



Evaluation of Urban Planning Projects Criteria Using Fuzzy AHP Technique

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ABSTRACT

In this research, Fuzzy Analytic Hierarchy Process technique is applied (Fuzzy AHP) which is one of multi-criteria decision making techniques to evaluate the criteria for urban planning projects, the project of developing master plan of Al-Muqdadiah city to 2035 has been chosen as a case study. The researcher prepared a list of criteria in addition to the authorized departments criteria and previous researches in order to choose optimized master plan according to these criteria. This research aims at employing the foundations of (Fuzzy AHP) technique in evaluating urban planning criteria precisely and flexible. The results of the data analysis to the individuals of the sample who are specialists, in this aspect. The land use criteria are more important than the rest of the criteria in these projects, where it received the relative importance with percentile (42.1 %).

Key words: Fuzzy AHP , urban planning , master plan criteria.

تقييم معايير مشاريع التخطيط الحضري باستخدام تقنية Fuzzy AHP

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الخلاصة

في هذا البحث تم تطبيق تقنية التحليل الهرمي الضبابي (Fuzzy AHP) وهي احدى تقنيات اتخاذ القرار المتعدد المعايير لتقييم المعايير الخاصة بمشاريع التخطيط الحضري وقد اختير مشروع تطوير التصميم الاساس لمدينة المقدادية للعام 2035 كحالة دراسية. قام الباحث بأعداد قائمة من المعايير بالإضافة الى معايير الدوائر المختصة والبحوث السابقة لكي يتم اختيار المخطط الاساس الامثل وفق هذه المعايير. يهدف هذا البحث الى توظيف اسس تقنية (Fuzzy AHP) في تقييم معايير التخطيط الحضري بشكل دقيق ومرن. وتشير نتائج تحليل البيانات لأفراد العينة من ذوي الاختصاص في هذا المجال ان معايير استعمالات الارض هي اكثر اهمية من بقية المعايير في هذه المشاريع حيث حصل على اهمية (42.1%).

الكلمات الدالة: عملية التحليل الهرمي الضبابي ، التخطيط الحضري ، معايير المخطط الاساس.



1. INTRODUCTION

Urban planning is the science of large combines of many variables natural, social and engineering work to guide the city's growth and to address their problems, and provides them with their requirements for urban balanced life, and that the most important quest is to minimize the environmental problems caused by human-induced air pollution and haphazard construction and other, **Mahmoud, 2012**. Whereas **Pleho, and Avdagic, 2008** have defined urban planning as to predict possible number of people in space and fulfill people needs for living, working and other activities, with providing needs for infrastructure (water, energy, traffic, etc.). The urban planning is to be balanced with and meets the requirements of the current generation for resources and energies without exposure to, or consuming the share of future generations; the urban planning must be sustainable, **Abdallah, 2015**.

The importance of urban planning is contributing to a sustainable pattern of development. Despite the emergence of urban regeneration and sustainable development as parallel strands of urban policy, there has been little co-ordination between them and an imbalance in action, with greater emphasis given to achieving urban regeneration especially economic regeneration, than to sustainability. It can be argued that all urban regeneration contributes to sustainable development through the recycling of derelict land and buildings, reducing demand for peripheral development and facilitating the development of more compact cities, **Couch, and Dennemann, 2000**.

2- MASTER PLAN CRITERIA

The modern urban planning process includes multi-criteria analysis models. Numerous criteria are typically considered during decision making, **Kurtener, and Badenko, 2000**.

The standards mean provide a certain share of each individual, when standards applied properly it means everyone gets his share. Application planning standards accurately in all fields is to ensure proper implementation of the plans and achieve efficient performance. The criteria can be summarized as follows:

2-1 Economic Criteria

The existence of investments resulting in a number of jobs, it means raising taxes. This in turn will lead to an increase in spending, consumption and improving services is in one hand, while on the other hand, the presence of investment will lead to the presence of suitable work atmosphere. All this shows that the subject of the most important topics in the continuing evolution of urban life to any area it is known that good government is behind the investment, **Phillips, and Chistine, 2003**, as shown in **Table 1**.

2-2 Environmental Criteria

Environmental considerations into urban planning and administration gives noteworthy advantages in each place of urban life, crosswise over issues, for example, health, security and economic development. The initial stage in urban environment quality assessment is to recognize important environmental segments (air, water, chaos, waste substances, green zone) and after



that to set up significant assessment criteria by utilizing these components or segments, **Pleho, and Avdagic, 2008**. As shown in **Table 1**.

2-3 Social Criteria

It highlights the importance of citizen participation. It is not visible aspect in the planning process, but with visible results and that is considered as one of the important aspects for the planner because of a contactless directly to humans, **Silberstein et al., 2000**. **Jaafar ,2007** mentions that social criteria represents the social nature of society and the nature of the composition and unity of the neighborhood and the social values and symbols in that city. This is shown in **Table 1**.

2-4 Land use Criteria

There are multiple local standards to regulate land used within the master plans, including Iraqi cadres proposals that have been approved by the Urban Planning who is responsible for the master plans that addressed the urban organization of residential areas and land use, including global standards allocated to determine land use to be a benchmark in the preparation of the design basis, **Abdul Wahid, 2010**. The decision-making process for urban area used portion has dependably been entangled, **Arefiev et al., 2015**. When objectives are spatial, information are required on the geological areas, spatial formulations of objectives and data on the spatial pattern of criterion values, **Stewart, and Janssen, 2014**.

Haque, and Asami, 2014 clarify that land-use planning might be characterized as the procedure of assigning diverse exercises or uses, (for example, neighborhoods, manufacturing industries, recreational activities) to particular units of range inside a region.

2-5 Technical Criteria

At the beginning of this century, many countries for many reasons, mostly Arab countries adopt a standard 100 square meter for each individual, and on the basis of it , the future needs for urban expansion is accounted, per capita be according to that square meter and it is distributed according to the services that enjoy it. In light of the trend towards vertical construction, the minimum ratio to less than that and perhaps up to less than 50 square meter, thus the decline is limited in the residential share of first place, this is driven by the educational, health and entertainment and cars parking. So, it should reconsider with one per capita in sharing of the land and city thus the ratio is vary according to directions and the policy of every state, some of them directed to the vertical construction and the other toward the horizontal, where the need is increasing for greater expansion in the horizontal space and up per capita to more than 80 square meter, **Al-Diliamy, 2014**.

3. THE MAJOR CONSIDERATIONS INFLUENCING MASTER PLAN PREPARATION

Main concerns which may affect preparing master plan are as follows, **Al-Diliamy, 2014**:

1. Natural condition on topography and prevailing climatic characteristics, because it affect the engineering projects in construction roads, which need a large area of land,

- and the planning and design must be in harmony with the natural, topography and climate realities.
2. The social reality and the nature of the social situation in terms of customs, traditions and culture, as well as it must stay away from imported designs and plans that do not fit in often with social and environmental reality and the specificity of the Arab and Islamic societies.
 3. Achieving urban construction in harmony with the present and future construction, which is lacking in many Arab cities as well as the preservation of cultural heritage.
 4. Achieving homogeneity in the distribution of the urban land uses, which has approved standards at the local and global levels, also take into account the future expansion of the city, in many cities are given, land use planning in specific spot which may not be appropriate at the time, but it turns into an obstacle to the expansion of the city and its evolution in the future **Jaafar, 2007**.
 5. Achieving the requirements of the basic human beings and that means achieving the basic needs of a convenient housing, providing job opportunities for the residents of the city, providing recreational and cultural activities, road network and transportation planning that serves all residents and facilitate their transition, community planning of services (schools, health, etc.), infrastructure (water, electricity, sewage and solid waste) in accordance with approved standards in tourism.
 6. Sewerage network and rain water planning according to rigorous studies to take into account the future expansion, damaging interfaces and the risks that ensue, through the study of treatment plants, take advantage of the solid and water caused by waste, and avoid directing them to the rivers before they are treated properly, as it is resulted environmental and humans risks **Al-Diliamy, 2002**.
 7. Locating suitable solid waste landfill sites within residential neighborhoods and other areas in the city. It must allocate specific places approved in plans and basic designs, also waste collection ought to be outside of the city sites, not leave it in the form of piles of scattered but buried in deep pits, that such those wastes in the landfill areas used in China for the production of electrical power **Al-Diliamy, 2002**.

3. FUZZY AHP TECHNIQUE STEPS

The Fuzzy Analytic Hierarchy process technique (Fuzzy AHP) is to develop AHP technique was developed by **Thomas L. Saaty in 1980**. Hierarchical structure for FAHP, is shown in **Figure.1**

The steps are as follows, **Kahramana et al. , 2004**:

Decision Maker compares the criteria via linguistic terms shown in **Table.2** and **Table1.3**.

Where g_i is the goal set ($i= 1,2,3,4,\dots,n$) and M_{gi}^j ($j=1,2,3,4,\dots,m$), all are Triangular Fuzzy number, as shown in **Figure.2**.

1. The value of fuzzy synthetic extent with respect to the i th object is defined as:



$$S_i = \sum_{j=1}^m M_{g_i}^j \otimes [\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j]^{-1} \tag{1}$$

To obtain $\sum_{j=1}^m M_{g_i}^j$, form Eq.(3):

$$\sum_{j=1}^m M_{g_i}^j = (\sum_{j=1}^m l_j, \sum_{j=1}^m m_j, \sum_{j=1}^m u_j) \tag{2}$$

and to obtain $[\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j]^{-1}$, where $M_{g_i}^j$ ($j=1, 2, 3, 4, \dots, m$) such that:

$$\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j = (\sum_{i=1}^n l_i, \sum_{i=1}^n m_i, \sum_{i=1}^n u_i) \tag{3}$$

and then compute the inverse of the vector in Eq. (3) such that

$$[\sum_{i=1}^n \sum_{j=1}^m M_{g_i}^j]^{-1} = \left(\frac{1}{\sum_{i=1}^n u_i}, \frac{1}{\sum_{i=1}^n m_i}, \frac{1}{\sum_{i=1}^n l_i} \right) \tag{4}$$

2. $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ are two TFNS, the degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ and can be equivalently expressed as follows:

$$V(M_2 \geq M_1) = \begin{cases} 1, & \text{if } m_2 \geq m_1. \\ 0, & \text{if } l_1 \geq u_1 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & \text{otherwise} \end{cases} \tag{5}$$

where d is the ordinate of the highest intersection point D between M_1 and M_2 . To compare M_1 and M_2 ; both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$ are needed.

3. The degree possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i ($i=1, 2, 3, 4, \dots, K$) can be defined by:

$$V(M \geq M_1, M_2, M_3, M_4, \dots, M_K) = V[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and } \dots \text{ and } (M \geq M_K)] = \min V(M \geq M_i), i= 1, 2, 3, 4, \dots, k. \tag{6}$$



Assume that $d'(C_i) = \min V(S_i \geq S_k)$ for $k= 1,2,3,4,\dots,n$. $k \neq i$, then the weight vector is given by :

$$W' = [d'(C_1), d'(C_2), d'(C_3), d'(C_4), \dots, d'(C_n)]^T \quad (7)$$

4. Via normalization, the normalized weight vectors is given :

$$W = [d(C_1), d(C_2), d(C_3), d(C_4), \dots, d(C_n)] \quad (8)$$

4. RESULTS

Through the received data from questionnaire related to the assessment of criteria by experts and relying on applying (FAHP) technique, forming of pair-wise comparison matrix of criteria which is shown in Table 3 is done. Also, it is based on comparison values that are illustrated in Table 2, after making the required calculations to extract the relative importance of each criterion of the main criteria used as shown in Table 5. It is shown that the relative importance of land used criteria has a larger relative importance (42.1%) compared with the other criteria which obtained the following relative importance: economic (18.3%), environmental (17.2%), social (14.1%) and technical (8.3%). Through these criteria, master plans can be evaluated and chosen the optimal ones, because land uses criteria is considered as the most important part of the project. When there is any defect it will influence the rest of the project criteria where land use criteria mainly affect the possibility of implementing the master plan, the land use has touched an impact of land use the progress of works special master plan projects of cities, their impact large and clear and on the possibility of completing the project according to the required specifications and requirements.

5. CONCLUSIONS

That formation of the city depends on the criteria used in the selection of the optimized master plan because the importance of criteria and indicators selection enhances the linking of optimized master plan by economic efficiency, production efficiencies, structural balance of land use and distribution of infrastructure services are reducing the operational costs and increase economic benefits by encouraging investment and environmental benefits such as an example the issue of transport within cities to gain access to public services (health, education,..., etc.), it must promote effectively and good transport networks environmentally and easy to use and the least effective and sound banging. Reduce costs for random housing that weigh on the shoulders of the state within high costs for its exceeding the infrastructure to other areas services, therefore, the choice of the optimized master plan in accordance with the required criteria in this study, the optimum distribution of services and housing projects are achieved, leading to reduce the problems of cities.



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Table 1. The main criteria and sub-criteria.

Main Criteria	Sub-Criteria		Description
1) Economic	Financial		1- Directing investment in the city. 2-Consider construction cost for new infrastructures and updates to existing system. 3-Highlight major projects that significantly contribute to the capital cost. 4-Financial support availability of financial resources and support from local lending institutions are important to remove economic Constraints since most projects tend to expensive.
	Infrastructure		1- Availability of infrastructure for water, sewage, gas and electricity have an impact on overall investment required for the future projects. 2- Distance between transportation networks are important factors for industrial and commercial land uses (Effect on transportation costs of materials and transportation costs for products). 3- Highlight on level of ability to balance infrastructure costs with level of urban growth.
	Site conditions	Physical conditions	Physical conditions like geological risks, it will impact on the cost and feasibility of redevelopment.
	Site conditions	Environmental conditions	The type, severity and extent of the contamination must be evaluated to assess costs and time for remediation.



	Land value	Land prices in the city.
	Costs	1- Capital costs 2- Operation and maintenance costs 3-Other contingencies
	Economic revenue	
	Ability to interact with another sector economy	1- Projects which interact with more than one sector of the economy and creating greater opportunities for diverse sectors of the economy. 2- Evaluating how much the project would contribute to creating employment and an increase in income for the community productive sector.
2)Environmental	Noise pollution	The source of most noise worldwide is mainly caused by machines and transportation systems, motor vehicles, aircraft, and trains. . Poor urban planning may give rise to noise pollution because construction industrial buildings in residential regions can result in noise pollution in the residential regions.
	Water pollution	The contamination of water (Pollutants such as Materials' chemical, physical, radioactive ...etc.).
	Wastewater network	The Stations for wastewater must constitute in a way a correct and not harmful to the environment.
	Soil pollution	Contaminated soil is one of the most prominent environmental problems and the most complex. Soil contaminants may be a waste (industrial, radioactive... etc.).
		Impact of carbon dioxide emissions



	Local air quality	
	Aquatic impacts	Potential effects on water resources and not to overtaking on water natural that affect the environment.
	Environmental legislation	Global and local laws are restrictions.
	Protect the natural environment	Such as green space and Forests... etc.
3) Social	Services	1- Housing, transportation, schools, Medical, police, Firefighter...etc. 2- Projects that offer flexibility of servicing the city growth. 3- Utilization of existing infrastructure. 4- Ability to executing requirement and service level.
	Quality and cost of living	
	Job opportunities	Redevelopment can create new jobs and increase incomes.
	Population	Population size, Household size, Population density and Distribution of population.
	Aesthetic	Improving aesthetic by the redevelopment can provide significant benefit to areas with pleasant surroundings, redevelopment results giving better quality and appearance.
4) Land uses		1- Land uses Planning policies. 2- Coordination with existing and land uses. 3- Potential land requirements.
	Dealing with the regional dimension	
	Dealing with the concept of investment	
	Dealing with the problem of land occupancy	
	Dealing with public places	



	Types of land use	Residential use Commercial use Administrative use Industrial use Recreational use Cultural use Sports use Health use Educational use Agricultural use	Depending on the regional planning organization for the year 1977 , criteria of public housing for the year 1982 and The urban planning and design criteria / The Ministry of Housing and Construction and Municipalities and Public Works in 2008
5)Technical	The size of planned and existing infrastructure		Describe the difficulty of construction in limited areas and with possibility limited access.
	Servicing integrations structural		Potential impact related to opportunity for integrated planning, construction, design, with other servicing such as road improvement and bridge construction, establishing rail and airport... etc.
	Construction density		1- Structural density: is the relationship of the total area of origin to the site area. 2- Coverage (%), the ratio of building to the site area.
	Construction patterns		Construction vertical and horizontal construction
	Height for building		

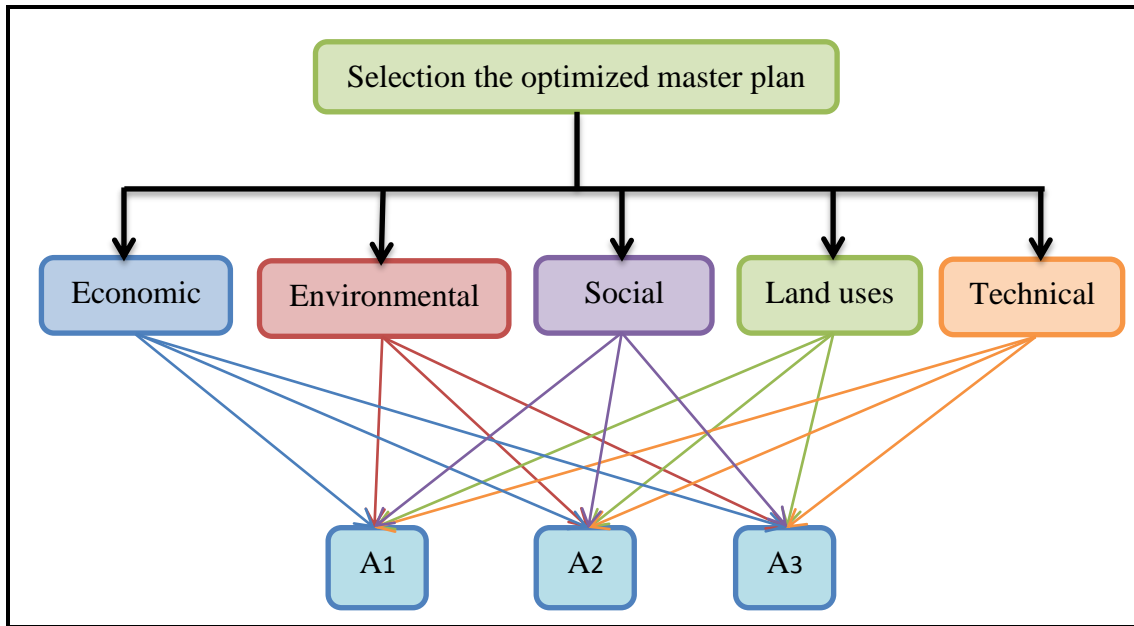


Figure 1. The hierarchical structure for FAHP.

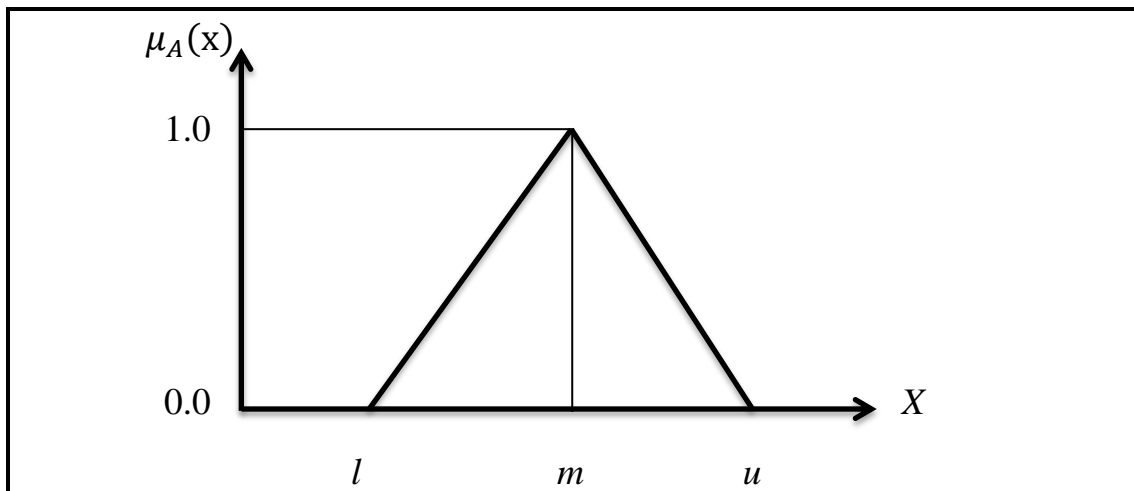


Figure 2. A triangular fuzzy number.

Table 2. Linguistic terms and the corresponding triangular fuzzy numbers, Ayhan , 2013.



Linguistic variable	Fuzzy number	Explanation
Equally important	(1 , 1 , 1)	The criterion i is equally important when compared to criterion j.
Weakly important	(2 , 3 , 4)	The criterion i is Weakly important when compared to criterion j.
Fairly important	(4 , 5 , 6)	The criterion i is Fairly important when compared to criterion j.
Strongly important	(6 , 7 , 8)	The criterion i is Strongly important when compared to criterion j.
Absolutely important	(9 , 9 , 9)	The criterion i is Absolutely important when compared to criterion j.
Intermediate values between the two adjacent judgments	(1, 2 ,3) (3, 4 ,5) (5 , 6 ,7) (7, 8 ,9)	When compromise is needed.
Reciprocals number	The reciprocals, such as 1/3, 1/5, 1/7, 1/9, etc.,	

Table 3. Aggregate fuzzy numbers decision making matrix.

Criteria	C1	C2	C3	C4	C5
C1	(1,1,1)	(2.01, 2.77, 3.54)	(1.69,2.09 , 2.53)	(0.34, 0.46, 0.64)	(1.02,1.44 ,1.91)
C2	(0.29, 0.36, 0.49)	(1,1,1)	(5 ,5.97 ,6.95 ,6.95)	(0.26 ,0.34 , 0.47)	(0.19, 0.26, 0.32)
C3	(0.39 , 0.48, 0.59)	(0.14, 0.17, 0.2)	(1,1,1)	(0.26, 0.34, 0.47)	(4.31 ,5.34 , 6.44)
C4	(1.59,2.17 , 2.94)	(2.13 , 2.94, 3.84)	(2.13,2.94 , 3.85)	(1,1,1)	(3.02,3.93 ,4.89)
C5	(0.52 ,0.69 ,0.98)	(3.13, 3.84, 5.26)	(0.16,0.19 , 0.23)	(0.21, 0.25 , 0.33)	(1,1,1)

**Table 4.** The relative importance of main criteria

Main criteria	Relative importance	%
Economic criteria	0.183	18.3
Environmental criteria	0.172	17.2
Social criteria	0.141	14.2
Land use criteria	0.421	42.1
Technical criteria	0.083	8.3