducts, open ventilation constructions, with content of dust flows and gases from the metallurgical process. Chimneys accounted for 93 % of S02 and 66 % of lead emissions [9].

From the foregoing, it can be deduced that the latent social conflict in La Oroya, of the National Government type, is due to the fact that the workers of the Metallurgical Complex of La Oroya demand the resumption of operations of the Metallurgical Complex in harmony with environmental standards, with the health of the population, in order to address their labor problems [10]. For this reason, based on the social problems generated by the closure of the Doe Run Peru metallurgical center, qualitative evaluations have been presented that result from dialogue roundtables, meetings and agreements that only allow the term for reaching a solution to continue to lengthen.

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Therefore, from our research project we propose to quantify the social impact evaluation, from the application of the Grey Clustering methodology, based on pre-established criteria with equal weight and importance to be evaluated [11].

II. METHODOLOGY

To obtain the desired data the Grey clustering method was used; which can be applied by incidence matrixes or by whitenization weight functions [12]. Center-point triangular whitenization weight functions (CTWF) is used in the present research in order to collect information, as typically people tend to be more certain about the center-points so the conclusions based on this cognitive certainty could be more scientific and reliable [12].

In this section, we describe the CTWF method, which was applied in the results obtained from the surveys that measured the perception of the impact of the metallurgical project on the participants of the city of Oroya.

First, assume that there are a set of m objects, n criteria, s grey classes, and sample value x_{ij}*(i=1, 2… m; j=1, 2…, n).* Now, the steps of the method applied in this study can be described below [13]:

Step 1: The center-points $\lambda_1, \lambda_2, \ldots$ *and* λ_s, of the *s* grey classes of each criterion are established [14].

Step 2: The s grey classes are prolonged, by adding of the grey classes *0* and *(s+1)* with their center-points λ_0 and λ_{s+1}; as shown in Fig. 1. For an observed value x_{ij}, of the kth grey class, and of the jth criterion, and where the λ represent the values of the levels, the triangular function is defined by Eq. 1 [15].

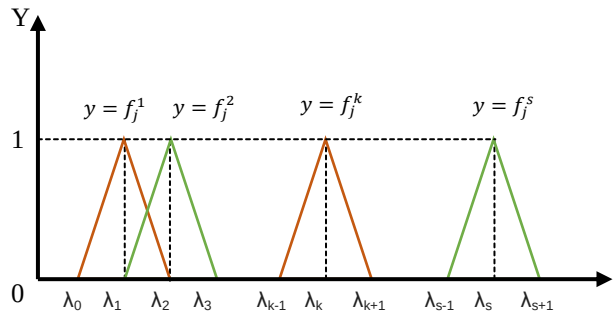

Fig. 1.CTWF [12]

$$f_j^k(x_{ij}) = \begin{cases} 0 \quad , & x \notin [\lambda_{k-1}, \lambda_{k+1}] \\ \frac{x-\lambda_{k-1}}{\lambda_k-\lambda_{k-1}}, & x \in [\lambda_{k-1}, \lambda_k] \\ \frac{\lambda_{k+1}-x}{\lambda_{k+1}-\lambda_k}, & x \in [\lambda_k, \lambda_{k+1}] \end{cases} \quad (1)$$

Step 3: The comprehensive clustering coefficient σ_i^k for object i, in grey class k, is given by Eq. 2 [16].

$$\sigma_i^k = \sum_{j=1}^{n} f_j^k(x_{ij}).n_j \quad (2)$$

Where n_j is the weight of criterion j [17].

Step 4: If $\max_{1 \le k \le s}\{\sigma_i^k\} = \sigma_i^{k*}$ is decided that the object I belongs to grey class *k**. In case, there are several objects in grey class *k**, these objects should be ordered according to the values of their σ_i^k [12].

III. CASE STUDY

The social impact assessment (SIA) was established using the Grey Clustering methodology, which has diffuse mathematics as its principle for the analysis of data collected in the field. From this and considering the purpose of this study and the economic and social situation of the population, 8 fundamental criteria were established to simultaneously measure implications on the environment according to the perception of the participants in the surveys. It is also worth to mention that the aforementioned selected criteria were as numerous as the questions in order to obtain a correct analysis and application of the method. These criteria are set out in Table I together with their respective values.

Table I: Criteria and Standards

	Description	Extra negative	Very negative	Negative	Normal	Positive	Very positive	Extra positive
C1	GDP per capita	0	1	3	5	7	9	10
C2	Employment rate	0	1	3	5	7	9	10
C3	Poverty rate	10	9	7	5	3	1	0
C4	Number of inhabitants per doctor	10	9	7	5	3	1	0
C5	Number of teachers in basic education	0	1	3	5	7	9	10
C6	Number of reported crimes	10	9	7	5	3	1	0
C7	Access to drinking water	0	1	3	5	7	9	10
C8	Pollutants in the air	10	9	7	5	3	1	0

Once the questionnaires had been applied in the urban group of the area (G1), the obtained results are shown in Table II.

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Table II: Field Results

Number of Surveys	C1	C2	C3	C4	C5	C6	C7	C8
1	7	3	5	5	5	9	3	9
2	7	7	5	5	5	5	5	7
3	7	7	7	3	3	7	7	5
4	7	7	5	5	5	7	5	7
5	5	5	5	5	5	7	3	7
6	7	7	3	5	7	3	7	7
7	7	7	3	3	7	7	5	7
8	9	9	3	7	5	7	3	7
9	9	9	3	7	7	7	5	7
10	9	9	3	9	9	5	5	7
11	9	9	3	7	7	7	5	5
12	7	7	5	5	7	7	5	7
13	7	3	7	7	7	5	5	7
14	3	7	7	3	7	3	7	7
15	1	1	7	3	3	3	5	7
16	5	5	5	5	3	5	5	9
17	9	1	1	7	3	3	5	9
18	1	1	1	5	3	3	5	7
19	5	3	7	5	5	3	5	9
20	1	1	1	3	1	7	3	7
Average	6.1	5.4	4.3	5.2	5.2	5.5	4.9	7.2

Having the defined criteria and levels, the determination of the functions of Clustering is made, in order to do so, the behavior of the criterion is considered since, as we can see in Table I, the decrease of certain criteria implies a negative impact, for which their levels go upwards (0, 1, 3 ..., 10) while other criteria before the same decrease imply a positive impact for these levels go downwards (10, 9, 7 ..., 0). The functions have the following representation (Fig. 2).

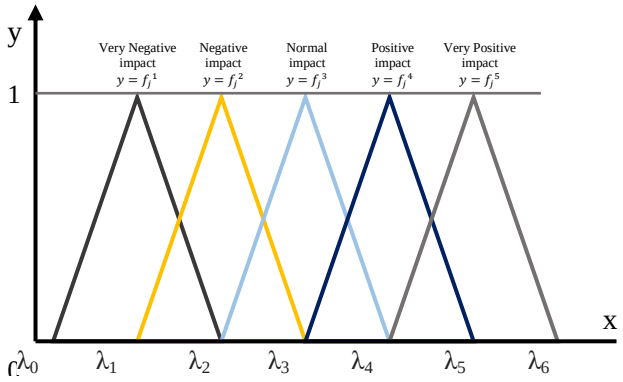

Fig. 2. Clustering Functions

Evaluating the values obtained in the field in the clustering functions, in Table III is obtained.

Table III: Clustering Function Results

G1	6.1	5.4	4.3	5.2	5.2	5.5	4.9	7.2
	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*
F1	0	0	0	0	0	0	0	0.1
F2	0	0	0	0.1	0	0.25	0.05	0.9
F3	0.45	0.8	0.65	0.9	0.9	0.75	0.95	0
F4	0.55	0.2	0.35	0	0.1	0	0	0
F5	0	0	0	0	0	0	0	0

Each of the values in each column will be affected by the percentage system, which is shown in the Table IV.

Table IV: Percentage System

Social Impact Class	Interval	a_k
Very negative	[20,30]	20
Negative	[30,50]	40
Normal	[50,70]	60
Positive	[70,90]	80
Very positive	[90,100]	100

Making the calculations of the values of Table III with the percentages system of Table IV, in Table V is obtained.

Table V: Final Values

Social Impact Class	ak	C1	C2	C3	C4	C5	C6	C7	C8	Total
Very Negative	20	0	0	0	0	0	0	0	2	0.25
Negative	40	0	0	0	4	0	10	2	36	6.5
Normal	60	27	48	39	54	54	45	57	0	40.5
Positive	80	44	16	28	0	8	0	0	0	12
Very positive	100	0	0	0	0	0	0	0	0	0
Analysis		71	64	67	58	62	55	59	38	59.25

As can be seen in Table V, what is evaluated is each of the criteria obtained in the questionnaires applied, and the "Total" which is the average of each corresponding row. This is due to the fact that for this evaluation equal weightings are assumed in terms of the importance of the criteria.

For the final analysis, the vertical sum of each criterion and the column "Total" is made, obtaining at a general scale a level of normal social impact in the sample of study with respect to the influence of metallurgical activities by the company Doe Run Peru in the city of La Oroya, in the district of Junín, Peru.

IV. RESULTS

Once the Grey Clustering method was applied, we obtain that the Social Impact Assessment in the population near the metallurgical complex La Oroya had a normal social impact since 6 of the 8 criteria established obtained a normal social impact. In contrast, there is an antagonism between the C1 (GDP per capita) which states that the metallurgical activities would have a positive social impact; and C8 (Pollutants in the air), which states that the aforementioned activities would have a negative social impact [18].

In C1 (GDP per capita), the population expressed that there would be a positive social impact because the economic results of metallurgical activities allow the economic sustenance of the families of 3500 workers in the area studied [1].

It is also necessary to remember that extraction activities allow both the citizen community where the activities are performed, and the State to enjoy immeasurable income [19].

On the other hand, in C2 (air pollution), the analysis population expressed that there would be a negative impact; this shows that there is concern for the health and environment of the sample population, a situation understandable since it is considered among the ten most polluted cities in the world [20], the results are presented in Table VI.

Table VI: Results

Social Impact Class	a_k	C1	C2	C3	C4	C5	C6	C7	C8	Total
Very Negative	20	0	0	0	0	0	0	0	2	0.25
Negative	40	0	0	0	4	0	10	2	36	6.5
Normal	60	27	48	39	54	54	45	57	0	40.5
Positive	80	44	16	28	0	8	0	0	0	12
Very positive	100	0	0	0	0	0	0	0	0	0
Analysis		71	64	67	58	62	55	59	38	59.25
		Positive	Normal	Normal	Normal	Normal	Normal	Normal	Negative	Normal

V. CONCLUSIONS

The Grey Clustering methodology allows to quantify the subjective perception of social impact assessments, through center-point triangular whitenization weight functions.

The criteria established for the social impact assessment made it possible to obtain more information when conducting the surveys, since they were related to the problematic reality and because they were established with the same evaluation weight.

The twenty surveys conducted were answered by residents who have lived through the process and its effects of the closing of the Doe Run Peru metallurgical complex.

The social impact assessment obtained for each established criterion is: C1 (positive social impact), C2/C3/C4/C5/C6/C7 (normal social impact) and C8 (negative social impact).

The results obtained from the application of the Grey Clustering method indicate that the social impact assessment in the city of La Oroya is 59.25, which within the range of intervals is between [50.70] representing a Normal Social Impact.

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