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Original Research

A study on place distribution of elementary schools in Shirvan city using GIS

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ABSTRACT:

A quantitative approach to the establishment of schools and lack of attention to the relationship between educational use and other uses in the past led not only to reduced education efficiency but also to the prevalence of various mental and physical illnesses, waste of time and money for students. In this study, after explicating the subject, the effective criteria and regulations on locating schools were identified. Then, the criteria influencing school site selection were weighted according to their importance using Analytic Hierarchy Process (AHP) and considering the weight obtained, information layers were converted to the appropriate format. Then, the layers prepared in this study were combined by weighted overlay method. The results showed that the majority of primary schools in Shirvan, largely satisfy the site selection criteria. However, spatial distribution of schools in Shirvan is not consistent at the local level and in relation to the population; some neighborhoods suffered from the lack of primary schools. On the other hand, several neighborhood schools were located very close to each other indicating misallocation of schools at the local scale.

Keywords:

Site selection, AHP, Spatial distribution, Primary schools

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INTRODUCTION

Today, many city dwellers feel that urban areas are undesirable places to live because, population growth and rapid urbanization over the past decades have created adverse effects such as a variety of social problems, service delivery failure, lack of recreational spaces, inadequate educational facilities, etc. Clearly, the main effect of rapid urbanization on urban spaces is disruption of service distribution system and service system failure. Development of service spaces are not consistent with rapid growth and physical development of cities and ultimately population growth rate surpassed the service spaces leading to the disrupted structures of most urban spaces.

In recent years and in line with the growing trend of urbanization in Iran, many issues and problems have been emerged so that it is felt that cities need continuity in their vital structures. One of the challenges is ensuring security and welfare for students concerning their education and inappropriate site selection of schools. Urban population growth and development of cities in recent decades have been accompanied by uncontrolled expansion of residential and commercial areas. In this regard, educational needs of the population, which is perhaps one of the most basic and vital needs, must be evaluated; especially when such cases as uncontrolled population growth and disproportionate combination of limited resources have created many problems for the education sector. Considering the urgent need to the entire population centers be covered by schools, the precise site selection for establishing new schools is very important in particular, when it is revealed that the factors affecting school site selection are different in different educational stages and different regions of the country.

The city of Shirvan suffers from inadequate service centers compared to its population growth rate and physical development; one of such service centers is educational services as the most sensitive services the urban societies need.

Lack of attention to the students' population in demographic planning on one hand and limited financial resources, lack of planning, lack of suitable lands, not to use urban planning and geographic information system on the other hand, have caused location not being applied in most educational spaces. Students and educational officials also suffer from unfair distribution of spaces resulting in problems such as too much time and money spent to get to school, endangered physical and mental health of students, fatigue and irritability and ultimately academic failure of students.

MATERIALS AND METHODS

Geographic Information System (GIS)

GIS is a powerful tool for working with data. In GIS, data is stored digitally, thus occupying much less volume than traditional methods. In GIS, huge amounts of data can be stored and retrieved at high speed and relatively low cost by using computer capabilities (Hosseini *et al.,* 2010).

In definition of geographical information system, two aspects of the system are emphasized; technology-based approach and problem-solving approach. In technology-based approach, GIS is defined as a set of tools used to log, store, retrieve, process and analyze spatial data and ultimately get output of them. Problem-solving approach involves an integrated and coordinated set of data that can be considered in spatial dimensions. The way in which data is entered, stored and analyzed in a GIS must mirror with the way information will be used for a specific task or a decision making task (The Geographer's Craft, 2014). GIS should be viewed as a process consisting of an array of functions and commands, rather than only a software or hardware, by which and in supporting decision making based activities facilities in entry, store, process and analysis and finally output of data in descriptive form can be generated (Karimi, 2007).

Analytic Hierarchy Process (AHP)

To evaluate any issue we need measures or

indicators. Selecting appropriate indicators will allow us to compare alternatives correctly. However, when multiple indicators are considered in the evaluation, the task becomes more complex; the complexity rises when multiple indicators are in conflict and of different types. It is when the evaluation and comparison is no longer a simple analytical task that the mind is able to do but a powerful scientific analyzer is needed. One of the powerful tools for such situations is Analytic Hierarchy Process (AHP) (Esfandiar, 2001).

Site selection

In principle, site selection is said to be an activity by which the capabilities of a particular region in terms of suitable and sufficient lands and its relevance to urban and rural land uses are analyzed to select an appropriate site for the desired use. According to the above definition of site selection, changes has a long history of use dating back to when mankind attempted to recognize their environment in order to find a suitable dwelling or better supply of foods and meet their needs.

It is clear that as human needs became more sophisticated and diverse over time then site selection also gradually became more complex requiring the use of more complex tools and methods as well as more precise planning. Today site selection in most cases requires careful and regular planning and geographic information systems would be of great help to expedite the process; however, it should be noted that in many cases, the site is impossible or at least very difficult to be selected correctly without using geographic information systems. It is note that although the criteria used in site selection are different according to the type of application, all of them are consistent to find the best site for desired use. Clearly, to use measures and criteria for site selection, particularly school site selection, it is necessary to have accurate and complete information of the location and access to the information requires performing extensive research. It is also clear that the desired site for a particular project would be selected only after analyzing and assessing data (Nejad, 2004).

MRTHODOLOGY

In order to evaluate the spatial distribution of schools in GIS, first the region has been investigated and then the criteria influencing school site selection were determined. In the next step, determined indicators were weighed according to their importance using Analytical Hierarchy Process (AHP) and considering the weight obtained, information layers were converted to the appropriate format and structure using GIS analytical functions. Then, the layers prepared in this study were combined by weighted overlay method.

General characteristics of primary schools in Shirvan

The 2010 statistics showed that the city of Shirvan includes 41 girls and boys primary schools, of which 21 are girls-only and 20 are boys-only primary schools. Of total number of 6970 primary school students, 3393 (49%) are girls and 3577 (51%) are boys (Shirvan Department of Education, 2011).

The important point in the discussion of site selection is geographical location of schools. Given that in this study, school location is considered so schools for both boys and girls attended in two different shifts have been analyzed as a single educational institution.

Identifying criteria for school site selection

In determining the spatial characteristics of each land use type or any type of urban activities, two guiding factors, economic well-being and social welfare are measured (Saeed-Nya, 2004).

For school site selection, various criteria have been provided according to the international standards. Indeed applying all criteria mentioned is not possible for various reasons and selection of criteria not only depends heavily on the availability of information, but also is influenced by the natural and physical conditions of the respective region. Thus, given to the results obtained from investigating the current status of the city of Shirvan and access to information, the following criteria were selected

for school site selection in Shirvan. It should be noted that different land uses within the city can be categorized into two major forms; compatible or incompatible neighborhoods and appropriate or inappropriate desirability in terms of their relationship with the school location.

Weighing criteria and measures

Among different weighing methods, AHP was used to weight variables. This method can be helpful when conflicting decision making criteria make the process of choosing among alternatives difficult. Organizing the components of a system hierarchically, using quantitative and qualitative criteria simultaneously, controlling the logical compatibility of judgments used in prioritization, ranking options and employing group views can be mentioned as the advantages of AHP (Esfandiar, 2001). In the present study, despite the presence of required standards for the selection of and weighting criteria, to have a more applied research, some adjustments were applied in accordance with the specific conditions of the city, including due to the absence of a cemetery in the city this criteria was eliminated and since the city has been built on a relatively flat plain, the slope criteria was eliminated. Standards and criteria of modernization and equipping of school organization were used to weigh the criteria and sub-criteria. Since, AHP method employees expert knowledge, it is more useful than other weighing methods.

Modeling school site selection

To model the school site selection, the following information was extracted:

- Information on the existing schools and surrounding areas, and their radii
- Information on urban pathways network and their type of access and positions
- Information on land use and important uses in school site selection

The next steps of AHP include calculating the weights of (coefficient of importance) criteria, weights of (coefficient of importance) options and the final score of options and examining logical consistency of judgments.

After preparing the above layers, the initial map for each criterion in site selection was prepared. The top layers were superimposed by using spatial analyses and

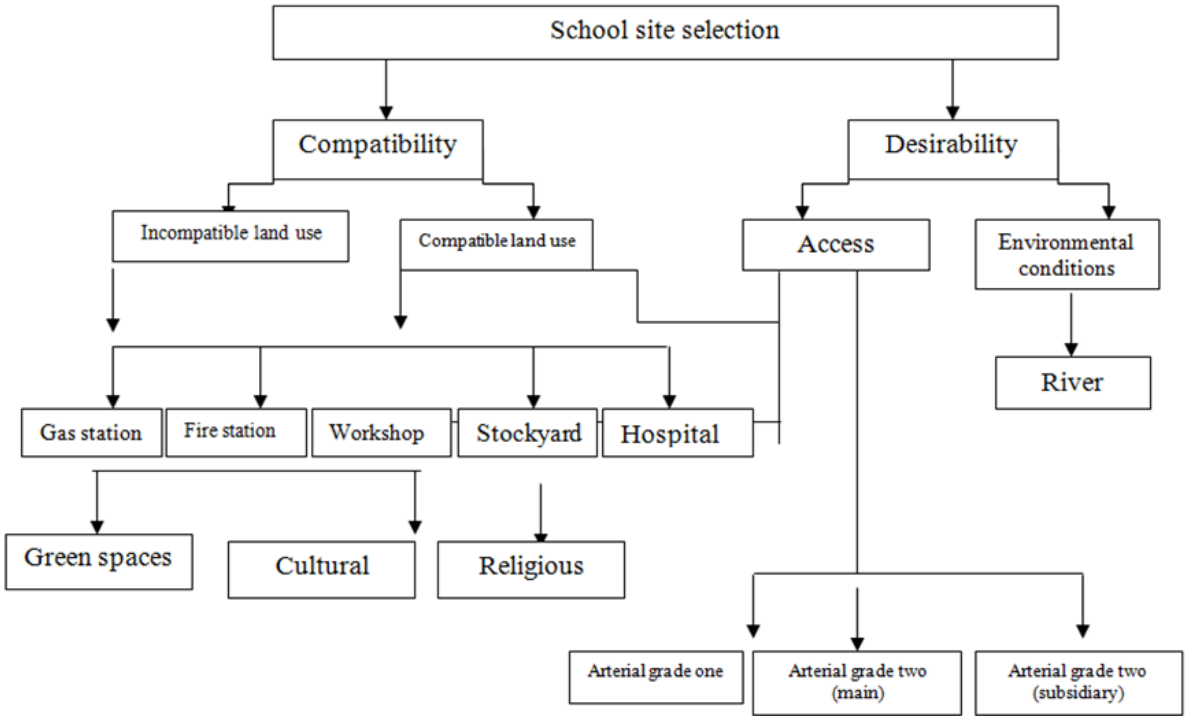


Figure 1. Site selection model used for this research

Figure 2. Site selection conditions of schools in Shirvan with respect to green space and park land use

the command map calculation, so that the locator map of desired sites were prepared. Figure 1 indicates site selection model used in this research.

RESULTS

Effective school site selection criteria (Table 1 and 2)

Park and green space land use (compatible land use)

Most research performed on educational spaces has focused on the relationship and proximity of educational institutions and green spaces (Ministry of Housing and Urban Development, 1987). Thus, in this study regarding the distance to green space, a classification was done for of every one hundred meters; so the closer the green spaces and parks to primary schools more weight they will receive and vice versa, (Figure 2).

Cultural land use (compatible land use)

The effects of social and cultural factors on urban planning and urban development are too widespread that none of various urban elements can be considered without their impact (Shia, 2005).

Cultural centers such as libraries, culture house, etc., where students use non-academic books, attend drawing and calligraphy and other non-academic classes as well as the role of cultural land use in development of educational structures are considered as one of the important and compatible land uses to educational institutions, (Figure 3).

Religious land use

Religious land use including mosques and religious sites has long been concerned for their contribution both to religious practices and use of the space for some school activities, if the different events held in mosques causes no noise pollution and traffic congestion for students (Naseri, 2005). Therefore, mosques should not be built near (50 m) the educational institutions. To this end, a classification was suggested for the religious criterion so that in the first 50 m the coefficient of importance is low, however, in the next 50 m (50-100 m) the coefficient of importance increases and after that again decreases, (Figure 4).

Table 1. Criteria for School Site Selection

Sl. No	Hospital	Stock yard	Workshop	Fire Station	Gas station	Incompatible	Compatibility
1	Religious		Cultural		Green space	Compatible	
2	Arterial grade two (subsidiary)	Arterial grade two (main)			Arterial grade one	Access	Desirability
3					River	Environmental conditions	

Table 2. The weights of items evaluated

Sl. No	Desirability				Compatibility			
	Environmental conditions		Availability		Compatible uses		Incompatible uses	
	Score from 100	Evaluated item	Score from 100	Evaluated item	Score from 100	Evaluated item	Score from 100	Evaluated item
1	8	River	4.19	Arterial grade one	12.5	Parks and Green spaces	5.98	Gas station
2			17.5	Arterial grade two(main)	9	Cultural	6.89	Fire station
3			5.76	Arterial grade two (secondary)	2.5	Religious	10.75	Woporksh
4							7.04	Stockyard
5							9.87	Hospital

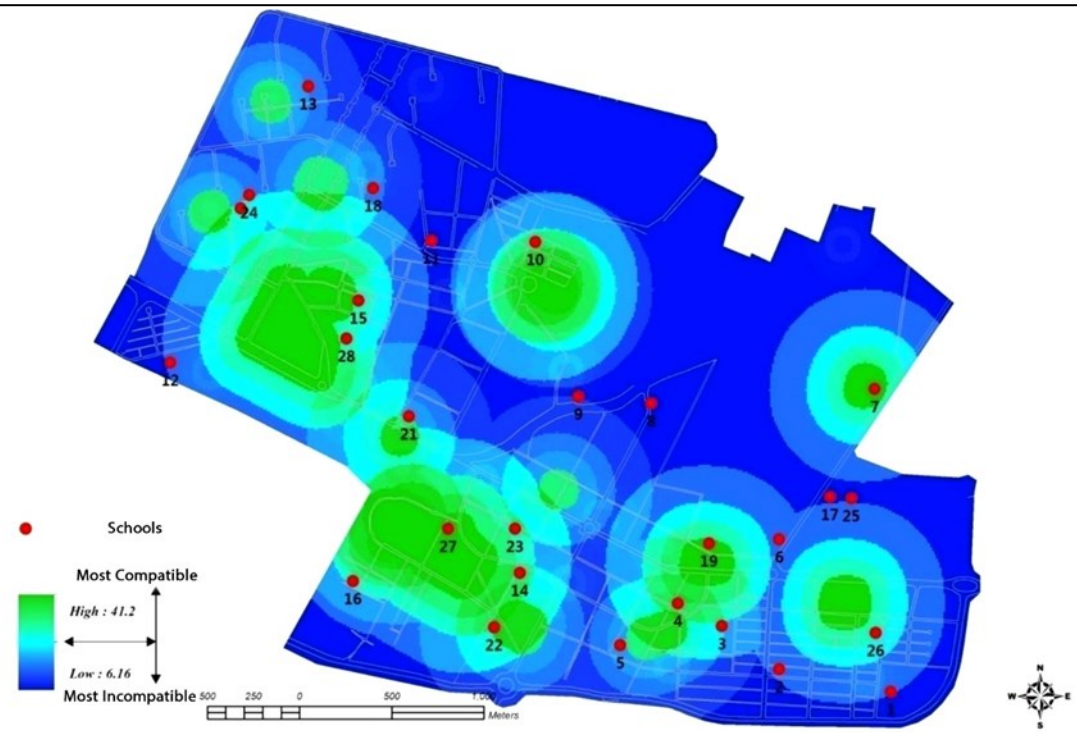
Figure 3. Site selection conditions of schools in Shirvan with respect to cultural use

Figure 4: Site selection conditions of schools in Shirvan with respect to religious land use

Integration of compatible land use

Map No. 1 shows the final layer of compatible neighborhoods. Three land uses were considered for compatible neighborhood; parks and green spaces, cultural centers and religious land use. In this map, the most appropriate to the most inappropriate places were classified in different colors. In other words, those compatible land uses in the vicinity of schools may have the greatest impact on school site selection.

Integration of the respective layers are obtained



Map 1. Most appropriate places with respect to the integration of compatible neighborhood sub-criteria

by the following equation:

([Recluses of Distance to green space *0.52)]+ ([Recluses of Distance to Cultural space *0.38)] + ([Recluses off Distance to religious space *0.10])

Using the above equation and with respect to each layer multiplied by the respective weight and the sum of them and other land uses, the final layer of compatible neighborhood was formed (Map No.1).

Gas station (incompatible land use)

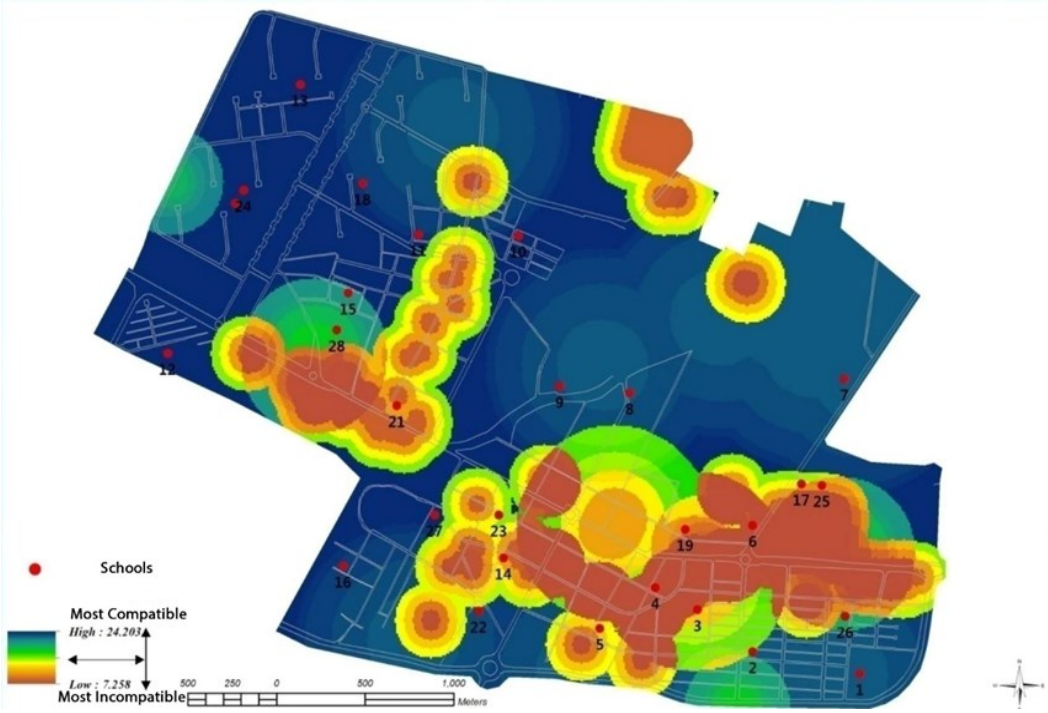
In the area studied, urban facilities such as gas station have been distributed at three points of the city which were presented as incompatible land uses. Since these centers require vehicles to be stopped and concentrated to refuel, so noise and air pollutions and offensive odors are created. Thus, it is better the schools and stations are as far apart as possible. According to the results obtained, the relationship of the stations with schools distributed throughout the city indicated that they are fully compatible with the city's schools. 93% of schools are in full compliance with this criterion; one school is in a relatively good condition and one in relatively poor and completely with inappropriate condition i.e., located near a filling station. The reason for the full compatibility of most schools with this criterion is that, of three filling stations two are located outside the city and within the appropriate distance from schools; the filling station in the city is incompatible in terms of proximity.

Fire station (incompatible land use)

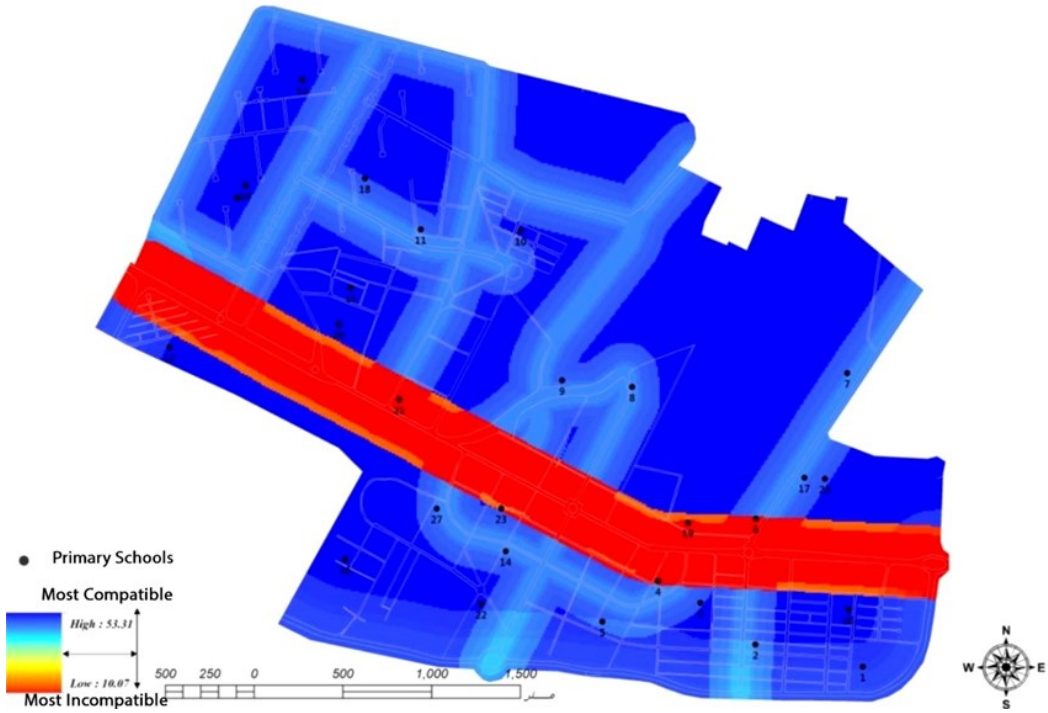
Studying the relationship of the fire station in the eastern and western Shirvan indicate that of 28 primary schools, 24 (86%) are in fully appropriate conditions and three are in relatively appropriate conditions and only one (Shahid Rejaee Male school) is in relatively inappropriate conditions of site selection.

Workshops (incompatible land use)

Workshops in the cities could adversely affect the educational atmosphere due to air and noise pollution caused by these centers and ultimately jeopardizes students' health. So, it is essential to observe the appropriate distance from schools. Of 28 educational institutions, 19 are fully compatible with workshops, one is relatively compatible, six are relatively incompatible and two are completely incompatible.



Map 2. Most appropriate and most inappropriate places with respect to the integration of incompatible neighborhood sub-criteria



Map 3. Desirability radius of pathways to schools

Stock yard (incompatible land use)

Such places are usually on the outskirts of the city and are incompatible with educational institutions due to bad smell that can be dispersed to great distances. So that's why the distance of 650 m to educational institutions were suggested as the best condition for school site selection; with decreasing distance, the condition is far away from appropriate and the weight is

also reduced. Of 28 educational institutions, eight are relatively and completely incompatible and 20 are in better conditions in terms of site selection.

Hospital (incompatible land use)

Because of microbial and chemical contamination sources that may have their proximity with educational institutions, it has been considered incompatible and should be avoided. The distances suggested indicated that less the distance of hospital to schools the higher, the incompatibility will be.

Integrating incompatible neighborhoods

As seen, the mathematical equations applied to form the incompatible neighborhood layer were proposed based on the weight obtained from AHP. Map No.2 is a combination of incompatible neighborhoods, taking into account their normal weight. In this map, workshop use has the greatest impact followed by hospital, stockyard, fire station and gas station. The most compatible to the most incompatible places are classified by different colors. (Map No.2)

Integration of the respective layers were obtained by the following equation:

([Recluses of Distance to gas station*0.15)]+([Recluses of Distance to atashneshani*0.16)]+([Reclass of Distance to kargahi*0.256])+([ )]+([Reclass of Distance to damdari*0.179])+([ )]+([Reclass of Distance to bimarestan*0.243])

Using the above equation and with respect to each layer multiplied by the respective weight and the sum of them and other land uses, the final layer of incompatible neighborhood was formed.

Desirable land uses for schools

Access

Routes are connecting factors in the city so their importance in cities is significant. Connecting use due to the kind of functionality is considered as the main sources of noise and air pollutions and on the other hand, is incompatible with educational land use for life-threatening reasons for students. However, it is compatible in terms of ease of access to distribution networks and connection to other parts of the city. Since every user demands its appropriate connecting network, it is reasonable to choose the educational location carefully.

Integrating accesses

Map No.3 shows a combination of different degrees of access, main degree 1, main degree 2 and subsidiary degree 2 that schools should observe the standard distance to them. In this map, main degree 2 access has the most effect.

([Reclass of Distance to D1*0.15])+([Reclass of Distance to D2_asli*0.64])+([Reclass of Distance to D2_farey*0.21])

Environmental conditions

River

The river's path and its flooding must be considered during school site selection; because lack of attention to it may cause so many problems and risks for facilities and equipments built around it. The river divided the city of Shirvan into two parts. There flows one of the major tributaries of Atrek River having a history of great floods and much damages not long ago. For this reason, observing rules and standards for school site selection is necessary, (Map No.4).

Final integration of layers

Data and layers prepared in previous steps were integrated in the form of adaptive and overlay operations after taking weights by AHP. Overlay and adaptive operation of layers logically and arithmetically is an integral part of all GIS software packages. Mathematical adaptation includes operations such as addition, subtraction, division and multiplication of values in one of data by the values in another layer. Logical adaptation includes finding those areas in which a set of conditions is true. To find appropriate locations for primary schools, the criteria used in this research were studied considering the interaction with school's performances and each was placed on a separate layer with the respective sub-criteria in Arc GIS software and using spatial analyst extension,

Map 4. Desirability radius of river to schools

positions in which site selection criteria were satisfied were determined. Having determined the criteria affecting school site selection, their weights were specified to form the final layer. Then, the maps for each criterion were prepared using Raster format including distance map for each land use. The criteria and their sub-criteria were classified using the command "Reclassify" and the respective weights. The maps for each of the first level criteria were prepared for final integration using the command "Raster calculator".

Integrating layers affecting school site selection was calculated using the following equation and appropriate and inappropriate final school site selection were obtained using the following equation, (Map No.5).

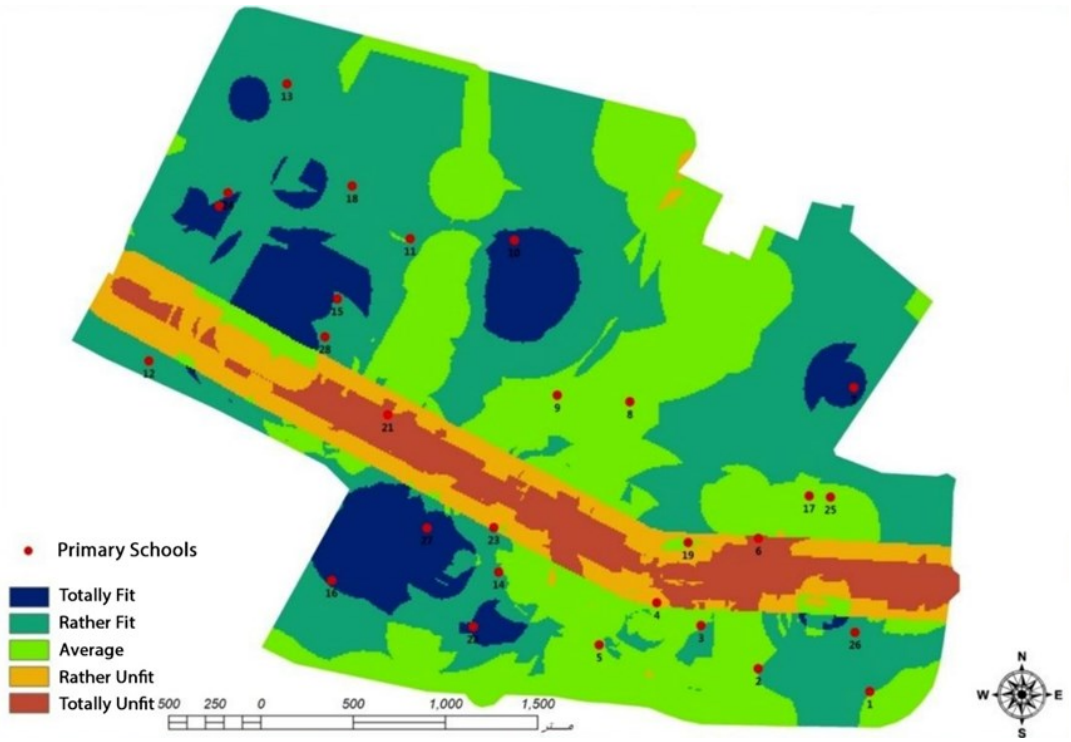
([Weighte-sazegar*24]) + ([Weightenasazegar*40.53]) + (Weightenetwork*27.45]) + ([Weighte-river*8])/100

DISCUSSION

Importance of attention to the relationship between educational use and other uses was the main goal in this study. By attention of locating schools in saving time and money and various mental and physical illnesses for students, this study showed that final analysis of school site selection in Shirvan and parameters determined, locations specified in Map No. 5 is the most appropriate ones for establishing schools. As seen in Table 3; out of total 28 educational institutions, 24 satisfied averages to high site selection criteria and only four were in inappropriate conditions. In urban land uses, five uses were identified as incompatible neighborhood

Table 3. Final site selection of schools in Shirvan

Sl. No	Number of schools	School code	Site selection
1	6	7-10-16-20-22-27	Completely appropriate
2	11	1-2-11-12-13-14-15-1-24-26-28	Relatively appropriate
3	7	3-5-8-9-17-19-25	Medium
4	2	4-23	Relatively inappropriate
5	2	10-14	Completely inappropriate
6	∑ =28		



Map 5. Final site selection map of primary schools of Shirvan

with schools among which workshop and hospital land uses with 25% normal weight (of total one) played the most important role and gas station with 15% normal weight played the least important role in site selection of educational institutions. Among compatible uses with schools, parks and green spaces were the most effective with 52% normal weight and religious land use was the least effective with 10% normal weight.

CONCLUSION

In general, according to the studies performed, establishing each urban element in a particular spatial-physical situation of the city follows special principles, rules and mechanisms which, in case of observing them, will result in the success and functional efficiency of that element in the specific location otherwise problems may occur.

Changing incompatible land uses in the vicinity of some educational institutions, if possible, to land uses compatible with educational institutions seems necessary and the ability of GIS as a powerful tool for dealing with spatial and decision-making data cannot be denied.

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