Development of "Land Rent Model" Using Multicriterional Analysis and Geographical Information Systems

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The application of multicriterional analysis and geographical information systems in the development of land rent model, is presented in this paper. The objective of the model is to provide the basis for the evaluation of urban areas. The aim of the research is to find out the most suitable model for definition of the city rent in coastal urban areas. The presented research is based on information technology, including graphical and numerical processing of appropriately handled and structured information. The rent model includes all the relevant factors considering values of the urban environment, especially historical and cultural heritage. Such evaluation, together with information technologies, represent very useful and practical tool for environmentally sound management of urban areas, and a support to decision makers.

Keywords: Multicriterional analysis, Geographical information systems, Urban rent.

1. Introduction

Information technology is concerned not only with collecting, storing, processing and transmitting information, but also with the use of computer to support decision making. This paper shows how to use geographical information sytems (GIS) and software for multicriterional analysis as elements of information technology, solving land rent model in urban coastal zones characterized by specific historical, economical, socio-cultural and ecological elements. The spatial rent, the urban rent and the rent resulting from land equipment, all of them being derived forms of the land rent, have been particularly dealt with. All above rent types are powerful instruments of economic policy which can influence behavior and profitability of people and activities in coastal zones. Furthermore, the rent in those areas is collected from all users of a space and natural resources and it is spent exclusively on the protection and the enhancement of environment. The stated rent types can substantially contribute to the successful management of coastal areas and the management of natural resources of coastal zones. The rent stimulates the development, yet it helps to select the most appropriate activities. It should be pointed out that the rent always equals the cost of equipping and protecting a particular area. However, in the management of coastal areas the rent varies from site to site, depending on the management policy, but in the end, it should always equal the total cost of equipping the whole area.

2. Problem Description

According to a highly simplified definition, management means exact knowledge of what should be done and readiness to do it in the best and most economical way. Although management is very complex at any level, basically it is composed of a small number of elements, such as planning and decision-making, organization, guidance, and control. In this order within the management process, these elements lead towards the desired objective. The basic input to the management system come from the environment; i.a. human, financial, physical and

information resources. Human resource stand for talent and work, financial for capital, physical for space and equipment, and information for available data required for taking effective decisions.

Is it possible to talk about the management of a town and its development?

From the point of view of the theory of systems, on which the above description of management is based, and according to which town is a system, we can say that it is possible to apply a management system in the town. Unlike other systems, a town is characterized by the notion of amalgam, or, from the point of view of the theory of systems, a town is "a system of systems". In other words, a town is a heterogeneous structure of activities which differs greatly in character, purpose and ways of implementation, but which are interdependent, such as, for example, production, services, culture, health, and arts.

Certain economic activities go on in a town, which, exactly because they go on in the town, are based on the rules of site, specific rules of production and market, and particularly on the specific rules of the people, commodities and flows of information. With regard to this complex economic system in the town, we can speak of a management systems of the town's economy.

There is a certain socio-cultural system of a specific organizational pattern in a town, of contents and market, which require a management approach to make it function. Accordingly, we can speak of the management of town's natural resources, of cultural heritage, parks and green areas, water resources, etc.

Even if we disregard the concern for managing the activities going on in theterritory of the town, the town's organism and soul will always remain, its physical skeleton and its space, which develop and change and which need to be managed.

The purpose of this work is to point out the rent as an instrument of town management and a source of necessary funds for reconstruction and development of a town. Since the rent is a product of the level of equipment of an urban area, we shall only deal in this paper with that part of the management system which regards the management of urban areas.

Development of a town is primarily recognized by its activities and structures serving for production and services, housing, recreation and traffic, or in other words, construction of buildings and facilities for work, living, recreation and all kinds of traffic. On the other hand, it is far more difficult to note the equipment of the land which enables the town to develop.

Since the land equipment is a prerequisite for development of a town, it is necessary that it is well organized and successfully implemented. The relevant literature says that a town with surplus of equipped land develops with greater success than a town with lack of such land. The overall development of Split over the past 50 years had to cope with a lack of equipped land. This shortcoming is typical of all Croatian towns.

It cannot be denied that there was a management process in the communal domain, but it is certain that it was not a management system with a closed management machine. This means that the human resources (management), financial resources (rent), physical resources (equipped and unequipped land) and information in the function of decision-making has never made a homogeneous composition, but rather actions which were scattered without links and which were under the responsibility of overall (not even urban but communal) management. It happened thus that unequipped land was often sold and bought, rent was charged without estimating whether it was really adequate, the funds collected to rent went for other purposes or ended in the pockets of the land owners, decisions were made without analytical bases, which all led to disintegration of the system, and eventually to lowering of the level of the town land equipment.

Management of the urban area is a modern necessity according to which the area is equipped and rented out with a positive financial continuity, which means a further reproduction of the town. This simplified paradigm of a town management requires an elaboration of a comprehensive system based on:

- analysis, planning and recording of the development courses of the town;
- preparation of land management instruments;
- organization of land acquisition;

- land rehabilitation and clearing, and other;
- institutionalization of the management structure, levels and a reas, and of the managers;
- control and monitoring of all courses, strategic control, technical control, information and preparation of new decisions.

The basis for functioning of the management system of an urban area is made of land (which, since it is urban, has the ability of) producing gains by which the urban area is permanently equipped and by which new area is gained for a continuous growth of the town. The principal objective of a town management should be to stimulate the best possible use of land over the entire urban area. Therefore, people and activities should be attracted to less attractive areas and all parts of a town equipped, as well as people and activities made capable of paying an adequate rent. From that point of view it is clear that the rent is not an unjust tax, nor a formal, or merely economically just impost, but it is also an instrument to influence the behaviour and success of people and commodities in the building land of the town.

The rent is collected from all who use the space, but is spent also on the unused space. Thus the rent is an instrument used to the benefit of the entire urban space.

The rent is an instrument of urban space management which, on one hand, stimulates some activities which are desirable and lead to progress, and on the other, it discourages the activities which burden town and have no future.

If business is successful, the rent enables the land equipment to go ahead in development, increasing development dynamics and building quality.

As an urban space management instrument, the rent is very sensitive because it never has to be equal to the expense or lower to overall cost. Therefore, the rent as an instrument is elaborated, it changes along with behaviour, and it is permanently the object of attention, analysis, adaptation and orientation.

The rent is an economically powerful factor as it functions as a primary agent with all economic and urban activities. It moves them, it feeds them, but also destroys them if those activities are unable to make the rent fruitful or be useful to the town.

Analyzing the practice of an urban land management in our conditions, we almost cannot find the rent in its original and pure form. The rent is either hidden within one or more imposts, or is totally absent. The reasons for such a mess lie primarily in the fact that all elements of the social system have not developed at the same rate. The public utilities, one of the basic components of the social system, is the most backward one. It still shows both market and non-market features, vague basic categories of the system of values, and instruments of various levels of efficiency. In the domain of land policy, for example, instruments are considered more efficient if they provide higher income from imposts, regardless the consequences. It is obvious that such procedures are not based on the market philosophy. Due to all those inconsistencies of a system, a large number of various imposts appear in the practice. Those impost often overlap in some parts, i.e. various imposts collected much more money for one and the same function. Let us mention just several kinds of imposts, most common in our practice:

- price of public utilities
- land use impost
- investor's impost for rented land
- tax on property, income from property, real estate, etc.

There is no doubt that all those and other imposts *per definitionem* can be fully acceptable, but in practice they become quite problematic due to insufficiently clear delimitations. The reason for such situation lies not only in the theoretical vagueness, but also in the fact that the imposts were not collected by one and the same subject, nor were they intended for the same purpose within the land policy. This is at the same time, the answer to the question why the urban building land of all our towns has been so impoverished, and why there is no wider reproduction. All that in spite of several times stressed fact and supported by documents in this text that in urban economy and building land management, the economic effects always have to be positive and reproductive. And since this is so, we shall point out another fact in the policy of urban area management: that the urban area dealt with on such a basis largely contributes to the increase of all economic effects of production and service units of the town.

Defining the level of urban rent for concrete users of the urban land is a complex task, with regard to the large number of relevant factors influencing the value of the land.

Further in the text, the use of a hybrid model will be presented, which has been developed and tested in the area of the town core of Split within a pilot-project, in order to gain the necessary experience for determining the town rent.

3. Development of the Land Rent Model

For the needs of the application of the land rent model, the historic core of Split was by an expert assessment defined as the study area. It is not only a residential area, but also consists of a whole variety of tourist and other commercial uses. Since the study area is relatively small and very homogenous, the dominating criteria determining the rent differential were insignificant. Therefore, it was necessary to determine other parameters that differentiate this area for business and other commercial uses.

Since business results in the study area are greatly affected by the frequency of consumers, traffic connections, attractiveness of the ambiance etc., the dominating criteria are those developed on the basis of these parameters.

The following criteria were used for the analysis:

C1. Proximity of banks and post offices;

C2. The state of pavements;

C3. Easy pedestrian flows;

C4. Proximity of green areas;

C5. Public transport accessibility;

C6. Parking area accessibility;

C7. View of the sea;

C8. Attractiveness with regard to historic values;

C9. Housing conditions;

C10. Quality of the infrastructure;

C11. Intensity of pedestrian flows;

C12. Density of the existing business premises.

The density of the existing business premises was derived from the data on location and surface area of the existing business premises within the study area. For some of the criteria it was possible to use the exact values resulting from counting pedestrians or parking spaces or number of lines of public transport in the study area and their frequency. However, other criteria were determined only by the attributive assessment made by experts.

As a basis for assignment of the criteria values, the structures within the study area were chosen. It was suggested to the experts who were giving the values for the criteria concerning polygons, to follow, where possible, the boundaries of the structures when defining the boundaries of the categories for the criterion values.

Concerning the expert opinions, a structured data base was designed and created. It was important to define mapping between criteria (objects) defined by experts, and predefined fundamental spatial objects in GIS (points, lines, polygons). The attributive data on existing business premises (from which the values for the criterion C12 were derived), were assigned to the points representing the location of the premises; criteria referring to the pavements (criteria C2, C3 and C11) are line-referred, and others are polygon-referred.

Since the analysis resulted in categorization of the study area (division into areas that represent the categories of site quality within the study area), point- and line-referred criteria had to be transformed assigning the values to their "areas of influence" — neighboring polygons. As mentioned before the data on location and surface area of the existing business premises were used to determine density categories of the existing business premises. A number of the existing business premises was used as the basis for density categorization and the sum of their surface areas were calculated for the structures within the study area. This information was smoothed; for example, when there was a structure with no business premises, and the neighboring structures had many of them, such a structure was put into the category of areas with a dense business premises. Line-referred criteria were transformed in the way that the structures were divided in two parts along their longitudinal axis. Thus derived parts were assigned the criterion value for the pavement used for the access to this part of the structure.

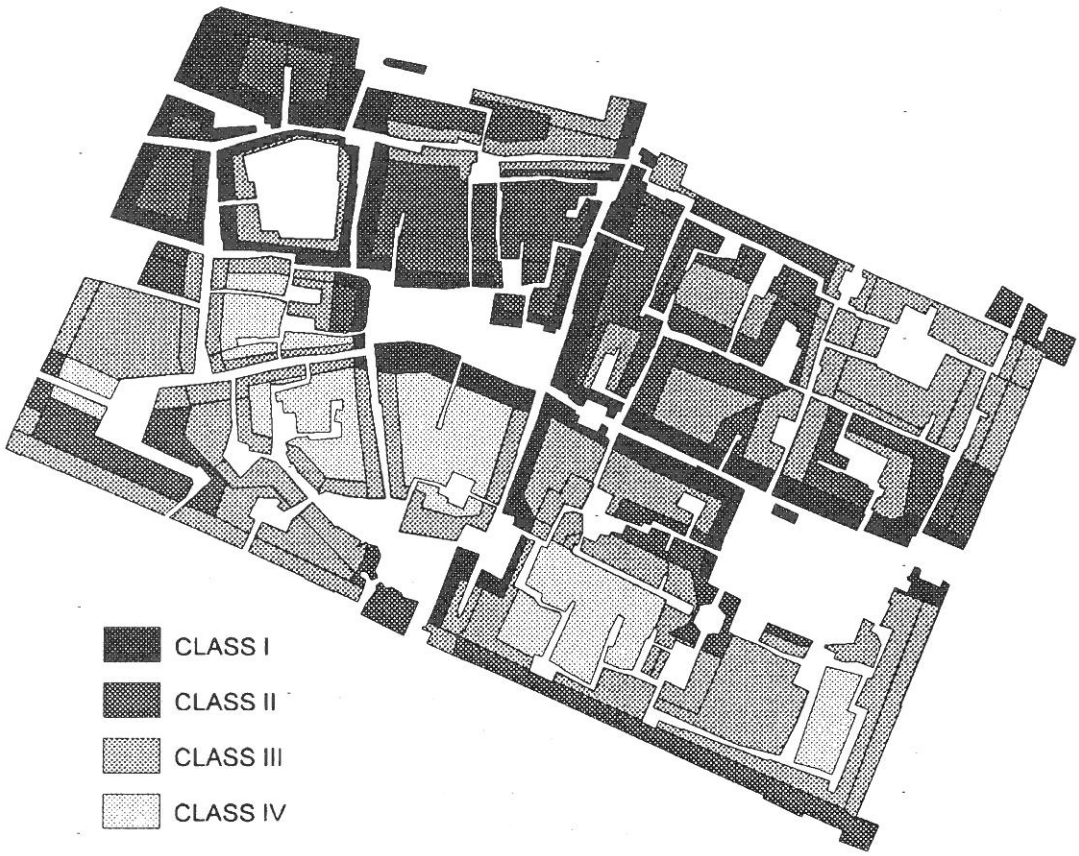

Fig. 1. Categories obtained by preliminary filtering

As the basis of the PROMETHEE multicriterional analysis, the overlay map was produced from the basic maps containing criteria values. Despite a preliminary analysis of data input, the number of polygons with various criteria values in the resulting map was still too big, especially with regard to the size of study area. Before a further analysis, it was necessary to reduce the number of various combinations of the criteria values; namely criteria values for some polygons had to be changed. When reducing the number of various combinations of criteria values, two factors were considered: spatial relationship among polygons, and the significance of criteria for the further analysis.

In order to achieve a rough categorization of the study area (9 categories A1, A2,... A9), the results of this preliminary filtering of the criteria value combinations have been exported to the software for multicriterional analysis using PROMETHEE method. The result of this method, a synthetic indicator (net flow PHI) was used to identify 9 categories within the study area (Fig. 1).

Since the critical point in multicriterional analysis is the assignment of weights to each criterion, various treatment scenarios have been developed, with different approaches to the problem, i.e. with different criteria weights. The treatment of this problem includes five scenarios. Table 1 shows input data for multicriterional analysis: the criteria values and weights for the five scenarios.

Fig. 2 shows PROMETHEE II analysis performed using the first weight scenario. Two of these scenarios are the result from the work performed by experts from the city management authorities (Institute for Town Management), and by experts having specific knowledge about the study area. One scenario was developed according to the experience obtained from two similar projects, carried out using different methodology. To decrease the number of zones in various rent differentials for an easier administrative management, a further analysis was carried out, supported by GAIA

Table 1. Input data for multicriterional analysis

	Actions									Scenarios of weights				
	A1	A2	A3	A4	A5	A6	A7	A8	A9	I	II	III	IV	V
C1	1.69	1.55	1.58	1.80	1.61	1.53	1.77	1.96	2.00	4	8	5	8	6
C2	2.00	1.80	2.25	2.27	2.19	2.44	2.22	2.57	2.92	10	8	10	4	9
C3	1.83	2.11	1.46	1.19	1.83	1.60	1.57	1.41	1.64	5	5	10	8	4
C4	2.87	2.97	3.00	1.34	2.95	2.58	2.86	2.87	3.00	4	2	5	3	5
C5	2.00	2.00	2.00	1.10	1.98	1.75	2.00	2.00	2.00	3	3	5	10	8
C6	1.51	1.68	1.56	1.43	2.31	2.39	1.62	1.33	2.07	20	7	5	8	11
C7	1.51	1.32	1.44	1.76	1.19	1.19	1.49	1.81	1.40	15	9	5	2	2
C8	1.05	1.16	1.44	2.24	2.33	2.25	1.33	1.79	2.60	20	6	5	6	7
C9	1.51	1.91	2.14	1.24	1.96	2.35	2.65	2.46	3.10	5	13	10	14	15
C10	1.00	1.00	1.07	1.00	1.05	1.18	1.10	1.19	1.57	2	12	5	3	3
C11	1.07	2.03	2.49	1.14	2.73	2.52	3.88	3.93	4.00	5	11	20	20	14
C12	1.00	1.42	1.42	2.66	2.69	2.47	3.63	3.85	3.83	7	16	15	14	17

programme (Geometrical Analysis for Interactive Aid), which enabled visualization of multicriterional problem. Using geometrical presentation, zones having similar characteristics were combined into zones considered as homogenous, having quite the same rent differential values. Fig. 3 shows GAIA-plane for the first weight scenario. The problem turned out to be very sensitive to changes of the criteria weights, since four quite different results have been obtained. The analyses resulted in, respectively, two, three or four mini-homogenous zones, which can be used as a basis for determining the rent differential. Fig. 4 shows four mini-homogenous zones obtained from GAIA analysis. The selection of the best solution has

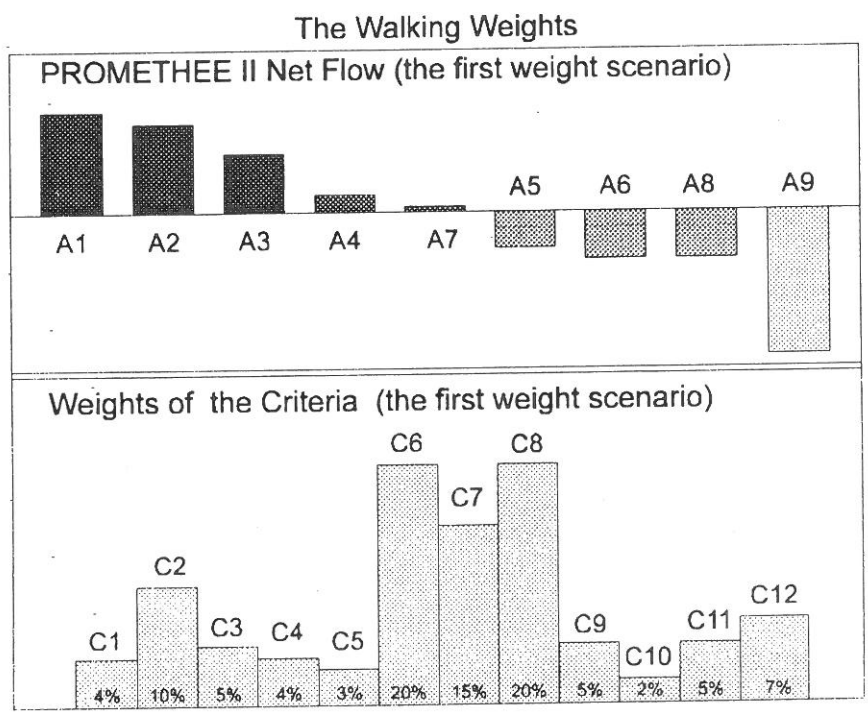

Fig. 2. Graphical presentation of net flows and the weights for each criterion (PROMETHEE II)

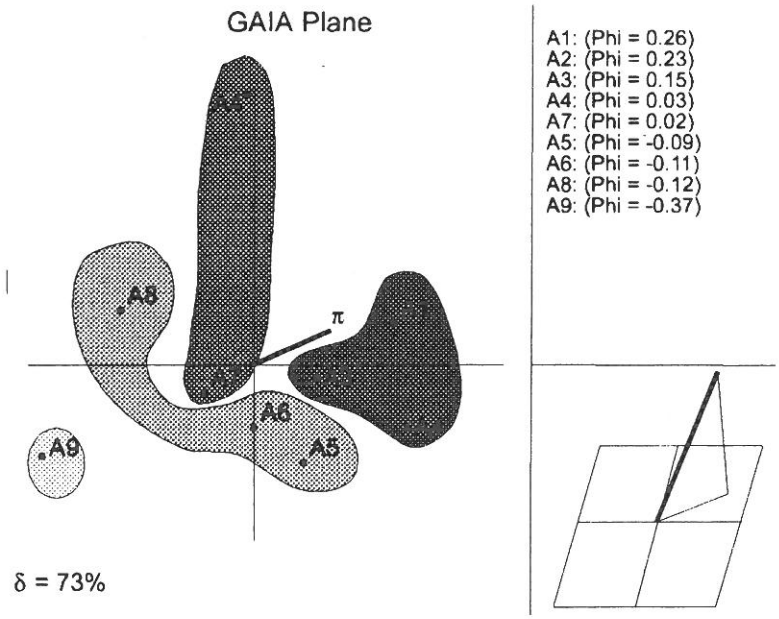

Fig. 3. Graphical presentation of mini-homogenous zones in GAIA-plane

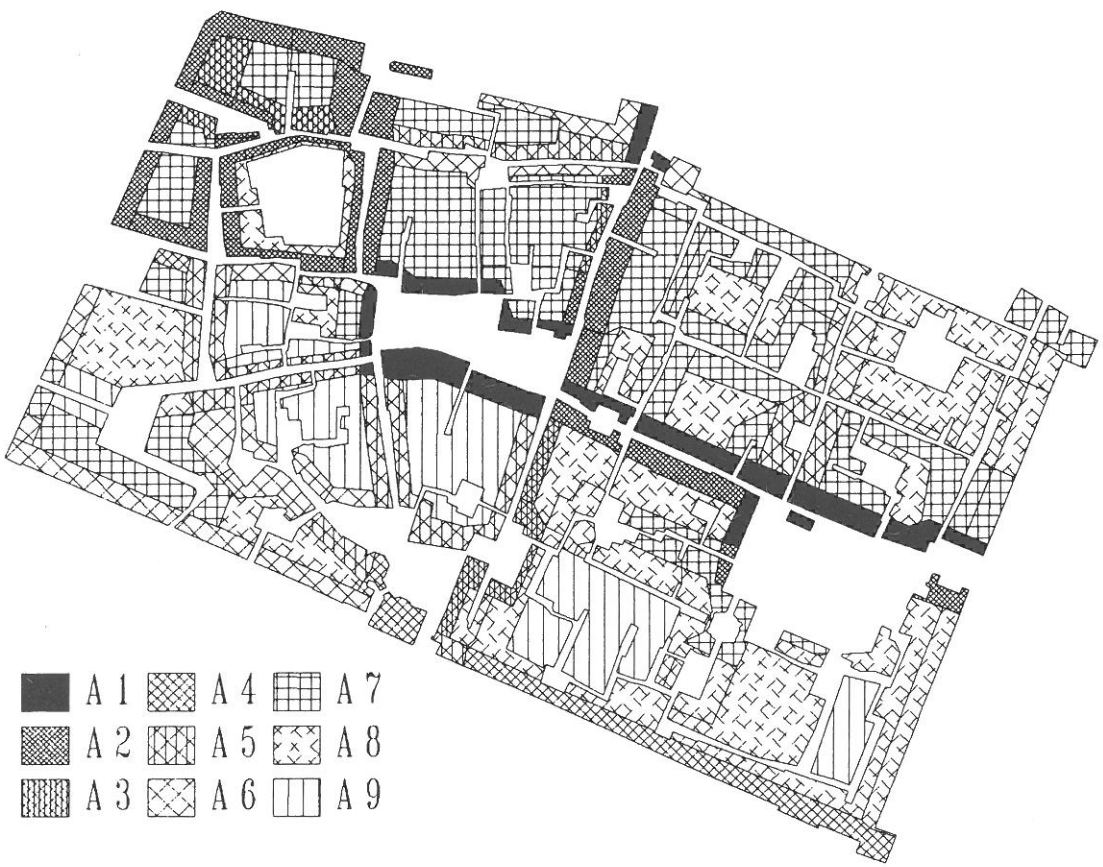

Fig. 4. Four zones corresponding to rent differentials obtained by multicriterional analysis

to be performed in cooperation with the management authorities, i.e. the management policy in the commercial area of the town.

A flow chart of the procedure performed in the analysis is presented in Figure 5

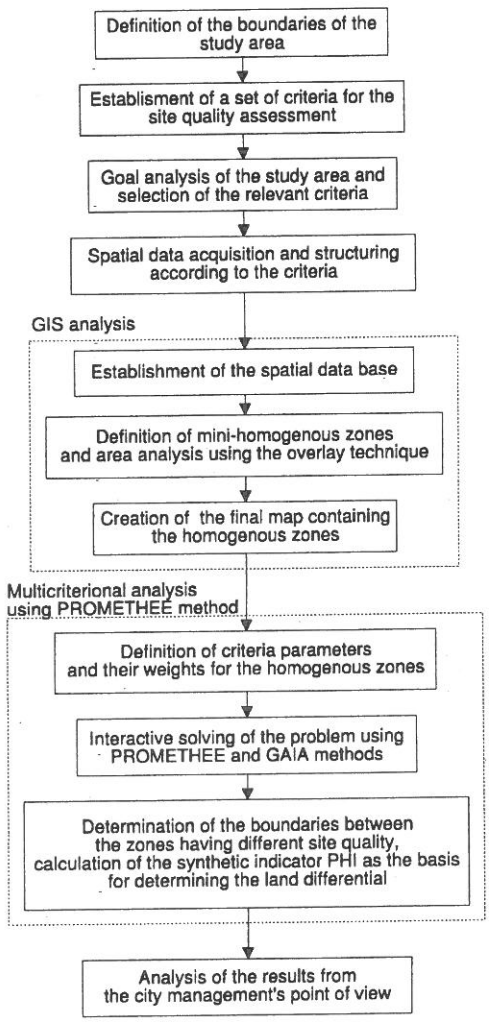

Fig. 5. Flow chart of the procedure

4. Conclusions

This project has proven that GIS and the multicriterional analysis method represent powerful and efficient tool in solving such complex problems as the city rent. Combining GIS and multicriterional analysis method into a unique decision support system produces a tool which could be used by the city management authorities with great possibilities of application in operational, tactical and strategic decision making, particularly in the coastal zones characterized by very sophisticated criteria.

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