Assessment of perception from engineering students on an environmental conflict using the grey clustering method

Alexi Delgado, PhD[1], Robert Buleje, BSc[2], Zilmer Muñoz, BSc[2], Bianca Reyes, BSc[2], Raquel Tenorio, BSc[2] and Chiara Carbajal, BSc [3]
[1] Pontificia Universidad Católica del Perú, Lima, Peru, kdelgadov@pucp.edu.pe
[2] Universidad Nacional de Ingeniería, Lima, Peru, kdelgadod@uni.edu.pe
[3] Universidad de Ciencias y Humanidades, Lima, Peru, ccarbajal@uch.edu.pe

Abstract*– The objective of this research is to assess the perception of the students of the National Engineering University through the method of Grey Clustering, with respect to the socio-environmental conflict of Las Bambas, an emblematic conflict in Peru. The students were selected according to the direct relationship of their careers with the conflict. For this particular study, the following faculties were chosen: Faculty of Environmental Engineering (FIA by its Spanish acronym), Faculty of Geological, Mining and Metallurgical Engineering (FIGMM by its Spanish acronym), Faculty of Economic Engineering, Statistics and Social Sciences (FIEECS by its Spanish acronym). For this method, the following evaluation criteria were defined: Land Use, Water Availability, Environmental Pollution, Employment and Economic Development. Through the method of Grey Clustering, it was found that the perception of the National Engineering University students is Normal with respect to the social conflict in Las Bambas. This means that, according to their perspective, the conflict will continue as it is. On the other hand, this study could be a tool for the analysis and prevention of socio-environmental conflicts, as it defines the kind of impact according to each stakeholder, which would help local and regional authorities, as well as mining companies, in their decision-making.

***Keywords--* Grey Clustering method, Perception, Environmental conflict.**

I. Introduction

Las Bambas mining project is located in the districts of Challhuahuacho and Progreso, in the provinces of Cotabambas and Grau, respectively, at the department of Apurimac, Peru [1].

Las Bambas project initially comprised three areas: Las Bambas area, pipeline area and the Tintaya area. These areas are located in the regions of Apurímac and Cusco.

- Las Bambas area (Apurímac Region) is composed of: the mine, the dumps, the concentrator plant and auxiliary components.
- The area of the pipeline comprised 206 km from the concentrator plant (located in Apurimac) to the molybdenum and filter plants (located in Espinar, Cusco).
- The Tintaya area, where the pipelines arrived, for the processing of copper and molybdenum concentrates.

However, since the approval of the first Environmental Impact Assessment (EIA) in 2011, the project has had five modifications of its components with respect to the initial configuration [2].

In the second modification of the EIA of Las Bambas, the company MMG refused to carry out the pipeline to be considered since it was not profitable to exploit the mine, and the use of the road was changed to include the transport of the minerals extracted from Las Bambas, in which it was estimated that 250 truckloads of large tonnage spent every day transporting the material. In this modification of the EIA, several communities and populated centers were also excluded from the area of social influence that were in the path of the pipeline, but that would also be influenced by the use of the highway as a mining corridor [3].

In addition, there was a refusal by the government and the company to inform the communities about the modifications to the Las Bambas EIA, as well as during these modifications no further hearings or workshops were held.

The conflict began over the months, due to the continuous dust, noise and vibrations that were daily on the road, for which the communities asked the mining company to pay for the passage of servitude on their land as well as measures to improve the road to avoid impacts [4]. Therefore, it is necessary that the company and the government communicate these changes to the population and negotiate appropriately.

One of the tools to prevent conflicts during the planning and execution of projects is the analysis of environmental conflicts through a quantitative method that is the Grey Clustering method, in which the theory of the grey system is relied upon, and which takes uncertainty into account as part of its analysis [5].

Therefore, in the present research the objective is to assess the perception of the students of the National Engineering University applying the Grey Clustering method, with respect to the socio-environmental conflict of Las Bambas, thus showing interesting results about the opinions of students on the national reality [6].

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II. Methodology

Grey Clustering methodology has been based on the theory of Grey systems [7]. Grey systems, on the other hand, explore issues with either small or restricted data, which is beneficial as research on socio-environmental phenomena is likely to possess this feature, therefore the methodology used has already been implemented in a variety of fields including the management of water [8], environmental disputes [9], and labor management [10].

The present methodology has been employed to categorize indexes or objects of observation within categories through the use of Grey incidence matrices or Whitenization weights. It is principally used in order to check whether observation groups pertain to particular categories [11]. In the present study, the Grey Clustering method based on Center-point Triangular Whitenization Weight Functions (CTWF), was used [12].

A set of "m" groups, a group of "n" criteria, and a series of different "s" classes of greys are assumed, depending on the value of the sample x_{ij} $(i = 1,2,\dots,m;\ j = 1,2,\dots,n)$, in which for the group you have $(i = 1,2,\dots,m)$, and for the criterion you have $(j = 1,2,\dots,n)$. Furthermore, the stages for class clustering, on the basis of the CTWF, can be described as shown below [13]:

Step 1: Each of the individual ranges of criteria is separated in "s" Grey classes, in order to then establish the central points of each range at: $\lambda_1,\ \lambda_2,\dots,\lambda_s$ for the Grey classes $1,2,\dots,s$.

Step 2: Grey classes are spread out into two directions, adding the Grey 0 and $(s+1)$ classes with their central points λ_0 and λ_{s+1} respectively. Therefore, the new sequence of central points is established $\lambda_0,\lambda_1,\ \lambda_2,\dots,\lambda_s,\lambda_{s+1}$ (see Fig. 1). Therefore the CTWF for class k^{th}, *k = 1, 2,..., s*, from criterion j^{th}, *j = 1, 2,..., n*, for an observed value x_{ij} is defined by (1) and (2).

$$f_j^1 = \begin{cases} 1 \quad , & x \in [0,\lambda_j^1] \\ \frac{\lambda_j^2 - x}{\lambda_j^2 - \lambda_j^1} \ , & x \in (\lambda_j^1,\lambda_j^2) \\ 0 \ , & x \in [\lambda_j^2,\ +\infty) \end{cases} \tag{1}$$

$$f_j^k(x_{ij}) = \begin{cases} \frac{x - \lambda_j^{k-1}}{\lambda_j^k - \lambda_j^{k-1}} \quad , & x \in (\lambda_j^{k-1},\lambda_j^k] \\ \frac{\lambda_j^{k+1} - x}{\lambda_j^{k+1} - \lambda_j^k} \quad , & x \in (\lambda_j^k,\lambda_j^{k+1}) \\ 0, & x \in [0,\ \lambda_j^{k-1}] \cup [\lambda_j^{k+1},+\infty) \end{cases} \tag{2}$$

Where:

$f_j^k(x_{ij})$ represents the CTWF of the k^{th} class Grey of criterion j^{th}, and n_j is the weight of criterion j.

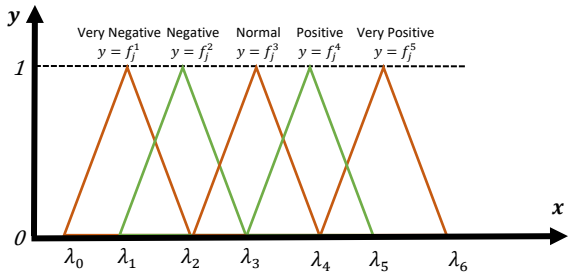

Fig. 1 Center-point Triangular Whitenization Weight Functions (CTWF) [14].

Step 3: The clustering coefficient σ_j^k, that denotes the criteria weight, corresponding to group $i, i = 1,2,\dots,m$, in the grey class $k, k = 1,2,\dots,s$, is computed by using (3).

$$\sigma_i^k = \sum_{j=1}^{n} f_j^k(x_{ij}).n_j \tag{3}$$

Where n_j is the criterion weight of j [15].

Step 4: According to the clustering coefficient, the social impact class will be as it is shown in Table I.

TABLE I
CLUSTERING COEFFICIENT ACCORDING TO INTERVAL

Social impact class	Interval	σ_j^k
Very Negative	[20,30]	20
Negative	[30,50]	40
Normal	[50,70]	60
Positive	[70,90]	80
Very Positive	[90,100]	100

III. Case Study

The application of the method of Grey Clustering is used for assessing students of the National Engineering University's perception of the socio-environmental conflict in Las Bambas, an emblematic conflict in Peru [16]. The students were selected according to the direct relationship of their career with the conflict. For this particular study, faculties were chosen:

- Faculty of Environmental Engineering (FIA by its Spanish acronym)
- Faculty of Geological, Mining and Metallurgical Engineering (FIGMM by its Spanish acronym)
- Faculty of Economic Engineering, Statistics and Social Sciences (FIEECS by its Spanish acronym)

The criteria that were defined for this study are shown in Table II.

TABLE II
EVALUATION CRITERIA

Criteria	Code	Description
Land use	P1	The actions, activities and interventions carried out by people on a given type of surface in order to produce, modify or maintain it.
Water Availability	P2	It refers to the total volume of liquid in a region. In order to know the quantity existing for each inhabitant, the volume of water is divided by the number of people in a population.
Environmental Pollution	P3	Introduction of substances or other physical elements into an environment that makes it unsafe or unsuitable for use.
Employment	P4	It is the concretion of a series of tasks in exchange for a retribution called salary.
Economic Development	P5	Ability of the income of countries or regions to create wealth in order to maintain the prosperity or economic and social well-being of their inhabitants.

The questions that were asked to the students of the National University of Engineering were the following:

1. What effects would Las Bambas project have on land use in the region where it is developed?
2. What effects would Las Bambas project have on water availability in the region where it is developed?
3. What effects would Las Bambas project have on the concentration of pollutants in the environment in the region where it is developed?
4. What effects would Las Bambas project have on the percentage of formal employment in the region where it is developed?
5. What effects would Las Bambas project have on regional economic development?

Being the possible answers:
- Notably negative
- Negative
- Does not affect
- Positive
- Notably positive

IV. RESULTS AND DISCUSSION

The results and discussion are presented from Step 1 to Step 4.

Step 1: All surveys of students in the different faculties were averaged (see Table III).

TABLE III
AVERAGE RESULTS OBTAINED BY FACULTY

Criteria code	**FIA**	**FIGMM**	**FIEECS**
P1	2,20	4,87	3,13
P2	3,40	4,73	3,27
P3	2,07	5,93	5,13
P4	7,80	7,13	7,27
P5	7,53	7,67	7,80

In addition, the central and extreme points were defined for each question as following (see Table IV):

TABLE IV
ASSOCIATED LEVELS FOR EACH QUESTION

	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7
P1	0	1	3	5	7	9	10
P2	0	1	3	5	7	9	10
P3	10	9	7	5	3	1	0
P4	0	1	3	5	7	9	10
P5	0	1	3	5	7	9	10

Step 2: The functions were constructed and the values of each group were evaluated as it is shown from Table V to Table VII.

TABLE V
EVALUATION OF THE VALUES OF FACULTY OF ENVIRONMENTAL ENGINEERING (FIA BY ITS SPANISH ACRONYM)

FIA	f_1	f_2	f_3	f_4	f_5
P1	0,40	0,60	0,00	0,00	0,00
P2	0,00	0,80	0,20	0,00	0,00
P3	0,00	0,00	0,00	0,53	0,47
P4	0,00	0,00	0,00	0,60	0,40
P5	0,00	0,00	0,00	0,73	0,27
Total	0,08	0,28	0,04	0,37	0,23

TABLE VI
EVALUATION OF THE VALUES OF FACULTY OF GEOLOGICAL, MINING AND METALLURGICAL ENGINEERING (FIGMM BY ITS SPANISH ACRONYM)

FIGMM	f_1	f_2	f_3	f_4	f_5
P1	0,00	0,07	0,93	0,00	0,00
P2	0,00	0,13	0,87	0,00	0,00
P3	0,00	0,47	0,53	0,00	0,00
P4	0,00	0,00	0,00	0,93	0,07
P5	0,00	0,00	0,00	0,67	0,33
Total	0,00	0,13	0,47	0,32	0,08

TABLE VII
EVALUATION OF THE VALUES OF FACULTY OF ECONOMIC ENGINEERING, STATISTICS AND SOCIAL SCIENCES (FIEECS BY ITS SPANISH ACRONYM)

FIEECS	f_1	f_2	f_3	f_4	f_5
P1	0,00	0,93	0,07	0,00	0,00
P2	0,00	0,87	0,13	0,00	0,00
P3	0,00	0,07	0,93	0,00	0,00
P4	0,00	0,00	0,00	0,87	0,13
P5	0,00	0,00	0,00	0,60	0,40
Total	0,00	0,37	0,23	0,29	0,11

Step 3: The clustering coefficient was determined (from Table VIII to Table X).

TABLE VIII
CLUSTERING COEFFICIENT VALUES OF FACULTY OF ENVIRONMENTAL ENGINEERING (FIA BY ITS SPANISH ACRONYM)

FIA	f_1	f_2	f_3	f_4	f_5	Total
P1	8,00	24,00	0,00	0,00	0,00	32,00
P2	0,00	32,00	12,00	0,00	0,00	44,00
P3	0,00	0,00	0,00	42,67	46,67	89,33
P4	0,00	0,00	0,00	48,00	40,00	88,00
P5	0,00	0,00	0,00	58,67	26,67	85,33
Total	1,60	11,20	2,40	29,87	22,67	67,73

TABLE IX
CLUSTERING COEFFICIENT VALUES OF FACULTY OF GEOLOGICAL, MINING AND METALLURGICAL ENGINEERING (FIGMM BY ITS SPANISH ACRONYM)

FIGMM	f_1	f_2	f_3	f_4	f_5	Total
P1	0,00	2,67	56,00	0,00	0,00	58,67
P2	0,00	5,33	52,00	0,00	0,00	57,33
P3	0,00	18,67	32,00	0,00	0,00	50,67
P4	0,00	0,00	0,00	74,67	6,67	81,33
P5	0,00	0,00	0,00	53,33	33,33	86,67
Total	0,00	5,33	28,00	25,60	8,00	66,93

TABLE X
CLUSTERING COEFFICIENT VALUES OF FACULTY OF ECONOMIC ENGINEERING, STATISTICS AND SOCIAL SCIENCES (FIEECS BY ITS SPANISH ACRONYM)

FIEECS	f_1	f_2	f_3	f_4	f_5	Total
P1	0,00	37,33	4,00	0,00	0,00	41,33
P2	0,00	34,67	8,00	0,00	0,00	42,67
P3	0,00	2,67	56,00	0,00	0,00	58,67
P4	0,00	0,00	0,00	69,33	13,33	82,67
P5	0,00	0,00	0,00	48,00	40,00	88,00
Total	0,00	14,93	13,60	23,47	10,67	62,67

Step 4: The summary table is made and the class of social impact is determined (see Table XI).

TABLE XI
SUMMARY OF RESULTS

Criteria code	FIA	FIGMM	FIEECS
P1	32,00	58,67	41,33
P2	44,00	57,33	42,67
P3	89,33	50,67	58,67
P4	88,00	81,33	82,67
P5	85,33	86,67	88,00
TOTAL	67,73	66,93	62,67
Impact class	Normal	Normal	Normal

From what is shown in Table XII of summary of results, it can be seen that the three faculties of study (FIA, FIGMM and FIEECS) concur that criteria P4 and P5 (Employment and Economic Development, respectively) would have a positive impact, the only criteria where they all coincide at the same level. Furthermore, a perception of normal impact is shown at a general level in the five selected criteria, without distinction of their respective careers; as even when they are categorized in the "normal" impact class group, their averages do not vary substantially. Situation that could be altered if other careers are taken into consideration, as well as if other criteria are selected in the analysis.

V. CONCLUSION

Through the methodology of the Grey Clustering, it has been acquired that the UNI Students' perception is Normal with respect to the social conflict in Las Bambas.

The criteria whose perspective of the students is to generate the most positive effect is the economic development. In the same way, the criterion with the most negative perspective is the land-use modification.

In the future, the Grey Clustering method might be used for other kinds of projects in its evaluation of social impact and analysis of environmental conflicts.

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