A MUNICIPALITY SELECTION PROPOSAL FOR THE EXPANSION OF THE HELLENIC CADASTRE USING FUZZY LOGIC

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ABSTRACT

The implementation of the Hellenic Cadasrte is a long-term project of significant importance for the development of the country. The selection of the areas that will gradually be under cadastral survey is a critical issue for the success and sustainability of the project.

The basic targets that have to be satisfied are: the parallel development of the Hellenic Cadastre Project in all parts of the jurisdiction, the decentralization of the system, the priority of areas of special interest (for environmental protection etc), and the harmonized transfer from the currently used System of Transfers and Mortgages to the new Cadastral System. The criteria that must be met to obtain these targets are various and in many circumstances conflicting. For that reason the result is not univocal, but it depends on the criteria and the methodology used together with their restrictions. The suggested methodology utilizes GIS technology for the input, management and visualization of the geographic data, while fuzzy logic is used for the analysis of the data and the evaluation of the final results. The basic elements of the fuzzy logic methodology as well as its potential in the specific problem are described.

A case study took place in the region of Thessaly, one of the thirteen country regions of Greece. All the appropriate geographic objects and attributes were digitized and linked. The geographic data base was analyzed with fuzzy logic and the result is an hierarchical ranking of the municipalities concerning their time priority to participate to the Hellenic Cadastre Project. The results drawn up by fuzzy logic are compared with them of the classical Boolean approach of data analysis.

1. INTRODUCTION

Greece is one of the very few European countries where Cadastre does not exist. The present operating system of Transfers and Mortgages Bureau is a ‘person-centric’ system, where deeds are registered together with all legal rights concerning the real estates, but without any geographic documentation. It does not have the necessary tools that would help the development of the country, the environmental monitoring of areas of special interest, the protection of public land , the security of land tenure and the development of land market. In the year 1995 started the project for the implementation of the Hellenic Cadastre (HC). The new system will be a ‘land parcel-centric’ digital GI system and it will cover the whole jurisdiction of Greece. Its size and complexity make it one of the most important project of that kind under construction worldwide.

HC implementation cost, according to the existing technical specifications, definitely is going to be high (a few billion US$), although there is none reliable total cost estimation since the project is still in pilot phase. The compilation time of each cadastral survey, which normally includes one up to ten communities (out of approximately 6,000 of the whole country), is estimated to be not less than three years. Consequently, the selection of the areas which will be declared ‘under cadastral survey’ is one of the most critical issues for the success of the project. It is directly connected not only with the transparency of the development process of the HC and thus with its public acceptance, but also with the operation and the recoverability of the project since this priority can influence the establishment and operation of the regional cadastral offices in the jurisdiction.

Up till now, due to the pilot phase, the selection of the areas is being done according to one basic criterion: the sporadic selection of municipalities scattered in all country regions so that they will cover almost every different situation, i.e. urban, suburban, rural areas, islands, areas of special environmental interest, areas close to the boarders etc. This fact led to a great segmentation and distribution of the cadastral surveys and to the creation of an irrational mosaic, which brings a lot of difficulty and delay to the implementation of the cadastre in areas of appropriate size for the operation of the new Cadastral Offices. In addition, the final selection of some areas was based on personal preferences, without any scientific approach that would have been independent of human interference, easily and automatically applicable.

The scope of this paper is to help in that direction, and this is achieved by giving an appropriate methodological framework in the selection process. The suggested methodology utilizes a combination of GIS technology and fuzzy logic. GIS offers a powerful set of tools for the input, management and visualization of the data, while fuzzy logic is used for the analysis of the data and the evaluation of the results. In recent literature there are a lot of fuzzy logic applications on a GIS context. For example, a land evaluation system based on Fuzzy logic and GIS was developed at the University of Guelph (Hall et al, 1992) and at the National Institution of Agricultural Research of Greece (Davidson D. et al, 1994). Also, Sui D. (1992) applied Fuzzy logic along with muticriteria analysis for the evaluation of urban land through GIS. Yet, very few studies have indicated the use of fuzzy logic in regional planning through GIS, as it is suggested in this paper.

The suggested approach is applied to Thessaly, one of the thirteen country regions of Greece. The results are presented together with a comparison with the results of the classical Boolean approach of data analysis.

2. SUGGESTED METHODOLOGY

2.1 Using GIS for the selection of the municipalities

GIS provides the decision maker with a powerful set of tools for the manipulation and analysis of spatial information. The idea of GIS as a box of tools for handling geographical data is useful. Like most toolboxes, however, the list of tools provided by GIS although impressive is not complete. For example in most GIS packages spatial analytical functionality, lies mainly in the ability to perform deterministic overlay and buffer functions (Carver, 1991). Such abilities whilst ideal for performing spatial searches based on nominally mapped criteria, are of limited use when multiple criteria and targets are applied. So, the application of GIS technology in the case of municipalities selection for the implementation of the HC (Ioannidis, 1996) gave useful decision making tools for a more objective approach to the problem, yet not achieving an integrated fully automated procedure.

The integration of GIS with analytical techniques will be a valuable addition in GIS toolbox. As Fotheringhm and Rogerson (1994) note “progress in this area is inevitable and future developments will continue to place increasing emphasis upon the analytical capabilities of GIS”. Along these lines it is suggested that GIS can anthropomorphizing their analytical abilities through the incorporation of fuzzy logic. The fuzzy approach is most suited to applications where decision criteria are not rigid, where the boundary between A and NOT A is gradual. Inexact boundaries or class overlap appear to be more the rule than the exception in geographical problems (Openshaw, 1997).

Practically the integration of GIS with fuzzy logic is achieved by external linking of the software packages used.

2.2. Fuzzy logic

Classic Boolean logic is binary, that is a certain element is true or false, an object belongs to a set or it doesn’t. Fuzzy logic, introduced by Zadeh in 1965 permits the notion of nuance. Apart from being true, a proposition may be anything from almost true to hardly true (Kosko, 1991). In comparison with the Boolean sets, a fuzzy set does not have sharply defined boundaries. The notion of a fuzzy set provides a convenient way of dealing with problems in which the source of imprecision is the absence of sharply defined criteria of class membership rather than the presence of random variables (see Figure 1.)

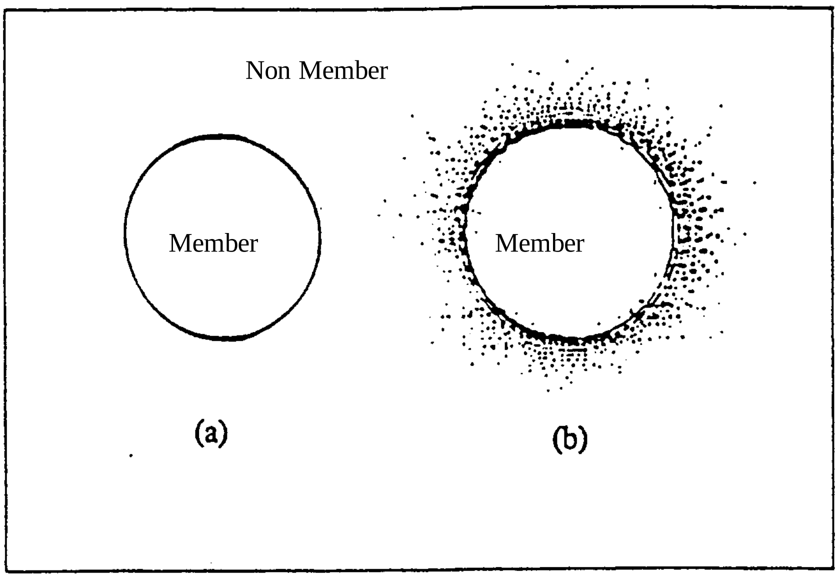


Figure 1. Difference between the Boolean sets (a) and fuzzy logic sets (b)

As mentioned a significant fact about statistical logic is the defect that each point of a set U is unequivocally grouped with other members of its group and thus bears no similarity to members of other groups. One way to characterise an individual point’s similarity to all the groups was introduced in 1965 by Zadeh. The key to Zadeh’s idea is to represent the similarity a point shares with each group with a function (termed the membership function) whose values (called memberships) are between $0 < m < 1$. Each point will have a membership in every group, memberships close to unity signify a high degree of similarity between the point and a group while memberships close to zero imply little similarity between the point and that group. Additionally the sum of the memberships for each point must be unity.

In Figure 2. some differences are illustrated between crisp sets and fuzzy sets. The complement of A is NOT A . Although in Boolean logic A and not A are unique, in fuzzy logic the following equation is true: $m_{not\,A} = 1 - m_A$

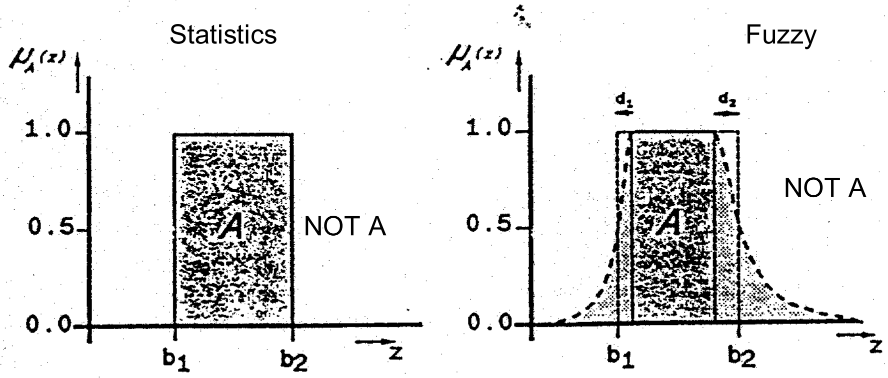


Figure 2. Crisp and Fuzzy sets (from Burrough, 1992)

Fuzzy degrees are not the same as probability percentages. Probabilities measure whether something will occur or not. Fuzziness measures the degree to which something occurs or some condition exists. Crisp sets are a subset to fuzzy sets. Only when an object belongs 100% to a group fuzzy sets are identical to crisp sets.

In order to solve a problem whith a knowledge-based fuzzy system it is necessary to describe and process the influencing factors in Fuzzy terms and provide the result of this processing in a usable form. The basic elements of a knowledge-based Fuzzy system are:

a. Fuzzification
   Every continuous math function can be approximated by a fuzzy set. Several types of membership functions can be utilized (Bezdek 1981, Burrough, 1996). The membership function reflects the knowledge for the specific object or event. The assignment of a membership function to every variable of the problem is called fuzzification process. During this process crisp subsets are transformed to linguistic subsets. The concept of the linguistic variable illustrates particularly clearly how fuzzy sets can form the bridge between linguistic expression and numerical information.

b. Knowledge base
   The second step in the Fuzzy systems methodological approach is the definition of the rules which connect the input with the output. These rules are based on the form “if …then” and. The knowledge in a problem-solving area can be represented by a number of rules. The task of rules definition is usually accomplished by experts with general knowledge on the specific field. There is no need for assigning weights in the criteria used. The weights are indirectly taken in account through the rules defined.

c. Processing of the rules
   The next step is the processing of the rules. This step is also called inference. It comprises the three stages: aggregation, implication and accumulation. Aggregation provides the degree of fulfillment for the entire rule concerned. All the Boolean algebra operations, like intersection, union, negation etc, can be easily extended to fuzzy set operations (Kandel,

1986) and they can be used in this stage. In implication the degree of fulfillment of the conclusion is determined. Accumulation brings together the individual results of the variables used.

d. Defuzzification
The result of rules processing can be transformed back into a linguistic expression or a crisp value. This process is called defuzzification and there are several methods to achieve it (Bezdek, 1981). For example
for fuzzy results: 73% poor suitability, 37% appropriate suitability,
the result of the defuzzification is: poor suitability.

3. AREA SELECTION CRITERIA

The area selection method so far was empirical, for the compilation of the cadastral surveys (CS) of the two pilot programmes and the 1st main programme of the HC. The possible selection criteria are quite a few, some of them conflicting with each other, and according to the given priorities and their application to the various areas the results will vary. Consequently, the appropriate use and hierarchy of the criteria and the procedure of their application each time defines the results.

The main application criteria, in combination with the existing statistical data, as derived according to a relative study (Ioannidis, 1996) and without any hierarchical structure, are:

- The agreement with the European Committee, who supports the project financially through the action ‘Environment’, for the parallel coverage of urban areas (appr. 40%), rural areas (appr. 30%) and environmental sensitive areas (appr. 30%)
- The distribution of CS’s in all regional areas of the country and the distribution of the budget in relation with their population, their size of the area or other special characteristics (close to the frontiers, touristic areas etc)
- The priority to selecting neighboring areas which belong to the same Mortgage Bureau, in order to make easier the transfer to the new system of Cadastral Offices
- The recoverability of the operation of the Cadastre, which means that areas with high transactions volume or with high revenue derived from the deeds submitted to the Mortgage Bureau, should be selected. It is obvious that this criterion selects urban areas of high population density and touristic areas of high land value
- The selection of areas where already exist relevant data, from previous similar studies, land consolidation etc, so that a quicker and cheaper integration of CS’s to be achieved
- The protection of public–state own land and the monitoring of informal–illegal settlements on forest land, coastal zone, rivers etc.

In addition to the above, other criteria like: the priority of areas which belongs to the same administrative unit, areas with special situations concerning the land tenure or the topography, have been tested. But their usage was considered to be not sound, as criteria of second priority or completely conflicting with the others.

The empirical approach which was used in the past and leaded in many cases to completely subjective selection of the areas, was:

- distribution of the available budget to the regions and prefectures of the country, according to the number of transactions registered at the Mortgage Bureau, the population, the size of urban areas, the segmentation of land and the priority policy according to the special characteristics of each region or prefecture

- selection of the appropriate areas within a region
- selection of groups or individual communities within the selected areas, which correspond better to the criteria or which have some specific characteristic (i.e. industrial developing communities, mountainous areas that need protection etc).

3.1 Application of fuzzy logic analysis

For the application of the mentioned combined method of GIS and fuzzy logic, five (5) basic criteria were selected according to the above analysis and the existing experience:

a. Percentage of the Mortgage Bureau area covered by Cadastral Surveys
b. Revenue from deeds registered at Mortgage Bureau
c. Urbanization, in percentage of the municipality area
d. Areas of natural beauty, in percentage of the municipality area
e. Agricultural area, in hectares.

As spatial unit was selected the municipality, as it was prior to the new law for the administrative division of Greece. There are about 6,000 communities in the country. The same application unit was used also for the empirical selection of the areas followed until now.

For each of the five criteria a membership function is assigned, based on the experts knowledge for each region or for the whole jurisdiction. During this process crisp subsets of values are transformed to linguistic subsets, such as low (or small), medium and high (or large). The concept of the linguistic variable illustrates clearly how fuzzy sets can form the bridge between linguistic expression and numerical information. In order to define completely the fuzzy system in this stage, another variable must be set. This variable concerns the fuzzy output. The output variable is the priority of municipalities, comprised by three subsets: high, medium and low. According to this, at the end of the whole process, each municipality will be assigned with a value (priority indicator) from 100 to 0.

For this reason, it is necessary to define the rules that connect the input values of the criteria through their membership functions with the output subclasses. The rules used to determine the priority of the municipalities to be declared under CS are the following:

1. If *Mortgage Bureau coverage percentage* is High and *Urbanization* is High
   Then the Priority is High with a certainty of 100%

2. If *Natural Beauty* is High and *Mortgage Bureau coverage percentage* is High and *Revenue from deeds* is High
   Then the Priority is High with a certainty of 100%

3. If *Agricultural area* is High and *Revenue from deeds* is Medium
   Then the Priority is High with a certainty of 100%

4. If *Revenue from deeds* is High and *Urbanization* is High
   Then the Priority is High with a certainty of 80%

5. If *Revenue from deeds* is Medium and *Natural Beauty* is High
   Then the Priority is High with a certainty of 80%

6. If *Revenue from deeds* is Medium and *Natural Beauty* is Medium and *Mortgage Bureau coverage percentage* is Medium
   Then the Priority is High with a certainty of 80%

7. If *Revenue from deeds* is Medium and *Mortgage Bureau coverage percentage* is High
   Then the Priority is High with a certainty of 80%

8. If *Agricultural area* is Medium and *Mortgage Bureau coverage percentage* is High
   Then the Priority is High with a certainty of 80%

9. If *Urbanization* is Medium and *Mortgage Bureau coverage percentage* is Medium
   Then the Priority is High with a certainty of 60%

10. If *Agricultural area* is Medium and *Mortgage Bureau coverage percentage* is Medium and *Revenue from deeds* is Medium
    Then the Priority is High with a certainty of 60%.

The rest of the rules that could have been formulated to specify the relationship between the five criteria and the low priority subclasses, are automatically assigned. There is no need for assigning weights in the criteria used. The weights are indirectly taken in account through the rules defined.

The next stage of the method is the inference, that is the processing of the rules. It comprises of three steps:
- Aggregation, which provides the degree of fulfillment for the entire rule concerned. The operator 'Algebraic Sum' was used.
- Implication, in which the degree of fulfillment of the conclusion is determined. The operator 'Algebraic Product' was used.
- Accumulation, which brings together the individual results of the variables used. The operator 'Maximum' was used.

The results of the above analysis, through defuzzification, transformed back into a crisp value. So, in each municipality a coefficient of 'incorporation' or a 'priority indicator' is appointed, with maximum 100 for areas to be directly included to the CS regional programme. According to the totally available budget and the financial development of the cadastral project, the communities with the highest value of the priority indicator are selected.

4. CASE STUDY

4.1 Application in the region of Thessaly

For the application of the suggested method for the selection of areas to declared under cadastral survey, the region of Thessaly was selected, which is one out of the 13 administrative regions of the country. In Figure 3. the location of Thessaly region is shown on the map of Greece. The region of Thessaly consists of 524 municipalities with a total area size of 1.4 million hectares approximately, which represents the 10.7% of the area of Greece. Its population, according to the statistical census of the year 1991, is 735,000 inhabitants or the 7.2% of the total population of Greece. The rural land are up to 0.5 million hectares, the urban land about 54,000 hectares and the rest region is covered by forest and infertile land.

Figure 3. Location of Thessaly region in Greece

The region has 28 Transfers and Mortgages Bureaux, which cover the 8% approximately of the total number of deeds in Greece, according to the available statistical data for the deeds and rights from the Ministry of Justice for the years 1991, 1992 and 1993.

For the compilation of the particular application, data were collected from various Ministries (Ministry of Environment, Physical Planning and Public Works, Ministry of Interiors, Ministry of Justice, Ministry of Agriculture), organizations (Hellenic Mapping and Cadastre Organization, National Statistical Service of Greece, Public Real Estate Company, Prefectures) and existing studies (i.e. Ioannidis, 1996). The regional administrative boundaries, the Mortgage Bureau area boundaries, the areas of natural beauty, the consolidation areas were defined. Also, the existing forest maps and maps of the public real estate, statistical data for each municipality (population, size of each land cover type, enrollment or not in the pilot CS etc), data for each Mortgage Bureau (the number of deeds and rights and the amount of revenues per year) and any other relevant information were selected.

4.2 Application of the suggested method

For the data analysis and the visualization of the results, a PC with a Pentium III processor and an HP Designjet plotter as hardware and the packages ARC/INFO 7.0.4, ArcView 3.2 and DATA ENGINE as software were used.

The collected data, geometric and attributes, were structured and processed in a GIS environment. The derived information was presented in thematic maps and in a database, whose every record contains all available data (numerical or coded descriptive) of each municipality. Figures 4., 5. and 6. show three thematic maps with the basic regional administrative division and some processed descriptive information, like the annual revenue of the Mortgage Bureaux distributed to each municipality, the coverage of urban land per municipality and the outline of the legally defined areas of Natural Beauty on a relief map.

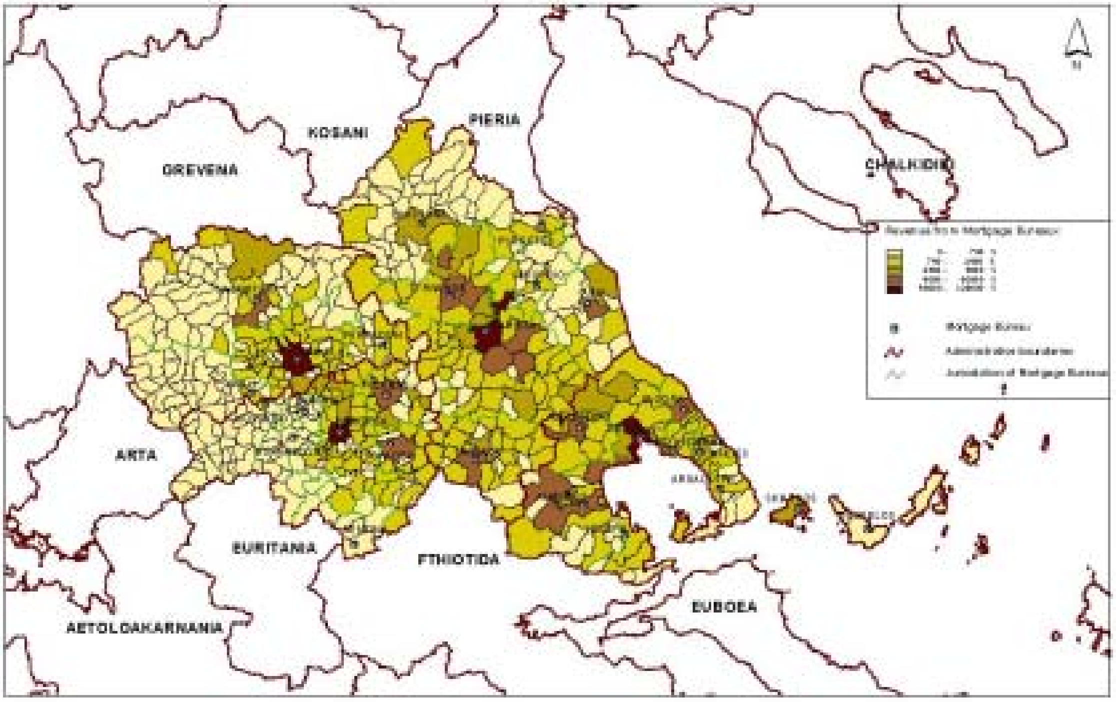


Figure 4. Annual revenues of Transfers and Mortgages Bureaux per municipality

For the fuzzy logic analysis the membership functions, especially for the region of Thessaly, for each one of the five criteria were defined. Table 1. shows the transfer of numeric values into linguistic expression and the Figure 7. shows diagrams with the membership functions.

Criterion	Linguistic expression	Membership function
a. Percentage of the Mortgage Bureau area covered by Cadastral Surveys	Low	0 – 50 %
	Medium	25 – 75 %
	High	> 50 %
b. Revenue from deeds registered at Mortgage Bureau	Low	0 – 20,000 US$
	Medium	2,000 – 50,000 US$
	High	> 20,000 US$
c. Urbanization in percentage of the municipality area	Low	0 – 30 %
	Medium	20 – 40 %
	High	> 30 %
d. Areas of natural beauty in percentage of the municipality area	Low	0 – 75 %
	Medium	50 – 100 %
	High	> 75%
e. Agricultural area	Small	0 – 2,000 hectares
	Medium	1,000 – 5,000 hectares
	Large	> 3,000 hectares

Table 1. Criteria, expressions and functions used

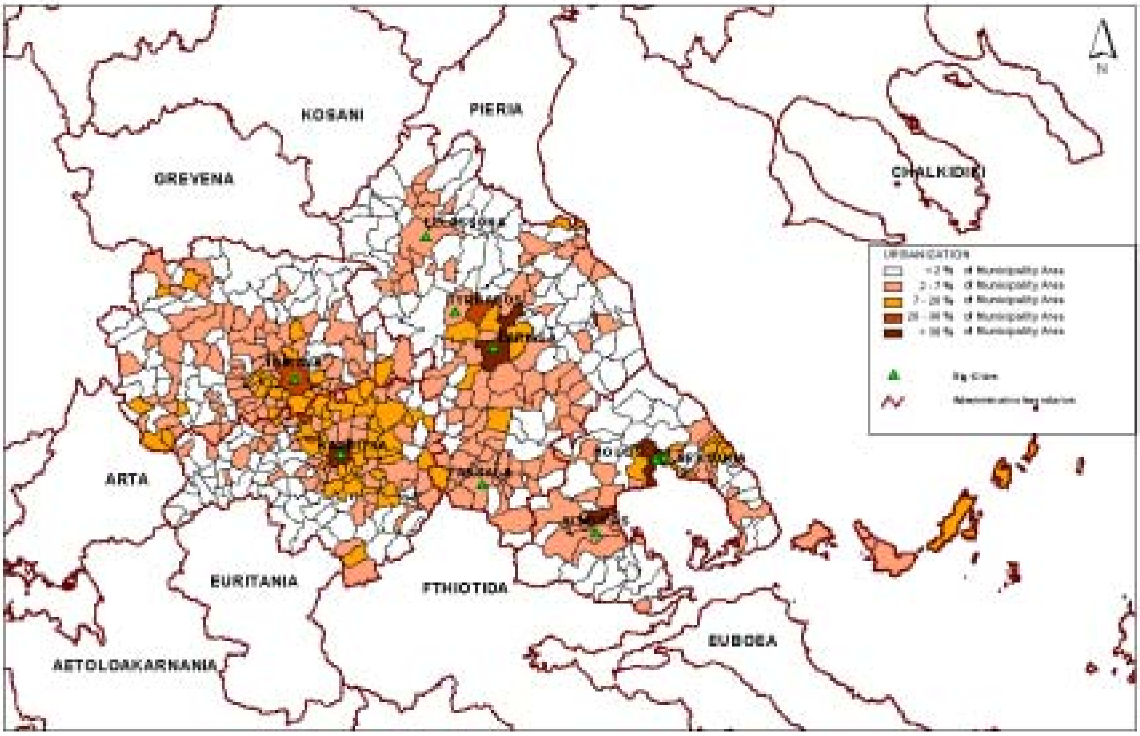


Figure 5. Urbanization map

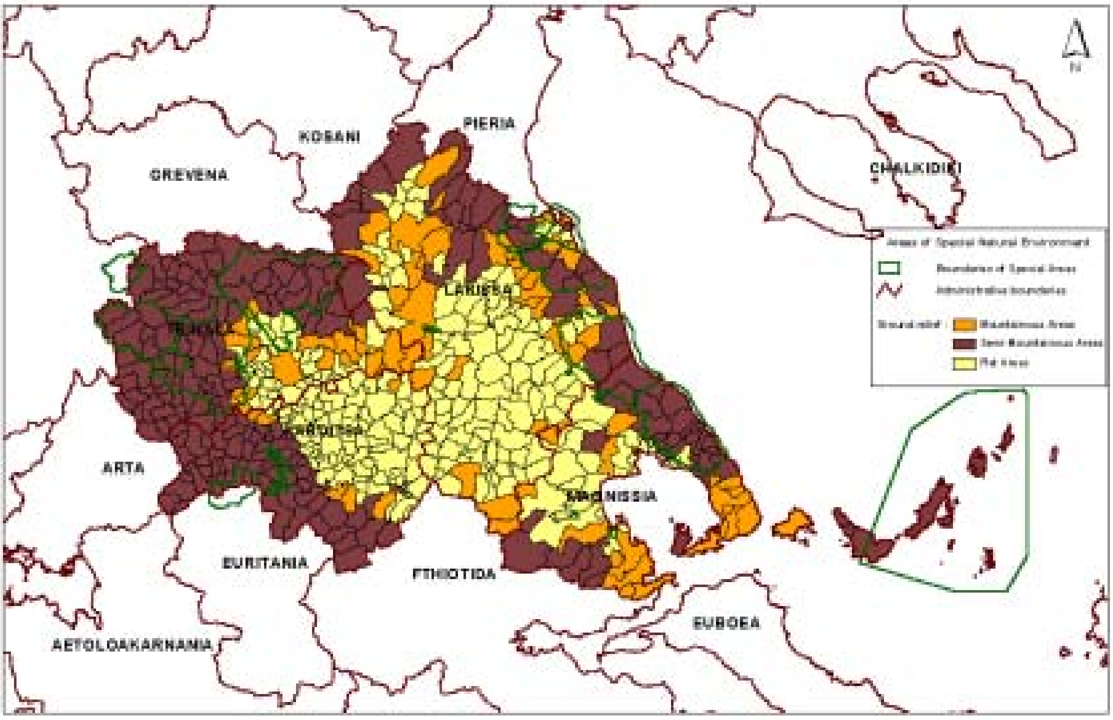
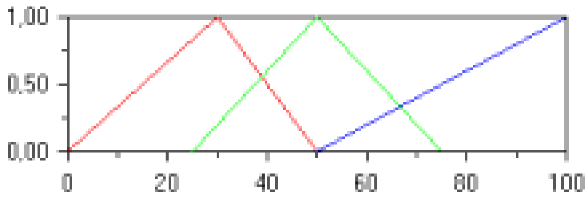
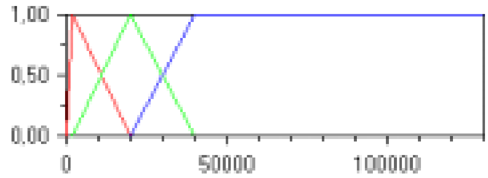


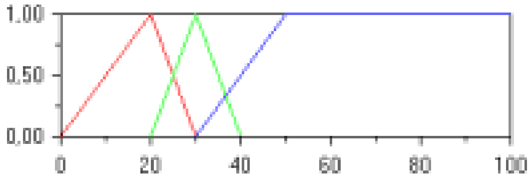
Figure 6. Areas of natural beauty on a relief map of Thessaly region



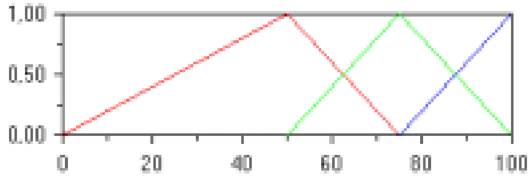
a. Percentage of the Mortgage Bureau area covered by Cadastral Surveys



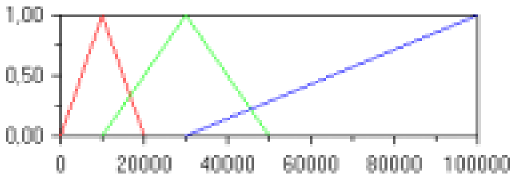
b. Revenue from deeds registered at a Mortgage Bureau (in US$)



c. Urbanization, in percentage of the municipality area



d. Areas of natural beauty, in percentage of the municipality area



e. Agricultural area, in stremma (0.1 hectares)

Figure 7. Membership functions of the 5 criteria

The result from the application of the criteria and the processing of the rules is the correspondence of a 'priority indicator' to each municipality, at a range between the values 0 and 100. Table 2 shows the 50 municipalities with priority indicator greater than 50. In order to make this table practically useful, an estimation of the cost for the compilation of CS in each municipality should be made and according to the available budget for the region of Thessaly the selection of the areas to be declared under CS should be done with a priority series. With the GIS tools (ArcView layouts) thematic maps can be produced with a categorization of the municipalities according to the value of their priority indicator, such as in Figure 8., or their sequentially inclusion in the CS programmes.

4.3 Procedure of the final area selection

The successful area selection by the above described automated method, depends to a great extend on the level of the available budget of each CS programme for the particular region. From the next 3rd programme of the main phase for the compilation of the HC, the region of Thessaly is expected to take approximately US$11.25 millions. With this amount of money, 19 municipalities can be included to the CS programme, shown in brown color on the map of Figure 8. As derived from the map this low financial support creates a big scattering of the selected areas. The alternative solutions to this problem are:

- the modification of the membership functions, by emphasizing more the 'neighboring' criterion, so that the other criteria will consequently underestimated
- the introduction of additional spatial criteria
- the adoption of a semi-automated procedure in stages, that would not alter the objectiveness of the selection method, following certain rules.

CODE	NAME	VALUE	CODE	NAME	VALUE
423001	LARISSIS	100.00	425125	STAUROU	60.02
432002	VOLOU	100.00	431118	SOURPIS	60.00
431001	ALMIROU	100.00	423116	ZAPPIOU	59.80
423129	MELIAS	79.67	441107	CHASION	58.14
422122	LIVADIOU	79.20	423148	RACHOULAS	57.73
411001	KARDITSAS	78.34	424114	RODIAS	57.60
425001	FARSALON	78.00	424102	ARGIROPOULIOU	57.60
411135	GRAMMATIKOU	77.82	424106	DELERION	57.60
422001	ELASSONOS	77.60	424103	VRIOTOPOU	57.60
424105	GONNON	76.71	422110	DAMASSIOU	57.60
432144	RIZOMILOU	73.06	422128	MESSOXORIOU	57.60
423130	MELISSAS	71.60	422106	VLACHOGIANIOU	57.60
431117	PTELEOU	71.08	425115	KRINIS	54.58
432004	NEAS IONIAS	70.26	411132	GEFIRION	54.36
424107	DENDRON	69.60	432119	KALON NERON	54.00
431116	PLATANOU	69.60	411177	LEONTARIOU	53.00
423139	NEON KARION	69.34	423128	M. MONASTIRIOU	52.74
425112	KALLITHEAS	69.19	411003	PALAMA	52.48
432111	ARGALASTIS	68.00	421111	KASTRIOU	52.40
423109	GLAUKIS	67.59	411190	MATARAGKAS	52.00
432003	IOLKOU	65.00	432147	STEFANOVIKIOU	51.65
423153	TERCHITHEAS	64.40	432001	VELESTINOU	51.60
423118	KILELER	64.06	411239	FILLOU	50.80
432120	KANALION	60.80	423154	CHALKIS	50.69
425116	MEG. EUIDRIOU	60.60	432121	KATO LECHONIA	50.00

Table 2. Table of the 50 municipalities with the highest values of the priority indicator

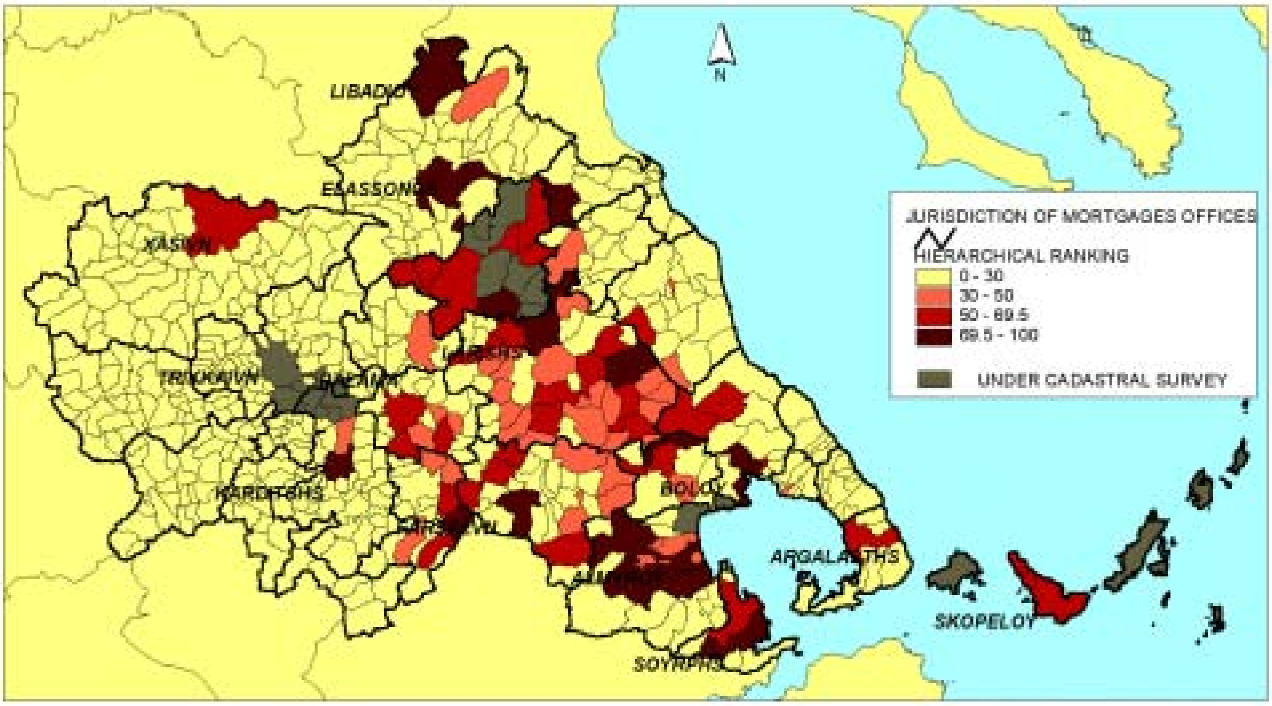


Figure 8. Municipality categorization according to the value of their priority indicator

The development of the last alternative solution, which is considered to be the most appropriate, will follow. The suggested steps of the procedure are:

- application of the methodology of combining GIS and fuzzy logic, which was described in chapter 4.2, on all the municipalities of Thessaly region
- selection of ‘high priority’ municipalities, i.e. with value of the priority indicator above 50
- location of the responsible Mortgage Bureaux, where the above municipalities and those that have already been under CS: 14 out of 28 Mortgage Bureaux
- creation of a new database with all municipalities which belong to the authorities of the above 14 Mortgage Bureaux, that is 282 municipalities out of 524 of Thessaly region
- repetition of the fuzzy logic methodology on the municipalities included in the new database, with the same criteria and rules but different membership function limits
- creation of the new final priorities table of the municipalities.

By this way almost only neighboring municipalities are selected, without living out those, which according to the criteria, should be directly included to the next CS programme.

The municipality selection procedure must be repeated each time a new CS programme is planned, since the priority indicators of the remaining municipalities will have changed.

5. CONCLUDING REMARKS

The suggested methodology gives sufficient results, as derived from the application on the region of Thessaly. These results vary according to the definition of the particular parameters of the method. For the selection of the most appropriate membership functions, the criteria, the rules and their processing in order to avoid unsuccessful results, experience and knowledge of the issue is necessary. Since the above mentioned criteria, rules etc are been selected, an easily repeated procedure, almost fully automated, using tools of modern technology such as artificial intelligence, follows.

It is worth noticing that by applying the Boolean logic the selected areas are to a great extent different from those selected by fuzzy modeling. The selection, using the classical method, of 59 municipalities from all the four prefectures of Thessaly is announced by KTIMATOLOGIO S.A. for the next cadastral surveys programme. By applying the suggested selection method with fuzzy modeling, the municipalities are limited to approximately 20, for the same budget of CS and for the same way of estimating their cost. Also, the interest focuses mainly on two of the four prefectures and no municipality of the prefecture of Trikala is selected, since the capital of this prefecture is already under CS. On the contrary, by using the Boolean logic the 15% of the budget of Thessaly region is given to the prefecture of Trikala.

It is also important, that the more experience we have from the CS programmes, the better improvement of the membership functions and the rules of fuzzy logic approach we can achieve, so the better results we have. In general, it can be considered as a continuously improving and developing approach, whose main advantages are:

- automation of the process, utilizing tools of artificial intelligence
- more realistic approach through linguistic variables instead of numbers
- hierarchical ranking of the municipalities concerning their priority to participate to the HC and not an inclusion-exclusion list
- quicker achievement of the final solution, with fewer repetitions of the model, compared with Boolean logic where many attempts with different values in the rules must be made.

On the other hand, the most pressing problem in using fuzzy modeling is the derivation of the membership functions used. Until now all approaches are ad hoc in nature. The development of appropriate functions will be instrumental for further applications.

Concluding, it can be said that fuzzy modeling can be applied successfully in the selection process of municipalities to be declared under cadastral survey and has several advantages. The task of evaluation and development of appropriate methods of spatial analysis, as fuzzy logic is a real challenge in a period of great geographical data availability. The more visible become the advantages of the method the more GIS will be considered as a powerful decision support tool.

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