Applying Fuzzy Analytic Hierarchy Process (FAHP) to Evaluate Factors Locating Emergency Logistics Platforms

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ABSTRACT
This paper presents the results in terms of characterization of humanitarian supply chains, it also proposes a framework for modeling the problem of locating logistics platforms in emergency affected areas based on the use of Fuzzy Analytical Hierarchy Process (FAHP).

General Terms
Making decision, artificial intelligence, Multicriteria analysis, Logistics.

Keywords
Disaster, Humanitarian logistics, Industrial logistics, Disaster management cycle, Emergency logistics platforms, Vulnerability, Multiple criteria decision making (MCDM), Fuzzy Analytical Hierarchy Process (FAHP).

1. INTRODUCTION
The growth of natural and technological hazards is a worldwide worrying phenomenon. Is mainly caused by industrialization and the increase of areas with high occupant densities. The risks therefore pose a global challenge for the future and constitute one of the main problems of sustainable development.

Given their geographical location, many counties, are exposed in terms of natural hazards, to climatic, meteorological, geological or biological phenomenon, which may cause major risks such as floods, flash floods, earthquakes and landslides. These natural phenomena can cause damage or compromise the socio-prone areas natural disaster countries (see Figure1).

In the case of emergency operations, humanitarian logistics is used to support the organization and the implementation of response actions, so that they can be not only quick, but also agile and effective. The mobilization of personnel, equipment and the necessary materials for the work of organizations that provide assistance, and even casualty evacuation procedures or reorientation of people affected by the disaster, need a logistics system so that these activities can be efficiently implemented.

Humanitarian supply chains have many particularities that generate a number logistical issue very different from those usually encountered in the private sector. The study of humanitarian supply chains is a prerequisite necessary for the understanding of the best practices that should be adapted and transferred in different situations.

The choice of location logistics units determines the performance of the humanitarian supply chain. They play an essential role in defining the strategy to be adopted by the humanitarian supply chain. To consider these, we need to identify the criteria for their evaluation and define their mutual impacts and their dependencies to better opt for a satisfactory place. This approach requires the development of a multi-criteria decision making (MCDM) developed on the basis of work that we published previously [1].

One of the useful methods of MCDM is Analytical Hierarchy Process (AHP) introduced by Saaty (1980) [2], it plays an important role in alternatives selecting [3], [4]. AHP is one of the extensively methods used to resolve the MCDM problems [5],[6]. AHP uses understanding and informed knowledge without the need of specific data. But the weakness of AHP is that it deals with expert's judgment which évluate their eigenvalues by a number varying between 1 and 9 in order to handle the uncertainty associating to their judgments. So as to overcome this deficiency, Fuzzy set is used within AHP calculations to determine the best alternative [6], [7].

The association between AHP and fuzzy, represented by the FAHP term, set leads to more flexibility in judgment and decision making. Fuzzy AHP (or FAHP) reflects human thinking as it uses approximate information and uncertainty to generate decision in addition to inheritance of the advantages of AHP, ease of handling qualitative and quantitative data, use of hierarchical structure, pairwise comparison, reduce inconsistency, and generates priority vectors [4].

This paper is organized as follows: section 2 provides presentation of humanitarian logistics, in section 3 the introduction and application of fuzzy Analytical Hierarchy Process (FAHP) in the section 5 is the conclusion and prespectives.

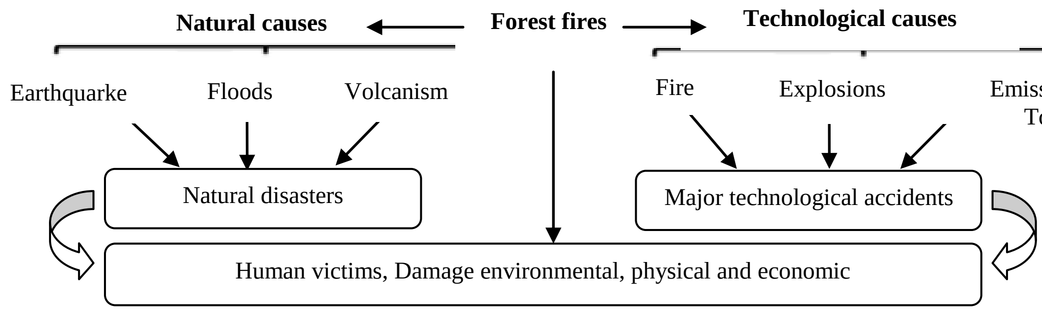

Fig 1: Type of disaster

2. HUMANITARIAN LOGISTICS

2.1 What is humanitarian logistics?

Humanitarian logistics is the implementation of an action aimed at improving the situation of a group of persons temporarily or permanently in an emergency situation or in one which does not allow them to meet their specific first aid needs requirements.

In this context, the "Humanitarian Logistics" will be all the tasks undertaken by an organization in a given area, so that it can carry out humanitarian activities for populations at risk. A breach of this set of delicate and difficult operations may compromise the chain of life that they had helped to maintain or restore [9].

2.2 Industrial logistics vs Humanitarian logistics

Aspects of humanitarian logistics are in no way different from the problems of industrial logistics. The above-mentioned differences are planning difficulty, lack of long-term strategic perspective, which opposes development agencies relief agencies operating in case basis.

A fundamental difference is that trade supply chain is structured so as to satisfy the consumer who is the source of income while a humanitarian supply chain seeks to satisfy the claimant, but derives its income from the donor [9][10].

You find a table at dessu recuperative different characteristic compared to humanitarian logistics Industrial logistics (see Table 1).

Table 1. Industrial logistics vs Humanitarian logistics

	Industrial logistics	**Humanitarian logistics**
Supply chain	Supplier-customer	Donor and recipient supplier
Life	Start and finish dates	Depends on the type of disaster, a few weeks to a few months assembling and dismantling included
Customer	buyer	Recipient, donor
Supplier	2-3 supplier	Supplier and / or uncertain and multiple donor
Financial flows	Bilateral and known	Unilateral (from donor to recipient) and uncertain
Cast	known, aligned with incentives	Multiplicity of nature, but the rarity of + numbers differing motivations
Information flow	well-structured	Great importance of media communication reduces
Flux human	limited	flow of people of knowledge transfer
Environment	More volatilles	Highly volatile and unstable

2.3 Humanitarian logistics and disaster management

Operations of humanitarian organizations in disaster management can be divided into four main phases.

The first one is the "Mitigation" phase which aims to eliminate or reduce the risks and impacts of a future disaster. The second phase is the "Preparedness "of taking preparatory measures to avoid the negative consequences of a given threat. The third one is the "Response" in the disaster, i.e. the mobilization and deployment of emergency services within the affected area in order to protect the public and reduce human and material damage. The last phase is the "recovery" it consists of measures leading to a return to normal life.(see Figure 2).

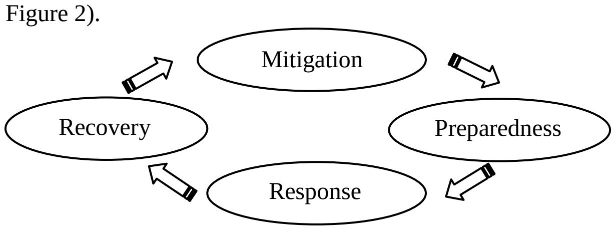

Fig 2: Disaster management cycle

For humanitarian operations, there will be an overlap between the different phases. Table 2 we show the differing tasks and features throughout the disaster management cycle (seeTable2)[11].

Table 2. Humanitarian logistics and disaster management

Phase	Period	LogisticsVolume	SuppliesRequired
Mitigation	Long Term	Low	Varied supplies
Preparedness	Long Term	Low	Specific standard supplies prepositioned for disaster response
Response	Days Months	High : Lead times for supplies can make the difference between life and death.	Specific standard supplies:Food, medical supplies, water and sanitation equipment, shelter, household kits, etc.
Recovery	Months Years	Medium : There may be government and donor pressure to complete recovery activities	Varied supplies depending on the context of the disaster: reconstruction material, livelihoods equipment

2.4 Logical framework

Table 3 presents the logical framework of two poles necessary for successful logistics operation, must logistics coordination and common logistics services (see Table 3)[9].

Table 3. Logical framework

Strategic Objective	Improve living conditions and protection of affected populations
Specific Objective Coordination	Provide humanitarian organization the appropriate coordination mechanisms to facilitate the delivery of humanitarian aid
Indicator	Coordination and information sharing on the logistics team with the humanitarian
Activities	Logistical coordination between the various actors in order to reduce duplication of efforts already in place and the best use of infrastructure and logistic services available in the area affected
	Put at the disposal of all other sectors the most updated information
	possible on existing offers
	The pooling of resources and information for assessments and surveys
Specific Objective Location of emergency logistics platform	Humanitarian organizations to provide logistical assistance required to facilitate the reception and delivery of humanitarian aid
Indicator	Humanitarian organizations have access to reception centers and warehouses to store humanitarian goods
Activities	Maintain and ensure a welcoming space and storage
	Maintain and ensure a welcoming space and temporary storage
Indicator	Humanitarian partners have access to the means for transporting materials humanitarian
Activities	Support and facilitate the delivery of human and material resources on the ground in a timely manner, quality and quantity at the lowest cost and in the right place with minimum possible risk.
	Maintain the infrastructure
Indicator	Humanitarian actors have access to vulnerable populations through the rehabilitation of the number of km of roads in the affected areas
Activities	Identify the type and number of infrastructure rehabilitation

3. MODELING LOCATION OF EMERGENCY LOGISTICS PLATFORMS

The choice of location logistics units determines the performance of the humanitarian supply chain. They play an essential role in defining the strategy to be adopted by the humanitarian supply chain[4].

The organization of the humanitarian supply chain requires the establishment of places of transhipment, storage, assembly or reconditioning, service information, service management, etc. Whose location is often strategic for humanitarian organizations.The impact of these organizations in the affected areas is far from negligible [10][11].

Given these challenges, policymakers must make choices relevant to the location of these areas.

In the first section, we will define more precisely the emergency logistics platforms. Then, we will show approach proposed resolution localization emergency logistics platform.

3.1 Definition of emergency logistics platforms

Emergency logistics platforms are the spatial manifestation of logistics activities such as static activities entroposage broadly.

It is logistics sites by which humanitarian goods to be sorted in particular, grouped, ungrouped, packaged and repackaged. It is an area of value creation.

Emergency logistics platform must be positioned so as to bring relief throughout the region. We want to provide resources permanently stored closer to the area potentially affected. We must assess the likelihood of a disaster happening in a region of the world, and determine the most suitable place to receive emergency logistics platform.

3.2 Approach proposed resolution localization logistics plateforms

Our goal is to develop a multicriteria multiobjective model which can help us find a solution to our problem tracking. We then apply this approach in real cases by choosing the best location of emergency logistics platform while taking into account a set of criteria[1].

Resolution procedure is to apply the method in the first phase FAHP. This approach aims to transform the qualitative criteria, from the judgment of decision makers, a numerical scale with some priority values relative weights. Similarly we FAHP provides a hierarchical decomposition of the problem to understand the situation of study, identify and explain the overall goal.

3.2.1 Fuzzy Analytical Hierarchy Process (FAHP)[6][7][8]

FAHP is an extension of AHP. The assessment of different criteria requires using of fuzzy number. While, AHP based on the use of crisp numbers. FAHP overcomes that defect in AHP.

FAHP is to represent a decision problem of a hierarchical structure reflecting the interactions between the various elements of the problem, then proceeding to pairwise comparisons of the elements of the hierarchy, and finally to determine the priorities for action. It breaks down into four steps:
<u>Step 1:</u> Decomposition of the problem into a hierarchy of interrelated elements. At the top of the hierarchy are the objectives and the lower levels, the elements contributing to achieving this objective. The last level is that of actions.

<u>Step 2:</u> Conduct pair-wise comparisons of criteria for each hierarchical level relative to an element of higher level. This step allows us to construct matrices of comparisons. The values of these matrices are obtained by the transformation of judgments into numerical values according to Saaty scale (see Table 5), while respecting the principle of reciprocity.

Table 5. Saaty's scale for comparison

Intensity of importance	Definition	Description
1	Equal importance	Two alternatives contribute equally to the same goal
3	Moderate importance	On the basis of experience and evaluation one alternative is slightly preferred to the other.
5	Strong importance	On the basis of experience and evaluation one alternative is favored strongly over the other.
7	Very strong, demonstrated Importance	One alternative is favored strongly over the other; its dominance demonstrated in practice.
9	Extreme importance	The evidence on the basis of which one alternative is favored of the highest possible order of an affirmation.
2,4,6,8	Intermediate values	

The comparison matrix defined by Saaty employs 1-9 scales. Our new fuzzy comparison matrix differs with Saaty's in that we use membership scales, instead of the 1-9 scales, as the values of the elements.

The meanings of our membership scales can olso be expressed in the same way as Saaty's scale (see Table 6).

Table 6. Scale for fuzzy comparison

Intensity of importance	Definition
0.5	Equally important
0.55 (or 0.5 0.6)	Slightly important
0.65 (or 0.6 0.7)	Important
0.75 (or 0.7 0.8)	Strongly important
0.85 (or 0.8 0.9)	Very strongly important
0.95 (or 0.9 1.0)	Extremely important

Step 3: To determine the relative importance of the components by calculating the eigenvectors corresponding to the eigen values of the matrices of maximum comparison.

$$A = \begin{bmatrix} r11 & \cdots & r1n \\ \vdots & \ddots & \vdots \\ rn1 & \cdots & rnn \end{bmatrix}$$

A matrix results of step 2 with:

- r_{ij} scale for fuzzy pair-wise comparison
- n number of criteria

W= (w_1, w_2,…,w_n) priority vector with w_i priority of criterion Ci given by:

$$wi = ai \,/\, (\sum_{i=1}^{n} ai) \qquad (1)$$

Where

$$ai = 1 \,/\, ([\textstyle\sum_{j=1}^{n} 1/rij] - n)$$

Step 4: Check the consistency of judgments, the answers are often a degree of inconsistency. FAHP method does not require that judgments be consistent or transitive. Against by Saaty defined a consistency index IC rated, with:

$$IC = (\lambda\text{max} - \text{n}) \,/\, (n - 1) \qquad (2)$$

With λmax is the value corresponding to the proper maximum pairwise comparisons matrix and n is the number of elements compared. More consistency index, the greater the user's judgments are inconsistent and vice versa.

Saaty has define, by experimentation, a consistency ratio as the ratio of the consistency index calculated on the matrix corresponding to the judgments of the decision maker and the random index (IA) of a matrix of the same size.

Table 7. Consistency index means

Number of criteria	IA
2	0
3	0.58
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49
11	1.51

The ratio of coherence is given by the following formula:

$$RC = IC/IA \qquad (3)$$

The ratio of coherence can be interpreted as the probability that random matrix is full. The overall coherence of appreciation is assessed using the consistency ratio RC.

According Saaty, the value of the latter must be at most equal to 10%. In case this value exceeds 10%, the testimonials may require some revisions.

3.2.2 *Evaluation of the factors of locating emergency logistics platforms*

Now we use FAHP to evaluate the factors locating emergency logistics platforms. First, set up the analytic hierarchy model of location factors (see Figure 3).

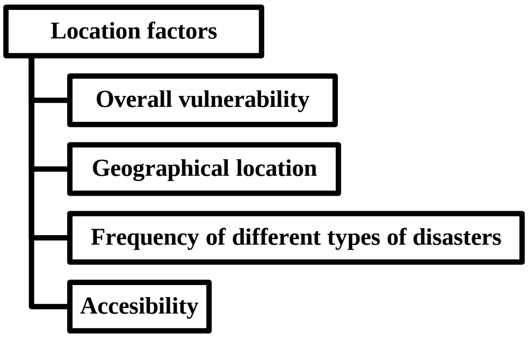

Fig 3: Location factors

The establishment of a comprehensive analysis of the vulnerability requires the integration of a variety of information about the human element, infrastructure, resources, and type of construction (see Figure 4).

Next, we give the fuzzy comparison matrixes of the criteria level and sub-criteria level. For instance, Tables 8-9 show the original fuzzy paire-wise comparison matrixes for overall vulnerability.

Table 8. Fuzzy comparison matrix at criteria level

	C1	C2	C3	C4	C5
C1	0.5	0.8	0.7	0.5	0.9
C2	0.2	0.5	0.4	0.1	0.4
C3	0.3	0.6	0.5	0.3	0.7
C4	0.5	0.9	0.7	0.5	0.7
C5	01	0.6	0.3	0.3	0.5

Table 9. Comparison matrix at sub-criteria level, for criterion C5

	C51	C52	C53	C54
C51	0.5	0.2	0.7	0.5
C52	0.7	0.5	0.6	0.7
C53	0.3	0.4	0.5	0.4
C54	0.5	0.3	0.6	0.5

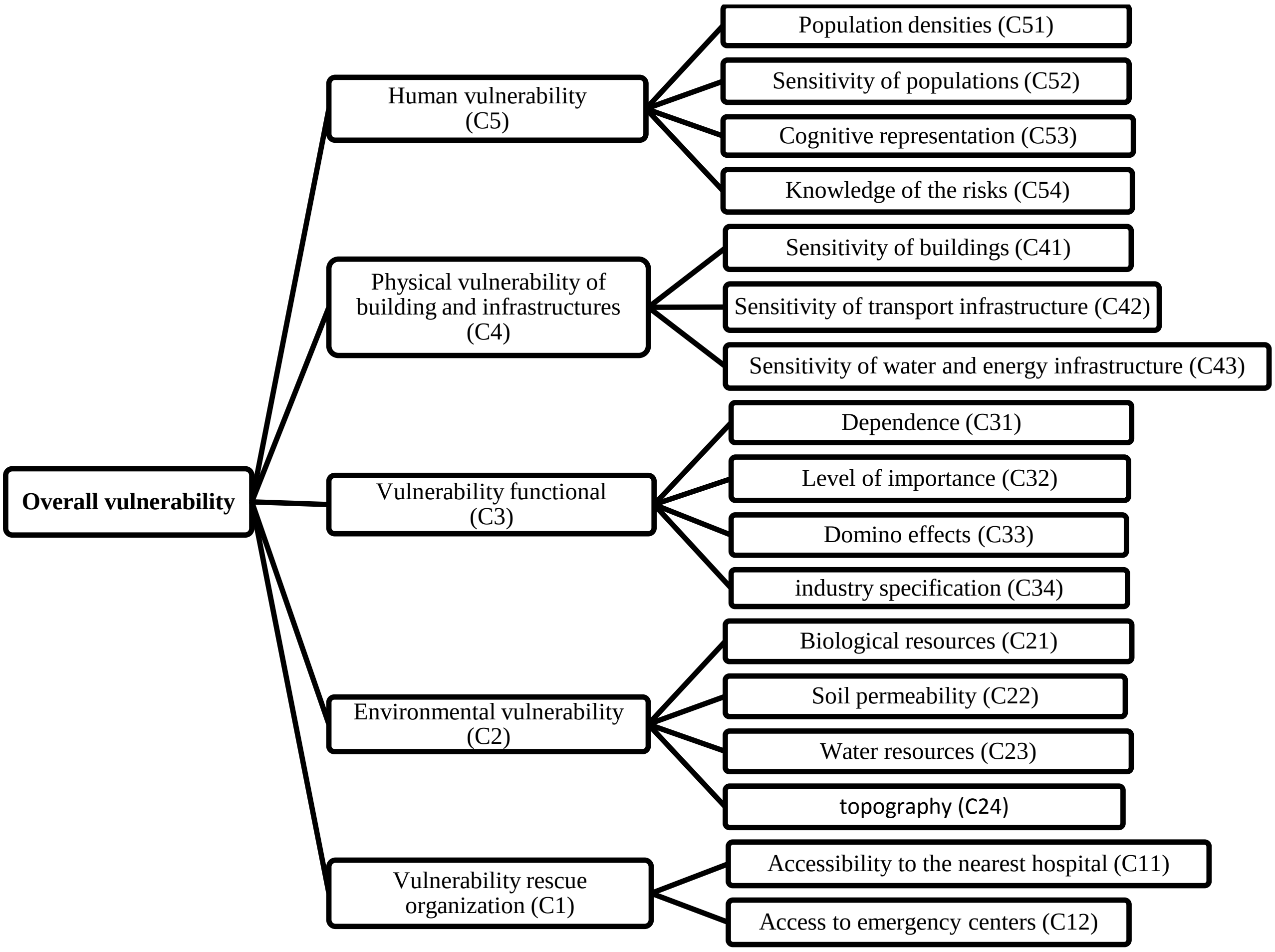

Fig 4: Overall vulnerability

Table 10. Comparison matrix at sub-criteria level, for criterion C4

	C41	C42	C43
C41	0.5	0.7	0.6
C42	0.3	0.5	0.4
C43	0.4	0.6	0.5

Table 11. Comparison matrix at sub-criteria level, for criterion C3

	C31	C32	C33	C34
C31	0.5	0.2	0.7	0.4
C32	0.8	0.5	0.9	0.6
C33	0.3	0.1	0.5	0.2
C34	0.6	0.4	0.8	0.5

Table 12. Comparison matrix at sub-criteria level, for criterion C2

	C21	C22	C23	C24
C21	0.5	0.6	0.7	0.4
C22	0.4	0.5	0.6	0.3
C23	0.3	0.4	0.5	0.2
C24	0.6	0.7	0.6	0.5

Table 13. Comparison matrix at sub-criteria level, for criterion C1

	C11	C12
C11	0.5	0.7
C12	0.3	0.5

Then calculate the relative priority weights of each criterion and each subcriterion. Applying equation 1,2 and 3, the results of the instance are shown in table 10.

Table 10. Priority and Consistency ratios

Criterion	Priority of criterion	Sub-criterion	Priority of subcriterion	RC of subcriterion	RC of criterion
C1	0.37	C11	0.7	0	0.05
		C12	0.3		
C2	0.06	C21	0.3	0.05	
		C22	0.2		
		C23	0.1		
		C24	0.4		
C3	0.15	C31	0.15	0.1	
		C32	0.5		
		C33	0.06		
		C34	0.3		
C4	0.34	C41	0.5	0	
		C42	0.2		
		C43	0.3		
C5	0.07	C51	0.2	0.1	
		C52	0.4		
		C53	0.2		

We can see that the essential factors are factors C1 and C4; while C11 is the most critical factor within C1 and C41 is the most critical factor within C4.

4. CONCLUSION AND PERSPECTIVES

The choice of the location of logistics units determines the performance of the humanitarian supply chain as it defines the strategy to be adopted.

In order to contribute in this approach and improve emergency logistics, we opted to use a multicriteria and multiobjective model by applying FAHP method which is an extension of the AHP method. FAHP propose a hierarchical decomposition of the problem to understand the situation of the study, identify and explain the overall goal.

Its principle is to make the interaction between the different elements of the problem and to make pairwise comparisons of elements in the hierarchy, and finally determine the priorities for action.

The approach of modeling issues related to disaster management logistics company presented in this is based on the use of techniques for the use of AHP methods. These take into account: human element, infrastructure and equipment needs, with a view to achieve a result that allows for the prediction to estimate potential risks and the requirements needed to face them.

The application of this principle to the logistics of disaster management (emergency logistics and humanitarian logistics) can lead to a FAHP oriented model which takes into account: the human element needs, infrastructure and equipment in order to achieve a result that allows the prediction to estimate the potential risks and the necessary conditions to cope.

The work we present here reflects the way we organize our searching. It will be enriched by expert judgments. This latter axis will be a computer module that allows self-regulation (learning techniques) through games and simulations by taking account only of collaborative work through the use of multi-agents. The purpose of our work should result in a computer tool type Toolbox.

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