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Research paper



Suitability Analysis for the Locations of Schools Using Geographic Information System (GIS) and Remote Sensing for Al-Diwaniyah City, Iraq

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Abstract

There are several factors affect the determination of the best location for schools, however, it is very difficult to satisfy by one method for location determination. These factors can be classified to environmental, economic, technical and political social demands. In this study, a frame work, depended on analytic hierarchy process, for determination of the best location an ArcGIS10.1 software was applied to deal with geographical information system and uncertainty situations. Nine sets were used in this study: distance from emergency facilities, distance from existing schools, distance from roads, distance from rivers, distance from railway, distance from land use, distance from gas pipe and population density. Four scores then were found depending on normalizing of the nine sets: Unsuitable, Less Suitable, Suitable and Most Suitable areas. This research aims to find the best locations for primary schools by creating a model which applied into construction and making digital maps and hard copy for the schools that can be updated with demanded. Using GIS will make a huge development in selecting the locations of new schools and also can be applied in different other sectors.

Keywords: *Multi-criteria, GIS, AHP, Al-Diwaniyah, Schools.*

1. Introduction

The education sector is one of the most important sectors of the society. Governments pay special attention to this sector as it represents the real investment in the future of the people [1]. Education statistics are used as an appropriate tool to measure government and community performance in providing a positive environment for children and young people to exercise their right to education [2, 3, and 13].

The selection of any site for a particular project within a specific area is subjected to specific terms, conditions and bases for the activity of this project [4]. As all projects are affected by several criteria, whether direct standards which hinder the establishment, including indirect criteria that would intersect with them in the future [5]. The topic of selecting a site for the establishment of a school is a subject of no less importance than the rest of the projects. Its importance is not limited to the importance of the school [6].

In order to address this problem, Geographic Information System (GIS) was integrated with the multi-criteria decision-making method analysis hierarchy process (AHP) associated standards: Environment/slope, land cover and distance from controlled areas (private and public land, conservation restoration, distance from natural heritage areas and distance from hazardous waste). Safety/distance from flood range, distance from fire stations, distance from police stations and distance from emergency medical services, accessibility/distance from libraries, distance from public high schools, distance from main roads and number of persons under the age of 15 years [7 and 8].

This research aims to find the best locations for primary schools' by creating a model that applies into construction and making digital maps and hard copy for the schools. This can be updated with demanded using GIS with AHP will benefit future generations and decision-makers in shaping future policies in the distribution of Al-Diwaniyah schools. This can be achieved through analytical study of the status of schools in the city in terms of efficiency in their distribution and the conformity of their locations and specifications with global and local standards.

2. Case Study Description

The city of Al-Diwaniyah, the center of Al-Qadisiyah, contains commercial, industrial and educational centers, universities and government institutions. The city is in the north of Al-Qadisiyah (31°55'30"- 32°1'30") N, (44°52'30"- 44°58'30") E. The nature of the land is flat and shallow. The depth of the ground water is lower than the surface level by 2 meters. The population increases with the migration from the countryside to the city caused the continued expansion [9]. Multiculturalism in the city and the diversity of communities in Al-Diwaniyah because of the universities, institutes and educational centers that attract expatriates as show in Figure 1.

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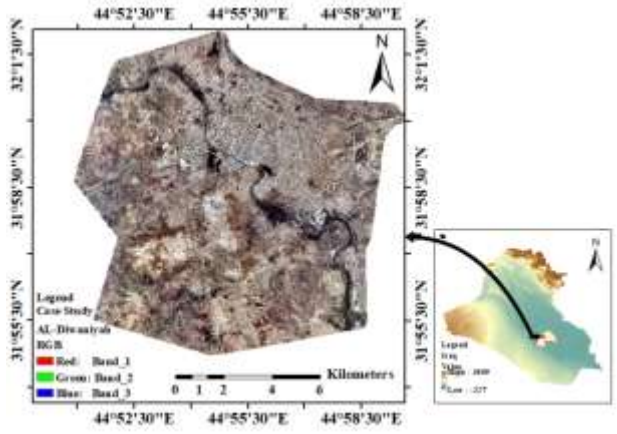


Fig. 1: Case study town of Al-Diwaniyah, Al-Qadisiyah, Iraq

3. Materials and Methods

The research was based on the application of a GIS-based technique, multi-criterion analysis hierarchy process (AHP), data collection, the establishment of a geographical database and digital mapping, Geographic Information System (GIS) data analysis, results and recommendations as shown in Figure 2.

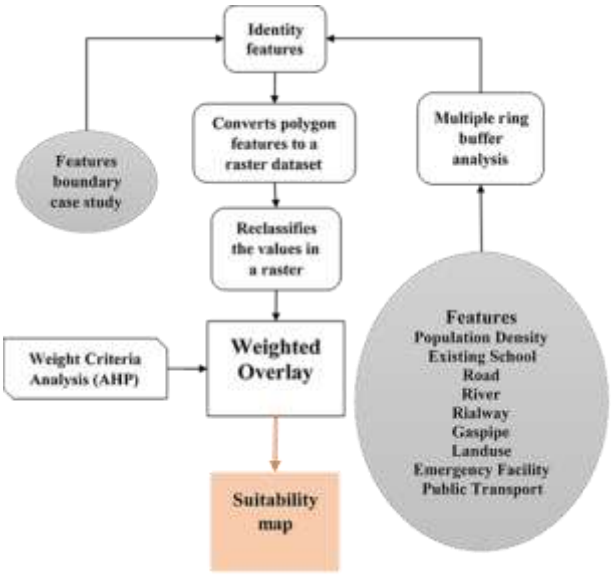


Fig. 2: Methodology model study for site suitable school.

To select the best places for schools, required to determine the criteria that will be worked on, then weighing and calibrating which will arrange the sites based on the degree of the ideal location. The criteria were based on the study area reality.
Determination of the relative weight of the standards: The relative weight of each criterion was given based on its importance in determining the location of the school. This done by extrapolating the opinions of the academics and specializes in the distribution of public services, planning, public works, and education to select the weight for each criterion [10]. The formulation of weights is the most important stage in the spatial analysis, Table 1 shows the criteria that select:

Table 1: Shows the criteria selected

Criteria	sub-criteria	levels sub-criteria
Population density	0 – 1.5 people per km2	**2**
	1.5-44 people per km2	**5**
	44-118 people per km2	**7**
	118 -350 people per km2	**9**
	> 350 people per km2	**0**
Existing School	Buffer 0 – 200 m	**3**
	Buffer 200-500 m	**5**
	Buffer 500-1000 m	**7**
	Buffer >1000 m	**9**
Roads	Buffer 0 – 20 m	**0**
	Buffer 20-150 m	**9**
	Buffer 150-250 m	**7**
	Buffer 250-350 m	**5**
	Buffer 350 – 450 m	**3**
	Buffer >450 m	**1**
River	Buffer 0 – 200 m	**0**
	Buffer 200 – 400 m	**5**
	Buffer > 400 m	**9**
Railways	buffer 0 -500 m	**0**
	> 500 m	**9**
Gas pipe	buffer 0 -250 m	**0**
	>250 m	**9**
Land use	Used lands	**0**
	Unused lands	**9**
Emergency Facility	Buffer 0-300 m	**9**
	Buffer 300-600 m	**7**
	Buffer 600 – 900 m	**5**
	Buffer > 900 m	**0**
Public Transport buffer	Buffer 0 – 200 m	**4**
	Buffer 200-500 m	**6**
	Buffer 500-1000 m	**8**
	Buffer >1000 m	**9**

The matrix is the preferred formula for conjugal comparisons. A matrix is a simple and well-known tool that provides a framework for testing consistency and obtaining additional information by making all possible comparisons and analyzing the sensitivity to overall priorities for changes in governance [10]. The process of hierarchical analysis measures the overall stability of judgments in the calculation of the consistency ratio, and the fixed ratio must be 10% or less. After obtaining the value of the Consistency Index CI, it should compared with the Random Index RI to identify the CR ratio) [11]. As in Equations 1, 2 and 3, the CR stability ratio is closer to zero, the higher the stability 0.1 (10%) If further, the provisions have some inconsistencies, the decision be reviewed as in Tables 2,3 and 4:

m =Number of items in comparison.

CA= column (Criteria) *Row(AHP-1) (1)

$\lambda_{max} = \frac{1}{m}\sum_{i=1}^{m} \frac{(AW)i}{\square_i}$=SUM(CA)=10.112

CI=(λ_max-m)/(m-1) (λ_max (Lambda-9)/9-1=0.041 (2)

Randomness Index, RI= 1.44

CR=CI/RI = 0.023~ 3% (3)

To Check results CR=CI/RI <0.1;"Consistency OK"

Table 2: Matrix values to calculate the stability ratio.

CRITERIA	tio n	in g	Ro ad	Ri ve	il w	as pi	La nd	us ge	nc Tr
Population Density	1	1	1	1	1	1	1	6	5
Existing School	1	1	4	2	1	1	1	5	4
Road	1	1/4	1	1	1	1	1	4	4
River	1	1/2	1	1	1	1	1	5	2
Railways	1	1	1	1	1	1	1	1	1
Gas pipe	1	1	1	1	1	1	1	1	1
Land use	1	1	1	1	1	1	1	1	1
Emergency Facility	1/6	1/5	1/4	1/5	1	1	1	1	2
Public Transport	1/5	1/4	1/4	1/2	1	1	1	1/2	1

Table 3: Values of weights for AHP scales.

	AHP-1	CA	(Weight Criteria)%
Population Density	0.147	1.083	14.7%
Existing School	0.182	1.127	18.2%
Road	0.119	1.252	11.9%
River	0.118	1.024	11.8%
Railways	0.103	0.929	10.3%
Gas pipe	0.103	0.929	10.3%

Land use	0.103	0.929	10.3%
Emergency Facility	0.063	1.555	6.3%
Public Transport	0.061	1.284	6.1%
SUM	1	10.112	100%

Table 4: Values of random stability index (RI).

Dimension	1	2	3	4	5	6	7	8	9
Random Index	0.0	0.0	0.57	0.8	1.11	1.22	1.40	1.44	1.49

4. Analysis and Results

The study reached a number of important results:

The layers of the values of each criterion were converted into layers representing the extent of the spatial adequacy of each individual criterion; several appropriate preliminary models were reached. For example, Figure 3, (A) shows the spatial fit model of the population density standard, where the high suitable sites are the population of (118-350) person per square kilometer shape.

Figure 3, (C) Model of spatial compatibility of the criterion of distance from the roads, where the high sites are suitable for the distance from (20-150 m) network lines as the network of roads extends almost throughout the administrative region.

The model of compliance with the criterion of the distance from the river was demonstrated in Figure 2, (D) which shows more spatial locations as the river penetrates the middle of the region.

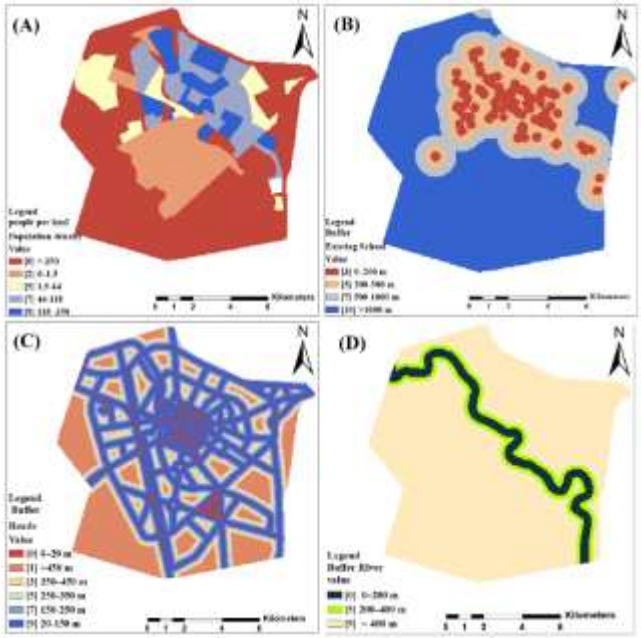


Fig. 3: Layers used in the study, where (A) Population Density, (B) Existing School, (C) Road and (D) River.

The model of compatibility with the criterion of distance from railway was illustrated in Figure 4, (A) which shows more spatial locations, extending almost in the western part of the administrative area. Figure 4, (B) shows that the standard of separation from gas lines is observed in the southwestern part of the study area. The model of compliance with the criterion for distancing from emergency institutions as in Figure 4, (C) which shows more spatial locations, extending almost across the administrative area. Figure 4, (D) reviled spatial fit model for land use criterion for the baseline study area, where we noted that high-suitable sites are currently free of use. Figure 4, (E) shows the model of compliance with the criterion of distance from the Public Transport. It can be concluded that the most suitable spatial locations are not more than (0-200m).

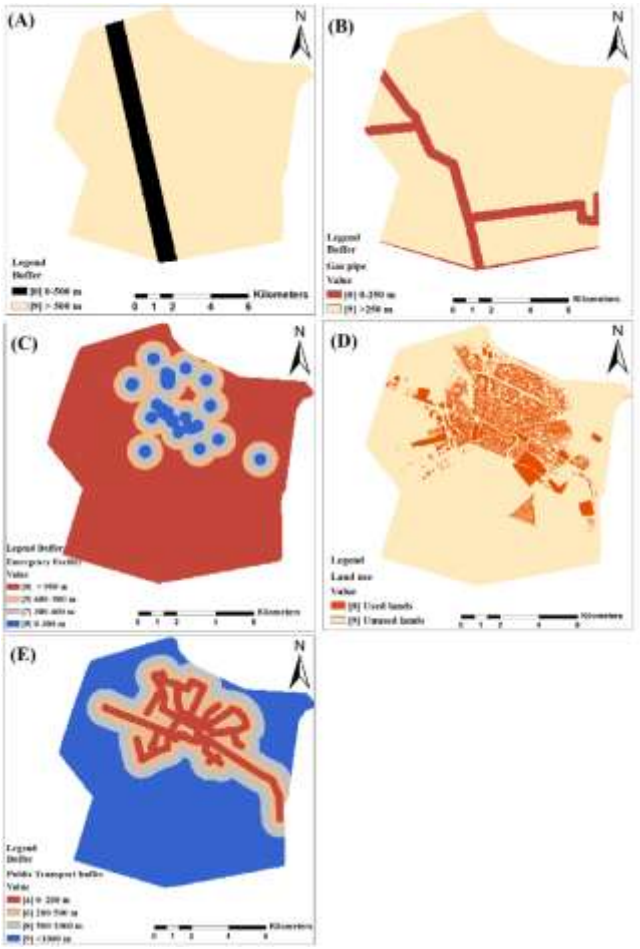
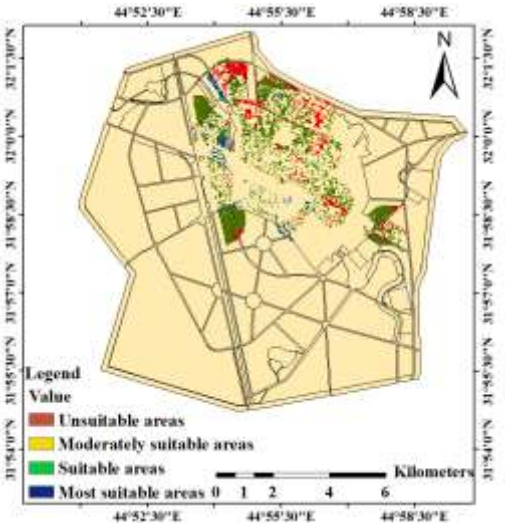


Fig. 4: Layers used in the study, where (A) Railways, (B) Gas pipe, (C) Land use, (D) Emergency Facility and (E) Public Transport.

In Figure 5, the map can be interpreted as it is divided from the least to the most suitable places for the establishment of schools in the city of Al-Diwaniyah, where the red color is the least suitable, the yellow color is suitable medium and the green is suitable and



the highest suit with the most appropriate standards.

Fig. 5: Stability map to distribute the best location for primary schools.

5. Conclusion

The study suggests integrating the multi-standard decision-making methodology. AHP with the GIS technique is an effective method of positioning. Thus, to select the best locations for the primary

school, mainly rely on the opinion of the Committee of Experts of Education Academics and Municipal Engineers. Stability map is shown need schools in the north and center of the city despite the availability of demand due to the high population density. In the south city, not the actual need for schools due to the important criterion population density, which is currently lacking. Geographic information systems employing to document the current locations of schools in the city and reach the most important criteria in the selection of school sites to suit the city of Al-Diwaniyah in particular and the neighboring provinces in general. This can be relied upon to select future school locations and building an appropriate application model to choose the most suitable sites for the establishment of a school and exit from paper and digital maps of the schools can be updated.

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