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EVALUATION OF ERGONOMICS OF AN INDUSTRIAL ZONE BASED ON FUZZY COMPREHENSIVE EVALUATION METHOD

EL M'HADI HAJAR[1] , CHERKAOUI ABDELGHANI[2]

[1] EMISys, Engineering 3S Research Centre, EMI, Mohammed V University, Rabat, Morocco

[2]EMISys, Engineering 3S Research Centre, EMI, Mohammed V University, Rabat, Morocco

E-mail: [1]hajar.mhadi@gmail.com, [2]cherkaoui@emi.ac.ma

ABSTRACT

In this paper, we will evaluate the level of ergonomics in an existing industrial zone. This evaluation will enable the community to ensure that the industrial zone meets the expectations of the companies and the involved actors, to identify improvements track and to initiate actions. The aim of this approach is to improve the quality of the area, to give it the maximum chance of perpetuating direct and indirect jobs and to preserve environmental resources (water, energy, landscape, air, etc.).To meet this evaluation objective, we proposed a model based on the combination of the AHP method and the fuzzy comprehensive technical evaluation. Considering the fuzzy characteristics of factors influencing the level of urban ergonomics in an industrial zone, a two-level evaluation index system was established. The degree of adherence of factors is determined by the knowledge and experience of the experts. Then the weight of each factor is determined by the AHP method and a final judgment matrix is determined by the end. This method allows us a quantitative ergonomic evaluation.

Keywords: *Fuzzy sets, AHP Theory, Industrial Zone, Ergonomics Evaluation.*

1. INTRODUCTION

In most cases, the industrial zone is a space setting up by local authorities in order to be marketed to companies for the purpose of carrying out their economic activities. There are approximately 80 industrial parks in Morocco for a cumulative area of 4600 hectares [1]. They comprise 25% of jobs and one third of firms. The purpose of these sites is to strengthen and structure the local economic fabric through an adapted land and property supply

Whatever their name (Activity Areas, Commercial Activity Zone, Industrial park ...), they are real local showcases.

If the initial vocation of the first "Industrial Zones" was to leave the factories away from the population, by regrouping the polluting activities outside the city, today we try to make these spaces more human. Other needs are also evident during the creation of these sites: the safety of premises and people, the proximity of the site with the main traffic routes, flowing traffic and efficient signage within the zone, access to current technologies (high-speed network, even very broadband, etc.).

In addition, today's entrepreneurs are looking for ways to make their employees lives more enjoyable, by proposing, in particular, transit offers adapted to work schedules and places of residence. Restoration, the provision of meeting rooms is all considered useful, and the various services or other tertiary activities (hotels and nurseries for example) are now increasingly present in these new "Business villages".

Therefore, to ensure the quality of a zone of activity over the long term, it will be wise to implement an ergonomic evaluation of the area of activity to monitor its evolution over time. This assessment will help to understand the strengths and weaknesses of the area and to consider, in the short, medium or long term, the measures to be implemented to correct deficiencies or failures.

In the light of this observation, the idea of evaluating ergonomics in an industrial zone is hardly mentioned in the literature, but it is part of the ‘’urban ergonomics’’ concept, of which several research studies have been carried out. The transfer of the ergonomics of a city or of an urban space in general to the ergonomics of an industrial zone, although still little rose in the literature, seems

fruitful. As early as the 1970s, the psychologist J.C Spérandio (1976) [2,3] studied the extent to which ergonomics could be applied to the built environment, which is understood to include housing and working buildings on the one hand, and by neighborhoods and towns (or villages), including roads, up to the planning of the territory, on the other hand.

Defining ergonomics of the urban space as the fitting of a given space in compatibility with the various characteristics of activities or users for greater comfort or efficiency (i.e. taking into account of "human factors" in spatial planning which corresponds rather closely to the definition of ergonomics) [2], he undertakes to list several themes for which works exist and possibilities emerge:

-The housing scale for which it identifies numerous studies designed to optimize the physiological dimension of the habitat with active solutions in the building sector, push towards more energy-efficient collective housing and participate in reducing its environmental impact, while respecting the way of life of the occupants.[4]. Skeptical about the very intuitive approach of architects in this field, in particular that of Le Corbusier [5], he advocates the use of a methodology based on a behavioral analysis in the Human Machine-Systems. On this scale, Ergonomics has also been widely emphasized by E. Attaianese (2000) [6], who studied the principles and habits of domestic work (in Sweden, Switzerland, France, Germany and England) before proposing a number of recommendations concerning space for the human body, the physiological design of furniture, the dimensioning of rooms and buildings, the climate inside dwellings , Lighting, noise. We also notice the work of A.ADEM that present how Green ergonomics reflects on the bi-directional interaction between natural and human structures to ensure the well-being and efficacy of human and social systems. [7].

-The scale of buildings and environment, for which D.Clements-Croome (2000) [2,3], notes that (many dysfunctions result from inappropriate spatial implantation). He concludes that a "spatial organization conceived taking into account the analyze of actual work would obviously reduce a great part of these dysfunctions, provided, however, that they intervene as soon as plans are drawn up. As before, there is also J. H Burgess (1981) [8]. who finds that human factors in built environments are of major importance if we are concerned with human efficiency, safety, comfort, morale and the general utility associated with the characteristics of the environment Interior design of built buildings.

-The scale of accessibility, for which the Center for Studies on Networks, Transport, Urban Planning and Public Construction of France (CERTU, 2005) has developed an ergonomic evaluation tool for facilitate access to urban resources in urban public spaces. The objective is to present a computer tool developed under the Access database, to constitute a database of observations and qualification of the activity of the users in a public space chosen, according to this ergonomic approach [9]. M.PUISET (2022) who developed a methodology for measuring accessibility and modes of travel in urban areas of Sydney. It includes graphic measures of physical accessibility, a numerical accessibility index in accordance with graphic measures, and the accessibility of residents weighted by the availability of transportation.

These 3 scales are just a part of the general criteria that will be discussed in the following sections

In order to evaluate ergonomics in an industrial park we propose the Analytical Hierarchy Process (AHP) combined with the fuzzy comprehensive evaluation method. A two-stage fuzzy comprehensive evaluation model is proposed to evaluate the level of ergonomics in the industrial park. The fuzzy comprehensive evaluation method [7] is a powerful tool that may be used to make a decisions when multiple and conflicting criteria are present, it reduces complex decisions to a series of pairwise comparisons. It also allows managers to structure the complex problems they face by making judgments based on their experience and available information.

The study utilized the hesitant fuzzy analytic hierarchy process as one of the multi-criteria decision-making approaches to calculate the weight of ergonomics framework principles. The hesitant fuzzy linguistic term set approach was adopted to develop especially for the cases where experts hesitate during the decision-making process.

2. CASE OF STUDY

As a first step, the strategic objectives of urban ergonomics must be laid down. On the contrary, one approaches the position defended by SEN (SEN, 1993) in the field, neighbor, of the evaluation of the individual well-being. SEN argues in favor of a "reasoned pragmatism" in the definition of the dimensions of well-being, adapted

to the specific contexts of the study and refined by the comparison of several sources and / or points of view on what should be include in the objectives of the measure.

At the service of the user, urban ergonomics analyzes, understands and translates human behaviors in a given environment, in order to provide a creative value response. It is an engine that can allow conditions for economic or demographic development both in the installation of a new territory and in an already existing site or to meet the needs for revitalization, which in fact crosses the three pillars of the Sustainable development with spatial form and temporal reality, offering a 360 °, three-dimensional and evolutionary treatment. Urban ergonomics are therefore thought of in space and time, in the short, medium and long term ... as well as sustainable development. [12]

In this paper, we anchor our approach on the 4 main criteria of sustainable development put forward by the local Agenda 21 *[13]:

1. Promote a good management and an economical and renewable use of resources in the industrial zone.
2. Promote local development and attractiveness of the area.
3. Ensure a quality living environment and urban comfort for employees and businesses.
4. Improve the local environment in the area.

These 4 main criteria are drawn from different approaches and references:

- The MEFISTO reference system **(CHARLOT-VALDIEU and OUTREQUIN, 2009) for sustainable development, which is a tool for assessing quality in an urban space…[14]
- ***ISO 37120:2014*** : As part of a new series of International Standards being developed for an integrated approach to sustainable development and resilience, the indicators and associated test methods in this International Standard have been developed in order to help cities measure performance management of city services and quality of life over time. It can be used in conjunction with ***ISO 37101*** (*Sustainable development in communities , Management systems*) and ***ISO 1996-2*** (*Acoustics Description, measurement and assessment of environmental noise — Part 2: Determination of environmental noise levels*) [15].

  This International Standard is applicable to a city, an industrial park or local government that undertakes to measure its performance in a comparable and verifiable manner, irrespective of size and location.
- ***ISO 14031***: describes environmental performance evaluation as a regularly recurring process as well as placing general requirements for indicators. It also lists detailed examples for each evaluation area. The basis for environmental performance evaluation is the so-called operational system, which corresponds to an input–output analysis of material flows.[16]
- Computer Assisted Web Interviews. It was an on-line questionnaire designed for expert in urbanism that helped us to identify the criteria for evaluating ergonomics in the industrial zone.

On the basis of these pluralistic approaches, we obtain a short list of synthetic factors selected on the basis of the frequency of their occurrence in the various sources. The mainly influencing factors for the ergonomics in an industrial park are illustrated in Table. 1.

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Table 1: The hierarchy factor structure of ergonomics in an industrial park

	1st class factors	*2nd class factors (sub-factors)*
Ergonomics of an industrial zone C	**Management and economical use of ressources C_1**	Economy C_{11}
		Maintenance C_{12}
		Management C_{13}
	Local development and attractiveness C_2	Services offer C_{21}
		Safety and security C_{22}
		Leisure and entertainment C_{23}
		Mobility C_{24}
		Attractiveness C_{25}
	Quality liviing and urban comfort C_3	Accessibility C_{31}
		Architecture C_{32}
		Visuel quality C_{33}
	Environmental quality C_4	Noise, water, air C_{41}
		Climate confort C_{42}
		Sanitation C_{43}

3. FUZZY COMPREHENSIVE EVALUATION MODEL

3.1 A factor set

In the practical case, we need to evaluate something based on multiple factors instead of a single factor: this is called a multi-criteria approach... Here, evaluation means determining merits (good) and bad things according to the given conditions. Therefore, a comprehensive evaluation is a method used to solve problems that include many evaluation factors.

The evaluation factor procedures start with the determination of the factor set. A set of factors is composed of factors that influence the evaluation of an object. It is defined as:

$$U= \{u_1, u_2 \dots u_m\} \quad (1)$$

With u_i $(i=1,2,\dots,m)$ being ith factor of the first class , u_i is determined by nth factor of the second class as $u_i = (u_{i1},u_{i2},\dots,u_{ik})$, k the number of sub-factors for each factor.

3.2 Defining the assessment set

The assessment set presents the results of fuzzy evaluation, it is expressed as $V= \{v_1, v_2 ,\dots v_n \}$, where n is the number of levels. Therefore, we propose a qualitative partition of five levels :

$$V= \{\text{Good, less good, general, poor, bad}\} \quad (2)$$

Fuzzy relationship matrix is determined by experts' knowledge and experience. The graded marks are then balanced and integrated. Finally, we calculated hierarchically every membership degree of the factor set for every element of the assessment set.

3.3 Defining the assessment set

The weight coefficient matrix of each class is defined as :

$$A= (a_1 ,a_2 ,\dots ,a_m) \quad (3)$$

where $\sum^{m}_{i=1} a_i = 1$

3.4 Determining the fuzzy judgment matrix

The judgment matrix result of m evaluation factors and n level is:

$$R = \begin{pmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{pmatrix} \quad (4)$$

Where $0 \le r_{ij} \le 1$, i= 1,2,…, m , j=1,2…,n

r_{ij} is the fuzzy evaluation result of the ith factor by the jth level.

3.5 Fuzzy comprehensive evaluation set

Using the fuzzy hierarchy comprehensive evaluation calculation model B = A • R. The fuzzy comprehensive evaluation vector set is: (5)

$$B = A \bullet R = (a_1 ,a_2 ,\dots,a_m) \bullet \begin{pmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{pmatrix}$$

$$B = (b_1 ,b_2 ,\dots ,b_n)$$

Where b_i (i=1,2…,n) is the fuzzy comprehensive evaluation vector.

In this equation, m is the number of evaluation factors, n is the number of levels. The use of a multi-level fuzzy comprehensive assessment method means that the fuzzy global evaluation should be carried out from the lowest class to the top class until the final result is obtained [9].

The result of the evaluation depends on the maximum value of B:

$$b_k = \max_{1 \le i \le n} \{ b_i \} \quad (7)$$

3.6 Analytic hierarchy process AHP to determine factor weights

Using the fuzzy hierarchy comprehensive evaluation calculation model B = A • R. The fuzzy comprehensive evaluation vector set is:

The AHP method consists in representing a decision problem by a hierarchical structure that reflect the interactions between the various elements of the problem, then making paired comparisons of the elements of the hierarchy, and finally determining the priorities of the actions

Step 1: Divide the problem into a hierarchy of interconnected elements. The top of the hierarchy is the 'objective', and in the lower levels, the elements contributing to this objective. The last level is that of actions. [7, 10]

Step 2: Perform pair-wise comparisons of elements of each hierarchical level with an element of the higher hierarchy level. This step helps to construct matrices of comparisons. The values of these matrices are obtained by transforming the judgments into numerical values according to the Saaty scale (Scale of binary comparisons) [11]:

Table 2: Binary Comparaisons Scale Of SAATY

1	Equally preferred
2	Equally to moderately preferred
3	Moderately preferred
4	Moderately to strongly preferred
5	Strongly preferred
6	Strongly to very strongly preferred
7	Very strongly preferred
8	Very to extremely strongly preferred
9	Extremely preferred

Step 3: Determine the relative importance of the elements by calculating the eigenvectors corresponding to the maximum eigenvalues of the matrices of comparisons.

Step 4: Check the judgments consistency. First, we calculate the consistency index CI:

$$CI = (\lambda_{max} - n)/(n-1) \quad (8)$$

Where λ_{max} is the maximum eigenvalue corresponding to the matrix of the pairwise comparisons and n is the number of elements compared.

Second, the coherence ratio (CR) is calculated by:

$$CR = CI / RI \quad (9)$$

Where RI is the average consistency index obtained by randomly generating judgment matrices of the same size. The table of Random Index is shown below [11]:

Table 3: Table Of Random Index

n	1	2	3	4	5	6	7	8	9
RI	0,00	0,00	0,58	0,90	1,12	1,24	1,32	1,41	1,45

A CR value less than 10% is generally acceptable; otherwise pairwise comparisons need to be revised to reduce inconsistencies.

Step 5: Determination of the relative performance of each action and selecting the best design alternative

4. APPLICATION OF EVALUATION IN THE INDUSTRIAL ZONE

The management and economical use of resources, the local development and attractiveness, The quality living and urban comfort, and the environmental quality are denoted as the notations of C_1, C_2 , C_3 , C_4 . Utilizing the AHP method, the pairwise comparison matrix, weight vector, the maximum eigenvalue λ_{max} and the consistency ratio *CR* for ergonomics in the industrial zone factors are obtained in table 4.

Table 4: Relative Weights Influencing Ergonomics In An Industrial Zone

Sub-factors influencing , local development and attractiveness C_2	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	***Weight vector***	λ_{MAX}	***CR***
C_{21}	1	2	4	3	6	0,394		
C_{22}	1/2	1	8	5	4	0,353		
C_{23}	1/4	1/8	1	1/4	1/2	0,048	5,358	0,080 <0,1
C_{24}	1/3	1/5	4	1	3	0,137		
C_{25}	1/6	1/4	2	1/3	1	0,068		

Thus, the set of factor's weight influencing ergonomics in the industrial zone can be regarded as:

A = [0,118 0,479 0,064 0,339]

We continue in the same way for each factor C_1, C_2, C_3, C_4 separately. The results are shown in Table 5, 6, 7 and 8 respectively.

Table 5: Relative Weights Influencing Management And Economical Use Of Resources

Sub-factors influencing management and economical use of resources C_1	C_{11}	C_{12}	C_{13}	***Weight vector***	λ_{MAX}	***CR***
C_{11}	1	1/8	1/3	0,082		
C_{12}	8	1	3	0,682	3,001	0,0014 <0,1
C_{13}	3	1/3	1	0,236		

Table 6:Relative Weights Influencing Local Development And Attractiveness

Sub-factors influencing ergonomics in the industrial zone C	C_1	C_2	C_3	C_4	***weight vector***	λ_{MAX}	***CR***
C_1	1	1/4	3	1/5	0,118		
C_2	4	1	6	2	0,479	4,216	0,08 <0,1
C_3	1/3	1/6	1	1/4	0,064		
C_4	5	1/2	4	1	0,339		

Table 7: Relative Weights Influencing Living Quality And Urban Comfort

Sub-factors influencing living quality and urban comfort C_3	C_{31}	C_{32}	C_{33}	***Weight vector***	λ_{MAX}	***CR***
C_{31}	1	8	4	0,727		
C_{32}	1/8	1	1/2	0,091	3,0009	0,0008 <0,1
C_{33}	1/4	2	1	0,182		

Table 8: Relative Weights Influencing Environmental Quality

Sub-factors influencing C_4	C_{41}	C_{42}	C_{43}	***WEIGHT VECTOR***	λ_{MAX}	***CR***
C_{41}	1	2	1/3	0,238		
C_{42}	1/2	1	1/4	0,136	3,023	0,02 <0,1
C_{43}	3	4	1	0,625		

The factor weight set of influencing the Management and economical use of resources, local development and attractiveness, quality living and urban comfort and the environmental quality can be regarded as:

A_1 = [0,082 0,682 0,236]
A_2 = [0,394 0,353 0,048 0,137 0,068]
A_3 = [0,727 0,091 0,182]
A_4 = [0,238 0,136 0,625]

After having determined the factors influencing ergonomics in the industrial zone are evaluated according to the 5 levels already defined in the assessment set: V= {Good, less good, general, poor, bad}

Based on the evaluation of experts of the delegation of industrie, the result of judgment matrix is established as

Table 9: The judgment matrix of the evaluated system

1 class F C_i	2 class F C_{ij}	Levels good	Less good	general	poor	bad
	C_{11}	0	0,6	0,2	0,2	0
C_1	C_{12}	0	0,5	0,2	0,3	0
	C_{13}	0	0	0	0,5	0,5
	C_{21}	0	0	0,3333	0,6666	0
	C_{22}	0	0	1	0	0
C_2	C_{23}	0	0	0	0,5	0,5
	C_{24}	0,66666	0,3333	0	0	0
	C_{25}	0,2	0,2	0,6	0	0
	C_{31}	0	0	1	0	0
C_3	C_{32}	0	0	0,5	0,5	0
	C_{33}	0	0	0,2	0,3	0,5
	C_{41}	0	0	0	0	1
C_4	C_{42}	0	0	0	1	0
	C_{43}	0,4	0,4	0,2	0	0

Therefore, the respective evaluation matrices R_1, R_2, R_3, R_4 are

$$R_1=\begin{pmatrix} 0 & 0,6 & 0,2 & 0,2 & 0 \\ 0 & 0,5 & 0,2 & 0,3 & 0 \\ 0 & 0 & 0 & 0,5 & 0,5 \end{pmatrix}$$

$$R_2=\begin{pmatrix} 0 & 0 & 0,3333 & 0,6666 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0,5 & 0,5 \\ 0,66666 & 0,3333 & 0 & 0 & 0 \\ 0,2 & 0,2 & 0,6 & 0 & 0 \end{pmatrix}$$

$$R_3=\begin{pmatrix} 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0,5 & 0,5 & 0 \\ 0 & 0 & 0,2 & 0,3 & 0,5 \end{pmatrix}$$

$$R_4=\begin{pmatrix} 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 \\ 0,4 & 0,4 & 0,2 & 0 & 0 \end{pmatrix}$$

The first order fuzzy comprehensive evaluation is expressed as

$B_1 = A_1 \circ R_1$ = [0 0,390 0,152 0,339 0,118]
$B_2 = A_2 \circ R_2$ = [0,104 0,059 0,525 0,286 0,024]
$B_3 = A_3 \circ R_3$ = [0 0 0,808 0,100 0,091]
$B_4 = A_4 \circ R_4$ = [0,250 0,250 0,125 0,136 0,238]

The second order fuzzy comprehensive evaluation matrix is

$$= A \circ \begin{pmatrix} 0,118 \\ 0,479 \\ 0,064 \\ 0,339 \end{pmatrix} \circ \begin{pmatrix} A_1 \circ R_1 \\ A_2 \circ R_2 \\ A_3 \circ R_3 \\ A_4 \circ R_4 \end{pmatrix} \qquad B = A \circ R$$

cThe final result is

$$B = \begin{pmatrix} 0 & 0,390 & 0,152 & 0,339 & 0,118 \\ 0,104 & 0,059 & 0,525 & 0,286 & 0,024 \\ 0 & 0 & 0,808 & 0,100 & 0,091 \\ 0,250 & 0,250 & 0,125 & 0,136 & 0,238 \end{pmatrix}$$

[0.134 0.159
0.363 0.229 0.111]

According to the biggest membership of the fuzzy comprehensive evaluation set, the level of ergonomics in an industrial zone is ‘’general’’.

5. IMPROVEMENT ACTIONS TO DEVELOP THE INDUSTRIAL ZONE

The various actions that can be approached to improve the ergonomic quality of the Mohammadia industrial zone can be divided into six sections: animation and life of the activity zone; landscape and living environment; transport and infrastructure; industrial and natural hazards; air and noise; [18].

5.1 Animation and life of the industrial zone

5.1.1 Reception of new companies

The reception and accompaniment of the companies favor the environmental and economic integration on the territory of the zone. To facilitate the establishment of companies, we can set up:

• A welcome booklet. The purpose of this document is to help the head of the company by providing him with the information he may need: manager, various administrative, economic and environmental actors, environmental management approach, qualifying criteria to be respected, existing services in the area, presentation and contact details of companies present in the area, network management.

• A welcoming commission comprising the key actors: manager, consulting architect, landscaper.

• An integration event with other companies.

• An adequate offer of reception: rental buildings, nurseries, incubators.

5.1.2 Service offer

The services offered in the area are a real advantage for users and companies. These services can be organized on the activity area itself but can also be developed in relation to the territory. The management of these services makes it possible to federate the companies, to develop complementarities between them and to initiate their implication by facilitating the dialogue. To meet the needs and expectations of users and companies, we can set up:

• Inter-company restaurant.
• Common meeting room.
• Central purchasing supplies.
• Banking agency / money distributor.
• Post Office.
• Timeshare environment advisor.
• Training offer.
• Collective transport.
• Sports and cultural activities.
• Nursery for moms working in the area.

5.2 Landscape and living environment

The service green is made to meet the requirements of the development. The service green works can be:

✓ Visual barriers for noise;

✓ Green roofs;

✓ Road green spaces (parking, boulevards, roundabouts, devices for channeling traffic).

✓ Adopting green spaces can be an effective mitigation action from the point of view of visual perception and contributes to the production of other positive effects on the environment [19]

✓ Regulation of the microclimate, in particular summer thermal peaks;

✓ Permeability and protection of soil and groundwater;

✓ Filtration and purification of air from powders and pollutants such as sulfur and nitrogen oxides, carbon monoxide, particulates and PAHs (polycyclic aromatic hydrocarbons);

✓ Attenuation of noise pollution;

✓ Creation of a resting habitat from a psychological point of view;

✓ Protection of the environment in deteriorated or sensitive areas (banks, embankments, landslides);

✓ Recreational and social function by the presence of public gardens, flowerbeds, boulevards planted with trees that promote the well-being of workers and visitors.

5.3 Transport and infrastructure

The traffic concerns the various modes of transport, the ease of access to the zone and the companies, the safety with respect to the environment. Road maintenance promotes traffic flow, reduces accidents and gives a positive image of the area. To imitate the risks of accidents and the impacts on the environment, actions can be put in place:

✓ Develop with each company concerned a plan and access schedules for the transport of hazardous materials.

✓ Establish strict rules of circulation.

✓ Optimize or create a system for recovering leaks and fire water.

✓ Improve the time needed to cut different networks.

✓ Ensure compliance with the regulations for the signage and labeling of road vehicles.

✓ Writing the procedures to follow in the event of an accident. ✓ Organize exercises and training in companies.

5.4 Industrial and natural risks

5.4.1 Fire defense

It is important that the water supply is sufficient on the area of activities. The flow, pressure and number of fire hydrants must be monitored. Annual tests on fire water supply equipment are mandatory. A "disaster" basin can be built to receive water from fire extinguishing or the discharges resulting from an accidental pollution.

5.4.2 Risks related to industrial concentration

To avoid the risk of domino effects (cascading accidents), a good knowledge of the activities, the associated perimeters and compatibilities between them is necessary. The actions to put in place are:

✓ Identify each company presenting an industrial risk and define the nature and the consequence of the risk.

✓ Evaluate the improvement actions that can be implemented by companies.

✓ Writing the procedures to follow in case of risk.

✓ Optimize the response of the helpers.

✓ Create physical barriers to counter the domino effect.

✓ Organize exercises and training in companies.

✓ Raise awareness among users, local residents and businesses [20].

5.5 Air and noise

5.5.1 The management of atmospheric emissions

In order to limit the diffusion of atmospheric pollution and to avoid the inconvenience of local residents and users, companies with particular atmospheric emissions may be located in the area depending on topography and prevailing winds. A monitoring system ensures compliance with the discharge limits. The actions to put in place to reduce atmospheric emissions are:

✓ Incorporate thresholds in the development plan and the urban planning by-law in relation to the regulations in force. - Set up measurement sensors.

✓ Reduce the use of substances known to pollute for certain uses.

✓ Promote the use of cleaner energies.

✓ Promote the use of public and / or alternative transport.

✓ Reduce dust emissions at the source.

✓ Put in place treatment, purification and dispersion devices at the source.

✓ Provide training on preventing and reducing nuisances to improve air quality

5.5.2 The reduction of sound nuisance

Two kinds of noise are characteristic and must be taken into account: the noise emitted by the implanted companies and the noise emitted by the industrial area itself. In order to reduce the impact of sound nuisance related to activities, solutions can be found in terms of location and layout, planning and reduction at source. It is possible to set maximum sound levels when setting up a new company. There may be special locations for noisy companies in the center of the area for example. Quiet companies can be used as a screen for noise emissions from noisy activities. Developments can reduce noise: draining asphalt, cladding, walls and noise abutments...

6. CONCLUSION

In this research, we proposed the fuzzy comprehension evaluation method to evaluate the level of ergonomics in an industrial zone. The use of this technique is very innovative and operational. We calculated the factor weights of each hierarchy using AHP and we verified the rationality of the weights using the judgment matrix to ascertain whether their consistency is satisfactory or not. Among the main advantages of this technique is that the factors influencing ergonomics in an industrial zone can be represented directly by different layers and subsequently can guarantee the objectivity and effectiveness of the overall assessment. The results and analyzes proposed by this research are intended to guide local actors, and in particular elected officials, in the implementation of their projects to create or reclassify industrial spaces of activity on their territory., in an ergonomic frame. Of course, the perfection of this method must be compared with other methods such as the DEA, the raw set, and the entropy theory that have been useful in another field. It will be studied in future research for further progress. The ergonomic management of an area of activities allows organizing and registering in time a management to respect the human factor but also to assist the development of companies present in the area or wishing to establish. The organization of this management is far from static and must evolve continuously. The evaluation of the area allowed us to deepen our knowledge of these strengths and weaknesses through an investigation on the ground, where we were able to determine the real deficiencies and weaknesses from which this area suffers and where the real goal was to consolidate our problem and affirm the character to which our

study area is related. This work allowed us to schematize the different problems and try to bring the first ideas of urban intervention serving as a primary solution to the different stakeholders in this redevelopment project (urban agency, perfecture, municipality, developer ALMOMRANE). This intervention will be a basis for reflection for future operators (industrial company) who will occupy the project in the next five years

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