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Urban park site selection at local scale by using geographic information system (GIS) and analytic hierarchy process (AHP)

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ABSTRACT

The Significance of urban green space situates it among the five important urban uses. Site selection of public green spaces necessitates social requirements. This study aimed at optimal site selection of urban parks at local level in the City of Shahrood. The only option on the table to do so included integrating GIS with Overlaying. First, criteria were incorporated into GIS and new information layers were created, which in turn were employed in conjunction with the existing data to gain information such as conflicting uses (military, industrial) as well as wasteland situation. In so doing, statistics and maps with a scale of 1:10,000 were utilized. After overlaying, four sites were considered as alternatives. In the next step, the determinant criteria were weighted in AHP, and pair wise comparison was conducted in order to discover the optimal alternative to build a local scale park. The results reveal that Site 2 in Area 4 is the best alternative.

Keywords: Site Selection, Local Park, GIS, AHP, Shahrood

INTRODUCTION

Urban green spaces are so important that they are counted among the five significant urban uses [1]. They also play role in tackling urban pollution and providing leisure activities and sport [2]. Parks support the complementary and bilateral relationship between “the nature and culture” or “parks and the city” [3]. To highlight their importance, it is enough to say that nowadays the urban climate, affected by congestion and centralization of activities, is transformed to such an extent that it is taken into account independently when it comes to regional urban studies [4]. The most significant effect of urban green space involves its environmental functions which signify the city as the human society’s environment and combat adverse impacts of industrial development and inappropriate use of technology – hence enhancing urban ecological capability [5]. The urban green space holds so much importance that it finds its position among the development indicators [2]. Some of functions it offers are as follows:

- Absorption of CO₂ and other toxic gasses and oxygen production;
- Moderating urban climate [4];
- Reducing noise pollution [5];

- Boosting individual spirits [4];
- Preventing water and wind erosion [5];
- Mitigating risks of floods; and
- Aesthetics and preventing urbanization and suburbanization [6].

The key point in the site selection of public green spaces is social requirements for building a park [7]. Today, urban green spaces and parks are known as Vitamin G [8]. A local scale park is a space within a neighborhood with an area twice as big as a neighborhood scale park – about 1ha. The farthest a child should travel to the former comes to twice as much as that of the latter. On the way to a local park, a child may cross an avenue with fast, but not very fast, traffic.

Its users include children and the elderly. Its amenities are tailored to this population as well. Improper site selection of urban green spaces may ultimately lead to low use rate, limitations upon favorable architectural designing, limitations on plant arrangement, urban visual chaos, problems regarding irrigation and soil modification, lack of descent social interactions, management and maintenance issues, mental and social security depletion, etc [2, 4 & 8].

MATERIALS AND METHODS

Study area

Shahrood County, with an area of 51,419Km, stands the largest county in Semnan Province, located north of the Kavir and south of the Alborz Ranges. It holds, according the 2011's Census, 238,830 individuals. Since, according to the Master Plan of Shahrood, Area 4 situated within District 1 is the most populated, it needs specific attention in terms of site selection of local parks. It is the furthest western area in District 1, bordering Area 3 westward, Area 2 and Area 6 eastward [9].

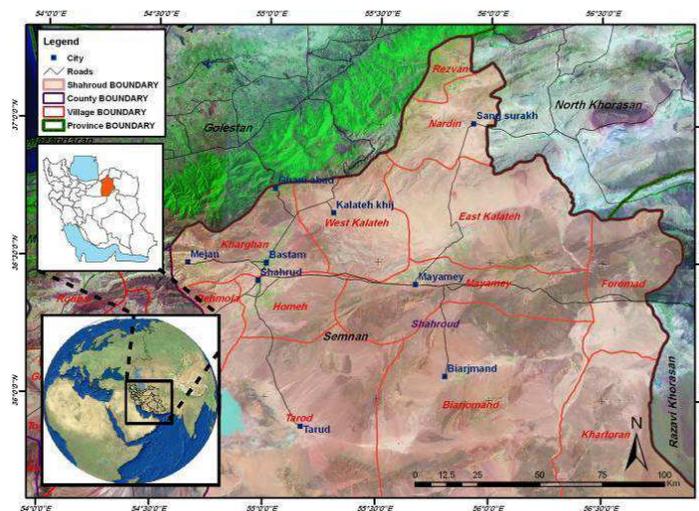


Figure 1. the location of the study area globally and in Iran

Data required for this study consisted of local and non-local (descriptive). Urban maps with the scale of 1:10,000, data on the types of land use as well as their area and percentage, and the climate and social characteristics were among the most significant data employed in this study.

The following criteria were used for local park site selection:

- Proximity to the residential areas
- Proximity to the urban facilities
- Distance to the existing local parks
- Access to transportation
- Proximity to educational areas

- Enough distance from incompatible uses such as military, industrial, etc.
- Site selection in current wastelands

In order to determine the potential of each district within the study area, the only option involved employing GIS along with Overlaying. To do so, the above mentioned criteria were incorporated into GIS to obtain new information layers, and by using existing data, new information such as distance form incompatible uses as well as site selection in current wastelands were produced. Next, the best alternative in terms of park location was chosen by weighting determining criteria in Analytic Hierarchy Process (AHP). AHP is a flexible, simple, and effective method used for decision making when conflicting decision-making criteria complicate seeking the best alternative [10]. Previous studies show that it can be employed in dealing with urban planning because of AHP simplicity and flexibility, simultaneous use of qualitative and quantitative criteria, and judgment consistency [11 & 12].

Analytical Hierarchy Process

In the process of site selection, after defining and introducing overall goals, objectives, operational milestones, and alternatives, appraisal is conducted to choose the best alternative [13]. To evaluate relative eligibility of each option, criteria and prioritizing is employed [14].

Structuring a Hierarchy

In the first place, structuring involves four levels, including goals, criteria, sub-criteria, and alternatives [14]. Transforming a problem into a hierarchal structure holds the major significance in hierarchical analysis [15]. In this method, each criterion has a certain weight to be employed by the user and can be broken down into smaller components, a sub-criterion, to make a weighted comparison [16].

Determining the weight of criteria and sub-criteria

There are several methods to determine the weight of criterion and sub-criterion, among which pair wise comparison is the most usual [10 & 17]. Accordingly, pair wise comparison between every two criterion is carried out to ascertain the importance of one relative to the other. There is one standard method, introduced by L. Saati, to accomplish this. To carry out a pair wise comparison, each comparison is assigned a value between 1 and 9, whose interpretations are demonstrated in table 1. Then, weights should be normalized [13]. Different methods exist to normalize these weights; however, in this study, dividing each weight by the column aggregate was used [16].

Table 1. 9 scale pair wise comparisons introduced by L. Saati

Score	Definition	Explanation
1	Equal importance	The two criteria have the same importance in attaining the goal
3	Moderately more important	Based on experience, <i>i</i> is more important than <i>j</i> in attaining the goal
5	Strongly more important	Based on experience, <i>i</i> is strongly more important than <i>j</i> in attaining the goal
7	Very strongly more important	Based on experience, <i>i</i> is very strongly more important than <i>j</i> in attaining the goal
9	Extremely important	Absolute importance of <i>i</i> over <i>j</i> has been proved
2, 4, 6, 8		When intermediate intervals exist

Source: [10 & 18]

RESULTS AND DISCUSSION

The results suggest that the land use is mostly comprised of wasteland (24.8%) and residential area (24.56%), while parks and green spaces account for merely 0.61% (figure 2).

The map produced by overlaying information layers (criteria) shows the optimal zone to be assigned to park and urban green space. Obviously, the most appropriate zone includes that with great potential for urban park establishment.

Figure 3 demonstrates zoning of the existing urban facilities and wastelands.

Figure 4 shows the incompatible uses with urban parks of local scale.

Figure 5 depicts the incompatible and compatible uses with military use.

Figure 6 distinguishes the incompatible and compatible areas in terms of park site selection.

Accordingly, after determining land applicability for the favorable use in GIS, a map was produced by integrating the compatibility layer and information layer (figure 7).

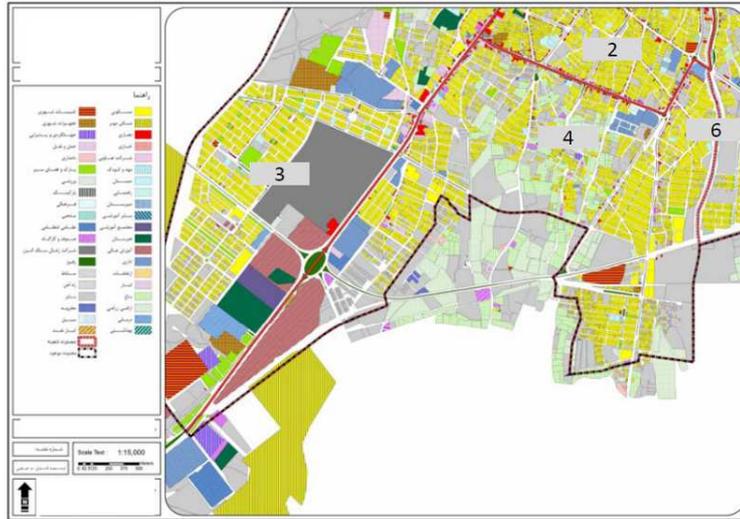


Figure 2. Current land use in Area 4, District 1, Shahrood

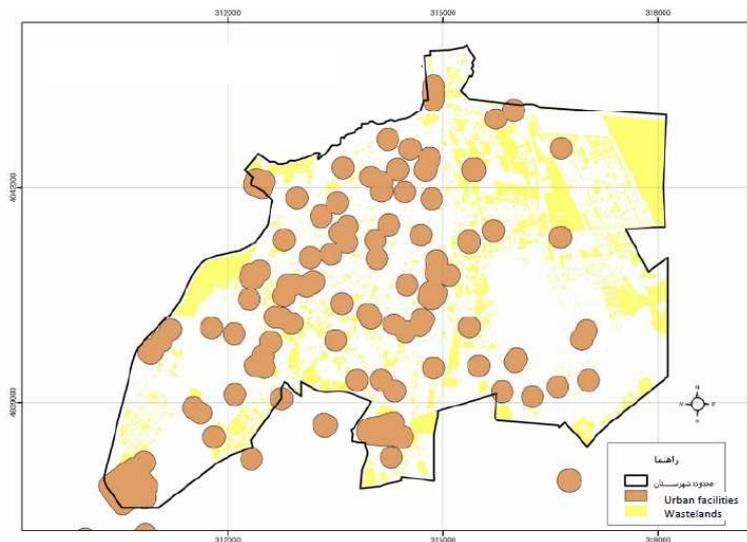


Figure 3. zoning of urban facilities within Area 4, District 1, Shahrood

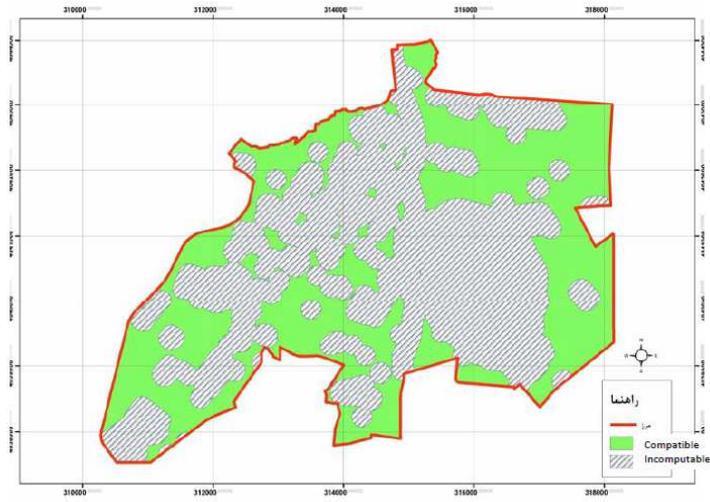


Figure 4. zoning of Area 4, District 1, Shahrood for incompatible and compatible uses

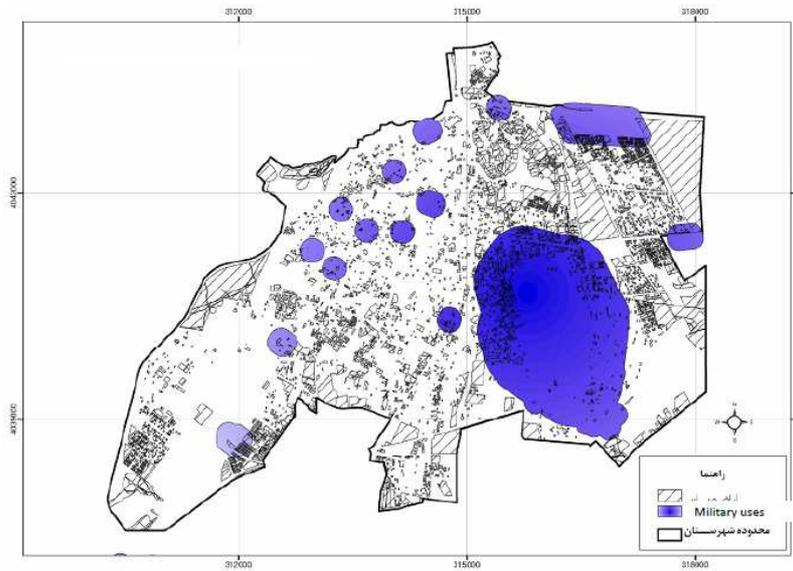


Figure 5. zoning of incompatible uses with military use in Area 4, District 1

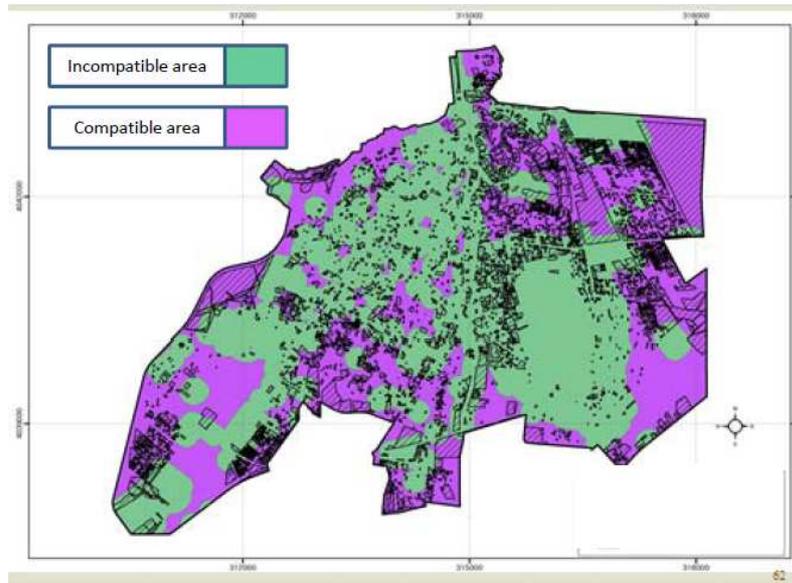


Figure 6. Distinguishing incompatible and compatible zones in terms of site selection

Ultimately, 4 sites were considered as alternatives for establishing an urban park at local scale within Area 4, District 1 (figure 8).

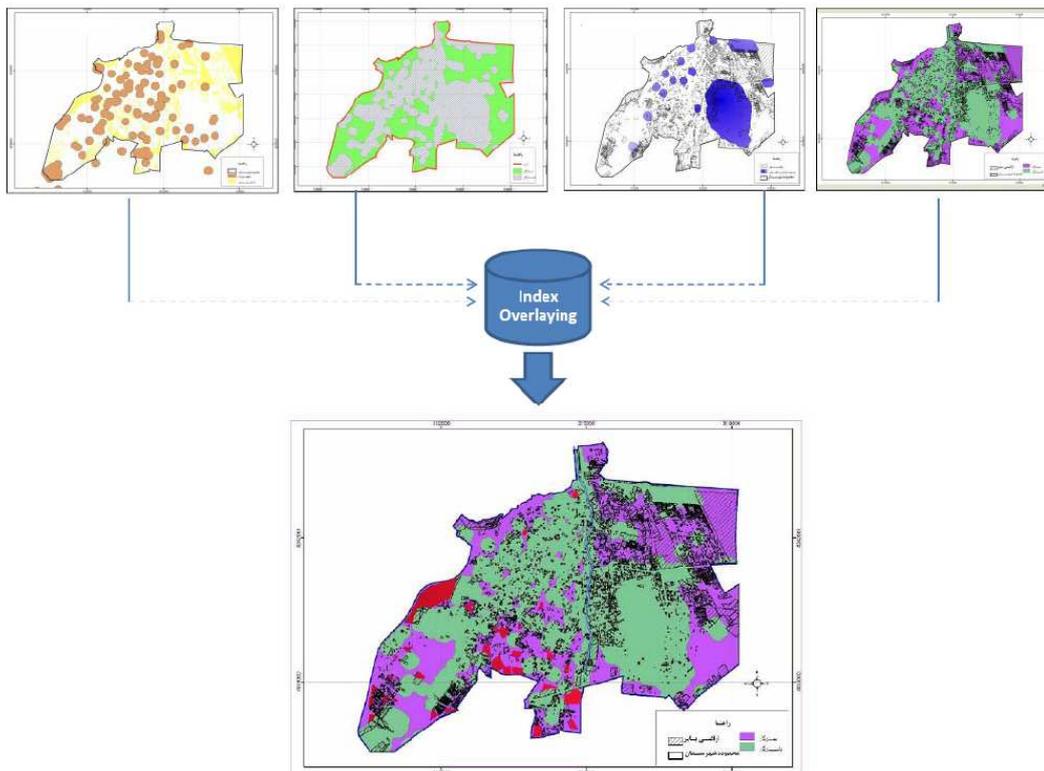


Figure 7. Identifying appropriate spots to establish an urban park at local scale

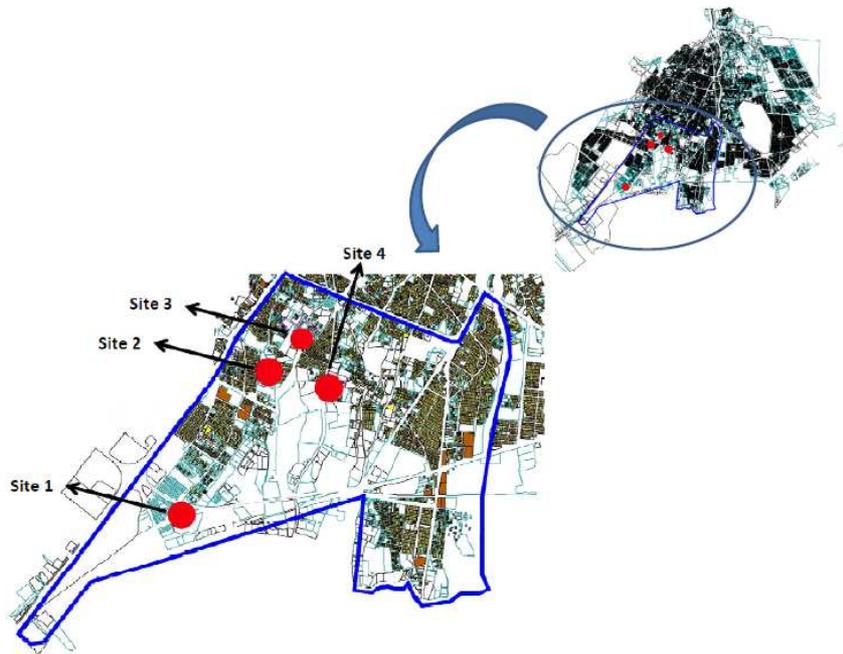


Figure 8. four sites considered as alternatives

Finally, Site 4 was chosen as an appropriate location to build the park. AHP was employed to make pair wise comparison between alternatives and choose the best one.

In so doing, first, the criteria underwent a pair wise comparison resulting in an inconsistency 0.04 which was acceptable.



Figure 9. pair wise comparison of criteria

Next, the alternatives were compared in regard to the criteria. Figure 10 demonstrates the comparison between alternatives based on population density on each site; figure 11 shows the result of comparing the alternatives from accessibility point of view; figure 12 displays alternatives based on their development and figure 13 on local and social state. Figure 14 indicates the overall comparison between the four sites.



Figure 10. comparison of the alternatives based on population density



Figure 11. comparison of the alternatives based on accessibility



Figure 12. comparison of the alternatives based on extent of the area development



Figure 13. comparison of the alternatives based on local and social state

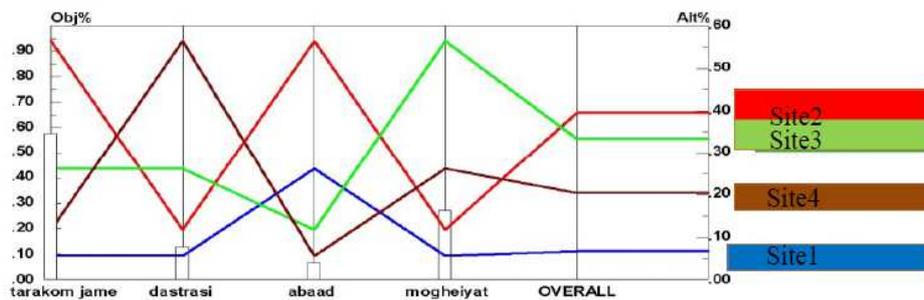


Figure 14. overall comparison of site based on all the criteria

Overallly, Site 2 was considered as the best location for establishing a park of local scale in Area 4, District 1, Shahrood.

CONCLUSION

The results show that both overall and per capita area of green space in Shahrood is not satisfactory. Considering increasing population in Shahrood, outstanding potential of this area for tourism development as well as the city’s rapid expansion, it deems necessary that local scale urban parks be increased and enhanced in number and area in a fashion consistent with population and housing distribution in Shahrood. The AHP outcome indicates that, considering its population, Area 4 lacks enough parks to fulfill the ecological and social needs of the residents, so at least one local scale park deems necessary to be built. As far as per capita green space and its distribution are considered, the appropriate number of the parks needed to be built amount to two.

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