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Development of an Optimal Model of Space use through AHP Model and Boolean Logic in GIS Context Case study: Kurdistan of Iran–Sanandaj

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Abstract. Sports spaces are one of the most important urban Land-uses to increase the physical and mental health of citizens, it seems necessary to pay attention to the fact that sports spaces should be properly located in the city. The purpose of this study is to provide an optimal model for locating sports facilities in Sanandaj regarding Urban Facilities` improvements. The research method is descriptive and analytical based on field and library observations and the use of analytical tools AHP, Boolean logic, and GIS. In the re-search process, the study area in terms of population density, building density, access, neighborhoods in the city is examined and the AHP model is used to weigh the criteria then using ARC GIS maps are prepared according to the criteria finally, a combination map of the criteria is extracted then using Boolean, two criteria of existing sports spaces and river area are included as a limit for establishing sports uses and a map. The usage of these research methods let us to decrease the uncertainties and achieve much trustable outcomes. The final that represents the best places for sports spaces in this area is obtained. By combining and stacking the maps, it is determined that the places that have a higher population density and a high building density, as well as places that have suitable uses for adjacent to sports spaces and passages that are more suitable for establishing sports spaces. The places that have existing sports use and areas are located in the river area should not be constructed sports facilities, so four locations were selected as the best locations for sports facilities.

Keywords: Sustainable city, urban space, socio-spatial development, GIS, Sanandaj.

1 Introduction

Rapid population growth and disproportionate physical development in large cities have created complex and un-solvable problems. Urban development in previous decades has been such that it has led to an imbalance in how urban land is used, turning villages into cities and small towns into large cities, while most of these transformations and changes without Planning has been done and has not been commensurate with the

needs of society. Improving this situation has made the responsibility of urban planners heavier and has required them to respond (thoughtfully) to inconsistencies (Fazelnia et al., 2010). Urban spaces are one of the most important parts of the city. These spaces are located in the framework of settlements and habitats, can be distributed in different scales in the city and create landmarks in the city. They are a function of human goals and collective activities, urban complexes are a tool to promote the spirit of collective thinking, cooperation, understanding and sincere communication and create a safe, comfortable and identity environment. Therefore, paying attention to the required spaces that guarantee the health of the body and soul of citizens, seems necessary in the planning and structure of the city (Nejati, 2006: 7).

Challenges and the Necessity of Modeling: Sports facilities are also among the public service centers that for their great importance cannot be left to the mechanism of the market economy. It should be noted that every year, many sports venues are built in different parts of the country, which according to studies conducted by the organizations in charge, it was determined that their location is based on traditional methods. It seems that in some of these constructions or giving licenses for establishing the important points of the correct location, some attention has not been paid, which may reduce the optimal efficiency of these spaces or create problems for the city and citizens (Razavi Et al., 2009). Undoubtedly, the optimal and successful management and implementation of physical education and sports programs require the provision of a set of conditions and facilities. One of the most important conditions is the creation, development and optimal use of sports facilities providing the necessary facilities for easy access of sports enthusiasts to these spaces (Razavi, et al., 2007). How to build a city and design urban environments and how to access the natural environment, can be considered as an important motivating factor or a major barrier to physical activity and active living.

There are other barriers to physical activity in community settings where people are educated, or work, play and live. Many people who suffer from the negative effects of obesity and chronic diseases are those who experience poverty and social exclusion. The necessary condition to ensure equality and inclusion of measures related to the promotion of physical activity and active life is to assess the needs and participation of all citizens in various areas of daily life (Edward and Taurus, 2008: 34). Health is an important driver of economic development and productivity. Promoting active life in cities can have many economic and social benefits in addition to ensuring the health of citizens. Active living is a way of life that incorporates physical activity into everyday life. This physical activity can include walking and cycling for recreation and movement, playing and exercising in parks, or any other form of recreation. Physical activity is one of the most important measures that people of any age can take to improve their health (Pate, 2009, 2). The purpose of this study is to use the capabilities of Advanced Geographic In-formation System (GIS) software to find suitable locations for the construction of sports centers in Sanandaj.

Literature Review: The background of the present study has shown that relevant scientific resources regarding the organization of sports facilities have been scarce and most of the research conducted has been related to the location and development of sports facilities. Attention to the combined approach of capabilities with GIS, models and techniques that can be used in solving urban problems and especially the optimal location of urban uses has been considered by scientific and executive circles.

Table 1. Resources related to the location of sports spaces.

2020	Armana Sabiha, and Behnaz aminzadeh.	Evaluation of Physical Urban Management Strategies in Major Crisis Management Policies in Tehran.	In this research the Significant Urban Factors and the amount of level of responsiveness have been evaluated.
2020	Farid Karimipour, A javidaneh.	An Approach for Automatic Matching for Descriptive Addresses, Journal of Geomatics	This article proposes a solution for automatic matching of descriptive addresses.
2018	Farid Karimipour, RA Abaspour, and S faze	Investigation the Capabilities of Geo-Simulation Based Approaches to Urban Development Modeling.	In this research the Agent-based Modeling and the Cellular automata have been studied to examine their performance in the field of Urban Forecasting and Physical Development.
2018	Kiomars Naimi, Freydon Babaii Aghdam	City and Spatial Justice; The Analysis of The Distribution of Urban Public Services In The 22 Areas of City Sanandaj	Spatial and environmental justice means the fair distribution of resources to achieve a balanced society, and one of the approaches is social justice. The measurement of spatial justice in the distribution of urban public services is Superior goal and important for urban planners, and is the of needs urban management.
2017	Hassan Karimi, Bobak Karimi	Geospatial Data Science Techniques and Applications	This published book highlights the unique characteristics of geospatial data, demonstrate the need to different approaches and techniques for obtaining new knowledge from raw geospatial data, and present select state-of-the-art geospatial data science techniques and how they are applied to various geoscience problems.
2016	Miguel Felix Mata River and et al	Environmental GIS to identify municipalities with high potential of biogas production in Mexico	This research proposes a methodology to make a system that performs geographic analyses to show potential landfill locations, and the calculation of potential to support the municipalities in building a landfill that has the necessary infrastructure to capture, treat and take advantage by the MSW.
2016	Shahrevar Rostai, Kiomars Naimi, Salman Mahmodi	A Spatial Analysis of Educational Inequalities and Its Role in Urban Social Sustainability the Spatial Statistical Methods (a Case Study of Saqqez)	Urban sustainability depends on relative welfare, citizen participation and social awareness for all community members.
2010	California Land Use Institute	Advantages of locating sports complexes in case of good design	Policymakers must be committed to addressing the key challenges of designing leisure centers and sports complexes in the public interest.
2010	Isfahan Municipality	Spatial analysis and location of sports venues using GIS	Relying on the results of this study, in addition to knowing the location of their sports venues in the area, sports managers can proceed with the construction of different types of venues with a much higher confidence factor.
2009	Mohammad Taghi Rahnamaei and Leila Aghaei	The Role of Municipalities in the Development of Sports Spaces for Citizens' Leisure Time (Case Study: District 6 of Tehran Municipality)	The results of this study showed that the municipality, due to its continuous and close relationship with consulting engineers and other decision-making elements and preparers of documents and urban plans and detailed plans, has a special place in the development of recreational and sports spaces (parks and sports spaces).
2000	Chapin team	Political Economy Location of Sports Facilities: A Review	The location of a sports center in urban areas is always tied to three categories of decision-making factors: technical factors such as site characteristics, economic factors such as land costs, and political factors such as economic development plans.

Therefore, it will be necessary for urban planners to pay attention to the proper organization of sports venues. Some of the major sources related to the research topic are listed in Table 1.

2 Research Methods

This research has been done in two descriptive-analytical sections. In the descriptive section, using library-documentary studies in order to provide an optimal model for the location of sports facilities in the study area, criteria appropriate to the purpose of the research were selected and then the mentioned descriptive data were collected. Effective factors that have been studied in order to provide an optimal model for the location of sports spaces. These are access to the communication network, population density, building density, suitable neighborhoods. In the analytical section, in order to perform location operations, standard maps obtained from the previous steps were provided to integrate the standardized layers, using two methods, **Boolean Logic Model** and **AHP**: In the following, the results of each of these methods and their combination are presented:

Location: It is an activity to select a suitable place for special use, which analyzes the capabilities and capabilities of an area in terms of the existence of suitable and sufficient land and also its relationship with specific land uses and urban land uses (Salehi, 2004).

Sports centers: All spaces where there are sports, physical activities and sports and recreational movements for all people in a community can be considered as sports venues (Atshan, 1997).

Analytic Hierarchy Process (AHP): This process incorporates various options in decision making and allows the analysis of sensitivity to criteria and sub-criteria. In addition, it is based on the pairwise comparison, which facilitates judgments and calculations and shows the degree of consistency and incompatibility of the decision, which is one of the advantages of this technique in multi-criteria decision making. The process is designed to conform to and proceed with the human mind and nature. This process is a set of personal judgments (decisions) and personal evaluations in a logical way so that it can be said that the technique, on the one hand, depends on personal perceptions and experience, to form and plan a hierarchical problem. On the other hand, it is related to logic, understanding and experience for final decision and judgment (Ghodsipour, 2006).

Models for the Combination of Maps. Boolean region model. In this model, an input map is generated for each factor. A value of one indicates the appropriateness and a value of zero indicates the inadequacy of its spatial position. It is a pixel. If the integration of the maps is done using the AND operator, the pixels containing the value 1 in the output map indicate locations that meet the criteria for the intended application, and if the input maps are used with the OR operator, an output map identifies that one or more criteria apply.

Index Overlay Model: The index overlap model can be performed in two ways. In both methods, weight is first assigned to all effective factors based on relative importance and according to expert opinions. These weights are determined as positive integers or real numbers in a given interval. In the first method, the invoice input maps are binary, as in the Boolean method. In this method, each factor map has a single weighting factor and, for the combination of other maps, is multiplied only by its own weighting factor. The importance of the different classes in an invoice map is considered the same in the

first method. The second method has more flexibility than the first method. In this method, in addition to being assigned to each of the weight input maps, it is also assigned to each of the classes and spatial units in each invoice map based on the relative importance and weight expert opinions. In other words, the different classes on a single map have different weights.

Fuzzy Logic Model: The fuzzy logic is the developed region of Boolean. In fuzzy logic, the membership rate of an element in a set is defined by a value in the range of one (full membership) to zero (no full membership). Types of fuzzy operators include Fuzzy AND operator, Fuzzy OR operator, Fuzzy Algebraic product, and Fuzzy Algebraic Sum operator (Qahroudi Tali, 2012).

Case Study: The city of Sanandaj in recent years with the prosperity of gambling and land grabbing, lack of proper control and management and the formation of various land and housing cooperatives has witnessed an explosive development, inconsistent and contrary to the basic principles of urban planning. At the same time, due to the increasing attractiveness of urban life and the growing poverty of the villagers, migration to the city has developed into an insecure and problematic face called marginalized neighborhoods. According to the latest information of the consultant, more than one-third of the population and area of the city is allocated to these contexts.

Total Areas in Sanandaj:

- The area of Sanandaj City is 6.6886 hectares.
- The built-up area of the city is 2187/8 hectares.
- The empty tissue area is 7703/1,500 hectares.

The Population of Sanandaj City in 2021:

- According to the Statistics Center of Iran, its population in the population and housing population of 2021 is 417177 people.
- The population growth rate is 1.9 percent per year.

Densities:

- The gross density of Sanandaj is now 87.42 people per hectare.
- The net density of Sanandaj is currently 321.87 people per hectare.
- The net density of the city in 437,1364 people was per hectare (Sanandaj Govern).

3 Results and Discussion

In this section, the practical steps performed to provide the optimal model for locating sports spaces in Sanandaj are presented: At first, suitable and compatible indicators for the construction of sports spaces were extracted from the sources and due to the availability of this information, the following indicators were considered in this research. In the first stage, in order to find the most suitable places for establishment

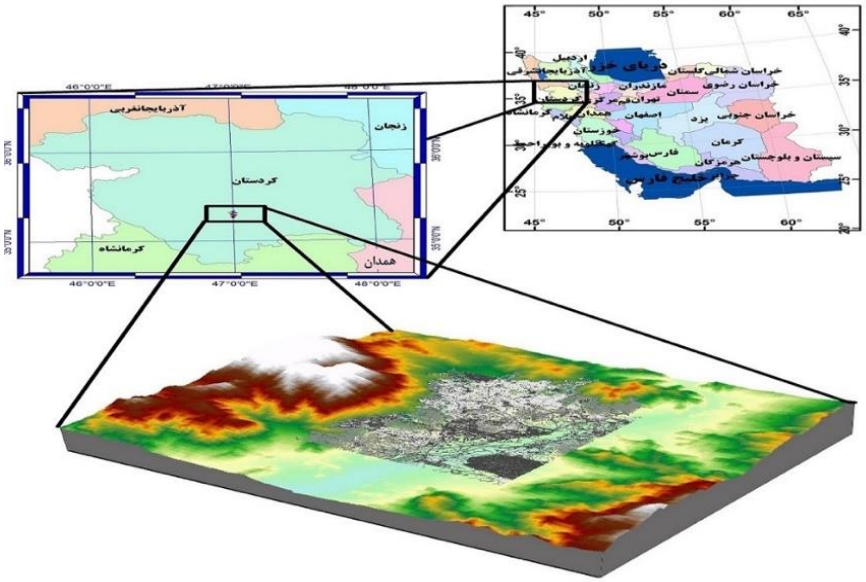

Fig. 1. Case study.

Table 2. Matrix of pairwise comparisons of indicators.

Indicators	Population Density	Building Density	Accessibility	Proximity
Population Density	1	2	3	5
Building Density	1/2	1	3	4
Accessibility	1/3	1/3	1	3
Proximity	1/5	1/4	1/3	1

sports spaces the AHP model is used. Criteria selected for the location of sports spaces in the city are.

Density: In this model, places with high population density will have more priority in order to establish sports use. Figure 2 shows the population density of Sanandaj.

Building density: As the population grows in the region, access to land and open spaces for different uses decreases and building density increases in the regions. In this model, neighborhoods with high building density will have a higher priority for sports use. Figure 3 shows the building density of Sanandaj.

Access: In this model, passages with a width of 15 to 20 meters have the most opportunity for the establishment of sports use, so the places that are placed in different classes according to the distance from these passages. Figure 4 shows the access map of Sanandaj City.

Table 3. Relative weight of indicators.

Indicators	Population Density	Building Density	Accessibility	Proximity
Relative Weight	0.461	0.310	0.156	0.073

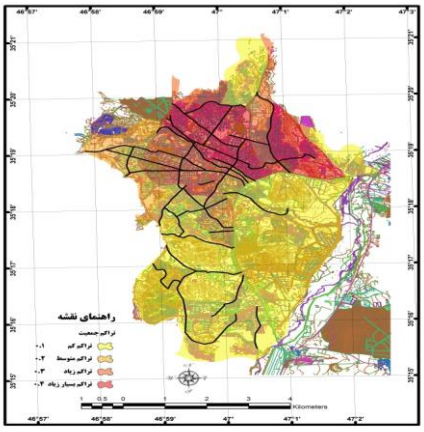

Fig. 2. Population density map.

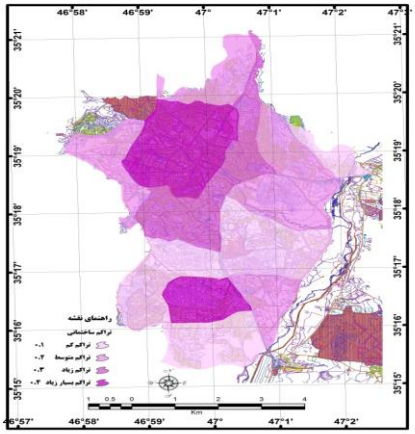

Fig. **3** Building density map.

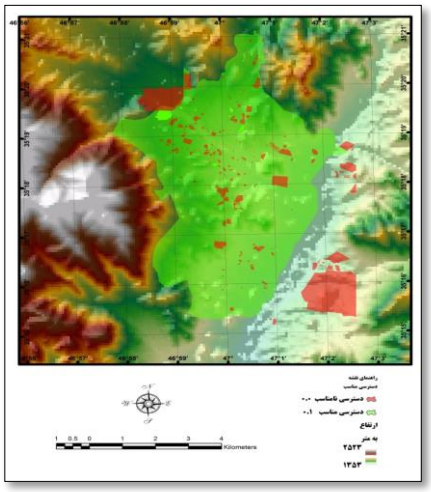

Fig. 4. Access map.

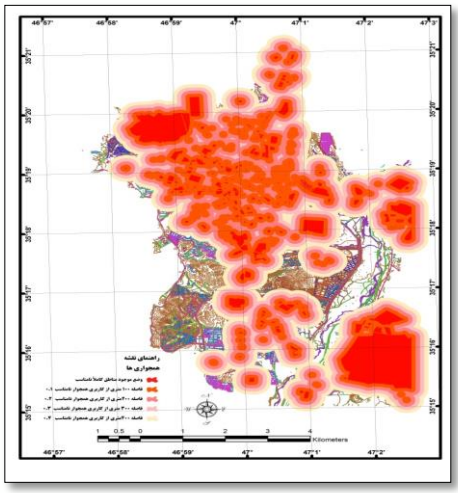

Fig. 5. Neighborhood map.

Proximity: In this section, military, medical, health, and workshop workshops are not suitable neighborhoods for sports use. As a result, all places are classified in terms of distance from this type of use. Figure 5 shows the map of the neighborhoods of Sanandaj.

Then, in order to apply the AHP model, the matrix pairwise comparisons of the indices were formed as follows and we obtained the relative weight of the indices

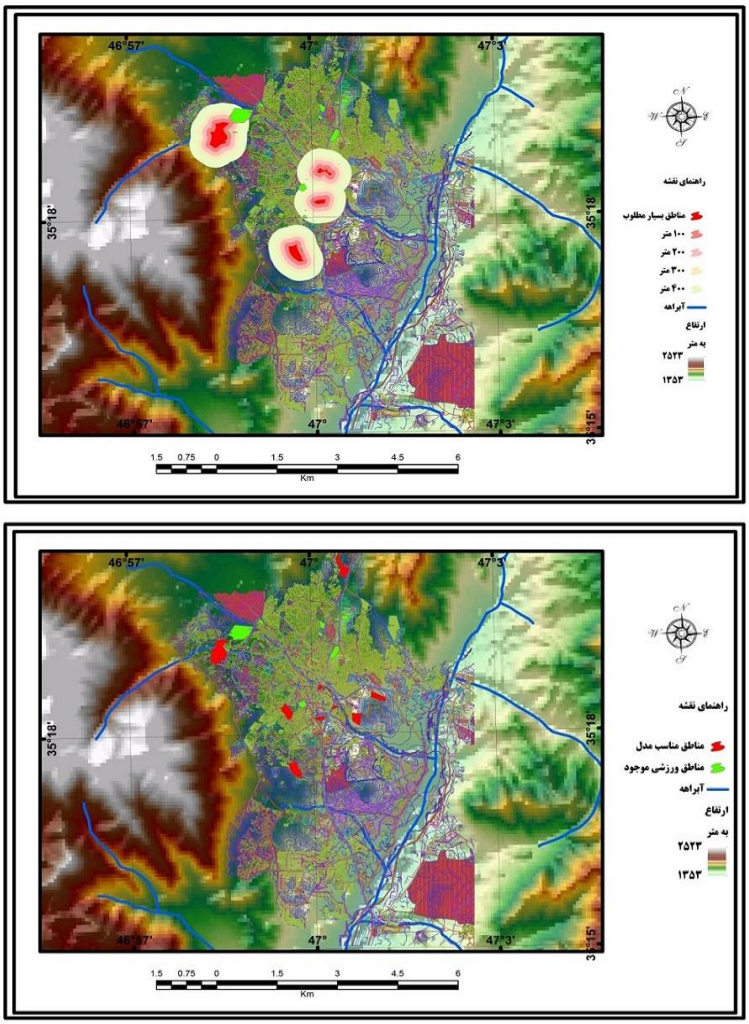

Fig. 6. Final map based on AHP model.

(Tables 2 and 3). Then, with the help of GIS, all the layers related to these criteria have been prepared and the relevant layers have been placed on top of each other according to their relative weight, and the most suitable places for the establishment of sports spaces have been obtained.

In the next step, the limitations that exist in the location of land uses should be considered that according to the characteristics of the study area, the two factors of existing sports spaces and the river area are considered as restrictions for the establishment of sports spaces.

Existing sports facilities: In areas covered by existing sports facilities, embryos should not be located. As a result, all places that have existing sports use have been identified. Figure 7: The map of existing sports areas in Sanandaj is shown.

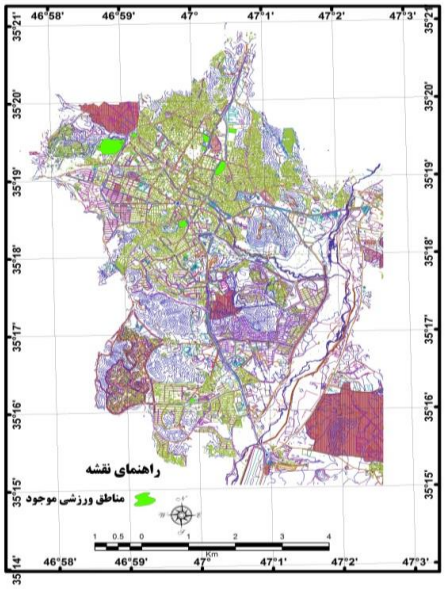

Fig. 7. Map of existing sports areas

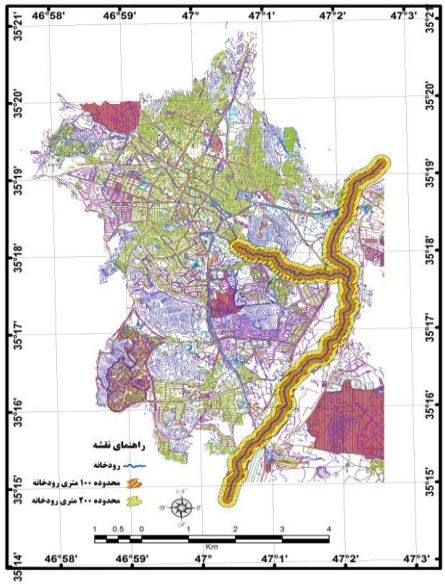

Fig. 8. River area map

River area: It has been assumed that there are restrictions on the establishment of sports uses in the river area.

Then, using GIS, information layers related to these criteria were created and also scored according to Boolean logic. Then, the most suitable places (final map based on the AHP model) and restrictions were placed on top of each other and options were

obtained to establish sports spaces. Figure 9: The map shows the most suitable options for establishing sports facilities in the city of Sanandaj.

4 Conclusions

Sports facilities are one of the most important urban uses to increase the physical and mental health of citizens, therefore, it is necessary to pay attention to the fact that sports facilities should be properly located in the city because to its significant role in as-assessment of any urban situation and criteria, so as to identify the best places for Sanandaj sports spaces were studied according to the criteria of population density, building density, access, neighborhoods and existing sports spaces, river area and using AHP model and Boolean logic in GIS environment. It was found that places that have a higher population density and have a high building density, as well as places that have suitable uses for adjacent to sports spaces and have passages that are more suitable for establishing sports spaces, and places that have existing sports use and areas that they are located in the river area, sports facilities should not be built, so four urban areas were selected as the best areas for the establishment of sports facilities. Therefore, paying attention to these factors and augment their responsiveness plays vital role in attracting individuals to healthy and sport activities in a proper urban texture. Considering these urban roles help urban managers and planners in raising the urban flexibilities.

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