International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Geospatial Analysis and Optimization Techniques to Select Site for New Business: The Case Study of Washtenaw County, Michigan, USA

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Abstract

Geographic information system (GIS) can provide an optimal solution in case of site selection. Therefore, using GIS is a common practice for spatial decision support. The study area and the purpose of this study was to find the best location for a new Wal-Mart store in Washtenaw County, Michigan, USA. Population, distance from existing stores, land uses, and slope were factors that considered in this research. Moreover, these factors weighted, based on their importance. Then, by using the raster calculator, the best location for the new store was defined. Based on the assumption; the results indicated that the optimal location should be in the northwest part of the city of Ann Arbor, around the highway.

Keywords: Geographic information system (GIS); Site selection

1. Introduction

When planning to construct a new building, whether for a commercial, research, medical, or other business, an optimal solution for where to put it is the target for in all such cases. Choosing the location or appropriate place for a business is very important not only to reduce costs and risks but also to increase profits. This paper presents a report on the search for the optimal or “suitable” location, for a new Wal-Mart store in Washtenaw County, Michigan, USA. The work was done using spatial analysis in ArcMap plus tools such as classifying, buffer, distance, and raster calculator.

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A geographic information system (GIS) was used for this work. According to the authors in [1], GIS "integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information" (p. 38). GIS provides a useful tool for managing and coordinating many project elements, such as project tracking, cost estimating, project cortical path method (CPM), and site selection. The GIS can generate graphic maps, including charts, bar charts, histograms, and scatter plots, which can be very useful for engineers [2]. Information Systems (IS), including GIS, have gained importance because of the increased complexity and globalization of many projects. According to [3], IS helps in:

- Providing an IT backbone,
- Exchanging information and data,
- Managing vast amounts of information, and
- Proving the optimization techniques for the global networks.

1.1 Why spatial analysis?

What is Spatial Analysis? According to [4], "the emphasis of Spatial Analysis is to measure properties and relationships, taking into account the spatial localization of the phenomenon under study in a direct way"(p. 416). Spatial Analysis is the most useful application for industrial engineers and urban planners. This tool can help to analyze the geo-data in order to make better decisions about many problems, such as the optimal place, the best route, and the highest level of surface for a new building.

1.2 Objective of the project

The purpose of this study was to find the best location for a new Wal-Mart store in Washtenaw County, Michigan, USA. Many factors had to be considered in this project, such as population, distance from existing stores, land uses, and slope. After that consideration, these factors had to be weighted, based on their importance. Then, by using the raster calculator, the best location for the new store was defined. This process led to the optimal location for the new Wal-Mart store.

1.3 Literature review

According to [5], the term GIS "has come to symbolize a technology, an industry, a way of doing work" (p. 177). The author of [6] offered a similar definition when he wrote that a "geographic information system is an organized collection of computer hardware and software designed to efficiently create, manipulate, analyze, and display all types of geographically or spatially referenced data" (p. A-1). In addition, the GIS can be used as a decision support system by using spatial data to solve environmental problems. Three elements in using spatial data were defined by [6]:

- Input (encoding)
- Data Management (storage and retrieval)
- Output (Maps) (p. A-2)

The author in reference [7] combined GIS-based spatial analysis and optimization techniques to find the best facility location. He used two approaches in his study. First, multi criteria modeling was used to identify the candidate sites for schools in the area. The second approach was to identify the optimum sites among those chosen in the first approach. Doing this, the best location for the school was found. Moreover, this methodology can be used for other types of services, such as health centers, stations, among others.

The authors of [8] used a GIS based model to select the best municipal solid waste collection site in Nikea, a suburb of Athens, Greece. The methodology they used in their study was GIS technology, which provided modeling for decision makers in this research. ArcGIS's Network Analyst was used to improve waste collection and transport in Nikea. The researchers [8] compared two scenarios (a) one considering vehicle routing or bins, and (b) a routing optimization. The result showed that both scenarios had savings compared to the current situation for waste collection and transport in Nikea.

2. Research Methodology

The GIS-based optimization technique was used to find best location for a new Wal-Mart business in Washtenaw County, MI, USA. The GIS provided effective tools to manage and analyze spatial-based data. The methodology used in this work consisted of the following five steps :

1. Collect and Input data
2. Derive datasets of distance, slope, and buffer.
3. Reclassify the datasets.
4. Weight those that are more important to consider (Assumption).
5. Combine the datasets to find the most suitable locations (Raster Calculator).

2.1 The study in Washtenaw County, Michigan, USA

This paper presents how the optimal, or "suitable" location for a new Wal-Mart store in Washtenaw County (Fig. 1), Michigan, USA was determined. The work was done using spatial analysis in ArcMap and other tools, such as classifying, buffer, distance, and raster calculator.

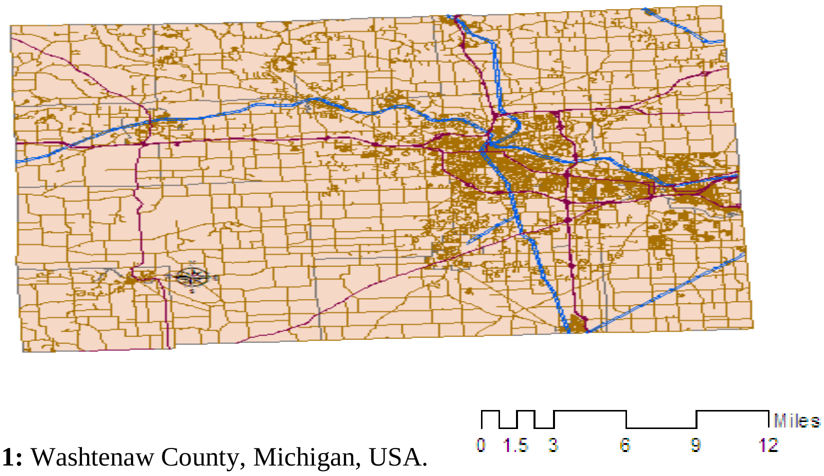


Figure 1: Washtenaw County, Michigan, USA.

2.2 What are the needed data, and where were they found?

In this research, five types of data were used. All these data were available on the Michigan government website and the Environmental Systems Research Institute (ESRI) website, which provides all geographical data. The following steps were done to download data to ArcMap:

The first step is to go to www.michigan.gov From there, find the following:

- The Michigan Geographic Data Library
- Geographic Extent
- http://www.mcgi.state.mi.us/mgdl/?action=ext
- County: Washtenaw
- Washtenaw Geographic Extent

The next step is to download all the following data:

- MI Geographic Framework Transportation (v11a)
- 1992 National Land Cover Dataset
- Digital Elevation Model (DEM).

After downloading the data, go to www.esri.com

- Download Census 2000 TIGER/Line® Data
- Michigan
- Washtenaw.

Then, download the following:

- Block Groups 2000

After that, create a new shipfile for the existing Wal-Mart store in Washtenaw County and Edit

- Start Editor
- Select the address and add the point for the existing Wal-Mart store.

3. Results

3.1. Input datasets

In the first step, the input data that were used were defined. The datasets needed for this were: land-use, elevation, existing Wal-Mart store, blackgroup population, and transportation (roads and highways).

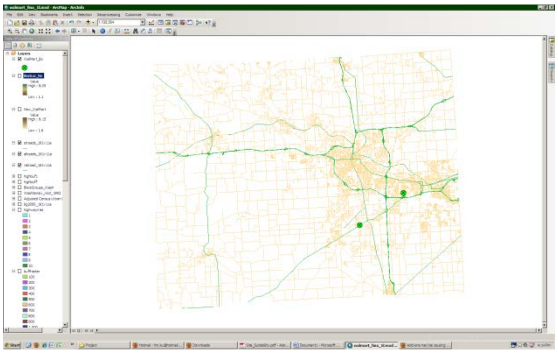


Figure 2: Transportation and existing Wal-Mart store

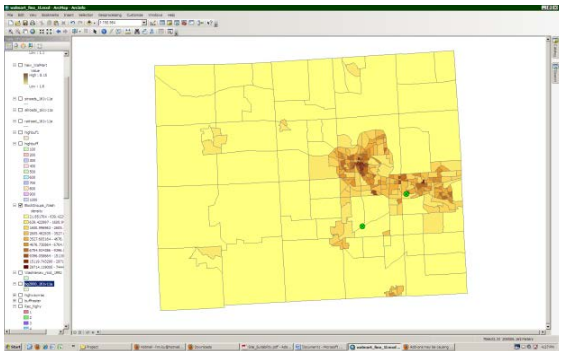


Figure 3: Blackgroup population

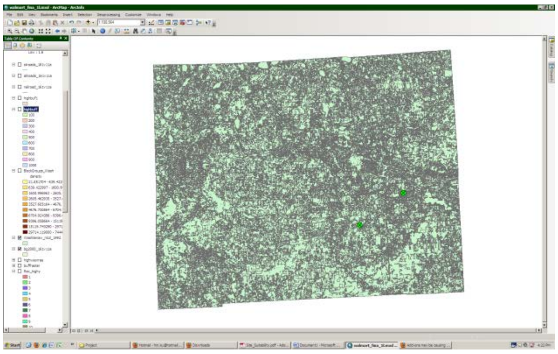


Figure 4: Land Uses

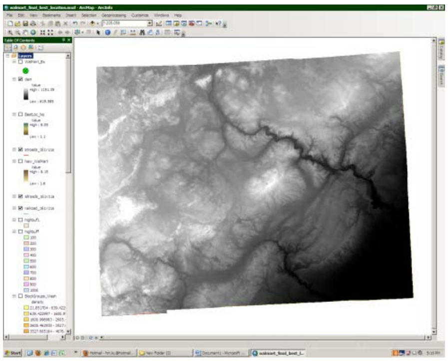


Figure 5: DEM

3.2. Derive datasets of distance and slope and buffer.

The next step in the suitability model was to derive data from the input datasets as in the following:

- Slope of the DEM
- Distance from the existing W-M store
- Buffer around the highways
- Population (From joining the cense with the blockgroup, then creating a new layer)

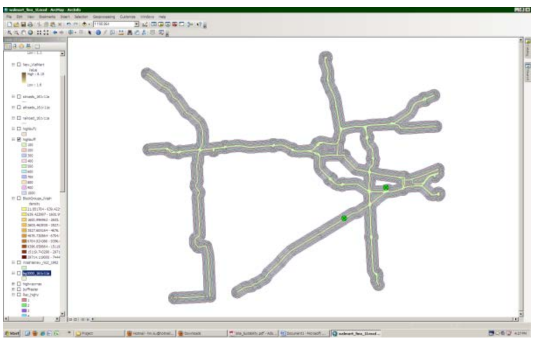


Figure 6: Highway buffer

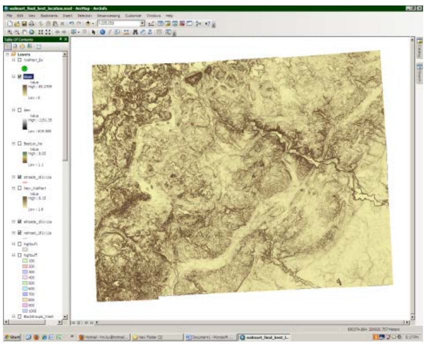


Figure 7: Slope

3.3. Reclassify datasets.

In this step, the datasets need to be combined and given a common scale. To do this, each dataset needs to be reclassified to a common scale. This scale was 1-10, which meant 10 was the best and most suitable location for this project.

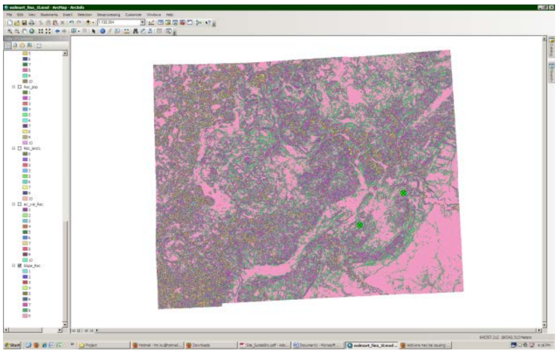


Figure 8: Reclassify Slopes

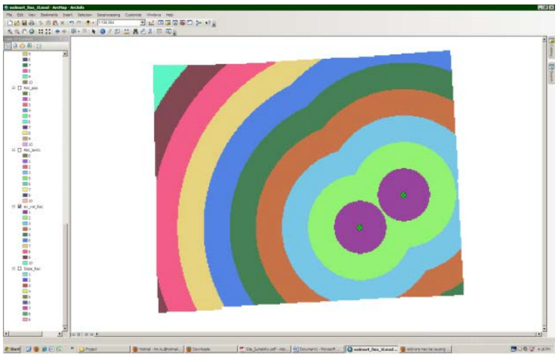


Figure 9: Reclassify Existing Store

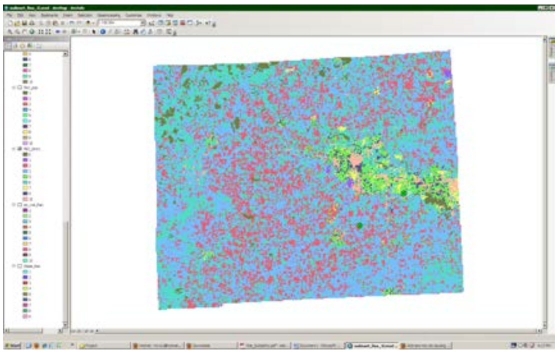


Figure 10: Reclassify Landuse

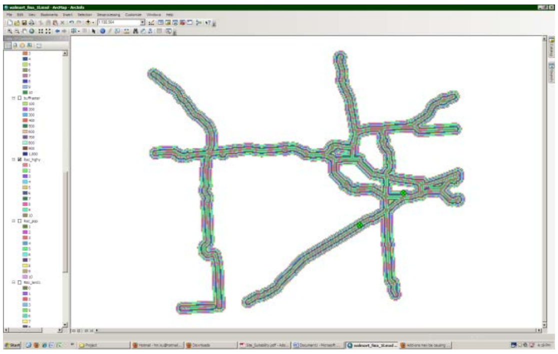


Figure 11: Reclassify Highway

3.4. Weight those that are more important to consider.

All data for a specific common scale to the datasets, where higher values mean "more suitable" within each dataset, were reclassified. Then, all datasets were combined to find the most suitable locations by weighting each one by its importance. It was assumed that the location for the new store should be close to a high-population area, near the highways, with less elevation, zoned for commercial land use, and far from the existing Wal-Mart. To do that, the layers were given the following percent influence (each percentage was divided by 100 to normalize the values):

3.5. Reclassification

- Reclassify distance to existing stores "ex_wal_Rec: " 0.25 (25%)
- Reclassify distance to highways "Rec_highy:" 0.10 (10%)
- Reclassify land use "REc_land1:" 0.20 (20%)

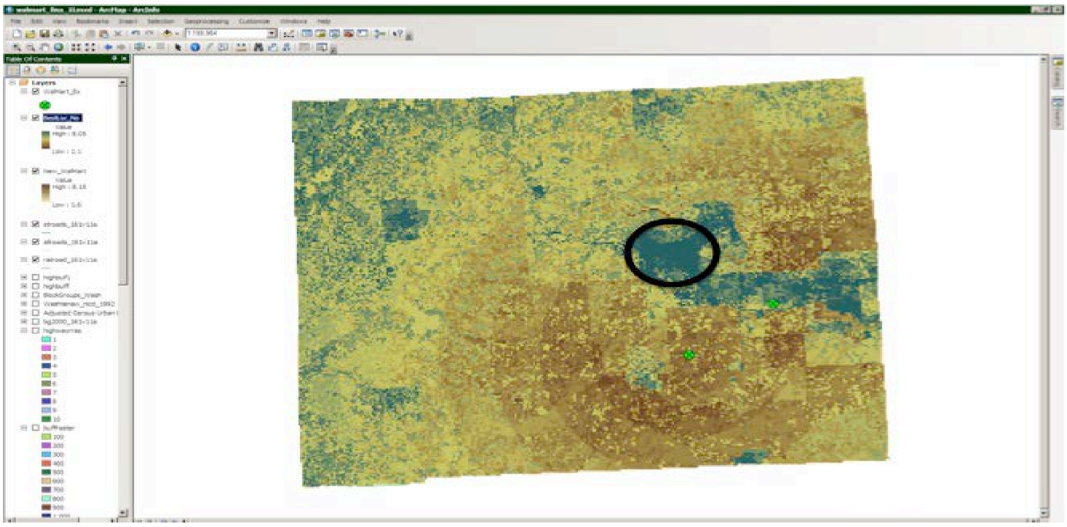
- Reclassify population “Rec_pop:” 0.4 (40%)
- Reclassify slope "Slope_Rec:" 0.05 (5%)

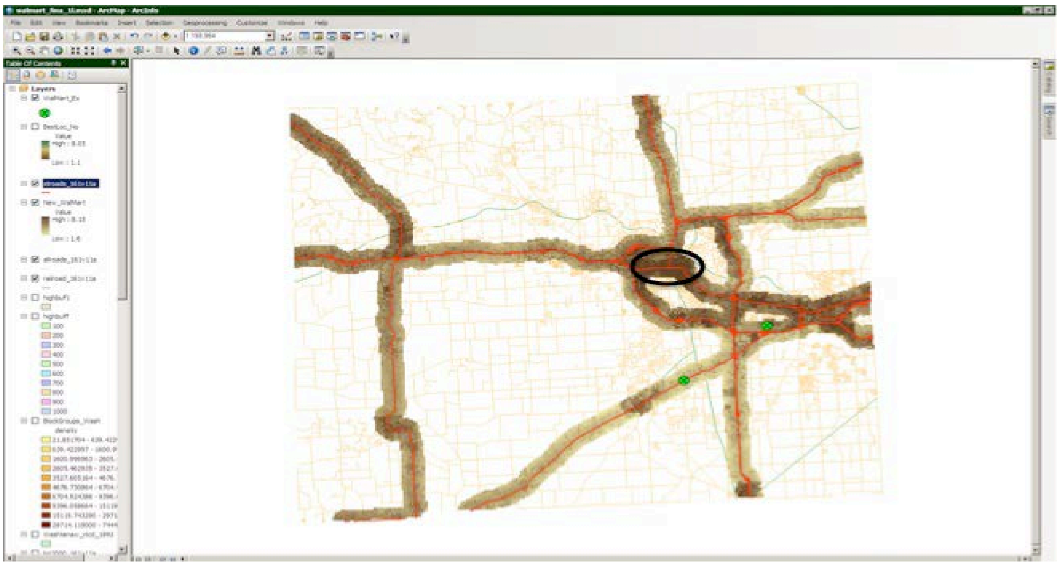
3.6. Combine the datasets to find the most suitable locations.

The next step was to calculate these layers using the Raster Calculator. To do this, click the Spatial Analyst dropdown arrow and then click Raster Calculator. The weight of each layer was then entered as follows:

]"Rec_highy" * 0.1 + "Rec_pop" * 0.4 + "Slope_Rec" * 0.05 + "REc_land1" * 0.2 + "ex_wal_Rec" * 0.25

The following show the results





4. Conclusion and recommendations

In this project, Geospatial analysis in ArcGIS technology was used for the development of a methodology for the optimization of a selected new Wal-Mart store in Washtenaw County, Michigan, USA.

The method used various geographical data (Land use, DEM, slope, highway map, population, and existing store). The results indicated that the optimal location should be in the northwest part of the city of Ann Arbor, around the highway. This site was based on the assumption that it would have a good chance to make the new business profitable. The project demonstrated the value of the site selection techniques of geospatial analysis technology, and that it is capable of guiding decision making in this situation. It is suggested that future work should focus on techniques of choosing elements that can be considered in a similar study, for example, the place of warehouses or similar businesses or markets.

As the results show, geospatial analysis in ArcGIS provided a support system upon which to base decisions. The researcher recommends that this type of method should be used to support decisions for any site selection project.

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