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Urbanistic assessment of city compactness on the basis of GIS applying the COPRAS method

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Sustainability is very important to modern societies. Current patterns of land use and development are environmentally, economically, and socially destructive. Cities have occupied great territories, and it is already difficult to discern their borders. Sites of service objects also do not become obviously certain. Such a scattered urban structure causes numerous problems on the global and local scale. On the global scale, it is climate warming, bigger CO_2 emissions and higher pollution, and on the local scale it implies dependence on automobile, congested roads and non-vital environment inside the cities. The concepts of sustainable future development of cities are always focusing on these main problems. In the present paper, ensuring sustainable development through implementation of compact city principles is discussed. The existing city structure in terms of sustainable compactness is described as a multidimensional object. City territory is divided into cells according to similarity of character. The application of a multi-criteria Complex Proportional Assessment method (COPRAS) for evaluation of city cell adequacy to a theoretical sustainable compact city is offered. The method is combined with the geographical information system for the purpose of an efficient calculation of parameters and visualisation of city compactness. On the basis of the geographical information system, the databank of inhabitants, addresses, stops of public transport and public visiting places is prepared. This technique will help town planning authorities and city planning specialists to establish and localize problems of building density in an urban territory, to strengthen the integrated approach and substantiate the decisions. The model is applied to the Kaunas city.

Key words: sustainable development, compactness, urban structure, population density, GIS, multi-criteria, COPRAS method

INTRODUCTION

In last decades, rapid changes were observed in most cities of the world, including Europe. The cities became centres of global consumption and evoked numerous environmental and ecological problems. It is inadmissible to leave abandoned lands in the cities and to steer their development to the adjacent territories without taking care of the existing situation. There is a lot of wasteland inside the cities, and the boundaries of cities are stretching and ruining the countryside. The city provision centres became difficult to localize because the level of spatial organization is now very minimal and based mostly on access by automobile (Urban Task Force, 1999; Rogers, Power, 2000). Measures must be taken to calculate the damaging impact of city sprawl; a sparing way of economic development and more effective land use must be found. The filling of wastelands must be an underlying option, given the higher population density, mixed-use adaptive environment, balanced planning and maximum dependence on public transport (Cervero, 2003; Frey, 1999; Burinskiene, 2003).

On average, for 11 major European cities, the urban area per inhabitant and workplace increased from 88 m^2 in 1960 to 122 m^2 in 1990, implying a 38% increase during a 30-year period (Newman, Kenworthy, 1999). Suburban residential areas became closely linked to the private car. They were originally planned and developed for car availability and accessibility, and the households have become heavily dependent on car use in all their daily activities. The increase in individual mobility is impressive throughout all world's developed countries. Houses now became situated in residential areas which have increased substantially over the last decades. We are all familiar with the process of suburbanization, resulting in extensive residential areas of single-family houses.

The concept of the *cathedral of consumption* was launched by the American sociologist George Ritzer and is connected to his theory on *the new means of consumption*. Shopping malls and amusement parks are obvious examples. But similar processes are going on in other arenas as well: athletic and football stadiums, theme parks, museums, and also universities (Ritzer, 1998,1999). If they are to maintain their ability to attract a sufficient number of consumers, it depends on their growing increasingly spectacular. A most usual course chosen is the "spectacle" of *enormous physical space*: ever-larger malls, amusement parks, and the like. The results are larger buildings and parking lots, and more extensive encroachments into natural and other valuable land areas (Høyer, Næss, 2001).

The form of a contemporary city has been perceived as a source of environmental problems (Alberti et al., 2003; Beatley, 2000; U.S. Environmental..., 2001; Frey, 1999; Newman, Kenworthy, 1999). The EPA (2001) concludes that the urban form directly affects habitat, ecosystems, endangered species, and water quality through land consumption, habitat fragmentation, and replacement of natural cover with impervious surfaces. In addition, urban form affects travel behavior which, in turn, affects air quality; premature loss of farmland, wetlands, and open space; soil pollution and contamination; global climate, and noise.

The concept of sustainable development has given a major stimulus to the question of the contribution that certain urban forms might make to lower energy consumption and lower pollution levels (U.K. Department..., 1996; Breheny, 1999).

The popularization of sustainable development has contributed to the promotion of the urban compactness idea by enhancing the ecological and environmental justifications behind it. Since the 1990s, research has generally led to the advocacy of cities that are spatially compact, with a mix of uses. Most of the scholars agree that compact cities offer opportunities to reduce fuel consumption for travelling, since work and leisure facilities are closer together (Newman, Kenworthy, 1999). Compact cities are also favored because urban land can be reused, while rural land beyond the urban edge is protected. Ultimately, it is argued that a good quality of life can be sustained, even with high concentrations of people. The compact form can be implemented on a variety of scales, from urban infill to the creation of entirely new settlements, such as the ideas of Urban Villages in the United Kingdom and New Urbanism in the United States. Compactness proposes density of the built environment and intensification of its activities, efficient land planning, diverse and mixed land uses, and efficient transportation systems. The European Commission's Green Paper (Commission..., 2004, 2005) advocates very strongly the "compact city," assuming that it makes urban areas more environmentally sustainable and improves quality of life. The compact city is being promoted in the United Kingdom and throughout Europe as a component of the strategy formed to tackle the problem of unsustainability (Livingstone, Rogers, 2003).

Most of the scholars argue that compact cities proposals are unrealistic and undesirable. Instead, various forms of "decentralized concentration," based around single cities or groups of towns, may be appropriate (Breheny, 1999). Essentially, this is a high-density, mixed-use city, with clear (i.e. nonsprawling) boundaries (Jenks, 2000).

In the 1970s, the idea of a compact city was advocated. It was considered that a round-shaped, compact city with a population of 250,000 inhabiting in a radius of slightly less than 3 kilometers would function most efficiently. In the 1990s, the main arena for discussion about the question moved to the European Union. Opinion is divided over this issue. Some hold that extreme concentration makes it possible to achieve sustainability and contributes to the preservation of the global environment, while others are skeptical about it because they attach importance to the freedom of human nature, quality of life and lifestyle. Still others take a conciliatory stand between concentration and decentralization.

Gradual and more concentrated development is more effective. It gives opportunity to use existing infrastructure and makes it possible to use city wastelands. Clever planning of inner areas leads to minimizing hard covering per citizen and greening of an environment. Several examples of European cities show that development can be targeted to the inside city. It is enough to develop existing unused territories if planning is good. Such planning minimizes the amount of land taken, creates sustainable environment with a population density sufficient for normal functioning, gives benefit to the city and protects the countryside (Commission..., 2004, 2005). There are various possibilities to densify the urban fabric of the cities before concerning which measures should be taken a detailed analysis of city compactness is needed.

Increasing city compactness is a complex and long-term process (it must take ~50 years to make the best) which supposes a flexible legal system and support of local politicians (Chinyio et al., 1998; Urban Task Force, 1999; Commission..., 2005).

There are three ways of dealing with the mismatch between population and built-up area:

- Strategy one: to increase the population in the areas with a population density below the city average. This strategy is based on the assumption that people will be attracted to move from the countryside or from city outskirts to under-populated areas of the city.
- Strategy two: to increase the population in the areas below the threshold average by redistribution of population from areas with densities above average.
- Strategy three: to decrease the size of the built-up area of the city in the districts below the population average. It is based on the assumption that the population in higher density areas will not be reduced and the population in the lower density areas needs to be more concentrated.

Figueira et al. (2005) stated that Locational Analysis has become a very active field of research in the last decades among both practitioners and academia. G. Munda (Figueira et al., 2005) states that sustainable development is a multidimensional concept including various perspectives. He showed that multi-attribute decision analysis is an adequate approach to dealing with sustainability conflicts at both micro and macro levels of analysis. Barbier (1987) writes that sustainable development implies "to maximise simultaneously the biological system goals (genetic diversity, resilience, and biological productivity), economic system goals (satisfaction of basic needs, enhancement of equity, increasing useful goods and services), and social system goals (cultural diversity, institutional sustainability, social justice, participation)". This definition correctly points out that sustainable development is a multidimensional concept, but as our everyday life teaches us, it is generally impossible to maximise different objectives at the same time, and by a formalised multi-attribute decision analysis, compromised solutions must be found.

THE PROBLEM OF CITY COMPACTNESS

Analysis of a city form in the aspect of compactness is quite a new subject of research. This is the reason why there are no steady methods of such analysis. For the evaluation of city compactness, different statistical analysis methods are applied, the main difference among these methods being the way how the area of the city is divided and what attributes are used. Using these methods, different subsystems of the city, such as street network, public transportation, infrastructure, built-up area, population density, location of the working places, etc. can be explored. It can be calculated how these characteristics change in the teritorry and with time. Usually the territory is divided in concentric circles, segments of concentric circles or simply by dividing a territory with a rectangular grid (Thingh et al., 2001). The value of used land for each cell is evaluated. For each pair of cells i and j with their used land areas z_i and z_j, mutual gravitation is counted according to the law of gravitation. The more built-up land is dispersed the less is spatial gravitation. The more compact the structure, the greater the spatial interaction among the cells.

Similarly, the GIS, while recognized as useful decision support technologies, does not provide the means to handle multiple decision factors. Jun (2000) provided a framework for integrating the strengths of GIS, expert systems, and the analytic hierarchy process to incorporate the decision maker's preferences on a range of factors used in finding optimally suitable sites. Kitsiou et al. (2002) presents a study in which a methodology was developed for the multidimensional evaluation and ranking of coastal areas using a set of attributes and based on the combination of multi-attribute choice methods and GIS.

Many methods have been proposed to model the decision-making phase. Triantaphyllou (2000), Figueira et al. (2005), Zanakis et al. (1998) state that several methods have been proposed for solving multi-attribute decision-making problems (MADM). A major criticism of MADM is that different techniques may yield different results when applied to the same problem. In a simulation experiment they investigated the performance of eight methods: ELECTRE (Zavadskas, 1987), TOPSIS (Zavadskas et al., 2002, 2003), Multiplicative Exponential Weighting (MEW), Simple Additive Weighting (SAW) (Zavadskas et al., 2007), and four versions of AHP (original vs. geometric scale and right eigenvector vs. mean transformation solution). Dissimilarities in weights produced by these methods become stronger in problems with few alternatives; however, the corresponding final rankings of the alternatives vary across the methods, more in problems with many alternatives. Although less significant, the distribution of attribute weight affects the methods differently (Ginevichius, Podvezko, 2007).

INITIAL DATA AND CALCULATION METHODS USED IN ANALYSIS

Data used for the analysis characterize land use intensity. In a sustainable city, it is one of the major factors (Burinskiene, Rudzkiene 2003). There were three groups of data – living places, working places and places of strongest public attraction (provision, service, market and trading centers). For the description of these data the GIS was used.

Living places were chosen from the unified Kaunas city geo-addressing data base and the list of registered citizens with their living adresses. The compiled GIS contained point objects for each building with aditional data on the number of people living in a building. Operations required to calculate these values were programmed using Oracle DBMS. The objects selected from the initial data and used in the calculation comprised 87% of the total. The prepared data were processed in the ArcGIS program medium.

Locations of working places were calculated using data kindly presented by the social insurance information service. These are very dynamic and rapidly changing data, and their accuracy is less than that of data on living places. In calculations, some presumptios and indirect analytical methods were used also.

Information on public attraction centres was obtained from the recently developed specialized plan of the dislocation of big market-places in the Kaunas city and data on visitors of such centres.

Another group of data, recognized by experts as important in a compact city, concerns the level of public transport network development. To estimate these data, data on land use intensity and a plan of public transport routes and stops were used.

The results of the comparative analysis of districts are presented as a decision-making matrix in which the columns contain n alternative districts, while all quantitative and conceptual information pertaining to them is found in Table.

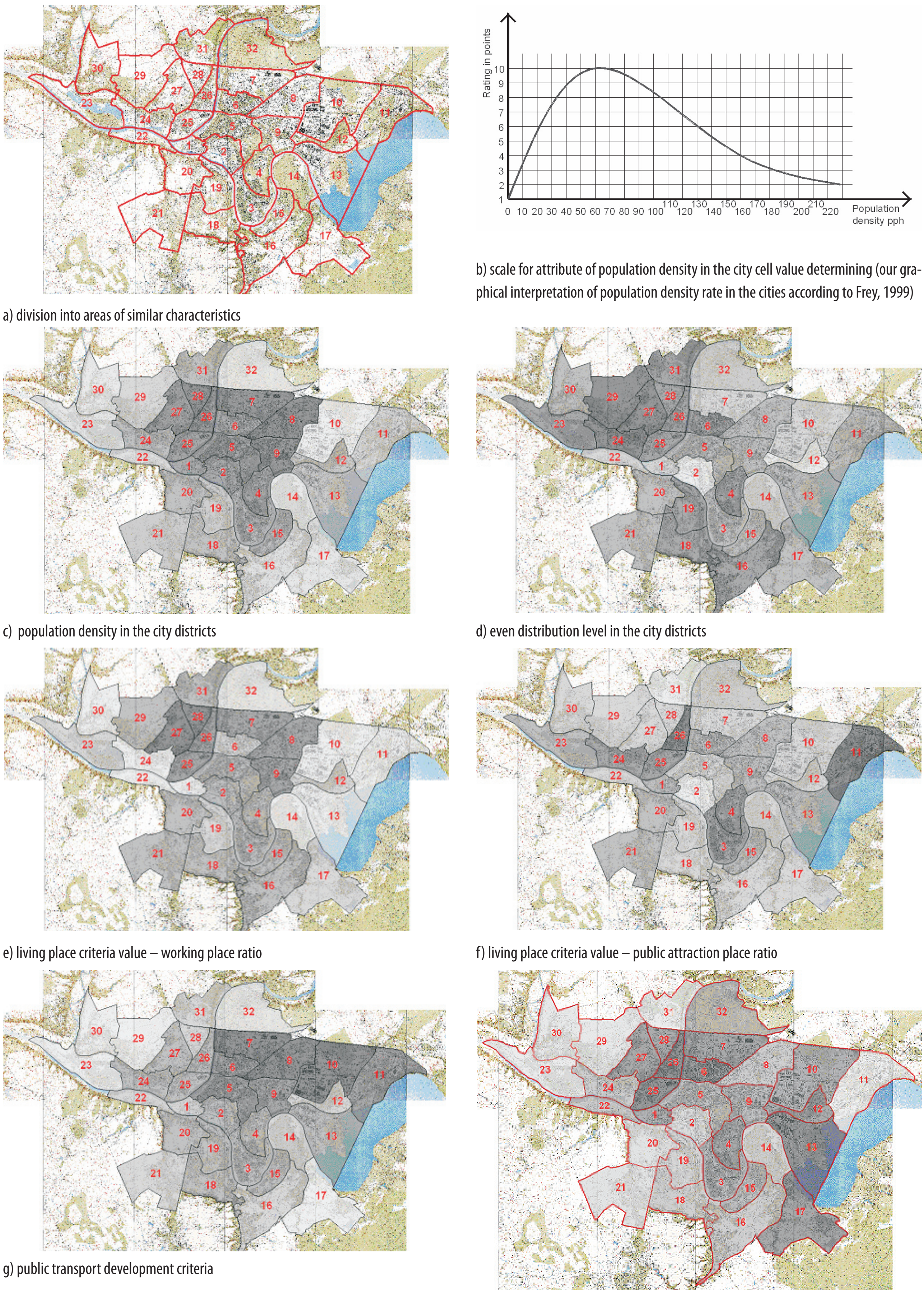
In order to perform a complete study of a district, a complex evaluation of its land use intensity, public transport development level and other aspects is needed. Quantitative descriptions provide this information. Quantitative information is based on attribute systems and subsystems, units of measure, values and initial weights of the project alternatives. Quantitative information is more accurate and reliable than conceptual and allows using multi-attribute decision-making methods.

The grouping of information in the matrix should be performed so as to facilitate the calculation process and to express its values. The attribute system here is formed from attributes describing the city compactness expressed in the quantitative form (quantitative attributes) and the attributes describing the sustainability of the city land use which cannot be expressed in the quantitative form (qualitative attributes) (Turskis et al., 2006).

The values of qualitative attributes must be expressed in the numerical and comparable form. They must be comparable because the mean value for one qualitative attribute must receive approximately the same numerical values as the mean values of the other qualitative attributes (Turskis et.al., 2006).

In our case study, a built-up territory is divided into n parts with similar characteristics, which are called cells (Figure, a). Analysis was performed for the data of each cell. Attributes of sustainable city compactness were selected on the basis of interrogation of competent experts in territory planning. Thirty-eight experts participated in this process. As a result of the analysis of interrogation data, the most important attributes were selected.

The different characteristics of the cells were counted, and the level of matching to the compact city model was calculated by the COPRAS method (Zavadskas, Kaklauskas, 1996; Zavadskas, Vilutiene, 2004; Vilutiene, Zavadskas, 2003;



a) division into areas of similar characteristics

b) scale for attribute of population density in the city cell value determining (our graphical interpretation of population density rate in the cities according to Frey, 1999)

c) population density in the city districts

d) even distribution level in the city districts

e) living place criteria value – working place ratio

f) living place criteria value – public attraction place ratio

g) public transport development criteria

h) evaluated city compactness

Figure. Characteristics of Kaunas city districts

Zavadskas, Antucheviciene, 2007). The obtained results are displayed in a picture by cells of different intensity to show the most problematic areas.

The five attributes selected to characterize the properties of a district were as follows:

1. Population density.
2. The level of the even distribution of population.
3. The ratio of population and working places.
4. The ratio of population and objects of public attraction.
5. The density of public transport network.

The future developing of this methodology will include an additional attribute from the rules and regulations of territorial planning documents.

Population density **(x_1)** has an optimal value which is 60 people/ha and is dimensioned by points (1–10 interval). The relation between population density in people/ha and point value is shown in Figure (b). From the compact city theory approach, a higher population density is better than lower as compared to optimal. In the Kaunas city territory, population density varies from 12 to 95 people per hectare (Figure, c). The population density is highest in block housing areas built up in the Soviet Union period. In these districts live around 65% of the city inhabitants. In the other areas, population density is much lower than optimal for a compact city. The values were taken from a GIS database compiled from the Kaunas city municipality inhabitant registry.

The level of even distribution of population (x_2) is the second strongest factor showing how the district is built up. The best building style in terms of compactness is of constantly changing density, and building with intervals or a sharp change in density shows a less sustainable development of a district. The most even distribution of population in the Kaunas city is found in the private house territories without nature objects and green belts (Figure, d). Data were taken from the GIS.

The ratio of population and working places (x_3) shows possibilities for the citizens to work near the living place and in this way to make shorter daily trips. According to data of the Lithuanian Department of Statistics, 56% of the citizens are of employable age. The relation between living places and working places confirms that the value is best when people have all the working places in their district. If there are more working places than people living in the district, it is also a problem in a compact city because it urges other people to come and produces longer distances to cover. The same situation takes place when the number of working places is less than 56% of the number of living places: people from this district will have to migrate to other places. Of course, not all people work near their living place, but it is an objective to be reached in a compact city, at least in theory.

In the Kaunas city, working places are situated mostly in the city center and industrial zones. Most of the city districts are very monofunctional, and the distribution and location of working places in them is bad (Figure, e). Data on working places were taken from the Lithuanian social insurance institution and entered into the GIS database.

The ratio of population and the objects of attraction **(x_4)** shows the possibilities for the citizens to find provision objects, services to satisfy daily needs near their living place and in this way to make daily trips shorter. When calculations are made, it is reputed that the more such provision centres are nearby the better is the development of a district. There is one theoretical problem in the case when there are very little people living in a district and there are huge objects that attract thousands of people. In this case, there is the maximum barrier for this ratio, and if it expands this limit it is stated that a district meets the compact city requirements at a medium level (Figure, f).

In the Kaunas city, objects of public attraction are located near popular living and working areas. In peripheral areas there are no such objects, and it is bad. The city center has too little provision objects compared to the number of people working there. Data on the public attraction objects were taken from the plan of trade and commerce objects recently developed by the Kaunas municipality planning enterprise. The objects that attract most people today are the biggest supermarkets, shopping centers, shopping malls.

The level of the public transport network development is also one of the most important points in a compact city. This category in our case is defined by the ***Public transport network density (x_5)*** in a district. Public transport stops and the number of routes are calculated and divided by the sum of living places, working places and public attraction places. In the Kaunas city, public transport is developed sufficiently in the eastern and northern sides of the city. In the central and western parts, its network is not sufficient (Figure, g). There are three main types of public transport – trolleybuses, buses, private micro-buses. Data on the public transport routes were taken from the general Kaunas city plan approved in 2004.

DETERMINATION OF ATTRIBUTE WEIGHT

Multi-attribute analysis is widely used in selecting the best alternative from a finite set of decision alternatives with respect to multiple, usually conflicting attributes. A special feature of the model is determination of attribute weight. Many methods in multi-attribute decision-making require information on the relative importance of each attribute. A number of methods for determining attribute weight in multi-attribute analysis have been developed.

In order to find the best and worst areas, a group decision-making matrix is calculated to perform a comparative multi-attribute analysis of the districts. Comparing attribute values and weight leads to making a selection. The compactness of an area can be described on the basis of an attribute system including many attributes with different values and dimensions. One of the major problems is to determine the weight of the attributes. This is most often done employing expert methods. The theoretical and practical aspects of expert methods have been dealt with in various papers by many authors (Arditi, Gunaydin, 1998; Kale, Arditi, 2001; Bana e Costa, 1988; Bana e Costa, Vansnick, 1997; Bana e Costa et al., 1999; Chinyio et al., 1998 and others). To determine the significance of the attributes, the expert judgement method proposed by Kendall (1970) was used. Zavadskas and others (Ustinovichus, 2001, 2004, 2007; Zavadskas, 2003; Zavadskas, Vilutiene, 2006; Turskis et al. 2006; Podvezko, 2005, 2007) discussed the application of the expert judgement method in the field of construction.

DESCRIPTION OF THE COPRAS METHOD AND ITS APPLICATION FOR EVALUATING THE COMPACTNESS OF KAUNAS CITY DISTRICTS

A decision maker, using the expert methods, determines the system of attributes and calculates their values from the initial weights of qualitative attributes (Table). A decision matrix is formed, in which the values of the attributes are measured in points. The weighted normalized decision-making matrix is formed. The purpose here is to receive dimensionless weighted values from comparative indices. When the dimensionless values of the indices are known, all attributes can be compared.

The method of complex proportional evaluation (Zavadskas, Kaklauskas, 1996) assumes a direct and proportional dependence of significance and the utility degree of investigated versions on a system of criteria adequately describing the alternatives and on the values and weights of the criteria. A decision maker, by using the expert methods, determines the system of criteria and calculates the values and initial weights of the qualitative criteria.

When the rationality of the alternatives is obtained, the results show that the sustainable Kaunas city compactness is not even and N_j varies from 100 to 53. According to solution results N_j, a figure was drawn, which represents the sustainable Kaunas city compactness. The most compact areas are darkest and not sustainable areas are light. According to this chart, the lightest areas are problematic from the point of view of sustainable compactness (Figure, h).

CONCLUSIONS

Estimating city compactness and sustainability is a complex problem. The method described in this article may be used as a

Table. **Compactness evaluation of the Kaunas city territory cells**

Initial decision making matrix criteria values, in points						***Stage 1:* The weighted normalized decision making matrix *D***					S_{+j}	S_{-j}	Q_j	Rank	N_j
Cell	x_1	x_2	x_3	x_4	x_5	d_1	d_2	d_3	d_4	d_5					
Q	**0.31**	**0.26**	**0.18**	**0.13**	**0.12**										
23	2	2	3	5	2	0.00388	0.00510	0.00643	0.005	0.00264	0.02305	0	0.02305	27	61.11
24	5	1	4	5	3	0.00969	0.00255	0.00857	0.005	0.00396	0.02977	0	0.02977	19	78.92
27	10	3	1	3	3	0.01938	0.00765	0.00214	0.003	0.00396	0.03613	0	0.03613	5	95.78
28	9	4	1	3	2	0.01744	0.01020	0.00214	0.003	0.00264	0.03542	0	0.03542	7	93.98
31	3	3	2	1	3	0.00581	0.00765	0.00428	0.001	0.00396	0.0227	0	0.0227	32	60.18
32	1	4	5	4	4	0.00194	0.01020	0.01071	0.004	0.00527	0.03212	0	0.03212	16	85.15
26	10	2	2	5	3	0.01938	0.00510	0.00428	0.005	0.00396	0.03772	0	0.03772	1	100.00
7	9	3	1	2	5	0.01744	0.00765	0.00214	0.002	0.00659	0.03582	0	0.03582	11	94.96
6	7	3	3	5	3	0.01356	0.00765	0.00643	0.005	0.00396	0.0366	0	0.0366	29	97.03
25	10	2	1	5	4	0.01938	0.00510	0.00214	0.005	0.00527	0.03689	0	0.03689	2	97.80
22	2	3	5	5	2	0.00388	0.00765	0.01071	0.005	0.00264	0.02988	0	0.02988	17	79.22
1	7	1	5	5	2	0.01356	0.00255	0.01071	0.005	0.00264	0.03446	0	0.03446	10	91.36
5	7	3	2	3	3	0.01356	0.00765	0.00428	0.003	0.00396	0.03245	0	0.03245	15	86.03
2	7	2	2	1	3	0.01356	0.00510	0.00428	0.001	0.00396	0.0279	0	0.0279	30	73.97
20	4	3	2	5	2	0.00775	0.00765	0.00428	0.005	0.00264	0.02732	0	0.02732	25	72.43
19	3	4	3	5	1	0.00581	0.01020	0.00643	0.005	0.00132	0.02876	0	0.02876	23	76.25
21	3	3	2	5	3	0.00581	0.00765	0.00428	0.005	0.00396	0.0267	0	0.0267	31	70.78
18	4	4	2	4	2	0.00775	0.01020	0.00428	0.004	0.00264	0.02887	0	0.02887	22	76.54
16	3	4	2	5	3	0.00581	0.01020	0.00428	0.005	0.00396	0.02925	0	0.02925	18	77.55
3	6	3	2	5	4	0.01162	0.00765	0.00428	0.005	0.00527	0.03382	0	0.03382	12	89.66
15	6	3	2	5	3	0.01162	0.00765	0.00428	0.005	0.00396	0.03251	0	0.03251	14	86.19
4	7	2	2	5	5	0.01356	0.00510	0.00428	0.005	0.00659	0.03453	0	0.03453	9	91.54
14	1	4	5	4	1	0.00194	0.01020	0.01071	0.004	0.00132	0.02817	0	0.02817	24	74.68
17	2	5	2	5	3	0.00388	0.01274	0.00428	0.005	0.00396	0.02986	0	0.02986	18	79.16
13	3	4	4	5	5	0.00581	0.01020	0.00857	0.005	0.00659	0.03617	0	0.03617	4	95.89
9	9	4	1	3	3	0.01744	0.01020	0.00214	0.003	0.00396	0.03674	0	0.03674	3	97.40
12	3	5	3	5	2	0.00581	0.01274	0.00643	0.005	0.00264	0.03262	0	0.03262	13	86.48
11	3	4	5	4	3	0.00581	0.01020	0.01071	0.004	0.00396	0.03468	0	0.03468	8	91.94
10	1	5	1	2	1	0.00194	0.01274	0.00214	0.002	0.00132	0.02014	0	0.02014	28	53.39
8	9	3	2	2	2	0.01744	0.00765	0.00428	0.002	0.00264	0.03401	0	0.03401	11	90.16
30	1	4	5	4	2	0.00194	0.01020	0.01071	0.004	0.00264	0.02949	0	0.02949	20	78.18
29	3	2	2	5	4	0.00581	0.00510	0.00428	0.005	0.00527	0.02546	0	0.02546	26	67.50
$\sum_{j=1}^{n}$	160	102	84	130	91	0.31010	0.26007	0.17988	0.130	0.12005	1.0001	0	1.0001		

basis for further development. A simple set of five attributes describing the basic structure and functionality of a city was used. City sustainability must be described by many attributes. The attribute weight and sets may vary depending on situations and the character of research. Additional attributes and different sets may be applied in this universal method.

When science is used for policy making, an appropriate management of decisions implies including the multiplicity of participants and perspectives. This also implies the impossibility of reducing all dimensions to a single unity of measure. Our concern is with the assumption that in any dialogue, all valuations or 'numeraries' should be reducible to a single one-dimensional standard. It is noteworthy that this call for citizens' participation and transparency, when science is used for policy making, is geting an increasing institutional support inside the European Union, where perhaps the most significant examples are the White Paper on Governance and the Directive on Strategic Environmental Impact Assessment. Multi-attribute evaluation supplies a powerful framework for implementation of the incommensurability principle. In fact, it accomplishes the goals of being multi-disciplinary (with respect to the research team), participatory (with respect to the local community) and transparent (since all attributes are presented in their original form without any transformations in money, energy or whatever common measurement rod). As a consequence, multi-attribute evaluation looks as an adequate assessment framework for (micro and macro) sustainability policies.

In this work, graphical charts of different attributes were made to indicate problematic areas. These charts can be used by planners as a motivation for decisions to deal with a specific problem. The GIS gives powerful tools to visualize the results. Here, we used simple shaded charts. However, the results can be shown in a more complex way putting some attributes together and using raster overlaying techniques.

Only by calculating the values of different attributes such a complex subject as sustainability of a city can be measured. Multi-attribute analysis methods can give a numerical expression to the sustainability of regions, cities, city districts. In our case, we have used small territories with similar characteristics as units, but the whole regions, cities or city districts may be chosen as well. The numerical expression of sustainable city compactness sheds more light on the concept of city sustainability and also gives an opportunity to visualize the results by graphical charts.

The case study of the Kaunas city has revealed the most problematic areas. Most problems occur in the peripheral zones, but there is also a big problem in the area near the city centre. Problems near the centre occur mainly because there are very little living places here. The best ranked areas are mainly block-housing areas to the north of the city centre where around 65% of the city population live.

This work presents a universal methodology and a simplified practical model for measuring sustainable city compactness. According to the model, calculations can be made using any geographical data, and the methodology may be expanded and adjusted to specific environments.

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MIESTŲ KOMPAKTIŠKUMO URBANISTINIS ĮVERTINIMAS TAIKANT GIS COPRAS METODĄ

Santrauka

Darna yra labai svarbi moderniai visuomenei. Dabartiniai žemės naudojimo ir plėtros pavyzdžiai kartu yra destruktyvūs aplinkos, ekonominiu ir socialiniu požiūriais. Miestai užima dideles teritorijas, sunku nustatyti jų ribas. Aptarnavimo objektų išsidėstymo vietos taip pat netampa neabejotinomis bei priimtinomis. Esama reta miesto struktūra yra rezultatas daugelio problemų, kylančių globaliu ir vietiniu lygiu. Globaliu mastu tai – klimato atšilimas, didesnė CO_2 emisija bei užterštumas, vietiniu mastu tai – priklausomybė nuo automobilio, perkrautos gatvės ir negyvybinga aplinka mieto viduje. Darnių miestų plėtros koncepcijos visada taikomos šioms pagrindinėms problemoms spręsti. Čia aptariamas ir palyginamas darnios plėtros įgyvendinimas, panaudojant kompaktiško miesto principus bei kitas populiarias teorijas. Šiame straipsnyje esamos miestų struktūros analizė atliekama darnaus kompaktiškumo požiūriu ir aprašoma kaip daugiamatis subjektas. Miesto teritorija yra suskaidoma į ląsteles pagal būdingus bruožus. Pasiūlytas daugiakriterinio kompleksinio proporcinio vertinimo metodo (COPRAS) pritaikymas, įvertinant miesto ląstelių adekvatumą teoriniam darniam kompaktiškam miestui. Šis metodas sujungtas su geografine informacine sistema (GIS), kad būtų galima efektyviai apskaičiuoti parametrus ir vizualiai pavaizduoti miesto kompaktiškumą. Geografinės informacinės sistemos bazėje sukuriamas duomenų bankas apie gyventojus, adresus, viešojo transporto sustojimus ir viešąsias lankomas vietas. Ši technologija padės miestų planavimo įstaigoms ir specialistams nustatyti bei susieti užstatymo tankio problemas miesto teritorijoje, sustiprinti integruoto planavimo požiūrio taikymą ir pagrįsti priimamus sprendimus. Šis modelis praktiškai pritaikytas Kauno miestui.

Raktažodžiai: darni plėtra, kompaktiškumas, miesto struktūra, gyventojų tankis, GIS, daugiakriterinis metodas, COPRAS metodas