Integral Assessment of Risk Level in Libraries using the Grey Clustering Method

Alexi Delgado, J. Maguiña, R. Cabezas, S. Hidalgo, Ch. Carbajal

Abstract*: The purpose of this study is to simultaneously analyze the different risk factors (lighting, noise, and ergonomics), obtain an overall assessment of the risk of these factors and classify them in scales of levels of: Very poor, poor, good and very good, from three libraries of the National University of Engineering. In order to classify them, the grey clustering method was used, which establishes two types of data: Standard data and sampling data, the first one refers to the minimum standards required to be met by a library according to each criterion (lighting, noise, ergonomics). The second one refers to the real data obtained in the field. Both data are evaluated in the indicated methodology and the clustering vector is constructed, which will allow to classify the libraries in the scales of established levels. According to the results obtained, it was determined that the lowest noise levels were obtained in the library of the Faculty of Environmental Engineering; nevertheless, these levels are not within the minimum standards of noise for libraries; in addition, it was determined that the lowest values obtained in illumination of each library correspond to the library of the Faculty of Environmental Engineering, since it is in levels of illumination significantly below what is required according to the minimum standards. On the other hand, adequate lighting levels were obtained in the library of the Faculty of Sciences, and it was determined that the best ergonomic comfort was obtained in the Central Library. According to the overall assessment of each of the libraries under study, according to the scale of levels established, it is concluded that the library of the Faculty of Environmental Engineering is at a poor level with respect to the other libraries (good level).

Keywords*: Ergonomics, Industrial Safety, Industrial Hygiene, Grey Clustering, Risk Assessment.

I. INTRODUCTION

Nowadays the libraries of the different universities are concerned about giving a level of comfort to the student, such as: Low level of noise, adequate temperature and illumination, anthropometric furniture, etc. This due of that there are factors that affect the comfort of the students, generating distractions, stress, sleep, lack of concentration, among others [1].

Manuscript published on 30 September 2019
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In turn, some of the most important factors are Noise, since silence in the library is a need, because it is considered an area conducive to focus, reading, consultation and research, where interference and distractions should be minimal [2]. In the same way, another factor to be considered is the illumination since a deficient illumination causes loss of visual acuity as a consequence of the overexertion in the visual perception of the task; ocular fatigue as an effect of a confinement of people in environments with deficient illumination; dazzling due to contrasts in the visual field or excessive brightness of luminous sources; generating fatigue of the central nervous system [3]. Also, the ergonomic factor can be aggravated by noise factors, lighting or a combination of all the risk factors mentioned. In the present study, these factors were evaluated in three National Engineering University libraries, in Lima, Peru: Faculty of Environmental Engineering, Faculty of Sciences, and Central Library.

Now, these factors affect the students' learning, concentration, comfort, tranquility, etc., intensifying when they occur simultaneously. Although it is possible to measure the risks of each factor separately, there is little literature in which a global level of risk produced by simultaneous risk factors (noise, lighting, noise) is obtained [4].

For this reason, it is necessary to use a methodology that allows measuring jointly the global risk level in relation to noise, lighting and ergonomics of each library. In the present study, the Grey Clustering methodology was used, which helps to solve problems with small samples or with limited information, and also enables libraries to be categorized according to the results obtained from the global risk level [5].

Therefore, the general objective of this study is to analyze simultaneously the different risk factors (lighting, noise, and ergonomics), to obtain an overall risk assessment according to the indicated methodology and to classify in scales of levels of: very poor, poor, good and very good of each library [6].

According to the various factors such as antiquity, architecture, noise sources, distribution of lights, academic furniture of each library, study room, etc. The present study raises the following hypothesis: The Faculty of Environmental Engineering is at a poor level with respect to the other libraries (good level), according to the overall assessment of each one, according to the scale of established levels. This work is organized in the following sections: Introduction, Methodological development, Results and Discussions, Conclusions, and References.

II. METHODOLOGY

The sample of the present study will be determined by three National Engineering University libraries.

1. Central Library – BC (by its acronym in Spanish).
2. Faculty of Sciences – FC (by its acronym in Spanish).
3. Faculty of Environmental Engineering – FIA (by its acronym in Spanish).

Fig. 1, 2 and 3 show the aforementioned libraries in their respective faculties.

Fig. 1. Central Library

Fig. 2. Faculty of Environmental Engineering

Fig. 3. Faculty of Sciences

Source: *The images were extracted through the Google Earth Pro application.*

Description of the images: Location of the three (3) libraries of study of the study paper, are in the National University of Engineering, Av. Túpac Amaru s/n, Rimac, Lima 25, Peru, Av. Túpac Amaru 210, Rimac Lima, Peru.

A. The grey clustering method

The grey clustering method is based on the theory of grey systems, which was developed by Deng [7]. Grey systems study problems with small samples or with limited information, and there are many real life problems of this type, this fact makes grey systems can be applied to different fields. For example to evaluate water management [8], environmental conflicts [9] or occupational safety management [10], among others.

The grey clustering method was developed to classify observation indices or observation objects into categories using grey incidence matrices or whitenization weight functions. The method is mainly applied to test whether observation groups belong to predetermined categories.

In the present study we use the Grey Clustering method based on the triangular central-point whitenization weight functions (CTWF), since interest groups can be treated as observation objects for the integral risk factor.

The grey clustering method based on (CTWF) is developed according to the following definition [11]:

Definition 1. It is assumed that there is a set of "m" groups, a set of "n" criteria and a set of "s" different Grey classes, according to the sample x_{ij} ($i = 1, 2,..., m; j = 1, 2,..., n$), in which for the group you have ($i = 1, 2,..., m$), and for the criterion you have ($j = 1, 2,..., n$). In addition the steps for class grouping, based on CTWF can be expressed as follows:

Step 1:

The individual ranges of criteria are divided into "s" Grey classes, then determine the focal points of each range at: $\lambda_0, \lambda_1, \lambda_2, \ldots, \lambda_s$, of Grey classes 1,2,...,s.

Step 2:

Grey classes are expanded in two directions, adding Grey classes 0 and (s+1) with their central points λ_0 and λ_{s+1} respectively. Therefore, the new sequence of central points is established $\lambda_0, \lambda_1, \lambda_2, \ldots, \lambda_s, \lambda_{s+1}$ (see Fig. 4). Therefore the CTWF for class Grey kth, $k=1, 2, \ldots, s$, from criterion jth. $j=1, 2, \ldots, n$, for an observed value x_{ij}, is defined by Equation 1.

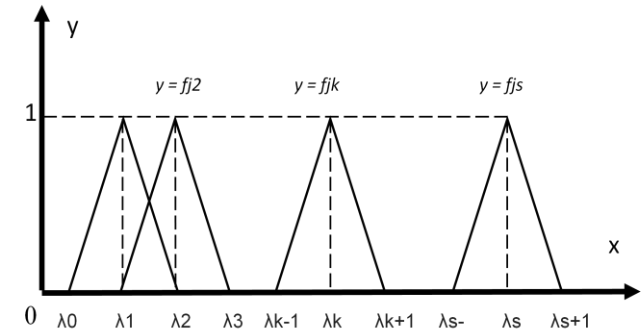

Fig. 4. Centre Point Triangular Whitenization Functions

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

Where $f_j^k(x_{ij})$ is the CTWF of the kth grey class of the jth criterion, and η_j is the weight of criterion j.

Step 3:

The clustering coefficient σ_i^k which indicates the weight of the criteria, for group $i, i=1, 2, \ldots, m$, with respect to the grey class $k, k=1, 2, \ldots, s$, is calculated using Equation 2.

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

Step 4:

If $\underset{1\le k\le s}{\text{máx}}\{\sigma_i^k\} = \sigma_i^{k*}$, we decided that object i belongs to

Retrieval Number: C5695098319/2019©BEIESP
DOI:10.35940/ijrte.C5695.098319
Journal Website: www.ijrte.org

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class Grey k*. When there are several objects in the Grey k* class, these objects can be ordered according to the magnitudes of their clustering coefficients.

In turn, in the present study the "i" groups are determined by:

- i_1 = Central Library (BC by its acronym in Spanish).
- i_2 = Library of the Faculty of Sciences (FC by its acronym in Spanish).
- i_3 = Library of the Faculty of Environmental Engineering (FIA by its acronym in Spanish)

And the criteria "j" are determined by:

- j_1 = Noise (dB).
- j_2 = Illumination (Lux).
- j_3 = Ergonomics (Likert).

Likewise, the ranges of these criteria are divided into 4 Grey classes: s1, s2, s3 and s4. They are shown in Table I.

Table I. Evaluation scale

Criteria	Very Poor	Poor	Good	Very Good
Noise (dB)	⟨52,56⟩	⟨48,52⟩	⟨44,48⟩	⟨40,44⟩
Illumination (Lux)	⟨100,200⟩	⟨200,400⟩	⟨400,800⟩	⟨800,1600⟩
Ergonomic (Likert)	⟨0,2⟩	⟨2,4⟩	⟨4,6⟩	⟨6,8⟩

These ranges were established according to the minimum levels required in a library according to the criteria of noise [12], illumination [13] and ergonomics [14].

Therefore, in order to categorize the study groups it is necessary to take real sampling data through noise and lighting measurements and a descriptive closed response survey in the case of ergonomic risk. Thus, they can be evaluated in the aforementioned method.

B. Noise

1) Measuring Instrument

Evaluations must be made with class 1 or class 2 sonometer according to IEC 61672-1:2002 or whichever supersedes it [15]. In the present study, a class 1 sonometer will be used (see Fig. 5), which was calibrated before and after each measurement.

Fig. 5. Sonometer class 1

Source: Photo of the paper researchers, taken in the BC CENTRAL-UNI.

2) Noise measurements

To take measurements of sound pressure levels in the libraries of the BC, FC and FIA, the protocol for measuring noise generated by static sources has been followed [16]. Also, the location and number of points to evaluate were established according to the geometry of each study environment, and the static noise sources, in order to obtain representative measurements (see Fig. 6).

Since the noise is stable (i.e., fluctuates in a range of 3dB), a minimum of 3 measurements of 5 minutes each were taken to avoid incurring in measurements that could result in low representativeness.

In addition, the sonometer was located 1.5 m from the floor level with an inclination angle of 45° in direction of the noise source.

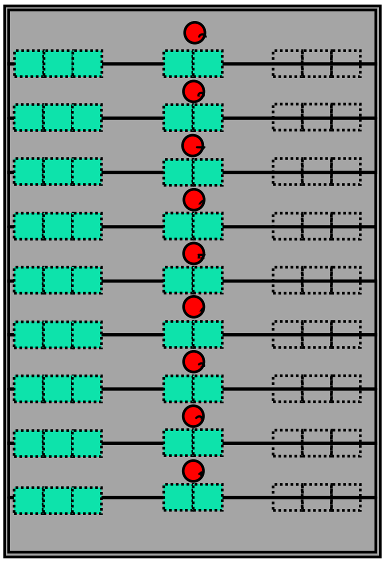

Fig. 6. Noise measuring points - BC

The plane represents the distribution of the measurement points in occupational noise, in the BC-UNI study area, which are located with the symbol $\#_{(\text{number})}$.

Following the same monitoring procedure, the libraries of the Faculty of Science (FC) and the Faculty of Environmental Engineering (FIA) will be evaluated.

3) Average Noise Pressure Level

To calculate the average noise pressure level in each of these libraries, it will be calculated following the static noise measurement protocol [16]. Which establishes the Equation 3.

$$L_{Aeq} = 10 \log \left[\frac{\sum 10^{\left(\frac{LAeq,Ti}{10}\right)}}{N} \right] \qquad (3)$$

Where:

L_{Aeq} = Average representative equivalent of continuous noise pressure level, dB(A).

$LAeq, Ti$ = Equivalent continuous noise level with rapid time response of each individual measurement event, dB(A).

Ti = Measuring time interval of the individual event with level $LAeq, Ti$ min.

C. Illumination

1) Measuring Instrument

The evaluation of the average illumination level was made with a heavy-duty light meter - Professional (Luxometer), which provides the measurement of light Type: Fluorescent. In the present study, an EXTECH professional Luxometer will be used (see Fig. 7).

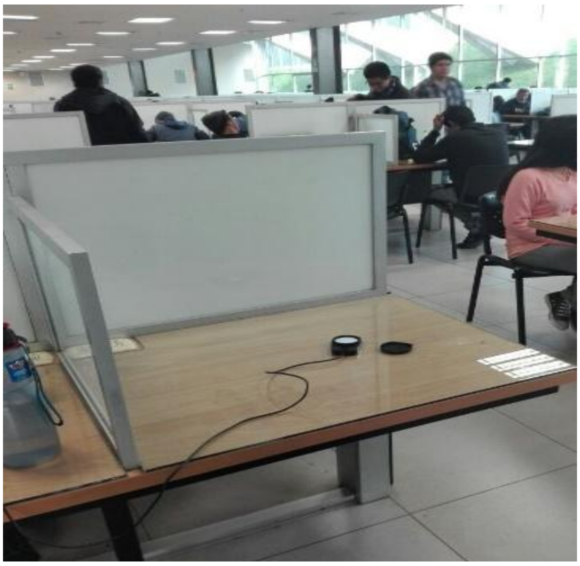

Fig. 7. Professional Luxometer EXTECH

Source: Own photo of the paper researchers, taken in the BC CENTRAL-UNI.

2) Illumination measurements

To measure the levels of lumens in the libraries of the BC, FC and FIA, the measurement method based on a grid of measurement points covering the entire area analyzed was followed. The basis of this technique is the division of the inner part into various equal areas, each of them ideally square.

The existing illumination in the center of each area was measured at tabletop height (typically 0.85 meters above ground level) and an average illumination value was calculated. There is a relationship that allows the minimum number of measurement points to be calculated from the value of the Room Index (RI) applied to the Interior being analyzed. This is calculated using Equation 4.

$$Room\ Index\ (RI) = \frac{L\ x\ A}{Mx\ (L + A)} \quad (4)$$

Where:

L = Enclosure length

A = Width of the enclosure

M = Mounting height, indicates the vertical distance between the center of the light source and the work plane.

The above relationship is expressed by the following Equation 5.

$$Min.\ n°\ of\ measuring\ points = (x + 2)^2 \quad (5)$$

Where: "x" is the value of the local index rounded up, except that for all RII values equal to or greater than 3, the value of x is 4. The minimum number of measurement points is derived from the equation, but conditions usually require the use of a number of points greater than this minimum [17]. The number and distribution of points to be measured in lighting in the Central Library are shown in Fig. 8.

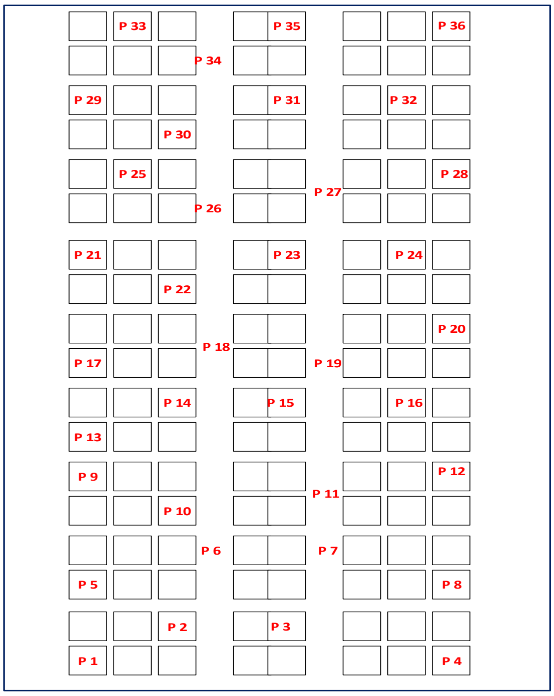

Fig. 8. Lighting measuring points - BC

The map represents the distribution of the measuring points in the BC-UNI study area, which are located with the symbol $P\#_{(number)}$.

Following the same monitoring procedure, the libraries of the Faculty of Science (FC) and the Faculty of Environmental Engineering (FIA) will be evaluated.

a) Illumination

Illumination and its distribution in the task area and the surrounding area have a great impact on how a person perceives and performs the visual task in a fast, safe and comfortable way.

All the illumination values specified in this standard are maintained illuminations and will provide facilities to satisfy the needs of comfort and visual performance [18].

Once the minimum number of measurement points was obtained, the values were taken at the center of each grid area. The average illumination was then obtained (E_{Media}), which is the average of the values obtained in point (2.3.1). According to UNE-EN-12464-1 requirements. The E_{Media} equation is expressed by Equation 6.

$$E_{Media} = \frac{\sum Measured\ values\ (Lux)}{Number\ of\ points\ measured} \quad (6)$$

Where:

E_{Media}: It is the average value obtained in (lux) the BC, FC and FIA libraries

D. Ergonomics

1) Measuring Instrument

The evaluations were performed using a Likert type additive scale, according to NTP 15 [19]. In the present study, surveys were conducted with closed responses in accordance with the Likert scale, in order to evaluate the perception of comfort of the users of each library.

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DOI:10.35940/ijrte.C5695.098319
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2) Likert Scale

The Likert scale is an ordinal scale and has the advantage that it is easy to build and apply. It also provides a good basis for a first ranking of individuals in the characteristic being measured.

3) Questionnaire and Assessment

For the assessment of the users of their respective libraries, a series of items related to the attitude we want to measure, i.e. exposure to lighting, noise and comfort levels in libraries, were collected.

In addition, each item was evaluated qualitatively and quantitatively, as follows: Strongly Disagree (1), Disagree (3), Agree (5) and Strongly Agree (7).

Subsequently, a representative sample of 15 users per library was selected; and they responded, choosing in each item the alternative that best describes their personal position. Finally, the results of each library (FIA, BC, FC) are given by the quantitative average of the highest score obtained in each library. The questionnaire used to collect information can be seen in Fig. 9.


UNIVERSIDAD NACIONAL DE INGENIERÍA

PERCEPCIÓN DE LOS NIVELES DE CONFORT EN LA BIBLIOTECA DE LA FIA

Facultad:
Especialidad:
Edad:
Fecha:

Para la siguiente encuesta, considerar la tabla de puntuación que se muestra a continuación; y marcar su respuesta con una "X":

A	B	C	D
MUY EN DESACUERDO	EN DESACUERDO	DE ACUERDO	MUY DE ACUERDO

1) ¿Para Ud., los niveles de iluminación son los adecuados para desarrollar tu estudio en la biblioteca?

A B C D

2) ¿Para Ud., los niveles de sonido presentes en la biblioteca son factores de distracción y

A B C D

3) ¿Para Ud., el mobiliario de la biblioteca es el adecuado para estudiar de forma satisfactoria?

A B C D

4) Según su percepción, considera que la biblioteca es confortable para estudiar?

A B C D

5) De acuerdo a Ud., qué acciones se deberían implementar para mejorar el nivel de confort de la biblioteca?

Fig. 9. Questionnaire based on the Likert scale - FIA

III. RESULTS AND DISCUSSION

A. Measurement Results

1) Noise

Using Equation 3, the average representative equivalent continuous sound pressure level of each library is calculated, obtaining the following results presented in Table II.

Table II. Average representative equivalent continuous sound pressure level

LIBRARIES	Laeq (dB)
BC	60.6
FC	62.1
FIA	57.8

2) Illumination

Using Equation 4, the average lighting level of each library is calculated and the following results are obtained and presented in Table III.

Table III. Average illumination level

LIBRARIES	Em (lux)
BC	406
FC	1536
FIA	234

3) Ergonomics

Through the questionnaires constructed according to a Likert additive scale and distributed in each library, the following average score was obtained as shown in Table IV:

Table IV. Average of scores obtained

LIBRARIES	(Likert)
BC	5,27
FC	4,87
FIA	4,27

B. Establishment of measurement data Evaluation (λ1, λ2, λ3 and λ4)

The parameters used were chosen considering their importance with respect to lighting levels, noise and ergonomic conditions of the libraries.

These ranges were established according to the minimum levels required in a library of study, according to the criteria of noise [20], lighting [18] and ergonomics [19], and are shown in Table V.

Table V. Values to illumination, noise and ergonomic

CRITERIA	f_j^1	f_j^2	f_j^3	f_j^4
	Very Poor	*Poor*	*Good*	*Very Good*
C1	150	300	600	1400
C2	54	50	46	42
C3	1	3	5	7

Due to the fact that the values of the parameters have different measurement units, it is necessary to dimension the values for a correct application of the Grey Clustering method as it is seen in Table VI.

Table VI. Values used to evaluate lighting levels, noise and ergonomic, dimensionless conditions

CRITERIA	f_j^1	f_j^2	f_j^3	f_j^4
	Very Poor	*Poor*	*Good*	*Very Good*
C1	0,27	0,53	1,07	2,13
C2	1,13	1,04	0,96	0,88
C3	0,25	0,75	1,25	1,75

Then the results obtained from the measurements and questionnaires are shown in Table VII.

Table VII. Values obtained from the measurements and questionnaires taken in each library

CRITERIA	UNIT	LIBRARIES		
		FIA	*BC*	*FC*
C1	Lux	234	406	1536
C2	dB	57,8	60,6	62,1
C3	Likert	4,27	5,27	4,87

From the results shown in Table VII, the dimensioned values are presented in Table VIII:

Table VIII. Dimensioned values obtained after the measurements taken in each library

CRITERIA	UNIT	LIBRARIES		
		FIA	*BC*	*FC*
C1	Lux	0,40	0,69	2,61
C2	dB	1,20	1,26	1,29
C3	Likert	1,07	1,32	1,22

C. Whitenization functions elaboration

Whitenization functions are elaborated by each parameter or evaluation criterion, so in this case we have 3 groups of functions [21]. Next, the function corresponding to the dimensioned parameters of the evaluation of the levels of illumination is presented; resulting in a "Growing" function. It should be noted that the functions of the other parameters have a similar structure as it is shown in Fig. 10.

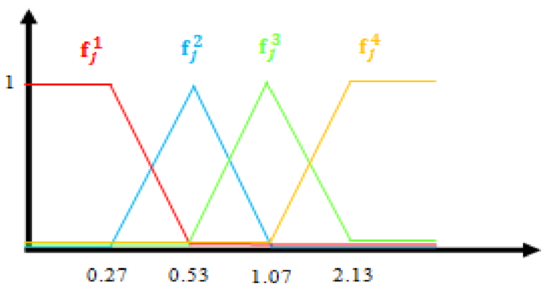

Fig. 10. Whitenization Functions

The functions corresponding to Criterion 1 (C1), level of illumination, are presented in the Equations 7, 8, 9 and 10.

$$f_j^1(x) = \begin{cases} 1; & x \in [0;\ 0.27) \\ \dfrac{-(x-0.53)}{0.53-0.27}; & x \in [0.27;\ 0.53) \\ 0; & x \in (0.53; +\infty) \end{cases} \qquad (7)$$

$$f_j^2(x) = \begin{cases} 0; x \in [0;\ 0.27] \cup [\,1.07;\ +\infty) \\ \dfrac{(x-0.27)}{0.53-0.27}; x \in (0.27;\ 0.53) \\ \dfrac{-(x-1.07)}{1.07-0.53}; x \in (0.53;\ 1.07) \end{cases} \qquad (8)$$

$$f_j^3(x) = \begin{cases} 0;\ x \in [0;\ 0.53] \cup [2.13;\ +\infty) \\ \dfrac{(x-0.53)}{1.07-0.53};\ x \in (0.53;\ 1.07] \\ \dfrac{-(x-2.13)}{2.13-1.07};\ x \in (1.07;\ 2.13) \end{cases} \qquad (9)$$

$$f_j^4(x) = \begin{cases} 0;\ x \in [0; 1.07] \\ \dfrac{(x-1.07)}{2.13-1.07};\ x \in (1.07; 2.13) \\ 1;\ x \in [2.13;\ +\infty) \end{cases} \qquad (10)$$

The other parameters or criteria functions are developed following the same procedure as above. The results are presented in Table IX.

Table IX. Function values evaluated in the respective libraries (FIA, BC, FC)

Faculty Of Engineering Environmental (FIA by its acronym in Spanish)			
Criteria	***C1***	***C2***	***C3***
f_j^1	0,42	1,00	0,00
f_j^2	0,58	0,00	0,36
f_j^3	0,00	0,00	0,64
f_j^4	0,00	0,00	0,00
Central Library (BC by its acronym in Spanish)			
Criteria	***C1***	***C2***	***C3***
f_j^1	0,00	1,00	0,00
f_j^2	0,65	0,00	0,00
f_j^3	0,35	0,00	0,86
f_j^4	0,00	0,00	0,14
Faculty of Sciences (FC by its acronym in Spanish)			
Criteria	***C1***	***C2***	***C3***
f_j^1	0,00	1,00	0,00
f_j^2	0,00	0,00	0,06
f_j^3	0,00	0,00	0,94
f_j^4	1,00	0,00	0,00

D. Setting the criteria weight (Clustering Weight) n_j^k

We use Equation 11, to establish the criteria weight.

$$n_j^k = \frac{1/\lambda_j^k}{\sum_{j=1}^{m} 1/\lambda_j^k} \qquad (11)$$

Therefore, the results obtained are shown in Table X

Table X. Criteria weights for each library evaluated

Weights	f_j^1	f_j^2	f_j^3	f_j^4
C1	0,43	0,45	0,34	0,21
C2	0,10	0,23	0,38	0,52
C3	0,46	0,32	0,29	0,26

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DOI:10.35940/ijrte.C5695.098319
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E. Calculating the Clustering Coefficient σ_j^k

To establish the weight of the criteria the Grey Clustering model Equation 12, is used.

$$\sigma_j^k = \sum_{j=1}^{m} f_j^k(x_{ij}).n_j^k \qquad (12)$$

Therefore, it can be observed that the clustering coefficient is a function of the criteria weight and the Whitenization functions.

F. Building the clustering vector

The Clustering vector, as well as the evaluation of the lighting levels, noise and ergonomic conditions of each library (FIA, BC and FC) are summarized in the following table:

Table XI shows clustering coefficient ordered by each library evaluated.

Table XIII. Clustering coefficient for each library

LIBRARIES	Very Poor	Poor	Good	Very Good
	f_j^1	f_j^2	f_j^3	f_j^4
FIA	0,29	0,38	0,18	0,00
BC	0,10	0,29	0,37	0,04
FC	0,10	0,02	0,27	0,21

The shaded boxes indicate the level of comfort experienced by users of the respective libraries in this study. The results are presented in Table XII.

Table XIIII. Results for each library

Library	σ_j^k	Level
FIA	0,38	Poor
BC	0,37	Good
FC	0,27	Good

Finally, the grey clustering method, which was used in this work showed its efficiency [22], as this method considers the uncertainty within its analysis [23], this fact is an advantage regarding to other approaches, such as Delphi method [24] or AHP method [25].

IV. CONCLUSIONS

The initial hypothesis was demonstrated, which indicates that the library of the Faculty of Environmental Engineering is in a poor level with respect to the other libraries (good level), according to the global valuation of each one, in conformity with the scale of established levels.

It was determined that the lowest noise levels were obtained in the library of the Faculty of Environmental Engineering; however, these levels are not within the minimum noise standards for libraries.

It was determined that the best lighting level was obtained at the Faculty of Science library, which is within the minimum lighting standards required for libraries.

It was determined that the lowest values obtained in lighting of each library corresponds to the library of the Faculty of Environmental Engineering, as it is at illumination levels well below the minimum standards.

REFERENCES

1. M. Gupta and S. Jetty, "Library in Everyone's Pocket with reference to Bundelkhand University App," in *IEEE 5th International Symposium on Emerging Trends and Technologies in Libraries and Information Services, ETTLIS 2018*, 2018, pp. 79–82.
2. F. Moreno Ceja, M. G. Orozco Medina, and M. del R. Zumaya Leal, "Los niveles de ruido en una biblioteca universitaria, bases para su análisis y discusión," *Investig. Bibl. Arch. Bibl. e Inf.*, vol. 29, no. 66, pp. 197–224, May 2015.
3. Y. Rodríguez Cisneros, "Evaluación de la ergonomía y el confort ambiental en la Biblioteca Agrícola Nacional," Universidad Nacional Agraria La Molina, 2016.
4. N. Yamamoto, "Performance Evaluation of an Active Learning System to Improve Students Self-Learning and Concentration," in *Proceedings - 2015 10th International Conference on Broadband and Wireless Computing, Communication and Applications, BWCCA 2015*, 2015, pp. 497–500.
5. S. Liu, C. Lin, and Y. Yang, "Several problems need to be studied in grey system theory," in *2017 IEEE International Conference on Grey Systems and Intelligent Services, GSIS 2017*, 2017, pp. 1–4.
6. F. Dong, J. Liu, and B. Liu, "Study on improved grey integrated clustering method and its application," in *2009 IEEE International Conference on Grey Systems and Intelligent Services, GSIS 2009*, 2009, pp. 702–707.
7. D. Julong Deynrt, "Introduction to Grey System Theory," *J. Grey Syst.*, pp. 1–24, 1988.
8. L. N. Zhang, F. P. Wu, and P. Jia, "Grey Evaluation Model Based on Reformative Triangular Whitenization Weight Function and Its Application in Water Rights Allocation System," *Open Cybern. Syst. J.*, vol. 7, no. 1, pp. 1–10, 2013.
9. A. Delgado and I. Romero, "Social impact assessment on a hydrocarbon proyect using triangular whitenization weight functions," in *CACIDI 2016 - Congreso Aergentino de Ciencias de la Informatica y Desarrollos de Investigacion*, 2016.
10. C. Li, K. Chen, and X. Xiang, "An integrated framework for effective safety management evaluation: Application of an improved grey clustering measurement," *Expert Syst. Appl.*, vol. 42, pp. 5541–5553, 2015.
11. A. Delgado, D. Vriclizar, and E. Medina, "Artificial intelligence model based on grey systems to assess water quality from Santa river watershed," in *Proceedings of the 2017 Electronic Congress, E-CON UNI 2017*, 2018, vol. 2018-Janua.
12. W. Shiqiang, S. Ruixiang, Y. Kun, and W. Yu, "The research of noise induced tympanic membrane perforation in cotton textile industry," in *2008 IEEE International Conference on Industrial Engineering and Engineering Management, IEEM 2008*, 2008, pp. 1587–1590.
13. M. Zalesinska, S. Szwedek, and A. Pawlak, "Evaluation of Lighting Parameters at the Workplace with the use Replacements for Incandescent Lamps," in *7th Lighting Conference of the Visegrad Countries, LUMEN V4 2018 - Proceedings*, 2018.
14. A. F. Burkov, I. V. Zaychenko, and S. A. Goncharova, "Development of a Comprehensive Criterion for Evaluating the Ergonomics Configuration of the Seat," in *2019 International Science and Technology Conference "EastConf,"* 2019, pp. 1–4.
15. ISO 9613-2, "Acoustics — Attenuation of sound during propagation outdoors — Part 2: General method of calculation," 1996.
16. C. Echeverri and A. González, "Protocolo para medir la emisión de ruido generado por fuentes fijas," *Rev. Ing. Univ. Medellin.*, vol. 10, no. 18, pp. 51–60, 2011.
17. J. Guasch, R. Forster, F. Ramos, A. Hernández, and A. Smith, "46. Iluminación," *Encicl. Salud Y Segur. En El Trab. - OIT*, vol. II, pp. 46.1-46.19, 1998.
18. Comité técnico AEN/CTN 72., "UNE-EN 12464-1:2003," 2003.
19. I. Fernández de Pinedo, "Construcción de una escala de actitudes tipo Likert," 1982.
20. L. L. Beranek, "Criteria for Noise in Buildings and Communities," in *Noise and Vibration Control Engineering: Principles and Applications: Second Edition*, Hoboken, NJ, USA: John Wiley & Sons, Inc., 2007, pp. 887–909.
21. A. Delgado, "Citizen criminality assessment in lima city using the grey clustering method," in *Proceedings of the 2017 IEEE 24th International Congress on Electronics, Electrical Engineering and Computing, INTERCON 2017*, 2017.
22. C. Bindu, M. Padmaja, and J. A. Chandulal, "Evaluating Web Sites Based on GHAP," *Int. J. Comput. Sci. Eng.*, vol. 2, no. 3, pp. 674–679, 2010.
23. A. Delgado, A. Aguirre, E. Palomino, and G. Salazar, "Applying triangular whitenization weight functions to assess water quality of main affluents of Rimac river," in *Proceedings of the 2017 Electronic Congress, E-CON UNI 2017*, 2018, vol. 2018-Janua.
24. L. Davis, H. Taylor, and H. Reyes, "Lifelong learning in nursing: A Delphi study," *Nurse Educ. Today*, vol. 34, no. 3, pp. 441–445, 2014.
25. A. Delgado and I. Romero, "Selection of a method for social impact assessment using AHP," *Rev. ECIPerú*, vol. 12, no. 1, pp. 84–91, 2015.