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Application of sustainable urban development in environmental suitability analysis of educational land use by using AHP and GIS in Tehran

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Abstract

Fulfilling present needs while reducing the impact of human activity is a challenge requiring new ideas. As there is shortage of suitable locations, financial resource limitations and limited using of information technology, it is seen an imbalance between request and services around education in Tehran. Educational land use faces with matters such as unsuitable site selection and imbalance distribution of places which makes problems in the way of sustainable urban development. This research focuses on environmental dimension of sustainable urban development and is going to do environmental suitability analysis of educational land use in Tehran by using AHP and GIS. Suitability analysis is a process of systematically identifying or rating potential locations with respect to a particular use. A number of locations for educational land use are founded in Tehran and some factors such as access range, slope ,and compatibility are evaluated, then Analytical Hierarchy Process (AHP) is applied to give weight to each indicator and by use of analytical functions of GIS for overlaying the indicators, it will be decided that which location is environmentally suitable for educational land use.

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Keywords: sustainable urban development; suitability analysis; GIS; analytical hierarchy process (AHP)

1. Introduction

Increasing population growth, lack of enough service centres and disorder of service distribution and suitable locations are some of major problems of today metropolitans. Nowadays information technology is being used for management of such complicated cities. GIS is a system for creating, managing and

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analysing graphic and attribute data and it can be used as a decision support system (DSS) by managers, planner and decisions maker. One of the most useful applications of GIS for planning and management is the land use suitability mapping and analysis (McHarg, 1969; Hopkins, 1977; Brail and Klosterman, 2001; Collins et al., 2001). [3]

Broadly defined, land-use suitability analysis aims at identifying the most appropriate spatial pattern for future land uses according to specify requirements, preferences, or predictors of some activity (Hopkins, 1977; Collins et al., 2001). The GIS-based land-use suitability analysis has been applied in a wide variety of situations including ecological approaches for defining land suitability/habitant for animal and plant species (Pereira and Duckstein, 1993; Store and Kangas, 2001), geological favourability (Bonham-Carter, 1994), suitability of land for agricultural activities (Cambell et al., 1992; Kalogirou, 2002), landscape evaluation and planning (Miller et al., 1998), selecting the best site for the public and private sector facilities (Eastman et al., 1993; Church, 2002), regional planning (Janssen and Rietveld, 1990) and environmental impact assessment (Moreno and Seigel, 1988) which is to be applied in this research.[3]

Suitability analysis in a GIS context is a geographic or GIS-based process used to determine the appropriateness of a given area for a particular use. The basic premise of GIS suitability analysis is that each aspect of the landscape has intrinsic characteristics that are in some degree either suitable or unsuitable for the activities being planned such as educational land use. [4] The results are often displayed on a map that is used to highlight areas from high to low suitability. A GIS suitability model typically answers the question, "Where is the best location?" whether it involves finding the best location for a new educational centre. [3]

Suitability is determined through systematic, multi-factor analysis of the different aspect of the terrain. Model inputs include a variety of physical, cultural, economic and environmental factors [2] which is to be focused on environmental factor in this research and AHP is applied for evaluating the factors. AHP is a structured technique for dealing with complex decisions and is a Multi-Attribute Decision Method that refers to a host of quantitative techniques used to facilitate decisions that involve multiple competing criteria. Rather than prescribing a "correct" decision, the AHP helps decision makers find one that best suits their goal and their understanding of the problem. [7]

2. Theoretical framework

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable development has deep concepts in three fields of environmental, economic and social sustainability [9] Indicators for sustainability provide information to communities on what are sustainable and what is not; and a good indicator alerts society to a problem before it gets too bad and helps communities recognize what needs to be done to fix the problem and show the links between the economy, environment, and society. Sustainability requires integrated view of the world. Following figure is shown three fields of Sustainable Development with the emphasis on environmental dimension which is focused on it in this research.

Because of importance sustainability in our community and its effect on citizens quality of life especially on children, urban planner have to consider sustainability indicators to select sites of Land uses in urban spaces. One of these Land uses that urban planner must be attend to it is educational land use. Lack of attention to locating Educational land use in relation with environmental suitability will lead to physical and mental health, time and resources wasting, tiredness and boredom of students. So we are going to find the best location for educational land use considering environmental suitability in Tehran.

After determining factors which are access range, compatibility and slope in this case study in order to analyzing for Educational land use, we need to use weight assignment methods and models for map

overlaying.

In general, giving weight to factors can be performed by Driven Knowledge or Data Driven or a combination of them. In Driven Knowledge, experience and Knowledge of specialists are being used to give weight to factors. Some of weight assignment methods which use Driven Knowledge are ranking methods, rating methods and Pair wise comparison. Pair wise comparison is a sub set of Analytic Hierarchy Process method in which the scales are compared in pairs and their importance to each other is determined. [1]

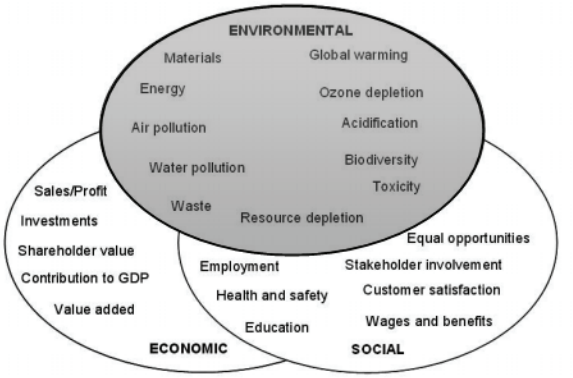

Fig. 1. Sustainability fields

There are models for map overlaying as Boolean logic Model, Fuzzy logic Model, and Index Overlaying Model which Index Overlaying Model is used to dedicate effective factor's weight according to relative importance and ideas of specialists. These weights are positive numbers in a specified range. [1]

3. Evaluation of needed factors in modelling optimum construction of new educational land use

We have considered factors of compatibility of educational use with other land uses and determination of access boundaries to existing schools and slope of region.

3.1. Compatibility of educational land use with other land uses

This parameter will actually present the standards that an area must full fill to be suitable for educational land use. When the limits of compatible and incompatible land use with primary educational land use activities are determined and used in the area, we can choose suitable location of new educational land use. [8] Classification of compatibilities between land uses is as following:

- A complete compatible land use with educational centres: This group includes those land uses that have similar futures and their existence is useful for schools.
- Compatible land uses with education centres: Land uses which are closely similar to each other.
- Fairly incompatible land uses with education centres: Land uses that their incompatibilities are more noticeable than their compatibilities.
- A complete incompatible land use with educational centres: Land uses which do not have any compatibility and are opposed to each other. [5]
- To determine the compatibilities of two land uses we must consider their usage for usual activities and compare their futures and characters to determine their compatibilities and incompatibilities.

- In this research, according to the instructions issued by ministry of housing and urban affairs, we prioritized land use according to their compatibilities with educational use as following:
- Vicinity of public green fields such as protected green fields and public parks and gardens.
- Vicinity of educational and cultural institutes such as library, cinema, theatre, museum, gallery, cultural centres, permanent exhibitions and recreational centres and sports complexes.
- Vicinity residential areas such as residential towers, parking garages, vicinity of commercial use such as department areas, markets and small workshops.

3.2. Determination of access boundaries for existing educational land use

One of the most important factor to find the best location for educational land use are chronological and destinations factors; in order to determine the access rang of existing educational land use following rating have been done: (as shown in tables 1 and 2). [6]

Table 1. Rating parameters of Determination of access boundaries [6]

Parameter	Sub Parameter	Point
Urban texture and physical properties and width of routes	Dense with narrow route	6
	Semi dense with narrow route	4
	Semi dense with wide route	2
	Less dense with wide route	1
population density	Ultra high density	6
	Very dense	4
	Semi dense	2
	Less dense	1
capacity of educational centers of different areas	Completely unsuitable	6
	unsuitable	4
	suitable	2
	Completely suitable	1

Table 2. method of determination of access radius based on gained points [6]

Access radius of primary schools	Gained points
300-400	15-18
401-500	11-14
501-600	7-10
601-700	3-6

3.3. Slope

One of the most important factors in finding suitable location for educational land use is the slope of area. It goes without saying that the less this slope is the easier access to educational land use. According to standards, the maximum allowed slope for constructing new educational land use must not exceed 6 degrees. [8]

4. Case study: Environmental Suitability Analysis of new educational land use in Tehran

The area we studied is the sixth region of Tehran municipality which this area is about 576 hectares and includes 9 schools for girls and 4 schools for boys. In summary we can present the execution steps as

following the diagram:

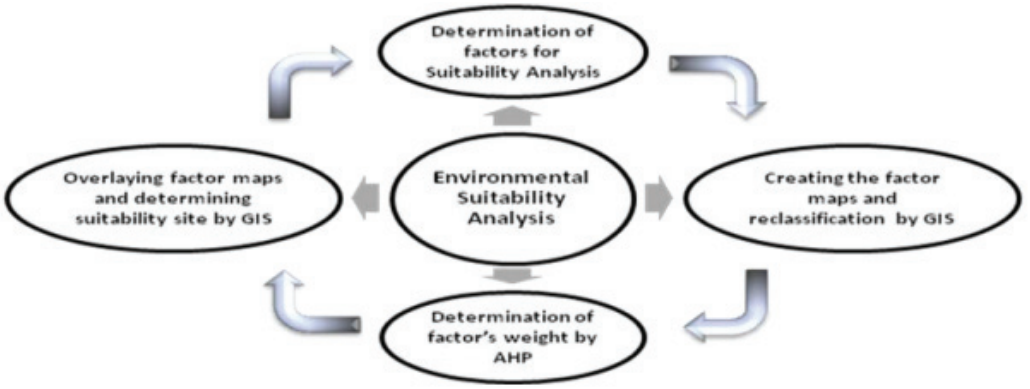

Fig. 2. View of execution steps

4.1. Evaluation of current compatibilities of educational land use with other land uses

In order to evaluate, we have consider the relationship between land use activities and educational use. Land uses which are placed in the influence zone of others should be homogeneous with each other. According to this point, in area of our case study, existing land uses might be compatible with educational use. According to definition in part 3.1 and using compatibility matrix of each land use with educational use and it extension is defined as the following table.

Table 3. Radius of coverage area and kind of compatibilities of existing land uses in study area

Compatibility	Radius of coverage area(m)	Land use
Fairly compatible	500	Park
Completely compatible	500	Mosque
Completely incompatible	150	Hospital
Fairly incompatible	150	Gas station
Fairly incompatible	40	Power transmission lines
Fairly compatible	150	Cinema
Completely incompatible	150	High way
Fairly incompatible	100	Main street

4.2. Creating the factor map and reclassification of data by GIS

We have considered 3 factors of sustainability in Environmental Suitability Analysis such as compatibility, access boundaries of educational land use and slope of the area. To create the factors maps, the following steps have been done:

Compatibility factor: For all features related to compatibility we created the distance maps with access range presented in table 2 and according to land use compatibility or incompatibility to educational land use, these maps are classified and graded from 1(the worst value) to 10 (the best value).

Access boundaries factor to educational land use: The access boundaries in Environmental Suitability Analysis (access range) are prepared for every existing educational land use, according to part 3.1 as following table. Then with these access range, we have create distance map and reclassify them, from 1 (the nearest) to 10 (the farthest). Determining access rang of existing educational land use is shown in

table in appendix A.

Slope factor: With height points and using TIN[a] model, we created the digital elevation model and then we used surface analysis to create the map of slope factor and classified it. Finally, since new educational land use must be built in areas with a maximum slope of 6 degrees, we graded the levels of slope and assigned values between 1 (the worst value) to 10 (the best value).

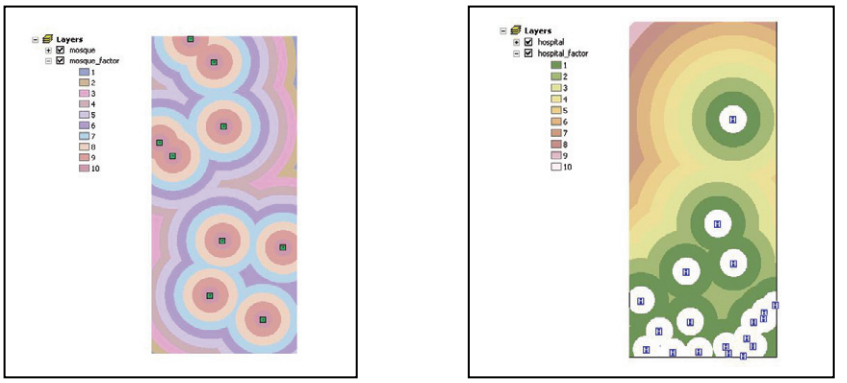

Fig. 3. (a) compatibility factor, (b) Incompatibility factor

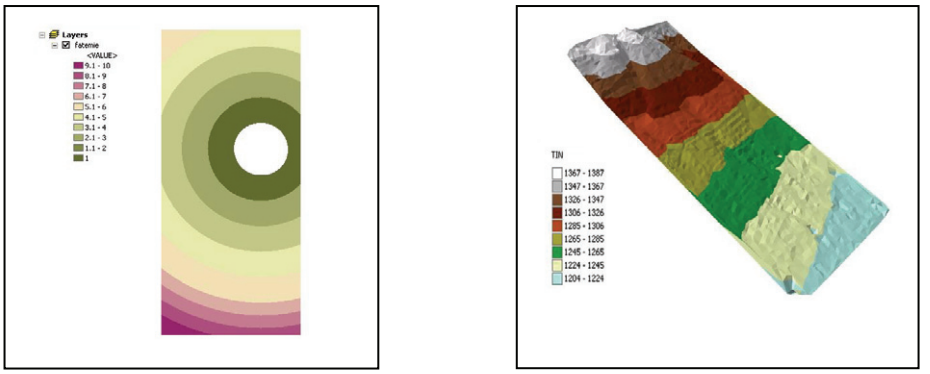

Fig. 4 . (a) Access boundaries factor, (b) digital elevation model

4.3. Determination of factors weight by AHP

In order to determining of factors weight for modelling optimum construction of new educational land use, pair wise comparison is used which is a sub set of Analytic Hierarchy Process method in which the scales are compared in pairs and their importance to each other is determined by using nine degrees Sa'aty matrix. Expert Choice soft ware is used to calculating the exact weight of each factor which the result is shown in the following figure.

a. Triangulated Irregular Network

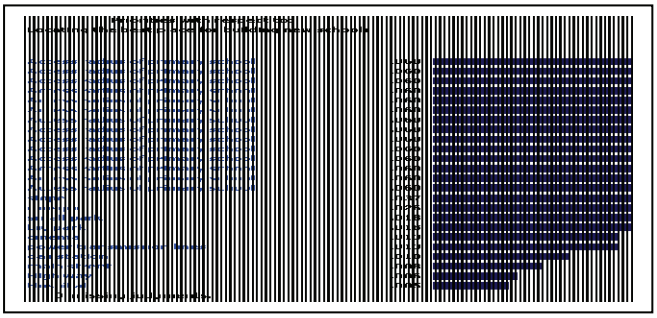

Fig. 5. Result of factors weight in Expert Choice soft ware by using AHP method

4.4. Overlaying maps of factor and site selection schools by GIS

The main aim of overlaying maps of factors is finding a suitable locations for constructing new schools. It is better to overlay factor maps in a way that the value of each pixel presents suitability of relevant location for new schools. regarding all effective factors since used factors in different ranges have different values, we used the second method of index overlaying model in this research.

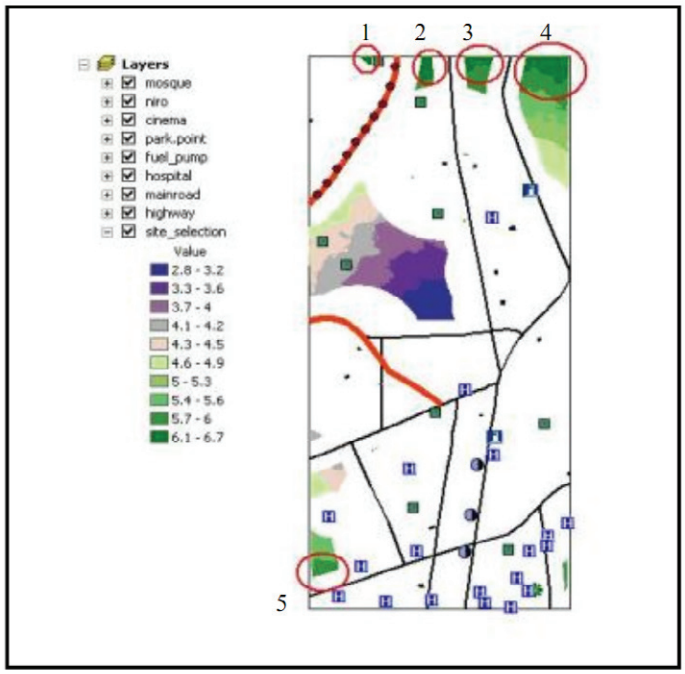

Fig. 6. Suitable locations for constructing new schools

4.5. Determination of priorities of locations for constructing new schools by AHP

As the suitable locations are determined, AHP method is used to find finally priority steps between locations for constructing new schools. The calculations are performance by Expert Choice soft ware which results are shown in the following figure.

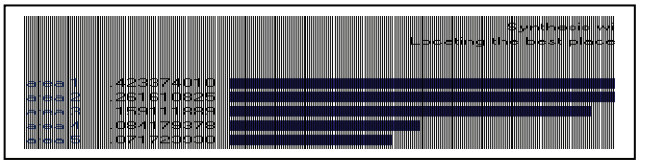

Fig. 7. priorities of locations for constructing new schools

5. Conclusion and suggestions

The continued spread of urbanisation will challenge the land's capacity to meet those demands. Integrating environmental dimensions into land management practices in urban areas from the earliest stages of the planning process can greatly contribute to the future sustainability of cities. It is a matter of moving away from urban management practices based on narrowly focused land use policies towards a broader vision based on the premise that land use practices which compromise the carrying capacity of the environment for urban development jeopardise the long-term sustainability of cities. The natural environment is under strain from human activity. The issue regarding the environmental dimension is to determine whether or not the project has a positive environmental impact and how the key aspects of environment have been considered. Environmental suitability analysis is a process of systematically identifying or rating potential locations with respect to environmental capacity. The role of GIS in land-use suitability analysis has evolved to determine the appropriateness of a given area for a particular use such as educational land use.

As suggestion, In order to evaluate suitability of current land use rather than compatibility matrix, desirability, capacity and dependency matrices should be inspected as well. Regarding differences in explaining compatibility of land use and access radius of each land use and importance of parameters in the site selection new schools, we suggest to provide a complete standard.

Acknowledgement

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Appendices

Appendix A. Determining access rang of existing educational land use

Name school	physical properties urban texture		Population density		Capacity		Gained points	Access range(m)
	type	Point	type	Point	type	point		
Shahid abaspoor	Less dense and wide	1	Less dense	1	unsuitable	4	6	601-700
Alame tabatabaii	Very dense and narrow	6	Very dense	4	completely unsuitable	6	16	400-301
Andishe dokhtaran	Less dense and wide	1	Less dense	1	completely unsuitable	6	8	600-501
Farhang va honar	Ultra high density, narrow	6	Ultra high density	6	Suitable	2	14	500-401
fatemie	Ultra high density, narrow	6	Ultra high density	6	unsuitable	4	16	400-301
hejrat	Less dense and narrow	4	Less dense	1	suitable	2	7	600-501
iman	Less dense and wide	1	Less dense	1	completely unsuitable	6	8	600-501
sajadie	Less dense and narrow	4	Less dense	1	completely unsuitable	6	11	500-401
velayat	Ultra high density, narrow	6	Ultra high density	6	completely suitable	1	13	500-401
15 khordad	Less dense and wide	1	Less dense	1	completely suitable	1	3	700-601
Shahid beheshti	Very dense and wide	6	Very dense	4	completely unsuitable	6	14	500-401
Shahid motahari	Semi dense and narrow	4	Semi dense	2	suitable	2	10	600-501
Rahe danesh	Ultra high density, narrow	6	Ultra high density	6	Unsuitable	4	16	400-301
Mostafa khomaini	Less dense and narrow	4	Less dense	1	Unsuitable	4	9	600-501