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Pixel-based Site Selection of Local Park Using Integrated Method of GIS, FTOPSIS and AHP

Lotfi S*[1], Manouchehri A[2], Ahar H[3] and Ramazani M[2]

*[1]Corresponding author, Associate Professor, University of Mazandaran, Iran, Email-s.lotfi@umz.ac.ir
[2]University of Tehran, Iran
[3]Payam Noor University, Tehran, Tran

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Abstract

Urban green space and its distribution are very important in cities as today are looked as one of the indicators of sustainable development. Convenient access to parks has been one of the main concerns of new urbanism. Evidences show that the existing urban parks are not well sited in many cities of developing world which in practice many residents stay out of park accessibility. Tabriz is one of the major metropolises of the North West part of Iran and the political center of East Azerbaijan province. The city is divided into 8 municipal zones which the zone of 4 is selected to apply the model for site selection of new parks. This research aims to integrate Fuzzy-Analytic Hierarchy Process Technique for Ordered Preference by Similarity to Ideal Solution (TOPSIS) and Analytic Hierarchy Process (AHP) to find the best areas for new parks of the city in a hierarchical order from neighborhood units to zone as whole. For this purpose several criteria such as accessibilities to main and sub arterial roads, centrality, distance from the existed parks and alike were used. The final analysis was done using integrated AHP and Fuzzy TOPSIS in GIS by defining the appropriate components and weighting on the base of green space standards. The results show that 3.11 percent zone 4 is highly compatible for park establishment and 1.2 percent shows incompatible condition. Also the research indicated that the model had 56.25 percent of high performance to select the suitable lands for construction of neighborhood-scale parks with first priority and 87.5 percent above the second priority.

Keywords: neighborhood unit, fuzzy logic, Tabriz

Introduction

Provision of community public space such as parks became difficult due to high density of urban population and the accelerated change of urban lands to physical structures[1]. There is a common acceptance about the importance of urban parks with green space landscape as ecological value which provides a place for recreation and amusement[2,3]. Many researchers believe an efficient park which has high compatibility with its surrounding land uses could increase the quality of life and economic health of cities[4-7]. Although concept of per capita for public green spaces, public parks and resorts is the most important factor in making a city livable, pleasant and engaging citizens[6]. But the inappropriate location of them has led to inefficiency as many residents were reluctant to use which such condition increase the probability of vandalism would change to deserted area[8]. Access to park should be in a fifteen minutes as evidences show in many European cities like Glasgow, Madrid, Paris, Milan[9]. The most important issue considering to park site selection is the idea of Jacobs who defended the social function of this public space where life is present and is the place of culture, trade and residential land use, she believed that number of such valuable districts could be find in a city to establish parks and other public spaces[10]. Also she proposed a question of why people are present in location where there is not parks and vice versa. The present paper attempted to study first; modeling and selecting the best location for urban parks by using integrated AHP and FUZZY TOPSIS and second; selecting appropriate local parks in the zone of 4 in Tabriz city.

Patterns of urban green spaces

Urban green space is defined as segments with different sizes and functions in the physical division of cities which ranges from Neighborhood Park with limited function to Regional Park with diverse functions[11]. This model is practiced in many developed countries with longer history of urbanism. Urban parks are recreational spaces which provide service to all parts of a city. The main function of these parks is creating comfort, revitalization and pleasure. So, calm and safety should be present without seizure factors[12].

1. **Neighborhood parks (small):** It consists of spaces which is located in a neighborhood scale and has an area less than half hectare. On the base of standard a nine year old child should be able to walk to park from farthest place without crossing arterial roads.
2. **Urban parks in neighborhood scale (medium):** The park that has located in a neighborhoods units and has an area of a hectare (twice the area of neighborhood park), it should be accessible for a nine year old child from farthest place (twice the area of neighborhood park) and cross the road via local street network.
3. **Urban Park in district scale:** A park which is located in a residential area and has an area of two to four times of urban park (4 hectare). It should be accessible on food within half an hour by residents.
4. **Urban Park in zone scale:** It has located in a residential area and has an area of at least twice the size of district parks (8 hectare). It also should be accessible from farthest place by vehicle about a quarter hour or more[13].

Table 1: Urban park classification and their functions[13,14]

Park	Area (hectare)	Accessibility (m)
Neighborhood (small)	-0.5	200
Neighborhood (medium)	1-2	400-600
District	2-4	800-1200
Zone	4-10	1500-2500
Urban-regional	+10	25-30 minutes driving

Main criteria for park location

As Jane Jacobs pointed out parks should locate in areas where people live and there is activities of daily life and culture. Some parts of cities have such focal points which are valuable and appropriate for creating parks or other public uses. A public park should take advantage of its natural setting and supported by its adjacent diversity to stay as public arena because the risk of becoming a private area will increase[15]. The main criteria for site selection of an urban park are as follow:

-Centrality: public green spaces land uses should place in the center of physical divisions ranging from neighborhoods, districts and region's centers.

-The hierarchy structure: The urban green spaces should locate in a hierarchical order for more accordance with the spatial structure of cities.

-Accessibility: Each city park should have access to the road network to provide the possibility of to attract more people and the possibility of social control and increase park security. Meanwhile, using the attractive visual environment for the pedestrians.

-Adequacy of other characteristics such as appropriate size of the plots, water and soil quality.

Experimental

Tabriz city is one of the biggest metropoles of the north west of Iran with an area of 131km and average height of 1340m in plain of Tabriz region[16]. The city is one of the most populous areas with an industrial-oriented economy which has observed many migrants from the province of East Azerbaijan. Such conditions led to the rapid physical expansion of the city due to its horizontal growth towards the agricultural lands and orchards. The zone of 4 with an area of 3100 hectare selected as study area with a population of 296015 in 1996 and 328124 in 2009[17]. The zone placed 21.4 percent of the total population of Tabriz. The geographical position of Tabriz in the middle of industrial zone of the western province (West Azerbaijan) with brick kilns, and business -traffic center of the region created a polluted weather which getting worse. The park per capita is 1.14 which is vey low compared to the global and national standards (Table 2).

As Table 2 indicates the per capita of parks is 1.14 and the other types of green space is 0.47 m which together sum 1.16m for the zone 4. Such situation is not comparable with the national and internal standards.

Selecting the park

The present research concentrates on the neighborhood parks as place of rest, comfort and amusement for the residents. Neighborhood parks with their biological diversity and natural setting are the first contact place which influences the mental and physical health of people[19-23]. Evidences show that population growth has increased the demand for urban land to be constructed for residential and other uses which undermine the importance of parks especially in developing countries[24]. Today accessibility to the neighborhood parks is a key issue as for example in UK the distance from residential units to the park should not exceed from 300m[25-27]. So neighborhood park is the most vital infrastructure of a city and in modern planning there is a threshold limit by square meter for each person which meet the real needs of residents in the hierarchical order in the level of neighborhoods or other urban divisions. The following Table 3 & 4 and Fig.1 & 2 indicates the distribution of parks in Tabriz.

Table 2: Per capita of urban green space in Tabriz[18]

Region	Population	Area (ha)	Area of parks (m)	Density (ha)	Per capita (m)
4	328124	2721.49	375225	60.6	1.14
The city	1528164	25213	3356886	128.6	2.19

Table 3: Distribution of parks in Tabriz

Park	Number	Total area	Area %	Number %	Standard by Number %
Neighborhood (small)	45	126789	3.9	3	45
Neighborhood (medium)	52	518377	15.47	4.54	35
District	25	736518	21.7	19	12
zone	6	332021	9.9	39.46	0.5
City	4	1640000	49	34	0.2
Total	132	3356886	100	100	-

Table 4: Distribution of parks in zone 4 (Tabriz)

Park	Number	Total area(m^2)	Area(%)	Number(%)
Neighborhood (small)	20	53317	14	48
Neighborhood (medium)	16	144816	39	38
District	5	127092	34	12
Zone	1	50000	13	2

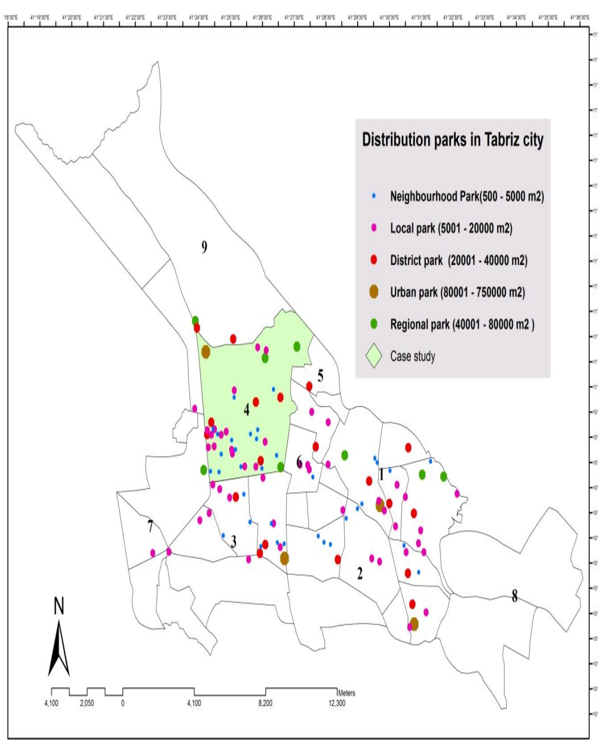

Fig.1. Hierarchical distribution of parks in Tabriz

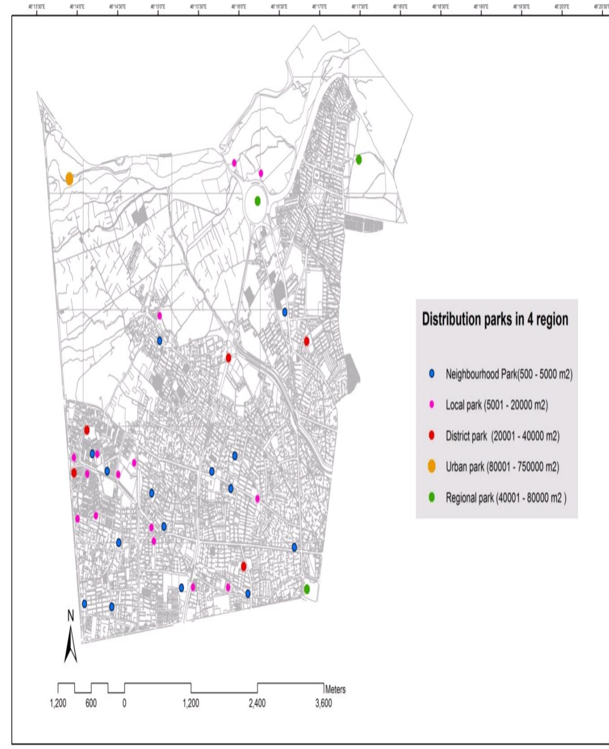

Fig.2. Park distribution in zone 4 (Tabriz)

There were 42 parks in the zone 4 of the city which the majority of them had a neighborhood function. The total area of these parks was 475225.4m^2 and the largest one had an area of 5 hectare. All of the zone's parks were classified based on criteria of accessibility and their area. As **Fig. 2** illustrates most of the parks are located in the south west part of the zone so a considerable part of the zone stay out of park reach.

The statistical data was obtained from the Organization of green space of Tabriz Municipality which were verified spatially on 1:2000 map and then the location of all parks were studied with respect to the theoretical viewpoints. To determine the appropriate sites of new parks an integrated model of AHP and Fuzzy-TOPSIS was employed in GIS. Fig. 3 shows the research flow chart.

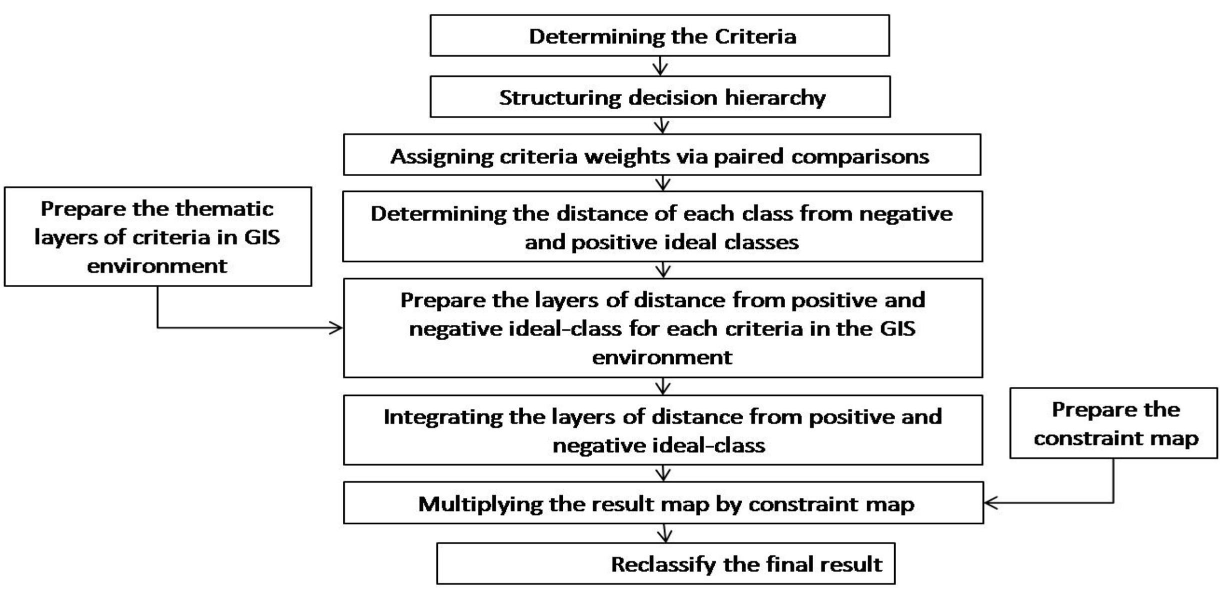

Fig.3. The flow chart of the research

Results

Selection of the Spatial criteria for urban green space

Four matrices of compatibility, suitability, capacity and dependency were used to selecting sites for neighborhood parks. These four matrices mainly evaluate qualitative characters. Evaluation of urban different land uses are primarily in quantitative and qualitative form to reassure that they place in a reasonable areas and there are appropriate relevance among them[14]. Table 2 indicates the suitability of plots based on priority for construction of parks in the vicinity of the neighborhood center in the initial site selection.

The effective compatible layers to neighborhood parks

The size of plot as one of the desirability parameters was considered after the final analysis for park site selection. Seven layers (Table 5) were defined for measuring the level of compatibility. Two factors of existence of park and density was considered to assess capacity after final analysis in GIS. Also accessibility to communication network was studied based on factor of dependency. Finally a layer was defined in GIS as the external factors (constrains) where the possibility of creating park was minimum or zero.

Land priority Layer

To find an appropriate location for park is an important issue which usually it is acquiesce from land use changes from agricultural lands or orchards. The evidences show that acquisition of lands for parks are limited in many Iranian cities due to their high price and the financial limitation of local municipal has led to the failures of many urban projects. This study prioritizes plots which are under possession of government and have the potential to be changed into parks. The barren and abandoned lands have the primary priority for park since the present research aimed to propose new location and increase the green space per capita for establishing new parks. From this perspective, all lands are classified in five classes which have higher potential and relevance for park site selection. These are prioritized from first as compatible to the last incompatible. In this context, all of service uses such as educational, commercial and medical which provide basic services are prioritized in last (Table 6 and Fig. 4).

Compatibility with adjacent uses:

All of the neighboring uses have to coordinate and complete each others to provide better function, which ranges from compatible to incompatible uses. In this regard, initially the compatible uses with neighborhood parks like educational or cultural were identified and also the uses like military and transport were determined as incompatible. Then, by defining buffer in five classes the level of compatibility for park creation were determined on the base of proximity or distance from nuisance uses (Table 6 and Fig. 4).

Centrality and the neighborhood park

One of the most important factors in determining the optimal location for the construction of neighborhood-scale parks is the equitable access of all people. So the park should locate somewhere in the neighborhood that allows easy access for residents. For this purpose one of the layers that were defined in this study is centrality of park in neighborhood. On the base of given criteria the center neighborhoods were specified, then by defining buffer from the center of each neighborhood, the level of compatibility or incompatibility were determined. Finally the map of neighborhood centers was produced for analyzing (Table 6 and Fig. 4).

Access to communication networks

One of the main criteria for park design is easy access to sub arterial roads. Each park has to connect to surrounding commuting networks to attract more visitors and the possibility of social control with security increase. Yet the beautiful landscape would provide a visual advantage for the passers[15]. Also a study showed that when cites are compared accessibility of urban parks is one of important aspects by the international standers[28]. It needs be reminded that neighborhood parks should never enter or connect directly to main arterials. In the hierarchy of urban green space and parks determining the appropriate type of access is most important criteria for site selection, it provide optimal access of different park scale from small to large urban parks. There are permitted accessibilities for different types of urban parks as

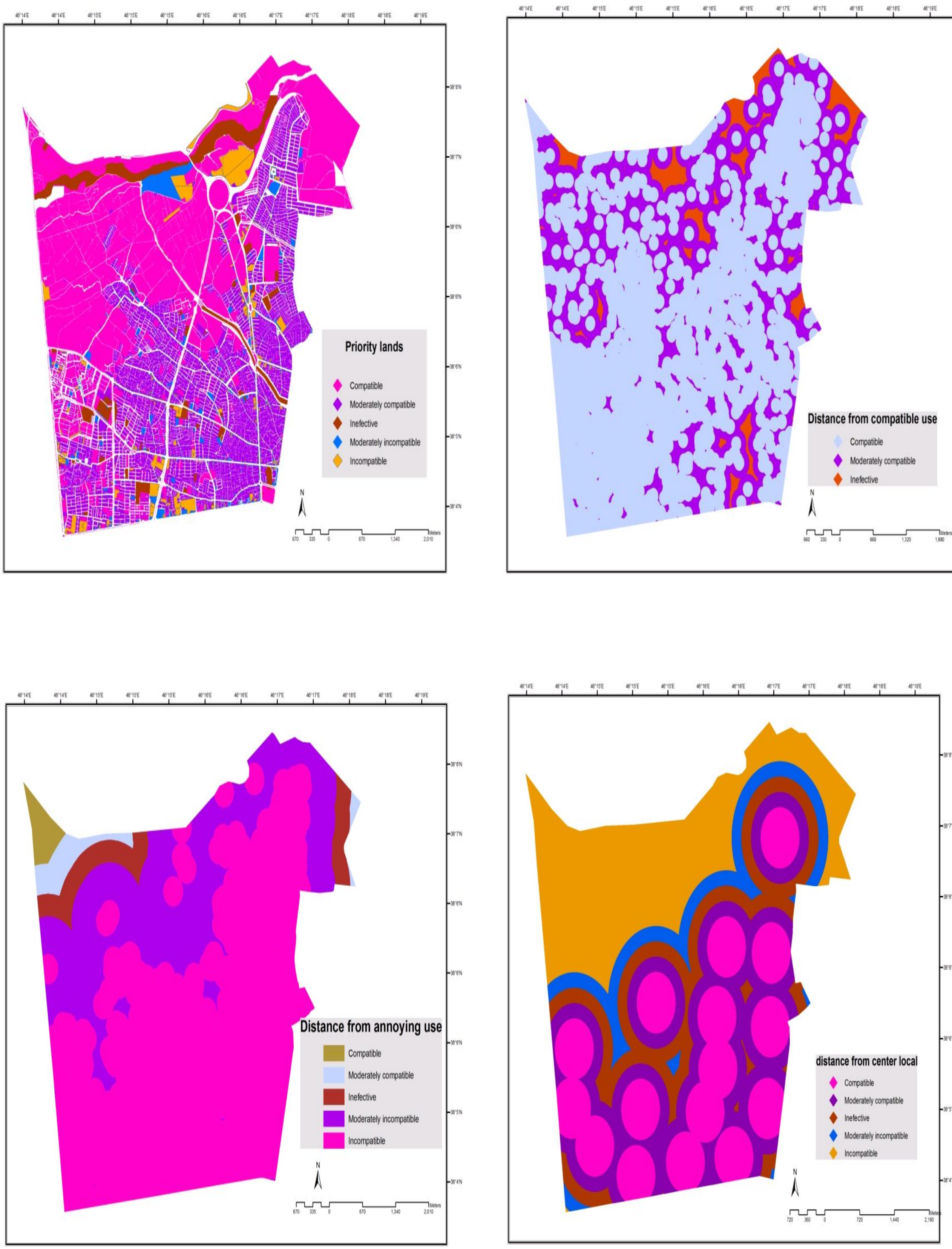

Fig.4. Different layers of the model in zone 4 Tabriz

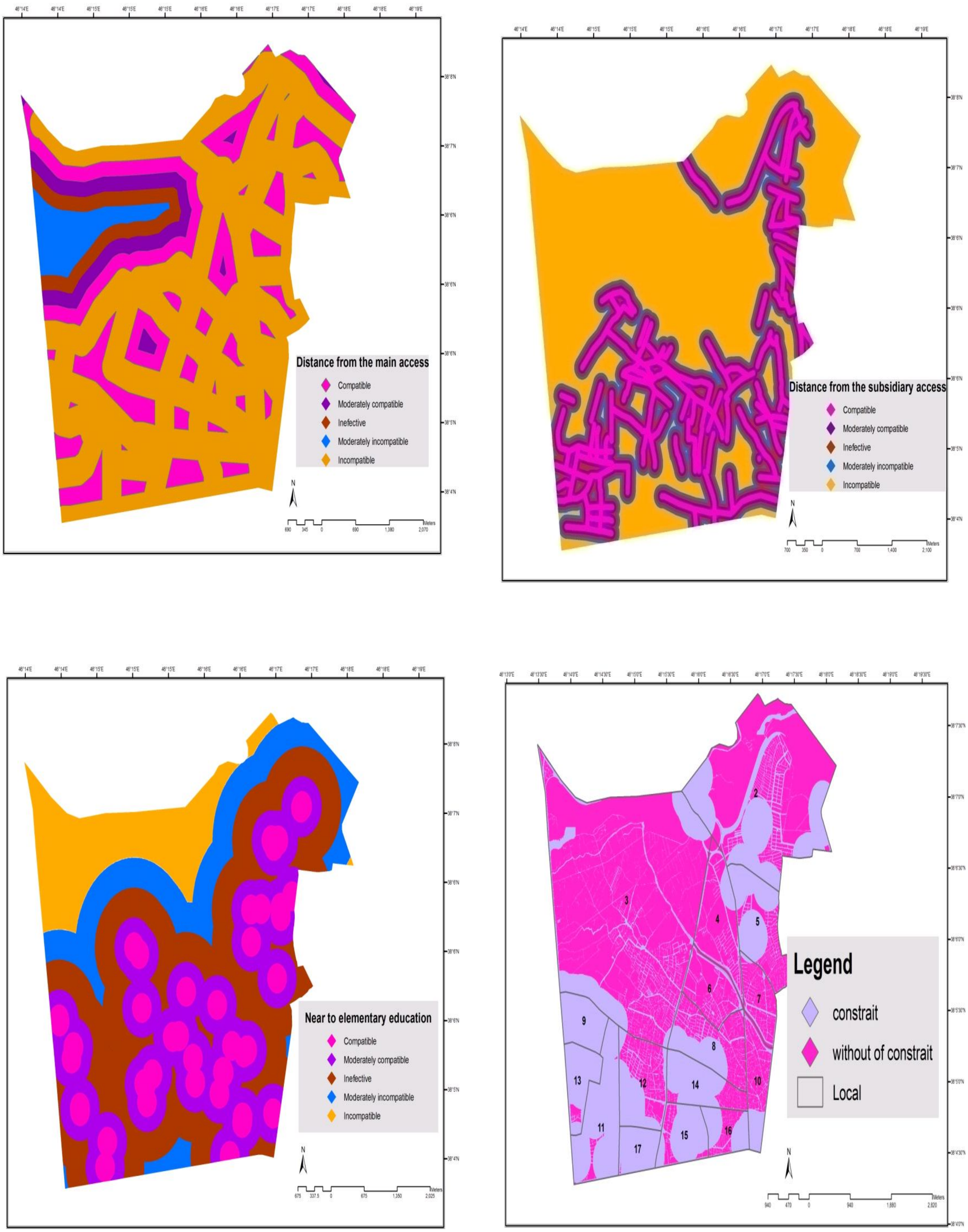

Fig.4. continued

Table 5. Main criteria in park site selection in neighborhood

S.No.	Layer (Model criteria)	Matrix	Relative weight
1.	Land priority (land use)	Suitability	35
2.	Proximity to primary schools	Compatibility	18
3.	Proximity to population center of neighborhood	Suitability	15
4.	Access to sub-arterial roads	Dependency	8
5.	Distance from arterial roads	Compatibility	8
6.	Distance from nuisance uses	Compatibility	8
7.	Proximity cultural centers	Compatibility	8
	None model criteria	**Matrix**	**Relative weight**
8.	Plot size	Suitability	0
9.	Existence of neighborhood park	Capacity	0
10.	Density	Capacity	0

Table 6: Model's layers and their priority

Compatibility	Land priority (land use)	Distance of compatible use	Distance of Annoying use	Distance of center Neighborhood	Distance of the main access	Distance of the Subsidiary access	Proximity to primary schools
Compatible	Abandoned, barren	0-100	0-200	0-300	800-1800	0-40	0-200
Moderately compatible	Agriculture and orchards	100-200	200-500	300-600	600-800	40-80	200-400
Neutral	Nuisance uses	200-400	500-800	600-900	400-600	80-120	400-800
Moderately incompatible	Residential	400-800	800-1200	900-1200	200-400	120-160	800-1200
Incompatible	Others	>800	>1200	>1200	0-200<1800	>160	>1200

follow on the base of the subdivision regulations. The centers of neighborhoods and districts connect to local and sub arterial roads. Centers of zones have access to the regional transport networks and the city has connection to main roads[15]. Accordingly, proximity to minor and local roads is the best choice for neighborhood - scale Park (Table 6 and Fig. 4).

Proximity to primary schools

Other criteria which seemed necessary was proximity to the primary educational centers, this closeness would increase the possible use of neighborhood park by pupils. The present study defined a layer for this criterion in the zone 4 of the city which classified from compatible to incompatible uses and the relevance map was produced for analysis (Table 6 and Fig. 4).

Distance from nuisance (hazardous) uses

A neighborhood park should place away from nuisance uses such as heavy industries, military bases, noise pollution and alike to provide a comfortable environment without a possible danger. So, it was a criterion in this research and ranged from compatibility to incompatibility(Table 6 and Fig. 4).

Constrain layer:

Since establishing a new park needs plots of lands which could convert to parks, the research defined the constraint layers as they cannot change to parks like military bases, religious and communication networks. The useful functional radius of neighborhood park scale has special place in the hierarchical order of urban green uses. Each type of green space by covering a specified area could meet the needs of citizens in the form of physical divisions. So the areas with neighborhood scale park were excluded from the final process of selection. Size and dimension of the plot was the last factor in choosing the location of park, therefore the new plot should have one hectare area.

Other factors outside the model

The real conditions of ground were compared by the informational layers and weight overlaying to select the optimal locations for new neighborhood scale parks. The density layer only showing the priority of park establishment, this criterion never used for the research as there was not population information in block level.

Analytical hierarchical process (AHP)

AHP is a quantitative method for ranking decision alternatives and selection the one given multiple criteria. AHP is a process for developing a numerical score to rank each decision alternative based on how well each alternative meets the decision maker's criteria[29-31]. AHP was developed by[32] in the 1980s and has been extensively studied and refined since then. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative[32]. It is based on three principles: a) estabilishing a structure and hierarchical order b) establish preferences through comparisons with related output (as a final rate of substitution) c) establishing the logical consistency of measurement[16]. AHP is used widely to solve problems of complex decisions[33-36]. As Table 7 shows weight of each criteria obtain from pairwise comparison after determining the criteria and decision hierarchy.

Fuzzy TOPSIS

TOPSIS (technique for order performance by similarity to ideal solution) was first developed by[37]. The primary concept of TOPSIS approach is that the most preferred alternative should not only have the shortest distance from the positive ideal solution (PIS), but also have the farthest distance from the negative ideal solution (NIS)[37,38]. General speaking, the advantages for TOPSIS include (a)

Table 7: Pairwise comparison of criteria and matrix of preferences

Factors	Land use	Distance from compatible use	Distance from nuisance use	Distance from center Neighborhood	Distance from arterial roads	Distance from sub arterial roads	Proximity to primary schools	Weight
Land use	1	5	3	3	5	3	5	0.33
Distance from compatible use		1	3	1/5	5	1	5	0.123
Distance from nuisance use			1	1/7	1/2	1/3	1/3	0.034
Distance from center Neighborhood				1	7	4	5	0.302
Distance from the arterial roads					1	1/5	1/5	0.036
Distance from the sub arterial roads						1	3	0.115
Proximity to primary schools							1	0.06

simple, rationally comprehensible concept, (b) good computational efficiency, (c) ability to measure the relative performance for each alternative in a simple mathematical form[39].

Fuzzy TOPSIS model, proposed in[40] allows the values and weights of the attributes are defined using fuzzy numbers instead of precise numbers. However, this flexibility is applied only in the definition of values. The process of analysis and recommendation of the best alternative is based on conventional optimization techniques[41]. Other characteristic of the method presented, is that the linguistic value considered in the process will be only the fuzzy set of greater pertinence for the input numeric value. In this research we have used Fuzzy triangular due to the fact that numerical triangular can be applied easily and directly by the decision makers, moreover it has been proved that using triangular fuzzy modeling is an effective way of formulating the information which are subjective and inexact[42-45]. In practical applications, often the triangular forms of membership function are used as representative of fuzzy numbers[46]. This study has used triangular fuzzy numbers in Fuzzy TOPSIS. Fig.5 indicates triangular in (a_1, a_2, a_3).

The membership of each numbers is corresponding with equation (1).

$$triangle\ (a_1, a_2, a_3) = \begin{cases} 0 & x < a_1 \\ \dfrac{x - a_1}{a_2 - a_1} & a_1 \le x \le a_2 \\ \dfrac{a_3 - x}{a_3 - a_2} & a_2 \le x \le a_3 \\ 0 & x > a_3 \end{cases}$$

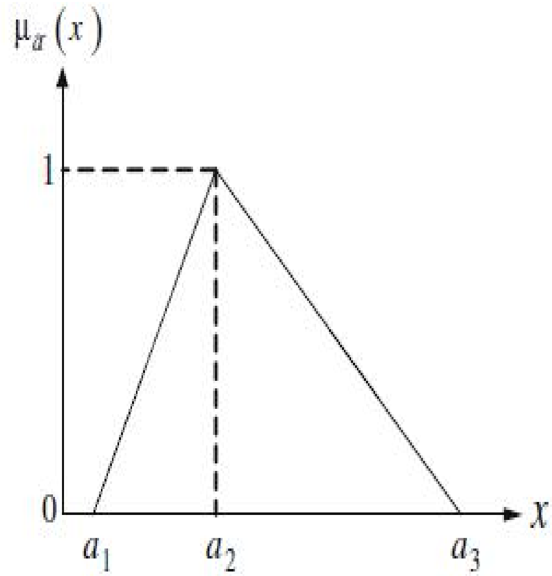

Fig.5. Triangular Fuzzy numbers *a*

If $\tilde{a}(a_1, a_2, a_3)$ and $\tilde{b}(b_1, b_2, b_3)$ are two triangular numbers, their mathematical relations are shown in Eq. 2 - 6.

The linguistic values changes to triangular numbers (Fig. 6).

In this stage after changing linguistic values to triangular numbers, these numbers were multiplied to weight of site selection criteria of neighborhood scale park from experts by AHP method, then the fuzzy weight was obtained (Table 8).

The distance of each criterion from the positive and negative ideal was obtained using TOPSIS after consisting decision matrix with fuzzy numerical components, and then the informational

$$\tilde{a}\ (+)\ \tilde{b} = (a_1, a_2, a_3)\ (+)\ (b_1, b_2, b_3) = [(a_1 + b_1), (a_2 + b_2), (a_3 + b_3)] \quad \text{Eq.2}$$

$$\tilde{a}\ (-)\ \tilde{b} = (a_1, a_2, a_3)\ (-)\ (b_1, b_2, b_3) = [(a_1 - b_1), (a_2 - b_2), (a_3 - b_3)] \quad \text{Eq. 3}$$

$$\tilde{a}\ (\times)\ \tilde{b} = (a_1, a_2, a_3)\ (\times)\ (b_1, b_2, b_3) = [(a_1 \times b_1), (a_2 \times b_2), (a_3 \times b_3)] \quad \text{Eq. 4}$$

$$\tilde{a}\ (\div)\ \tilde{b} = (a_1, a_2, a_3)\ (\div)\ (b_1, b_2, b_3) = [(a_1 \div b_1), (a_2 \div b_2), (a_3 \div b_3)] \quad \text{Eq. 5}$$

$$k\tilde{a} = (ka_1, ka_2, ka_3) \quad \text{Eq. 6}$$

layers of distance from positive and negative ideal were defined for each criterion as follow. If $W = (w_1, ..., w_m)$ is weight vector of criteria with the condition of $\sum_{j=1}^{m} W_j = 1$ which obtained from pairwise comparison and T (equation 7)as decision matrix of park location in neighborhood unit and $\tilde{a}_{ij}$ is triangular number which shows the preference of i class of j criteria to the rest of classes based on expert opinion.

$$T = \begin{bmatrix} \tilde{a}_{11} & \tilde{a}_{12} & \tilde{a}_{1j} \\ \tilde{a}_{21} & \tilde{a}_{22} & \tilde{a}_{2j} \\ \tilde{a}_{i1} & \tilde{a}_{i2} & \tilde{a}_{ij} \end{bmatrix}$$

By multiplying W_j in each components of column j of T based on Equation 8, the matrix V with components of $\tilde{V}_{ij} = (W_j (\times) \tilde{a}_{ij})$ will form. Since the used fuzzy numbers have same scale there is no need for normalization. Equations of 9 and 10 show the alternative vector of the positive and negative ideal of matrix V.

$$W = (W_1, W_2, ..., W_n)$$
$$V_{mn} = W_n R_{mn}$$
$$A^+ = (\tilde{V}_1^{max}, \tilde{V}_2^{max}, ..., \tilde{V}_j^{max})$$
$$A^- = (\tilde{V}_1^{min}, \tilde{V}_2^{min}, ..., \tilde{V}_j^{min})$$

By subtracting each components of matrix V from $\tilde{V}_j^{max}$ (Eq.11) and dividing the sum components of each fuzzy number to 3 (Eq.12) will form. The distance matrix of positive ideal $(D^+ = (d_{ij}^+))$ (Eq. 13) obtains from equations 11 and 12 in which d_{ij}^+ is the distance of i of criteria j from positive ideal of j.

$$\tilde{d}_{ij}^+ = \tilde{V}_j^{max} (-) \tilde{V}_{ij} \quad \text{Eq. 11}$$

$$d_{ij}^+ = \frac{d_{ij1}^+ + d_{ij2}^+ + d_{ij3}^+}{3} \quad \text{Eq. 12}$$

$$D^+ = \begin{bmatrix} d_{11}^+ = \frac{d^+_{11_1} + d^+_{11_2} + d^+_{11_3}}{3} & d_{12}^+ ... d_{1j}^+ \\ d_{21}^+ & d_{22}^+ ... d_{2j}^+ \\ d_{i1}^+ & d_{i2}^+ ... d_{ij}^+ \end{bmatrix} \quad \text{Eq. 13}$$

Distance matrix from negative ideal D^- (Eq. 16) obtains from equations 14 and 15 which d_{ij}^- is distance of i class of criteria j from negative ideal of j.

$$\tilde{d}_{ij}^- = \tilde{V}_{ij} (-) \tilde{V}_j^{min} \quad \text{Eq. 14}$$

$$d_{ij}^- = \frac{d_{ij1}^- + d_{ij2}^- + d_{ij3}^-}{3} \quad \text{Eq. 15}$$

$$D^- = \begin{bmatrix} d_{11}^- = \frac{d^-_{11_1} + d^-_{11_2} + d^-_{11_3}}{3} & d_{12}^- ... d_{1j}^- \\ d_{21}^- & d_{22}^- ... d_{2j}^- \\ d_{i1}^- & d_{i2}^- ... d_{ij}^- \end{bmatrix} \quad \text{Eq. 16}$$

Difference of criteria with positive and negative ideal is shown in Table 9.

Relative proximity of each alternative to the Ideal Solution (RCi) obtains from equation 17. The final layer would attained by integrating the positive and negative ideal layers in GIS and multiplying it with constrain layer, and final prioritization of alternatives would be done on the base of it. In this equation m is the number of criteria.

$$RC_i = \frac{\sum_{j=1}^{m} d_{ij}^-}{\sum_{j=1}^{m} d_{ij}^- + \sum_{j=1}^{m} d_{ij}^+} \quad \text{Eq. 17}$$

According to the results from land pixel-based calculation and with respect to equation 17 in GIS environment shows that 3.11 percent area

Table 8: The numerical fuzzy factors and their weights

				Priority lands				
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight (AHP)	a1	a2	a3
Compatible	(0.75 1 1)	0.75	1	1	0.33	0.2475	0.33	0.33
Moderately compatible	(0.5 0.75 1)	0.5	0.75	1	0.33	0.165	0.2475	0.33
Neutral	(0.25 0.5 0.75)	0.25	0.5	0.75	0.33	0.0825	0.165	0.2475
Moderately incompatible	(0 0.25 0.5)	0	0.25	0.5	0.33	0	0.0825	0.165
Incompatible	(0 0 0.25)	0	0	0.25	0.33	0	0	0.0825
				Distance from compatible use				
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight	a1	a2	a3
Incompatible	(0.75 1 1)	0.75	1	1	0.123	0.092	0.123	0.123
Moderately compatible	(0.5 0.75 1)	0.5	0.75	1	0.123	0.0615	0.0922	0.123
Neutral	(0.25 0.5 0.75)	0.25	0.5	0.75	0.123	0.0307	0.0615	0.09225
Moderately incompatible	(0 0.25 0.5)	0	0.25	0.5	0.123	0	0.0307	0.0615
Incompatible	(0 0 0.25)	0	0	0.25	0.123	0	0	0.03075
				Distance from nuisance use				
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight	a1	a2	a3
Compatible	(0.75 1 1)	0.75	1	1	0.034	0.0255	0.034	0.034
Moderately compatible	(0.5 0.75 1)	0.5	0.75	1	0.034	0.017	0.0255	0.034
Neutral	(0.25 0.5 0.75)	0.25	0.5	0.75	0.034	0.0085	0.017	0.0255
Moderately incompatible	(0 0.25 0.5)	0	0.25	0.5	0.034	0	0.0085	0.017
Incompatible	(0 0 0.25)	0	0	0.25	0.034	0	0	0.0085
				Distance from neighborhood center				
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight	a1	a2	a3
Compatible	(0.75 1 1)	0.75	1	1	0.302	0.2265	0.302	0.302
Moderately compatible	(0.5 0.75 1)	0.5	0.75	1	0.302	0.151	0.2265	0.302
Neutral	(0.25 0.5 0.75)	0.25	0.5	0.75	0.302	0.0755	0.151	0.2265
Moderately incompatible	(0 0.25 0.5)	0	0.25	0.5	0.302	0	0.0755	0.151
Incompatible	(0 0 0.25)	0	0	0.25	0.302	0	0	0.0755
				Distance from arterial roads				
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight	a1	a2	a3
Compatible	(0.75 1 1)	0.75	1	1	0.036	0.027	0.036	0.036
Moderately compatible	(0.5 0.75 1)	0.5	0.75	1	0.036	0.018	0.027	0.036
Neutral	(0.25 0.5 0.75)	0.25	0.5	0.75	0.036	0.009	0.018	0.027
Moderately incompatible	(0 0.25 0.5)	0	0.25	0.5	0.036	0	0.009	0.018
Incompatible	(0 0 0.25)	0	0	0.25	0.036	0	0	0.009
				Distance from sub arterial roads				
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight	a1	a2	a3
Compatible	(0.75 1 1)	0.75	1	1	0.115	0.0862	0.115	0.115
Moderately compatible	(0.5 0.75 1)	0.5	0.75	1	0.115	0.0575	0.08625	0.115
Neutral	(0.25 0.5 0.75)	0.25	0.5	0.75	0.115	0.0287	0.0575	0.08625
Moderately incompatible	(0 0.25 0.5)	0	0.25	0.5	0.115	0	0.02875	0.0575
Incompatible	(0 0 0.25)	0	0	0.25	0.115	0	0	0.02875
				Proximity to primary schools				
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight	a1	a2	a3
Compatible	(0.75 1 1)	0.75	1	1	0.06	0.045	0.06	0.06
Moderately compatible	(0.5 0.75 1)	0.5	0.75	1	0.06	0.03	0.045	0.06
Neutral	(0.25 0.5 0.75)	0.25	0.5	0.75	0.06	0.015	0.03	0.045
Moderately incompatible	(0 0.25 0.5)	0	0.25	0.5	0.06	0	0.015	0.03
Incompatible	(0 0 0.25)	0	0	0.25	0.06	0	0	0.015

Table 9. Difference of criteria with positive ideal and negative ideal

							Land use							
Classes		V*			d̃_ij^+			v-			d̃_ij^ –		D*	D-
1	a1	a2	a3	a1	a2	a3	a1	a2	a3	a1	a2	a3	0.00	0.28
2	0.25	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.08	0.25	0.33	0.25	0.06	0.22
3	0.25	0.33	0.33	0.08	0.08	0.00	0.00	0.00	0.08	0.17	0.25	0.25	0.14	0.14
4	0.25	0.33	0.33	0.17	0.17	0.08	0.00	0.00	0.08	0.08	0.17	0.17	0.22	0.06
5	0.25	0.33	0.33	0.25	0.25	0.17	0.00	0.00	0.08	0.00	0.08	0.08	0.28	0.00
							Distance from compatible use							
Classes		V*			d̃_ij^+			v-			d̃_ij^ –		D*	D-
1	0.09	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.03	0.09	0.12	0.09	0.00	0.10
2	0.09	0.12	0.12	0.03	0.03	0.00	0.00	0.00	0.03	0.06	0.09	0.09	0.02	0.08
3	0.09	0.12	0.12	0.06	0.06	0.03	0.00	0.00	0.03	0.03	0.06	0.06	0.05	0.05
4	0.09	0.12	0.12	0.09	0.09	0.06	0.00	0.00	0.03	0.00	0.03	0.03	0.08	0.02
5	0.09	0.12	0.12	0.09	0.12	0.09	0.00	0.00	0.03	0.00	0.00	0.00	0.10	0.00
							Distance from nuisance use							
Classes		V*			d̃_ij^+			v-			d̃_ij^ –		D*	D-
1	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.03	0.03	0.00	0.03
2	0.03	0.03	0.03	0.01	0.01	0.00	0.00	0.00	0.01	0.02	0.03	0.03	0.01	0.02
3	0.03	0.03	0.03	0.02	0.02	0.01	0.00	0.00	0.01	0.01	0.02	0.02	0.01	0.01
4	0.03	0.03	0.03	0.03	0.03	0.02	0.00	0.00	0.01	0.00	0.01	0.01	0.02	0.01
5	0.03	0.03	0.03	0.03	0.03	0.03	0.00	0.00	0.01	0.00	0.00	0.00	0.03	0.00
							Distance from neighborhood center							
Classes		V*			d̃_ij^+			v-			d̃_ij^ –		D*	D-
1	0.23	0.30	0.30	0.00	0.00	0.00	0.00	0.00	0.08	0.23	0.30	0.23	0.00	0.25
2	0.23	0.30	0.30	0.08	0.08	0.00	0.00	0.00	0.08	0.15	0.23	0.23	0.05	0.20
3	0.23	0.30	0.30	0.15	0.15	0.08	0.00	0.00	0.08	0.08	0.15	0.15	0.13	0.13
4	0.23	0.30	0.30	0.23	0.23	0.15	0.00	0.00	0.08	0.00	0.08	0.08	0.20	0.05
5	0.23	0.30	0.30	0.23	0.30	0.23	0.00	0.00	0.08	0.00	0.00	0.00	0.25	0.00
							Distance from arterial roads							
Classes		V*			d̃_ij^+			v-			d̃_ij^ –		D*	D-
1	0.03	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.04	0.03	0.00	0.03
2	0.03	0.04	0.04	0.01	0.01	0.00	0.00	0.00	0.01	0.02	0.03	0.03	0.01	0.02
3	0.03	0.04	0.04	0.02	0.02	0.01	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02
4	0.03	0.04	0.04	0.03	0.03	0.02	0.00	0.00	0.01	0.00	0.01	0.01	0.02	0.01
5	0.03	0.04	0.04	0.03	0.04	0.03	0.00	0.00	0.01	0.00	0.00	0.00	0.03	0.00
							Distance from sub arterial roads							
Classes		V*			d̃_ij^+			v-			d̃_ij^ –		D*	D-
1	0.09	0.12	0.12	0.00	0.00	0.00	0.00	0.00	0.03	0.09	0.12	0.09	0.00	0.10
2	0.09	0.12	0.12	0.03	0.03	0.00	0.00	0.00	0.03	0.06	0.09	0.09	0.02	0.08
3	0.09	0.12	0.12	0.06	0.06	0.03	0.00	0.00	0.03	0.03	0.06	0.06	0.05	0.05
4	0.09	0.12	0.12	0.09	0.09	0.06	0.00	0.00	0.03	0.00	0.03	0.03	0.08	0.02
5	0.09	0.12	0.12	0.09	0.12	0.09	0.00	0.00	0.03	0.00	0.00	0.00	0.10	0.00
							Proximity to primary schools							
Classes		V*			d̃_ij^+			v-			d̃_ij^ –		D*	D-
1	0.05	0.06	0.06	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.06	0.05	0.00	0.05
2	0.05	0.06	0.06	0.02	0.02	0.00	0.00	0.00	0.02	0.03	0.05	0.05	0.01	0.04
3	0.05	0.06	0.06	0.03	0.03	0.02	0.00	0.00	0.02	0.02	0.03	0.03	0.03	0.03
4	0.05	0.06	0.06	0.05	0.05	0.03	0.00	0.00	0.02	0.00	0.02	0.02	0.04	0.01
5	0.05	0.06	0.06	0.05	0.06	0.05	0.00	0.00	0.02	0.00	0.00	0.00	0.05	0.00

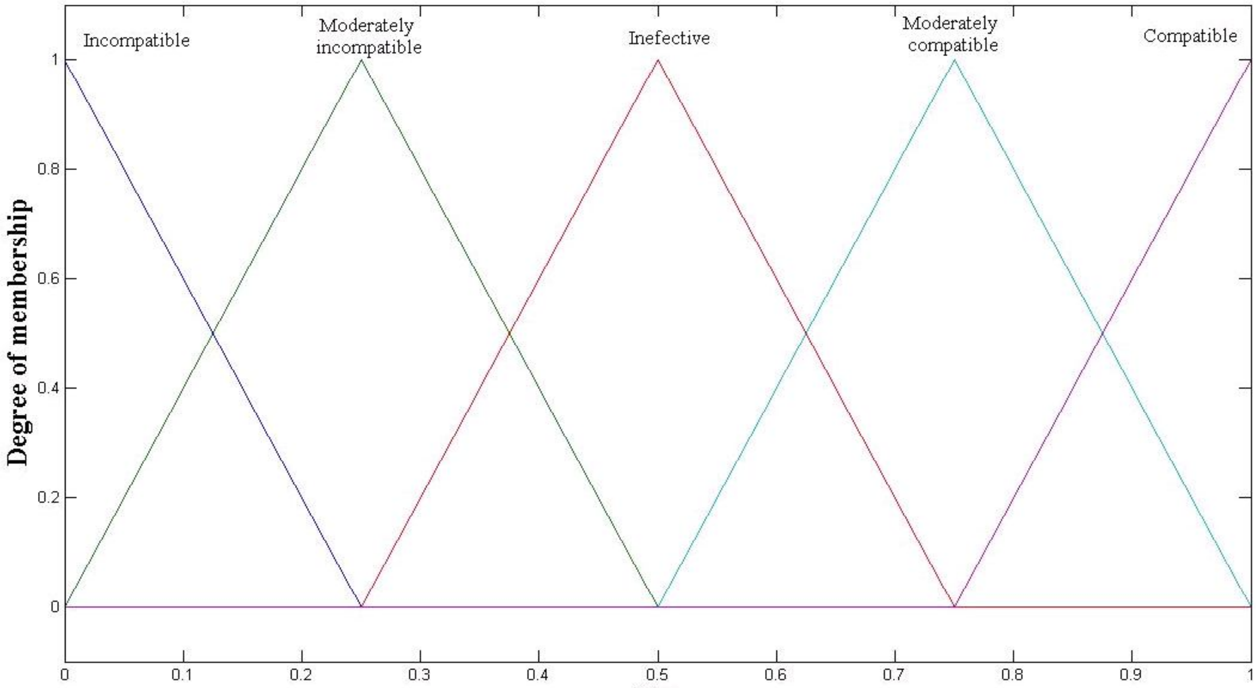

Fig. 6. Linguistic values for criteria rating.

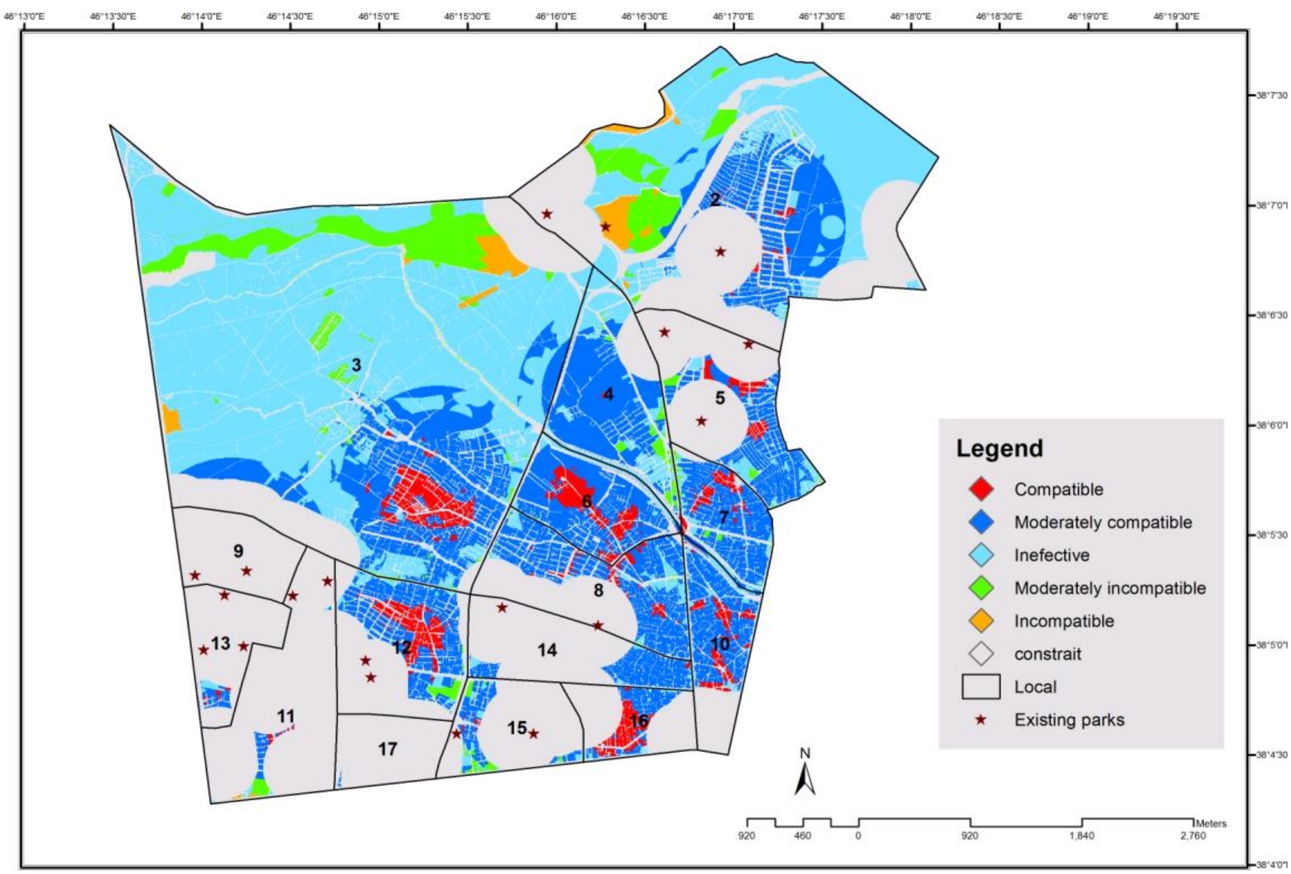

Fig 7: Final map for neighborhood parks in zone 4 of Tabriz

Table 10. The level of Compatibility of uses in zone 4 for Neighborhood Park

Compatibility	No. of pixels	m^2	%
Limited	280508	7012700	30.87
Incompatible	10925	273125	1.2
Moderately incompatible	45576	1139400	5.02
Neutral	324119	8102975	35.67
Moderately Compatible	219396	5484900	24.14
Compatible	28224	705600	3.11

in zone 4 of Tabriz is compatible for establishing neighborhood scale park, and 24.14 percent is moderately compatible, 35.67 neutral, 1.2 percent incompatible, 5.02 percent moderately incompatible and finally 30.87 percent of the area has limitations for creating neighborhood park creation (Table 10).

Discussion and Conclusion

The research showed that the present parks have not been spatially distributed well on the principles of urban planning regarding to the field studies and the distribution of existed park in zone 4; which are concentrated in the south west of the region. For example while there is suitable conditions for neighborhood park in the north east of the neighborhood 12, but the two existing parks are located in the south west, or there is a park in neighborhood of 2 in west which is far from the residential area and located in the vicinity of a highway and the entrance squire of the city. The final map (Figure 7) from the model showed that it has a high efficiency to site selection of urban uses.As in the present case study, despite the appropriate uses (priority map) for establishing parks in the north and west part of the zone, the model placed these parts as incompatible areas for neighborhood parks due to its proximity to main arterial roads and remoteness to residential areas. The final map indicated that more than 50 percent of the zone has a high priority (compatible) for creating neighborhood parks. Also the model revealed that the neighborhoods of 15, 11, 13, 9, 14 and 17 have limitations for park establishment. In the case of neighborhood 4 which is without plot of high priority, the park will be located in residential lands with low quality in adjacent of mosque with second priority.

The total numbers of neighborhood parks are recommended in final map by considering all effective factors which 4 parks will locate on barren lands. 3 of them will create on the existing green space like orchards and the rest have residential uses. In the end regarding to the density and the present population of the zone it is recommended that establishing neighborhood parks prioritize in neighborhoods of 3, 6, 7, 10, 12 and 16 respectively.

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