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Research paper



Evaluation of Sustainable Site Selection Using Analytical Hierarchy Process for Hospitals: Karbala City as A Case Study

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Abstract

Site selection for a hospital location is one of the pivotal strategy- related decisions taken by the government. The selection of a suitable site for a hospital requires consideration of multiple alternative solutions and assessment factors. The present study aims at determine the optimum site out of three alternative sites to build a new hospital in Kerbala city. The main sustainability factors are; urban factors (including **size, accessibility, restrictions, availability),** environmental factors (including **geomorphology, hydrology, vegetation, climate, other environmental factors)** and economic factors (including **service and utilities, cost**) factors. The Analytical Hierarchy Process (AHP) as a multi criteria decision support system was adopted to find the weights of each factor and reach to select the most suitable site from three alternative sites. The results showed the site number (2) was the most sustainable site to construct the hospital project, where the alternative site records a biggest normal index of 0.419.

Keywords: *Sustainable site selection, Hospital building, Analytical Hierarchy Process***.**

1. Introduction

Countries and institutions place great emphasis on choosing a hospital location. The selection of hospital location is an important problem for the planner and decision-makers [1]. Selecting a perfect location from a range of available alternatives is difficult and complex process. Multi-Criteria Decision-Making (MCDM) is one of the most important branches of decision theory with is used to identify the best solution from all possible solutions available. AHP represents a popular MCDM method that has attracted considerable attention throughout industry, including construction, over the past two decades [2].
Selecting a site for a hospital project is the initial step to start the project. The available sites should be first identified, and then the required data are collected and evaluated. This evaluation can be made by selecting a set of preset standards criteria that should be used in site selection and assigning a certain weight to each one to ensure that the proposed project start on time and will be delivered on budget and to the satisfaction of all future users.

2. Research objective:

The main objective of this research is to prioritize the available sites and to determine the optimum site to build new hospital by using multi-Criteria- Decision- Making model to study site sustainability for hospital construction.

3. Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) is a method developed by Professor Thomas L. Saaty in (1980) as a Multi-Criteria Decision-Making tool, where inputs can be obtained through actual measurements such as price and weight, or through personal opinion such as satisfaction [3] ,[4]. The main vectors are called priority vectors. The first vectors show the relative weights between the factors was compared, where the sum of all factors is (1) [5]. The AHP is an effective tool to deal with the complex decision-making process, where decision making is made by setting priorities and thus making the ideal decision [3], [6].
AHP helps to bias decision-making by examining the objective and subjective aspects of the decision and checking the consistency of decision maker assessments. [1].
AHP creates an efficient framework for determining, analyzing and finding selection criteria. The AHP process involves four phases: construct the decision hierarchy, determine the relative importance of factors and sub-factors, evaluate each alternative and calculate its overall weight in regard to each attribute, and check the consistency of the subjective evaluations [7].

4. General Site Selection and Planning Criteria

The criteria that proposing represents a set of representative generally criteria, covering most whole requirements to which a place should respond to be appropriate for a hospital project of such a caliber [8].

4.1 Urban Factors

4.1.1 Size

Selection of the site is according to the size must be precarious for many reasons. The proposed facilities do not need only a large adequate to accommodate in whatever conformation deemed to be

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the most sensitive to the requirements of the space program, but it has also to accommodate appropriate spaces, parking and driveways can making to several entrances. Moreover, the extra size has to deliver for future extension of the preliminary facility and perhaps for the ultimate construction of other buildings in a campus-like setting [8, 9].

4.1.2 Accessibility

Accessibility deal with the proximity of the site to the center of city and the surrounding province areas as this deal with the public users of the project such as operating staff, public , patients and other [8, 9].

4.1.3 Restrictions

under restrictions for any limitation for the purpose of developing the site by some factors which giving it specific privacy, in reviewing such restrictions, such as ownership right , property planning , current and future developments of the region. The legal aspect must know the impact consideration on future development and documentation [8, 9].

4.1.4 Availability

The site must to be available in a timely basis the work conform according to the progress schedule and construction plans. Availability of the site can affects by such factors, for example the acquisition of the site and the establishment of roads for the purpose of access to the site as well as the time necessary to improve the site before starting the building works [8, 9].

4.2 Environmental Factors [9, 10]

4.2.1 Geomorphology

The soil conditions and the topography of the site is important. Geomorphologies which deal with these factors. For the purpose of moral construction and the absence of structural problems, the soil must be suitable for the construction, and should not require the establishment of the basis of expensive price. In addition, the soil must be not shown any unusual subsurface conditions and also no changes such as groundwater or pollution, which could be require expensive cost [9].

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4.2.2 Hydrology

Hydrology deals with drainage and potential flood problems. An ideal site would have good natural drainage and not be subject to flooding. Potential drainage systems and flooding are an important problem when choosing a site. Choosing the right location is guaranteed to avoid these potential problems for on-site hydrology.

4.2.3 Vegetation

When we design the landscaping of the site, it is possible to take advantage of the available vegetation in the environment of the place. The top of the soil should also be of a quality capable of preserving the type of the plants as well as the possibility of bringing other plants.

4.2.4 Climate

It is assumed that choosing a site in the same geographic nature will have the same climate. However, sometimes there may be a slight change in the micro-climate such as exposure to wind.

4.2.5 Other Environmental Features

The site is of pure air quality and there is no pollution or odors not desirable and also the absence of noise, this is one of the required characteristics of the desired site.

4.3 Economic Factors

4.3.1 Services and Utilities

The availability of services and utilities is very necessary for the site and should be readily available. Natural gas, electricity, water, sewage and telephone are services and utilities need to be available from the services provided for the ideal location. In the absence of such services, the cost will be guaranteed and taken into account.

4.3.2 Cost

The cost is intended for the cost of acquisition for the site and cost of future improvements. For whole and subjectively evaluation purposes of this criteria, the cost of these requirements must be known, whether they are personal or public. The cost of alternative or established methods of access to the site is add to the cost of improvements. Other consideration must take in the site like remove pollution or improve the sewage network or raise the landscape of the site according to the design purposes as well as providing services and public facilities [10].

The figure (1) shows an abstract view of such a hierarchy of the main factors and sub-factors for selection the sustainable site.

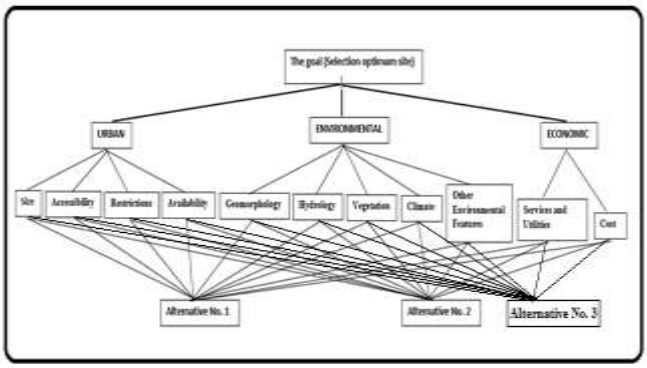


Figure 1: Hierarchy distribution of the main/sub factors for sustainable site selection.

5. Build an Analytic Hierarchy Process (AHP Model)

The figure (2) shows the model of sustainable site selection by super decision software (AHP).

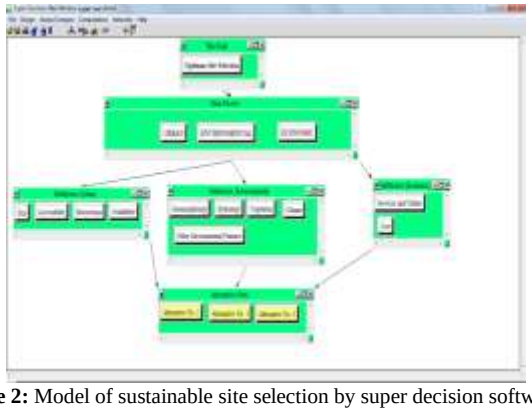


Figure 2: Model of sustainable site selection by super decision software (AHP).

The researchers selected three proposed sites for the application of the study, these sites are as follows:
1-Proposal site number 1

The first alternative site that to be beside or next to the university site and an area of 300 acres and from the side of the area there is a drainage channels as well as the separation between it and the university with drainage channel too. The land of this alternative is level or semi-level but contains random housing for some people. The presence of these houses represents a major obstacle and essential when use this land for the purpose of establishing a hospital site of 50 acres. The presence of these obstacles is main reason for not selecting this site is because of the existence of houses or random person where they cannot be removed at the present time .This alternative can be seen near the university site through the Google Maps as shown in figure 3 [11].
2-Proposal site number 2

For the second alternative proposal ,which located is on the opposite side of the university site and the area of it 90 acres and 500 meters away from the university site and surrounded by one of its side by drainage channels. This land contains alternative water pools and some flatlands fill partial with water. The presence of these water pools was a major obstacle when we wanted to use this land for the purpose of establishing a hospital site of 50 acres. But it is possible to use benefit from different levels of land in design and this is one of the advantages of this site as make different level in the landscape. The site of this alternative can be seen from the university site through Google maps as in figure (3).
3-Proposal site number 3

This site represents the third alternative proposal and its location is in the same side location of the university but at a distance of 1500 meters and the area of 12 acres and surrounded by one of the drainage channels. The land of this trunk is flat and very flat and close to the main street. The small space of this alternative represents a major obstacle and essential to use this land for the purpose of establishing a hospital site with an area of 50 acres. Therefore it's very difficult to design in a small area for hospital. The site of this alternative can be seen from the university site through Google maps as in figure (3).



Figure 3: Google map of the proposal sites for hospital project.

6. Assessment of factors/ sub-factors importance

The program AHP method used to determine the relative weights for main factors and sub-factors. The program will done to identify these important through the pair comparison between factors/ sub-factors, and for access to indicators (indexes) for which the comparison, the researchers embarked on a self-experience within the local engineering professionals to enter the data in the software program.
The table (1) shows the relative weights for the factors and sub-factors.

Table 1: The relative weights for the factors and sub-factors by AHP program.

Factor	Relative Weight	Sub factor	Relative Weight
Urban	**0.4**	**Size**	**0.243**
		Accessibility	**0.102**
		Restrictions	**0.511**
		Availability	**0.144**
Environmental	**0.2**	**Geomorphology**	**0.5**
		Hydrology	**0.228**
		Vegetation	**0.06**
		Climate	**0.077**
		Other Environmental Features	**0.135**
Economic	**0.4**	**Services and Utilities**	**0.667**
		Cost	**0.333**

7. Assessment of Alternatives proposals

After calculating the relative weight of each factors/sub-factors, the best selection of sustainable site determined by comparing the alternatives with the main factors and sub-factors of sustainability using the AHP software program, the table (2) shows the result of priority for each alternative.

Table 2: The final results of priority for each alternative.

Name	Graphic	Ideals	Normals	Raw
Alternative No. 1		0.847464	0.355443	0.118481
Alternative No. 2		1.000000	0.419420	0.139807
Alternative No. 3		0.536782	0.225137	0.075046

8. Conclusions

Major conclusions arrived at by the researchers as a result of this work can be a bridged as follow:
1-It was found that the AHP program can be used efficiently and easily to be evaluation of sustainable site selection.

2-The results shows that the main factors urban and economic have the same weights (40% for each) while the factor environmental get (20%) weight.

3-After a work pair comparison between the sub-factors, the results of the program AHP showed the sub-factor restrictions get the highest weight for the main factor urban, the geomorphology get the highest weight for the main factor environmental, and the services and utilities get the highest weight for the main factor economic.

4-Three alternatives proposals site selection for the hospital project, the results shows the selection of alternative (proposal site) number (2) for the best sustainable site to construct the hospital project in accordance with the main and sub factors.

5-The results above concluded based on the nature and the surrounding circumstances of the proposal sites, as well as the type and function of the proposal project.

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