Zoning the land-capability of Roudehen for agricultural usage by the OWA1 technique in geographic information system environment

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ABSTRACT

One of the most sensitive issues that must be considered in many decisions are environmental factors. Planning for the optimal use of land makes it possible to maintain natural resources for using in future by the Earth too. Locating is one of the most widely used spatial decision-making which can be influenced by many environmental factors. The aim of the locating is to find a set of appropriate spatial options for a particular application. The locating issue is a multi-criteria decision-making problem. In current article, we have used OWA land-capability classification using GIS in order to prepare, evaluate, classify and overlay the layers. We have used six parameters of height, land use, climate, soil, slope and tilt direction for evaluating and categorizing land power. Finally, the areas that indicates the best potential of farming and other classes have been identified.

1. Introduction

Any exploitation of the land that we are above capable of in the long run will destroy and reduce fertility. Thus, it is vital to recognize land production capacity and allocate it to the best and most profitable type of using. Planning for optimal land usage makes it possible to preserve natural resources for future use by the Earth too (Leopold, 1968). To do this, land resources must be identified first and their capacities and capabilities must be determined for possible uses. This kind of studies can be made in the form of land plot plans too, because in discussing land management and the discussion is about the proper use of resources and land, which is necessarily a kind of adaptation of suitable land usage and is a special advantage to this. It is according to a quantitative assessment based on expert judgement and a quantitative assessment according to the predetermined stages (model) (Van Beek, 2009).

Decision-making can be considered as the vital challenge facing experts and analysts to solving a variety of problems. Therefore, various methods and algorithms have been indicated for supporting the decision-making over the last few decades. Multi-criteria decision-making issues usually consists of a set of location that must be according to several criteria in GIS as a process that determines spatial data (maps) and valuation values (priorities and criteria of analysts). In better words, the MCDA suggests a specific model to optimize spatial decision-making, and many studies have been done so far. Heywood, Oliver, and Tomlinson (1995) recommended multi-criteria analyses in GIS, it consists of a comparison of the results obtained from various decision rules.
Jankowski, Andrienko, and Andrienko (2001) used the multi-criteria DECADE/Common GIS analysis on decision-wing search and discovery stressed. It is notable that, many studies have been done on multivariate statistics in multi-criteria evaluation methods too (Andrienko, Andrienko, & Jankowski, 2003).

Providing location mapping and evaluating various areas is one of the most useful GIS applications for spatial planning and management (Collins, Steiner, & Rushman, 2001). During the last decade, the issue of locating suitable applications has been used in multi-criteria evaluation methods in GIS increasingly, (Barredo, Benavides, Hervás, & van Westen, 2000; Dai, Lee, & Zhang, 2001; Joerin, Thériault, & Musy, 2001). The conventional methods of multi-criteria analysis in GIS, like boolean overlapping operators and weighted linear composition methods, have been used in several locational and land use assessment problems too (Beedasy & Whyatt, 1999).

These methods have also combined with the weighted average weighting principles in various applications (Makropoulos, Butler, & Maksimovic, 2003).

The outcomes obtained from the application of multi-criteria evaluation methods, that include boolean overlapping operators and weighted linear constituents, can be determined by the use of the weighted average weighted average (OWA) method that had been improved. Conventional and traditional methods of OWA have been used in many GIS spatial applications (Calijuri, Marques, Lorentz, Azevedo, & Carvalho, 2004). OWA is a family of multi-criteria combination methods (Yager, 1988).

This method consists of two categories of weights: weights belongs to relative importance of criteria and sequential weights. Rinner and Malczewski have developed the ability of supporting the decision-making by adding an OWA module to Common GIS. Though, the studies have indicated that conventional OWA methods have limited impacts when they have broad evaluation criteria. In these situations, the combination of criteria in such a way that assumptions are decisive will be very complicated.

For many criteria, the person encounters the issue of combining the criteria maps to the extent that their outcomes meet the priorities. In such cases, the key aspects of the decision issue may be indicated in terms of some fuzzy conceptual quantities such as “Most criteria must be estimated” or “80% of the criteria must be met.” This needs a change in the multi-criteria decision-making methods, thus the conditions of these fuzzy quantities can be met (Boroushaki & Malczewski, 2008).

Figure 1. Location of the studied area.

Table 1. The classes of various parameters and their coefficients.

| Soil   | 16 ‘VALUE’ (1 1; 2 2; 3 3) |
|--------|----------------------------|
| Climate| 16 ‘VALUE’ (1 5; 2 4; 3 3; 4 2; 5 1) |
| Land use| 18 ‘VALUE’ (1 1; 2 2) |
| 20 Height| ‘VALUE’ (1 5; 2 4; 3 3; 4 2; 5 1) |
| 12 Direction| ‘VALUE’ (1 4; 2 3; 3 2; 4 1) |
| 18 Slope| ‘VALUE’ (1 8; 2 7; 3 6; 4 5; 5 4; 6 3; 7 2; 8 1) |

Table 2. Combination of classes and coefficients.

| Row | Criteria (parameters) | Coefficients | Classes |
|-----|-----------------------|--------------|---------|
| 1   | Soil                  | 16           | 1:1; 2:2; 3:3 |
| 2   | Climate               | 16           | 1:1; 2:2; 3:3; 4:4; 5:5 |
| 3   | Land usage            | 18           | 1:2 |
| 4   | Height                | 20           | 1:5; 2:4; 3 |
| 5   | Direction             | 12           | 1:4; 2:3; 3:2; 4:1 |
| 6   | Slope                 | 18           | 1:8; 2:7; 3:6; 4:5; 5:4; 6:3; 7:2; 8:1 |

Table 1. The classes of various parameters and their coefficients.

Table 2. Combination of classes and coefficients.
2. Material and methods

First of all, the natural features of the Roudehen area had been studied. This study consist of topographic, slope, climatic characteristics, soil talent, land use and orientation and the area of Roudehen in terms of agricultural land by considering the OWA method has been studied in GIS.

Case Study of Area: Roudehen district, Damavand city, Tehran province.

2.1. Introducing the Roudehen section

The Roudehen section is 35 km North-east of Tehran province and in the foothills of southern Alborz southern wall. The average height of the town is 1850 m and its area is over 200 km². The area is between 55 and 51 and latitude 43 and 35. More precisely, the northern boundary is formed by the mountain ridge of the north of Lavasan to the hill of Emanzadeh Hashem. From the south, the mountains of Quch mountain, Suri Qal’eh and … have separated this region from the central region of Iran. It has mild climate. Roudehen section is in north of Amol city in Mazandaran province, and from the east it has neighbourhood with central part of Damavand, and from the west it has neighbourhood with the central part of Tehran (with Boumehen and Pardis town) and from the south it has neighbourhood with the mountains and Varamin and Pakdasht deserts (Figure 1).
For $j = 1, 2, \ldots, n$ with map layers and standard weights, the OWA combination operator to the cell location $i$ is a set of sequential weights $v_1, v_2, \ldots, v_n$ assigns, since for each $j = 1, 2, \ldots, n$ we will have. The OWA combination operator is defined as follows (Yager, 1988):

$$\text{OWA}_i = \sum_{j=1}^{n} \left( \frac{u_j v_j}{\sum_{j=1}^{n} u_j v_j} \right) z_{ij}$$

where in that $z_{i1} \geq z_{i2} \geq \cdots \geq z_{in}$ by sorting the $a_{i1}, a_{i2}, \ldots, a_{in}$

Descriptive values are achieved and $u_j$ is the same weight criterion that is sorted due to the order of $z_{ij}$. As you can see, two types of weight have been used in this

### 2.2. Research methodology

#### 2.2.1. OWA

Multi-criteria evaluation methods in GIS usually consist of a set of spatial assessment criteria in the form of maps and layers. But the problem that normally happens in spatial decision-making is how to combine the criteria maps with a set of descriptive values (weights) beside decision-makers’ preferences. Spontaneous decision-making must lead to the selection of one (or multiple options are spatial options. Each of these options, $(i = 1, 2, \ldots, m)$, is described with a standardized set of values ($a_{ij}$). The multi-criteria evaluation question consists of a priority set as a weight of the criteria too,

$$a_{ij} \in [0, 1]$$

$[0,1] = W_{ij}$ for $j = 1, 2, \ldots, n$ with map layers and standard weights, the OWA combination operator to the cell location $i$ is a set of sequential weights $v_1, v_2, \ldots, v_n$ assigns, since for each $j = 1, 2, \ldots, n$ we will have. The OWA combination operator is defined as follows (Yager, 1988):

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Figure 4. Climate classes.

Figure 5. Sloping classes map.
in relation to evaluation criteria. For instance, the following criteria can be combined: “More criteria are met,” “All criteria must be met,” “At least half of the criteria are met.”

Such kinds of methods are called multi-criteria evaluation by fuzzy quantizers (Yager, 1988). This method consists of three main steps: (1) determining the type of the Q quantizer; (2) producing a set of sequential weights related to Q; and (3) calculating and evaluating the position of each of the cells using the combinative function of OWA (Boroushaki & Malczewski, 2010).

Case Study Parameters: Slope, direction, elevation, climate, soil and land use (Tables 1 and 2).
3. Results

See Figures 2–8.

4. Conclusion

In current research, we have used GIS for preparing, evaluating, classifying and overlapping layers. We have used six parameters for evaluating and classifying the power of the land. Finally, the areas that indicate the best potential for farming and other classes are identified. Totally, using this technique, we are able to evaluate the potential of the land for a variety of uses, but there are more precise techniques that we recommend, the multi-criteria decision-making techniques combined with fuzzy functions must be used in next researches.

Disclosure statement

No potential conflict of interest was reported by the authors.

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