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The Efficiency of Using the Mixed Model of Fuzzy and Integer Programming in Selecting the Optimal Location for Emergent Health Services in Najaf City

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This paper included building and solving a fuzzy linear programming model, to specify the optimal site for the emergent health service by identifying proposed sites in the city according to two main goals that seem to maximize services and consisting of three sites, directly in providing emergency health services, each according to its location, so we decided That the fuzzy linear programming model suffers from the quality of fog and the trapezoid type in restrictions, and the fuzzy linear model consists of a target function and restrictions, where the goal is to maximize the service for the largest number of auditors, as well as the distances covered to reach service sites, were foggy Trilogy, also Measured. After building the application model of the exclusive routine process to convert it into a regular linear programming model (CLP) (clear linear programming) and the model was able to use the ready program (WIN QSB) and put the results in special tables that include the optimal solution.

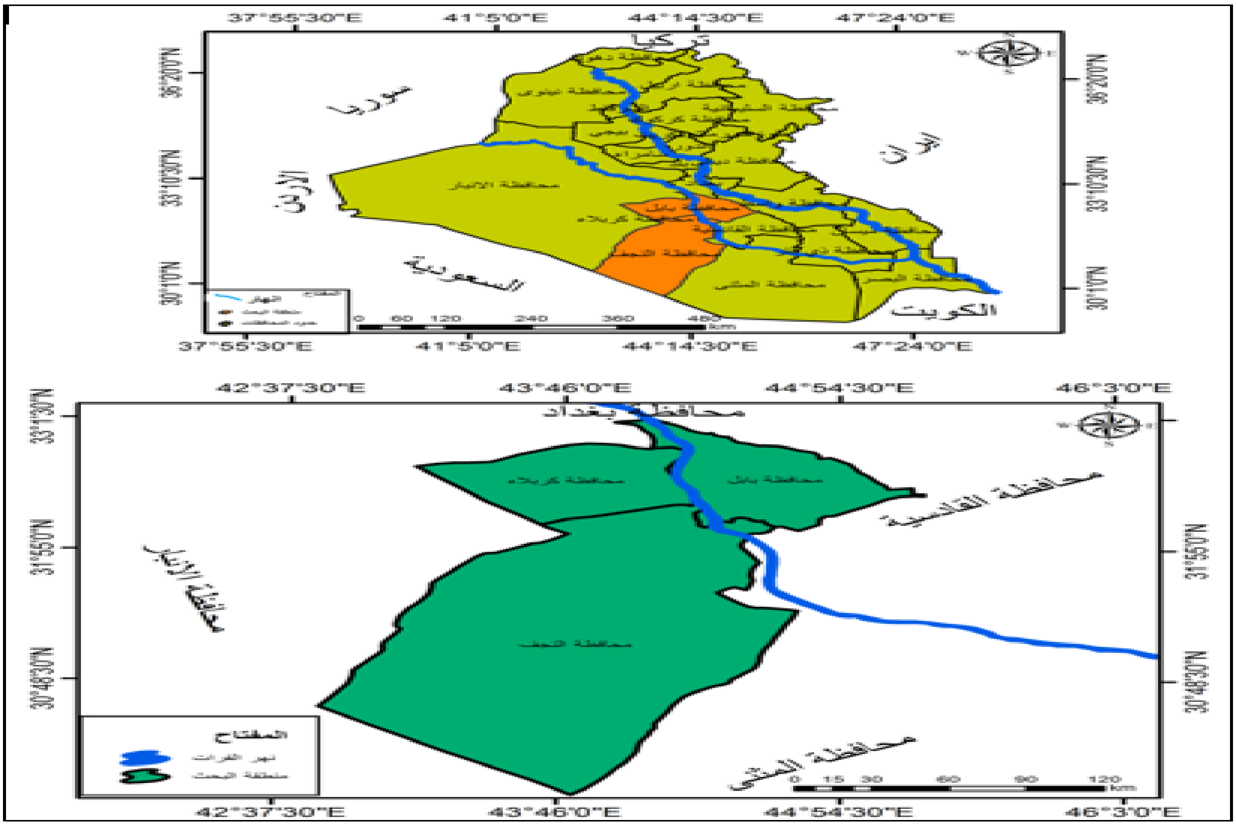
Key words: *Fuzzy linear, clear linear programming, WIN QSB.*

Research Problem and Research Objectives

Health institutions are affected badly from the lack of planning of the spatial distribution to establish emergency and ambulance service centers. It is noticed that there is human traffic on hospitals occasionally, and that timing is an important factor in such cases. The decision makers may also be suffering from the absence of an obvious scientific mechanism of criteria and objectives for selecting sites and their locations in a manner that achieves the highest degree of optimization of health services, and their beneficiaries. So, it became fundamental to develop scientific plans based on field case studies to achieve it.

- Establish a scientific mathematical method that determines the optimal site for establishing emergent health services centers.
- Providing clear scientific mechanisms that allow decision-makers, which provide flexibility in decision-making and planning to improve the quality of services.
- Setting a standard period of time so that the injured person can reach the lowest possible time period for the sites.
- Identify the mixed and probabilistic model of fuzzy and numerical programming in site selection.

Map 1. Case study location



Introduction

The administrative system in light of the technical revolution that we live in today is considered one of the most important information-producing systems. Perhaps operations research represents the most important part of this administrative system that specializes in assisting officials in making decisions through the use of good and appropriate information in choosing the optimal alternative in solving administrative problems (Groeneveld, Tummers, Bronkhorst, Ashikali, & Van Thiel, 2015). Hence, the process of selecting the information required for effective decision-making becomes based on a continuous flow of good and updated information, especially for major projects that continue to provide services. Therefore, operations research aims to apply the scientific method when alternatives are available and choose the optimal alternative for solving a specific problem. A good decision is that decision based on logic which takes into account available data and information and gives the most likely alternatives to help make the appropriate decision (Mohanaselvi & Ganesan, 2012).

Mathematical Programming and Operations Research Methods

One of the most important and prominent methods of operations research / management science OR / MS and the most used in various sectors and institutions is the mathematical formulation and modeling problems. Math Programming, linear and non-linear models, is one of the fruits of this method. During the last two decades, many important developments have taken place on traditional mathematical programming models in general, whether in terms of defining the vocabulary of formulation or the structure of the model or the ways in which it is solved, or even its assumptions and attributes in terms of its static and single goals in its general models (Winston & Goldberg, 2004). These developments were accompanied by recent uses in the field of Decision Support System (DSS) and decision-making under several criteria (MCDM) of different individual types, group, supported by special developments in the field of different computer technologies, programming languages, communication systems, information networks and wide use for the internet (Cadenas & Verdegay, 1997).

- **Mathematical Programming (MP)**

Math Programming is one of the most prominent and key models of operations research and decision-making science commonly used in its various models. Linear Programming (LP) is one of the most important and most famous of these models. Simplex method is the most prominent method of solution which leads us to the optimal solution, known as "the best possible solution at all and there is no better solution than it and it is often alone". This is what traditional mathematical programming models have cared for decades for application (Hillier, 2012). The MP model (*) has a general mathematical form, which can be expressed in Model No. (1) as follows:

$$\begin{aligned} &Max\ or\ \min f = c^{T}x \\ &\quad S.to.\ A\,x = b \end{aligned} \quad \ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

The above equation contains one target function, a decision variable (n) and a constraint (m) in addition to this equation can be linear or non-linear. However, this model has a set of assumptions and conditions that must be available when formulating and building the model and the solution as well. It also includes the described mono-objective function, usually either to maximize or minimize, and cumulative and relative links between the decision variables and these variables are static models giving the functions and formulated constraints of importance, weight and precedence when finding solutions and that the decision variables have the characteristic of continuity (Taha, 2011; Winston & Goldberg, 2004). As for the solution, it assumes relying on the zero solution to reach the desired ideal solution found in one of the corners of the possible solution area, which is usually described as limited and closed. Mathematical programming models have many well-known applications in the fields of planning, control, quality control, production scheduling, distribution, and transport ... etc. All of this could be used in many different sectors, local and international institutions. All could be used in many sectors, local and international institutions. The interest in mathematical programming models generally focuses on what the system should be, or making the system, under study and research, optimum in performance and resource exploitation, whether this system is military, civilian, industrial, educational, agricultural, or even chemical. Thus, mathematical programming occupied wide applications in the sixties and seventies and it is still so now, especially after the developments that were introduced in the decade of the eighties and nineties and which dealt with its initial assumptions in drafting and modeling as well as ways to solve it. This coincided with the development in the scientific programming languages on the one hand, and the technical development of the computer on the other hand. All these developments gave mathematical programming additional advantages to go into finding solutions to problems related to large systems (Hojati, Bector, & Smimou, 2005).

- **Fuzzy programming**

The term of ambiguity is known as a specific form of logic which can be used in some systems and applications specialized in artificial intelligence. The term was proposed in 1965, by the Azerbaijani scientist "Lotfi Zada" (the University of California). He developed this term in order to use it as the best way to date processing; his theory was neglected until 1974 where mystery was used to make some regulations for the steam engine (Vasant, 2003). The applications of steam engine were developed until it reached to create a fuzzy logic chip used in some products such as cameras. Various motives instigated scientists to create and develop a fuzzy logic. By the development of computers and software, the interest to create or program systems that can handle inexact human-style information grew up, but created a specific problem where the computer system can only cope with exact, precise and specific data (Vasant, 2003). This approach resulted in specialized expert systems or what is known as artificial intelligence, and fuzzy logic. It is one of many theories through which such systems can be built by. In classical or traditional groups, a particular element can either belong to the group or never belong to it. Let us consider, for instance, Group (A) and Group (U). If defining the function μ_A that gives each element of group U the degree of its affiliation with group A, by giving it the number 1 in the form of element which belongs to the group i.e. $\mu_A(x) = 1$ if the element of group U, that is element x belongs to group A. If the element x does not belong to A, then the function μ_A gives it the number 0, $\mu_A(x) = 0$. Accordingly, the function μ_A can be expressed as follows:

$$\begin{aligned} \mu_A : U &\rightarrow \{0,1\} \\ X &\rightarrow \mu_A(x) \end{aligned} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The fuzzy logic processing system is incorporated into FIU (fuzzy inferencing unit). FIU includes three basic processing units; the first unit includes the input and output system. The second unit includes provision by users. The third unit handles the given base (Vasant, 2003).

- **Integer programming**

This model is one of the mathematical models derived from the general mathematical model for linear programming. (Hillier, 2012). It includes a target function, restrictions and conditions of non-negative and it differs from regular linear programming in that it must be one of the solution values or more in the integer form and particularly in the table of final solution (optimal). Indicatively, the variable values must be whole numbers free from fractions. Programming with integers is defined as: ((Mathematical method of linear programming provides solutions for the problems of linear programming as numbers or integers)).

Approximation errors in solving numerical problems are among the most important mathematical difficulties in numerical programming. These computational difficulties have led to thinking about using alternative methods to solve the problem. One of these alternative methods is to solve the problem as a regular linear programming. If the optimal solution includes variables with fractional values, fractions are approximated to the nearest integer whole number. For example, if the final solution shows that the number of machines = 9.7, this number is approximated to 10. The problem with this approximation method is to reach solutions that are not possible beyond the restrictions imposed. For example, the available funds are for purchasing (9.7) machines at most, so, the process of rounding to the purchase of 10 machines will make the solution impossible (Hillier, 2012).

- **Numerical programming methods**

Numerical programming can be classified into two groups:

1- Cutting methods: These are methods based on deduction and cutting solution.
2- Search methods: These are methods that depend on the search for a solution.

- **Integer algorithm**

At first, the problem was solved as a linear programming problem without concerning the constraining integers.

A. In case the optimal solution is shown as integers, the condition of integers is achieved in this case (no further step is required).
B. When the optimal solution had been shown, that includes inaccurate numbers, secondary restrictions were created which would be forced to go towards numerical integers. We assume that the following table represents the final optimal schedule for linear programming (Hojati et al., 2005):

Solution variables	X_1	X_i	X_m	W_1	W_j	W_n	**Solution quantity**
Z	O	O	O	$\overline{C}_1$	$\overline{C}_j$	$\overline{C}_n$	B_o
X_1	1	O	O	a_1^1	a_1^j	a_1^n	B_1
X_j	O	1	O	a_j^1	a_i^j	a_i^n	B_I
X_m	O	O	1	a_m^1	a_m^j	a_m^n	B_m

Where:
X_i (I = 1, 2, 3 ………… M) Essential variables.
W_j (j = 1, 2, 3 ………… N) Nonessential variables.

Assuming the base variable X_i of the equation (i) appears with an inaccurate numerical value in the final solution table, and it is:

$$X_i = B_i - \sum_{j=1}^{n} a_i^j \ W_j \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where B_i is an incorrect numerical value and stands for X_i values in the column of solution quantities in the final table. This equation is called (upstream or downstream line).

- **Site Selection**

It is the process of determining the geographical location of specific organization operations, whether in industry or services. Important factors (nearness to clients or suppliers - labor and transportation costs - availability of facilities and services). Selecting the site is one of the important strategic decisions that must be paid sufficient attention and study for service organizations such as health and education, treating the site as part of its sustainable strategy (Dubois, Kerre, Mesiar, & Prade, 2000).

- **The purpose of Choosing the Site**

The goal should be clear from the selection process, whether for private service organizations and aimed at achieving profits such as restaurants, bank branches, maintenance services or public service that aims to maximize the amount of public interest provided to beneficiaries such as emergency services, universities, communications and in all cases the decision The choice depends on the weight of the goal to be achieved (Yuan, 1991).

- **Choosing a Health Services Site**

There must be some things in choosing a site for health services from them

1- A quiet place and away from pollution.
2- It is close to the road hubs, so that it can be reached easily and quickly.
3- The site provides enough space that includes spaces for both the building, parking and horizontal expansion.
4- It is next to the residential area.

- **Method of Fortified Ranks**

It is a mathematical method which converts the fuzzy formula based on human intuition to linear form and if (ã) is indicated as a fuzzy number, then the fortified rank function can be as follows:

$$R(\tilde{a}) = \int_0^1 (0.5)(a_\alpha^L a_\alpha^U)da \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where:

a_α^L, a_α^U maximum and minimum fuzzy span at α

The Practical Section

Health planning and policy-making process in the health system is treated as an essential pillar in defining the future of this system and ways to make optimal use of available resources. It defines the strategic programs and their objectives, as well as sheds lights on health needs and priorities in line with the directions of the health plan and providing best services. Henceforth, we must take into consideration all the potentials of these plans, at the closely reached and far levels, in establishing health service centers (emergency, therapeutic centers) in terms of location in addition to human resources by work continuously to enhance and develop these centers.

- **Data collection**

The data included a lineup of guessed and estimated arrival times in minutes with possibility of 95% from the city centers in Najaf City to the proposed site for establishing emergency health services centers there, as shown in the table below.

To the proposed sites / of city centers	Al-Hakim General Hospital	Al-Sadr Teaching Hospital	Middle Euphrates Hospital
Najaf city	(15,10,7)	(20,12,8)	(35,27,20)
Kufa district	(20,15,10)	(20,12,7)	(40,30,25)
Al Manathiraa district	(35,30,20)	(15,10,5)	(40,35,30)

- **The Mathematical Model**

Assume the variable (X_{ij}) to represent the solution variable and the time lapsed to get from location (i) to location (j).

Where i: represents the start position of the city centers.

J: represents the proposed arrival site.

Since the principal goal is to reach places with the least possible actual time, the target function will be a category of minimize assuming the standard time to reach is (15) minutes.

Accordingly, the mathematical model is written as:

Target function. Min $Z=X_{11}+X_{12}+X_{13}+X_{21}+X_{22}+X_{23}+X_{31}+X_{32}+X_{33}$
Constraints. S.to
$X_{11}+X_{12}+X_{13}>=1$
$X_{21}+X_{22}+X_{23}>=1$
$X_{31}+X_{32}+X_{33}>=1$
All X 0 or 1

- **Converting data to linear formula and finding the solution:**

By using the fortified rank function and applying it to the data in the above table and for all cells, the table becomes as follows:

To the proposed sites / of city centers	Al-Hakim General Hospital	Al-Sadr Teaching Hospital	Middle Euphrates Hospital
Najaf city center	10.6	13.3	27.3
Kufa district	11.6	13	31.6
Al Manathiraa district	28.3	10	35

By replacing the values in the above table with the mathematical model, the formula becomes as follows:

$MinZ=10.6X_{11}+13.3X_{12}+27.X_{13}+11.6X_{21}+13X_{22}+31.6X_{23}+28.3X_{31}+10X_{32}+35X_{33}$
$X_{11}+X_{12}+X_{13}>=1$
$X_{21}+X_{22}+X_{23}>=1$
$X_{31}+X_{32}+X_{33}>=1$
All X 0 or 1

By using the ‘’winqsb’’ program and compensating variables by values and solving the model, it was found that the proposed location that achieves the outstanding time and for all of the cases is the second location which is (Al-Sadr Teaching Hospital). The program results appeared ($1=X_{12}$, X_{22}, X_{32}) and these variables follow the second suggested site.

- **Result Discussions**

Accordingly, the decision to establish the center will be within the proposed site located in Al-Sadr Teaching Hospital, at a standard rate of time (12.1 minutes). It shall be the best of all the proposed locations that achieve the possibility that the patient arrives at any site of the province to the proposed site, which reflects positively on the performance of the center as it can provide a vital service.

City centers	AL-Sadir Hospital
Najaf city center	13.3
Kuffa district	13
Al Manathiraa district	10
Average / 12.1. mint	

Conclusions

- The mixed model of fuzzy and numerical programming is the best in positioning as it provides more flexibility for decision-making in the long run.
- There is a kind of weakness between cities in the means of communication, which delay the arrival of the ambulance to the patient.
- There are great deals of deficiencies within the vital emergency services where they suffer from a lack of capacity for patients.

Recommendations

- The possibility of adopting scientific studies for decision makers to develop the quality of the health services provided.
- The possibility of highlighting weights and priorities for cities and goals according to the proportions of the population and the beneficiaries of services in developing the mixed mathematical model solution.
- Developing means of communication so that emergency vehicles can arrive at the lowest possible time.

- Providing, supporting and supplying emergency units with all experience human resources and providing emergency medicine supplies.

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