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Applying the integration of the Spatial Multi-Criteria Decision Making (SMCDM) with GIS in urban land use planning

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ABSTRACT

The evaluation of the proportion in urban land territorial use planning will be done for allocation of each use planning to the most suitable land with the aims of achieving the most efficiency in allocate use planning in regarding to giving the services to citizens and other controls and urban land activities as well. This operation is as a complicated process for its effects and its more dependencies of other different controls on each other and also on daily urban land activities and the effects of profits and several factors on urban land controls activities will increase the complexity of the problem. The mentioned complexity is lead synchronizing to use of the different tools for decision support informational system (space) and analyses the multi-criteria (SMCDM). One of the most important problems in urban land programming is determining the adequacy in land control. In this problem should be determined the best use planning for each unit of land according to environmental factors such as slope, height, aspects of slope, continent, erosion, lands sufficiency, dust and social and economical factors too. In this research work is conveyed four suitable methods to controls by spatial decision making methods in terms of Topsis, Electre, Saw, Ahp according to environmental criteria. The result of this research work is the most important usage for SMCDM in urban land programming subjects, determining the scale of different applies for each spatial unit in which is able to calculate by spatial multi-Criteria decision making systems.

Introduction

With growing and developing the areas and cities, the essential information is seriously increased and complicated for the urban and regional programming. The numerous urban facilities nets, the dignity of population, the usage for lands and most items like this, has effect on increasing the complexity of this planning that there exists no other ways to use expect using the new land informational system for gathering the information and processing them in frame of new theories of the urban and regional planning.

The land informational system with special facilities in precise and speed, the input and output of data and maps from other systems, the ability to programming, providing the data banks of land, the analysis of vicinity and cohesion, the introspection, finding the path etc, all are the most important designed systems in recent years that can simplify the performance of complicated and advanced techniques in planning in least period of time. It is as a tool can help us in updating and organizing and keeping data meanwhile it can be easily and quickly available in all situations. In modern cities and areas with complexities and unconditioned and several factors that effects on the principles of its developing, the traditional procedures cannot be responsible for solving the spatial problems e.g. the manual jerrybuilding. The rate of growth and changing the cities also the mass volume of effective factors on spatial problems in city leave not any ways expect the using of codified frames based on land informational system in civilization. The recent progress on informational technology can provide the suitable condition for appraisal the new guidelines about the computer processing of geographical data, data managing, data analysis, structuring the several scenarios and data preparing. Through these progresses, more effective solutions are possible for the several problems related to space e.g. those that are related to planning issues. This research determines on the supply of integration the spatial multi-criteria decision making (SMCDM) and land informational system (GIS) regarding to solve the decision making problems in urban territorial control.

The contracting of the methods SMCDM and GIS in urban planning

The method multi-criteria decision making included of a series of techniques (e.g. Sum of weights or convergence analyses) that allows to classify a series of dependant criteria to weighting and assessing subject then by experts and beneficiary groups. Multi-criteria decision making determines a process to value the options which are evaluated by multi criteria. Multi-criteria decision making can divided into two levels; multi-attribute and multi-object decision making. If an evaluating problem is a set of options in order to choose the best in relevant weights of those options characteristics, this problem is as a multi-attributes decision. Multi-objects decision making for choosing the best options based on a series of more irreconcilable objects. Multi-objects decision making models are used to design while multi-attributes decision making models are used to selecting the best option among all.

In decade 1990, the guideline of integration the Multi-criteria decision making (MCDM) with land information system (GIS) in order to solve the spatial planning problems, are emphasized by the urban planners.

In analyzing the urban planning problem s, should be considered synchronistically the mass volume of variables thus decision making must be based on value and weight of each of

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the variables. It is natural the inadequate awareness about the effective variables in the urban problems can pose the failure in results of made decision and lead to serious loss.

The method of multi-criteria decision making has high potential regarding to decreasing the cost and time inverting to raising the precise in the spatial decision making and can provide a suitable frame for solving the spatial problems of the urban territorial control. According to statistics, more than 80 percent of information volume the usual life for people in town state on space and situation. Thus, for optimizing the method multi-criteria decision making using an analytical device in order to be able to analyze the mass volume of spatial data, is useful and necessary.

The spatial informational system as a tool which can easily work with this volume of data and analyze the data is a suitable tool regarding to integration with multi-criteria decision making. Then in order to deciding in solving the spatial problems in civilization, using the model of integration of multi-criteria decision making (MCDM) and land informational system(GIS) can have more efficiency. However, in this method on one hand can use guideline of multi-criteria that can provide codified frame for effective criteria and factors on spatial problems in town and valuating to these criteria and on the other hand with using the powerful analyzing tool as land informational system (GIS) can analyze the mass volume of these criteria and factors and making the best decisions.

Steps for performance of the territorial use planning as a land decision making Cognition of current statement

Before defining the considered criteria in order to find the urban territorial control, must be conveyed the current source in the town. In general, the resources divided into two parts permanent and impermanent; the permanent sources is to called for being stable in their own physical form in terms of rocks, the shape of land and geomorphology, dust and plants. The impermanent sources are the ones which are unstable in their own position and the changes of these sources even if not being affected by natural and human forces, are slow in time unit. In brief these sources included in climate, source of water and animals.

Determining the evaluating criteria for the urban territories

In determining the use planning of every land should be considered the permanent and impermanent state of source. In general, for determining the scale of use planning in agriculture, industry, hesitancy, tourism etc. must consider different criteria are included in slope, height, dust, water source, climate, erosion, plant cover, aspects of slope, animate shelter etc. . The designed map for the criteria including slope, the aspects of slope, height, dust, plant cover all are in permanent source and the designed map for the criteria including of climate and source of water are in impermanent source

After determining a set of criteria, each criterion will be pretended as a level of the plan in database based on spatial informational system, for evaluating each of the spatial units rather the use planning for each criterion. The levels which describe the evaluating criteria in plan called as criterion. Thus, in this research, providing the plans would be essential for criteria in terms of slope, the aspects of slope, height, climate, erosion, dust and plant cover in GIS.

Weighting the criteria

After providing the plans for criteria related to each use planning in this step, the plan for the criteria must be weighted based on type of control. For instance, the plan for criteria slope is weighted for types of controls in terms of industry, agriculture, residency, tourism etc. and is not important as the same. On the other hand, the effective procedure of slope for each use planning is different. E.g. in agriculture the value for the criteria of dust is more than slope i.e. the higher weight will be allocated to it.

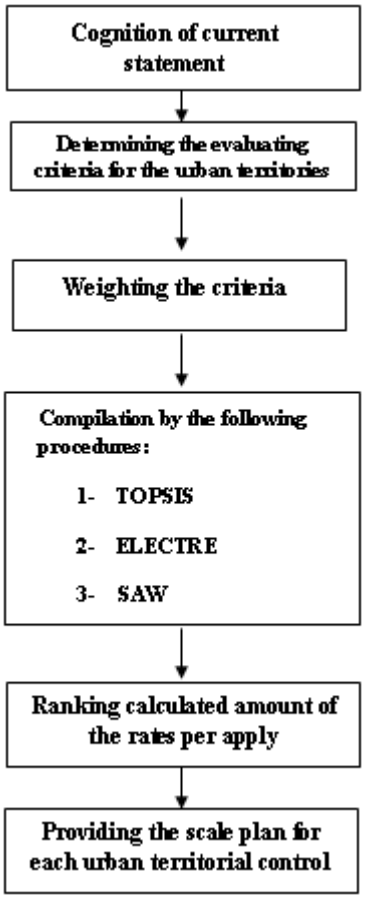

Fig.1. The conceptual model of the scales for each urban territorial control

Provide the standard plan for weights

The plans for criteria have various scales. For contracting the plans in criteria, it must be standardized the various plans. In general, the plans for criteria are classified to quality and quantity levels. The plans for the types of dust, plant cover and one of its samples is like quality data which can be derivate the plans of quality criteria is based on them. The relevant samples are the plans for criteria the quantity in terms of the plans for heights, slops and etc.

Step for contracting and using the methods of spatial multi-criteria decision making and GIS in urban land use planning

The contracting step is done by the methods of TOPSIS, ELECTRE, SAW and AHP and determines each spatial unit is used for which suitable use planning and in which level it is.

The suitable methods for contracting

In this research is used four methods in terms of TOPSIS, ELECTRE, SAW and AHP. All will be determined and explained in the following sections;

TOPSIS Method

In this method, the best option is the option that simultaneously the nearest unit to the ideal point and the farthest unit the negative ideal point. The ideal is as a supposed option that the most suitable standardized level of weights for each criterion among the considered options and also the negative ideal point is the worst standardized level of weights among the whole options.

Topsis method is necessary to have not only the monotonous suitable increase (the bigger value of criteria be, the

better it is) but also is necessary to have the monotonous suitable decrease (the lesser value of criteria be, the option is better).

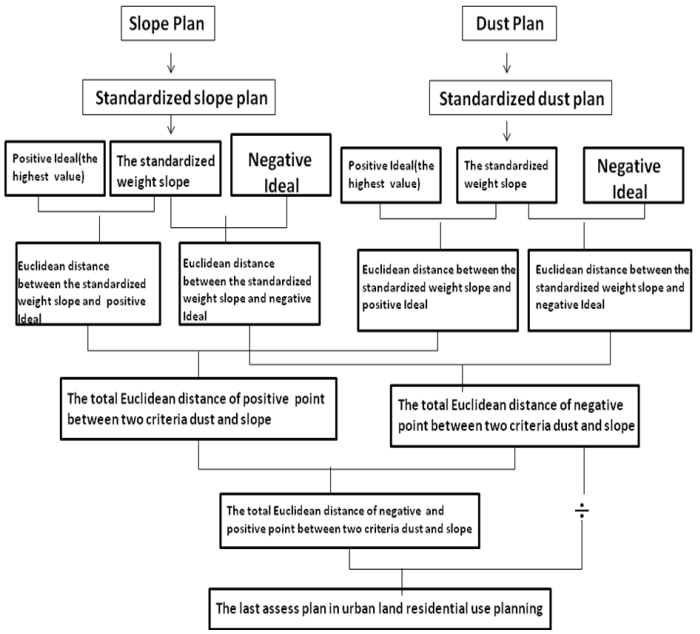

Fig. 2. The steps for the residential use planning in TOPSIS Method

Electre Method

This method is based on the comparison of spatial units pair by pair and achieves an arranged ranking of spatial units that the time when the pair compare with each other, this method is determined that the spatial unit A is more preferable than the spatial unit B and it doesn't show its value. In this method, the comparison in pairs is based on the limited value amount in which the scores for the necessity criteria and weights are determined as conformity or repugnance with the pair wise rules. The basic terms in this method are included in the conventional measures (based on the semi-step set and subordinated by all the criteria that the criterion ***i*** is not worse than ***i'***) according to the Masam Method (1980) which is used for defining the general score as following part;

$$c_{ii'} = \frac{\sum_j w_{jii'}}{\sum w_i} \qquad (1)$$

$$c_i = \sum_i c_{ii'} \qquad (2)$$

That $\sum w_{jii'}$ is as the sum of criteria weights wnen optıon ***i*** is not worse than option ***i'*** . $\sum w_i$ is as the sum for all the weights. e.g. in the following section and fig., the conventional matrix for industrial use is in four spatial units.

Table 1. The criteria standardized score in industrial use for four spatial units

Criteria	Slope	Dust	Continent	Erosion	Sum of rows	Rank
First spatial unit	0.5	0.4	0.4	1.0	1.0	0.0
Second spatial unit	0.0	0.6	0.6	0.6	0.6	1.0
Third spatial unit	0.3	1.0	0.4	0.4	0.4	0.4
Fourth spatial unit	1.0	0.0	0.5	0.5	0.5	0.5
Weight	0.2	0.3	0.1	0.1	0.1	0.4

SAW Method

The methods for simple total weighting are the most usual used techniques for contracting the criteria. In formal, in decision making rule for evaluating the measure for each option or $\mathbf{A_i}$ can use of the following formula:

$$A_i = \sum_j WX_{ij} \qquad (3)$$

that X_{ij} is the option ***i*** and in related to criteria ***j*** and W_j is the standardized weight; so that $\sum W_j = 1$, the weights emphasize on the random importance. By defining the most value measure for A_i (i = 1,2,3, . . ,m) the most preferable option will be chosen.

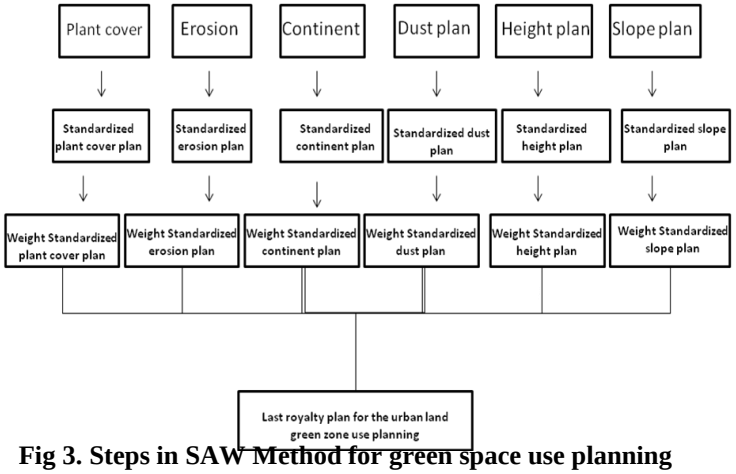

Fig 3. Steps in SAW Method for green space use planning

AHP Method

This method which is introduced and determined by Saaty (1980) is used in many regional, location facility and etc. . The steps are as following;

Creating an AHP system

In this step are identified the main goal, sub-goal, decision making criteria and options;

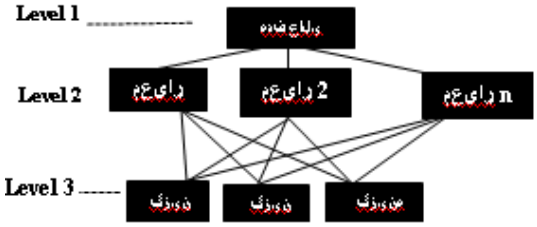

Fig 4. AHP Structure

Comparison evaluating criteria in pair

In this step, decision maker must compare every pair of decision making criteria with each other. The comparison of random importance of every pair of decision making criteria to each other, firstly is acted as qualified then will become quantitative in a numerical scale include one to nine (1-9).

Creating the pair wise matrix

In this step, a matrix is included of pair wise results of decision making criteria that will be achieved at last the random weights of decision making criteria.

Calculating the criteria weights

Calculating the criteria weights as the matrix of ranking is in the following part;

1. Calculating the geometry mean per row in matrix (the route n multiplied n criteria per row).
2. Calculating the total of calculated geometry means in step 1.
3. Standardizing each calculated geometry mean in step1. In division of it to the resulted total amount from step2.

Creating the general ranking in preferences

In the final step of random weights related to criteria must be summed. The final amount is as the proportion amount of spatial units in each urban land use.

Conclusion and Discussion

In this research are applied the variety of methods TOPSIS, ELECTRE, SAW and AHP for contracting the evaluating criteria and defining the urban land use. The method based on SAW method can use by each GIS system for the easiness use of it, today is applied in the field of urban land territory use planning. However, in the SAW method the evaluating criteria must be independent of each other and there doesn't exist any adhesion between them otherwise the incorrect result will be achieved in SAW method. The effective criteria in model of proportion of urban land use planning cannot consider as an independent from each other.

AHP method by having the strong and usable theoretical basis is used in different fields of decision making especially in determining the urban land use planning. However, usage of this method in developed level is hard to calculate for its high amount of comparison in pair wise and matrixes.

In TOPSIS method, there is no need for independency of criteria, thus this method is used to solve the space decision making problems in which most of them are include in the complex interaction dependencies in criteria.

In ELECTRE method, there is least need for information by decision maker but this method is impossible to perform in GIS system and also its performance in GIS system is necessary to use in special designed style.

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