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A GEOGRAPHIC INFORMATION SYSTEMS-BASED DECISION SUPPORT SYSTEMFOR SITE SELECTING OF CINEMA: AN EXAMPLE FROM TEHRAN, IRAN

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ABSTRACT

The aim of this study is to model site selection of cinema center in Tehran which is the most populated city in Iran. Since Tehran has been attracting a large population from smaller cities and rural areas, it has caused a considerable increase in the population of Tehran. The growth in population and the enormous youth of people create new spending demand areas. This is the most powerful motivation to generate new sites in the city for locating cinema centers. A number of conflicting qualitative and quantitative criteria such as: accessibility, Population, distance to faults and land use exist for evaluating alternative sites. Qualitative criteria are often accompanied by ambiguities and vagueness. The study proposes a combined GIS-MCDM methodology. Fuzzy Analytic Hierarchy Process (AHP) is utilized for assigning weights of the criteria for site selection and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is used to GIS overlay and to determine the most suitable alternative using these criteria weights. The study was followed by use geographic information systems technology to assess alternatives and to identify potential locations in Tehran for cinema centers.

KEYWORDS: Site selection, Analytic Hierarchy Process (AHP), cinema center, Geographic Information Systems (GIS), TOPSIS, Fuzzy AHP, Triangular Fuzzy Number (TFN), Multiple Criteria Decision-Making (MCDM)

Site selection requires consideration of a comprehensive set of factors and balancing of multiple objectives in determining the suitability of a particular area for a defined land use. The selection of an industrial site involves a complex array of critical factors drawing from economic, social, technical and environmental disciplines. Traditional decision support techniques lack the ability to simultaneously take into account these aspects. Within the framework of GIS, MCDM models have been increasingly applied in the last five years as a useful methodology for spatial decision support in land-use related problems. Several approaches to integrating GIS with MCDM models have been developed, ranging from a simple integration based on loose coupling of one or more MCDM models with a GIS (Carver, 1991; Pereira and Duckstein, 1993; Jankowski and Richard, 1994; Jankowski, 1995), to a closely integrated system where MCDM models become an integral part of the GIS (Janssen and Rievelt, 1990; Eastman, 1997; Tkach, 1997; Semih Onut et al., 2010).

MATERIALS AND METHODS

In The methodology of the study consists of two parts. In the first part, we use the Fuzzy AHP to calculate criteria weights. In the second part, we apply TOPSIS to rank and select the alternatives in geographic information systems. Theoretical descriptions of the Fuzzy AHP, TOPSIS and GIS are elaborated in the following subsections.

Fuzzy AHP: In the proposed methodology, the AHP with its fuzzy extension, namely fuzzy AHP, is applied to obtain more decisive judgments by prioritizing the machine tool selection criteria and weighting them in the presence of vagueness. There are various fuzzy AHP applications in the literature that propose systematic approaches for selection of alternatives and justification of problem by using fuzzy set theory and hierarchical structure analysis. Decision makers usually find it more convenient to express interval judgments than fixed value judgments due to the fuzzy nature of the comparison process (Bozdag et al., 2003). This study concentrates on a fuzzy AHP approach introduced by Chang (1992), in which triangular fuzzy numbers are preferred for pairwise comparison scale. Extent analysis method is selected for the synthetic extent values of the pairwise comparisons. Some papers published (Kahraman et al., 2003; 2004) used the fuzzy AHP procedure based on extent analysis method and showed how it can be applied to selection problems. The outlines of the fuzzy sets and extent analysis method for the fuzzy AHP are

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given below. A fuzzy number is a special fuzzy set F = {(x,lF(x),x 2 R}, where x takes its values on the real line, R: _1 6 x 61 and lF(x) is a continuous mapping from R to the closed interval [0, 1]. A Triangular Fuzzy Number (TFN) expresses the relative strength of each pair of elements in the same hierarchy and can be denoted as M = (l,m,u), where l 6 m 6 u. The parameters l; m; u; indicate the smallest possible value, the most promising value and the largest possible value respectively in a fuzzy event. Triangular type membership function of M fuzzy number can be described as in Eq. 1:

$$\mu_M(x) = \begin{cases} 0 & x < l \\ (x-l)/(m-l) & l \le x \le m \\ (u-x)/(u-m) & m \le x \le u \\ 0 & x > u \end{cases} \qquad (1)$$

when l = m = u, it is a nonfuzzy number by convention.

A linguistic variable is a variable whose values are expressed in linguistic terms. The concept of a linguistic variable is very useful in dealing with situations, which are too complex or not well defined to be reasonably described in conventional quantitative expressions (Zadeh, 1965; Zimmermann, 1991; Onut et al., 2009).

In this study, the linguistic variables that are utilized in the model can be expressed in positive TFNs for each criterion as in Fig. 1.

TOPSIS for MCDM

Multiple Criteria Decision-Making (MCDM) is used to select a project from several alternatives according to various criteria. The technique for order preference by similarity to ideal solution (TOPSIS) was first developed by Hwang and Yoon (1981) based on the concept that the chosen alternative should have the shortest distance from the Positive Ideal Solution (PIS) and the farthest from the Negative-Ideal Solution (NIS) for solving a multiple criteria decision-making problem. Thus, the best alternative should not only have the shortest distance from the positive ideal solution, but also should have the largest distance from the negative ideal solution. In short, the ideal solution is composed of all best values attainable of criteria, whereas the negative ideal solution is made up of all worst values attainable of criteria. The calculation processes of this method are as follows (Chen and Tzeng, 2004):

Normalize the evaluation matrix: the process is to transform different scales and units among various criteria into common measurable units to allow comparisons across the criteria. Assume x_{ii} to be of the evaluation matrix R of alternative i under evaluation criterion j then an element r_{ij} of the normalized evaluation matrix R can calculated by many normalization methods to achieve this objective.

- Construct the weighted normalized evaluation matrix: we cannot assume that each evaluation criterion is of equal importance because the evaluation criteria have various meanings. There are many methods that can be employed to determine weights, such as the eigenvector method, weighted least square method, entropy method, AHP, as well as linear programming techniques for multidimensional of analysis preference (LINMAP). The selection of method depends on the nature of the problems. The weighted normalized evaluation matrix can be calculated by multiplying the normalized evaluation matrix r_{ij} with its associated weight w_j to obtain the result $V = [w_j r_{ij}] = [v_{ij}]$.
- Determine positive and negative ideal solutions: the positive ideal solution A^+ indicates the most preferable alternative and the negative ideal solution A^- indicates the least preferable alternative.
- Calculate the separation measure: the separation from the positive and negative ideal for each alternative can be measured by the n-criteria Euclidean distance:

$$DA_i^+ = [\sum_{j=1}^{n} (v_{ij} - v_j^+)^2]^{1/2}, i = 1,2,...,k$$

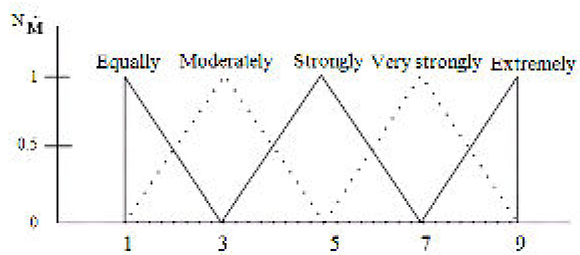

Figure 1: Linguistic variables for the importance weight of each criterion

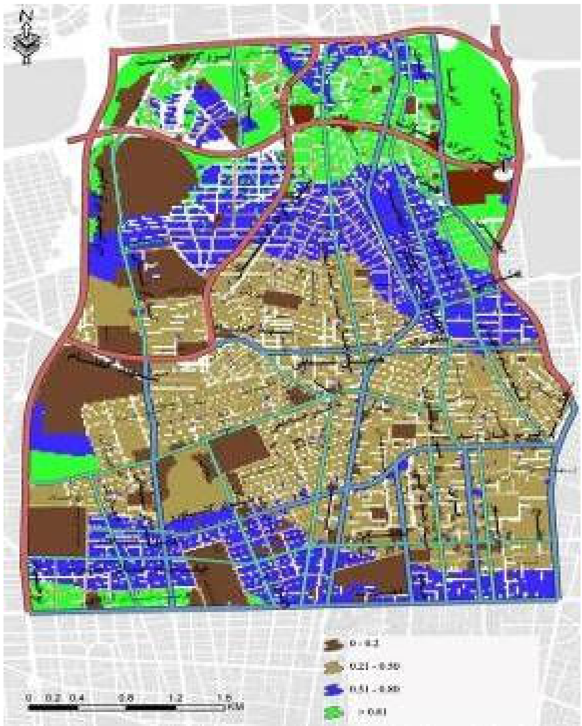

Figure 2: Ranking of alternatives

Table 1: Criteria weights for site selecting of cinema

Population characteristics	0.125
Environmental considerations	0.175
Accessibility	0.404
Economical	0.114
land cost	0.099
Flexibility	0.231
Attractiveness	0.098

$$DA_i^- = [\sum_{j=1}^{n} (v_{ij} - v_j^-)^2]^{1/2}, i = 1, 2, ..., k$$

- Calculate the relative closeness to the ideal solution: the relative closeness of the i^{th} alternative with respect to ideal solution A^+ is defined as:

$$R_i^+ = \frac{DA_i^-}{DA_i^+ + DA_i^-}, 0 \le R_i^+ \le 1, i = 1, 2, ..., K$$

- Rank the priority: a set of alternatives then can be preference ranked according to the descending order of R_i^+

The role of GIS in site-selection

Some of use Geographic Information Systems (GIS) to find suitable locations. It to help decision makers find a suitable site within a certain geographic area. The process applied is systematic, flexible and reproducible. Moreover, the study has demonstrated the utility and feasibility of using GIS for addressing the issue of site-selection for cinema. The use of GIS enhanced the capability to view present condition within a broader landscape context, rather than just on individual sites . The easy and quick implementation of overlay and Boolean operations made it a very useful tool in the process. Criteria requirements were fed in as GIS layers and were overlaid accordingly. GIS was also capable of calculating attributes by means of spatial analysis. One of the major advantages of using GIS in this study was assess of alternatives and then ranking them in the map.

Cinema site selection in Tehran

Beginning from the late-1980s, Persian society has witnessed a rapid transformation in many aspects, due to economic restructuring. Since Tehran as a metropolitan city has been attracting a large population from smaller cities and rural areas, it has caused a considerable increase in the population of the city of Tehran. The study is performed for Tehran, which is the most populated city of Iran with a lot of international links and relations. The growth in population and the enormous shift of people from old to newly developed districts in Tehran also create new spending demand areas. This is the most powerful motivation to generate new sites in the city for locating attractive cinemas, which must be multi-functional, large in size and exclusive.

As we mentioned earlier, we cannot assume that each evaluation criterion is of equal importance. Here, we employed the Fuzzy AHP method to determine the importance weights of the criteria that will be employed in TOPSIS method. The priority weight vector describes the importance degree of the criteria in decision matrix. After getting the importance degree of criteria, TOPSIS technique in GIS (ArcGIS software) was employed to evaluate alternative locations. Result of Fuzzy AHP showed Accessibility is important criteria rather than other (Table 1).

Figure 2 shows result of assesses alternatives and identifies potential locations for cinemas. Alternatives distribution analyses showed that the best Alternatives

(>0.81) are located in north and south-west of study area with 19.5% area (Fig. 2).

RESULTS AND DISCUSSION

Today, increase in population and income causes the emergence of cinema in various locations considering the requirements of citizens. Therefore, to investigate the best location for a new cinema becomes a difficult task for decision makers. This research primarily focuses on the methodology for developing a GIS-based Multi-Criteria Decision Making system (GIS-MCDMS) and proposed a combined MCDM approach based on the AHP and TOPSIS techniques within the framework of GIS for selecting a suitable cinema location. A real world case study from Tehran was presented to explain the combined approach. In the proposed method, the fuzzy AHP was used to determine the weights of the criteria, while TOPSIS was employed to GIS overlay analysis and to rank the alternative locations then result showed in GIS. The AHP is a useful method in comparing the criteria and TOPSIS is a practical method in obtaining the compromise solutions for multi criteria problems. As a result of the study, we find that the used method is practical for ranking alternatives with respect to multiple conflicting criteria for the large scale problems.

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