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A GIS BASED MULTI-CRITERIA DECISION MAKING FOR SELECTING SITES FOR SCHOOLS IN GREATER CAIRO AL SHAIMAA SHAKER ABDELAAL

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Abstract:

Education is one of the basic pillars of human civilization and progress, the school site selection are the most important components of the educational process, this paper concerns on using a GIS spatial analysis tools on school site selection.

There are many problems surrounding schools Egypt, For example, some schools are surrounded by many pollutants such as garbage, workshops, factories and other sources of pollution, there are also some schools located on main roads, which endanger students' lives.

The main problem of this paper that there are no clear criteria for school site selecting to provide maximum safety and provide a good atmosphere for the educational process, the study aims to solve this problem in determining the School site selection and using geographic information systems in selecting the most appropriate location for the establishment of new schools.

The purpose of this study is to develop a public school site selection model using Graphical Information Systems (GIS), the study has used GIS based Multi-Criteria Decision Analysis (MCDA) technology to improve the accuracy of school site selection model and also apply this model to El- Zaytoun district in Cairo governorate, how to implement this model, how to use it and produce a map showing the land's validity to establish new schools.

Keywords: Geographic Information system (GIS), School site selection, Multi Criteria Decision Analysis (MCDA), Weighted Overlay Analysis (WOA).

1- Introduction:

Officials face difficult moments when decisions are made, especially with regard to treatment of lack of services like (education, health, infrastructure ... etc.), in light of the scarcity of opportunities and the lack of resources. (Wang, 2009)

The data and information and the extent of availability are the most important pillars in making sound decisions towards the school site selection and achieving their adequacy in comparison to the needs of the population, here is the need to establish GIS databases to store the huge collected data that will be used in the School site selection GIS Model.

The development of the service defines a set of criteria (economic, social, political, environmental, cultural, public, etc.) through which this development decision is reached and the available alternatives are identified.

All of the above shows the need to prepare a comprehensive database that can be reviewed immediately and accurately for all available alternatives and information layers, Geographic Information System (GIS) is one of the important tools in this framework, and the study will depend on it.

GIS is a technological tool for data mining, storage, processing, and classification as layers, for analysis, reporting, and production of maps and geo-processors that contribute to decision making more closely, GIS is the basic platform through which data can be easily stored, A package of applications and digital models that benefit specialists in all fields, which helps the decision-maker to take the proper action in solving any problem encountered.(Ahmad A. Asker, 2015)

Data is one of the main pillars in the application of the digital model of school site selection, the accuracy and efficiency of the data are the most important factors for the successful implementation of this model, the data sources on which the digital model relies are based on three basic sources. High resolution spatial images such as Google Earth, Bing, Yahoo and other free space images. The third of these sources are available through surveying and data collection from field work.

This requires a comprehensive and accurate database that can be reviewed immediately and accurately for all available alternatives and information layers. Geographic Information System (GIS) is one of the most important tools in this framework and will be the basis of the study.

The Site selection process is subject to reference, the decision to Site selection is a particular service requires setting the criteria for establishing and settling the service, the

characteristics of the service recipient, their geographical distribution, substitutions of the location of the service, topography in the candidate areas. (Ahmad A. Asker, 2015)

The main objectives to the study is to build a digital model using GIS to build a schools site selection based on a set of planning criteria and extract a layer named Land suitability for schools within any area that determines the best places to establish the school and apply this model in El-zayton district in Greater Cairo - Egypt.

2- using Geographical Information System (GIS) in school site selection:

GIS have a powerful tools to develop that according to the Site selection especially in Schools, and also GIS is considered a huge platform to developing a lot of applications in school site selection, and the GIS is very helpful tool in produce the Maps of school land suitability. (Thapa, 2008)

GIS has many powerful tool in implementing a school site selection subject, especially a tools of spatial analysis technique that manipulate and convert a vector data into raster format, and handle all criteria of school site selection and ranking this criteria using a weighted overlay tool to produce a layer of land suitability for schools, that determine all sites that suitable to locate a new schools in it.

3- GIS applications in School Site selection:

The Geographical Information System is considered one of the most important tool to building a business model for a school site selection, implementing and development an attribute data and a spatial data to produce a land suitability for school map. (Zucca, 2008)

The use of GIS provides a free platform to handle a satellite images to audit, make a quality control and update a spatial data, one of the most important capabilities of using Geographical Information systems that is to facilitate the use of planning criteria in site selection for school with a lot of powerful tools as a weighted overlay analysis. (Wang, 2009)

4- The proposed GIS conceptual design for School Site selection

The main objective of this research is to build a conceptual design model depends on using a planning criteria to make a site selection for school and produce a land suitability map for schools then apply this model by using a Geographical Information system. (Ahmad A. Asker, 2015)

First step is to determine the objectives of the study very clear, and determine the planning criteria to make a site selection for school by surveying a literature Reviews and viewing a lot of applications in this field, Second step is to collecting attributes and spatial data that helps in handling the multi-criteria for site selection for school by make a field work for a pilot area, third step is to build a Geographical Data base, fourth step is to building a

GIS model to handle a site selection and produce a land suitability map for school, then finally applying this model into El-zayton District in Greater Cairo - Egypt. (Richard, 2005)

5- building a GIS surveillance conceptual model for School Site selection

5.1 Study preparation

The process of school site selection is concerned about solving many problems, which is a hindrance in the regularity of the educational process either to the remote location of the student residence or lack of safety elements on the site and the uncommon choice of the school site is a waste of funds and to benefit from the available resources, The study is based on GIS as an effective tool to summarize and visualize geographical differences to determine the optimum location and accessibility of the school. This instrument can effectively assist government organizations. The essence of the site's problems is to locate a range of facilities in a given site area to provide some services to a group of actors that are supposed to sponsor some of these facilities, this means that the information referred to geographically Represents the basic condition for modeling and solving such problems. (Rafael, 2009)

5.2 Determination of objectives

Building a digital model to make a school site selection for schools will help in the development of the educational process, and to achieve the following objectives:

- a-Demonstrate the effectiveness of using a GIS in school site selection studies, which will contribute to the identification of optimum sites for the establishment of new schools.
- b- Build a Digital Model with GIS that using Multi Criteria to school site selection to produce a distributed map for land suitability for suggested school sites.
- c- Apply this GIS Model into el-zayton district in greater Cairo Egypt.



Figure (1) main objective

5.3 Survey of all Elements

The process of data collection is divided into two parts, the first part is survey the multi criteria for school site selection, using the available resources and Literature Review as (masters, PHDs, Periodicals, Questionnaire, internet sites etc.), such as the master of Ahmad A. Asker that present a Spatial Analysis of Governmental schools in Gaza City using GIS techniques and implements a schools Multi-criteria site selection such as (Environmental Pollutants, Main roads, infrastructure, medical services etc.), and build a GIS model that ranking this criteria and produce a most suitable lands for schools.

The second part is mainly focuses on collecting spatial data that will be used from the model from a City maps (scale of 1:5000), the high resolution Satellite images, field works, the spatial data include (Residence, main streets, Utilities, Ambulance, Police stations, Firefighter points, Factories, Manufacturing workshops, Noise sources, Mobile towers, Random & public car Stations, Public libraries, gas stations, Hospitals and health services, Recreation places).

ser	Standard	Relative weighted overlay for sub- classes			Weighted overlay value	Base factor	Base distance
1.	Housing	Less than 400 m 4%	400 -800 m	More than 800 m	4%	-1	400
2.	Main Streets	Less than 100 m 0	100 -200 m 7.5%	More than 200 m 15%	15%	+1	100
3.	Infrastructure	Fully available 4%	Partially available 2%	Not available 0%	4%	+1	1
4.	Services	Less than 500 m 28%	500 - 1000 m 14.5%	More than 1000 m 0	28%	-1	500
5.	Pollution	Less than 500 m 0	500 - 1000 m 24.5%	More than 1000 m 49%	49%	+1	500

Table (1) criteria for site selecting of school

Source// Ahmad A. Asker, 2015.

5.4 Analysis and Design

The planning criteria for school site selection were categorized into five main criteria with weights of each of them as shown in Table (1), that all relative weights that express the sub-classes of each criteria, each sub-classes is determined by the distance that separates each cell within the study area and the closest elements that represent this criteria (eg roads, etc.), the relative weight is calculated by the following equation,

The (RWO) represents a Relative Weighted Overlay, (B.F) acts as the base factor that among two values (-1 or +1) the Positive factors to create a new Schools that have a value of (+1), the negative factors for establishing a new schools have a values of (-1), while a (b. dist) is the distance that considered as a good value for the criteria, The following are the criteria for selecting a school location: (A. Asker, 2015)

A. Housing:

The distance to the student from residence to school is one of the most important factors determining the location of the school, the longer this distance, the more negative it will affect this criterion, which represents about 4% of the total relative weights of the different planning criteria for the location of the school.

The relative weight of the housing factor is about 4% if the distance between the dwelling and the school is less than 400 meters, it is about 2.8% if the distance varies from 400 to 800 meters, if the distance exceeds 800 meters, and the relative weight is about zero.

B. Main streets:

The distance between schools and the main streets are a major criteria for planning the school's location, the main streets are the sources of danger to the students, so it is necessary to move away from them in order to ensure the safety of the students.

If the distance between the school and the main roads is more than 200 meters, the relative weight of this standard is about 15%. If the distance ranges from 100-200 meters to about 7.5%, the distance of 100 meters is about zero.

C. Infrastructure:

The availability of the infrastructure of drinking water, electricity, sanitation and communications is one of the criteria for selecting the school site. If all these facilities are available within the plot, the full rate of this standard will be 3% of the total relative weights. 1.5% of the total relative weights, but if the infrastructure is not available within the plot, the relative weight of this standard is about 0%.

D. Services:

The service worker should be available next to the piece of land, such as the availability of health services (hospitals, health units, ambulance), security services (police stations, fire brigade, police departments, etc.). If the service is complete in an area not exceeding 500 meters, about 28% of the total relative weights. If, in circumference of 500 to 1000 meters, the plot takes about 14.5% of the total relative weights, and if these services have a circumference of more than 1 km.

E. Pollution:

Sources of pollution affect the operation and quality of the educational process and the sources of pollution should be available from sources of audio such as noise centers such as public and private car parking and sources of air pollution such as workshops, factories and visual pollution as garbage collection sites and other pollutants that affect the course of the educational process.

The location of the school must be kept away from pollution sources at a distance of not less than 1 km. The total land weight of the pollutant dimension factor of 49% of the total relative weights of all the criteria specified for the location of the school shall be calculated. Ranging from 500 meters up to 1 km, the value of this standard is about 24.5% of the total relative weights, if however, the pollutant reaches the plot for a distance of less than 500 meters, the relative weight of this standard is lost.

5.5 Policy and Plan formulation

The numerical model, as shown in Figure (2), depends on the analysis of the characteristics of the study area in the group of classes described in the form and the application of the set of parameters and criteria for school site selection in El-zayton district:



Figure (2) GIS conceptual Design for School Site Selection

A. Rasterizing Data:

At this stage, the layers are transferred from the vector format to the raster format so that these layers can be used in the next steps in the digital model using the spatial analyst, this process is shown in Figure (2) using the Euclidean Distance process.

B. Reclassification layers:

At this stage, the raster cells categorized into sub-classes according to distance between cell and features that present a certain criteria so that the digital model can calculate the weight of each cell and save its value. As shown in Table (1), all classes on which all layers should be classified in the digital model, The Reclassify tool is used from within the Arc toolbox within the ARCMAP program.

C. Weighted Overlay Analysis:

In this stage, all categories that were built in the previous phase (Reclassification) are given a relative weight until a digital layer is constructed to show the validity of the land to choose the location of the school, which extends from zero (unsuitable land to choose the location of the school), value (1 - 5) are the middle ground for selecting the school location.

The values (6 - 8) are good enough to choose the location of the school, to value 9, which is excellent land to choose the location of the school.



Figure (3) El-zayton location & geographic Elements

6- Case Study: Applying a GIS Site selection Conceptual Model for School Site selection in El-zayton District - Cairo - Egypt

6.1 case study overview

Collect all spatial data for El-zayton district (Housing, Main Streets, Infrastructure, Services, Pollution), by field work and other resources, then apply a GIS model using this data to produce the land suitability map for school and then support the decision maker in suggestion a new suitable sites for establishing a schools.

As shown in figure (2) the distributed maps of all elements in el-zayton district in a GIS vector format that will be used in this model

6.2 Spatial Analysis on El-zayton district

By applying the GIS model in El-zayton district that passes through 3 level:

a) Rasterizing Data:

In this step a GIS model convert all collected vector data to Raster data using a spatial analyst extension (using ARCMAP software) by running an Euclidian distance tool, to facilitate using the collected layers into the model.

b) Reclassification Layers:

The GIS model use the raster layer that converted from the previous step to class's raster depending on a planning multi-criteria that located the school site selection.

c) Weighted overlay:

This process is one of the most important processes carried out in this digital model where the relative value and weight of each cell is given to represent the extent of the advantage of this cell to build a school site selection by translating each layer to a relative weight represents the priority of this layer and then collect these values to represent the relative weight of this cell.

For example the main streets in El-zayton district converted after rasterizing data to raster layer each Cell into this raster layer have a distance value between each cell and the nearest main street, then this raster layer converted into three sub-class according to distance between cells and main roads, the first sub-class has a range distance less than 100 meter that have code value of (1), the second sub- class have a code value of (2) that have a distance between (100 - 200 m) from cell to main street, and last sub-class that have a distance between cell and main road more than 200 meter that have a code of (3).

In the weighted overlay process (a final part of weighted overlay) the coded value of (1, 2, and 3) is converted to ranking (1 - 9), that the code of (3) scale to rank of (9), and the code value of (2) is scale to rank of (4), and the final code of (1) is scale to rank of (1), then finally sum ranking from all criteria and build the land suitability layer that classify the suitable lands for school site selection that classified into the following sections:

1. Section I (Premium class): All sections include value bearing from 9 to 8.

- 2. Section II (good class): All sections including value bearing are from 7 to 6.
- 3. Section III (Acceptable Class): All sections including value bearing are from 5 to 4.



4. Section IV (Bad class): All sections include value bearing from 3 to 1.

Figure (4) Land suitability for school map

6.3 land suitability Map For school site selection

The final output of the GIS Model of School Site Selection that showing in figure (4) that shows El-zayton district classified into degrees depends on the availability of establishing a school, which are classified into:

a) Poor Lands:

They represent areas that have land suitability values of (zero - 4), it's concentrated into the North and in the middle of El-zayton district, and this areas are not qualified to establish a school in this areas.

b) Medium validity lands:

It represents areas that have land suitability values of (5 - 6), it's concentrated into the south and in the middle of El-zayton district, and this areas are medium qualified to establish a school in this areas.

c) Good validity lands:

It represents areas that have land suitability values of (7 - 8), it's not existed in El-zayton district.

d) Excellent validity lands:

It represents areas that have land suitability value of (9), it's not existed in El-zayton district.



Figure (5) Digital Model Functions

7- Discussion

This paper aims to introduce a digital model that depends on a geographic information systems and using spatial data and detailed maps of the study area in determining the proposed locations for the establishment of schools.

Using this model, the user can view the detailed data on the study area and update it and insert it in a series of spatial and digital analyses and facilitate the use of all the planning multi-criteria that will help in producing the map of the land suitability for the establishment of new schools and then identify all areas suitable for the establishment of schools Reports and statistics on those areas, which make it easier for the decision maker to choose the location of the school.

8- Conclusion and Future work

This proposed model introduce this conclusions:

- 1. Relying on information systems applications, especially geographic information systems, in location studies, providing time and effort, as well as a tool to confront corruption.
- 2. Emphasis on the integration of the applications of information systems in the choice of the location of the schools, including the application that ended the study.
- 3. Apply the digital model for the study is Progress of the status quo to the decisionmakers regarding the school site selection for El-zayton district as this application was prepared based on planning criteria.
- 4. Expanding applied of this type of scientific studies that apply school site selection for other districts in Cairo in the present time, and publishing them in universities and research centers that combine theoretical and applied studies with practical results that can be utilized in all aspects of life.
- 5. The speed of activation of the data dissemination and circulation law to facilitate the availability of the necessary data for scientific research and the application of governance procedures in institutions in Egypt, especially those responsible for localization of services delivery sites, including educational services.
- 6. Expand production and reliance on land suitability maps in all work sites in the Arab Republic of Egypt.
- 7. The preparation of an Egyptian code for the selection of school sites as international standards often do not accept the application to some areas, to help researchers in Egypt to identify the multi criteria for school site section, and it is best to put each country's own standard code for the establishment and selection of sites of different services, including schools of all kinds.
- 8. The preparation of a spatial information centralized bank at the state level that provides information on the extent to which each region needs a particular type of school, the excess density in each region and the quality of education required, and linking your zakl to demographic data for each region

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